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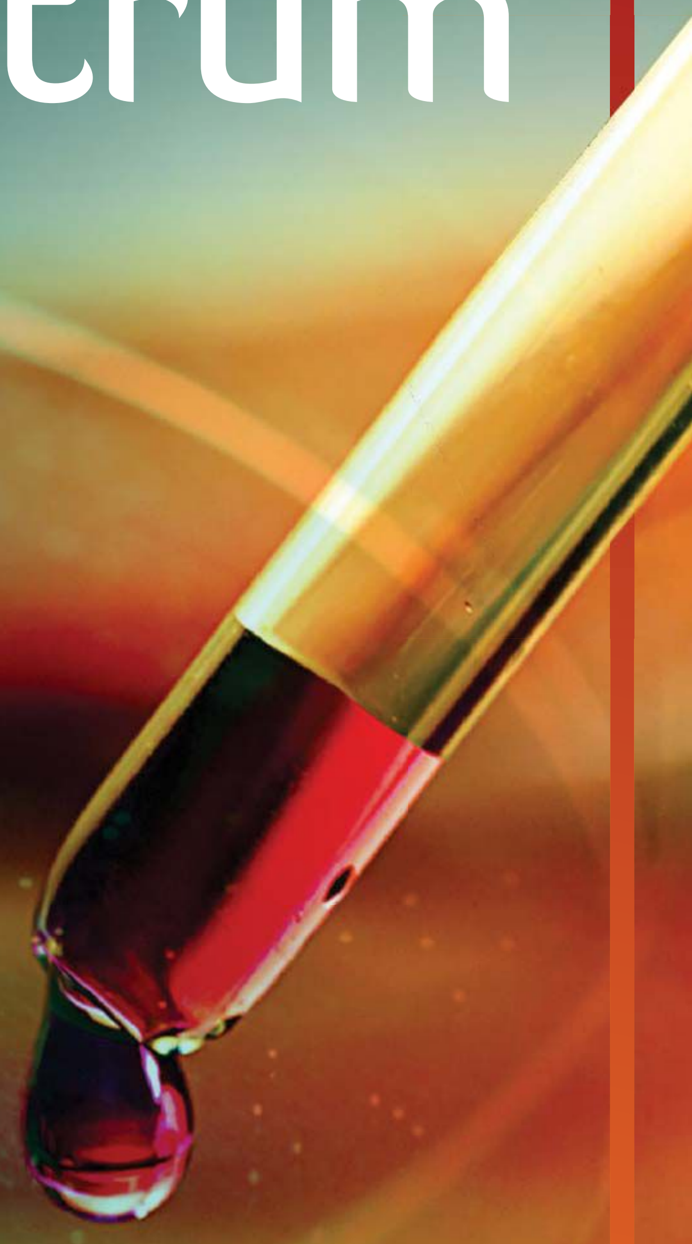
CHEMISTRY Spectrum



TARGET 2017

Rapid Concept Revision

States of Matter
p-Block Elements (Group 13 & 14)

FROM CLASS XIth SYLLABUS

Coordination Compounds
Chemistry in Every Day Life

FROM CLASS XIIth SYLLABUS

TEST RiDER FOR JEE Advanced

Two Test Papers

TEST RiDER FOR BITSAT

Two Test Papers

MEDi QUEST FOR NEET

Two Test Papers

JUVENILEZ

GOLDEN OLDIES *Transition & Inner Transition Elements*
TOUCH UP CLASS XII *Solid State*
RAINBOW *Qualitative and Quantitative Analysis*
FUN ARCADE

MEGA ISSUE 5
More Pages
More Features
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Revision *cum*
CRASH COURSES

40 DAYS
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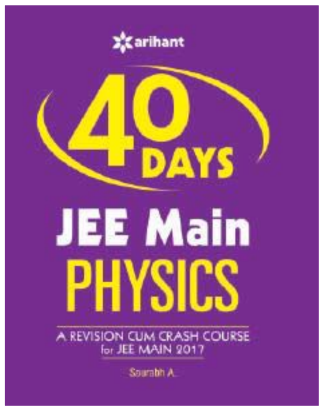
PHYSICS, CHEMISTRY, MATHEMATICS



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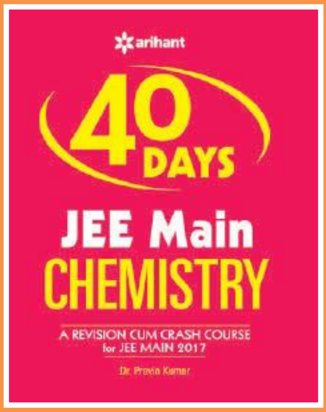

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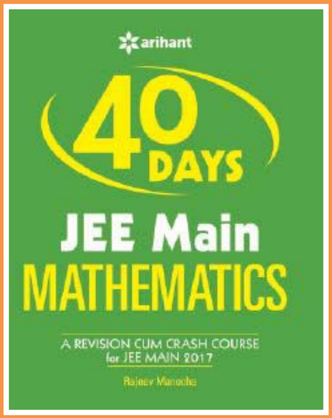

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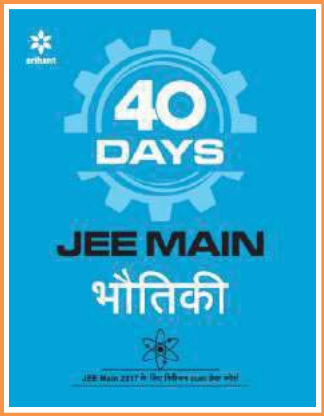

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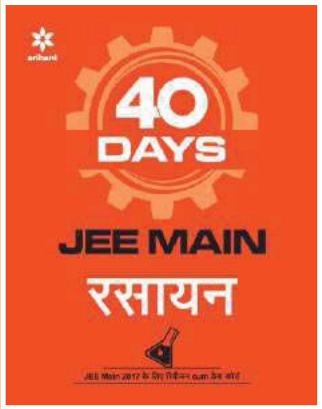

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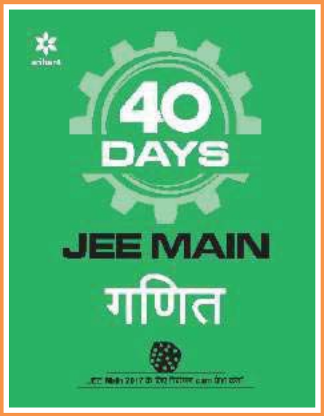

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Issue 3 Vol 5

Dear Aspirants,

The month of April and May are the months of competitions. Three major competitions of this period are JEE Mains, NEET, BITSAT and JEE Advanced. For us, these months are most productive from creativity point of view. The month of April, especially, is the best for the effective functioning of brain with optimum weather conditions.

"If a liquid is heated in an open container, it gradually evaporates away. But if the heating is carried out in a closed container, liquid evaporates and the evaporation causes increase in the density and the pressure of the vapour. Eventually, as the temperature increases, a point is reached where the vapour and the liquid have the same density. This point is known as critical point (for water it is 674 K and 220 bar). Above this temperature and pressure distinction between the liquid and the gaseous phases is not possible and the substance can only be considered as fluid. Such fluids above the critical level are called super critical fluids." In the few lines described above a clear categorization of liquid, vapour and fluid is given. All the three words look more or less similar but have their own definition which demarcates their limits. Chemistry is full of such words like molar and molecular masses, and atoms, molecules and elements etc. Thus to grip chemistry, one has to work over these kind of small words is necessary.

Hope all of you will also be working to succeed in your efforts. But remember! Success and failure entirely depends upon how you spend 24 hours of a day? Following lines of Thomas Edison always inspire me regarding the same

> ***"Time is really the only capital that any human being has and the only thing he can't afford to lose"***

We are trying hard to provide more and more material for your practice within the purview of our limitations. The spectrum team will be anxiously waiting for your feedbacks and comments.

Good luck

Sharma

Contents

@ CLASS XI SYLLABUS

Rapid
CONCEPT REVISION

TARGET 2017

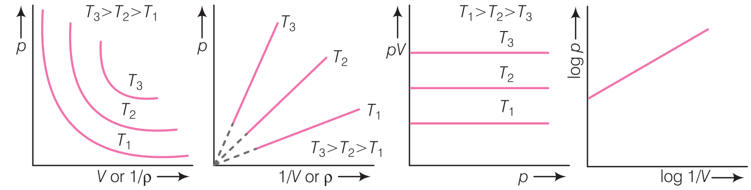
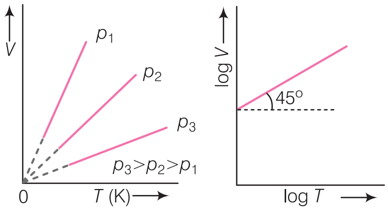
STATES OF MATTER

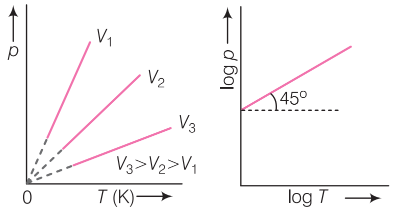
Anything that has mass and occupies space is called **matter**. In general, matter exists in three states which are described as follows:

- **Solids** They have definite volume, shape and are rigid due to the strongest intermolecular forces of attraction.
- **Liquids** They have definite volume but no definite shape and are non-rigid due to weaker intermolecular forces of attraction.
- **Gases** They have neither definite shape nor definite volume and are non-rigid due to weakest intermolecular forces of attraction.

Gas Laws

Gases show dependency on temperature, pressure and volume. The relationship of these three factors can be analysed by the gas laws described in the following table.

	Name of gas law and definition	Formulae	Graphs
1.	**Boyle's law** At constant temperature, the volume of the given mass of a gas is inversely proportional to pressure.	$V \propto \frac{1}{p}$ (T and n constant) or $p_1V_1 = p_2V_2$ $\rho \propto p \propto \frac{1}{V}$ (T constant) or $\frac{\rho_1}{\rho_2} = \frac{p_1}{p_2} = \frac{V_2}{V_1}$	 These curves are called **isotherms**.
2.	**Charles' law** At constant pressure, the volume of a given mass of a gas is directly proportional to absolute temperature.	$V \propto T$ (p and n constant) or $\frac{V_1}{T_1} = \frac{V_2}{T_2}$, $\rho \propto \frac{1}{T} \propto \frac{1}{V}$ (p constant) $\frac{\rho_1}{\rho_2} = \frac{T_2}{T_1} = \frac{V_2}{V_1}$ where, p, V, T and ρ are pressure, volume, temperature and density of gas, respectively.	 These curves are called **isobars** or **isoplestics**.

3.	**Gay-Lussac's law** At constant volume, the pressure of a given mass of a gas is directly proportional to absolute temperature.	$p \propto T$ (V and n constant) or $\frac{p_1}{T_1} = \frac{p_2}{T_2}$	 These curves are called **isochores**.
4.	**Avogadro's law** At constant temperature and pressure, equal volumes of all the gases contain equal number of molecules.	$V \propto n$ (T and p constant) or $\frac{V_1}{n_1} = \frac{V_2}{n_2}$	

Plasma and Bose-Einstein Condensate

The Fourth and Fifth States of Matter

Plasma is considered as the fourth state of matter consisting of highly energetic and excited particles that exist in ionised form. Plasma is found inside the sun and other stars. It is also found inside fluorescent bulbs.

According to Indian physicist Satyendra Nath Bose and German physicist Albert Einstein, there also exists a fifth state of matter called **Bose-Einstein Condensate** (BEC). It consists of a dilute gas of bosons cooled to a temperature very close to absolute zero (–273.15° C). The density of this state of matter is about one hundred thousandth time the density of normal air.

REMEMBER

- Charles' obtained experimentally that for 1°C increment in temperature of gas, the volume increase by a fraction of $\frac{1}{273}$.
- If V_0 is the volume of a gas at 0°C and it is recorded to be V at t°C, then

$$V = V_0 + \frac{1}{273} tV_0 = V_0 \left[1 + \frac{t}{273}\right]$$

Ideal Gas Equation

- On combining Boyle's, Charles' and Avogadro's law, we have

$$\frac{pV}{T} = \text{constant}$$

or $pV = RT$ [where, R = universal gas constant]

For 'n' moles of gas,

$$pV = nRT = \frac{mRT}{M}$$

where, m = mass of substance in grams

M = Molecular mass of substance

This is called **ideal gas equation** and is obeyed by isothermal and adiabatic processes.

- In terms of density (d), ideal gas equation can be written as

$$p = \frac{dRT}{M} \qquad \left[\because d = \frac{\text{mass}\,(m)}{\text{volume}\,(V)}\right]$$

- If temperature, volume and pressure of a fixed amount of gas vary from T_1, V_1 and p_1 to T_2, V_2 and p_2, then

$$\frac{p_1V_1}{T_1} = nR \text{ and } \frac{p_2V_2}{T_2} = nR$$

$$\therefore \quad \frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

This equation is called **combined gas equation**.

REMEMBER

R has different values for different units of pressure (p) and volume (V) and is given as

- $R = 8.314\ \text{J mol}^{-1}\text{K}^{-1}$ when p is in Nm^{-2} or Pa and V is in m^3.
- $R = 0.08205\ \text{L atm mol}^{-1}\text{K}^{-1}$, when p is in atm and V is in L.
- $R = 1.99\ \text{cal mol}^{-1}\text{K}^{-1}$, when $p \times V$ is in calorie.

  It is important to note that, temperature is always taken in Kelvin for any value of R.
- Gas constant, R for a single molecule is called **Boltzmann constant** (K).

$$K = \frac{R}{N} = \frac{8.314 \times 10^7}{6.023 \times 10^{23}}$$

$$= 1.38 \times 10^{-16} \text{ ergs mol}^{-1}\text{degree}^{-1}$$

$$= 1.38 \times 10^{-23} \text{ J mol}^{-1}\text{degree}^{-1}$$

Dalton's Law of Partial Pressure

If two or more chemically non-reacting gases are enclosed in a vessel, the total pressure exerted by the gaseous mixture is the sum of partial pressures exerted by the constituent gases. This statement is called Dalton's law of partial pressure.

$$p_{\text{total}} = p_1 + p_2 + p_3 + \dots$$

$$= \frac{RT}{V}(n_1 + n_2 + n_3 + \dots)$$

On dividing p_1 by p_{total}, we get

$$\frac{p_1}{p_{\text{total}}} = \left(\frac{n_1}{n_1 + n_2 + n_3 + \dots}\right)\frac{RTV}{RTV}$$

$$\therefore \quad p_1 = \chi_1\, p_{\text{total}} \qquad \left[\because \chi_1 = \frac{n_1}{n_1 + n_2 + \dots}\right]$$

Similarly, $p_2 = \chi_2\, p_{\text{total}}$ and so on.

where, $p_1, p_2, p_3, \ldots$; $n_1, n_2, n_3, \ldots$ and $\chi_1, \chi_2, \chi_3, \ldots$ are pressure, mole and mole fraction of 'n' gases present in a vessel.

Applications of Dalton's law

(i) It is used to calculate mole fraction of gas.

$$\text{Mole fraction of gas } (\chi) = \frac{\text{partial pressure of gas } (p)}{\text{total pressure } (p_{\text{total}})}$$

(ii) It is used to calculate pressure of gas collected over water. If a gas is collected over water, water vapour is mixed with the collected gas. Hence, the corrected pressure of the gas must be used as given below:

$$p_{\text{dry gas}} = p_{\text{moist gas}} - p_{\text{water vapour}}$$

(iii) It is also used to calculate relative humidity (R_H) at a given temperature,

$$R_H = \frac{\text{partial pressure of water in air}}{\text{vapour pressure of water}}$$

Note
- This law is only applicable when the component of gases in the mixture do not react with each other e.g. $N_2 + O_2$, $CO + CO_2$, $N_2 + Cl_2$, $CO + N_2$.
- But this law is not applicable to gases which combine chemically, e.g. $H_2 + Cl_2$, $CO + Cl_2$ etc.

Graham's Law of Diffusion
(or Effusion)

- If a gas is allowed to escape from its container through a small hole into vacuum, the process is called **effusion**.
- On the other hand, **diffusion** is the passage of gas through a porous partition.
- According to Graham's law of diffusion (effusion), "the rate of effusion (or diffusion) of non-reacting gases under similar conditions of temperature and pressure are inversely proportional to the square root of their densities or molar masses".

  Hence, rate of diffusion (or effusion), $r \propto \frac{1}{\sqrt{d}} \propto \frac{1}{\sqrt{M}}$
- If r_1 and r_2 are the rates of diffusion of two gases of molecular weights M_1 and M_2 and densities d_1 and d_2, then $\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$
- If V_1 and V_2 are the volume of two gases diffused (or effused) in time t_1 and t_2, then

$$r_1 = \frac{V_1}{t_1} \text{ and } r_2 = \frac{V_2}{t_2} \text{ or } \frac{r_1}{r_2} = \frac{V_1 t_2}{V_2 t_1} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$$

- If two gases are diffused (or effused) under different pressures p_1 and p_2, then

$$\frac{r_1}{r_2} = \frac{V_1 t_2}{V_2 t_1} = \frac{p_1}{p_2}\sqrt{\frac{d_2}{d_1}} = \frac{p_1}{p_2}\sqrt{\frac{M_2}{M_1}}$$

- Graham's law is used to determine vapour densities and molecular weights of gases.

Kinetic Theory of Gases

This theory explains ideal gas behaviour in terms of movement of molecules. The theory is based on the following assumptions

- A gas consists of extremely small discrete particles called molecules, dispersed through out the container.
- The molecules are so small that its volume is negligible in comparison to the total volume of the gas. Hence, the average distance between two gaseous molecules is much larger as compared to their size.
- The intermolecular forces are negligible. Hence, the gas molecules move freely independent of each other.
- The gas molecules moves in constant random motion with high speed. They continuously change direction on collision with each other or with the walls of container.
- The collisions are perfectly elastic resulting no loss of kinetic energy during collision.
- The effect of gravity on motion of molecules is negligible in comparison to the effect of collision.
- The pressure exerted by a gas is due to collision of gas molecules to the walls of container. Higher the number of collisions per unit time per unit area, higher is the pressure.
- At a particular instant, different molecules have different speeds, however the average kinetic energy of all molecules is assumed to be directly proportional to absolute temperature.

$$\bar{E}_{\text{KE}} \propto T \; (T \text{ is in kelvin})$$

- This theory explains macroscopic properties of gases like pressure, temperature, thermal conductivity, viscosity, etc., and microscopic properties like kinetic energy.

Kinetic Gas Equation

- Based on postulates of kinetic theory of gases the following equation was derived.

$$pV = \frac{1}{3} mNv_{\text{rms}}^2$$

where, p = pressure exerted by gas molecules
V = volume of the container
m = average mass of each molecule
N = number of molecules
v_{rms} = root mean square velocity of gas

- For 1 mole of a gas ($N = N_A$),

$$\text{KE} = \frac{3}{2} RT = \frac{3}{2} pV$$

- Average kinetic energy per molecule

$$= \frac{\text{average KE per mole}}{N} = \frac{3}{2}\frac{RT}{N} = \frac{3}{2} kT$$

where, $k = \frac{R}{N_A}$ = Boltzmann constant

- Hence, average KE is proportional to absolute temperature.

Molecular Velocities

Three different types of velocities are defined for gas molecules and are given as :

(i) **Average velocity** ($\bar{v}$) : For 'N' molecules of gas with velocities $v_1, v_2, \ldots, v_N$.

$$\bar{v} = \frac{v_1 + v_2 + \ldots + v_N}{N} = \sqrt{\frac{8RT}{\pi M}}$$

$$= \sqrt{\frac{8pV}{\pi M}} = \sqrt{\frac{8p}{\pi \rho}}$$

where, ρ = density of gas, M = molar mass of gas

(ii) **Root mean square velocity** (v_{rms})

$$v_{\text{rms}} = \sqrt{\frac{v_1^2 + v_2^2 \ldots v_N^2}{N}}$$

$$= \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3pV}{M}} = \sqrt{\frac{3p}{\rho}}$$

(iii) **Most probable velocity** (v_p) : It is the velocity which maximum number of molecules possess.

$$v_p = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2pV}{M}} = \sqrt{\frac{2p}{\rho}}$$

Relation between different molecular velocities

$$v_p : \bar{v} : v_{\text{rms}} = \sqrt{2} : \sqrt{\frac{8}{\pi}} : \sqrt{3} \quad (v_p < \bar{v} < v_{\text{rms}})$$

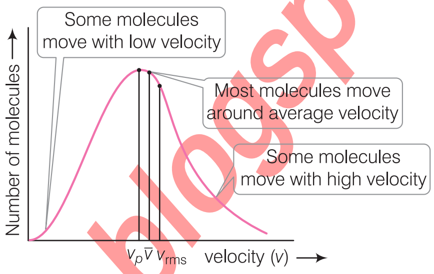
$$= 1 : 1.128 : 1.224$$

Trick to Solve Problems Related to Molecular Velocities

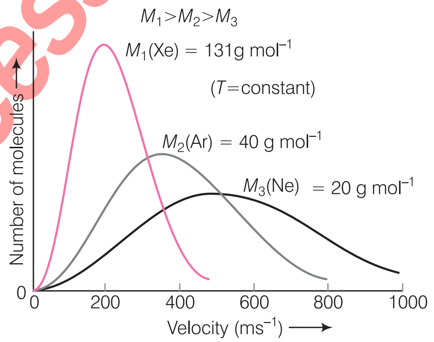
- To get velocity in ms^{-1}, take M in kg, T in K and $R = 8.314$ J mol^{-1} K^{-1}.
- If p and T both are given, apply the equation in terms of T i.e. $v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$ and not in terms of p.
- To get velocity in ms^{-1}, take ρ in kg m^{-3} and P in Nm^{-2}. or kgm^{-1}s^{-2}
- For two different gases at same temperature,
$$v \propto \sqrt{\frac{1}{M}} \text{ or } \frac{v_1}{v_2} = \sqrt{\frac{M_2}{M_1}}$$
- For gases at different temperatures,
$$v \propto \sqrt{T} \text{ or } \frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$$
- For two different gases at different temperatures,
$$\frac{v_1}{v_2} = \sqrt{\frac{T_1 M_2}{T_2 M_1}}$$

Maxwell-Boltzmann Distribution of Molecular Velocities

At any particular time, different molecules have different velocities and hence kinetic energies, then the average value of velocity and kinetic energy is considered. **Maxwell** and **Boltzmann** gave the following distribution curve for molecular velocity and number of molecules moving with that velocity at a particular time.



Distribution of velocity of gaseous molecules also depend on molar mass of gas and temperature, as shown in the curves below



For gases with higher molar mass, the average velocity is lower and the distribution of velocity is less broad in comparison to gases with lower molar mass at same temperature, $v \propto \sqrt{\frac{1}{M}}$.

Collision Properties

An effective molecular collision is important during a chemical reaction between gases. Also, transport properties of gases like diffusion, effusion etc. depends upon molecular collision. These are called collision properties and discussed below:

(i) Mean Free path (λ)

- It is the average distance travelled by a molecule between two successive collisions.
$$\lambda = \frac{\text{distance travelled in one second}}{\text{number of collisions in one second}}$$
- The mean free path is directly proportional to temperature and inversely proportional to pressure.

(ii) Collision Diameter (σ)

- It is the closest distance between the centres of two molecules taking part in a collision.
- The smaller the collision or molecular diameter, the lower is the mean free path.

(iii) Collision Frequency (Z)

- It is the number of collisions that a molecule undergoes per second.
- It depends on pressure (i.e. number of gas molecules per unit volume) and distance travelled by the molecules.

Ideal and Real Gases

- The gases which obey gas laws are called ideal gases while those which do not obey exactly are called real gases.
- Real gases show ideal behaviour i.e. obey gas equation under moderate conditions of temperature and pressure (especially when pressure tends to zero).
- At high pressure and low temperature, real gases show major deviation from ideal gas behaviour.

Causes of Deviation from Ideal Behaviour

It is mainly due to the following assumptions of kinetic theory of gases which do not hold good under all conditions.

(i) Intermolecular forces of attraction between gaseous molecules is negligible.

(ii) Volume occupied by gas molecules is negligible in comparison to the total volume of gas.

Explanation of Deviation from Ideal Behaviour

- The deviation from ideal behaviour can be explained on the basis of **compressibility factor** (Z).
- It is defined as the ratio of measured molar volume (V_m) of a gas to the molar volume of an ideal gas $\left[V_m^\circ = \frac{RT}{p}\right]$ at same temperature and pressure i.e.,

$$Z = \frac{V_m}{V_m^\circ} = \frac{V_m}{RT/p} = \frac{pV_m}{RT}$$

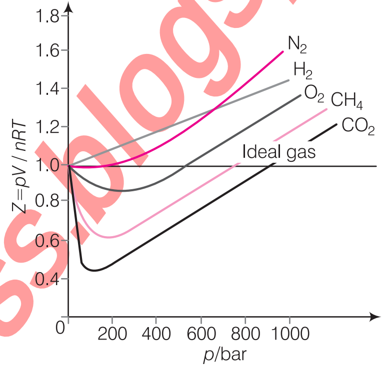
The following three values of Z are possible:

(i) When $V_m = V_m^\circ$, $Z = 1$ and the gas behave as ideal (perfect) gas. At very low pressure and high temperature real gases behave as ideal gas.

(ii) When $V_m > V_m^\circ$, $Z > 1$, i.e. the gas is less compressible than expected from ideal behaviour and shows **positive deviation**. This happens at high pressure, $pV_m > RT$.

(iii) When $V_m < V_m^\circ$, $Z < 1$, i.e. the gas is more compressible than expected from ideal behaviour and shows **negative deviation**. This usually happens at intermediate presssure, $pV_m < RT$.

- The variation of Z with pressure for different gases is shown by the following graph



van der Waals' Equation

- In order to rectify the errors caused by ignoring the intermolecular forces of attraction and volume of gas molecules, a correction in pressure and volume terms in ideal gas equation was necessary.
- Johannes van der Waals' proposed the following modified equation which is valid for real gases upto a large range of temperature and pressure.

$$\overbrace{\left(\underbrace{p_m}_{\text{Measured pressure}} + \underbrace{\frac{an^2}{V^2}}_{\text{Pressure correction factor to consider intermolecular forces}}\right)}^{\text{Ideal pressure }(p)} \overbrace{(\underbrace{V_m}_{\text{Measured volume}} - \underbrace{nb}_{\text{Volume correction factor to consider molecular volume}})}^{\text{Ideal volume }(V)} = nRT$$

- There is a positive sign to pressure correction because when intermolecular force is considered, the molecule will exert less pressure to the wall. Hence, measured pressure will be less than the pressure predicted by ideal gas equation.
- There is a negative sign to volume correction because when molecular volume is considered, the volume in which molecules can move becomes less than the total volume of container.

van der Waals' Constants and its Significance

- a and b are van der Waals' constants, where a is an indirect measure of magnitude of attractive forces between molecules. Higher the value of a, higher is the ease of liquefaction of the gas. Hence, higher the value of a, higher is the strength of van der Waals' force.

  Unit of a : atm L^2 mol^{-2} or Nm^4 mol^{-2} or $Jm^3 mol^{-2}$.
- b is a measure of the portion of the gas which is not compressible.

  Unit of b : L mol^{-1} or m^3 mol^{-1}

Note van der Waals' constants a and b are related as $T_B = \frac{a}{bR}$

where, T_B = Boyle's temperature.

van der Waals' Equation at different conditions

(a) **At low pressure** $V >> b$, hence van der Waals' equation (for 1 mole of gas) becomes

$$\left(p + \frac{a}{V^2}\right)V = RT$$

$$\text{or} \quad \frac{pV}{RT} = \left(1 - \frac{a}{VRT}\right) = Z$$

(b) **At extremely low pressure** $V >> a$ and b, hence both the terms $\frac{a}{V^2}$ and b can be neglected. Hence, van der Waals' equation becomes $pV = RT$ (for 1 mole of gas) i.e. real gas behaves as an ideal gas.

(c) **At high pressure** $p >> \frac{a}{V^2}$, hence $\frac{a}{V^2}$ can be neglected and van der Waals' equation becomes

$$p(V - b) = RT \text{ (for } n = 1 \text{ mole)}$$

$$\text{or} \quad \frac{pV}{RT} = Z = 1 + \frac{pb}{RT}$$

(d) **At low temperature** Both p and V are small and hence both pressure and volume corrections, are appreciable. Hence, there is no change in the van der Waals' equation.

(e) **At high temperature** At any pressure, if the temperature is extremely high, V is very large and hence, a/V^2 and b can be neglected. Thus, van der Waals' equation becomes

$$pV = RT$$

Limitations of van der Waals' Equation

(i) Although, it is able to explain behaviour of real gases over a wide range of pressure and temperature, yet appreciable deviation at too low temperatures and pressures have been observed.

(ii) The values of a and b do not remain constant over the entire ranges of temperature and pressure. Thus, it is valid only over specific range of temperature and pressure.

Liquefaction of Gases

A gas can be liquefied by decreasing temperature and increasing pressure.

The following critical states are defined for liquefaction of gases:

Critical Temperature (T_c) It is the minimum temperature above which the gas cannot be liquefied, even a large pressure is applied and is given by $T_c = \frac{8a}{27Rb}$

Critical Pressure (p_c) It is the minimum pressure required to liquefy the gas at its critical temperature and is given by $p_c = \frac{a}{27b^2}$

Critical Volume (V_c) It is the volume occupied by a mole of the gas at critical temperature and pressure and is given by

$$V_c = 3b$$

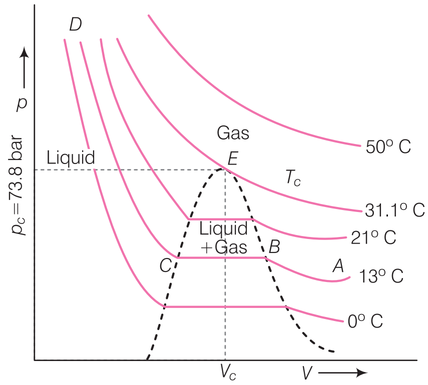
REMEMBER

- Gases having stronger intermolecular forces like NH_3, H_2O, SO_2, CO_2 etc., have higher value of T_c and can be easily liquefied.
- Gases having very weak intermolecular forces like H_2, He, N_2, Ar, O_2etc. have lower value of T_c and very difficult to liquefy.
- Critical compressibility factor (Z_c) is given by $Z_c = \frac{p_c V_c}{RT_c} = \frac{3}{8} = 0.375$

  All gases behave as van der Waals' gas if its critical compressibility factor is equal to 0.375.

Liquefaction of CO_2 Gas

Thomas Andrew studied the isotherm of CO_2 and obtained the following graph showing, T_c, p_c and V_c for CO_2.



Isotherm of CO_2 showing critical temperature

- From the given graph, it is clear that the T_c and p_c values for CO_2 are 31.3°C and 73.8 bar, respectively.
- At 50°C and above, the isotherm of CO_2 looks like that of an ideal gas. However, at any temperature below T_c, the graph has 3 parts.
- In the first part from A to B, volume decreases on increasing pressure. In the second part from B to C, volume decreases suddenly at constant pressure indicating liquefaction of gas and in the third part from C to D there is an appreciable change in pressure for very small change in volume.

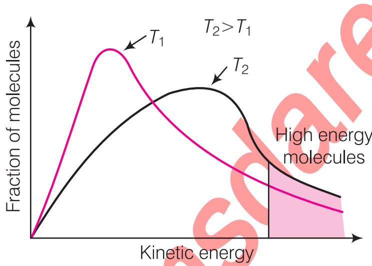
Liquid State

Intermolecular forces in liquids is intermediate of gases and solids, which is stronger than gases but weaker than solids.

- They are held together by van der Waals' forces like dipole-dipole attraction, London forces, hydrogen bonding etc.
- They have definite volume, but not shape as the intermolecular forces are not enough to fix the molecules at a definite position in crystal lattice.
- The densities of liquids are intermediate of gases and solids and decrease with increase in temperature.

Evaporation

- When kinetic energy of a liquid molecule exceeds intermolecular forces of attraction, it escapes as vapour and the process is called **evaporation**.
- It takes place at any temperature below the boiling point of a liquid and its rate increases with increase in temperature due to increase in kinetic energy of molecules.



Kinetic energy distribution in liquids

Vapour Pressure

- During evaporation or boiling, the pressure exerted by vapours in equilibrium with liquid at a particular temperature is called **vapour pressure**.
- Vapour pressure increases with rise in temperature and can be calculated by Clausius-Clapeyron equation as

$$\log\left(\frac{p_2}{p_1}\right)=\frac{\Delta H_{vap}}{2.303R}\left[\frac{1}{T_1}-\frac{1}{T_2}\right], (T_1 > T_2)$$

where, ΔH_{vap} is the molar enthalpy of vaporisation.

- Vapour pressure

$$\propto \frac{1}{\text{intermolecular forces}} \propto \text{temperature}$$

Surface Tension

- It is the force acting along the surface of a liquid at right angle to any line per unit length.

$$\text{Surface tension } (\gamma) = \frac{\text{force}}{\text{length}}$$

- Its unit is Nm^{-1}.
- Surface tension $\propto$ intermolecular forces $\propto \frac{1}{\text{temperature}}$
- Due to surface tension, the molecules at surface tend to acquire minimum surface area.
- To increase surface area, the given force must overcome surface tension.
- The energy required to increase surface area by one unit is called **surface energy**.

$$\text{Surface energy} = \frac{\text{work done}}{\text{change in area}}$$

- Due to surface tension, liquids tend to rise or fall in capillary tube and is given by

$$h = \frac{2\,\gamma \cos\theta}{r\rho g}$$

where, γ = surface tension, ρ = density of liquid, r = radius of capillary, θ = angle of contact

Viscosity

- It is the measure of the resistance in the flow of liquid due to internal friction between two liquid layers.
- The viscous force between two liquid layers with area of cross-section A, separated by a distance dx having velocity difference, dv is given as

$$F = \eta A \frac{dv}{dx}$$

where, η is coefficient of viscosity and constant for a liquid at a given temperature.

- Unit of η : Nsm^{-2} or Pa-s (SI unit), poise or $gcm^{-1}s^{-1}$ (CGS unit).
- Viscosity $\propto \frac{1}{\text{temperature}} \propto$ intermolecular forces
- The reciprocal of viscosity is called **fluidity**.

MASTER STROKES

1. At very high pressures, the compressibility factor of one mole of a gas is given by **[JEE main 2016]**

(a) $1 + \frac{pb}{RT}$
(b) $\frac{pb}{RT}$
(c) $1 - \frac{b}{(VRT)}$
(d) $1 - \frac{pb}{RT}$

2. When does a gas deviate the most from its ideal behaviour? **[JEE main 2015]**

(a) At low pressure and low temperature
(b) At low pressure and high temperature
(c) At high pressure and low temperature
(d) At high pressure and high temperature

3. If Z is a compressibility factor, van der Waals' equation at low pressure can be written as **[JEE main 2014]**

(a) $Z = 1 + \frac{RT}{pb}$
(b) $Z = 1 - \frac{a}{VRT}$
(c) $Z = 1 - \frac{pb}{RT}$
(d) $Z = 1 + \frac{pb}{RT}$

4. Kinetic energy of one mole of an ideal gas at 300 K is

(a) 3.48 kJ
(b) 3.74 kJ
(c) 37.4 kJ
(d) 34.8 kJ

5. The most probable velocity of a gas molecule at 298 K is 300 m/s. Its rms velocity (in m/s) is

(a) 420
(b) 245
(c) 402
(d) 367

6. The average velocity (in cm/s) of hydrogen molecule at 27°C will be

(a) 19.3×10^4
(b) 17.8×10^4
(c) 24.93×10^9
(d) 17.8×10^8

7. If a gas expands at constant temperature, it indicates that

(a) kinetic energy of molecules decreases
(b) pressure of the gas increases
(c) kinetic energy of molecules remains the same
(d) number of the molecules of gas increases

8. If the ratio of the rates of diffusion of two gases A and B is 4 : 1, then the ratio of their densities in the same order is

(a) 16 : 1
(b) 4 : 1
(c) 1 : 4
(d) 1 : 16

9. Compressibility factor for CO_2 at 400 K and 71.0 bar is 0.8697. Molar volume of CO_2 under these conditions is

(a) 22.4 L
(b) 2.24 L
(c) 0.41 L
(d) 19.5 L

10. At what temperature will the hydrogen molecules have the same kinetic energy per mole as nitrogen molecules at 280 K?

(a) 280 K
(b) 40 K
(c) 400 K
(d) 50 K

11. A sample of an ideal gas occupies 20 L under a pressure of 0.5 atm and under isothermal condition. On increasing its pressure to 1.0 atm, its volume will be

(a) 20 L
(b) 10 L
(c) 5 L
(d) 2.5 L

12. A gas at a pressure of 5.0 bar is heated from 0°C to 546°C and is simultaneously compressed to one-third of its original volume. Hence, final pressure is

(a) $\frac{5}{9}$ bar
(b) 15.0 bar
(c) 30.0 bar
(d) 45.0 bar

13. A person living in Shimla observed that cooking of food without using pressure cooker takes more time. The reason for this observation is that at high altitude

(a) pressure increases
(b) pressure decreases
(c) temperature increases
(d) temperature decreases

14. Rate of diffusion of a gas is

(a) directly proportional to its density
(b) directly proportional to its molecular weight
(c) directly proportional to the square root of its molecular weight
(d) inversely proportional to the square root of its molecular weight

15. A gas will approach ideal behaviour at

(a) low temperature and low pressure
(b) low temperature and high pressure
(c) high temperature and low pressure
(d) high temperature and high pressure

16. For a monoatomic gas kinetic energy = E. The relation of E with rms velocity is

(a) $u = \left(\frac{2E}{m}\right)^{1/2}$
(b) $u = \left(\frac{3E}{2m}\right)^{1/2}$
(c) $u = \left(\frac{E}{2m}\right)^{1/2}$
(d) $u = \left(\frac{E}{3m}\right)^{1/2}$

17. The rms velocity of hydrogen is $\sqrt{7}$ times the rms velocity of nitrogen. If T is the temperature of the gas

(a) $T(H_2) = T(N_2)$
(b) $T(H_2) > T(N_2)$
(c) $T(H_2) < T(N_2)$
(d) $T(H_2) = \sqrt{7}\, T(N_2)$

18. Positive deviation from ideal behaviour takes place because of

(a) molecular interaction between atom and $pV / nRT > 1$
(b) molecular interaction between atom and $pV / nRT < 1$
(c) finite size of atoms and $pV / nRT > 1$
(d) finite size of atoms and $pV / nRT < 1$

19. A, B and C are ideal gases. Their molecular weights are 2, 4 and 28 respectively. The rate of diffusion of these gases follows the order

(a) $C > A > B$
(b) $C > B > A$
(c) $A = B = C$
(d) $A > B > C$

20. An LPG cylinder, containing 15 kg butane at 27°C and 10 atm pressure is leaking. After one day its pressure decreased to 8 atm. The quantity of gas leaked is

(a) 1 kg
(b) 2 kg
(c) 3 kg
(d) 4 kg

21. A gas is found to have a formula, $[CO]_x$. Its vapour density is 70, the value of x is

(a) 3.0
(b) 3.5
(c) 5.0
(d) 6.5

22. The temperature at which 28g of N_2 will occupy a volume of 10.0 L at 2.46 atm is

(a) 299.6 K
(b) 0°C
(c) 273 K
(d) 10°C

23. According to kinetic theory of gases, for a diatomic molecule

(a) the pressure exerted by the gas is proportional to mean velocity of the molecule
(b) the pressure exerted by the gas is proportional to the root mean velocity of the molecule
(c) the root mean square velocity of the molecule is inversely proportional to the temperature
(d) the mean translational kinetic energy of the molecule is proportional to the absolute temperature

24. A bottle of dry ammonia and a bottle of dry hydrogen chloride connected through a long tube are opened simultaneously at both ends. The white ammonium chloride ring first formed will be

(a) at the centre of the tube
(b) near the hydrogen chloride bottle
(c) near the ammonia bottle
(d) throughout the length of the tube

25. In which one of the following, does the given amount of chlorine exert the least pressure in a vessel of capacity 1 dm^3 at 273 K?

(a) 0.0355 g
(b) 0.071 g
(c) 6.023×10^{21} molecules
(d) 0.02 mol

26. The average velocity of an ideal gas molecule at 27° C is 0.3 m/s. The average velocity at 927°C will be

(a) 0.6 m/s
(b) 0.3 m/s
(c) 0.9 m/s
(d) 3.0 m/s

27. At constant volume, for a fixed number of moles of a gas the pressure of the gas increases with rise of temperature due to

(a) increase in average molecular speed
(b) increase in rate of collisions amongst molecules
(c) increase in molecular attraction
(d) decrease in mean free path

28. Volume of an ideal gas is to be decreased by 10% by increase of pressure by x% under isothermal condition. Thus, x is

(a) $\frac{100}{9}$
(b) $\frac{9}{100}$
(c) 10
(d) $\frac{1}{10}$

29. Which one of the following statements is not true about the effect of an increase in temperature on the distribution of molecular speeds in a gas?

(a) The area under the distribution curve remains the same as under the lower temperature
(b) The distribution becomes broader
(c) The fraction of the molecules with the most probable speed increases
(d) The most probable speed increases

30. The vapour pressure of liquid water is 23.8 Torr at 25°C. By what factor does the molar volume of water increases as it vaporises to form an ideal gas under these conditions? The density of liquid water is 0.997 g cm^{-3} at 298 K?

(a) 4.32×10^4
(b) 2.31×10^{-5}
(c) 4.32×10^6
(d) 2.31×10^{-7}

31. Dominance of strong repulsive forces among the molecules of the gas (Z = compressibility factor)

(a) depends on Z and indicated by $Z = 1$
(b) depends on Z and indicated by $Z > 1$
(c) depends on Z and indicated by $Z < 1$
(d) is independent of Z

32. If helium is allowed to expand in vacuum, it liberates heat because

(a) helium is an inert gas
(b) helium is an ideal gas
(c) the inversion temperature of helium is very low
(d) helium is one of the lightest gases

33. The temperature at which real gases obey the ideal gas laws over a wide range of pressure is called

(a) critical temperature
(b) inversion temperature
(c) Boyle's temperature
(d) reduced temperature

34. Critical temperature of H_2O, NH_3, CO_2 and O_2 are 647 K, 405.6 K, 304.10 K and 154.2 K, respectively. If the cooling starts from 500 K to their critical temperature, the gas that liquefies first is

(a) H_2O
(b) NH_3
(c) CO_2
(d) O_2

35. If helium and methane are allowed to diffuse out of the container under the similar conditions of temperature and pressure, then the ratio of rate of diffusion of helium to methane is

(a) 2.0
(b) 1.0
(c) 0.5
(d) 4.0

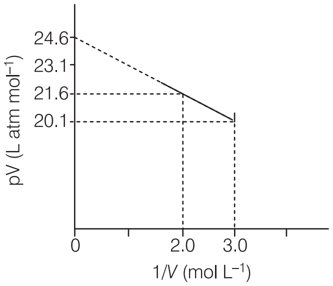
36. The term that corrects for the attractive forces present in a real gas in the van der Waals' equation is

(a) nb
(b) n^2a / V^2
(c) $-(n^2a / V^2)$
(d) $-nb$

37. For gaseous state, if most probable speed is denoted by C^*, average speed by $\bar{C}$ and root mean square speed by C, then for a large number of molecules, the ratios of these speeds are (JEE Main 2013)

(a) $C^* : \bar{C} : C = 1.225 : 1.128 : 1$
(b) $C^* : \bar{C} : C = 1.128 : 1.225 : 1$
(c) $C^* : \bar{C} : C = 1 : 1.128 : 1.225$
(d) $C^* : \bar{C} : C = 1 : 1.225 : 1.128$

38. For one mole of a van der Waals' gas when $b = 0$ and $T = 300$ K, the pV *vs* $1/V$ plot is shown below. The value of the van der Waals' constant a (atm L mol^{-2}) is



(*a*) 1.0 (*b*) 4.5 (*c*) 1.5 (*d*) 3.0

39. The surface tension of which of the following liquid is maximum ?

(*a*) H_2O (*b*) C_6H_6 (*c*) CH_3OH (*d*) C_2H_5OH

40. When a capillary tube of diameter 0.8 mm is dipped in a liquid having density 800 kg m^{-3}, then the height of liquid in the capillary tube rise to 4 cm. The surface tension of liquid is ($g = 9.8$ m / s^2)

(*a*) 4.3×10^{-2} Nm^{-1} (*b*) 5.6×10^{-2} Nm^{-1}
(*c*) 6.3×10^{-2} Nm^{-1} (*d*) 7.3×10^{-2} Nm^{-1}

41. Consider the following statements.

I. Vapour pressure of a liquid is the measure of the strength of intermolecular attractive forces.
II. Surface tension of a liquid acts perpendicular to the surface of the liquid.
III. Vapour pressure of all liquids is same at their freezing points.
IV. Liquids with stronger intermolecular attractive forces are more viscous than those with weaker intermolecular forces.

Choose the incorrect statement(s)

(*a*) II, III and IV (*b*) II and III (*c*) I, II and III (*d*) Only III

42. Which of the following is a correct statement?

(*a*) Surface tension of a liquid decreases with increase in temperature
(*b*) Vapour pressure of a liquid decreases with increase in temperature
(*c*) Viscosity of a liquid does not change with temperature
(*d*) In gravity free environments, droplets of a liquid on flat surface are slightly flattened

43. On increasing pressure, melting point of ice

(*a*) decreases
(*b*) increases
(*c*) remains unchanged
(*d*) changes in regular manner

44. The boiling point of water decreases at high altitudes because

(*a*) the atmospheric pressure is low
(*b*) the temperature is low
(*c*) the atmospheric pressure is high
(*d*) the temperature is high

45. Which of the following method is used to determine the surface tension of liquids?

(*a*) single capillary method (*b*) refractometric method
(*c*) polarimetric method (*d*) boiling point method

46. For 10 mL H_2 gas, it takes 26s to effuse through a porous membrane. For an unknown 10 mL gas under identical conditions it takes 130 s to effuse. Hence, molar mass of the unknown gas (in g mol^{-1}) is

(*a*) 40 (*b*) 50 (*c*) 80 (*d*) 100

47. 50 mL of H_2 gas diffuse through a small hole from a vessel in 20 min. Time taken by 40 mL of O_2 gas to diffuse under similar conditions will be

(*a*) 12 min (*b*) 64 min (*c*) 8 min (*d*) 32 min

48. Which of the following properties of water can be used to explain the spherical shape of rain droplets?

(*a*) Viscosity (*b*) Surface tension
(*c*) Critical phenomenon (*d*) Vapour pressure

49. A bubble of gas released at the bottom of a lake increases to eight times its original volume when it reaches the surface. Assuming that atmospheric pressure is equivalent to the pressure exerted by a column of water, 10 m height, the depth of the lake is

(*a*) 80 m (*b*) 90 m (*c*) 40 m (*d*) 70 m

50. At 100°C and 1 atm if the density of the liquid water is 1.0 g cm^{-3} and that of water vapour is 0.0006 g cm^{-3}, then the volume occupied by water molecules in 1 L of steam at this temperature is

(*a*) 6 cm^3 (*b*) 60 cm^3 (*c*) 0.6 cm^3 (*d*) 0.06 cm^3

51. Dissolving 3.00 g of an impure sample of $CaCO_3$ in an excess of HCl acid produced 0.656 L of CO_2 (measured at 20°C and 792 mm Hg). Thus, percentage by mass of $CaCO_3$ in the sample is

(*a*) 28.92% (*b*) 94.73% (*c*) 51.21% (*d*) 05.27%

52. Average molar mass of air is 29.0 g mol^{-1}. At the altitude of $x \times 10^3$ m, atmospheric pressure decreases from 1.00 bar to 0.50 bar. What is the value of x?

(*a*) 1 (*b*) 2 (*c*) 6 (*d*) 4

53. Density of an ideal gas at 298 K and 1.0 atm is found to be 1.25 kg m^{-3}. Density of the gas at 1.5 atm and at 298 K is

(*a*) 1.25 kg m^{-3} (*b*) 1.875 kg m^{-3}
(*c*) 1.00 kg m^{-3} (*d*) 1.20 kg m^{-3}

54. Assume that the air in the space vehicle cabin consists of O_2 with mole fraction, 0.20. If air contains both N_2 and O_2, then fraction of O_2 that comes out the hole is

(*a*) 0.20 (*b*) 0.80 (*c*) 0.19 (*d*) 0.81

55. Pressure of 1 g of an ideal gas A at 300 K is found to be 2 bar. When 2 g of another ideal gas B is introduced in the same flask at the same temperature, pressure becomes 3 bar. Thus,

(*a*) $m_A = m_B$ (*b*) $m_A = 3m_B$
(*c*) $m_A = 4m_B$ (*d*) $m_B = 4m_A$

56. A 8.3 L cylinder contains 128.0 g O_2 gas at 27°C. What mass of O_2 gas must be released to reduce the pressure to 6.0 bar ?

(a) 64.0 g *(b)* 32.0 g *(c)* 16.0 g *(d)* 8.0 g

57. The pressure of gaseous mixture of CO and CO_2 increased from 2.0 kPa to 5.0 kPa on passing through heated charcoal under ideal conditions. The mole fraction of CO in the original mixture is

(a) 0.25 *(b)* 0.75 *(c)* 0.50 *(d)* 0.33

58. The total pressure of a mixture of N_2 and H_2 is 1.00 bar. The mixture is allowed to react to form ammonia, which is completely removed to leave only pure H_2 at a pressure of 0.35 bar. Thus, mole fraction of H_2 in the original mixture is

(a) 0.75 *(b)* 0.25 *(c)* 0.22 *(d)* 0.78

59. 1.00 mole sample of O_2 and 3.00 moles sample of H_2 are mixed isothermally in a 100.0 L container at 400 K. Match the partial pressures of different species in Column I with their values in Column II and select answer from codes given below

	Column I		Column II
A.	Partial pressure of H_2 before reaction	1.	0.00 atm
B.	O_2 after reaction	2.	1.3136 atm
C.	Total before reaction	3.	0.3284 atm
D.	Total after reaction	4.	0.9852 atm

Codes

	A	B	C	D		A	B	C	D
(a)	1	2	3	4	*(b)*	4	3	2	1
(c)	4	1	2	3	*(d)*	4	2	2	4

60. A 1.10 L flask containing nitrogen at a pressure of 710.0 Torr is connected to an evacuated flask of unknown volume. The nitrogen, which acts ideally, is allowed to expand into the combined system of both flasks isothermally. If the final pressure of the nitrogen is 5809.0 Torr, volume of the evacuated flask is

(a) 4.056 L *(b)* 1.350 L *(c)* 0.247 L *(d)* 0.074 L

61. 1 g H_2 gas and x g O_2 gas exert a total pressure of 5 atm. At a given temperature, partial pressure of O_2 gas is 4 atm. Thus, O_2 in the mixture is

(a) 32 g *(b)* 64 g *(c)* 96 g *(d)* 125 g

62. Consider a tube that has a frilled disk sealed in its centre so that gases can effuse through it in both directions. If the left hand side contains H_2 at a pressure p and temperature T and the right hand side contains He at a pressure $2p$ and temperature T, then initial ratio of rate of effusion is

(a) 1.00 *(b)* 0.71 *(c)* 1.41 *(d)* 0.50

63. As critical point is approached,

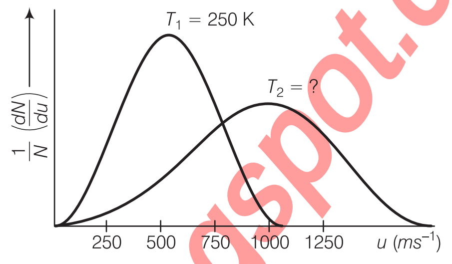
(a) the density of $CO_2(l)$ decreases and that of $CO_2(g)$ increases and at $T = T_C$, densities are equal

(b) the density of $CO_2(l)$ increases and that of $CO_2(g)$ decreases and at $T = T_C$, densities are equal

(c) the density of $CO_2(l)$ and that of $CO_2(g)$ increases

(d) the density of $CO_2(l)$ and that of $CO_2(g)$ decreases

64. The following diagram shows the Maxwell speed distribution curves for a certain ideal gas at two different temperatures (T_1 and T_2)



Temperature T_2 is

(a) 300 K *(b)* 400 K *(c)* 500 K *(d)* 600 K

65. Match the physical properties given in column I with the corresponding units given in Column II and select the correct answer from the cods given below.

	Column I		Column II
A.	Viscosity	1.	$J\ mol^{-1}K^{-1}$
B.	Surface tension	2.	Jm^{-2}
C.	Latent heat	3.	Nm^{-1}
D.	Surface energy	4.	$kg\ m^{-1}s^{-1}$

Codes

	A	B	C	D		A	B	C	D
(a)	4	3	1	2	*(b)*	4	3	2	1
(c)	3	4	2	1	*(d)*	3	4	1	2

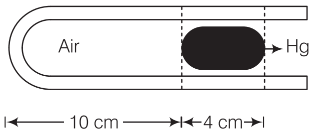
66. Total pressure of a mixture of H_2 and O_2 is 1.00 bar. The mixture is allowed to react to form water, which is completely removed to leave only pure H_2 at a pressure of 0.35 bar. Assuming ideal gas behaviour and that all pressure measurements were made under the same temperature and volume conditions, the composition of the original mixture is

	X_{H_2}	X_{O_2}		X_{H_2}	X_{O_2}
(a)	0.50	0.50	*(b)*	0.78	0.22
(c)	0.22	0.78	*(d)*	0.35	0.65

67. At what temperature will the collision frequency in N_2 be equal to that in He at 25°C if both gases are at a pressure of 1.00 bar, collision diameter = 0.373 nm for N_2 and 0.218 nm for He (Assume equal number of molecules per unit volume)

(a) 46 K *(b)* 365 K *(c)* 298 K *(d)* 400 K

68. A 10.0 cm column of air is trapped by a column of Hg which is 4 cm long in a capillary tube of uniform bore when the tube is held horizontally at 1 atm. Length of the air column when the tube is held vertically with the open end up is



(a) 9.50 cm *(b)* 10.52 cm *(c)* 3.53 cm *(d)* 4.61 cm

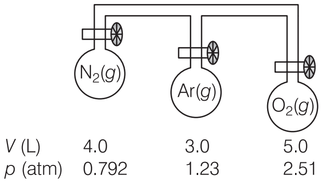
69. Consider the following pairs of gases *A* and *B*

	Gas *A*	**Gas *B***
I.	CO_2	N_2O
II.	N_2	CO
III.	O_3	O_2
IV.	D_2O	H_2O

The relative rates of diffusion of gases *A* and *B* is in the order

(a) III < IV < I = II *(b)* I = II < III < IV
(c) I = III < II = IV *(d)* I < II < III < IV

70. The following arrangement of flasks is set up. Assuming no temperature change, determine the final pressure inside the system after all stopcocks are opened. The connecting tube has zero volume.



(a) 1.62 atm *(b)* 4.53 atm
(c) 1.51 atm *(d)* 3.24 atm

71. Values of different types of temperatures have been given in Column II. Match these values with the correct definition of temperature in Column I and mark the correct answer from codes

	Column I	**Column II**
A.	Boyle's temperature (T_B)	1. $8a/27\,Rb$
B.	Critical temperature (T_C)	2. a/Rb
C.	Inversion temperature (T_i)	3. 4/27
D.	T_C/T_i	4. $2a/Rb$

Codes

	A	B	C	D		A	B	C	D
(a)	1	2	4	3	*(b)*	4	3	1	2
(c)	2	1	4	3	*(d)*	1	2	3	4

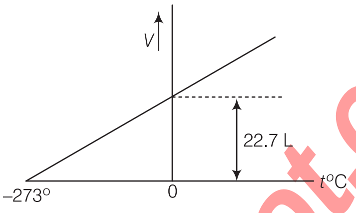
72. Hot air balloons are being used for experimental study. Assuming volume of the balloon is 100 m^3, the temperature of air is 25°C, the pressure is 1.00 bar and air is an ideal gas with an average molar mass of 29.0 g mol^{-1}. Temperature of the hot air balloon needed to lift 1.00 kg of mass is

(a) 3.0°C *(b)* 27.56°C
(c) 29.0°C *(d)* 30.71°C

73. What will be the volume change corresponding to an increase of 0.01 mole at 25°C if the molar volume of an ideal gas under these conditions is 24.8 L mol^{-1}?

(a) 2.65 L *(b)* 0.248 L *(c)* 0.02 L *(d)* 0.01 L

74. The volume of 1.00 mole of an ideal gas at 1.00 bar and 0°C decreased to 21.1 L when placed in a methanol-ice bath.



Thus, temperature of the methanol-ice bath is

(a) 0°C *(b)* – 19.24°C
(c) + 19.24°C *(d)* 273°C

75. The composition of air inhaled by a human is 21% by volume of O_2 and 0.03% CO_2 and that of exhaled air is 16% O_2 and 4.03% CO_2. Assuming a typical volume of 6200 L day^{-1}, moles of O_2 used and CO_2 generated by the body at 37°C and 1.00 bar are (assume ideal behaviour)

	Moles of O_2 used	**Moles of CO_2 generated**
(a)	12.04	9.64
(b)	12.04	12.04
(c)	9.64	9.64
(d)	9.64	12.04

76. A cylinder of 5 L capacity, filled with air at NTP is connected with another evacuated cylinder of 30 L capacity. The resultant air pressure in both the cylinders will be

(a) 10.8 cm of Hg *(b)* 14.9 cm of Hg
(c) 21.8 cm of Hg *(d)* 38.8 cm of Hg

77. A certain mass of the oxygen gas occupies 7 L volume under a pressure of 380 mm Hg. The volume of the same mass of the gas at standard pressure, with temperature remaining constant, shall be

(a) 26.60 L *(b)* 54.28 L
(c) 3.5 L *(d)* 7 L

78. In which one of the following, does the given amount of chlorine exert the least pressure in a vessel of capacity 1 dm^3 at 273 K?

(a) 0.0355 g *(b)* 0.071 g
(c) 6.023×10^{21} molecules *(d)* 0.02 mol

79. The temperature at which 28 g of N_2 will occupy a volume of 10.0 L at 2.46 atm is

(a) 299.6 K *(b)* 0° C
(c) 273 K *(d)* 10° C

80. Equal masses of H_2, O_2 and methane have been taken in a container of volume *V* at temperature 27° C in identical conditions. The ratio of the volumes of gases $H_2 : O_2 : CH_4$ would be

(a) 8 : 16 : 1 *(b)* 16 : 8 : 1
(c) 16 : 1 : 2 *(d)* 8 : 1 : 2

81. Density of carbon monoxide is maximum at

(a) 2 atm and 600 K *(b)* 0.5 atm and 273 K
(c) 6 atm and 1092 K *(d)* 4 atm and 500 K

82. At relatively high pressure, van der Waals' equation reduces to

(a) $pV = RT$ (b) $pV = RT - \frac{a}{V}$

(c) $pV = RT - \frac{a}{V^2}$ (d) $pV = RT + pb$

83. In van der Waals' equation of state of the gas, the constant 'b' is a measure of

(a) intermolecular repulsions
(b) intermolecular attraction
(c) volume occupied by the molecules
(d) intermolecular collisions per unit volume

84. The RMS velocity of molecules of a gas of density $4\ \text{kgm}^{-3}$ and pressure $1.2 \times 10^5\ \text{Nm}^{-2}$ is

(a) $900\ \text{ms}^{-1}$ (b) $120\ \text{ms}^{-1}$
(c) $600\ \text{ms}^{-1}$ (d) $300\ \text{ms}^{-1}$

85. For one mole of an ideal gas, increasing the temperature from 10°C to 20°C

(a) increases the average kinetic energy by two times
(b) increases the RMS velocity by $\sqrt{2}$ times
(c) increases the RMS velocity by two times
(d) increases both the average kinetic energy and RMS velocity but not significantly

86. If average velocity of a sample of gas molecules at 300 K is $5\ \text{cm s}^{-1}$, what is RMS velocity of same sample of gas molecules at the same temperature?

(Given, $\alpha : u : v = 1 : 1.224 : 1.127$)

(a) 6.112 cm/s (b) 4.605 cm/s
(c) 4.085 cm/s (d) 5.430 cm/s

87. One mole of oxygen at 273 K and one mole of sulphur dioxide at 546 K are taken in two separate containers, then

(a) kinetic energy of O_2 > kinetic energy of SO_2
(b) kinetic energy of SO_2 > kinetic energy of O_2
(c) kinetic energy of both are equal
(d) the temperature remains unaffected

88. If two molecules of A and B have mass 100 kg and 64 kg and rate of diffusion of A is 12×10^{-3}, then what will be the rate of diffusion of B?

(a) 15×10^{-3} (b) 64×10^{-3}
(c) 5×10^{-3} (d) 46×10^{-3}

89. In a flask of 'V' litres, 0.2 mole of O_2, 0.4 mole of N_2, 0.1 mole of NH_3 and 0.3 mole of He gases are present at 27°C. If total pressure exerted by these non-reacting gases is 1 atm, the partial pressure exerted by N_2 gas is

(a) 0.4 atm (b) 0.3 atm (c) 0.2 atm (d) 0.1 atm

90. If the ratio of masses of SO_3 and O_2 gases confined in a vessel is 1 : 1, then the ratio of their partial pressures would be

(a) 5 : 2 (b) 2 : 5 (c) 2 : 1 (d) 1 : 2

91. If both oxygen and helium gases are present at the same temperature, the rate of diffusion of O_2 is very close to

(a) 4 times that of He (b) 2 times that of He
(c) 0.35 times that of He (d) 8 times that of He

92. At identical temperature and pressure, the rate of diffusion of hydrogen gas is $3\sqrt{3}$ times than that of a hydrocarbon having molecular formula C_nH_{2n-2}. What is the value of n?

(a) 1 (b) 4
(c) 3 (d) 8

93. A 4.0 dm^3 flask containing N_2 at 4.0 bar was connected to a 6.0 dm^3 flask containing helium at 6.0 bar and the gases were allowed to mix isothermally. Then, the total pressure of the resulting mixture will be

(a) 10.0 bar (b) 5.2 bar
(c) 3.6 bar (d) 1.6 bar

94. The CO_2 gas does not follow gaseous laws at all ranges of pressure and temperature because

(a) it is triatomic gas
(b) its internal energy is quite high
(c) there is attraction between its molecules
(d) it solidify at low temperature

95. The van der Waals' equation for a real gas is given by the formula $\left(p + \frac{n^2a}{V^2}\right)(V - nb) = nRT$; where p, V, T and n are the pressure, volume, temperature and the number of moles of the gas. Which one is the correct interpretation for the parameter a?

(a) The parameter a accounts for the finite size of the molecule
(b) The parameter a accounts for the shape of gas phase molecules
(c) The parameter a accounts for intermolecular interactions present in the molecule
(d) The parameter a has no physical significance and van der Waals' introduced it as a numerical correction factor only

Answers

1. (a)	2. (c)	3. (b)	4. (b)	5. (d)
6. (b)	7. (c)	8. (d)	9. (c)	10. (a)
11. (b)	12. (d)	13. (b)	14. (d)	15. (c)
16. (a)	17. (c)	18. (a)	19. (d)	20. (c)
21. (c)	22. (a)	23. (d)	24. (b)	25. (a)
26. (a)	27. (a)	28. (a)	29. (c)	30. (a)
31. (b)	32. (c)	33. (c)	34. (b)	35. (a)
36. (b)	37. (c)	38. (c)	39. (a)	40. (c)
41. (d)	42. (a)	43. (a)	44. (a)	45. (a)
46. (b)	47. (b)	48. (b)	49. (d)	50. (c)
51. (b)	52. (c)	53. (b)	54. (c)	55. (d)
56. (a)	57. (d)	58. (d)	59. (c)	60. (c)
61. (b)	62. (b)	63. (a)	64. (d)	65. (a)
66. (b)	67. (b)	68. (a)	69. (a)	70. (a)
71. (c)	72. (b)	73. (b)	74. (b)	75. (a)
76. (a)	77. (c)	78. (a)	79. (a)	80. (c)
81. (d)	82. (d)	83. (c)	84. (d)	85. (d)
86. (d)	87. (b)	88. (a)	89. (a)	90. (c)
91. (c)	92. (b)	93. (b)	94. (c)	95. (c)

p-BLOCK ELEMENTS (Group-13 and 14)

Group 13 Elements (Boron Family)

This family contains Boron (B-5), Aluminium (Al-13), Gallium (Ga-31), Indium (In-49) and Thallium (Tl-81) with general valence electronic configuration of ns^2, np^1.

General and Physical Properties

- Aluminium is the third most abundant element and the most abundant metal in the earth's crust. Abundance of boron is very low while other members are, however, less common.
- Boron is a non-metal with high melting and boiling points due to the formation of strong crystal lattice. Rest of the elements are soft metals with low melting point and high electrical conductivity.

Trends in general and physical properties

General/Physical property	Irregularity in trends	Reasons
Atomic radius	Ga < Al	Poor screening effect of *d*-electrons of Ga.
Ionisation enthalpy	B > Tl > Ga > Al > In	Poor screening effect of *d* and *f*-electrons, which are unable to compensate increase in nuclear charges.
Electronegativity	B > Tl > In > Ga > Al	Irregularity in atomic radius.
Melting point	B > Al > Tl > Ga < In > Tl	Formation of strong crystal lattice in boron.

- Ga has the second lowest melting point (29.8°C) after Hg, but having very high boiling point (240.3°C). Hence, it can remain in liquid phase over a larger range of temperature.
- Boron forms covalent compounds due to high ionisation enthalpy. Rest elements form both ionic and covalent compounds.
- B and Al shows + 3 oxidation state and Ga, In, Tl shows both + 3 and + 1 oxidation states.
- The stability of + 3 oxidation state decreases and + 1 oxidation state increases down the group.

$$Ga^{3+} > In^{3+} > Tl^{3+} ; Ga^{+} < In^{+} < Tl^{+}$$

This is due to poor shielding effect of *d*-and *f*-electrons, that restrict *ns*-electrons to take part in bond formation (inert pair effect).

- Compounds in + 1 oxidation state are more ionic than the corresponding compounds in + 3 oxidation state.
- Due to incomplete octet, boron acts as a Lewis acid and forms coordinate bond. The tendency to behave as Lewis acid decreases down the group.

Chemical Properties

(i) Reaction with Air

- They react with O_2 and $_2$ at very high temperature forming oxides and nitrides, respectively.

$$4M(s) + 3O_2(g) \xrightarrow{\Delta} 2M_2O_3(s)$$

$$2M(s) + N_2(g) \xrightarrow{\Delta} 2MN(s)$$

where, M = group 13 elements.

- Tl also form Tl_2O with O_2.

REMEMBER

- Although Al is more reactive than B, it is stable in air and water due to the formation of Al_2O_3 (oxide) layer that prevents its further reaction.
- Acidic nature of oxides decreases down the group.

$$\underset{\text{Acidic}}{B_2O_3} > \underbrace{Al_2O_3 > Ga_2O_3}_{\text{Amphoteric}} > \underbrace{In_2O_3 > Tl_2O_3}_{\text{Basic}}$$

(ii) Reaction with Acids and Alkalies

- B does not react with acids and alkalies even at moderate temperature, but when fused with alkali, it liberates H_2.

$$2B + 6NaOH \longrightarrow 2Na_3BO_3 + 3H_2$$

- Both Al and Ga reacts with mineral acids and aqueous alkali showing amphoteric nature.

$$\underset{\text{(with acid)}}{2Al(s) + 6H_3O^+(aq) + 6H_2O(l)} \longrightarrow \underset{\text{Hexaaqua aluminium (III) ion}}{2[Al(H_2O)_6]^{3+}(aq)} + 3H_2(g)$$

$$\underset{\text{(with alkali)}}{2Al(s) + 2OH^-(aq)} + 6H_2O(l) \longrightarrow \underset{\text{Tetrahydroxy aluminate (III) ion}}{2[Al(OH)_4]^-(aq)} + 3H_2(g)$$

- In and Tl reacts with dilute acid liberating H_2 gas.

(iii) Reaction with Halogens

- They form trihalides of MX type (where, M is metal) except .
- The fluorides of Al, Ga, In and Tl are ionic while other halides are covalent when anhydrous.

REMEMBER

- Anhydrous $AlCl_3$ is covalent, but when hydrolysed, it gives Al^{3+} and Cl^- ions showing ionic character.

$$\underset{\text{White}}{AlCl_3} + 6H_2O \longrightarrow \underset{\text{Yellow}}{[Al(H_2O)_6]^{3+}} + 3Cl^-$$

- This solution conducts electricity and also acidic in nature, as it gives H^+ ion

$$[Al(H_2O)_6]^{3+}(aq) \rightleftharpoons [Al(H_2O)_5(OH)]^{2+} + H^+$$

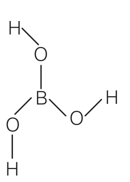
- The ability of halides to form complexes decreases down the group.
- All trihalides are Lewis acids and the electron accepting tendency decreases on moving down the group.
- For different trihalides, the acidic strength follows the order,

$$BF_3 < BCl_3 < BBr_3$$

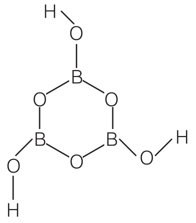
This is due to back bonding in case of BF_3.

(iv) Formation of Oxyacids

- Among group 13 elements, only B forms several oxyacids.
- These oxyacids are obtained by adding one or more molecules to one or more B_2O_3 molecules.
- The structure of some important oxyacids are given below:



Orthoboric acid (H_3BO_3)



Metaboric acid [$(HBO_2)_n$]

Anomalous Behaviour of Boron

Due to small size, high electronegativity and non-availability of *d*-orbitals, it shows the following anomalous properties:

(i) It is a non-metal with very high melting and boiling points, whereas other members are metals with low melting and boiling points.

(ii) It forms only covalent compounds, whereas other members form both covalent and ionic compounds.

(iii) Its maximum covalency is 4, while that of other members are 6 due to the presence of vacant *d*-orbitals.

(iv) Only boron exhibit allotropy and also exists in both crystalline and amorphous forms.

(v) Its oxides and hydroxides are acidic in nature. Its hydrides are more stable in comparison to other members.

(vi) It shows diagonal relationship with Si, due to its small size and similar *e*/*m* ratio.

Compounds of Group 13 Elements

Diborane (B_2H_6)

- It is prepared by the following methods :

(i) $4BF_3 + 3LiAlH_4 \xrightarrow{\text{Diethyl ether}} 2B_2H_6 + 3LiF + 3AlF_3$

(ii) $2NaBH_4 + I_2 \xrightarrow{\text{Diglyme}} B_2H_6 + 2NaI + H_2$

(Laboratory method)

(iii) $2BF_3 + 6NaH \xrightarrow{450\text{ K}} B_2H_6 + 6NaF$

(Industrial method)

(iv) $2BCl_3 + 6H_2 \xrightarrow[\text{discharge}]{\text{Electric}} B_2H_6 + 6HCl$

- It is a colourless, toxic gas that catches fire on exposure to air releasing enormous amount of energy.
- It shows the following chemical properties:

(i) $B_2H_6 + 6H_2O \longrightarrow 2H_3BO_3 + 6H_2(g)$

(ii) $B_2H_6 + 2KOH + 2H_2O \longrightarrow 2KBO_2 + 6H_2(g)$

(iii) $2B_2H_6 + 2Na \xrightarrow{\text{Ether}} NaBH_4 + \underset{\text{Sodium polyborane}}{NaB_3H_8}$

(iv) $B_2H_6 + 2CO \xrightarrow[\text{20 atm}]{100^\circ\text{ C}} 2BH_3CO$

(v) $B_2H_6 + Cl_2 \xrightarrow[\text{Explosive}]{25^\circ\text{C}} B_2H_5Cl + HCl$

$B_2H_6 + Br_2 \xrightarrow[\text{Rapid}]{100^\circ\text{C}} B_2H_5Br + HBr$

(vi) $B_2H_6 + HCl \longrightarrow B_2H_5Cl + H_2(g)$

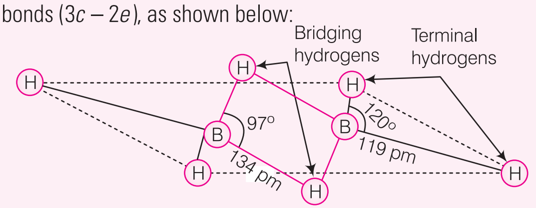
(vii) $B_2H_6 + 2NH_3 \xrightarrow[\text{temperature}]{\text{Low}} B_2H_6 \cdot 2NH_3$

$B_2H_6 \cdot 2NH_3$ is ionic and exists as $[BH_2(NH_3)_2]^+ [BH_4]^-$ which on further heating in excess of NH_3 forms boron nitride. However, on heating at 200°C, a volatile compound borazole or inorganic benzene or borazine is formed.

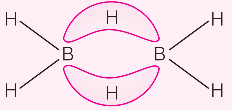
$$3B_2H_6 \cdot 2NH_3 \xrightarrow{200^\circ\text{ C}} \underset{\text{Borazole}}{2B_3N_3H_6} + 12H_2$$

Banana Bonding

B_2H_6 shows banana bonding, where the 4 terminal B — H bonds are regular two centred-two electron bonds ($2c - 2e$) whereas the bridged bonds (B — H — B) are three centred-two electron bonds ($3c - 2e$), as shown below:



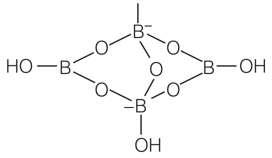
Structure of B_2H_6



Banana bond

Borax ($Na_2B_4O_7 \cdot 10H_2O$)

- Sodium tetraborate decahydrate is also called tincal.
- It contains the tetranuclear units, $[B_4O_5(OH)_4]^{2-}$ as shown below, hence its correct formula is $Na_2[B_4O_5(OH)_4]8H_2O$.



Structure of $[B_4O_5(OH)_4]^{2-}$

- It is crystalline solid and exists in three forms such as prismatic borax ($Na_2B_4O_7 \cdot 10H_2O$), octahedral borax ($Na_2B_4O_7 \cdot 5H_2O$) and borax glass ($Na_2B_4O_7$).
- Some of the important chemical reactions are :

$$Na_2B_4O_7 + 7H_2O \longrightarrow 2NaOH + 4H_3BO_3$$
$$Na_2B_4O_7 + 2HCl + 5H_2O \longrightarrow 2NaCl + 4H_3BO_3$$

- Borax when heated strongly forms a transparent glassy mass, called **borax bead**, which is used in qualitative analysis for the detection of coloured radicals like Ni^{2+}, Co^{2+}, Cr^{3+}, Cu^{2+} etc. **(Borax bead test).**

$$Na_2B_4O_7 \cdot 10H_2O \xrightarrow[-10H_2O]{\Delta} Na_2B_4O_7 \xrightarrow{\Delta} \underbrace{2NaBO_2 + B_2O_3}_{\text{Borax bead}}$$

$$CoO + B_2O_3 \xrightarrow{\Delta} \underset{\text{(Blue)}}{Co(BO_2)_2}$$

$$Cr_2O_3 + 3B_2O_3 \xrightarrow{\Delta} \underset{\text{(Green)}}{2Cr(BO_2)_3}$$

Orthoboric Acid (H_3BO_3)

- It is prepared from borax ($Na_2B_4O_7$).

$$Na_2B_4O_7 + 2HCl + 5H_2O \longrightarrow 2NaCl + 4H_3BO_3$$

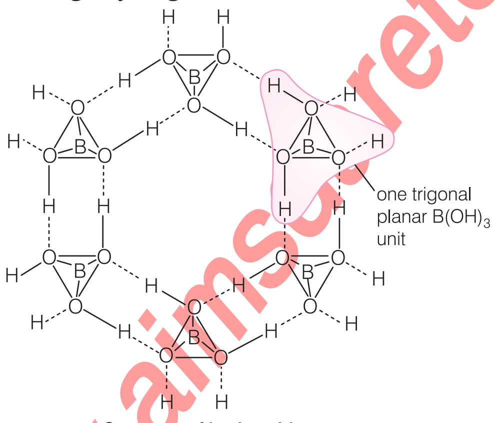
- It is a weak monobasic Lewis acid.
- It acts as a Lewis acid by accepting electron from $\bar{O}H$ ion such as:

$$B(OH)_3 + 2HOH \longrightarrow [B(OH)_4]^- + H_3O^+$$

- It is sparingly soluble in water, but highly soluble in hot water.
- It shows the following reactions on heating,

$$4H_3BO_3 \xrightarrow[-4H_2O]{\Delta} 4HBO_2 \xrightarrow[-H_2O]{\Delta,\,160\,°C} H_2B_4O_7 \xrightarrow[-H_2O]{\text{Red hot}} 2B_2O_3$$

- It has a layered structure in which planar BO_3 units are joined through hydrogen bonds.



one trigonal planar $B(OH)_3$ unit

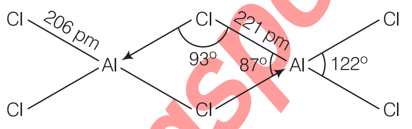
Structure of boric acid

Aluminium Trichloride ($AlCl_3$)

- It is prepared by heating Al in a stream of dry chlorine or hydrochloric acid.

$$2Al + 3Cl_2 \longrightarrow 2AlCl_3$$
$$2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$$

- It is white in pure form and acts as a strong Lewis acid.
- It is extremely hygroscopic and fumes in moist air due to the formation of HCl.
- It exists as monomer above 800°C with sp^2-hybridisation (trigonal planar) however, below 400°C, it forms dimer (Al_2Cl_6) with sp^3-hybridisation (3 covalent and 1 coordinate bond) as shown below:



- Some of important reactions of Al_2Cl_6 are :

$$Al_2Cl_6 \cdot 12H_2O \xrightarrow{\Delta} Al_2O_3 + 6HCl + 9H_2O$$
$$Al_2Cl_6 + 12NH_3 \longrightarrow 2(AlCl_3 \cdot 6NH_3)$$

Group 14 Elements (Carbon Family)

This family contains Carbon (C-6), Silicon (Si-14), Germanium (Ge- 32), Tin (Sn-50) and Lead (Pb-82) with general valence electronic configuration of ns^2, np^5.

General and Physical Properties

- C and Si are non-metals, Ge is a metalloid whereas Sn and Pb are metals.
- Melting point decreases from C to Sn and then increases from Sn to Pb, whereas boiling point regularly decreases down the group. This is because the metallic Sn and Pb do not use all the four valence electrons in metallic bond formation.
- Density decreases from C to Si and then normally increases from Si to Pb.
- The first ionisation energy decreases regularly upto Sn and then increases from Sn to Pb due to poor shielding of *d*-and *f*-orbital electrons, whereas second, third and fourth ionisation enthalpy follow irregular trend.
- They show common oxidation states of + 2 and + 4. Elements other than C exhibit oxidation state upto + 6 due to the presence of vacant *d*-orbitals.
- The order of stability of oxidation states is

$$Ge^{4+} > Sn^{4+} > Pb^{4+};\ Pb^{2+} > Sn^{2+} > Ge^{2+}$$

- On moving down the group, electronegativity decreases upto Si and then remains constant. It is due to the fact that *d*-orbitals are filled up in the case of Ge and Sn while *f*-orbital are filled up in case of Pb.

Catenation

- Carbon shows maximum property of catenation (ability to form chain and ring structures) due to high C—C bond enthalpy.
- The tendency of catenation decreases down the group due to decrease in bond enthalpy.

Allotropy

- All members of this group show allotropy (tendency to exist in different forms).
- Carbon exists in a number of allotropic forms due to the property of catenation and $p\pi - p\pi$ bond formation.

Allotropes of Carbon

It exists in two allotropic forms:

1. Crystalline Forms

Diamond, graphite and fullerenes are crystalline forms of carbon. They have different properties due to difference in their bonding as described below:

Diamond	Graphite
(i) All the four valence electrons takes part in bond formation resulting in three dimensional tetrahedral structure (sp^3-hybridisation).	(i) Only three valence electrons takes part in σ-bond formation resulting in two dimensional hexagonal planar ring (sp^2-hybridisation). The fourth electron forms delocalised π-bond.
(ii) The carbon atoms form a rigid three dimensional network, with directional covalent bonds.	(ii) The planar hexagonal rings join each other to form, two dimensional layers separated by a distance of 340 pm.
(iii) C—C bond length is 154 pm.	(iii) C—C bond length is 141.5 pm which is quite less than diamond due to formation of π-bond.
(iv) Does not conduct electricity.	(iv) Conducts electricity due to delocalised π-electron.
(v) It is the hardest material on earth due to compact three dimensional structure.	(v) It is soft and slippery as the layers are easily separated.

Fullerene These are crystalline cage like spheroidal molecules with general formulae of C_{2n} ($n \geq 30$), e.g. C_{60}, C_{70} etc.

- C_{60} look likes soccer ball containing 20 six membered rings and 12 five membered rings.
- Five membered rings are only attached to six membered rings whereas six membered rings are attached to both six and five membered rings. Each C-atom forms 3 σ-bond and 1 π-bond with sp^2-hybridisation.
- C_{70} have rugby ball like structure with 12 five membered and 25 six membered rings.
- Graphite is thermodynamically most stable allotrope of carbon ($\Delta_f H° = 0$) and the order of stability is $\Delta_f H°$ (graphite) < $\Delta_f H°$ (diamond) < $\Delta_f H°$ (fullerene, C_{60}).

2. Microcrystalline Forms

Coke, coal, charcoal, lamp black etc., belongs to this category.

Graphenes and Carbon Nanotubes

Graphenes and carbon nanotubes (CNTs) are one of the newly discovered allotropes of carbon. Graphene is a two dimensional sheet consisting of six membered rings of C-atoms. On the other hand, CNT has cylindrical structure consisting of carbon rings similar to that of graphene. Both of these have many unusual properties, which make them subject of high end researches and wide range of applications e.g. a graphene sheet is about 100 times stronger than a steel of same thickness. Likewise, CNTs having extraordinary electrical and mechanical properties are used in combination with other materials, as carbon fibre for manufacturing high performance steel, automobile parts, building construction materials etc.

Anomalous Behaviour of Carbon

Carbon shows anomalous properties due to small size, high electronegativity, high ionisation enthalpy and absence of *d*-orbitals. Some such properties are as follows:

(i) It has high melting and boiling points.
(ii) It has maximum tendency of catenation.
(iii) It has high tendency of formation of $p\pi - p\pi$ multiple bonds.
(iv) Maximum covalency of carbon is four while other members can expand their covalency upto six.
(v) Carbon remains unaffected by alkalies while other members react with alkali.

Chemical Properties

(i) Reaction with Oxygen

They form oxide of types, MO and MO_2. The acidity of oxides decreases down the group.

e.g.
$$\underbrace{CO_2 > SiO_2}_{\text{Acidic}} > \underbrace{GeO_2 > SnO_2}_{\text{Amphoteric}} > \underset{\text{Basic}}{PbO_2}$$

(ii) Hydrides

- All elements form covalent hydrides. Carbon forms a number of hydrides which are known as hydrocarbons. Other elements also form hydrides of type, M_nH_{n+2}.
- The stability of hydrides decreases down the group.
- SiH_4 decomposes in water and air as:

$$SiH_4 + 2O_2 \longrightarrow SiO_2 + 2H_2O$$
$$SiH_4 + 3H_2O \longrightarrow H_2SiO_3 + 4H_2$$

(iii) Reaction with Halogens

- They form halides of type, MX_4 and MX_2.
- The stability of tetrahalides decreases down the group, whereas that of dihalides increases down the group.

$$GeX_4 > PbX_4, PbX_2 > GeX_2$$
(order of stability of halides)

- Tetrachlorides undergo hydrolysis in which Cl-atoms are replaced by $\bar{O}H$ group, whereas others react with water in a different way.

$$SiCl_4 + 4H_2O \longrightarrow Si(OH)_4 + 4HCl$$

Compounds of Group 14 Elements

Carbon Monoxide (CO)

- Industrially, it is prepared by the following reactions:

$$\text{(i) } C(s) + H_2O(g) \xrightarrow{473-1273\text{ K}} \underbrace{CO(g) + H_2(g)}_{\text{Water gas or synthesis gas}}$$

$$\text{(ii) } 2C(s) + O_2(g) + 4N_2(g) \xrightarrow{1273\text{ K}} \underbrace{2CO(g) + 4N_2(g)}_{\text{Producer gas}}$$

- It is a colourless and odourless gas but highly poisonous as it combines with haemoglobin to form highly stable carboxy—haemoglobin complex.

Carbon dioxide (CO_2)

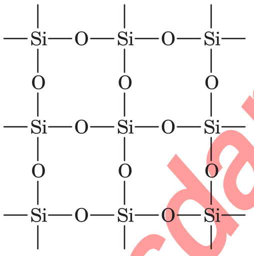
- It is obtained by burning C in excess of air.
- In laboratory, it can be prepared by the action of cold dilute HCl on $CaCO_3$ (marble).
- It is a colourless acidic gas with faint pungent smell. It is responsible for greenhouse effect.
- Solid CO_2 is called dry ice and used as a refrigerant.

Silica (SiO_2)

- It is obtained by heating silicon in oxygen.

$$Si + O_2 \longrightarrow SiO_2$$

- It is an acidic oxide and exists in Earth's crust as quartz, tridymite, cristobalite etc.
- Silica and silicates constitute 95% of Earth's crust.
- It has a covalent three dimensional network solid structure as shown below:



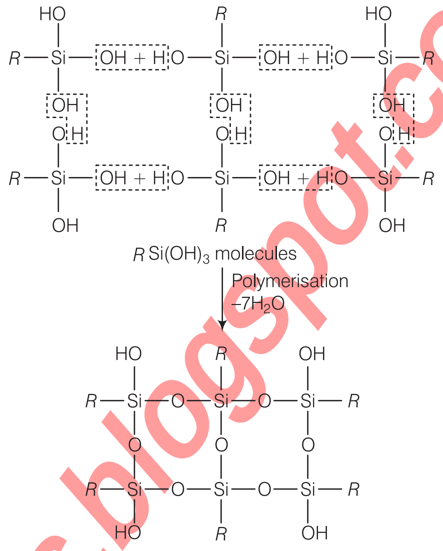
Structure of SiO_2

- It is used as a piezoelectric material, drying agent (silica gel), in filtration plants (kieselguhr) etc.

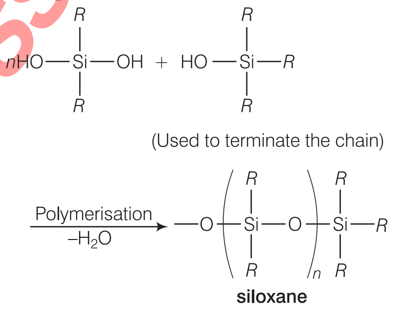
Silicones

- These are organosilicon polymers with —R_2SiO— as the repeating unit.
- The type of silicone obtained depends on the nature of alkyl or aryl hydroxy derivative and the way in which the hydroxy derivative undergoes polymerisation. For e.g.,

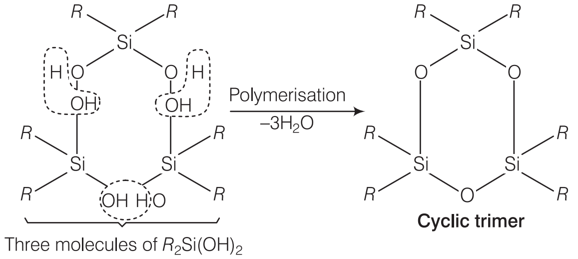
(i) $RSi(OH)_3$ forms cross-linked polymers.



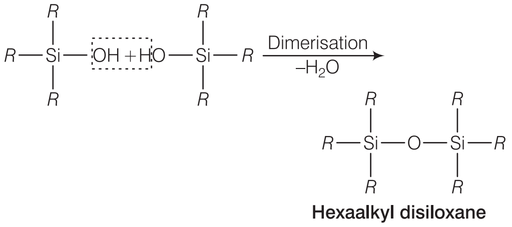
(ii) $R_2Si(OH)_2$ forms straight chain or cyclic polymers.



$3R_2Si(OH)_2$ polymerise to form cyclic trimer.



(iii) Two $R_3Si(OH)$ molecules undergo dimerisation to form R_3Si — O—SiR_3 as shown below:



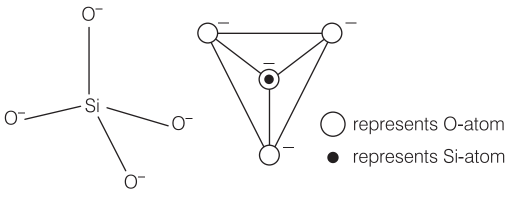
Silicates

- These are minerals of silicon containing tetrahedral SiO_4^{4-} units.
- Mica, asbestos, cement, glass, bricks, tiles are made from silicates.

On the basis of the way in which SiO_4^{4-} units are linked together, silicates are of the following types:

(i) Orthosilicates

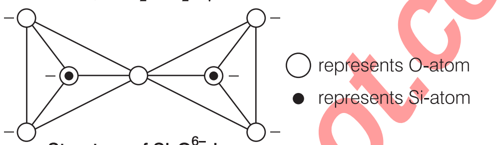
These contains discrete SiO_4^{4-} units, e.g. zircon ($ZrSiO_4$), willemite (Zn_2SiO_4) etc.



Structure of SiO_4^{4-} ion

(ii) Pyrosilicates

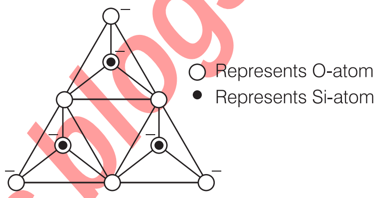
Two SiO_4^{4-} ions combine to form $Si_2O_7^{6-}$ that acts as the discrete unit, e.g. $Sc_2[Si_2O_7]$ etc.



Structure of $Si_2O_7^{6-}$ ion

(iii) Cyclic Silicates

Two oxygen atoms of each 2 SiO_4^{4-} ions are shared to form cyclic silicates.



Structure of $Si_3O_9^{6-}$ ion

MASTER STROKES

1. When Al is added to KOH solution
(a) hydrogen is evolved
(b) oxygen is evolved
(c) both hydrogen and oxygen are evolved
(d) no reaction takes place

2. In electrolysis of aluminium oxide which of the following is added to accelerate the process
(a) silica *(b)* silicate
(c) cryolite *(d)* nickel

3. Select the pair of methanides out of the following.
(a) CaC_2, Mg_2C_3 *(b)* Al_4C_3, Be_2C
(c) Al_4C_3, Mg_2C_3 *(d)* Be_2C, Mg_2C_3

4. Water glass is
(a) glass made up of water *(b)* sodium silicate
(c) water gas *(d)* crystal carbonate

5. Alum are used as mordant in dyeing because
(a) dye is adsorbed on $Al(OH)_3$ which is deposited on fibre in the hydrolysis process
(b) dye is adsorbed on KOH formed due to hydrolysis
(c) Both *(a)* and *(b)*
(d) None of the above

6. The element which exists in liquid state for a wide range of temperature and can be used for measuring high temperature is
(a) B *(b)* Al *(c)* Ga *(d)* In

7. Aluminium becomes passive in nitric acid because it
(a) is a noble metal
(b) forms α-thin film of oxide
(c) shows positive reduction potential
(d) None of the above

8. In which of the following cases, X—O bond length is not changed (where, X is the underlined atom)?
(a) $H_3\underline{B}O_3$ is taken in water
(b) $H_2\underline{S}O_4$ is taken in water
(c) $H\underline{N}O_3$ is taken in water
(d) None of the above

9. In the structure of diborane,
(a) all hydrogen atoms lie in one plane and boron atoms lie in a plane perpendicular to this plane
(b) 2 boron atoms and 4 terminal hydrogen atoms lie in the same plane and 2 bridging hydrogen atoms lie in the plane perpendicular to this plane
(c) 4 bridging hydrogen atoms and boron atoms lie in one plane and two terminal hydrogen atoms lie in a plane perpendicular to this plane
(d) all the atoms are in same plane

10. The geometry in which carbon atoms in diamond are bonded to each other is
(a) linear *(b)* tetrahedral
(c) square planar *(d)* octahedral

11. Which one of the following anions is present in the chain structure of silicates?
(a) $Si_2O_7^{6-}$ *(b)* $(Si_2O_5^{2-})_n$
(c) $(SiO_3^{2-})_n$ *(d)* SiO_4^{4-}

12. Supercritical CO_2 is used as
(a) dry ice
(b) fire fighting
(c) a solvent for extraction of organic compounds from natural sources
(d) a highly inert medium for carrying out various reactions

13. How many O-atoms shared per SiO_4^{4-} tetrahedral in silicate anion of beryl mineral?

(a) 3 *(b)* 4 *(c)* 1 *(d)* 2

14. $SiCl_4$ on hydrolysis forms '*X*' and HCl. Compound '*X*' loses water at 1000°C and gives '*Y*'. Compounds '*X*' and '*Y*' respectively are

(a) H_2SiCl_6, SiO_2 *(b)* H_4SiO_4, Si
(c) SiO_2, Si *(d)* H_4SiO_4, SiO_2

15. Moderate electrical conductivity is shown by

(a) silica *(b)* graphite
(c) diamond *(d)* None of these

16. H_3BO_3 is

(a) monobasic acid and weak Lewis acid
(b) monobasic and weak Bronsted acid
(c) monobasic and strong Lewis acid
(d) tribasic and weak Bronsted acid

17. Ge (II) compounds are powerful reducing agents whereas Pb (IV) compounds are strong oxidants. It can be because

(a) Pb is more electropositive than Ge
(b) ionisation potential of lead is less than that of Ge
(c) ionic radii of Pb^{2+} and Pb^{4+} are larger than those of Ge^{2+} and Ge^{4+}
(d) more pronounced inert pair effect in lead than Ge

18. The soldiers of Napoleon army at Alps during freezing winter suffered a serious problems with regards to the tin buttons of their uniforms. White metallic tin buttons got converted to grey powder. This transformation is related to

(a) a change in the crystalline structure of tin
(b) an interaction with nitrogen of the air at very low temperature
(c) a change in the partial pressure of oxygen in the air
(d) an interaction with water vapour contained in the humid air

19. White lead is

(a) Pb_3O_4 *(b)* PbO
(c) $2PbCO_3 \cdot Pb(OH)_2$ *(d)* $Pb(CH_3COO)_2 \cdot Pb(OH)_2$

20. Borax is used as a buffer, since

(a) its aqueous solution contains equal amount of weak acid
(b) it is easily available
(c) its aqueous solution contains equal amount of strong acid and its salt
(d) its aqueous solution contains equal amount of strong acid and its conjugate base

21. In laboratory burners, we use

(a) producer gas *(b)* oil gas *(c)* gobar gas *(d)* coal gas

22. On the acidification of mineral acid to an aqueous solution of borax, which of the following compound is formed?

(a) Boron hydride *(b)* Orthoboric acid
(c) Metaboric acid *(d)* Pyroboric acid

23. When metal *X* is treated with sodium hydroxide, a white precipitate of *A* is obtained, which is soluble in excess of NaOH to give soluble complex *B*. Compound *A* is soluble in dil.HCl and form compound *C*. The compound *A* when heated strongly gives *D*, which is used to extract metal. Compound *D* is

(a) aluminium hydroxide *(b)* sodium aluminate
(c) aluminium chloride *(d)* alumina

24. A metal *M* forms chlorides in + 2 and + 4 oxidation states. Which of the following statements about these chlorides is correct?

(a) MCl_2 is more volatile than MCl_4
(b) MCl_2 is more soluble in anhydrous ethanol than MCl_4
(c) MCl_2 is more ionic than MCl_4
(d) MCl_2 is more easily hydrolysed than MCl_4

25. Aluminium vessels should not be washed with materials containing washing soda since

(a) washing soda reacts with aluminium to form soluble aluminate
(b) washing soda reacts with aluminium to form insoluble aluminium oxide
(c) washing soda is expensive
(d) washing soda is easily decomposed

26. Pure boron is best prepared by

(a) heating B_2O_3 with H_2
(b) heating B_2O_3 with Na and K
(c) heating KBF_4 with Na or K
(d) heating BBr_3 with H_2 in presence of a catalyst

27. Tin reacts with dilute HNO_3 forming

(a) NO and $Sn(NO_3)_2$ *(b)* NO and $Sn(NO_3)_4$
(c) NO_2 and $Sn(NO_3)_2$ *(d)* NH_4NO_3 and $Sn(NO_3)_2$

28. Match the following columns and select the correct code.

	Column I		Column II
A.	Diborane	1.	Used as a flux for soldering metal
B.	Gallium	2.	Used as catalyst in petrochemical industry
C.	Borax	3.	Banana bonds
D.	Aluminosilicate	4.	Low melting point, high boiling point, useful for measuring high temperatures

Codes

	A	B	C	D
(a)	3	4	1	2
(b)	1	2	4	3
(c)	3	2	4	1
(d)	2	1	3	4

29. Match the items in Column I with its main use listed in Column II. [JEE Main 2016]

	Column I		Column II
A.	Silica gel	1.	Transistor
B.	Silicon	2.	Ion-exchanger
C.	Silicone	3.	Drying agent
D.	Silicate	4.	Sealant

Codes

	A	B	C	D
(a)	3	1	4	2
(b)	2	1	4	3
(c)	4	1	2	3
(d)	2	4	1	3

30. The metal which does not form ammonium nitrate by reaction with dil. HNO_3 is

(a) Al *(b)* Fe
(c) Pb *(d)* Mg

31. Which of the following is used to produce smoke screens?

(a) calcium phosphide *(b)* sodium carbonate
(c) zinc sulphide *(d)* zinc phosphide

32. Silicones have the general formula

(a) $(SiO_4)^{4-}$ *(b)* SiO_6^{7-}
(c) $(SiO_3)_n^{-2n}$ *(d)* $(R_2SiO)_n$

33. Which of the following is the correct statement for red lead?

(a) It is an active form of lead
(b) It decomposes into Pb and CO_2
(c) Its molecular formula is Pb_2O_3
(d) It decomposes into PbO and O_2

34. Basic nature of oxides of group 13 increases in the order

(a) $B_2O_3 < Al_2O_3 < Ga_2O_3 < In_2O_3 < Tl_2O_3$
(b) $Tl_2O_3 < In_2O_3 < Ga_2O_3 < Al_2O_3 < B_2O_3$
(c) $B_2O_3 < Ga_2O_3 < Al_2O_3 < Tl_2O_3 < In_2O_3$
(d) $B_2O_3 \approx Al_2O_3 < Ga_2O_3 \approx In_2O_3 < Tl_2O_3$

35. Properties of group 13 (Ga, In, Tl) are quite different from those of group 1 and group 2. It is due to the

(a) presence of d^{10} core electrons in Ga and In and d^{10} and f^{14} core electrons in Tl
(b) larger size of Ga, In and Tl
(c) increase in atomic number
(d) variable oxidation number

36. In which of the following arrangements, the sequence is not strictly according to the property written against it?

(a) $CO_2 < SiO_2 < SnO_2 < PbO_2$ (Increasing oxidising power)
(b) $CH_4 < SiH_4 < SnH_4 < PbH_4$ (Increasing reducing power of hydrides)
(c) $BBr_3 > BCl_3 > BF_3$ (Decreasing Lewis acid character)
(d) C > Si > Ge > Sn > Pb (Decreasing $(IE)_1$)

37. *X* reacts with aqueous NaOH solution to form *Y* and H_2. Aqueous solution of *Y* is heated to 323 - 333 K and on passing CO_2 into it, Na_2CO_3 and *Z* were formed. When *Z* is heated to 1200°C, Al_2O_3 is formed. *X*, *Y* and *Z* respectively are

(a) Al, $AlCl_3$, $NaAlO_2$
(b) Zn, Na_2ZnO_2, $Al(OH)_3$
(c) Al, $Al(OH)_3$, $AlCl_3$
(d) Al, $NaAlO_2$, $Al(OH)_3$

38. Which of the following statement is correct with respect to the property of elements in the carbon family with an increase in the atomic number?

(a) Atomic size decreases
(b) Stability of + 2 oxidation state increases
(c) Metallic character decreases
(d) Ionisation energy increases

39. Me_2SiCl_2 on hydrolysis will produce

(a) $(Me)_2Si(OH)_2$ *(b)* $(Me)_2Si = O$
(c) $[-O-(Me)_2Si-O-]_n$ *(d)* $Me_2SiCl(OH)$

40. The structure of silicates in which three oxygen atoms of $[SiO_4]^{4-}$ are shared is

(a) pyrosilicate
(b) sheet silicate
(c) linear chain silicate
(d) three dimensional silicate

41. Which of the following statement is not correct?

(a) Silicon is extensively used as a semiconductor
(b) Carborundum is SiC
(c) Silicon occurs in free state in nature
(d) Mica contains the element silicon

42. Catenation, i.e. linking of similar atoms depends upon size and electronic configuration of atoms. The tendency of catenation in group 14 elements follows the order:

(a) C > Si > Ge > Sn *(b)* C > Si > Ge = Sn
(c) Si > C > Sn > Ge *(d)* Ge > Sn > Si > C

43. Graphite is a good conductor of electricity. Its electrical conductivity is due to the fact that

(a) it is an allotrope of carbon
(b) it has C-atoms arranged in large plates of rings of strongly bound C-atoms
(c) in it C-atoms are sp^2-hybridised
(d) it is a non-crystalline substance

44. A mixture of boron trichloride and hydrogen is subjected to silent electric discharge to form *A* and HCl. *A* is mixed with NH_3 and heated to 200°C to form *B*. The formula of *B* is

(a) H_3BO_3 *(b)* B_2O_3
(c) $B_3N_3H_6$ *(d)* B_2H_6

45. Which of the following is the correct order of acidic strength?

(a) $CaO < CuO < H_2O < CO_2$
(b) $H_2O < CuO < CaO < CO_2$
(c) $CaO < H_2O < CuO < CO_2$
(d) $H_2O < CO_2 < CaO < CuO$

46. N_2 gas is passed into heated Mg and B. Product(s) formed is/are

(a) Mg_3N_2 and BN
(b) Mg_3N_2, BN and Mg_3B_2
(c) Mg_3N_2
(d) BN and Mg_3N_2

47. At higher concentration, orthoboric acid exists as polymeric metaborate species in the form of anion, which is

(a) $B_2O_4^{2-}$ *(b)* $[B_2O_4(OH)_4]^{6-}$
(c) $[B_3O_3(OH)_4]^-$ *(d)* $[B_2O_3(OH)_4]^{2-}$

48. The main reason that $SiCl_4$ is easily hydrolysed as compared CCl_4 is that

(a) Si—Si bond is weaker
(b) $SiCl_4$ can form hydrogen bonds
(c) $SiCl_4$ is covalent
(d) Si can extend its coordination number beyond four

49. $SnCl_2$ is a reducing agent. Which of the following is reduced to a metallic state by $SnCl_2$?

(a) $FeCl_3$ *(b)* $CuCl_2$ *(c)* $HgCl_2$ *(d)* $FeCl_2$

50. More than one —OH group is not possible on the same carbon. Select the species that can have two —OH groups at the same carbon.
(a) Carbonic acid *(b)* Chloral hydrate
(c) Both (a) and (b) *(d)* None of these

51. Element $M + N_2 \xrightarrow{\Delta} \xrightarrow{H_2O} NH_3$. The element M belongs to which of the following group 13 elements
(a) B or Al *(b)* Ga or Al
(c) Al or B or Mg *(d)* Mg or B

52. In the presence of $NaBH_4$ / THF, CO reacts with B_2H_6 forming
(a) BH_3CO *(b)* CH_3OH
(c) $(CH_3)_3B_3O_3$ *(d)* None of these

53. Heating of an aqueous solution of aluminium chloride to dryness will give
(a) $Al(OH)Cl_2$ *(b)* Al_2O_3
(c) Al_2Cl_6 *(d)* $AlCl_3$

54. Na_3AlF_6 is added to Al_2O_3 to
(a) improve the electrical conductivity of the cell
(b) increase the rate of production
(c) increase the melting point
(d) decrease the electrical conductivity

55. Which of the following oxides is amphoteric in nature?
(a) SnO_2 *(b)* SiO_2 *(c)* CO_2 *(d)* CaO

56. In silicon dioxide,
(a) there are double bonds between silicon and oxygen atoms
(b) silicon atom is bonded to two oxygen atoms
(c) each silicon atom is surrounded by two oxygen atoms and each oxygen is bounded to two silicon atoms
(d) each silicon atom is surrounded by four oxygen atoms and each oxygen atom is bonded to two silicon atoms

57. Graphite is a soft solid lubricant extremely difficult to melt. The reason for this anomalous behaviour is that graphite
(a) is a non-crystalline substance
(b) is an allotropic form of diamond
(c) has molecules of variable molecular masses like polymers
(d) has carbon atoms arranged in large plates of rings of strongly bound carbon atoms with weak interplate bonds

58. Red lead used as a primer for iron to prevent it from rusting is
(a) Pb_3O_4 *(b)* PbO *(c)* PbO_2 *(d)* Pb_2O

59. When zeolite is treated with hard water, there is exchange reaction between calcium/magnesium ion and
(a) aluminium *(b)* sodium ion
(c) water of hydration *(d)* sulphate ion

60. Select the correct statement(s).
(a) Oxides of carbon family (MO_2) are all network solids with octahedral coordination.
(b) Silicon dioxide (SiO_2, silica) is network solid with tetrahedral coordination and is a giant molecule.
(c) GeO_2, SnO_2 and PbO_2 all are acidic oxides.
(d) All of the above

61. Soda free glass fibres are made up of
(a) $H_3BO_3 \cdot B_2O_3$ and $Ca_3(BO_3)_2$
(b) H_3BO_3 and B_2O_3
(c) H_3BO_3
(d) B_2O_3

62. Borax is used as a primary standard in the titrations against acids.

$$Na_2B_4O_7 \cdot 10H_2O + 2HCl \longrightarrow 2NaCl + H_3BO_3 + 5H_2O$$

Indicator to be used in this titration is
(a) phenolphthalein *(b)* methyl orange
(c) methylene blue *(d)* borax itself

63. Aluminium chloride exists as dimer, Al_2Cl_6 in solid state as well as in solution of non-polar solvents such as benzene. When dissolved in water, it gives
(a) $Al^{3+} + 3Cl^-$ *(b)* $[Al(H_2O)_6]^{3+} + 3Cl^-$
(c) $[Al(OH)_6]^{3-} + 3HCl$ *(d)* $Al_2O_3 + 6HCl$

64. Which one of the following is the correct statement?
(a) Boric acid is a protonic acid
(b) Beryllium exhibits coordination number of six
(c) Chlorides of both beryllium and aluminium have bridged chloride structures in solid phase
(d) $B_2H_6 \cdot 2NH_3$ is known as 'inorganic benzene'

65. Boron also forms halides, B_2X_4. Select the correct statement(s) about B_2Cl_4.
(a) There is free rotation about (B — B) bond.
(b) It adopts a non-eclipsed conformation in gaseous and liquid state.
(c) It adopts a planar structure in the solid state because of crystal force and ease of packing.
(d) All of the above are correct

66. Borates can be tested by converting them into
(a) BF_3 which gives green-coloured flame
(b) $(C_2H_5O_3)B$ which gives green-edged flame
(c) Both (a) and (b) are correct
(d) None of the above is correct

67. Mellitic acid, $C_{12}H_6O_{12}$ (benzene haxacarboxylic acid) is formed when hot conc. HNO_3 reacts with
(a) diamond *(b)* graphite
(c) Both (a) and (b) *(d)* None of these

68. Structures of different allotropes of carbon have been compared. Which represents the incorrect comparison?
(a) Polyne (*sp*-hybridised carbon)
(b) Buckyball (*sp*-hybridised carbon)
(c) Graphite (sp^2-hybridised carbon)
(d) Diamond (sp^3-hybridised carbon)

69. B_2H_6 adds to CO to form BH_3CO. In this formation,
(a) BH_3 is a Lewis base, CO is a Lewis acid
(b) BH_3 is a Lewis acid, CO is a Lewis base
(c) BH_3 is a protonic acid and CO is a base
(d) BH_3 and CO both are electron-deficient

70. $B^{3+}(aq)$ ion is not known in aqueous solution because
(a) the ionisation energy required would be very large
(b) the small ion would be highly polarising
(c) Both (a) and (b)
(d) None of the above

71. Aluminium is made passive by the formation of oxide layer. The layer is so useful that in industry, it is purposely increased by an electrolytic process called anodising. This is done by
(a) conc. HNO_3
(b) electrolysing dil.H_2SO_4 with Al as anode
(c) electrolysing H_2O with Al as cathode
(d) electrolysing H_2O with Al as anode

72. Consider the following statements for diborane.

I. Boron is approximately sp^3-hybridised
II. B — H — B angle is 180°.
III. There are two terminal (B — H) bonds for each B-atom.
IV. There are only 12 bonding electrons available.

Select the correct statements.
(a) I, II and III *(b)* II, III and IV
(c) I, III and IV *(d)* I, II and IV

73. Consider the following facts about SiC.

I. It has diamond like structure in which C and Si-atoms each are tetrahedrally surrounded by four of the other kinds of atoms.
II. It is called carborundum.
III. It is used as an abrasive and in cutting tools.
IV. C and Si-atoms are sp^2 hybridised.

Mark the correct statements.
(a) Both I and III *(b)* I, II, III and IV
(c) Both II and III *(d)* I, II and III

74. The bond dissociation energy of B — F bond in BF_3 is 646 kJ mol^{-1} whereas that of C — F bond in CF_4 is 515 kJ mol^{-1}. The correct reason for higher B — F bond dissociation energy as compared to that of C — F bond is
(a) Smaller size of B-atom as compared to that of C-atom
(b) Stronger σ-bond between B and F in BF_3 as compared to that between C and F in CF_4
(c) Significance $p\pi$-$p\pi$ interaction between B and F in BF_3 whereas there is no probability of such interaction between C and F in CF_4
(d) Lower degree of $p\pi$-$p\pi$ interaction between B and F in BF_3 than that between C and F

75. Match the oxides in Column I with their corresponding property(ies) in Column II and mark the correct option from the codes given below.

Column I	Column II
A. PbO	p. Oxidation state +2
B. SnO_2	q. Oxidation state +4
C. PbO_2	r. Amphoteric
D. CO_2	s. Basic
E. GeO	t. Acidic

Codes

	A	B	C	D	E		A	B	C	D	E
(a)	p,r	q,r	q,r	q,t	p,t	*(b)*	p,r	p,r	q,t	q,t	q,r
(c)	q,r	p	q	q,t	p,r	*(d)*	p,t	q,s	q,s	q,t	p,r

76. When carbon monoxide is passed over solid caustic soda heated to 200°C, it forms
(a) Na_2CO_3 *(b)* CH_3COONa *(c)* $NaHCO_3$ *(d)* HCOONa

77. Glass having higher refractive index is prepared by using
(a) NiO *(b)* CoO *(c)* PbO *(d)* CaO

78. Suppose you have to determine the percentage of carbon dioxide in a sample of a gas available in a container. Which is the best absorbing material for the carbon dioxide?
(a) Heated copper oxide
(b) Cold, solid calcium chloride
(c) Cold, solid calcium hydroxide
(d) Heated charcoal

79. In laboratory silicon can be prepared by the reaction
(a) of silica with magnesium
(b) by heating carbon in electric furnace
(c) by heating potassium fluorosilicate with potassium
(d) None of the above

80. The colour of blue glass is due to the presence of oxide of
(a) Cr *(b)* Co *(c)* Au *(d)* Ag

81. In the electrolytic method of obtaining aluminium from purified bauxite, cryolite is added to the charge in order to
(a) minimise the heat loss due to radiation
(b) protect aluminium produced from oxygen
(c) dissolve bauxite and render it conductor of electricity
(d) lower the melting point of bauxite

82. Anodising can be done by electrolysing dilute H_2SO_4 with Al as anode, this result in
(a) the formation of protective oxide layer
(b) the formation of $Al_2(SO_4)_3$ and SO_2 gas
(c) the formation of AlH_3 and SO_2 gas
(d) the formation of $Al(HSO_3)$ and H_2 gas

83. Anhydrous $AlCl_3$ is obtained from
(a) aluminium and chloride gas
(b) hydrogen chloride gas and aluminium metal
(c) Both of the above
(d) None of the above

84. What is the state of hybridisation of carbon in fullerene?
(a) sp^2 *(b)* sp^3 *(c)* sp *(d)* sp^3d

85. Which one of the following statements about the zeolite is false?
(a) They are used as cation exchangers
(b) Some of the SiO_4^{4-} units are replaced by AlO_4^{5-} and AlO_6^{9-} ions in zeolite
(c) They have open structure which enables them to take up small molecules
(d) Zeolites are aluminosilicates having three dimensional structure

86. Carbon suboxide C_3O_2 has
(a) bent structure
(b) trigonal planar structure
(c) linear structure
(d) distorted tetrahedral structure

87. Alzheimer's disease is caused due to interaction of Al with internal organs of the body if food is contaminated with Al. This disease
(a) induces senility in young persons
(b) causes memory loss
(c) Both (a) and (b)
(d) None of the above

88. When tin is treated with concentrated nitric acid
(a) it is converted into stannous nitrate
(b) it becomes passive
(c) it is converted into stannic nitrate
(d) it is converted into metastannic acid

89. Which one of the following is correct statement?
(a) The hydroxide of aluminium is more acidic than that of boron.
(b) The hydroxide of boron is basic, while that of aluminium is amphoteric
(c) The hydroxide of boron is acidic, while that of aluminium is amphoteric
(d) The hydroxide of boron and aluminium are amphoteric

90. Which of the following compounds are formed when BCl_3 is treated with water?
(a) B_2O_3 + HCl
(b) B_2H_6 + HCl
(c) H_3BO_3 + HCl
(d) None of these

91. Which of the following waste materials can be used for producing biogas?
(a) Thermocol
(b) Glass bottle
(c) Tin cans
(d) Paper scrap

92. In aqueous solution GaCl disproportionates to
(a) $GaCl_2$ and $GaCl_3$
(b) Ga and $GaCl_3$
(c) $GaCl_2$ and Ga
(d) $GaCl_3$ and $GaCl_5$

93. Which is true for an element *R* present in III group of the periodic table?
(a) It has oxidation state of +4
(b) It is gas at room temperature
(c) It forms R_2O_3
(d) It forms RX_2

94. Which of the following glass is used in making wind screen of automobiles?
(a) Saftey
(b) Jena
(c) Crook's
(d) Pyrex

95. Which of the following statement is correct with respect to the property of elements in the carbon family with an increase in the atomic number? Their
(a) atomic size decreases
(b) stability of +2 oxidation state increases
(c) metallic character decreases
(d) ionisation energy increases

96. Which of the following statements about H_3BO_3 is not correct?
(a) It is prepared by acidifying an aqueous solution of borax
(b) It has a layer structure in which planar BO_3 units are joined by hydrogen bonds
(c) It does not act as proton donor but acts as Lewis acid by accepting hydroxyl ion
(d) It is a strong tribasic acid.

97. In diborane the two H—B—H angles are nearly
(a) 95°, 120°
(b) 60°, 120°
(c) 120°, 180°
(d) 95°, 150°

98. Which of the following is the electron deficient molecule?
(a) PH_3
(b) C_2H_6
(c) SiH_4
(d) B_2H_6

99. In the reaction, $B_2O_3 + C + Cl_2 \longrightarrow A + CO$.
The *A* is
(a) CCl_2
(b) BCl_3
(c) BCl_2
(d) B_2Cl_2

100. Which of the following is formed when aluminium oxide and carbon is strongly heated in dry chlorine gas?
(a) Aluminium chloride
(b) Hydrate aluminium chloride
(c) Anhydrous aluminium chloride
(d) None of the above

Answers

1. (a)	**2.** (c)	**3.** (b)	**4.** (b)	**5.** (d)
6. (c)	**7.** (b)	**8.** (d)	**9.** (b)	**10.** (b)
11. (c)	**12.** (c)	**13.** (d)	**14.** (d)	**15.** (b)
16. (a)	**17.** (d)	**18.** (a)	**19.** (c)	**20.** (d)
21. (b)	**22.** (b)	**23.** (a)	**24.** (c)	**25.** (a)
26. (d)	**27.** (d)	**28.** (a)	**29.** (a)	**30.** (c)
31. (a)	**32.** (d)	**33.** (d)	**34.** (a)	**35.** (a)
36. (d)	**37.** (d)	**38.** (b)	**39.** (c)	**40.** (a)
41. (c)	**42.** (a)	**43.** (c)	**44.** (c)	**45.** (a)
46. (b)	**47.** (c)	**48.** (d)	**49.** (c)	**50.** (c)
51. (a)	**52.** (c)	**53.** (b)	**54.** (a)	**55.** (a)
56. (d)	**57.** (d)	**58.** (a)	**59.** (b)	**60.** (b)
61. (a)	**62.** (b)	**63.** (b)	**64.** (c)	**65.** (d)
66. (c)	**67.** (b)	**68.** (b)	**69.** (b)	**70.** (c)
71. (b)	**72.** (c)	**73.** (d)	**74.** (c)	**75.** (a)
76. (d)	**77.** (c)	**78.** (c)	**79.** (a)	**80.** (b)
81. (d)	**82.** (a)	**83.** (c)	**84.** (a)	**85.** (b)
86. (c)	**87.** (c)	**88.** (d)	**89.** (c)	**90.** (c)
91. (d)	**92.** (b)	**93.** (c)	**94.** (a)	**95.** (b)
96. (d)	**97.** (a)	**98.** (d)	**99.** (b)	**100.** (c)

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PAPER I

SECTION 1 (MM : 18)

- This section contains **FIVE** questions.
- Each question has **FOUR** options (a), (b), (c) and (d). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories:

Full Marks : +3 If only the bubble corresponding to the correct option is darkened.
Zero Marks : 0 If none of the bubbles is darkened.
Negative Marks : −1 In all other cases.

1. The velocity of electron ejected from a platinum surface when radiation of 200 nm falls on it will be (given: work function of platinum is 5 eV)

(a) 6.54×10^5 ms^{-1} (b) 7.24×10^4 ms^{-1}
(c) 3.26×10^7 ms^{-1} (d) 4.23×10^6 ms^{-1}

2. The basic character of the transition metal monoxides follows the order (Atomic number, $Ti = 22, V = 23, Cr = 24, Fe = 26$)

(a) TiO > VO > CrO > FeO
(b) VO > CrO > TiO > FeO
(c) CrO > VO > FeO > TiO
(d) TiO > FeO > VO > CrO

3. 1.878 g of MBr_x when heated in a stream of HCl gas was completely converted into chloride, MCl_x which weighed 1.0 g. The specific heat of metal is 0.14 cal g^{-1}. The molecular weight of the metal bromide is

(a) 285.54 (b) 52.36
(c) 682.38 (d) 45.54

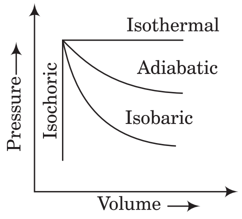
4. How many H$^+$ ions are required when the equation given below is balanced with the smallest whole number coefficients?

$$Cu(s) + NO_3^-(aq) + H^+(aq) \longrightarrow Cu^{2+}(aq) + NO(g) + H_2O(l)$$

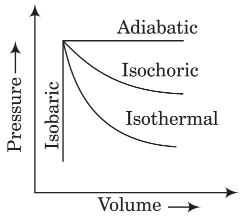
(a) 2 (b) 4
(c) 6 (d) 8

5. Which of the following is correct graphical representation of various thermodynamic processes?

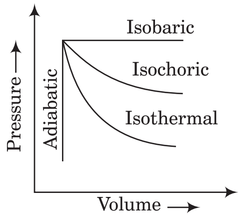
(a)



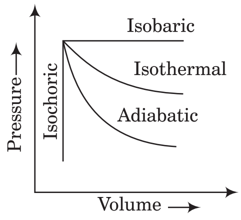
(b)



(c)



(d)



SECTION 2 (MM : 32)

- This section contains **EIGHT** questions.
- Each question has **FOUR** options (a), (b), (c) and (d). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct.
- For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS.
- For each question, marks will be awarded in one of the following categories:

Full Marks : +4 If only the bubble(s) corresponding to all correct option(s) is(are) darkened.
Partial Marks : +1 For darkening a bubble corresponding **to each correct option**, provided no incorrect option is darkened.
Zero Marks : 0 If none of the bubbles is darkened.
Negative Marks : −2 In all other cases.

For example, if (a), (c) and (d) are all the correct options for a question, darkening all these three will result in +4 marks; darkening only (a) and (d) will result in +2 marks and darkening (a) and (b) will result in −2 marks, as a wrong option is also darkened.

6. Which of the following statement(s) is/are correct?

(a) BF_4^- exhibit sp^3 hybridisation
(b) IF_3 and SO_3 exhibits sp^3d hybridisation
(c) Bond order in a diatomic molecule represents the number of covalent bonds
(d) Bond order of H_2^- ion is 0.5

7. Which of the following is/are correct order?

(a) Increasing bond angle : $SbH_3 < AsH_3 < PH_3 < NH_3$
(b) Increasing boiling point : $PH_3 < NH_3$
(c) Increasing basic nature: $SbH_3 > AsH_3 > PH_3 > NH_3$
(d) Increasing acidic nature: $NF_3 < NCl_3$

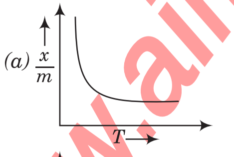
8. Which of the following statements are correct about E1cB reaction?

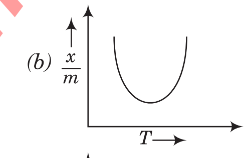
(a) It proceeds *via* the formation of a carbanion intermediate
(b) Strong electron withdrawing group and poor leaving groups favour the reaction
(c) It is a unimolecular reaction with second order kinetics
(d) When *D* is incorporated in the starting material by the solvent EtOD and the reaction is interrupted before completion, no *D* is found either in the substrate or in the product

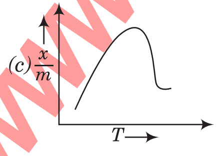
9. Which of the following is/are correct when a nuclide of mass number (*A*) and atomic number (*Z*) undergoes radioactive process?

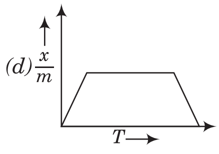
(a) Both '*A*' and '*Z*' decreases, the process is called α-decay
(b) '*A*' remains unchanged and '*Z*' decreases by 1. The process is called $\beta^{\oplus}$ or positron decay
(c) Both '*A*' and '*Z*' increases and the process is called nuclear isomerism
(d) Both '*A*' and '*Z*' remains unchanged and the process is called γ-decay

10. Which of the following is not the adsorption isobar for chemisorption?

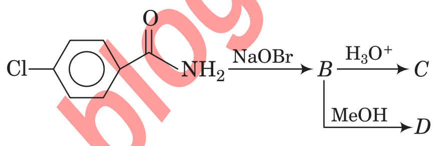




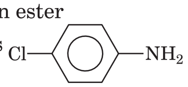




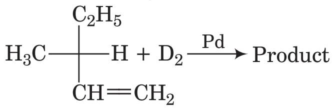
11. Which of the following statements are correct for the equation given below,



(a) It is an example of Lossen rearrangement reaction
(b) It is an example of Hofmann bromamide rearrangement reaction
(c) The product *D* formed is an ester
(d) The compound *C* formed is

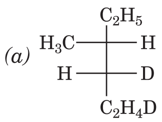


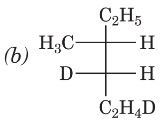
12. Consider the following reaction,

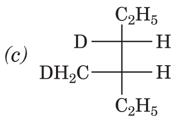


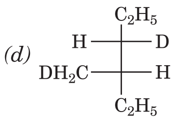
$H_3C-C(C_2H_5)(H)-CH=CH_2 + D_2 \xrightarrow{Pd} \text{Product}$

The product of the above reaction is/are





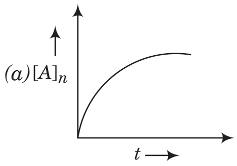


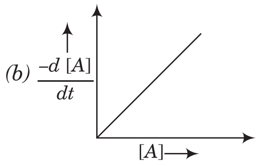


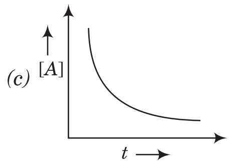
13. Consider the following first order reaction,

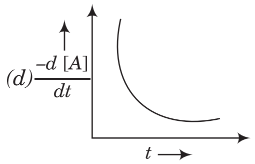
$$nA \rightleftharpoons (A)_n$$

Which of the following plots correctly represent the above reaction?









SECTION 3 (MM : 12)

- This section contains **FIVE** questions.
- The answer to each question is a **SINGLE DIGIT INTEGER** ranging from 0 to 9, both inclusive.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories:

Full Marks : + 3 If only the bubble corresponding to the correct option is darkened.
Zero Marks : 0 In all other cases.

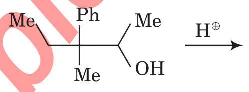
14. A vessel of volume 5 litres contains 1.4g of nitrogen at a temperature of 1800 K. The pressure of the gas (in atm), if 30% of its molecules are dissociated into atom is

15. For a sample of dil. H_2SO_4, density is 1.3 g mL^{-1} and purity is 40% (by volume). 50 mL of this acid were allowed to react with Zn. The volume of H_2 in litre (at NTP) liberated is

16. A drop of solution (volume 0.05 mL) contains 3.0×10^{-6} mole of H^+. If the rate constant of disappearance of H^+ is 1.0×10^7 mol $litre^{-1}$ sec^{-1}. The time (in nano seconds) taken for H^+ in drop to disappear is

17. The optically active stereoisomers possible in butane-2,3-diol are

18. The number of products obtained in the dehydration of following compound is



PAPER II

SECTION 1 (MM : 18)

- This section contains **SIX** questions.
- Each question has **FOUR** options (a), (b), (c) and (d). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories:

Full Marks : +3 If only the bubble corresponding to the correct option is darkened.
Zero Marks : 0 If none of the bubbles is darkened.
Negative Marks : −1 In all other cases.

1. The magnetic moment of $[Mn(CN)_6]^{3-}$ is 2.8 BM and the magnetic moment of $[MnBr_4]^{2-}$ is 5.9 BM. The geometries of $[Mn(CN)_6]^{3-}$ and $[MnBr_4]^{2-}$, respectively are

(a) Both are octahedral
(b) Trigonal planar and tetrahedral
(c) Tetrahedral and octahedral
(d) Octahedral and tetrahedral

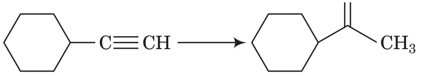
2. Two students use the same stock solution of zinc sulphate ($ZnSO_4$) and a solution of copper sulphate ($CuSO_4$). The emf of one cell is 0.03 V higher than the other. The concentration of copper sulphate in the cell with higher emf value is 0.5 M. The concentration of $CuSO_4$ in the other cell (2.303 $RT / F = 0.06$) is

(a) 0.01M *(b)* 0.09M *(c)* 0.05M *(d)* 0.02M

3. Among the following observations, the correct statement that differentiates between SO_3^{2-} and SO_4^{2-} is

(a) Both form precipitate with $BaCl_2$, SO_3^{2-} dissolves in HCl but SO_4^{2-} does not
(b) SO_3^{2-} forms precipitate with $BaCl_2$, SO_4^{2-} does not
(c) SO_4^{2-} forms precipitate with $BaCl_2$, SO_3^{2-} does not
(d) Both form precipitate with $BaCl_2$, SO_4^{2-} dissolves in HCl but SO_3^{2-} does not

4. Which of the following reagents are used for the conversion given below?



(a) (i) O_3/Red P (ii) $AlCl_3$ (iii) MeCOOH
(b) (i) $H_2SO_4 + HgSO_4$ (ii) H_2O, Heat
(c) (i) O_3/Zn – AcOH (ii) $H_2SO_4 + HgSO_4$ (iii) H_2O, Heat
(d) (i) CH_3COOH (ii) $H_2O_2 + \bar{O}H / H_2O$

5. The fraction of a mole of iron metal produced by passage of 4.00 A of current through 1.00 L of 0.100 M Fe^{3+} solution for 1.00 hour is

(a) 0.100 mol *(b)* 0.050 mol
(c) 0.025 mol *(d)* 0.075 mol

6. An aromatic compound, PhMe reacts with $2Br_2$ / Fe to give 2,4-$Br_2C_6H_3Me$ *(B)* that gives *(C)* when reacts with Mg and CO_2 followed by hydrolysis. '*C*' on further reaction with $KMnO_4/\Delta$ gives '*D*'. What is '*D*' in the reaction?

(a) 1, 2, 5 – $C_6H_3(COOH)_3$
(b) 1, 3, 6 – $C_6H_3(COOH)_3$
(c) 1, 3 – $C_6H_4(COOH)_2$
(d) 1, 2 – $C_6H_4(COOH)_2$

SECTION 2 (MM : 32)

- This section contains **EIGHT** questions.
- Each question has **FOUR** options (a), (b), (c) and (d). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct.
- For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS.
- For each question, marks will be awarded in one of the following categories:

Full Marks	:	+4 If only the bubble(s) corresponding to all correct option(s) is(are) darkened.
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Zero Marks	:	0 If none of the bubbles is darkened.
Negative Marks	:	−2 In all other cases.

For example, if (a), (c) and (d) are all the correct options for a question, darkening all these three will result in +4 marks; darkening only (a) and (d) will result in +2 marks and darkening (a) and (b) will result in −2 marks, as a wrong option is also darkened.

7. Consider a mixture of 1 mol of benzene ($p^0_{\text{benzene}} = 42$ mm) and 2 mol of toluene ($p^0_{\text{toluene}} = 36$ mm). Which of the following statement regarding the solution is/are correct?

(a) Total vapour pressure of mixture is 38 mm

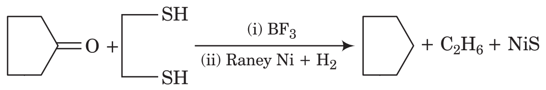
(b) Mole fraction of vapour of benzene above liquid mixture is 7/19

(c) It shows positive deviation from Raoult's law

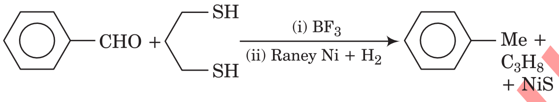
(d) It shows negative deviation from Raoult's law

8. Which of the following reactions is/are correct?

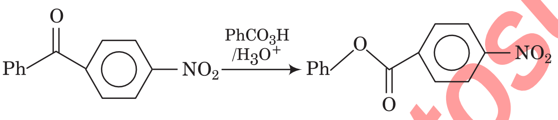
(a)



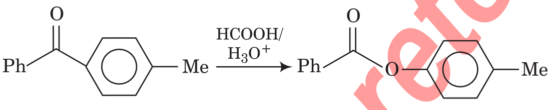
(b)



(c)



(d)



9. Which of the following statement is/are correct for the extraction of aluminium?

(a) Bauxite ore when fused with Na_2CO_3 forms fused sodium meta-aluminate

(b) Serpek's method is used when silica is present as impurity in considerable amounts in the bauxite ore

(c) Hall-Heroult's method is used when bauxite ore is contaminated with considerable amount of oxides of iron and silicon

(d) Baeyer's method is applied to bauxite ore containing ferric oxide as chief impurity

10. Which of the following statement is/are correct about the mixture of lysine (pH = 9.6) and glycine (pH = 5.97) separated by electrophoresis method or solubility method?

(a) At pH = 5.96 , the mixture makes changes, glycine precipitates out while lysine remains in the solution

(b) At pH = 5.97, glycine does not migrate while lysine moves to the cathode

(c) At pH = 5.97, glycine does not migrate while lysine moves to the anode

(d) At pH = 9.6, lysine does not migrate while glycine moves at the anode

11. If the radius of anion is 0.20 nm, the maximum radius of cations which can be filled in respective voids is correctly given in

(a) $r_+ = 0.0828$ nm for tetrahedral void

(b) $r_+ = 0.045$ nm for triangular void

(c) $r_+ = 0.1464$ nm for octaheral void

(d) None of the above

12. Consider the following reaction sequence.

I. $B_2H_6 + 2NH_3 \xrightarrow{\text{Low temperature}} \text{‘}X\text{’}$

II. $B_2H_6 + 2CH_3NH_2 \xrightarrow{\text{Low temperature}} \text{‘}Y\text{’}$

III. $B_2H_6 + NH_3 \xrightarrow{\text{High temperature}} \text{‘}Q\text{’}$

IV. $B_2H_6 + 2N(CH_3)_3 \longrightarrow \text{‘}Z\text{’}$

Choose the correct statements using the above reactions.

(a) ‘X’ obtained in the reaction is $[H_2B(CH_3NH_2)_2]^+ [BH_4]^-$

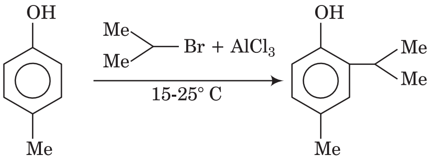
(b) $B_3N_3H_6$ is called inorganic benzene.

(c) ‘Z’ obtained in the reaction is $H_3B - N(CH_3)_3$

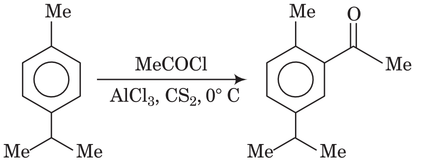
(d) ‘Y’ obtained is the reaction is $(BN)_x$

13. In which of the following reactions, the correct major product is formed?

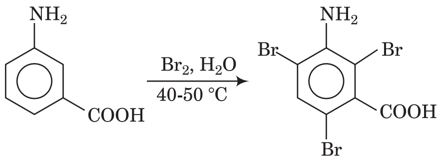
(a)



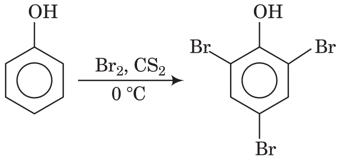
(b)



(c)



(d)



14. Which of the following statement is/are correct?

(a) $SiCl_4$ has sp^3 hybridisation

(b) PCl_5 molecule has trigonal bipyramidal geometry

(c) $[Ni(CN)_4]^{2-}$ complex has square planar geometry

(d) IF_7 has sp^3d^2 hybridisation

Comprehensive Based Type

Passage I

Phosgene is the chemical compound with the formula $COCl_2$. This colourless gas is used as a chemical weapon during world war-I where it was responsible for about 85% of the 1,00,000 deaths caused by chemical weapons. It is a valued industrial reagent and building block in synthesis of pharmaceuticals.

This $COCl_2$ gas dissociates according to

$$COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$$

At 101.325 kPa and at 724 K, density of the gas mixture is 1.162 g dm^{-3}.

15. Observed molar mass of the gaseous mixture is

(a) 69.0 g mol^{-1} (b) 99.0 g mol^{-1}

(c) 49.5 g mol^{-1} (d) 34.5 g mol^{-1}

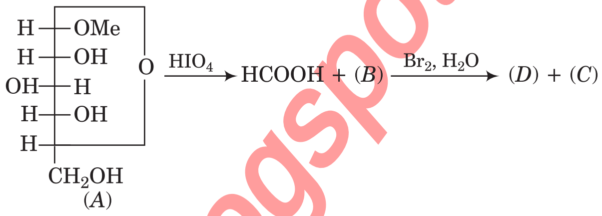
16. What will be the equilibrium constant, K_p

(a) 0.165 atm (b) 0.115 atm

(c) 0.233 atm (d) 0.466 atm

Passage II

Glucose is the main ingredient in human diet. It is a simple sugar with molecular formula, $C_6H_{12}O_6$. It circulates in the blood of animals as blood sugar. It is stored as a polymer in plants as starch and in animals as glycogen. Glucose structure was proved by various chemical reaction one of the important reaction of its derivative is



17. The name of the compound (A) is

(a) Methyl - α – D - glucofuranoside

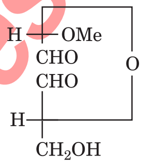
(b) Methyl - β – D - glucofuranoside

(c) Methyl - α – D - glucopyranoside

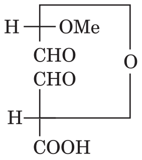
(d) Methyl - β – D - glucopyranoside

18. Which of the following is the correct structure of 'B'?

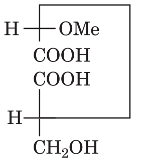
(a)



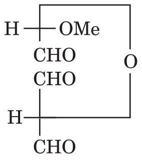
(b)



(c)



(d)



Answers with Explanation

Paper I

1. **(a)** Wavelength of radiation (λ) = 200 nm = 200×10^{-9}m

Work function (W) = 5 eV = $5 \times 1.6 \times 10^{-19}$J
$= 8.0 \times 10^{-19}$J

Energy of photon,

$$E = h\nu = \frac{hc}{\lambda}$$

$$= \frac{6.63 \times 10^{-34}\text{ Js} \times 3 \times 10^{8}\text{ ms}^{-1}}{200 \times 10^{-9}\text{ m}}$$

$$= 9.945 \times 10^{-19}\text{J}$$

Using Einstein photoelectric equation,

$$h\nu = \text{KE} + W$$

or, $\text{KE} = h\nu - W = 9.945 \times 10^{-19} - 8.0 \times 10^{-19}$
$= 1.945 \times 10^{-19}$J

$$\text{KE} = \frac{1}{2} mv^2 = 1.945 \times 10^{-19}\text{J}$$

(mass of electron = 9.1×10^{-31}g)

or, $$v = \left(\frac{2 \times 1.945 \times 10^{-19}\text{ J}}{9.1 \times 10^{-31}}\right)^{1/2} = 6.54 \times 10^{5}\text{ ms}^{-1}$$

2. **(a)** TiO > VO > CrO > FeO with the decrease in size of metal atom from Ti to Fe, the basic character of their monoxides decreases.

3. **(a)** $MBr_x + xHCl \longrightarrow MCl_x + xHBr$

Weight of MBr_x = 1.878 g

Weight of MCl_x = 1.0 g

For the above reaction,

Equivalent of MBr_x = Equivalent of MCl_x

$$\frac{1.878}{E + 80} = \frac{1.0}{E + 35.5}, E = 15.18$$

According to Dulong and Petit's law,

Atomic weight of metal × specific heat ≈ 6.4

$$\therefore \text{Atomic weight of metal, } M = \frac{6.4}{0.14} = 45.71$$

$$\therefore \text{ Valency of metal} = \frac{\text{Atomic weight}}{E} = \frac{45.71}{15.18} \simeq 3$$

$\therefore$ Exact atomic weight of metal = $15.18 \times 3 = 45.54$

$\therefore$ Molecular weight of $MBr_x = 45.54 + 80 \times 3 = 285.54$

4. ***(d)*** $3Cu(s) + 2NO_3^-(aq) + 8H^+(aq) \longrightarrow 3Cu^{2+}(aq) + 2NO(g) + 4H_2O(l)$

5. ***(d)*** In isothermal process, the temperature remains fixed i.e. $dT = 0$.

In adiabatic process, no exchange of heat takes place between the system and the surroundings i.e. $dq = 0$. This can be done by keeping the system in an insulated container.

In isobaric process, the pressure remains constant throughout the change i.e. $dp = 0$.

In isochoric process, volume remains constant throughout the change i.e. $dV = 0$.

6. ***(a, c, d)*** To determine hybridisation of central atom, we use

$X = \frac{1}{2}$ [number of valence electrons in central atom (V)] + [number of monovalent atoms surrounding the central atom (SA)] − [charge on ion with sign (E)]

$$\text{For } BF_4^-,\ X = \frac{1}{2}(V + SA - E) = \frac{1}{2}(3 + 4 + 1) = 4$$

$$= sp^3 \text{ hybridisation}$$

$$\text{Bond order} = \frac{[\text{Number of electrons in bonding M.O}] - [\text{Number of electrons in antibonding MO}]}{2}$$

$$= \frac{[N_b - N_a]}{2}$$

For H_2^- ion, E.C = $\sigma 1s^2, \overset{*}{\sigma} 1s^1$,

$$\text{Bond order} = \frac{2-1}{2} = \frac{1}{2}$$

7. ***(a, b, d)*** The correct increasing basic nature for Group-15 element is

$$SbH_3 < AsH_3 < PH_3 < NH_3$$

Basic nature of hydrides decreases from NH_3 to BiH_3. NH_3 is strongly basic, PH_3 is weakly basic while AsH_3, SbH_3 and BiH_3 are neutral.

8. ***(a, b, c)*** Statements (a), (b) and (c) are the characteristics of E1cB reaction. Statement (d) is wrong since in E1cB reaction, deuterated product is obtained.

9. ***(a, b, d)*** α-particles are the helium nuclide (^4_2He) with 2 proton and 2 neutrons, hence α-decay cause decrease in atomic number(Z) by 2 units and that in atomic mass (A) by 4 units. Formation of β^+ particle (positron) takes place with decomposition of proton (p) as follows

$$p \longrightarrow n + \beta^+ + \nu_e$$

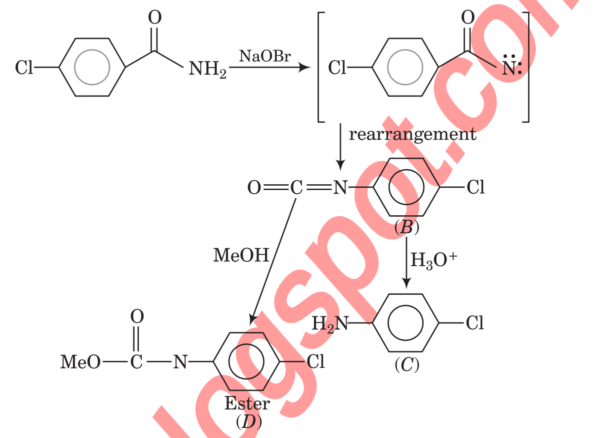
Here, ν_e is neutrino

Thus, atomic mass remains unchanged while atomic number decreases.

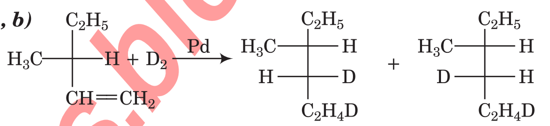
Emission of gamma rays does not involve breaking of any nuclear particles nor does γ-rays consist of any mass or charge unit hence its emission does not affect the A or Z of the nucleus.

10. ***(a, b, d)*** In chemisorption, adsorption first increases and then decreases after reaching maximum and finally becomes constant. It does not become constant for a while at maximum position nor does it become zero (as shown in option-d)

11. ***(b, c, d)*** The given equation is an example of Hofmann-bromamide rearrangement reaction.



12. ***(a, b)***



13. ***(a, b, c, d)*** In first order reactions, reactant decreases with increase in time and product increases. Therefore, graph (c) and (d) appears as hyperbolas.

14. ***(2)***

$$\begin{array}{lcc} & N_2 & \rightleftharpoons 2N \\ \text{Initial mole} & \frac{1.4}{28} & 0 \\ \text{Mole after dissociation} & \frac{1.4}{28} \times \frac{70}{100} & \frac{1.4}{28} \times \frac{2 \times 30}{100} \end{array}$$

$$\therefore \text{ Total number of moles} = \frac{1.4}{28} \times \frac{70}{100} + \frac{1.4 \times 60}{100 \times 28} = \frac{1.4}{28} \times \left[\frac{130}{100}\right]$$

Now, we know that

$$pV = nRT$$

$$\therefore \quad p \times 5 = \frac{1.4}{28} \times \frac{130}{100} \times 0.0821 \times 1800$$

$$p = 1.92 \text{ atm} \simeq 2 \text{ atm.}$$

15. ***(6)*** Volume of 100 g of $H_2SO_4 = \frac{100}{1.3} = 76.93$ mL

$$\left(\because \text{Volume} = \frac{\text{Mass}}{\text{Density}}\right)$$

i.e. 76.93 mL of dil. H_2SO_4 contain = 40 g pure H_2SO_4

$\therefore$ 50 mL of acid will contain $= \frac{40}{76.93} \times 50 = 26$ g pure H_2SO_4

Zn and H_2SO_4 reacts as follows:

$$\underset{1\text{ mole}}{Zn} + \underset{1\text{ mole} = 98\text{ g}}{H_2SO_4} \longrightarrow ZnSO_4 + \underset{\substack{1\text{ mole} \\ 22.4\text{ L}}}{H_2}$$

98 g of H_2SO_4 = 22.4 L H_2

$$\therefore \ 26 \text{ g } H_2SO_4 \text{ will give} = \frac{22.4}{98} \times 26 = 5.94 \text{ L}$$

$$H_2 \simeq 6 \text{ L}$$

16. ***(6)*** Since, rate constant = 1.0×10^7 mol litre^{-1} sec^{-1}

For zero order reaction,

$$t = \frac{x}{K} = \frac{\text{Concentration used}}{\text{Rate constant}} \qquad \text{...(i)}$$

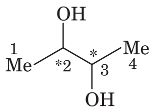
$$0.05 \text{ mL} = 3 \times 10^{-6} \text{ mole of } H^+$$

$$\therefore \quad 1000 \text{ mL} = \frac{3 \times 10^{-6} \times 10^3}{0.05} = 0.6 \times 10^{-1} \text{ mol/litre of } H^+$$

Now, using equation (i), we get

$$t = \frac{0.6 \times 10^{-1}}{1 \times 10^{7}} = 6 \times 10^{-9}\ \text{s}$$

17. *(2)*



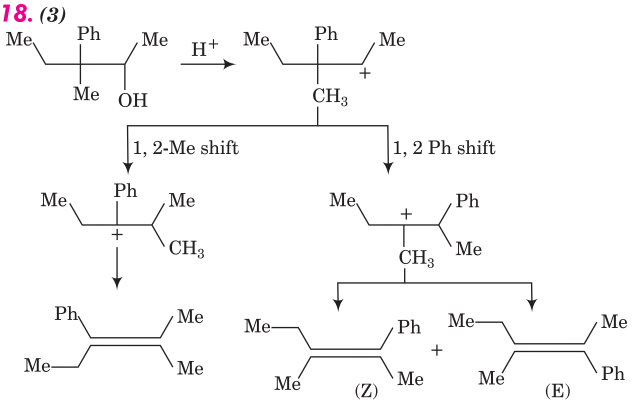
Number of asymmetric C atoms = 2

Here, terminal groups are same.

∴ Number of optically active isomers

$$= 2^{n-1} = 2^{2-1} = 2^1 = 2$$

18. *(3)*

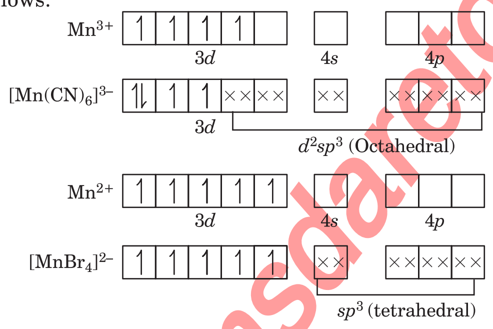


(Z) 2-methyl-2-phenyl pent-2-ene

(E) 2-methyl-2-phenyl pent-2-ene

Paper II

1. *(d)* From the spin only formula, it can be calculated that $[Mn(CN)_6]^{3-}$ has two unpaired electrons while $[MnBr_4]^{2-}$ have five. The electronic configurations and the complexes with indicated numbers of unpaired electrons are as follows:



2. *(c)* The cell is represented as:

$Zn(s)\,|Zn^{2+}\ (aq)\,||\,Cu^{2+}\ (aq)|\,Cu(s)$

$[Cu^{2+}]$ in the second cell = 0.5 M

$[Cu^{2+}]$ in the first cell may be calculated as follows,

According to Nernst equation,

$$E_1 = E^{\circ}_{\text{cell}} - \frac{2.303\ RT}{2F} \log \frac{[Zn^{2+}]}{[Cu^{2+}]_1}$$

$$E_2 = E^{\circ}_{\text{cell}} - \frac{2.303RT}{2F} \log \frac{[Zn^{2+}]}{[Cu^{2+}]_2}$$

$$E_2 - E_1 = \frac{2.303RT}{2F} \log \frac{[Cu^{2+}]_2}{[Cu^{2+}]_1}$$

$$0.03 = \frac{0.06}{2} \log \frac{[Cu^{2+}]_2}{[Cu^{2+}]_1}$$

$$\log \frac{[Cu^{2+}]_2}{[Cu^{2+}]_1} = \frac{0.03 \times 2}{0.06} = 1$$

$$\log \frac{[0.5]}{[Cu^{2+}]_1} = 1 \Rightarrow [Cu^{2+}]_1 = \frac{0.5}{10} = 0.05\ \text{M}$$

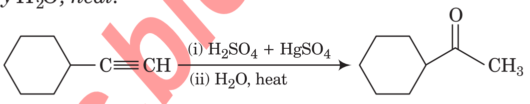
3. *(a)* SO_3^{2-} and SO_4^{2-} when treated with $BaCl_2$ give white precipitate of $BaSO_3$ and $BaSO_4$, respectively.

$$BaCl_2 + SO_3^{2-} \longrightarrow \underset{\text{Barium sulphite}}{BaSO_3} + 2Cl^-$$

$$BaCl_2 + SO_4^{2-} \longrightarrow \underset{\text{Barium sulphate}}{BaSO_4} + 2Cl^-$$

Out of these two, SO_3^{2-} is soluble in HCl but SO_4^{2-} does not.

4. *(b)* **Key concept** *$R—C\equiv CH$ is converted to ketone by catalytic hydration with reagents $H_2SO_4 + HgSO_4$ followed by H_2O, heat.*



5. *(c)* We know that, $Q = Zit$

$$(1.00\ \text{h})\left(\frac{3600}{hr}\right)\left(\frac{4.00}{\text{sec}}\right)\left(\frac{1\ \text{mol}\ e^-}{96500\ \text{C}}\right) = 0.149\ \text{mol}\ e^-$$

$$\text{Also, molarity} = \frac{\text{Moles of solute}}{\text{Volume of solution}}$$

$$\left(\frac{0.100\ \text{mol}\ Fe^{3+}}{\text{L}}\right)(1.00\ \text{L}) = 0.100\ \text{mol}\ Fe^{3+}$$

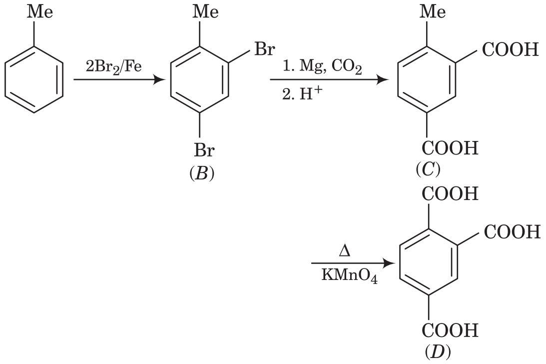
$$Fe^{3+} + e^- \longrightarrow Fe^{2+}$$

0.100 mole e^- is required to reduce all the Fe^{3+} to Fe^{2+} and leave 0.049 mol $e^{\ominus}$ to reduce the Fe^{2+} to Fe.

$$Fe^{2+} + 2e^- \longrightarrow Fe$$

$$(0.049\ \text{mole}\ e^-)\left(\frac{1\ \text{mol Fe}}{2\ \text{mol}\ e^{\ominus}}\right) = 0.0245\ \text{mol Fe}$$

6. *(a)*



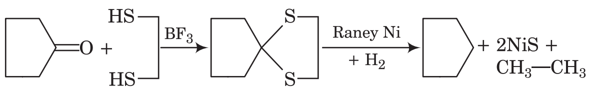
7. *(a, b)* Benzene and toluene will form an ideal solution,

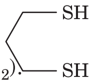
$$p_{\text{total}} = p^0_A\chi_A + p^0_B\chi_B = 42 \times \frac{1}{3} + 36 \times \frac{2}{3} = 38\ \text{mmHg}$$

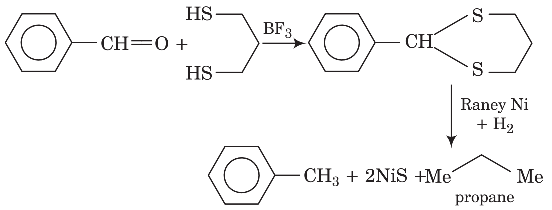
$$\chi_{\text{benzene}} = \frac{p_{\text{benzene}}}{p_{\text{total}}} = \frac{42 \times \frac{1}{3}}{38} = \frac{7}{19}$$

8. *(a, b, c, d)* All the reactions are correct.

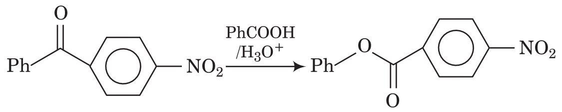
(a) The protection of $>C=O$ group by $\left[\begin{smallmatrix}SH\\SH\end{smallmatrix}\right.$ and then desulphurisation with (Raney Ni + H_2).



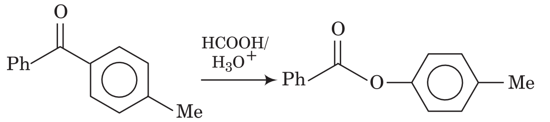
(b) The protection of (—CHO) group by  and then desulphurisation with (Raney Ni + H_2).



(c) It is an example of Baeyer - Villiger oxidation in which the migrating power of Ph – > p-nitrophenyl.



(d) It is also an example of Baeyer-Villiger oxidation in which the migrating power of p-tolyl > Ph.



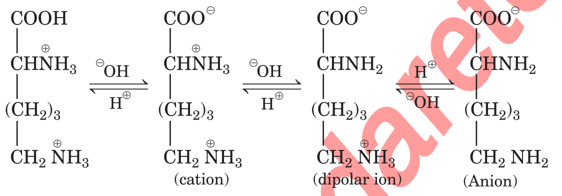
9. ***(a, b, c, d)*** When bauxite is fused with sodium carbonate, Al_2O_3 combines with Na_2CO_3 forming sodium meta aluminate.

$$Al_2O_3 + Na_2CO_3 \longrightarrow 2NaAlO_2 + CO_2$$

This is done during Hall-Heroult's method.

The extraction of Al from bauxite ore involves refining of bauxite. This refining can be done with Baeyer's method, Serpek's method and Hall-Heroult's method.

10. ***(a, b, d)***



11. ***(a, b, c)*** $r_+ / r_- = 0.732, 0.414$ and 0.225 which are maximum for octahedral void, tetrahedral void and triangular void, respectively.

12. ***(b, c)*** (I) $B_2H_6 + 2NH_3 \xrightarrow{\text{Low temperature}} [H_2B(NH_3)_2]^+[BH_4]^-$
(X)

(II) $B_2H_6 + 2CH_3NH_2 \xrightarrow{\text{Low temperature}} [H_2B(CH_3NH_2)_2]^+ [BH_4]^{\ominus}$
(Y)

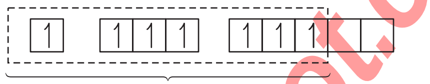
(III) $B_2H_6 + NH_3 \xrightarrow{\text{High temperature}} (BN)_x$
(Q)

(IV) $\underset{\text{Diborane}}{B_2H_6} + \underset{\text{Trimethylamine}}{2N(CH_3)_3} \longrightarrow \underset{\text{Borane}}{2H_3B} - \underset{\text{trimethylamine}}{N(CH_3)_3}$
(Z)

13. ***(a, b, c)*** Product (d) is incorrect Br_2 in non-polar solvent gives o – and p-products.

14. ***(a, b, c)*** In IF_7, Iodine is central atom.

I-atom (ground state) = $5s^2 5p^5$
I-atom (excited state) = $5s^1\ 5p^3\ 5d^3$



sp^3d^3 hybridisation

15. ***(a)***

$$COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$$

Initial moles	1	0	0
Moles at equilibrium	$(1-x)$	x	x
Mole fractions	$\frac{1-x}{1+x}$	$\frac{x}{1+x}$	$\frac{x}{1+x}$
Partial pressure	$\frac{p(1-x)}{1+x}$	$\frac{px}{1+x}$	$\frac{px}{1+x}$

$$p = 101.325\ \text{kPa} = 101325\ \text{Pa} = 1\ \text{atm}$$

$$p = \frac{n}{V}RT = \frac{w}{mV}RT = \frac{\rho}{m}RT$$

where, $m = \frac{\rho RT}{p}$

$$= \frac{1.162\ \text{g dm}^{-3} \times 0.0821\ \text{dm}^3\text{atm mol}^{-1}\text{K}^{-1} \times 724\text{K}}{1.0\ \text{atm}}$$

$$= 69.07\ \text{g mol}^{-1}\ \text{(observed molar mass)}$$

16. ***(c)*** Experimental vapour density (d)

$$d = \frac{\text{Molar mass}}{2} = \frac{69}{2} \approx 34.5$$

Theoretical vapour density (D)

$$D = \frac{99}{2} = 49.5 \qquad [\because \text{Molar mass of } COCl_2 = 99]$$

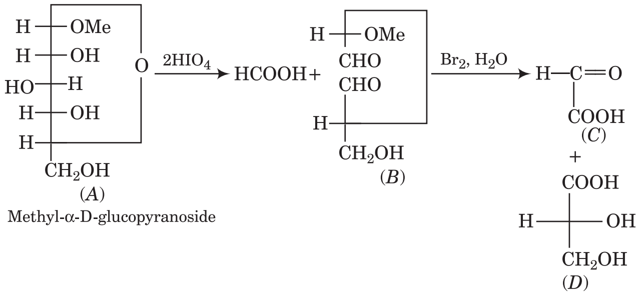
$$\therefore \quad x = \frac{D-d}{d} = \frac{49.5 - 34.5}{34.5} = 0.435$$

$$K_p = \frac{p_{CO}\, p_{Cl_2}}{p_{COCl_2}} = \frac{px^2}{(1-x^2)}$$

$$= \frac{1(0.435)^2}{[1-(0.435)^2]} = 0.233\ \text{atm}$$

17. ***(c)*** The correct nomenclature is methyl - α – D - glucopyranoside. It is six membered ring, hence is called pyranoside.

18. ***(a)***



TARGET JEE 2017

TEST RIDER

Comprehensive Simulator Test Series for JEE Main & Advanced

JEE ADVANCED

(PAPER TWO SCALE UP)

Mock Questions from Complete Syllabus with Answer Key

FULL TEST 2

(COMPLETE SYLLABUS) WITH ANSWER KEY

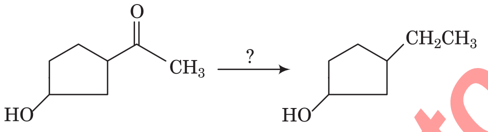
PAPER I

SECTION 1 (MM : 18)

- This section contains **FIVE** questions.
- Each question has **FOUR** options (a), (b), (c) and (d). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories:

Full Marks : +3 If only the bubble corresponding to the correct option is darkened.
Zero Marks : 0 If none of the bubbles is darkened.
Negative Marks : −1 In all other cases.

1. Identify the reagent (s) used for the following conversion.



(a) Zn(Hg), HCl (b) $NH_2NH_2, \bar{O}H$

(c) H_2 / Ni (d) $NaBH_4$

2. An evacuated glass vessel weighs 50 g when empty, 148 g when filled with a liquid of density $0.98\ \text{g mL}^{-1}$ and 50.5g when filled with an ideal gas at 760 mm Hg at 300 K. The molecular weight (g mol^{-1}) of the gas is

(a) 140 (b) 123

(c) 156 (d) 172

3. While testing BO_3^{3-}, there is green-edged flame on heating the salt with conc. H_2SO_4 and CH_3OH. The green colour is due to

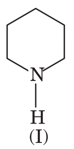
(a) $(CH_3)_3B$ (b) $(CH_3O)_3B$ (c) B_2O_3 (d) H_3BO_3

4. Which of the following has the lowest degree of paramagnetism per mole of the compound at 298 K?

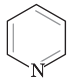
(a) $MnSO_4.4H_2O$ (b) $CuSO_4.5H_2O$

(c) $FeSO_4.6H_2O$ (d) $NiSO_4.6H_2O$

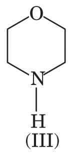
5. Which of the following is the correct increasing order of basic strength for the compounds?



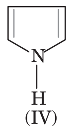
(I)



(II)



(III)



(IV)

(a) III > I > IV > II (b) I > III > II > IV

(c) II > I > III > IV (d) IV > I > III > II

SECTION 2 (MM : 32)

- This section contains **EIGHT** questions.
- Each question has **FOUR** options (a), (b), (c) and (d). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct.
- For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS.
- For each question, marks will be awarded in one of the following categories:

Full Marks : +4 If only the bubble(s) corresponding to all correct option(s) is(are) darkened.
Partial Marks : +1 For darkening a bubble corresponding **to each correct option**, provided no incorrect option is darkened.
Zero Marks : 0 If none of the bubbles is darkened.
Negative Marks : −2 In all other cases.

For example, if (a), (c) and (d) are all the correct options for a question, darkening all these three will result in +4 marks; darkening only (a) and (d) will result in +2 marks and darkening (a) and (b) will result in −2 marks, as a wrong option is also darkened.

6. Which of the following statements are incorrect?

(a) A *meso* compound is optically active

(b) A *meso* compound has chiral centres but exhibits no optical activity

(c) A *meso* compound has no chiral centres and thus exhibits no optical activity

(d) A *meso* compound has molecules which are superimposable on their mirror images even though they contain chiral centres

7. Which of the following statements about micelles are correct?

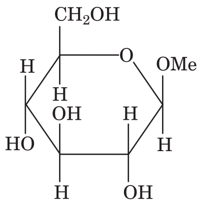
(a) At critical micelle concentration, several properties of solution of surfactants such as molar conductivity, surface tension and osmotic pressure change

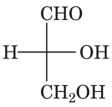
(b) Micelles from ionic surfactants can be formed only above a certain temperature called Kraft temperature

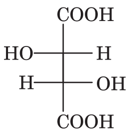
(c) Micelle formation is exothermic

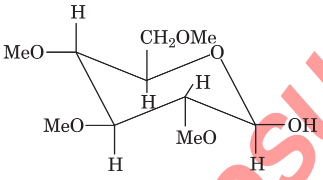
(d) Micelles are associated colloids

8. Which of the following carbohydrates are D-isomers?

(a)


(b)


(c)


(d)


9. A metal sulphide $\xrightarrow[H_2S]{HCl}$ Black ppt. (X) $\xrightarrow[\text{ammonium sulphate}]{\text{yellow}}$

$$\begin{tikzcd}\text{Residue} \arrow[r, "\text{dil.}", "H_2SO_4"'] \arrow[d, "\text{Aqua-regia}"] & \text{Insoluble} \\ \text{Soluble} & \end{tikzcd}$$

Identify the correct statement(s) about the ppt. (X)

(a) Nitrate ion of aqua regia in the presence of H^+ converts S^{2-} ion to free S

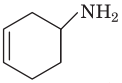
(b) Chloride ion of aqua-regia in the presence of H^+ converts S^{2-} ion to free S

(c) Metal forms a salt with NO_3^-

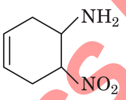
(d) Metal forms a soluble complex with chloride ion

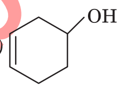
10. Which of the following pairs contain same number of electrons but their shapes are different?

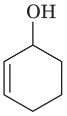
(a) BF_3, BCl_3 (b) CH_4, NH_3 (c) NH_3, H_2O (d) $BeCl_2, BeF_2$

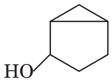
11.


on reaction with HNO_2 forms

(a)


(b)


(c)


(d)


12. When a mixture of NaCl and $K_2Cr_2O_7$ is gently warmed with conc. H_2SO_4 then

(a) a deep red vapour is evolved

(b) the vapour when passed into NaOH solution gives a yellow solution of Na_2CrO_4

(c) chlorine gas is evolved

(d) chromyl chloride is formed

13. A certain volume of dry air at NTP is expanded reversibly and isothermally to four times of its volume. The final pressure and temperature are respectively

(a) 25 atm and 273K (b) 0.25 atm and 0°C

(c) 25 atm and 0°C (d) 0.25 atm and 273 K

SECTION 3 (MM : 12)

- This section contains **FIVE** questions.
- The answer to each question is a **SINGLE DIGIT INTEGER** ranging from 0 to 9, both inclusive.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories:

Full Marks : + 3 If only the bubble corresponding to the correct option is darkened.
Zero Marks : 0 In all other cases.

14. The pH of an aqueous solution obtained by mixing 25 mL of 0.2 MHCl with 50 mL of 0.25 M NaOH is 1.3×10^x [take $K_w = 10^{-14}$ mol^{2}dm^{-6} at 25°C]. Calculate the value of x.

15. In ClF_3, if both lone pairs occupy axial positions then find the number of lone pair-bond pair repulsions.

16. The stopcock containing two bulbs of volume 5 L and 10 L containing an ideal gas at 9 atm and 60 atm, respectively is opened. What is the final pressure in atm if the temperature remains the same?

17. An organic compound having carbon, hydrogen and sulphur contains 4% of sulphur. The minimum molecular weight of the compound is $x \times 10^2$. The value of x is ....

18. Green vitriol is $FeSO_4 . xH_2O$ and white vitriol is $ZnSO_4 . yH_2O$. The value obtained by subtracting y from x is ....

PAPER II

SECTION 1 (MM : 18)

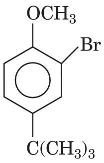
- This section contains **SIX** questions.
- Each question has **FOUR** options (a), (b), (c) and (d). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories:

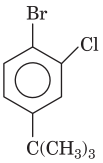
Full Marks : +3 If only the bubble corresponding to the correct option is darkened.
Zero Marks : 0 If none of the bubbles is darkened.
Negative Marks : −1 In all other cases.

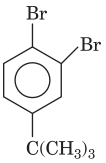
1. Consider the following reaction,

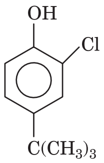
$$\text{Anisole} \xrightarrow[\text{Anhy. AlCl}_3]{(CH_3)_3CCl} A \xrightarrow{Cl_2/FeCl_3} B \xrightarrow[\Delta]{HBr} C$$

The product C in the above series of reaction is

(a) 

(b) 

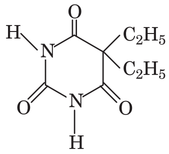
(c) 

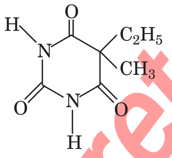
(d) 

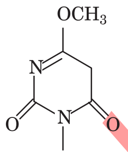
2. The correct decreasing order of X—O bond length in the following ions, where X is the central atom in $SiO_4^{4-}, ClO_4^-, PO_4^{3-}, SO_4^{2-}$ is

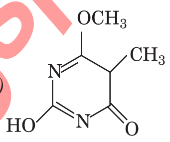
(a) $ClO_4^- > SO_4^{2-} > PO_4^{3-} > SiO_4^{4-}$
(b) $SiO_4^{4-} > PO_4^{3-} > SO_4^{2-} > ClO_4^-$
(c) $SO_4^{2-} > PO_4^{3-} > ClO_4^- > SiO_4^{4-}$
(d) $SiO_4^{4-} > SO_4^{2-} > PO_4^{3-} > ClO_4^-$

3. Veronal is a sleep producing drug derived from barbituric acid. It is

(a) 

(b) 

(c) 

(d) 

4. Consider the following complex ions, $P = [FeF_6]^{3-}$, $Q = [V(H_2O)_6]^{2+}$ and $R = [Fe(H_2O)_6]^{2+}$. The correct order of the complex ions according to their spin only magnetic moment value (in BM) is

(a) $R < Q < P$ (b) $Q < R < P$ (c) $R < P < Q$ (d) $Q < P < R$

5. The volume of 12 N and 3 N HCl that must be mixed to give 1 L of 6 N HCl is

(a) 0.33 L and 0.66 L
(b) 0.8 L and 0.2 L
(c) 0.33 L and 0.33 L
(d) 0.66 L and 0.66 L

6. Which of the following statement is incorrect?

(a) Rate of the reaction involving conversion of *ortho* hydrogen to *para* hydrogen $= -\frac{d[H_2]}{dt} = k[H_2]^{3/2}$
(b) Rate of the reaction involving the thermal decomposition of acetaldehyde $= k[CH_3CHO]^{1/2}$
(c) In the formation of phosgene from CO and Cl_2, the rate of the reaction $= k[CO][Cl_2]^{1/2}$
(d) In the decomposition of H_2O_2, the rate of reaction $= k[H_2O_2]$

SECTION 2 (MM : 32)

- This section contains **EIGHT** questions.
- Each question has **FOUR** options (a), (b), (c) and (d). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct.
- For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS.
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For example, if (a), (c) and (d) are all the correct options for a question, darkening all these three will result in +4 marks; darkening only (a) and (d) will result in +2 marks and darkening (a) and (b) will result in −2 marks, as a wrong option is also darkened.

7. Which of the following statements are incorrect?

(a) The third ionisation energy of lithium is 9 times than the second ionisation energy of helium
(b) The second ionisation energy of helium is 4 times than the first ionisation energy of hydrogen
(c) Radius of third orbit of Li^{2+} is 3 times than the radius of third orbit of hydrogen atom
(d) For designating an orbital, three quantum numbers are required

8. A radioactive element decays as follows,

$$X \xrightarrow[t_{1/2} = 30 \text{ min}]{\alpha-\text{decay}} Y \xrightarrow[t_{1/2} = 2 \text{ days}]{(-2\beta)\beta-\text{decay}} Z$$

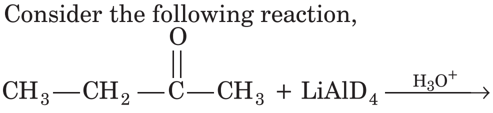
Which of the following statements about this decay process is correct?

(a) After two hours, less than 10% of the initial X is left
(b) Maximum amount of Y present at any time before 30 min. is less than 50% of the initial amount of X
(c) Atomic number of X and Z are same
(d) The mass number of Y is greater than X

9. Choose the correct statements about PCl_5.

(a) Three P—Cl equatorial bonds lie in one plane and make an angle of 120° with each other
(b) Two P—Cl axial bonds, one lying above and the other lying below the equatorial plane make an angle of 90° with the plane
(c) Axial bonds are slightly longer and slightly weaker than equatorial bonds
(d) Axial bonds are slightly shorter and slightly stronger than equatorial bonds

10. Consider the following reaction,



$$CH_3—CH_2—\overset{\overset{\displaystyle O}{\|}}{C}—CH_3 + LiAlD_4 \xrightarrow{H_3O^+}$$

Select the correct statement(s) regarding the product of the above reaction.

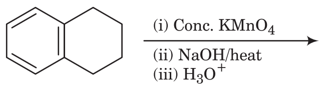
(a) a pure enantiomer of alcohol is formed
(b) racemic mixture of alcohol is formed
(c) product alcohol has deuterium attached to oxygen
(d) product alcohol has deuterium attached to α-carbon

11. If 2.84 g of P_4O_{10} is dissolved in 1 L aqueous solution, then

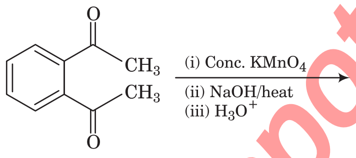
(a) resulting solution is 0.01 M
(b) it is neutralised to Na_3PO_4 by 400 mL of 0.3 M NaOH
(c) It is neutralised to $CaHPO_4$ by 400 mL of 0.1 M $Ca(OH)_2$
(d) it cannot be neutralised by basic solution

12. Which of the following reactions give phthalic acid as the major organic product.

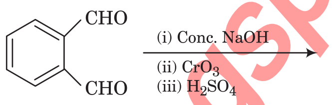
(a)



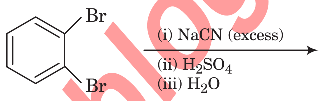
(b)



(c)



(d)



13. A solution containing 3.5 g of solute X in 50 g of water has a volume of 52.5 mL and a freezing point of –0.86°C. Thus, (K_f of $H_2O = 1.86°$ C mol^{-1}Kg)

(a) molality of the solution is 0.46 mol kg^{-1}
(b) molarity of the solution is 0.44 mol L^{-1}
(c) molar mass of solute X is 152 g mol^{-1}
(d) mole fraction of solute X is 0.0082

14. In which of the following orders the given sequence is strictly according to the property indicated against it?.

(a) $HF < HCl < HBr < HI$ (Increasing acidic strength)
(b) $H_2O < H_2S < H_2Se < H_2Te$ (Increasing pK_a values)
(c) $NH_3 < PH_3 < AsH_3 < SbH_3$ (Increasing acidic character)
(d) $CO_2 < SiO_2 < SnO_2 < PbO_2$ (Increasing oxidising power)

SECTION 3 (MM : 12)

- This section contains **TWO** paragraphs.
- Based on each paragraph, there are **TWO** questions.
- Each question has **FOUR** options (a), (b), (c) and (d). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories:

  Full Marks : + 3 If only the bubble corresponding to the correct option is darkened.
  Zero Marks : 0 In all other cases.

Paragraph I 1.05 g of lead ore containing impurity of Ag was dissolved in HNO_3 and the volume was made 350 mL. A silver electrode was dipped in the solution and E_{cell} of $Pt(H_2)|H^+ (1M)||Ag^+|Ag$ was 0.5 V at 298 K ($E^\circ_{Ag^+|Ag} = 0.8$ V).

15. Pure $[Ag^+]$ in the ore is

(a) 8.4×10^{-6} M
(b) 2.9×10^{-6} M
(c) 7×10^{-11} M
(d) 4.2×10^{-6} M

16. The percentage of silver in the sample is

(a) 0.03% *(b)* 0.06% *(c)* 3.4% *(d)* 1.2%

Paragraph II In two separate test tubes (1 and 2), ethanal is heated with a base. In test tube –1, nothing except the two mentioned reactants were present. In test tube – 2, malonic acid $[CH_2(COOH)_2]$ was also added. The final products of both test tubes (1 and 2) easily add 1, 3-butadiene molecule.

To be Continued at Page 78

GOLDEN OLDIES

TRANSITION AND INNER TRANSITION ELEMENTS

A collection of best asked questions from JEE to revise your concepts

1. The reaction of zinc with dilute and concentrated nitric acid, respectively produce **[JEE Main 2016]**

(a) NO_2 and NO *(b)* NO and N_2O
(c) NO_2 and N_2O *(d)* N_2O and NO_2

2. Which of the following compounds is metallic and ferromagnetic? **[JEE Main 2016]**

(a) CrO_2 *(b)* VO_2 *(c)* MnO_2 *(d)* TiO_2

3. Which one of the following species is stable in aqueous solution? **[JEE Main 2016]**

(a) MnO_4^{2-} *(b)* MnO_4^{3-} *(c)* Cu^+ *(d)* Cr^{2+}

4. In the following reaction sequence in aqueous solution, the species *X*, *Y* and *Z*, respectively are

$$S_2O_3^{2-} \xrightarrow{Ag^+} \underset{\text{Clear solution}}{X} \xrightarrow{Ag^+} \underset{\text{White ppt}}{Y} \xrightarrow{\text{With time}} \underset{\text{Black ppt}}{Z}$$

[JEE Adv. 2016]

(a) $[Ag(S_2O_3)_2]^{3-}$, $Ag_2S_2O_3$, Ag_2S
(b) $[Ag(S_2O_3)_3]^{5-}$, Ag_2SO_3, Ag_2S
(c) $[Ag(SO_3)_2]^{3-}$, $Ag_2S_2O_3$, Ag
(d) $[Ag(SO_3)_3]^{3-}$, Ag_2SO_4, Ag

5. A pink coloured salt turns blue on heating. The presence of which cation is most likely? **[JEE Main 2015]**

(a) Co^{2+} *(b)* Cu^{2+}
(c) Zn^{2+} *(d)* Fe^{2+}

6. $^{3+}$ is reduced to $^{2+}$ by using **[JEE Adv. 2015]**

(a) H_2O_2 in the presence of NaOH
(b) Na_2O_2 in water
(c) H_2O_2 in the presence of H_2SO_4
(d) Na_2O_2 in the presence of H_2SO_4

7. Which series of reactions correctly represent chemical relations related to iron and its compounds? **[JEE Main 2014]**

(a) $Fe \xrightarrow{\text{Dil. } H_2SO_4} FeSO_4 \xrightarrow{H_2SO_4,\, O_2} Fe_2(SO_4)_3 \xrightarrow{\text{Heat}} Fe$

(b) $Fe \xrightarrow{O_2,\, \text{Heat}} FeO \xrightarrow{\text{Dil. } H_2SO_4} FeSO_4 \xrightarrow{\text{Heat}} Fe$

(c) $Fe \xrightarrow{Cl_2,\, \text{Heat}} FeCl_3 \xrightarrow{\text{Heat, air}} FeCl_2 \xrightarrow{\text{Zn}} Fe$

(d) $Fe \xrightarrow{O_2,\, \text{Heat}} Fe_3O_4 \xrightarrow{\text{CO, 600°C}} FeO \xrightarrow{\text{CO, 700°C}} Fe$

8. Upon heating with Cu_2S, the reagent(s) that give copper metal is/are **[JEE Adv. 2014]**

(a) $CuFeS_2$ *(b)* CuO *(c)* Cu_2O *(d)* $CuSO_4$

9. Consider the following reaction, **[JEE Main 2013]**

$$x\,MnO_4^- + y\,C_2O_4^{2-} + z\,H^+ \longrightarrow x\,Mn^{2+} + 2y\,CO_2 + \frac{z}{2}$$

The values of *x*, *y* and *z* in the reaction, respectively are

(a) 5, 2 and 16 *(b)* 2, 5 and 8
(c) 2, 5 and 16 *(d)* 5, 2 and 8

10. Which of the following arrangements does not represent the correct order of the property stated against it? **[JEE Main 2013]**

(a) $V^{2+} < Cr^{2+} < Mn^{2+} < Fe^{2+}$: paramagnetic behaviour
(b) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$: ionic size
(c) $Y^{3+} < Lu^{3+} < Eu^{3+} < La^{3+}$: ionic radii
(d) $Sc < Ti < Cr < Mn$: number of oxidation states

11. The colour of light absorbed by an aqueous solution of $CuSO_4$ is **[IIT JEE 2012]**

(a) orange-red *(b)* blue-green *(c)* yellow *(d)* violet

12. Reduction of the metal centre in aqueous permanganate ion involves **[IIT JEE 2011]**

(a) three electrons in neutral medium
(b) five electrons in neutral medium
(c) three electrons in alkaline medium
(d) five electrons in acidic medium

13. Which of the following will not be oxidised by O_3? **[IIT JEE 2008]**

(a) KI *(b)* $FeSO_4$ *(c)* $KMnO_4$ *(d)* K_2MnO_4

14. Which of the following pair is expected to exhibit same colour in solution? **[IIT JEE 2008]**

(a) $VOCl_2$; $FeCl_2$ *(b)* $CuCl_2$; $VOCl_2$
(c) $MnCl_2$; $FeCl_2$ *(d)* $FeCl_2$; $CuCl_2$

15. $(NH_4)_2Cr_2O_7$ on heating gives a gas which is also given by **[IIT JEE 2007]**

(a) heating NH_4NO_2 *(b)* heating NH_4NO_3
(c) $Mg_3N_2 + H_2O$ *(d)* Na (comp.) + H_2O_2

16. The pair of compounds having metals in their highest oxidation state is **[IIT JEE 2007]**

(a) MnO_2, $FeCl_3$ *(b)* $[MnO_4]^-$, CrO_2Cl_2
(c) $Fe(CN)_6]^{3-}$, $[Co(CN)_3]$ *(d)* $[NiCl_4]^{2-}$, $[CoCl_4]^-$

17. When I^- is oxidised by MnO_4^- in alkaline medium, I^- converts into **[IIT JEE 2006]**

(a) IO_3^- *(b)* I_2 *(c)* IO_4^- *(d)* IO^-

18. When MnO_2 is fused with KOH, a coloured compound is formed, the product and its colour is **[IIT JEE 2006]**

(a) K_2MnO_4, purple green *(b)* $KMnO_4$, purple
(c) Mn_2O_3, brown *(d)* Mn_3O_4, black

19. Amongst the following, identify the species with an atom in + 6 oxidation state **[IIT JEE 2005]**

(a) MnO_4^- *(b)* $[Cr(CN)]_6^{3-}$ *(c)* $[NiF]^{2-}$ *(d)* CrO_2Cl_2

20. The actinoids exhibit more number of oxidation states in general than the lanthanoids. This is because **[IIT JEE 2004]**

(a) the 5*f*-orbitals are more buried than the 4*f*-orbitals
(b) there is a similarity between 4*f* and 5*f*-orbitals in their angular part of the wave function
(c) the actinoids are more reactive than the lanthanoids
(d) the 5*f*-orbitals extend farther from the nucleus than the 4*f*-orbitals

Answers with Explanation

1. ***(d)*** Zinc reacts with cold and conc. HNO_3 in which it is oxidised to $Zn(NO_3)_2$, here, HNO_3 is reduced to NO_2.

$$Zn + \underset{\text{(Conc.)}}{4HNO_3} \longrightarrow Zn(NO_3)_2 + 2H_2O + 2NO_2$$

Zinc reacts with cold and dil. HNO_3 (20%) in which it is oxidised to $Zn(NO_3)_2$, here, HNO_3 is reduced to N_2O.

$$4Zn + \underset{\text{(Dil.)}}{10HNO_3} \longrightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$$

2. ***(a)*** Only three elements iron (Fe), cobalt (Co) and nickel (Ni) show ferromagnetism at room temperature. CrO_2 is also a metallic and ferromagnetic compound which is used to make magnetic tapes for cassette recorders.

3. ***(a)*** MnO_4^{2-} does not dissociate in aqueous solution. It dissociates in neutral or acidic solution.

$$\underset{\text{Manganate ion}}{3MnO_4^{2-}} + 4H^+ \longrightarrow \underset{\text{Permanganate ion}}{2MnO_4^-} + MnO_2 + 2H_2O$$

4. ***(a)*** **Thinking Process** Silver ions are dissolved by thiosulphate solution, hence form a clear solution which on further reaction with silver ions from a white precipitate. The white precipitate quickly changes colour to yellow, brown and finally black due to the formation of silver sulphide.

$$2S_2O_3^{2-} + Ag^+ \longrightarrow \underset{\substack{\text{Clear solution}\\(X)}}{[Ag(S_2O_3)_2]^{3-}}$$

$$\underset{(X)}{[Ag(S_2O_3)_2]^{3-}} + 3Ag^+ \longrightarrow \underset{\substack{\text{White ppt}\\(Y)}}{2Ag_2S_2O_3}$$

$$\underset{(Y)}{Ag_2S_2O_3} + H_2O \longrightarrow \underset{\substack{\text{Black ppt}\\(Z)}}{Ag_2S} + H_2SO_4$$

5. ***(a)*** **Key Concept** The compounds of transition metals are coloured in solid state or solutions. The colour of transition metal ions arises from the excitation of electron from *d*-orbitals of lower energy to *d*-orbitals of higher energy. The transition metals which have either completely filled *d*-orbitals or completely empty *d*-orbitals are colourless.

Zn^{2+} salts are colourless but Fe^{2+} salts are rarely pink. Cu^{2+} salts are usually blue in hydrated form. Co^{2+} is pink in aqueous solution on heating it turns into blue colour.

6. ***(c, d)*** In basic medium, Fe^{3+} gets precipitated as $Fe(OH)_3$. There is no reduction in this process,

$$Fe^{3+} \xrightarrow[NaOH]{H_2O_2} Fe(OH)_3$$

In acidic medium, Fe^{3+} is reduced to Fe^{2+}.

$$Fe^{3+} \xrightarrow{H_2O_2/H_2SO_4} Fe(OH)_2$$

$$Fe^{3+} \xrightarrow{Na_2O_2/H_2SO_4} Fe(OH)_2$$

7. ***(d)*** **Thinking process** Analyse each reaction given in the question and choose the correct answer on the basis of oxidation state and stability of iron compounds.

The correct reactions are as follows:

(a) $Fe + \text{dil. } H_2SO_4 \longrightarrow FeSO_4 + H_2$

$H_2SO_4 + 2FeSO_4 + \frac{1}{2}O_2 \longrightarrow Fe_2(SO_4)_3 + H_2O$

$Fe_2(SO_4)_3 \xrightarrow{\Delta} Fe_2O_3(s) + 3SO_3\uparrow$

Thus, the option (a) is incorrect

(b) $Fe \xrightarrow[\Delta]{O_2} FeO$ [It could also be Fe_2O_3 or Fe_3O_4]

$FeO + \text{dil. } H_2SO_4 \longrightarrow FeSO_4 + H_2O$

$2FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2 + SO_3$

Thus, the option (b) is incorrect.

(c) $Fe \xrightarrow[Cl_2]{\Delta} FeCl_3 \xrightarrow[\text{air}]{\Delta}$ No reaction [It cannot give $FeCl_2$]

Thus, the option (c) is incorrect.

(d) $Fe \xrightarrow[\Delta]{O_2} Fe_3O_4 \xrightarrow[600°C]{CO} FeO \xrightarrow[700°C]{CO} Fe$

Thus, the option (d) is correct.

8. ***(b, c, d)*** All the reagents given in the question forms copper metal upon heating with Cu_2S except $CuFeS_2$.

(b) $4CuO \xrightarrow{1100°C} 2Cu_2O + O_2$

$2Cu_2O + Cu_2S \xrightarrow{\Delta} 6Cu + SO_2$

(c) $2Cu_2O + Cu_2S \xrightarrow{\Delta} 6Cu + SO_2$

(d) $CuSO_4 \xrightarrow{720°C} CuO + SO_2 + \frac{1}{2}O_2$

$4CuO \xrightarrow{\Delta} 2Cu_2O + O_2$

$2Cu_2O + Cu_2S \xrightarrow{\Delta} 6Cu + SO_2$

Reaction is believed to proceed as

$$Cu_2S \rightleftharpoons 2\,Cu^+ + S^{2-}$$
$$2Cu_2O \rightleftharpoons 4\,Cu^+ + 2O^{2-}$$
$$S^{2-} + 2O^{2-} \longrightarrow SO_2 + 6e^-$$
$$6Cu^+ + 6e^- \longrightarrow 6Cu;\ E^\circ_{cell} = 0.52$$

Here, copper sulphide is reduced to copper metal. Solidified copper has blistered appearance due to evolution of SO_2 and thus, obtained copper is known as blister copper.

While $CuFeS_2$ will not give Cu on heating. The heating in the presence of O_2 gives Cu_2S and FeS with the evolution of SO_2.

9. ***(c)*** The half equations for the reaction are as follows

$$MnO_4^- \longrightarrow Mn^{2+}$$
$$C_2O_4^{2-} \longrightarrow CO_2$$

The balanced half equations are

$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O \quad \ldots(i)$$
$$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^- \quad \ldots(ii)$$

On equating number of electrons, in both the above equations (i) and (ii), we get

$$2MnO_4^- + 16H^+ + 10e^- \longrightarrow 2Mn^{2+} + 8H_2O$$
$$5C_2O_4^{2-} \longrightarrow 10CO_2 + 10e^-$$

On adding both the equations, we get

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 2\times 5CO_2 + \frac{16}{2}H_2O$$

Thus x, y and z are 2, 5 and 16 respectively.

10. ***(a)*** The paramagnetic behaviour increases with increase in number of upaired electrons.

V^{2+} = 3 unpaired electrons
Cr^{2+} = 4 unpaired electrons
Mn^{2+} = 5 unpaired electrons
Fe^{2+} = 4 unpaired electrons

Hence, the order of paramagnetic behaviour should be

$$V^{2+} < Cr^{2+} \approx Fe^{2+} < Mn^{2+}$$

(b) Ionic size decreases from left to right in the same period.

(c) Eu and Lu are the members of lanthanide series (so they show lanthanide contraction) and La is the representative elements of all element of such series and Y^{3+} ion has lower radii as compared to La^{3+} because it lies immediately above it in the periodic table.

(d) The oxidation states increases as we move from group 3 to group 7 in the same period.

11. ***(a)*** The aqueous solution of $CuSO_4$ consist of the complex $[Cu(H_2O)_4]^{2+}$ ion which absorbed in orange-red region and impart deep blue colouration to solution.

12. ***(a, c, d)*** In neutral medium, $KMnO_4$ is directly reduced to MnO_2

$$2KMnO_4 + H_2O \longrightarrow 2KOH + 2MnO_2 + 3O$$
$$Mn^{7+} + 3e^- \longrightarrow Mn^{4+}$$

In alkaline medium,

$$2KMnO_4 + H_2O \longrightarrow 2MnO_2 + 2KOH + 3O$$
$$Mn^{7+} + 3e^- \longrightarrow Mn^{4+}$$

In acidic medium,

$$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5O$$
$$Mn^{7+} + 5e^- \longrightarrow Mn^{2+}$$

13. ***(c)*** $KMnO_4$ is itself a very strong oxidising agent, O_3 cannot oxidise it, while the other given compounds will be oxidised by O_3.

$$2K_2MnO_4 + H_2O + O_3 \longrightarrow 2KMnO_4 + 2KOH + O_2$$
$$O_3 + 2KI + H_2O \longrightarrow I_2 + 2KOH + O_2$$

14. ***(b)*** **Key concept** Colour of transition metal ion salt is due to d-d transition of unpaired electrons of d-orbital. Metal ion salt having similar number of unpaired electrons in d-orbitals shows similar colour in aqueous medium.

In $VOCl_2$, vanadium is present as V^{4+} and in $CuCl_2$ copper is present as Cu^{2+}

$V = [Ar]_{18} 3d^3,\ 4s^2;\ V^{4+} = [Ar]_{18} 3d^1$

$\boxed{\uparrow}\boxed{}\boxed{}\boxed{}\boxed{}$, number of unpaired electron = 1

$Cu = [Ar]_{18} 3d^9$

$\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow}$, number of unpaired electron = 1

Hence, $VOCl_2$ and $CuCl_2$ show similar colour.

15. ***(a)*** Ammonium dichromate on heating produces $N_2(g)$. NH_4NO_2 also gives N_2 on heating.

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2 + Cr_2O_3 + 4H_2O$$
$$NH_4NO_2 \xrightarrow{\Delta} N_2 + 2H_2O$$

16. ***(b)*** In $[MnO_4]^-$, Mn^{+7} is highest oxidation state possible for Mn. In CrO_2Cl_2, Cr^{+6} is highest oxidation state possible for Cr.

17. ***(a)*** In alkaline medium, MnO_4^- oxidises iodides (I^-) to iodates (IO_3^-).

$$2MnO_4^- + I^- + H_2O \xrightarrow{Alkali} 2MnO_2 + 2\bar{O}H + IO_3^-$$

18. ***(a)*** K_2MnO_4 (purple green) is formed which is the first step for the preparation of $KMnO_4$. The finely powdered pyrolusite (MnO_2) mineral is fused with KOH in presence of air or an oxidising agent like KNO_3, $KClO_3$ etc.

$$2MnO_2 + 4KOH + O_2 \longrightarrow \underset{\text{Purple green}}{2K_2MnO_4} + 2H_2O$$

19. ***(d)*** In CrO_2Cl_2, Cr is in +6 oxidation state because Cl is in (−1) and, oxygen is in (−2) oxidation states.

In MnO_4^-, Mn is in +7 oxidation state.

In $[Cr(CN)_6]^{3-}$, Cr is in +3 oxidation state.

In $[NiF_6]^{2-}$, Ni is in +4 oxidation state.

20. ***(d)*** The actinoid (5*f*-elements) exhibit more number of oxidation states in general than the lanthanoid because 5*f*-orbitals extend farther from the nucleus than the 4*f*-orbitals.

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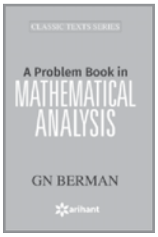
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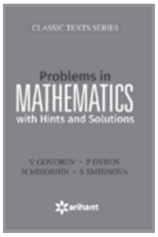
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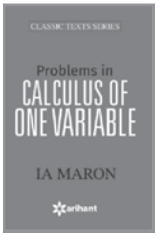
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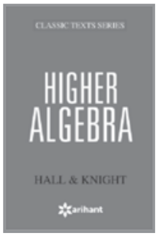
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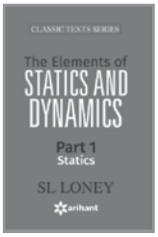
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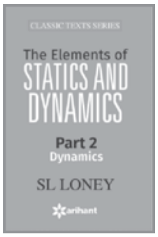
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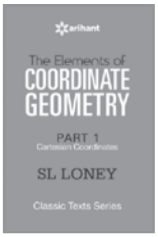
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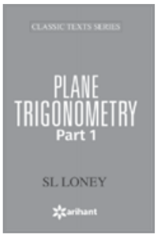
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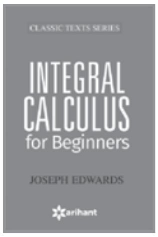
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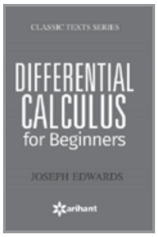
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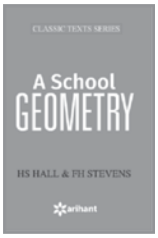
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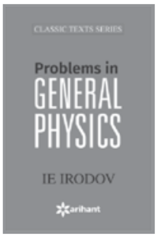
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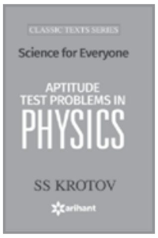
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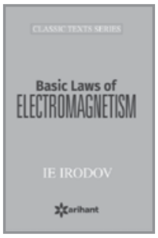
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Innovative problems targeted to improve your conceptual learning.

1. *Aldehydes and ketones have high dipole moment than those of alcohols. Why ?*

- The π-electrons of the $>C{=}O$ are loosely held and hence can be shifted towards O-atom more readily than the more tightly held σ-electrons of the $C-O$ bond in alcohols. Consequently, the magnitude of the positive and negative charge developed in $>C{=}O$ bond is higher than those on $C-O$ bond of alcohols. As a result, the dipole moment of aldehydes and ketones is much higher than that of alcohols.

2. *Cannizzaro reaction is a characteristic reaction of aldehydes without α-hydrogen but few aldehydes with α-hydrogen like $(CH_3)_2CHCHO$ also known to give this reaction. Explain.*

- Few aldehydes without α-hydrogen undergoes Cannizaro reaction, e.g.

$$2(CH_3)_2CHCHO \xrightarrow[NaOH]{200°C} (CH_3)_2CHCH_2OH + (CH_3)_2CHCO\overset{-}{O}N\overset{+}{a}$$

This is because it is difficult for the base to eliminate α-hydrogen from the sterically crowded α-carbon.

3. *Why aldehydes are more reactive than ketones?*

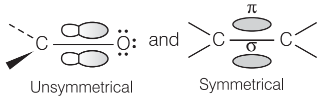
- Aldehydes are more reactive than ketones due to the following two reasons :
  - (i) Due to smaller + *I*-effect of an alkyl group in aldehydes as compared to large + *I*-effect of two alkyl groups in ketones the magnitude of positive charge on the carbonyl carbon is more in aldehydes than ketones. As a result, nucleophilic addition reactions occur more readily in aldehydes than ketones.
  - (ii) Due to presence of a H-atom on the carbonyl group, aldehydes can be more easily oxidised than ketones. As a result, aldehydes act as reducing agents and thus, reduce Tollen's reagent, Fehling's solution, etc.

4. *Benzaldehyde reduces Tollen's reagent but not the Fehling's or the Benedict's solution. Explain.*

- The electron-donating resonance effect (+*R*-effect) of the benzene ring increase the electron density in the carbonyl group of benzaldehyde. This, in turn, increases the electron density in the $C-H$ bond of the aldehyde group. As a result, the $C-H$ bond becomes stronger and hence only stronger oxidising agents like Tollen's reagent $[Ag(NH_3)_2]^+$ can oxidise $C-H$ to $C-OH$ to form carboxylic acids but weaker oxidising agents like Fehling's solution (Cu^{2+} + tartrate ion + base) and Benedict's solution (Cu^{2+} + citrate ion + base) fail to oxidise benzaldehyde to benzoic acid. Thus, in general, all these three reagents oxidise aliphatic aldehydes but only Tollen's reagent oxidises aromatic aldehydes.

5. *Although both $>C{=}C<$ and $>C{=}O$ have a double bond, yet they exhibit different type of addition reactions. Explain.*

- The $>C{=}C<$ undergoes electrophilic addition reactions while $>C{=}O$ shows nucleophilic addition reactions. This difference in behaviour is due to the different shapes of their π-electron clouds as shown below :

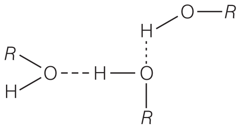


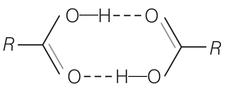
Since, the π-electron cloud of $>C{=}C<$ consists of loosely held electrons, therefore it readily allow electrophiles to react.

In contrast, the π-electron cloud of $>C{=}O$ is unsymmetrical shifts towards oxygen due to greater electronegativity of O than C. As a result, the C-atom of the $>C{=}O$ bond acquires a partial positive charge and hence readily attacked by nucleophiles.

6. *Aldehydes and ketones have lower boiling points than corresponding alcohols and acids. Explain.*

- Aldehydes and ketones are polar compounds having sufficient intermolecular dipole-dipole interactions between opposite ends of $>C{=}O$ dipoles. However, these dipole-dipole interactions are weaker than the intermolecular hydrogen bonds present in alcohols and carboxylic acids. Therefore, boiling points of aldehydes and ketones are lower than alcohols and carboxylic acids.


Alcohol (intermolecular H-bonding)

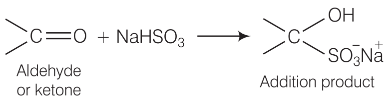

Carboxylic acid (intermolecular H-bonding)

7. *In the preparation of acetaldehyde from ethanol, it is distilled out as soon as it is formed. Explain.*

- Aldehyde is easily oxidisable to acetic acid. Therefore, to prevent its oxidation, it is distilled out as soon as it is formed.

8. *Why in the purification of aldehydes and ketones, sodium bisulphite is used?*

- Aldehydes and ketones react with sodium bisulphite to form addition compounds.

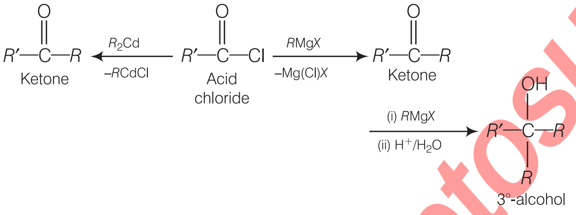


The addition products are crystalline solids. These can be decomposed by mineral acids or aqueous alkalies to give back the original aldehyde or ketone. Therefore, this reaction can be used for the purification of aldehydes and ketones.

9. *Explain why dialkylcadmium is considered superior to Grignard reagent for the preparation of a ketone from an acid chloride.*

- Dialkylcadmium are less reactive than Grignard reagents towards nucleophilic addition reactions because Cd is less electropositive than Mg. Dialkylcadmium react with the more reactive acid chlorides to give ketones but do not react further.

  In contrast, Grignard reagents being more reactive not only react with the acid chlorides but also with the ketones so formed to give *tert*-alcohols.



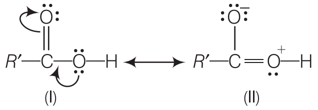
10. *Fluorine is more electronegative than chlorine even though p-fluorobenzoic acid is a weaker acid than p-chlorobenzoic acid. Give reason.*

- Halogens are more electronegative than carbon and also possess lone pairs of electrons, therefore, they exert both $-I$ and $+R$-effects. Now, in F, the lone pairs of electrons are present in $2p$-orbitals but in Cl, they are present in $3p$-orbitals. Since, $2p$-orbitals of F and C are of almost equal size, therefore, the $+R$-effect is more pronounced in *p*-fluorobenzoic acid than in *p*-chlorobenzoic acid.

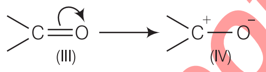
  Thus, in *p*-fluorobenzoic acid, $+R$-effect outweighs the $-I$-effect but in *p*-chlorobenzoic acid, it is the $-I$-effect which outweighs the $+R$-effect. Consequently, *p*-fluorobenzoic acid is a weaker acid than *p*-chlorobenzoic acid.

11. *Why carboxylic acids do not give the characteristic reactions of carbonyl group?*

- Due to the presence of lone pairs of electrons on the oxygen atom of the —OH group, the carboxylic acids may be regarded as a resonance hybrid of structures (I and II).



Similarly, a carbonyl group of aldehydes and ketones may be regarded as a resonance hybrid of structures (III) and (IV)

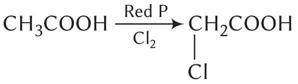


Due to contribution of structure (IV), the carbonyl carbon in aldehydes and ketones is electrophilic. However, due to contribution of structure (II), the electrophilic character of carboxyl carbon is reduced.

In other words, carbonyl carbon of carboxyl group is less electrophilic than carbonyl carbon in aldehydes and ketones.

12. *Acetic acid can be halogenated in the presence of red P and Cl but formic acid cannot be halogenated in the same way. Why?*

- Acetic acid is halogenated in the presence of red P in which substitution occurs at α-carbon atom. This is called as Hell-Vohlard Zelinsky (HVZ) reaction,



$$CH_3COOH \xrightarrow[Cl_2]{\text{Red P}} \underset{\displaystyle Cl}{CH_2}COOH$$

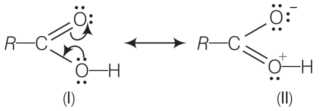
However, formic acid (HCOOH) has no α-hydrogen atom and therefore, cannot undergo HVZ reaction.

13. *Why are the boiling points of carboxylic acids higher than the corresponding alcohols?*

- Carboxylic acids have higher boiling point than alcohols of comparable molecular masses. The higher boiling point of carboxylic acid as compared to alcohol is due to greater hydrogen bonding in acids than in alcohols. As a result, the molecules of carboxylic acids are held together by two hydrogen bonds and have more attractive force and therefore, have higher boiling points.

14. *Why the bond length of C=O in carboxylic acids is slightly larger than that in aldehydes and ketones?*

- Carboxylic acid has resonance structures



Because of resonance structure (II), there is some single bond character in C=O bond, thereby making it longer than carbonyl compounds (aldehydes and ketones).

15. *During preparation of ammonia derivatives of aldehydes and ketones, pH of medium must be controlled. Why?*

- Formation of ammonia derivatives (oximes, hydrazone, semi-carbazone etc.) proceeds *via* the attack of carbonyl carbon with proton to form the conjugate acid. Therefore, presence of an acid is a must for preparing these derivatives (pH < 7).

However, in strongly acidic medium, the proton attacks the unshared pair of electrons on nitrogen to form the species $R\overset{+}{N}H_3$ which cannot attack the carbonyl carbon.

$$H^+ + :NH_2R \longrightarrow \overset{+}{N}H_3R$$

In basic medium, there is no protonation of carbonyl group and hence, no reaction takes place.

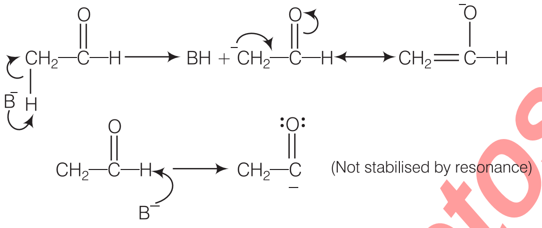
Therefore, preparation of ammonia derivatives require slightly acidic medium and its careful control is essential.

16. *Why is it more efficient to prepare an ester by the sequence : acid → acyl chloride → ester rather than acid → ester?*

- Reaction of acid with alcohol is slower and the equilibrium must be shifted to the right by removing a product i.e. H_2O. Acyl chlorides are easily prepared under non-equilibrium conditions (e.g. $SOCl_2$ is used) and their exothermic reaction with an alcohol goes to completion (HX being evolved).

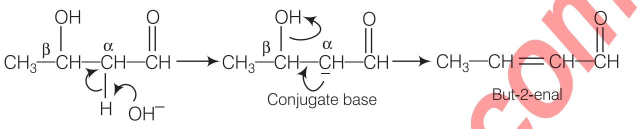
17. *In acetaldehyde, methyl hydrogen is more acidic than aldehydic hydrogen although it is attached to an sp^2-hybridised carbon. Why?*

- Although methyl hydrogens are attached to sp^3-carbon, they exhibit more acidity towards a base because the resultant carbanion (conjugate base) is stabilised by delocalisation. When aldehydic hydrogen is lost as proton, the resultant oxyanion is not stabilised by resonance or delocalisation.



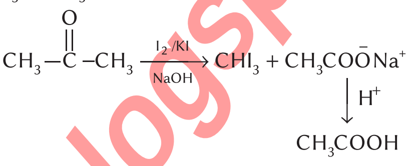
18. *Aldol undergoes base catalysed dehydration, although alcohols always undergo acid catalysed dehydration. Why?*

- α-hydrogen of an aldol is quite acidic and – OH group on the β-carbon atom is a bad leaving group. Consequently, aldol can undergo base catalysed $E1-cB$ elimination to give the dehydrated compound, but-2-enal.



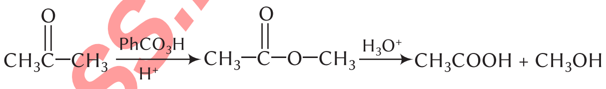
19. *Two students prepared CH_3COOH starting from CH_3COCH_3. Both of them used almost a one-step reaction following by usual workup. Can you guess the reactions they used?*

- One of the students carried out haloform reaction to convert CH_3COCH_3 to CH_3COOH.



$$CH_3-\overset{\overset{\large O}{\|}}{C}-CH_3 \xrightarrow[NaOH]{I_2/KI} CHI_3 + CH_3CO\bar{O}Na^+ \xrightarrow{H^+} CH_3COOH$$

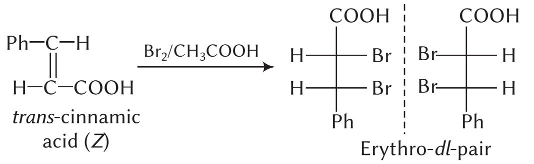
The second student carried out Baeyer-Villiger oxidation on CH_3COCH_3 to get methyl acetate and then hydrolysed it to CH_3COOH.



$$CH_3\overset{\overset{\large O}{\|}}{C}-CH_3 \xrightarrow[H^+]{PhCO_3H} CH_3-\overset{\overset{\large O}{\|}}{C}-O-CH_3 \xrightarrow{H_3O^+} CH_3COOH + CH_3OH$$

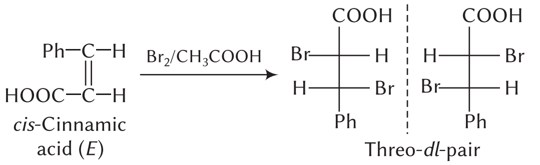
20. *Cinnamic acid shows geometrical isomerism. Why? What compounds are formed when they are brominated separately?*

- Cinnamic acid has the structure, PhCH = CHCOOH and belongs to a molecule having the general structure $C(ab) = C(ae)$. Therefore, it exhibits its *cis-trans* (E/Z) isomerism. These two diastereoisomers give different products when brominated.



trans-cinnamic acid (*Z*)

Erythro-*dl*-pair



cis-Cinnamic acid (*E*)

Threo-*dl*-pair

Sulphur

AMAZING CHEMISTRY

Sulphur is so abundant in its native form and the element has been known since ancient times. The Bible refers to sulphur as brimstone meaning 'burn stone' or 'stone that burns'. There have also been recorded uses of sulphur in ancient India, Greece, China and Egypt. Pure elemental sulfur is found near hot springs/pools and volcanic areas, most notably in countries around the Pacific Ring of Fire such as Indonesia, Chile, and Japan where these deposits are often mined. The pungent smell referred to as "sulphur" that is very distinctive in volcanic areas comes mainly from the compound hydrogen sulphide. In fact hydrogen sulphide and other sulphur forms produced by living organisms are responsible for the awful smell from skunks, rotton eggs and burning hair or feathers.

BRAIN TEASERS

To boost up your rank in JEE Main and Advanced

1. The amount of 0.3 M NaOH in mL which should be mixed with 30 mL of 0.2 M solution of NH_4Cl to give buffer solution of pH equal to 8.65 is [Given, $pK_b = 4.75$]

(a) 6 (b) 8
(c) 5 (d) 4

2. The active ingredient in aspirin is acetyl salicylic acid, $HC_9H_7O_4 + H_2O \rightleftharpoons H_3O^+ + C_9H_7O_4^-; K_a = 2.75 \times 10^{-9}$. What is the pH of the solution obtained by dissolving two aspirin tablets in 250 mL of water? [Assuming that each tablet contains 0.32 g of acetyl salicylic acid]

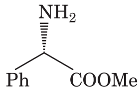
(a) 3.3 (b) 4.6 (c) 4 (d) 5.2

3. The body-centred cubic α-form of iron at 910°C undergoes a transition to the face-centred cubic γ-form. Assuming that the distance between nearest neighbours is same in both form, the ratio of the density of γ-iron to that of α-iron at the transition temperature is

(a) 2.09 (b) 2.0 (c) 1.09 (d) 1.90

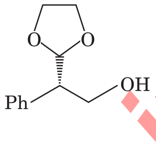
4. Which one of the following compounds has *R*-configuration? **[NSEC 2012]**

(I)

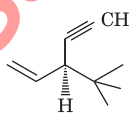


(II)

(III)

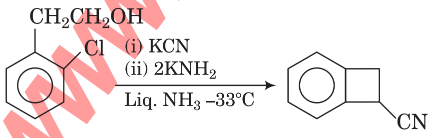


(IV)



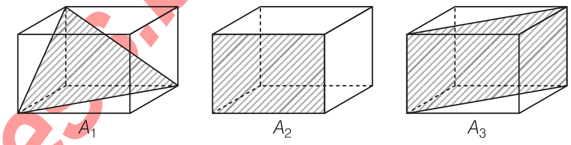
(a) I (b) II
(c) III (d) IV

5. The number of steps involved in the following conversion are



(a) 4 (b) 6 (c) 3 (d) 8

6. The three planes (A_1, A_2, A_3) in an fcc unit cell are shown in the below figure.

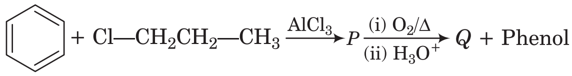


(a) A_1 contains no three dimensional voids
(b) A_2 contains only octahedral voids
(c) A_3 contains both octahedral and tetrahedral voids
(d) All of the above

7. The equivalent conductance of 0.1 N solution of $MgCl_2$ is 97.1 mho cm^2 eq^{-1} at 25°C. A cell with electrodes that are 1.5 cm^2 in surface area and 0.5 cm apart is filled with 0.1 N $MgCl_2$ solution. How much current will flow when the potential difference between the electrodes is 5 V.

(a) 1.624 A (b) 0.2184 A (c) 0.6218 A (d) 0.1456 A

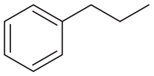
8.



$+ Cl—CH_2CH_2—CH_3 \xrightarrow{AlCl_3} P \xrightarrow[(ii)\ H_3O^+]{(i)\ O_2/\Delta} Q + \text{Phenol}$

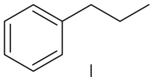
P and *Q* are respectively.

(a)



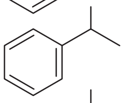
and CH_3CH_2CHO

(b)



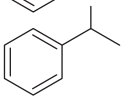
and CH_3COCH_3

(c)



and CH_3COCH_3

(d)



and CH_3CH_2CHO

9. A person inhales 640 g of O_2 per day. If all the O_2 is used for converting sugar into CO_2 and H_2O, then the energy evolved in consuming sucrose ($C_{12}H_{22}O_{11}$) in the body in one day is

[$\Delta H_{combustion}$ (Sucrose) = – 5645 kJ mol^{-1}]

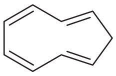
(a) 9482.14 kJ (b) 9408.34 kJ
(c) 8126.34 kJ (d) 7165.21 kJ

10. *(A)* is a compound of molecular formula, C_8H_9NO when boiled with NaOH, an oily liquid *(B)* was obtained along with a salt *(C)*. Liquid *(B)* gave carbylamine reaction while *(C)* on heating with sodalime produced methane. The compound *(C)* is

(a) sodium acetate *(b)* potassium tartrate

(c) benzoic acid *(d)* None of these

11. What makes the following compound aromatic ?



(a) Add one electron to π-bond to give $C_9H_{10}^-$

(b) Add two electrons to π-bond to give $C_9H_{10}^{2-}$

(c) Remove an ion, H^+ from sp^3-carbon

(d) Remove an ion, H^+ from sp^2-carbon

12. A photochemical reaction of H_2 and Cl_2 absorbs wavelength of 488 nm. When the Cl_2 gas is irradiated with a 60 watt lamp that emits radiation with 80% efficiency, 4.1 mmol of HCl are formed in 10 s. Calculate the quantum yield for the reaction. [INHCHO 2012]

(a) 1.28 *(b)* 2.09 *(c)* 2.84 *(d)* 3.61

13. Which of the following is incorrect for both cellulose and DNA? [NSEC 2013]

(a) Both are long chain polymers

(b) Both contains similar monomers

(c) Both have glycosidic linkages

(d) Both can break down by enzymatic hydrolysis

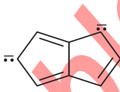
14. Upon irradiation, californium with neutrons, a scientist discovered a new nuclide having mass number of 350 and a half life of 0.6 h. After four hours of the irradiation, the observed radioactivity due to the nuclide was 15 dis./min. The atoms of the nuclide prepared initially are

(a) 0.79×10^{-4} *(b)* 0.79×10^4

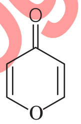
(c) 7.79×10^4 *(d)* 7.79×10^{-4}

15. Which of the following compound is non-aromatic ?

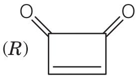
(*P*)



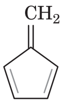
(*Q*)



(*R*)



(*S*)



Choose the correct option.

(a) Only *P* *(b)* Only *S* *(c)* *P* and *R* *(d)* *Q* and *S*

Answers with Explanation

1. **(c)** It is an example of basic buffer.

Given, pH = 8.65, pOH = 14 − 8.65 = 5.35

For basic buffer, pOH is given by the following formula,

$$\text{pOH} = \text{p}K_b + \log\frac{[\text{NH}_4^+]}{[\text{NH}_4\text{OH}]}$$

Substituting all the given values in the above formula, we get

$$5.35 = 4.75 + \log\frac{[\text{NH}_4^+]}{[\text{NH}_4\text{OH}]}$$

$$\log\frac{[\text{NH}_4^+]}{[\text{NH}_4\text{OH}]} = 5.35 - 4.75 = 0.6$$

$$\frac{[\text{NH}_4^+]}{[\text{NH}_4\text{OH}]} = \text{antilog}\,(0.6) = 4$$

$$\therefore \quad \frac{[\text{NH}_4^+]}{[\text{NH}_4\text{OH}]} = \frac{30 \times 0.2}{0.3 \times V} = 4$$

$$V = 5\text{ mL}$$

2. **(d)** [Acetyl salicylic acid] = $0.32 \times 2 \times 4\text{ gL}^{-1}$

$$= \frac{0.32 \times 8}{180}\text{ mol L}^{-1}$$

$$= 0.0142\text{ M}$$

∵ Aspirin behaves as a weak acid, hence ionisation is very small. $[H_3O^+]$ can be calculated by using Ostwald's dilution law.

$$\therefore [\text{H}_3\text{O}]^+ = \sqrt{K_aC} = \sqrt{2.75 \times 10^{-9} \times 0.0142} = 6.25 \times 10^{-6}\text{ M}$$

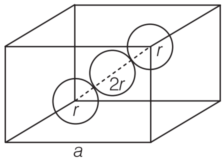
$$\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(6.25 \times 10^{-6}) = 6 - \log 6.25 = 5.2$$

3. **(c)** For body-centred cubic,

$$\text{Body diagonal} = 4r = \sqrt{3}a, \quad a = \frac{4r}{\sqrt{3}}$$

$$\text{Number of atoms per unit cell}\,(Z) = \frac{1}{8} \times 8 + 1 = 2$$

For face-centred cubic,



$$\text{Face diagonal} = 4r = \sqrt{2}a$$

$$\therefore \quad a = 2\sqrt{2}r$$

Number of atoms per unit cell (*Z*)

$$= \frac{1}{8} \times 8 + 6 \times \frac{1}{2} = 4$$

$$\text{Density} = \frac{ZM}{N_A \times a^3}$$

$$\therefore \text{Density ratio} = \frac{\gamma}{\alpha} = \frac{\dfrac{\dfrac{4}{(2\sqrt{2}r)^3}}{2}}{\left(\dfrac{4r}{\sqrt{3}}\right)^3} = \frac{\dfrac{\dfrac{4}{(2^{9/2})}}{2}}{\left(\dfrac{4^3}{3^{3/2}}\right)}$$

$$= \frac{4\sqrt{2}}{3\sqrt{3}} = 1.09$$

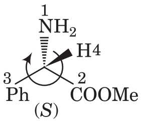
4. ***(d)*** **Thinking Process** *R and S configuration has the following priority sequence rules.*

(i) *Atoms directly attached to the chiral carbon are arranged in decreasing atomic number.*

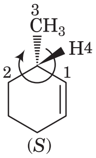
(ii) *If the sequence* $1 \rightarrow 2 \rightarrow 3$ *traces a clockwise turn, configuration is R*

(iii) *If the sequence,* $1 \rightarrow 2 \rightarrow 3$ *traces an anti-clockwise turn, configuration is S. If the lowest priority group is present above the plane then reverse the configuration (i.e R changes to S and S changes to R).*

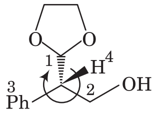
(I)



(II)

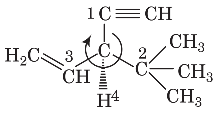


(III)



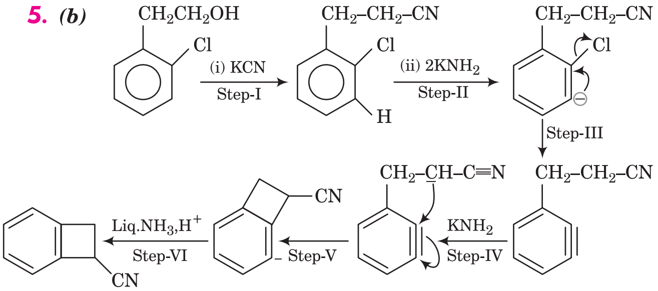
(S)

(IV)



(R)

5. **(b)**



6. **(d)** A_1 represents one of the closed packed layer containing only triangular voids. A_2 contains location of octahedral voids (edge centres of unit cell). A_3 contains three octahedral voids (one at body centre and two at edge centre). Also, plane A_3 contains the body diagonals, hence it contains tetrahedral location (tetrahedral voids lie at body diagonal).

7. **(d)** Cell constant $= \dfrac{\text{Length}}{\text{Area}} = \dfrac{0.5}{1.5} = \dfrac{1}{3}$

$$\text{Specific conductance} = \frac{\text{Equivalent conductance}}{\text{Volume (cc) containing 1 eq.}}$$

$$= \frac{97.1}{10{,}000} \text{ (For 0.1 N solution, } V = 10000 \text{ cc)}$$

$$= 0.00971 \text{ mho cm}^{-1}$$

$$\text{Conductance} = \frac{\text{Specific conductance}}{\text{Cell constant}} = \frac{0.00971}{1/3}$$

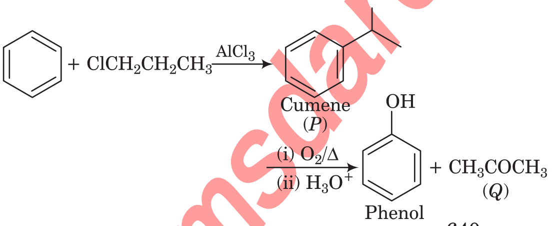
$$= 0.02913\,\Omega^{-1}$$

$$\therefore \text{ Resistance} = \frac{1}{0.02913}\,\Omega$$

$$\therefore \text{ Current (in ampere)} = \frac{\text{Potential difference (volt)}}{\text{Resistance (ohm)}}$$

$$= \frac{5}{1/0.02913} = 0.1456 \text{ Ampere}$$

8. **(c)**



9. **(b)** Moles of O_2 inhaled by a person in one day $= \dfrac{640}{32} = 20$

$$C_{12}H_{22}O_{11} + 12O_2 \longrightarrow 12CO_2 + 11H_2O;$$

$$\Delta H = -5645 \text{ kJmol}^{-1}$$

Thus, 12 moles of O_2 consume = 1 mole of sucrose

or, 12 moles of O_2 consume = 342 g of sucrose

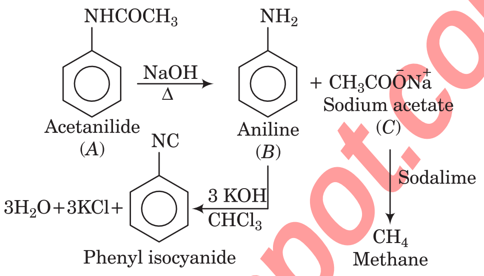
$\therefore$ 20 moles of O_2 consume $= \dfrac{342}{12} \times 20 = 540$ g of sucrose

Further, 342 g (1 mole) of sucrose liberates 5645 kJ of energy.

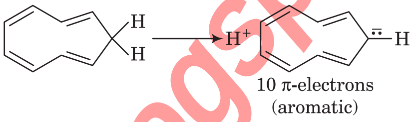
$\therefore$ 570 g of sucrose should liberate

$$= \frac{5645}{342} \times 570 = 9408.34 \text{ kJ}$$

10. **(a)** Compound (*C*) is sodium acetate, hence (*B*) would be aniline and therefore (*A*) is acetanilide.



11. **(c)**



12. **(b)** 1 Einstein = Energy of 1 mole of photon $= N \times \dfrac{hc}{\lambda}$

$$= 6.023 \times 10^{23} \times \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{488 \times 10^{-9}} = 245486.6 \text{ J}$$

Total energy absorbed $= 60 \times 10 \times 0.8 = 480$ J

$\therefore$ Number of Einstein $= \dfrac{480}{245486} = 0.0019$

Quantum yield $(\phi) = \dfrac{4.1 \times 10^{-3}}{0.0019} = 2.09$

13. **(b)** Cellulose and DNA possesses different monomers.
Monomers of cellulose = β-D-glucose
Monomers of DNA = Deoxyribose sugar, nucleic acids and phosphates

14. **(c)** At, $t = 0$, $r_0 = \lambda \times N_0$

$t = 4\text{h}$, $r_1 = \lambda \times N$

$$\therefore \quad 15 = \frac{0.693}{0.60 \times 60} \times N \qquad \left[\because \lambda = \frac{0.693}{t_{1/2}}\right]$$

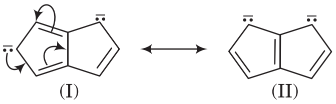
$$N = 799.22$$

Using, $2.303 \log \dfrac{N_0}{N} = \lambda T$

At $t = 4\text{h}$, $2.303 \log \dfrac{N_0}{799.22} = \dfrac{0.693}{0.6 \times 60}$

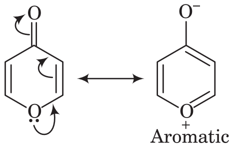
$$\Rightarrow 2.303 \log \frac{N_0}{779.22} = 4.62 \Rightarrow N_0 = 7.79 \times 10^{4} \text{ atoms}$$

15. **(b)** (*P*)

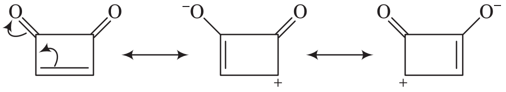


Both rings in (II) behave like cyclopentadienyl (aromatic) anions.

(*Q*)



(*R*)



Aromatic (follow $4n + 2\,(n = 0)$ rule)

(*S*) Non-aromatic, the two π-bonds of ring do not form close loop delocalised system.

CONCEPT MAP
your Revision Tool

ALCOHOLS, PHENOLS AND ETHERS

❶ ALCOHOLS

- These are hydroxy derivatives of aliphatic hydrocarbons.
- It can be monohydric, dihydric or polyhydric based upon the number of —OH groups.

Ⓐ MONOHYDRIC ALCOHOLS

- These are monohydroxy derivatives of hydrocarbons.
- They are generally represented as R—OH (where, R = alkyl group) and have general formula $C_nH_{2n+2}O$ or $C_nH_{2n+1}OH$.

ⓐ Methods of preparation

(i) **Hydrolysis of alkyl halides**

$$RX + aq.\ KOH \longrightarrow ROH + KX$$

- Hydrolysis of 1° halides proceeds by S_N2 mechanism while those of 3° halides by S_N1 mechanism.
- The hydrolysis of 2° alkyl halides may proceed by S_N1 or S_N2 reaction.

(ii) **Hydration of alkenes**

- It takes place in the presence of dil. H_2SO_4

$$(CH_3)_2C{=}CH_2 + H_2O \xrightarrow{dil\cdot H_2SO_4} (CH_2)_3\ C—OH$$

- **Oxymercuration–demercuration** reaction also give hydration product of alkene.

$$(CH_3)_2C{=}CH_2 \xrightarrow[\text{(ii) NaBH}_4]{\text{(i) Hg(OAc)}_2\,/\,H_2O} (CH_3)_3\ C—OH$$

(iii) **Hydroboration oxidation of alkenes**

$$3R—CH{=}CH_2 + BH_3 \xrightarrow{THF} (RCH_2CH_2)_3—B \xrightarrow{H_2O_2} RCH_2CH_2OH$$

- In this process, the carbocation are not the intermediate and hence, no rearrangement takes place.
- The reaction give product corresponding to anti-Markownikoff addition of H_2O to the $C{=}C$.

(iv) **Hydrolysis of esters and ethers**

$$RCOOR' + H_2O \overset{H^+}{\rightleftharpoons} RCOOH + R'OH$$

$$RCOOR' + H_2O \xrightarrow{\bar{O}H} RCOO^- + R'OH + H_2O$$

(v) **From alkynes**

$$HC{\equiv}CH \xrightarrow[Hg^{2+},\ H^+]{H_2O} CH_3CHO \xrightarrow{LiAlH_4} CH_3CH_2OH$$

(vi) **Reduction**

- $LiAlH_4$ or H_2/Ni, Pt, Pd, 250°C reduces —CHO, —COCl, $>C{=}O$, —COOH, $(CO)_2O$—CO_2R to —CH_2OH
- $NaBH_4$ reduces —CHO, —COCl, $>C{=}O$ to —CH_2OH.

(vii) **From Grignard's reagent**

- Reaction of Grignard reagent with HCHO results to 1°- alcohols other than CH_3OH.
- Reaction of Grignard reagent with aldehyde other than HCHO results to 2°- alcohols.
- Reaction of Grignard reagent with ketones results to 3°-alcohols.

(viii) **Fermentation**

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Maltase}} \underset{\text{Glucose}}{2C_6H_{12}O_6} \xrightarrow{\text{Zymase}} 2C_2H_5OH + 2CO_2$$

(ix) **Oxo process**

Alkenes react with CO and H_2 in the presence of $Co(CO)_4$ as catalyst under high temperature and pressure to give aldehydes.

$$CH_2{=}CH_2 + CO + H_2 \xrightarrow[\text{High } T \text{ and } p]{Co(CO)_4} CH_3CH_2CHO \xrightarrow{H_2/Ni} CH_3CH_2CH_2OH$$

(x) **Deamination**

$$\underset{(1°,\ 2°\ \text{or}\ 3°)}{RNH_2} + HNO_2 \longrightarrow \underset{(1°,\ 2°\ \text{or}\ 3°)}{ROH} + N_2\uparrow + H_2O$$

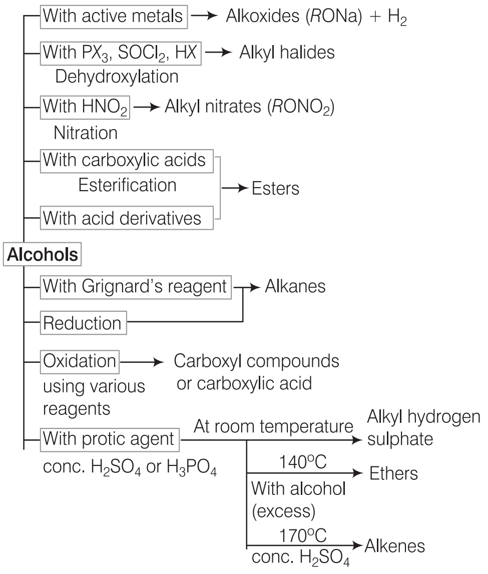
ⓑ Physical properties

- Lower alcohols are colourless toxic liquids whereas the higher members are waxy solids.
- The boiling point of alcohol is always higher than the corresponding ether, hydrocarbon and haloalkane due to the presence of hydrogen bonding.
- Boiling point $\propto$ number of —CH_2 group $\propto \dfrac{1}{\text{Branching}}$.

ⓒ Chemical properties

The reactivity of alcohol is different in different reactions, e.g.

- The reaction in which O—H bond cleaves, the reactivity order of alcohols is 1° > 2° > 3°.
- The reaction in which C—O bond cleaves, the reactivity order of alcohols is 3° > 2° > 1°.
- Alcohols shows the following chemical reactions :



- The different reagents are used for oxidation and their products as follows:

(i) Cu or Ag at about 300°C

1° alcohol ⟶ aldehydes + $H_2\uparrow$ (dehydrogenation)

❸ ETHERS

These are the organic compounds having —O— functional group with general formula R—O—R'.

Ⓐ METHODS OF PREPARATION

(i) **Williamson's Synthesis**

$$R\bar{O}Na^+ + R'X \longrightarrow ROR' + \overset{+}{Na}X^-$$

(ii) **Reaction of *RX* with dry silver oxide**

$$2RX + Ag_2O \longrightarrow ROR + 2AgX$$

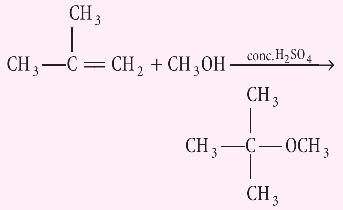
(iii) **By dehydration of alcohols**

$$\underset{\text{(Excess)}}{RCH_2OH} \xrightarrow[\text{or } Al_2O_3,\ 250°C]{\text{conc. } H_2SO_4\ /40°C} RCH_2—O—CH_2R$$

Order of ease of dehydration of alcohols is 3° < 2° < 1°.

(iv) **From alkenes**

- **By adding alcohols**



$$CH_3—\overset{\overset{CH_3}{|}}{C}{=}CH_2 + CH_3OH \xrightarrow{conc.\,H_2SO_4} CH_3—\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}—OCH_3$$

- **Alkoxy mercuration demercuration**

$$\text{Alkene} + \text{Alcohol} \xrightarrow[\text{(ii) } NaBH_4\,/\bar{O}H]{\text{(i) } Hg(OOCCF_3)_2} \text{Ether}$$

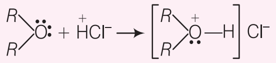
Ⓑ PHYSICAL PROPERTIES

- Dimethyl ether and ethyl methyl ether are gases at room temperature while other homologues are colourless liquids with characteristics ether smell.
- These have the boiling points lower than their isomeric alcohols.
- Ethers upto 3 C—atoms are soluble in water.

Ⓒ CHEMICAL PROPERTIES

(i) **Reactions involving ethereal oxygen**

- **Action of concentrated acids**



2° alcohol ⟶ ketones + $H_2\uparrow$ (dehydrogenation)

3° alcohol ⟶ alkenes + H_2O (dehydration)

(ii) $KMnO_4$, $K_2Cr_2O_7$ (acidic as well as alkaline), CrO_3 (in glacial acetic acid), PCC ($C_5H_5\overset{+}{N}ClCrO_3^-$)

1° alcohol ⟶ Aldehydes

2° alcohol ⟶ Ketones

(iii) MnO_2 selectively oxidises the —OH group of allylic and benzylic 1° and 2° alcohols to aldehydes and ketones, respectively.

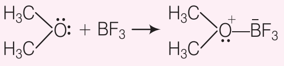
ⓓ Test for 1°, 2° and 3° alcohols

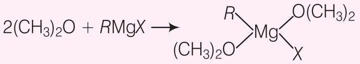
The following tests are carried out to detect the presence of 1°, 2° and 3° alcohols.

(i) **Victor Meyer's test**

- The alcohol is treated with P/ I_2 and then with $AgNO_3$ and HNO_3. The final product obtained is treated with NaOH and the colour is observed.
- 1° alcohol - Blood red colour
- 2° alcohol - Blue colour
- 3° alcohol - No colour

- **Formation of coordination complexes**





(ii) **Reactions involving cleavage of C—O bond**

- **With halogen acids**

$ROR + HX \xrightarrow{100°C} R—OH + HX$

Order of reactivity, HI > HBr > HCl

- **With sulphuric acid**

$\underset{(R = 1° \text{ ether})}{ROR} + H_2SO_4(\text{conc.}) \xrightarrow[\text{Under pressure}]{\Delta} 2ROH$

$\underset{(R = 2° \text{ or } 3° \text{ ether})}{ROR} + H_2SO_4(\text{conc.}) \xrightarrow{\Delta} \text{Alkene}$

- **With PCl_5**

$R—O—R + PCl_5 \longrightarrow 2RCl + POCl_3$

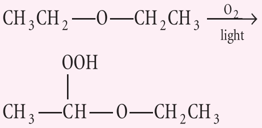
- **With acid derivatives**

$ROR + R'COCl \xrightarrow[\Delta]{AlCl_3 \text{ or anhyd. } ZnCl_2} RCl + R'COOR$

$ROR + (CH_3CO)_2O \xrightarrow[\text{or } ZnCl_2/\Delta]{\text{Anhyd. } AlCl_3} 2CH_3COOR$

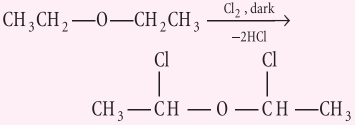
(iii) **Reaction involving alkyl group**

- **Action of air and light**



$CH_3CH_2—O—CH_2CH_3 \xrightarrow[\text{light}]{O_2} CH_3—\overset{\overset{OOH}{|}}{CH}—O—CH_2CH_3$

- **Halogenation**



$CH_3CH_2—O—CH_2CH_3 \xrightarrow[-2HCl]{Cl_2, \text{ dark}} CH_3—\overset{\overset{Cl}{|}}{CH}—O—\overset{\overset{Cl}{|}}{CH}—CH_3$

$C_2H_5—O—C_2H_5 \xrightarrow{Cl_2\ h\nu} Cl_5C_2—O—C_2Cl_5 + 10HCl$

(ii) **Lucas test**

- Alcohol is treated with Lucas reagent (equimolar mixture of anhyd. $ZnCl_2$ and conc. HCl).
- 1° alcohols do not produce turbidity at room temperature.
- 2° alcohols produce turbidity after 5 min.
- 3° alcohols produce turbidity immediately.

(iii) **Dehydrogenation**

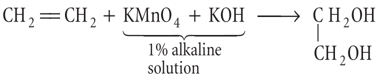
- Cu or Ag are used for dehydrogenation.
- 1° alcohols produce aldehydes.
- 2° alcohols produce ketones
- 3° alcohols dehydrated to give alkene.

Ⓑ DIHYDRIC ALCOHOLS

- The compounds which contains two —OH groups attached to two successive C—atoms are called glycols.
- Ethylene glycol is the simplest dihydric alcohol.

ⓐ Methods of Preparation

(i) **Oxidation of ethylene**



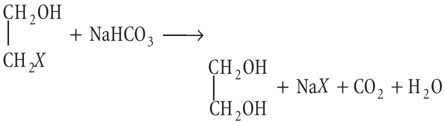
$CH_2{=}CH_2 + \underbrace{KMnO_4 + KOH}_{\text{1\% alkaline solution}} \longrightarrow \begin{array}{l} CH_2OH \\ | \\ CH_2OH \end{array}$

HCOOH is also used for the similar purpose.

(ii) **Hydrolysis of 1, 2-dibromo ethane**

$BrCH_2—CH_2Br + Na_2CO_3 + H_2O \longrightarrow OHCH_2—CH_2OH + 2NaBr + CO_2$

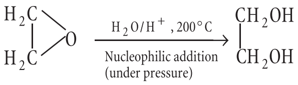
(iii) **Hydrolysis of ethylene halohydrin**



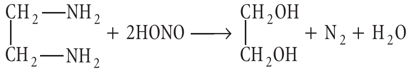
$\begin{array}{l} CH_2OH \\ | \\ CH_2X \end{array} + NaHCO_3 \longrightarrow \begin{array}{l} CH_2OH \\ | \\ CH_2OH \end{array} + NaX + CO_2 + H_2O$

The halohydrin are prepared by the electrophilic addition of HOX to alkene.

(iv) **Hydrolysis of ethylene oxide**

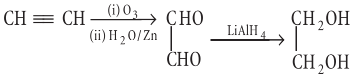


(v) **Deamination of ethylenediamine**



$\begin{array}{l} CH_2—NH_2 \\ | \\ CH_2—NH_2 \end{array} + 2HONO \longrightarrow \begin{array}{l} CH_2OH \\ | \\ CH_2OH \end{array} + N_2 + H_2O$

(vi) **Reductive ozonolysis of ethylene**



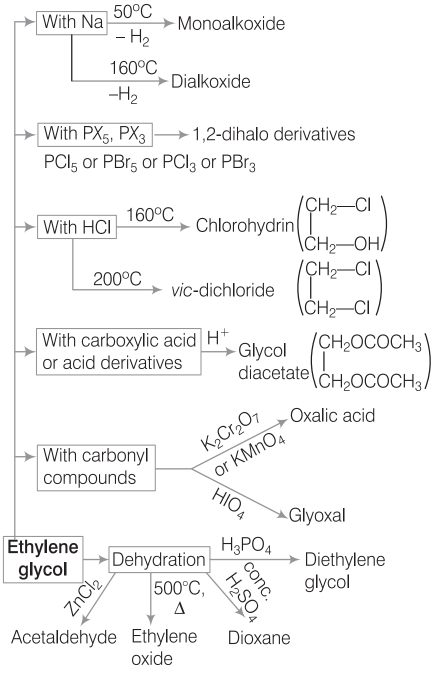
$CH \equiv CH \xrightarrow[\text{(ii) } H_2O/Zn]{\text{(i) } O_3} \begin{array}{l} CHO \\ | \\ CHO \end{array} \xrightarrow{LiAlH_4} \begin{array}{l} CH_2OH \\ | \\ CH_2OH \end{array}$

ⓑ Physical properties

- It is a colourless viscous solid with bp 197°C, mp – 13°C.
- It is sweet in taste, hygroscopic and miscible in water but insoluble in ether.
- It is toxic as methanol when taken orally.

ⓒ Chemical properties

Ethylene glycol gives the following chemical reactions.



❷ PHENOLS

- These are compounds in which a hydroxyl group is attached directly to the aromatic ring.
- It was discovered by Runge who named it as carbolic acid.

Ⓐ METHODS OF PREPARATION

(i) **By hydrolysis of Halobenzene**

$PhX \xrightarrow[340°C,\ 150 \text{ atm}]{aq.NaOH} Ph\overset{-}{O}\overset{+}{Na} \xrightarrow{H_2O/H^+} PhOH$

(ii) **Cumene process**

$PhCH(CH_3)_2 \xrightarrow[H_2O/H^+]{O_2,\ \text{Catalyst}} PhOH + CH_3COCH_3$

(iii) **From diazonium salt**

$Ph\overset{+}{N} \equiv N\overset{-}{X} \xrightarrow{H_2O/H^+} PhOH + N_2 + HX$

(iv) **Fusion of alkali metal salt of sulphonic acid**

$PhSO_3^-Na^+ + NaOH \xrightarrow{\text{Fuse}} Ph\overset{-}{O}\overset{+}{Na} \xrightarrow{H_2O/H^+} PhOH$

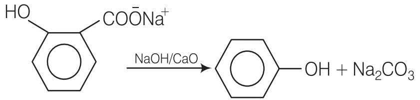
(v) **From Grignard's reagent**

$PhMgBr \xrightarrow{[O]} PhOMgBr \xrightarrow{H_2O/H^+} PhOH$

(vi) **Hydroxylation of benzene**

$C_6H_6 + H_2O_2 \xrightarrow{HSO_3F} PhOH$

(vii) **From salt of salicylic acid**



(viii) **By oxidation**

$2C_6H_6 + O_2 \xrightarrow[315°C]{V_2O_5} 2PhOH$

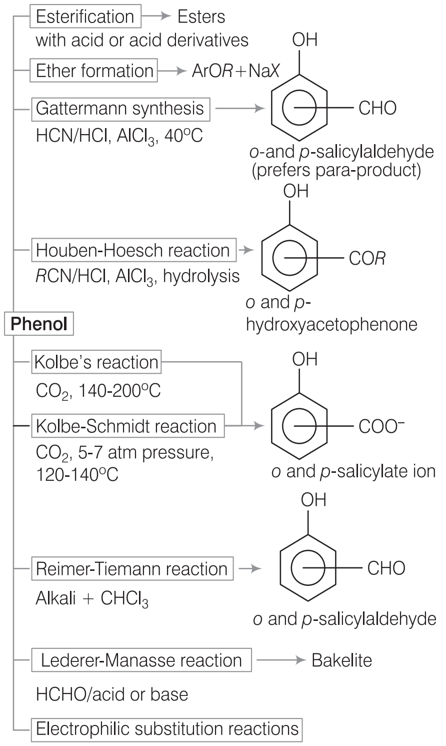
$C_6H_5CH_3 \xrightarrow[\text{Manganous and Cupric salts and catalyst}]{2O_2\ (\text{air})} C_6H_5OH + CO_2 + H_2O$

Ⓑ PHYSICAL PROPERTIES

- These are colourless liquids or solids and are highly toxic in nature.
- Their boiling points are higher than corresponding alcohols and are more miscible with water.
- They have high dipole moments and are more acidic than the corresponding alcohol.

Ⓒ CHEMICAL PROPERTIES

Phenol gives the following chemical reactions



@ CLASS XII SYLLABUS

Rapid CONCEPT REVISION

TARGET 2017

COORDINATION COMPOUNDS

- The transition elements exhibit a characteristic property of complex ion formation because of their smaller radii. The compound which contains complex ions are called **coordination compounds**.
- The branch of chemistry under which these compounds are studied is called the **coordination chemistry**.

Difference between Double Salts and Coordination Compounds

Double Salts	Complex/Coordination Compounds
(i) They exist only in crystalline state.	They exist both in crystalline and aqueous solution.
(ii) In aqueous solution, they yield simple ions.	In aqueous solution, they yield atleast one complex ion.
(iii) They lose their identity in solution.	They retain their identity in solution
(iv) Mohr's salt $[FeSO_4 \cdot (NH_4)_2 SO_4 \cdot 6H_2O]$, Potash alum $[K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O)]$	$[Ni(NH_3)_6] Cl_2$, $K_4[Fe(CN)_6]$, etc.

Important Terms Used in Coordination Compounds

(i) Complex Ion

- It is formed by the combination of a simple cation with one or more neutral molecules or one or more simple anions or in some cases positive groups also.
- It exists as a single entity and usually indicated within square bracket.

(ii) Central Metal Atom or Ion

- It is the atom/ion to which a fixed number of ions/groups are bound in a definite geometrical arrangement around it.
- In a complex, it behaves as the electron pair acceptor or **Lewis acids**.

(iii) Ligands

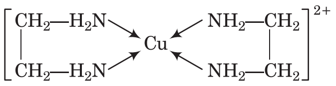
- The central metal ion is surrounded by number of the anions or the neutral molecules or sometimes positively charged ions possessing atleast one lone pair. These surrounded ions are called ligands.
- In the formation of coordination complexes, the ligands act as the electron pair donors or **Lewis bases**.

Depending upon the number of donor atoms the ligands may be classified into the following categories:

(a) **Unidentate or Monodentate ligands**
These contain only one donor atom which is capable of donating an electron pair.
e.g. CN^-, F^-, Cl^-, Br^-, NO_2^- etc.

(b) **Polydentate or Multidentate ligands**
These contain two or more donor atoms which can simultaneously serve as donor atoms. e.g. EDTA, oxalate, 1, 2-ethanediamine, etc.

(c) **Chelating ligands** When polydentate ligands uses its two or more donor sites to bind a single metal ion, it is called **chelating ligands**. e.g.



Chelate formation

REMEMBER

- Chelate complexes are more stable than ordinary complexes in which the ligand is monodentate. This increased stability of the compound due to chelation is called chelate effect.
- Generally, the chelate complexes with five membered rings are more stable.

Ambidentate ligands

It contain two or more donor atoms but in the formation of complexes only one donor atom is attached to the metal ion. e.g., $M \leftarrow NO_2$ (Nitro) and $M \leftarrow ONO$ (Nitrito).

REMEMBER

- Homoleptic complex has only one type of ligands linked to the central metal atom/ion e.g., $[Co(NH_3)_6]^{3+}$.
- Heteroleptic complex has more than one type of ligands linked to the central metal atom/ion e.g. $[Co(NH_3)_4Cl_2]$.

(iv) Coordination Sphere

The central atom and ligands which are directly attached to it, are enclosed in square brackets, called coordination sphere.

(v) Coordination Number (CN)

The total number of ligands attached to the central metal ion through coordinate bond is called the coordination number. e.g. in $[Cu(NH_3)_4]^{2+}$ the coordination number of Cu is 4.

(vi) Oxidation Number (ON)

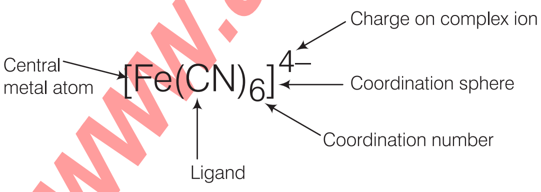
It is a number that represents electric charge which a metal atom or ion has or appears to have, when combined with ligands. e.g. in $[Fe(CN)_6]^{3-}$, the oxidation number of Fe is +3.

(vii) Charge on the Complex ions

It is the algebraic sum of the charges carried by central metal ion and the ligands coordinated to the central metal ion.

Representation of Complex Ion

The complex ion containing central metal, ligand, charge and coordination number can be illustrated as



Effective Atomic Number (EAN)

- Sidgwick proposed effective atomic number (EAN) in order to explain the stability of the complex.
- It is the resultant number of electrons of the metal atom or ion after gaining electrons from the donor atoms of the ligand.
- The effective number generally coincides with the atomic number of next inert gas except in some cases.
- EAN *can be* calculated as
- EAN = atomic number of the metal (Z) – number of electrons lost in the ion formation + number of electrons gained from the donor atoms of the ligands.

Complex	Oxidation State of metal ion	Atomic number of metal (Z)	Coordination number	Effective atomic number
$[Co(NH_3)_6]Cl_3$	+ 3	27	6	$(27-3)+(6\times 2)$ $= 36$ (Kr)
$K_4[Fe(CN)_6]$	+ 2	26	6	$(26-2)+(6\times 2)$ $= 36$ (Kr)
$Ni(CO)_4$	0	28	4	$(28-0)+(4\times 2)$ $= 36$ (Kr)
$K_2[PtCl_6]$	+ 4	78	6	$(78-4)+(6\times 2)$ $= 86$ (Rn)

Werner's Theory

It was the first successful theory, which explained the properties of complexes.

The main postulates of this theory are

(i) Metals possesses two types of valencies (linkages), primary or principal valencies and secondary valencies.

(ii) Primary valencies are ionisable and is also referred as oxidation state of the metal ion.

(iii) Secondary valencies are non-ionisable and is also referred as coordination number (CN) of the metal ion.

(iv) Primary valencies are satisfied by negative ions and non-directional in nature while secondary valencies are satisfied by neutral molecules or neutral ions and are directional in nature.

(v) Every metal atom or ion has a fixed number of secondary valencies or coordination number. Thus, the coordination number gives the total number of neutral molecules or negative or positive groups, which may be directly linked to the metal cation in the formation of its complexes.

(vi) Every metal has a tendency to satisfy both its primary and secondary valencies.

Nomenclature of Coordination Compounds

The various rules are applied in naming the coordination compounds according to the IUPAC (International Union of Pure and Applied Chemistry) system which are described as follows:

Naming of Ions

If the complex compound is ionic the positive ion (cation) whether simple or complex is named first followed by the negative ion (anion).

Naming of Ligands

(i) The number of each kind of ligand is specified using the Greek prefixes like di-, tri-, tetra- and penta- etc. The term mono is generally not mentioned. If the name of ligands itself is complex, i.e., it includes a numerical prefix, e.g. in case of organic molecules such as dipyridyl or ethylenediamine, then the terms *bis* (for two), *tris* (for three), *tetrakis* (for four), *pentakis* (for five), etc. are used followed by the name of the ligand placed without brackets.

(ii) The names of anionic ligands end with o, e.g. (Br^-, bromo) (CO_3^{2-}, carbonato) etc. They are usually obtained by changing the anion endings - ide to-o and -ate to -ato.

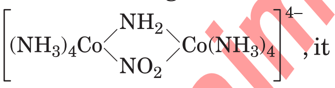
(iii) Neutral ligands are specified by their usual names, except for H_2O, NH_3 and CO, which are called aqua, ammine and carbonyl, respectively.

(iv) The positive ligands which are very few end with -ium e.g. NO_2^+ - Nitronium, etc.

(v) The ligands are named in an alphabetical order before the name of the central atom/ion.

Naming of Complex Ion

In naming the complex ion, number and name of the ligands are given first, then the central metal atom followed by its oxidation state indicated by Roman numeral in parenthesis.

- If the **complex ion is cation**, the name of the central metal ion is given as such, followed by its oxidation state indicated by numerals (such as II, III, IV) in the parenthesis at the end of the name of the complex without any space between the two e.g. $[CoCl(NH_3)_5]^{2+}$: pentamminechlorocobalt (III) ion.
- If the **complex ion is anion**, central atom is made to end in-ate followed by oxidation number in brackets without any space between them e.g. $[Ag(CN)_2]^-$: Dicyanoargentate (I) ion.
- If the complex contains two or more metal ions, it is termed polynuclear complex.
  The ligands, which link the two metal atoms are called bridge groups and are separated from the rest complex by hyphens and denoted by the prefix μ placed before their names. e.g.
-  , it is named as octaammine-μ-amido-μ-nitro dicobalt (III) ion.

Isomerism

- It is the phenomenon in which compounds have same molecular formula but different arrangements of their constituent atoms.
- Isomers are different compounds with different chemical reactivity and physical properties due to their different structures.

There are two main types of isomerism present in coordination compounds.

I. Structural Isomerism

It is mainly of the following types :

(i) Ionisation Isomerism

These isomers yield different ions in solution although they have same composition. This type of isomerism is due to the exchange of groups between the complex ion and ions present outside it, e.g.

$[Pt(NH_3)_4(OH)_2]\ SO_4$ and $[Pt(NH_3)_4\ SO_4]\ (OH)_2$

(ii) Hydrate Isomerism

The number of water molecules that are present inside the coordination sphere may vary, resulting in the formation of hydrate isomers. e.g.

$[Co(NH_3)_4(H_2O)Cl]\ Cl_2$ and $[Co(NH_3)_4Cl_2]\ Cl \cdot H_2O$

(iii) Linkage Isomerism

These type of isomerism occurs when two or more atoms of a monodentate ligand may function as a donor. e.g.

$[Co(NH_3)_3(NO_2)]Cl_2$ and $[Co(NH_3)_3ONO]\ Cl_2$

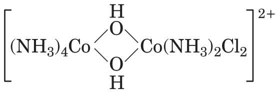
(iv) Coordination Isomerism

These type of isomerism is possible when both positive and negative ions of a salt are complex ions. The two isomers differ in the distribution of ligands in the cation and the anions, e.g.

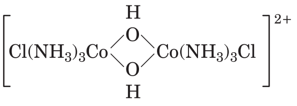
$[Co(NH_3)_6]\ [Cr(CN)_6]$ and $[Cr(NH_3)_6]\ [Co(CN)_6]$

(v) Coordination-position Isomerism

It is due to the difference in the distribution of ligands in two coordination centres. Generally, the bridged complex involving different ligands show this isomerism. e.g.



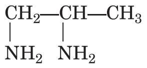
Unsymmetrical



Symmetrical

(vi) Ligand Isomerism

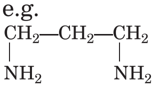
This isomerism arises in those complexes in which the two ligands are isomers themselves, e.g.



$CH_2{-}CH{-}CH_3$ with NH_2 on the first two carbons

1, 2-diaminopropane

and



$CH_2{-}CH_2{-}CH_2$ with NH_2 on the terminal carbons

1, 3-diaminopropane

When these form complexes, we get ligand isomers $[Co(1,2\ \text{diamino propane})_2Cl_2]^+$ and $[Co(1,3\text{-diamino propane})_2Cl_2]^+$.

II. Stereoisomerism

It arises due to different relative positions of the ligands. It is of two types:

1. Geometrical Isomerism

- It occurs due to different relative arrangements of ligands around central metal atom.
- When two ligands are relatively on same sides, the isomer is called *cis*-isomer and when on opposite sides it is called *trans* isomer.

REMEMBER

- Complexes having coordination number 2 or 3 do not show geometrical isomerism as it is not possible to have more than a single arrangement of ligands in space around the central ion in these cases.
- Geometrical isomerism with respect to the metal has not been found among tetrahedral complexes of type MA_4 or MA_3B or MA_2B_2 because all the four ligands are equidistant from each other.

Only square planar and octahedral complexes show this type of isomerism

(i) **Square Planar Complexes**

- Any complexes of the type MA_2B_2 and MA_2BC can exists in *cis-trans* form.
- For a complex of the type *MABCD*, three geometrical isomers are possible.
- It is also possible in bridged binuclear planar complexes of the type, $M_2A_4X_2$.

REMEMBER

Square planar complexes of the type, $[M(AA)_2]$, MA_4, MA_3B and MAB_3 do not show this isomerism since, all possible spatial arrangements for any of these complexes are identical.

(ii) **Octahedral Complexes**

- Octahedral complexes of types MA_3B_3, MA_4B_2, $M(AA)_2B_2$ (*AA* can be any symmetrical bidentate ligand like en) exhibit *cis-trans* isomerism.
- In case of complex of the type MA_3B_3, the *cis-trans* isomers are also called *fac-mer* isomers.
- Complexes having six different ligands $[M(ABCDEF)]$ shall exhibit geometrical isomerism. Theoretically, 15 different isomers should be possible.
- In practice, 3 isomers of the complex, $[Pt(C_5H_5N)(NH_3)(NO_2)(Cl)(Br)(I)]$ have actually been isolated.

REMEMBER

Octahedral complexes of type $[MA_5B]$ or $M(AA)_3$ (where, AA = symmetrical bidentate ligand) do not exhibit geometrical isomerism.

2. Optical Isomerism

- It arises when two isomers are structurally the mirror images of each other. Further, it has been found that these mirror image compounds are non-superimposable on each other and do not possess the plane of symmetry.
- Optical isomerism is common in octahedral complexes involving 2 or 3 symmetrical bidentate groups (*AA*) of the type $[M(AA)_2X_2]$, $[M(AA)_3]$ and $[M(AA)B_2X_2]$.
- $[M(EDTA)]$ and $[M(ABCDEF)]$ also exhibit optical isomerism.

REMEMBER

- The optical activity has been observed in tetrahedral complexes in which *bis* chelates with unsymmetrical ligand is found. These have been found in Be(II), B(III), Zn(II) and Cu(II) complexes.
- Square planar complexes are rarely optically active.

Bonding in Coordination Compounds

The formation of coordination compounds can be explained electronically by a number of theories such as

(i) Valence bond theory (ii) Crystal field theory.

Valence Bond Theory

This theory was evolved largely through the efforts of Linus Pauling based on ideas of the coordinate-covalent bond attempted by Lewis Sidgwick.

The main assumptions of valence bond theory are

(i) The central metal atom provides a number of empty orbitals equal to its coordination number for the formation of coordinate bonds with the ligands.

(ii) The empty orbitals of metal ion hybridise to give equal number of hybrid orbitals of equivalent energy.

(iii) These hybridised orbitals overlap with ligand orbitals. Ligand orbitals donate electron pair to the hybridised orbitals for bonding.

(iv) The overlapping may result in a σ-bond or a coordinate bond.

(v) When $(n-1)$ *d*-orbitals are used in bond formation, the complex formed is called **inner orbital complex** and when outer *nd*-orbitals are used for hybridisation, the complex is **outer orbital complex**.

(vi) The bond hybridisation involved and the resulting geometrical shapes of the complexes are given in following table:

Bond hybridisation	Geometrical shape	*d*-orbital used	Typical example
d^2sp^3	octahedral (inner orbital complex)	d_{z^2} and $d_{x^2-y^2}$	$[Fe(CN)_6]^{3-}$
sp^3d^2	octahedral (outer orbital complex)	$d_{x^2-y^2}$ and d_{z^2}	$[FeF_6]^{3-}$
sp^3	tetrahedral	d_{xy}, d_{yz}, d_{xz}	$[Zn(NH_3)_4]^{2+}$
dsp^2 or sp^2d	square planar	$d_{x^2-y^2}$	$[Ni(CN)_4]^{2-}$

(vii) When complex has unpaired electrons, it behaves as paramagnetic and when paired electrons, it behaves as diamagnetic.

(vii) Under the influence of a strong ligand, the electrons are forced to pair up against the Hund's rule of multiplicity.

Description of Some Complexes on the basis of VBT

Atom/Ion Complex	Configuration				Type of hybridisation and geometry	Magnetic nature
	3*d*	4*s*	4*p*			
$Ni^{2+}(d^8)$	⇅ ⇅ ⇅ ↑ ↑	☐	☐ ☐ ☐			
$[NiCl_4]^{2-}$	⇅ ⇅ ⇅ ↑ ↑	xx	xx xx xx		sp^3-tetrahedral	Paramagnetic
$[Ni(CN)_4]^{2-}$	⇅ ⇅ ⇅ ⇅ xx	xx	xx xx ☐		dsp^2-square planar	Diamagnetic
	3*d*	4*s*	4*p*			
$Cu^{2+}(d^9)$	⇅ ⇅ ⇅ ⇅ ↑	☐	☐ ☐ ☐			
$[CuCl_4]^{2-}$	⇅ ⇅ ⇅ ⇅ ↑	xx	xx xx xx		sp^3-tetrahedral	Paramagnetic
$[Cu(NH_3)_4]^{2+}$	⇅ ⇅ ⇅ ⇅ xx	xx	xx xx ↑		dsp^2-square planar	Paramagnetic
	3*d*	4*s*	4*p*			
$Cr^{3+}(d^3)$	↑ ↑ ↑ ☐ ☐	☐	☐ ☐ ☐			
$[Cr(NH_3)_6]^{3+}$	↑ ↑ ↑ xx xx	xx	xx xx xx		d^2sp^3-octahedral	Paramagnetic
$[Cr(H_2O)_6]^{3+}$	↑ ↑ ↑ xx xx	xx	xx xx xx		d^2sp^3-octahedral	Paramagnetic
	3*d*	4*s*	4*p*			
$Fe^{2+}(d^6)$	⇅ ↑ ↑ ↑ ↑	☐	☐ ☐ ☐			
$[Fe(CN)_6]^{4-}$	⇅ ⇅ ⇅ xx xx	xx	xx xx xx		d^2sp^3-octahedral	Diamagnetic
$[Fe(H_2O)_6]^{2+}$	⇅ ↑ ↑ ↑ ↑	xx	xx xx xx	xx xx ☐ ☐ ☐	sp^3d^2-octahedral	Paramagnetic

Limitations of valence bond theory

- It does not explain optical absorption spectra of complexes.
- It does not describe detailed magnetic properties of coordination compounds.
- It does not make exact predictions regarding the tetrahedral and square planar structures of four coordinate complexes.
- It does not distinguish between weak and strong field ligands.

Crystal Field Theory (CFT)

This theory was developed by H. Bethe and V. Vleck. The theory provides an approximate description of electronic energy levels. It is an electrostatic approach to describe the splitting of energies associated with metal *d*-orbitals.

The main points of this theory are as follows:

(i) It considers the anionic ligands as negative point charges and neutral ligands as dipolar. In neutral ligands, the negative end of ligands is oriented towards the metal.

(ii) The interaction between metal ion and ligand is purely electrostatic.

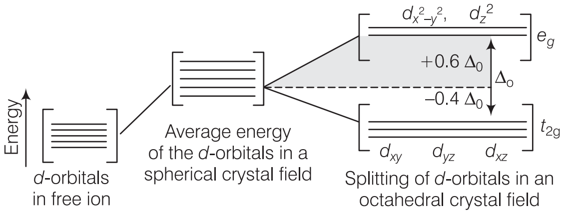
(iii) There is no interaction between metal orbitals and ligand orbitals.

(iv) The five *d*-orbitals in an isolated gaseous atom are of same energy. This degeneracy is maintained until metal ion is surrounded by symmetrical ligands.

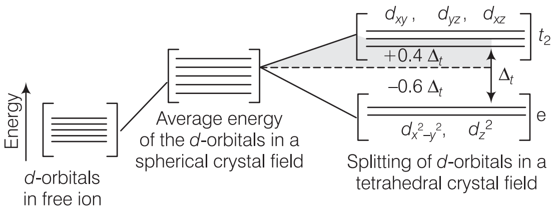
(v) The removal of degeneracy of *d*-orbitals is not affected by ligand field.

Crystal Field Splitting

- In complex, the electrons in *d*-orbitals are repelled by field produced by ligands. This repulsion raises the energy of *d*-orbitals.



d-orbital splitting in an octahedral crystal field



d-orbital splitting in a tetrahedral crystal field

- The orbitals which lie away from the ligands will have lesser interaction and their energy will be less. This conversion of degenerate *d*-orbitals into different sets of orbitals having different energies under the influence of field of ligands is known as **crystal field splitting**.
- The gain in energy achieved by preferential filling of electrons in orbitals is called **crystal field stabilisation energy** (CFSE).
- The tetrahedral crystal field splitting (Δ_t) is approximately 4/9 of the octahedral splitting (Δ_o) and there is no known low spin tetrahedral complex.

Factors Affecting CFSE

(i) **Nature of ligands** The ligands with smaller size, large negative charge, with good σ-donor and π-acceptor properties will give large crystal field splitting.

The ligands are arranged in **spectrochemical series** on the basis of their crystal field splitting power as follows:

$I^- < Br^- < S^{2-} < SCN^- < Cl^- < F^- < \bar{O}H <$ oxalate $O^{2-} < H_2O < NCS^- < EDTA^4 <$ py, $NH_3 <$ en $\approx SO_3^{2-}$ $<$ bipy, phen $< NO_2^- < CH_3^- < C_6H_5^- < CN^- < CO$

(ii) **Oxidation state of metal ion** Higher is the oxidation state of the metal, more will be crystal field splitting energy.

(iii) Geometry of the complex (as splitting is different for tetrahedral and octahedral complexes).

(iv) Higher is the oxidation state of the metal, more will be crystal field splitting energy.

(v) The order of CFSE for different transition series is 3*d* < 4*d* < 5*d*.

(vi) The value of Δ increases by 30% to 50% for 3*d* to 4*d* series and for 4*d* to 5*d* series.

Applications of Crystal Field Theory

(i) **Electronic arrangement of metal ion in complexes**

If $\Delta_o > P$ (pairing energy), electronic configuration $= t_{2g}^4, e_g^0$.

If $\Delta_o < P$, electronic configuration $= t_{2g}^3, e_g^1$.

Pairing energy is the energy which is required to pair up two electrons against electron repulsion in same orbital which is against **Hund's rule**.

(ii) **Magnetic properties of complexes**

Complexes containing unpaired electrons are paramagnetic and if all the electrons are paired then complex will be diamagnetic.

- Magnetic moment $(\mu) = \sqrt{n(n+1)}$ BM. where n = number of unpaired electrons.
- For diamagnetic complexes, $\mu = 0$.

(iii) **Colour of the complexes** In complexes, the difference in energies of t_{2g} and e_g lies in visible region and that is why transition metal complexes can absorb specific wavelengths in visible region (400-700 nm) and transmits or reflects the rest of the wavelengths.

Wavelength Associated with Different Colours

Coordination entity	Wavelength of light absorbed (nm)	Colour of light absorbed	Colour of coordination entity
$[CoCl(NH_3)_5]^{2+}$	535	Yellow	Violet
$[Co(NH_3)_5(H_2O)]^{3+}$	500	Blue green	Red
$[Co(NH_3)_6]^{3+}$	475	Blue	Yellow orange
$[Co(CN)_6]^{3-}$	310	Ultraviolet	Pale yellow
$[Cu(H_2O)_4]^{2+}$	600	Red	Blue
$[Ti(H_2O_6)]^{3+}$	498	Blue green	Purple

Limitations of Crystal Field Theory

- The position and intensities of spectral bands calculated on the basis of crystal field theory do not always coincide with those determined experimentally.
- A pure electrostatic interaction between central metal ion and ligand fails to explain the relative positions of ligands in spectrochemical series. There is a clear evidence that covalent bonding too makes a significant contribution towards the metal ligand bonding.

Stability of Complexes

The stability of complex is proportional to equilibrium constant for association. Thus, for a general reaction,

$$ML_{n-1} + L \rightleftharpoons ML_n \; (n = 1, 2, 3, \ldots)$$

$$K_n = \frac{[ML_n]}{[ML_{n-1}][L]}$$

$K_1, K_2 \ldots K_n$ are called stepwise stability constants. With a few exceptions, the value of successive stability constants decreases regularly from K_1 to K_n.

$$\beta_1 = K_1 \cdot K_2 \cdot K_3 \ldots K_n,$$

Factors Affecting Stability of Complexes

- Higher the charge on the central metal ion, i.e. greater ionic potential, greater will be its stability.
- Greater basic strength of the ligand, greater will be the stability.
- Ring formation (chelation) increases the stability of complex.

Importance of Coordination Compounds

(i) **In qualitative and quantitative analysis**

- Nickel is detected and estimated as its red dimethyl glyoxime complex which is a chelate compound.
- Mg and Al are estimated as complexes of oxime.

RAPID CONCEPT REVISION

- The separation of Ag^+ from Hg_2^{2+} in the first group of analysis is based on the fact that while, silver chloride is soluble in aqueous ammonia, Hg_2Cl_2 forms a black insoluble material.
- The separation of II B group sulphides from II A group sulphides is based on the fact that sulphides of II B group form complex sulphides with yellow ammonium sulphide which are soluble while, sulphides of II A group do not react.
- EDTA is used in the complexometric determination of several metal ions such as Ca^{2+}, Zn^{2+}, Fe^{2+}, Co^{2+}, Ni^{2+} etc.

(ii) **In the extraction of metals**

- Extraction of various metals from their ore involves complex formation, e.g. silver and gold are extracted from their ore by forming cyanide complex.
- Mond's process for purification of nickel.

(iii) **In Medicinal Chemistry**

- *cis*-platin complex is used in treatment of cancer.
- EDTA complex of calcium is used in the treatment of lead poisoning.

(iv) **In Estimation of Hardness of Water**

EDTA forms complex with various metal ions (Ca^{2+} and Mg^{2+}). Since, stability constant values of EDTA complex with Ca^{2+} and Mg^{2+} are 10^7 and 10^8 respectively, it helps in selective estimation of different ions.

(v) **In electroplating of Metals**

(vi) **As catalysts** A coordination complex of Ti and Al is used as a catalyst to convert ethylene and propylene into polythene.

MASTER STROKES

1. Which one of the following complexes will consume more equivalents of aqueous solution of $AgNO_3$? [JEE Main 2016]

(a) $Na_3[CrCl_6]$ *(b)* $[Cr(H_2O)_5Cl]Cl_2$
(c) $[Cr(H_2O)_6]Cl_3$ *(d)* $Na_2[CrCl_5(H_2O)]$

2. The IUPAC name of $K_2[Ni(CN)_4]$ is

(a) potassium tetracyanonickelate (II)
(b) potassium tetracyanatonickelate (III)
(c) potassium tetracyanatonickel (II)
(d) potassium tetracyanatonickel (III)

3. The IUPAC name of $[Ni(NH_3)_4][NiCl_4]$ is

(a) Tetrachloronickel (II)-tetraamminenickel (II)
(b) Tetraamminenickel (II)-tetrachloronickel (II)
(c) Tetraamminenickel (II)-tetrachloronickelate (II)
(d) Tetrachloronickel (II)-tetraamminenickelate (0)

4. When $AgNO_3$ solution is added in excess to 1M solution of $CoCl_3 . xNH_3$, one mole of AgCl is formed. What is the value of x?

(a) 1 *(b)* 2 *(c)* 3 *(d)* 4

5. The metal ion in complex *A* has EAN identical to the atomic number of krypton. *A* is
(atomic number of Cr = 24, Fe = 26, Pd = 46)

(a) $[Pd(NH_3)_6]Cl_4$ *(b)* $[Cr(NH_3)_5Cl]SO_4$
(c) $Na_4[Fe(CN)_6]$ *(d)* $K_3[Fe(CN)_6]$

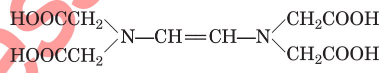
6. As per IUPAC nomenclature, the name of the complex $[Co(H_2O)_4(NH_3)_2]Cl_3$ is

(a) tetraaquadiaminecobalt (III) chloride
(b) tetraaquadiamminecobalt (III) chloride
(c) diaminetetraaquacobalt (III) chloride
(d) diamminetetraaquacobalt (III) chloride

7. The IUPAC name of the complex, $[(CO)_5Mn\text{-}Mn(CO)_5]$ is

(a) *bis* (pentacarbonyl dimanganese)
(b) *bis* (pentacarbonyl dimanganate (II)
(c) decacarbonyldimanganate (0)
(d) *bis* (pentacarbonyldimanganese (0)

8. The correct structure of ethylenediaminetetraacetic acid (EDTA) is

(a)


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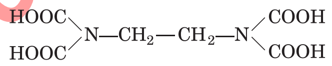

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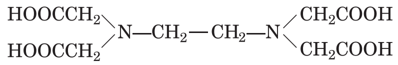
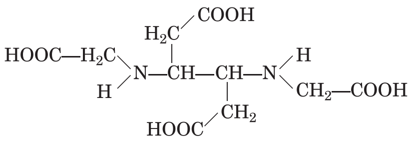


(d)


9. The two complexes, $PtCl_4 \cdot 2NH_3$ and $PtCl_4 \cdot 2KCl$ do not give precipitate of AgCl when treated with $AgNO_3$. The structures of these complexes are

(a) $[Pt(NH_3)_2Cl_4]$ and $K_2[PtCl_6]$
(b) $[Pt(NH_3)_2]Cl_4$ and $K_2[PtCl_6]$
(c) $[Pt(NH_3)_2Cl_2]Cl_2$ and $K_2[PtCl_4]Cl_2$
(d) $[Pt(NH_3)_2Cl_4]$ and $K_2[PtCl_5]Cl$

10. Which one of the following complexes shows optical isomerism? [JEE Main 2016]

(a) *cis* $[Co(en)_2Cl_2]Cl$ *(b)* *trans* $[Co(en)_2Cl_2]Cl$
(c) $[Co(NH_3)_4Cl_2]Cl$ *(d)* $[Co(NH_3)_3Cl_3]$

11. For the square planar complex, $[M(a)(b)(c)(d)]$ (where, M = central metal and a, b, c and d are monodentate ligands), the number of possible geometrical isomers are

(a) 1 *(b)* 2 *(c)* 3 *(d)* 4

12. Facial (*fac*-) and meridional (*mer*-) isomerism will be exhibited by

(a) $[Co(NH_3)_3Cl_3]$ *(b)* $[Co(NH_3)_4Cl_2]Cl$
(c) $[Co(en)_3]Cl_3$ *(d)* $[Co(NH_3)_5Cl]Cl_2$

13. The existence of two different coloured complexes with the composition $[Co(NH_3)_4Cl_2]^+$ is due to
(a) Ionisation isomerism
(b) Linkage isomerism
(c) Geometrical isomerism
(d) Coordination isomerism

14. Compounds $[PtCl_2(NH_3)_4]Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$, shows the following type of isomerism.
(a) Hydrate isomerism
(b) Ionisation isomerism
(c) Linkage isomerism
(d) Coordination position isomerism

15. Which of the following complex species is not expected to exhibit optical isomerism? [JEE Main 2013]
(a) $[Co(en)_3]^{3+}$
(b) $[Co(en)_2Cl_2]^+$
(c) $[Co(NH_3)_3Cl_3]$
(d) $[Co(en)(NH_3)Cl_2]^+$

16. The number of geometrical isomers that can exist for square planar, $[Pt(Cl)(py)(NH_3)(NH_2OH)]^+$ is (py = pyridine). [JEE Main 2015]
(a) 2
(b) 3
(c) 4
(d) 6

17. Which kind of isomerism is shown by $[Co(NH_3)_4Br_2]Cl$?
(a) Geometrical and ionisation
(b) Optical and ionisation
(c) Geometrical and optical
(d) Geometrical only

18. The ionisation isomer of $[Cr(H_2O)_4Cl(NO_2)]Cl$ is
(a) $[Cr(H_2O)_4(O_2N)]Cl_2$
(b) $[Cr(H_2O)_4Cl_2]NO_2$
(c) $[Cr(H_2O)_4Cl(ONO)]Cl$
(d) $[Cr(H_2O)_3Cl_2(NO_2)]\cdot H_2O$

19. The complexes $[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$ are the examples of which type of isomerism?
(a) Linkage isomerism
(b) Ionisation isomerism
(c) Coordination isomerism
(d) Geometrical isomerism

20. The geometries of the ammonia complexes of Ni^{2+}, Pt^{2+} and Zn^{2+}, respectively, are [JEE Adv. 2016]
(a) octahedral, square planar and tetrahedral
(b) square planar, octahedral and tetrahedral
(c) tetrahedral, square planar and octahedral
(d) octahedral, tetrahedral and square planar

21. Among $[Ni(CO)_4]$, $[NiCl_4]^{2-}$, $[Co(NH_3)_4Cl_2]Cl$, $Na_3[CoF_6]$, Na_2O_2 and CsO_2, the total number of paramagnetic compounds is [JEE Advanced 2016]
(a) 2
(b) 3
(c) 4
(d) 5

22. Which one of the following complex species does not involve inner orbital hybridisation?
(a) $[CoF_6]^{3-}$
(b) $[Co(NH_3)_6]^{3+}$
(c) $Fe(CN)_6]^{3-}$
(d) $[Cr(NH_3)_6]^{3+}$

23. The coordination number and the oxidation state of the element 'E' in the complex, $[E(en)_2(C_2O_4)]NO_2$ (where, (en) is ethylene diamine) respectively are
(a) 6 and 2
(b) 4 and 2
(c) 4 and 3
(d) 6 and 3

24. Among the following complexes (K to P),
$(K) = K_3[Fe(CN)_6]$, $(L) = [Co(NH_3)_6]Cl_3$
$(M) = Na_3[Co(ox)_3]$, $(N) = [Ni(H_2O)_6]Cl_2$,
$(O) = K_2[Pt(CN)_4]$, $(P) = [Zn(H_2O)_6](NO_3)_2$
the diamagnetic complexes are
(a) K, L, M, N
(b) K, M, O, P
(c) L, M, O, P
(d) L, M, N, O

25. Nickel ($Z = 28$) combines with a uninegative monodentate ligand X^- to form a paramagnetic complex, $[NiX_4]^{2-}$. The number of unpaired electrons(s) in the nickel and geometry of this complex ion, respectively are
(a) one, tetrahedral
(b) two, tetrahedral
(c) one, square planar
(d) two, square planar

26. Aluminium reacts with NaOH and forms compound 'X'. If the coordination number of aluminium in 'X' is 6. The correct formula of X is
(a) $[Al(H_2O)_4(OH)_2]^+$
(b) $[Al(H_2O)_3(OH)_3]$
(c) $[Al(H_2O)_2(OH)_4]^-$
(d) $[Al(H_2O)_6](OH)_3$

27. $[Cr(H_2O)_6]Cl_3$ (atomic number of Cr = 24) has a magnetic moment of 3.83 BM, the correct distribution of $3d$-electrons in the chromium of the complex is
(a) $3d^1_{x^2-y^2}, 3d^1_{x^2}, 3d^1_{xz}$
(b) $3d^1_{xy}, 3d^1_{x^2-y^2}, 3d^1_{yz}$
(c) $3d^1_{xy}, 3d^1_{zy}, 3d^1_{zx}$
(d) $3d^1_{xy}, 3d^1_{yz}, 3d^1_{z^2}$

28. Among $[Ni(Co)_4]$, $[Ni(CN)_4]^{2-}$, $[NiCl_4]^{2-}$ species, the hybridisation states of Ni atom are, respectively. (Atomic number of Ni = 28)
(a) sp^3, dsp^2, dsp^2
(b) sp^3, dsp^2, sp^3
(c) sp^3, sp^3, dsp^2
(d) dsp^2, sp^3, sp

29. How many electrons are present in $3d$ orbital of tetrahedral, $K_2[NiCl_4]$ complex?
(a) 8 electrons
(b) 10 electrons
(c) 7 electrons
(d) 6 electrons

30. Excess of silver nitrate solution is added to 100 mL of 0.01 M pentaquachlorochromium (III) chloride solution. The mass of silver chloride obtained in (gram) is
(a) 287×10^{-3}
(b) 143.5×10^{-3}
(c) 143.5×10^{-2}
(d) 287×10^{-2}

31. The pair having the same magnetic moment is [atomic number of Cr = 24, Mn = 25, Fe = 26 and Co = 27] [JEE Main 2016]
(a) $[Cr(H_2O)_6]^{2+}$ and $[Fe(H_2O)_6]^{2+}$
(b) $Mn[(H_2O)_6]^{2+}$ and $[Cr(H_2O)_6]^{2+}$
(c) $[CoCl_4]^{2-}$ and $[Fe(H_2O)_6]^{2+}$
(d) $[Cr(H_2O)_6]^{2+}$ and $[CoCl_4]^{2-}$

32. Identify the correct trend given below (Atomic number, Ti = 22, Cr = 24 and Mo = 42) [JEE Main 2016]
(a) Δ_o of $[Cr(H_2O)_6)]^{2+} < [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} < [Ti(H_2O)_6]^{2+}$
(b) Δ_o of $[Cr(H_2O)_6]^{2+} > [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} > [Ti(H_2O)_6]^{2+}$
(c) Δ_o of $[Cr(H_2O)_6]^{2+} > [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} < [Ti(H_2O)_6]^{2+}$
(d) Δ_o of $[Cr(H_2O)_6]^{2+} < [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} > [Ti(H_2O)_6]^{2+}$

33. Which of the following coordination entities should be expected to absorb light of lowest frequency?
(a) $[Cr(en)_3]^{3+}$
(b) $[CrCl_6]^{3-}$
(c) $[Cr(NH_3)_6]^{3+}$
(d) $[Cr(CN)_6]^{3-}$

34. Crystal field stabilisation energy for high spin d^4 octahedral complex is

(a) $-0.6\,\Delta_o$ *(b)* $-1.8\,\Delta_o$ *(c)* $-1.6\Delta_o + P$ *(d)* $-1.2\,\Delta_o$

35. From the following *d*-orbitals of the transition metal octahedral complexes, the low spin electronic configurations arises only for

(a) d^1 to d^3 complexes
(b) d^4 to d^7 complexes
(c) d^7 to d^9 complexes
(d) d^1, d^2 and d^8 complexes

36. The correct order for the wavelength of absorption in the visible region is

(a) $[Ni(NO_2)_6]^{4-} < [Ni(NH_3)_6]^{2+} < [Ni(H_2O)_6]^{2+}$
(b) $[Ni(NO_2)_6]^{4-} < [Ni(H_2O)_6]^{2+} < [Ni(NH_3)_6]^{2+}$
(c) $[Ni(H_2O)_6]^{2+} < [Ni(NH_3)_6]^{2+} < [Ni(NO_2)_6]^{4-}$
(d) $[Ni(NH_3)_6]^{2+} < [Ni(H_2O)_6]^{2+} < [Ni(NO_2)_6]^{4-}$

37. Among the following complexes, which has a magnetic moment of 5.9 BM?

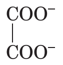
$Ni(CO)_4, [Fe(H_2O)_6]^{2+}, [Co(NH_3)_6]^{3+}, [MnBr_4]^{2-}$

(a) $[Ni(CO)_4]$ *(b)* $[Fe(H_2O)_6]^{2+}$
(c) $[Co(NH_3)_6]^{3+}$ *(d)* $[MnBr_4]^{2-}$

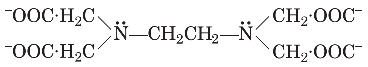
38. The increasing order of the crystal field splitting power of some common ligands is

(a) $H_2O < OH^- < Cl^- < F^- < CN^-$
(b) $H_2O < Cl^- < OH^- < CN^- < F^-$
(c) $CN^- < H_2O < OH^- < F^- < Cl^-$
(d) $Cl^- < F^- < OH^- < H_2O < CN^-$

39. Which ligand is useful for removal of the toxic effect of lead metal from body in chelate therapy treatment?

(a) 
$COO^- - COO^-$

(b) CH_3COO^-

(c) 

(d) AsO_4^{3-}

40. Consider the following complex ions, *P*, *Q* and *R*.

$P = [FeF_6]^{3-}, Q = [V(H_2O)_6]^{2+}$ and $R = [Fe(H_2O)_6]^{2+}$

The correct order of the complex ions, according to their spin-only magnetic moment values (in BM) is

(a) $R < Q < P$ *(b)* $Q < R < P$ [JEE Adv. 2013]
(c) $R < P < Q$ *(d)* $Q < P < R$

41. The octahedral complex of a metal ion M^{3+} with four monodentate ligands L_1, L_2, L_3 and L_4 absorb wavelengths in the region of red, green, yellow and blue, respectively. The increasing order of ligand strength of the four ligands is [JEE Main 2014]

(a) $L_4 < L_3 < L_2 < L_1$ *(b)* $L_1 < L_3 < L_2 < L_4$
(c) $L_3 < L_2 < L_4 < L_1$ *(d)* $L_1 < L_2 < L_4 < L_3$

42. In black and white photography, the developed film is fixed by washing with hypo solution which dissolves the undecomposed AgBr to form a complex ion which is

(a) $[Ag(S_2O_3)_2]^{3-}$ *(b)* $[Ag(S_2O_3)_2]^{2-}$
(c) $[Ag(S_2O_3)_3]^{2-}$ *(d)* $[Ag(S_2O_3)_2]^{-}$

43. The colour of $KMnO_4$ is due to [JEE Main 2015]

(a) $M \rightarrow L$ charge transfer transition
(b) $d \rightarrow d$ transition
(c) $L \rightarrow M$ charge transfer transition
(d) $\sigma \rightarrow \overset{*}{\sigma}$ transition

44. Choose the correct increasing order of wavelength of absorption for the complex ions

I. $[Cr(NH_3)_6]^{3+}$ II. $[CrCl_6]^{3-}$
III. $[Cr(H_2O)_6]^{3+}$ IV. $[Cr(CN)_6]^{3-}$

(a) IV < II < III < I *(b)* IV < III < II < I
(c) IV < I < III < II *(d)* II < III < I < IV

45. The CFSE for octahedral, $[CoCl_6]^{4-}$ is 18000 cm^{-1}. Then the CFSE for tetrahedral, $[CoCl_4]^{2-}$ will be

(a) 18000 cm^{-1} *(b)* 16000 cm^{-1} *(c)* 8000 cm^{-1} *(d)* 20000 cm^{-1}

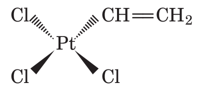
46. Crystal field theory does not explain which of the following property of coordination compounds?

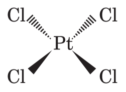
(a) The covalent character of the bond between metal and the ligand
(b) Magnetic property
(c) Colour
(d) Structure of coordination compounds

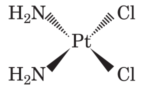
47. The magnitude of crystal field stabilisation energy in tetrahedral complexes (CFSE of Δ_t) is considerably less than that in the octahedral field because

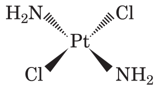
(a) there are only four ligands instead of six, hence the Δ_t is 2/3
(b) the direction of the orbitals does not coincide with the direction of the ligands. This reduce the crystal field stabilisation energy (Δ) by further 2/3
(c) Both points (a) and (b) are correct
(d) Both points (a) and (b) are incorrect

48. Which of the following is considered to be an anticancer species?

(a) 

(b) 

(c) 

(d) 

49. In which of the following octahedral complexes of Co (atomic number 27), will the magnitude of Δ be the highest?

(a) $[Co(CN_6)]^{3-}$ *(b)* $[Co(C_2O_4)_3]^{3-}$
(c) $[Co(H_2O)_6]^{3+}$ *(d)* $[Co(NH_3)_6]^{3+}$

50. Which of the following facts about the complex $[Cr(NH_3)_6]Cl_3$ is wrong?

(a) The complex involves d^2sp^3 hybridisation and is octahedral in shape
(b) The complex is paramagnetic
(c) The complex is an outer orbital complex
(d) The complex gives white precipitate with silver nitrate solution

51. For the coordination compound $Na_2[Cd(en)CN)_4]$, what are the coordination number (CN) and oxidation number (ON) of the central metal ion? (Note : The letter (en) represent the ligand ethylenediamine)
(a) CN = 6, ON = + 2 *(b)* CN = 5, ON = + 2
(c) CN = 4, ON = + 3 *(d)* CN = 4, ON = + 2

52. Which one of the following is expected to exhibit optical isomerism? (en = ethylenediamine)
(a) *cis*-$[Pt(NH_3)_2Cl_2]$ *(b)* *trans*-$[Pt(NH_3)_2Cl_2]$
(c) *cis*-$[Co(en)_2Cl_2]$ *(d)* *trans*-$[Co(en)_2Cl_2]$

53. Complexes in which the oxidation number of a metal is zero is/are
(a) $Cr(C_6H_6)_2$ *(b)* $Mn_2(CO)_{10}$
(c) $[Ni(CO)_4]$ *(d)* All of these

54. EAN values of the complex is not equal to 36 in
(a) $[Ni(H_2O)_6]^{2-}$ *(b)* $[Zn(OH)_4]^{2-}$
(c) $[Fe(CO_5]$ *(d)* $[Cr(CO)_6]$

55. Among the following, which is not the π-bonded organometallic compound?
(a) $(CH_3)_4Sn$ *(b)* $K[PtCl_3(\eta^2-C_2H_4]$
(c) $(Fe(\eta^5-C_5H_5)_2]$ *(d)* $Cr(\eta^6-C_6H_5)_2$

56. The isomeric complexes, $(Co(NH_3)_6][Cr(NO_2)_6]$ and $[Cr(NH_3)_6][Co(NO_2)_6]$ can be distinguished from one another by
(a) conductivity measurement
(b) measuring magnetic moment
(c) electrolysis of their aqueous solution
(d) optical measurement

57. Which of the following coordination compounds would exhibit optical isomerism?
(a) Pentamminenitrocobalt (III) lodide
(b) Diamminedichloroplatinum (II)
(c) *trans*-dicyano*bis*(ethylenediamine) chromium (III) chloride
(d) *trans*-(ethylenediamine) cobalt (III) bromide

58. The structure of the complexes $[Cu(NH_3)_4](ClO_4)$ in solution is
(a) square planar *(b)* octahedral
(c) trigonal bipyramidal *(d)* tetrahedral

59. Which of the following types of octahedral complexes will exhibit geometral isomerism (where, M = metal, a, b = achiral ligands)?
(a) $[Ma_6]$ *(b)* $[Ma_5b]$
(c) $[Ma_4b_2]$ *(d)* $[M(aa)_3]$

60. The compound formed by dissolving gold and plantinum in aqua-regia is
(a) $[AuCl_4]^{3-}$ and $[PtCl_6]^{2-}$ *(b)* $[AuCl_4]^-$ and $[PtCl_6]^{4-}$
(c) $[AuCl_4]^-$ and $[PtCl_6]^{2-}$ *(d)* $[AuCl_4]^-$ and $[PtCl_4]^{2-}$

61. Which of the following is correct arrangement of ligands in terms of the Dq values of their complexes with any particular 'hard' metal ion?
(a) $Cl^- < F^- < NCS^- < NH_3 < CN^-$
(b) $NH_3 < F^- < Cl^- < NCS < CN^-$
(c) $Cl^- < F^- < NCS^- < CN^- < NH_3$
(d) $NH_3 < CN^- < NCS^- < CI^- < F^-$

62. Oxidation states of iron in the complexes $[Fe(H_2O)_5NO]^{2-}$ and $[Fe(CN)_5NO]^{2-}$ are
(a) + 1 and + 2 *(b)* + 1 and + 1
(c) + 2 and + 2 *(d)* + 2 and + 1

63. Cr^{3+} form four complexes with four different ligands which are $[Cr(Cl)_6]^{3-}$, $[Cr(H_2O)_6]^{3+}$, $[Cr(NH_3)_6]^{3+}$ and $[Cr(CN)_6]^{3-}$. The order of CFSE in these complexes is in the order
(a) $[CrCl_6]^{3-} = [Cr(H_2O)_6]^{3+} = [Cr(NH_3)_6]^{3+} = [Cr(CN)_6]^{3-}$
(b) $[CrCl_6]^{3-} < [Cr(H_2O)_6]^{3+} < [Cr(NH_3)_6]^{3+} < [Cr(CN)_6]^{3-}$
(c) $[CrCl_6]^{3-} > [Cr(H_2O)_6]^{3+} > [Cr(NH_3)_6]^{3+} > [Cr(CN)_6]^{3-}$
(d) $[CrCl_6]^{3-} < [Cr(H_2O)_6]^{3+} = [Cr(NH_3)_6]^{3+} < [Cr(CN)_6]^{3-}$

64. The formula of the complex hexamminecobalt (III) chloride sulphate is
(a) $[Co(NH_3)_6]ClSO_4$ *(b)* $[CO(NH_3)_6Cl]SO_4$
(c) $[(Co(NH_3)_6ClSO_4]$ *(d)* None of these

65. The pair of compounds having the same hybridisation for the central atom is
(a) $[Cu(NH_3)_4]^{2+}$ and $[Ni(NH_3)_4]^{2+}$
(b) $[NiCl_4]^{2-}$ and $[Zn(NH_3)_4]^{2+}$
(c) $[Cu(NH_3)_4]^{2+}$ and $[Zn(NH_3)_4]^{2+}$
(d) $[Co(NH_3)_6]^{3+}$ and $[Co(H_2O)_6]^{3+}$

66. Ligands which can get attached to the central metal ion through more than one atom are called
(a) ambident ligands *(b)* polydentate ligands
(c) chelate ligands *(d)* neutral ligands

67. According to IUPAC nomenclature, sodium nitroprusside is named as
(a) sodium nitroferricyanide
(b) sodium nitroferrocyanide
(c) sodium pentacyanonitrosylferrate (III)
(d) sodium pentacyanonitrsoliumferrate (II)

68. The IUPAC name of $[Ni(PPh_3)_2Cl_2]^{2+}$ is
(a) *bis* dichloro(triphenylphosphine) nickel (II) ion
(b) dichloro *bis* (triphenylphosphine) nickel (II) ion
(c) dichloro triphenylphosphine nickel (II) ion
(d) triphenylphosphine nickel (II) dichloride

69. *Tris* (ethylenediamine) cobalt (III) cation, $[Co(en)_3]^{3+}$ can have
(a) three stereoisomers, all chiral and optically active
(b) two chiral stereoisomers (enantiomers) and one achiral
(c) three stereoisomers, all achiral
(d) two stereoisomers, both achiral

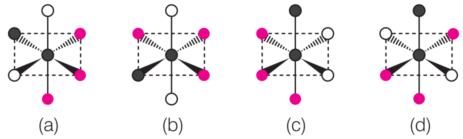
70. Match the following Columns.

Column I (Complex)		**Column II** (Structure and magnetic moment)	
A.	$[Ag(NH_3)_2]^+$	1.	Square planar and 1.73 BM
B.	$[Co(NH_3)_6]^{3+}$	2.	Linear and 0
C.	$[Fe(CN)_6]^{3-}$	3.	Octaheral and 0
D.	$[Cu(NH_3)_4]^{2+}$	4.	Octahedral and 1.73 BM
E.	$[Fe(CN)_6]^{4-}$		

Codes

	A	B	C	D	E		A	B	C	D	E
(a)	1	2	3	4	4	*(b)*	1	3	2	3	4
(c)	2	4	4	1	4	*(d)*	4	4	3	2	1

71. Consider the following isomers of $[Co(NH_3)_4Br_2]^+$. The black sphere represents Co, red sphere represents NH_3 and unshaded sphere represents Br.



(a) Structure (a) = structure (b) and structure (c) = structure (d)
(b) Structure (a) = structure (c) and structure (b) = structure (d)
(c) Structure (a) = structure (d) and structure (b) = structure (c)
(d) None of the above

72. Match the Column I with Column II and mark the correct option from the codes given below :

	Column I		Column II
I.	$[CoCl_2(NH_3)_3]$	p.	*cis* form is optically active
II.	$[Co(ox)_3]^{3-}$	q.	*trans* form is optically inactive
III.	$[CrCl_2(ox)_2]^{3-}$	r.	show meridian form
IV.	$[RhCl_3(py_3)]$	s.	show facial form
		t.	show both geomertical and optical isomerism

Codes

	A	B	C	D
(a)	p,q	q	p,t	r,s
(b)	r	r	q,p	p,q
(c)	p,t	s	p,t	p,r,t
(d)	r,s	p,q,t	p,q,t	r,s

73. The crystal field stabilisation energy (CFSE) and the spin only magnetic moment in Bohr magneton (BM) for the complex $K_3[Fe(CN)_6]$ respectively, are
(a) $0.0\Delta_o$ and $\sqrt{35}$ BM
(b) $-2.0\Delta_o$ and $\sqrt{3}$ BM
(c) $-0.4\Delta_o$ and $\sqrt{24}$ BM
(d) $-2.4\Delta_o$ and 0.0 BM

74. Match the Column I with Column II and mark the correct option from the codes given below :

	Column I		Column II
I.	$[CoCl_2(en)_2]^+$	P.	Shows geometrical isomerism only
II.	$[Cr(ox)_3]^{3-}$	Q.	Shows optical isomerism only
III.	$[RhCl_3(py)_3]$	R.	Shows optical as well as geometrical
IV.	$[ZnCl_2(NH_3)_2]$	S.	Shows no isomerism

Codes

	A	B	C	D
(a)	r	q,s	p	s
(b)	p	s	r	q
(c)	s	r	p	q,s
(d)	r	p	q	s

75. An octahedral complex with molecular formula $5NH_3 \cdot Cl \cdot SO_4$ has two isomers *A* and *B*. The solution of *A* gives a white precipitate with $AgNO_3$ solution and the solution of *B* gives white precipitate with $BaCl_2$ solution. The type of isomerism exhibited by the complex is
(a) linkage isomerism
(b) ionisation isomerism
(c) coordination isomerism
(d) geometical isomerism

76. The IUPAC name of the complex ion formed when gold dissolves in aqua-regia is
(a) tetrachloridoaurate (III)
(b) tetrachloridoaurate (I)
(c) tetrachloridoaurate (II)
(d) dichloridoaurate (III)

77. The hybridisation of central metal ion in $K_2[Ni(CN)_4]$ and $K_2[NiCl_4]$ are respectively
(a) dsp^2, sp^3 *(b)* sp^3, sp^3
(c) dsp^2, dsp^3 *(d)* sp^3, sp^3d^2

78. In $[CoF_6]^{3-}$, Co^{3+} uses outer *d*-orbitals (4*d*) in sp^3d^2 hybridisation. The number of unpaired electrons present in complex ion is
(a) 0 *(b)* 4
(c) 2 *(d)* 3

79. A magnetic moment of 1.73 BM will be shown by one among the following.
(a) $[Cu(NH_3)_4]^{2+}$ *(b)* $[Ni(CN)_4]^{2-}$
(c) $TiCl_4$ *(d)* $[CoCl_6]^{4-}$

80. Which of the following ligands is not a chelating agent?
(a) EDTA *(b)* en
(c) Oxalate *(d)* Pyridine

81. Which of the following salts is colourless?
(a) $CdCl_2$ *(b)* $CuSO_4 \cdot 5H_2O$
(c) $MnSO_4 \cdot 7H_2O$ *(d)* $NiSO_4 \cdot 7H_2O$

82. Which of the following complexes have lowest molar conductance?
(a) $CoCl_3 \cdot 3NH_3$ *(b)* $CoCl_3 \cdot 4NH_3$
(c) $CoCl_3 \cdot 5NH_3$ *(d)* $CoCl_3 \cdot 6NH_3$

83. Calculate the coordination number of the metal ion, its oxidation number, the number of electrons in *d*-orbitals and the number of unpaired electrons in *d*-orbitals respectively in complex $[Co(H_2O)_4SO_3]I$.
(a) 6, 3, 6, 4 *(b)* 6, 3, 6, 0
(c) 5, 3, 6, 4 *(d)* 5, 3, 6, 0

84. Number of isomeric forms (constitutional and stereoisomers) for $[Rh(en)_2(NO_2)(SCN)]^+$ is
(a) three *(b)* six
(c) nine *(d)* twelve

85. Which of the following compounds shows optical isomerism?
(a) $[Co(CN)_6]^{3-}$ *(b)* $[Cr(C_2O_4)_3]^{3+}$
(c) $[ZnCl_4]^{2-}$ *(d)* $[Cu(NH_3)_4]^{2+}$

86. In the brown ring complex $[Fe(H_2O)_5(NO)]SO_4$, nitric oxide behaves as

(a) NO^+ *(b)* neutral, no molecule
(c) NO^- *(d)* NO^{2-}

87. Which one of the following is an outer orbital complex and exhibits paramagnetic behaviour?

(a) $[Ni(NH_3)_6]^{2+}$ *(b)* $[Zn(NH_3)_6]^{2+}$
(c) $(Cr(NH_3)_6]^{3+}$ *(d)* $[Co(NH_3)_6]^{3+}$

88. Ammonia gas does not evolve from the complex $FeCl_3 \cdot 4NH_3$ but it gives white precipitate with aqueous solution of $AgNO_3$. Coordination number of central metal ion in the above complex is six. Give IUPAC name of the complex.

(a) Ammoniumtrichlorotriammineferric (III)
(b) Tetraammineferric (III) chloride
(c) Dichlorotetraammineferrate (II) chloride
(d) Dichlorotetraammineferric (III) chloride

89. In the complex ion $[Co(NH_3)_6]^{3+}$, the NH_3 molecules are linked to the central metal ion by

(a) ionic bonds
(b) covalent bonds
(c) coordinate bonds
(d) hydrogen bonds

90. An octahedral complex is formed when hybrid orbitals of the following type are involved

(a) sp^3 *(b)* dsp^2
(c) d^2sp^3 *(d)* sp^3d^2

91. Which one of the following complex ion has the highest magnetic moment?

(a) $[Cr(NH_3)_6]^{3+}$ *(b)* $[Fe(CN)_6]^{3-}$
(c) $[Fe(CN)_6]^{4-}$ *(d)* $[Zn(NH_3)_6]^{2+}$

92. In solid $CuSO_4 \cdot 5H_2O$ copper is coordinated to number of water molecules equal to

(a) 5 *(b)* 4
(c) 1 *(d)* 2

93. $[Ni(CN)_4]^{2-}$ ion is diamagnetic and it involves the following hybridisation

(a) dsp^2 *(b)* sp^3
(c) d^2sp^3 *(d)* sp^3d^2

94. Which of the following 0.1 M complex compound solutions will have the minimum electrical conductivity?

(a) Hexaammine platinum (IV) chloride
(b) Chloropentaammineplatinum (IV) chloride
(c) Dichlorotetraammineplatinum (IV) chloride
(d) Trichlorotriammineplatinum (IV) chloride

95. The pair in which both species have same magnetic moment (spin only value) is

(a) $[Cr(H_2O)_6]^{2+}, [CoCl_4]^{2-}$
(b) $[Cr(H_2O)_6]^{2+}, [Fe(H_2O)_6]^{2+}$
(c) $[Mn(H_2O)_6]^{2+}, [Cr(H_2O)_6]^{2+}$
(d) $[CoCl_4]^{2-}, [Fe(H_2O)_6]^{2+}$

96. Atomic number of Cr and Fe are 24 and 26, respectively. Which of the following is paramagnetic with the spin of electron?

(a) $[Cr(CO)_6]$ *(b)* $[Fe(CO)_5]$
(c) $[Fe(CN)_6]^{4-}$ *(d)* $[Cr(NH_3)_6]^{3+}$

97. The geometry of $Ni(CO)_4$ and $Ni(PPh_3)_2Cl_2$ are

(a) both square planar
(b) tetrahedral and square planar respectively
(c) both tetrahedral
(d) square planar and tetrahedral respectively

98. The hypothetical complex chlorodiaquatriammine cobalt (III) chloride can be represented as

(a) $[CoCl(NH_3)_3(H_2O)_2]Cl_2$
(b) $[Co(NH_3)_3(H_2O)Cl_3]$
(c) $[Co(NH_3)_3(H_2O)_2Cl]$
(d) $[Co(NH_3)_3(H_2O)_3]Cl_3$

99. Which of the following will give a pair of enantiomorphs?
$(en = NH_2CH_2CH_2NH_2)$

(a) $[Co(NH_3)_4Cl_2]NO_2$
(b) $[Cr(NH_3)_6][Co(CN)_6]$
(c) $[Co(en)_2Cl_2]Cl$
(d) $[Pt(NH_3)_4][PtCl_6]$

100. In the complex with formula $MCl_3 \cdot 4H_2O$, the coordination number of the metal M is six and there is no molecule of hydration in it. The volume, if 0.1 M $AgNO_3$ solution needed to precipitate the free chloride ions in 200 mL of 0.01 M solution of the complex, is

(a) 40 mL *(b)* 20 mL
(c) 60 mL *(d)* 80 mL

Answers

1. (c)	**2.** (a)	**3.** (c)	**4.** (d)	**5.** (c)
6. (d)	**7.** (c)	**8.** (c)	**9.** (a)	**10.** (a)
11. (c)	**12.** (a)	**13.** (c)	**14.** (b)	**15.** (c)
16. (b)	**17.** (a)	**18.** (b)	**19.** (c)	**20.** (a)
21. (c)	**22.** (a)	**23.** (d)	**24.** (c)	**25.** (b)
26. (c)	**27.** (c)	**28.** (b)	**29.** (a)	**30.** (a)
31. (a)	**32.** (b)	**33.** (b)	**34.** (a)	**35.** (b)
36. (a)	**37.** (d)	**38.** (d)	**39.** (c)	**40.** (b)
41. (b)	**42.** (a)	**43.** (c)	**44.** (a)	**45.** (c)
46. (a)	**47.** (c)	**48.** (c)	**49.** (a)	**50.** (c)
51. (a)	**52.** (c)	**53.** (d)	**54.** (a)	**55.** (a)
56. (c)	**57.** (d)	**58.** (a)	**59.** (c)	**60.** (c)
61. (a)	**62.** (a)	**63.** (c)	**64.** (a)	**65.** (a)
66. (a)	**67.** (d)	**68.** (b)	**69.** (b)	**70.** (c)
71. (b)	**72.** (d)	**73.** (b)	**74.** (a)	**75.** (b)
76. (a)	**77.** (a)	**78.** (b)	**79.** (a)	**80.** (d)
81. (a)	**82.** (a)	**83.** (a)	**84.** (d)	**85.** (b)
86. (a)	**87.** (a)	**88.** (d)	**89.** (c)	**90.** (c)
91. (a)	**92.** (b)	**93.** (a)	**94.** (d)	**95.** (b)
96. (d)	**97.** (c)	**98.** (a)	**99.** (c)	**100.** (b)

CHEMISTRY IN EVERYDAY LIFE

Chemistry plays a vital role in every aspects of our life. We use varieties of chemicals either natural or synthetic in our day-to-day life. These are drugs, alkaloids, essential oils, soaps, perfumes, etc.

Chemicals in Drugs and Medicines

- **Drugs** are chemicals of low molecular mass that interact with enzymes, nucleic acids, proteins, etc., to cause a biological response.
- When drugs are used in minute quantity in order to cause a therapeutic action, it is called **medicines**.
- Therapeutic use of different classes of drugs and their actions are given in the table below :

Class of the drug	Therapeutic use and example of drugs	Drug action in our body
Antihistamines	(a) As an antacid, e.g. cimetidine (tagamet), ranitidine (zanetac).	(a) Prevent the interaction of histamines with receptors present in stomach wall releasing lesser amount of acid.
	(b) As an anti-allergic drug, e.g. bromopheniramine (Dimetapp), terfenadine (seldane).	(b) Histamines are responsible for nasal congestion caused due to common cold and allergy. Anti-allergic drugs interfere with the natural action of histamine by competing with it for binding sites of receptors where histamine exerts its effect.
Neurologically active drugs (affect the message transfer mechanism from nerve to receptor)	(a) Tranquillisers (drugs that are used to treat stress and severe mental disorders) e.g. chlorodiazepoxide, meprobamate, valium, serotonin, derivatives of barbituric acid such as amytal, nembutal, luminal etc. and benzodiazepines.	(a) These drugs reduce stress, anxiety and irritability by inducing a sense of well being. They usually act on neurotransmitters and nerve-impulse transmission inside the brain.
	(b) Antidepressant drugs, e.g. iproniazid, phenelzine etc.	(b) During depression, the concentration of noradrenaline (a neurotransmitter responsible for mood changes) decreases. Antidepressant drugs inhibit the enzymes which catalyse the degradation of noradrenaline.
Analgesics (a class of neurologically active drug reduce pain without losing consciousness).	(a) Non-narcotic analgesics (non-addictive), e.g. aspirin, paracetamol (It has also antipyretic effect, i.e. reduce fever).	(a) Aspirin inhibits the synthesis of prostaglandins that stimulate inflammation in tissues and cause pain. It also prevents platelet coagulation and is used in the prevention of heart attack.
	(b) Narcotic analgesics (addictive), e.g. morphine (also called opiates as they are obtained from opium poppy) codeine, heroin, etc.	(b) Morphine cause its effect by binding to μ-opioid receptors in the Central Nervous System (CNS). These drugs directly act on CNS to relieve pain.
Antibiotics (a class of antimicrobials)	(a) Antibiotics with bactericidal effect, e.g. penicilline, ofloxacin, aminoglycosides, etc.	Antibiotics with bactericidal effect kill the bacteria, e.g. penicillin kill the bacteria by preventing the formation of cell wall. Some other antibiotics kill the bacteria by preventing the formation of genetic material.
	(b) Antibiotics with bacteriostatic effect, e.g. erythromycin, tetracycline, chloramphenicol, sulphonamides, etc.	These types of drugs inhibit the growth of bacteria by preventing replication, protein synthesis, etc.

Class of the drug		Therapeutic use and example of drugs	Drug action in our body
Antiseptics and Disinfectants (a class of antimicrobials that are applied outside our body)	(a)	Antiseptics are applied to living tissues such as skin having wounds, cuts or ulcers. They either kill or prevent the growth of bacteria, e.g. dettol (a mixture of chloroxylenol and α-terpineol), bithional (added to soaps), tincture of iodine (2-3% of I_2 in alcohol-water mixture), iodoform, boric acid, etc.	—
	(b)	Disinfectants are applied to non-living objects such as floors, toilets, etc., to either kill or prevent the growth of bacteria, e.g. phenol, chlorine, etc.	—
Antifertility drugs (used to check pregnancy in women)		Birth control pills (a mixture of synthetic estrogen and progesterone derivatives), synthetic progesterones used as norethindrone, lynestrenol, etc. Synthetic estrogens used as ethynylestradiol, mestranol etc.	These drugs act by regulating ovulation cycle, preventing fertilisation, etc. Synthetic progesterone derivatives are more effective than normal progesterone.

Chemicals in Food

Chemicals are used in food as preservatives, flavoring agents, antioxidant, colouring agent, etc.

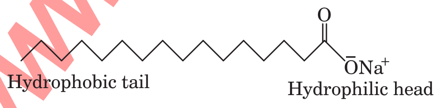
- Saccharin, aspartame, alitame, sucralose, cyclamate, etc. are used as **artificial sweetners**.
- Aspartame (Nutra sweet) is the most widely used artificial sweetner, however its use is limited to cold foods only, as it is unstable at cooking temperature.
- Table salt, sugar, vegetable oils, sodium benzoate salts of sorbic acid and propanoic acid are used as **food preservatives**.
- BHA (butylated *p*-hydroxyanisole), BHT (butylated *p*-hydroxy toluene) are used as antioxidants which prevent oxidation of food materials.
- **Vitamins** like ascorbic acid and tocopherols (vitamin-E) are carotenoids antioxidants.
- Colouring agents like amaranth (red brown powder), indigo carmine (blue) etc., are used in food.

Cleansing Agents

These are chemicals which improve the cleansing properties of water. These are also called **surfactants** as they act at the surface between two different substances. Soaps and detergents are used as cleansing agents.

Soaps

- These are sodium or potassium salts of higher fatty acids such as oleic acid ($C_{17}H_{33}COOH$), stearic acid ($C_{17}H_{35}COOH$), etc.
- It has a non-polar fat soluble hydrocarbon part and water soluble carboxylate part.



Sodium stearate

- The action of soap is based on the mechanism of micelle formation.
- Soaps do not work in hard water due to formation of a white curdy precipitate.

$$\underset{\text{Soap}}{RCOONa} + Ca^{2+}/Mg^{2+} \longrightarrow \underset{\text{White curdy ppt}}{(RCOO)_2Ca/Mg}$$

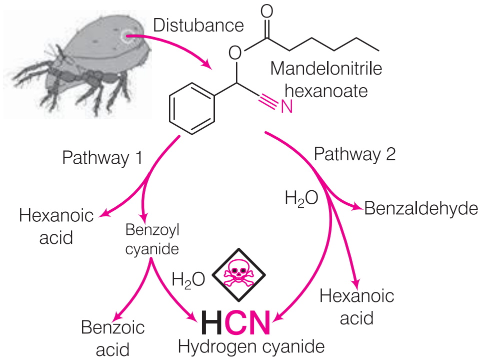
Synthetic Detergents

- They have all properties of soaps but having different chemical composition than normal soaps.
- Unlike soaps, they work in both hard and soft water.
- These are of three types, anionic, cationic and neutral (non-ionic) detergents.

CHEMISTRY IN action!

Tiny mite uses hydrogen cyanide to fight predators

Although the Oribatula tibialis mite is only the size of a pin head, it packs a punch when it comes to defending itself from predators. It produces a compound that releases hydrogen cyanide , one of the quickest acting and most toxic poisons, when it comes into contact with an attacker's saliva.

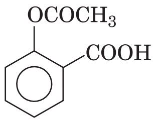


MASTER STROKES

1. Which of the following is an anionic detergent? [JEE Main 2016]
(a) Sodium lauryl sulphate
(b) Cetyltrimethyl ammonium bromide
(c) Glyceryl oleate
(d) Sodium stearate

2. The artificial sweetener that has the highest sweetness value in comparison to cane sugar is [JEE Main 2016]
(a) saccharin
(b) sucralose
(c) alitame
(d) aspartame

3. Which of the following is not an antacid? [JEE Main 2015]
(a) Aluminium hydroxide
(b) Cimetidine
(c) Phenelzine
(d) Ranitidine

4. 

is used as
(a) insecticide
(b) antihistamine
(c) analgesic
(d) antacid

5. Which of the following is used as an antiseptic?
(a) Phenol
(b) Benzaldehyde
(c) Benzalamine
(d) Maleic anhydride

6. Which of the following is not used as an antacid?
(a) Magnesium hydroxide
(b) Sodium carbonate
(c) Sodium bicarbonate
(d) Aluminium phosphate

7. Which of the following is an artificial edible colour?
(a) Saffron
(b) Carotene
(c) Tetrazine
(d) Melamine

8. Antiseptic chloroxylenol is
(a) 4-chloro-3,5-dimethyl phenol
(b) 3-chloro-4,5-dimethyl phenol
(c) 4-chloro-2,5-dimethyl phenol
(d) 5-chloro-3,4-dimethyl phenol

9. Which one of the following is employed as a tranquiliser drug?
(a) Mifepristone
(b) Promethazine
(c) Valium
(d) Naproxen

10. Which of the following is the basic dye?
(a) Congo red
(b) Methyl red
(c) Methyl orange
(d) Malachite green

11. Which of the following process will give soap?
(a) Hydrolysis
(b) Saponification
(c) Neutralisation
(d) Acidification

12. Which of the following is a local anaesthetic?
(a) Diazepam
(b) Procaine
(c) Chlorophenicol
(d) Penicillin-G

13. Which of the following antibiotics was first discovered?
(a) Ampicillin
(b) Amoxycillin
(c) Penicillin
(d) Chloramphenicol

14. Saccharin and artificial sweetener are manufactured from
(a) toluene
(b) cyclohexane
(c) starch
(d) cellulose

15. Which one of the following types of drugs reduces fever?
(a) Analgesics
(b) Antipyretics
(c) Aspirin
(d) Tranquilisers

16. The pair whose both species are used in antacid medicinal preparations is
(a) $NaHCO_3$ and $Mg(OH)_2$
(b) Na_2CO_3 and $Ca(HCO_3)_2$
(c) $Ca(HCO_3)_2$ and $Mg(OH)_2$
(d) $Ca(OH)_2$ and $NaHCO_3$

17. The reagent(s) used in the preparation of aspirin from salicylic acid is/are
(a) $SOCl_2$. pyridine
(b) $(CH_3CO)_2O, H^+$
(c) CH_3COOH, HCl
(d) $CH_3Cl, AlCl_3$

18. Detergents are prepared by the action of H_2SO_4 followed by neutralisation by starting with
(a) cholesterol
(b) lauryl alcohol
(c) cyclohexanol
(d) *p*-nitrophenol

19. Which of the following represents a synthetic detergent?
(a) $C_{15}H_{31}COOK$
(b) $CH_3(CH_2)_6COONa$
(c) 

(d) All of the above

20. Which one of the following compounds is used as broad spectrum antibiotics ?
(a) Ampicillin
(b) Pencillin-G
(c) Penicillin-K
(d) Tetracycline

21. Which of the following is not bacteriostatic antibiotic?
(a) Erthromycin
(b) Tetracycline
(c) Chloramphenicol
(d) Penicillin

22. An antibiotic effective in treatment of pneumonia, bronchitis etc, is
(a) penicillin
(b) patalin
(c) chloromycetin
(d) tetracyclin

23. The preservative which is used to preserve breads and cakes is
(a) sodium benzoate
(b) sodium metabisulphite
(c) sodium propionate
(d) sodium sorbate

24. Select the incorrect statement regarding detergents.
(a) These have a non-polar organic part and a polar group
(b) These are surface active reagent
(c) These are sodium salt of fatty acids
(d) These are not easily biodegraded

25. Which one of the following forms micelles in aqueous solution above certain concentration?
(a) Urea
(b) Dodecyl trimethyl ammonium chloride
(c) Pyridinium chloride
(d) Glucose

26. An insoluble dye is reduced to a soluble colourless leuco form by an alkaline reducing agent. The fibre is soaked in the dye solution and then exposed to air to develop the colour. The dye is
(*a*) mordant dye (*b*) vat dye
(*c*) azo dye (*d*) direct dye

27. Which of the following type of dyes are not used to dye nylon and polyester fibres?
(*a*) Vat dyes (*b*) Basic dyes
(*c*) Disperse dyes (*d*) Insoluble azo dyes

28. Detergents are known to pollute rivers and water ways. However, detergents can be made biodegradable and pollution free by taking
(*a*) cyclic hydrocarbon chain
(*b*) shorter hydrocarbon chain
(*c*) unbranched hydrocarbon chain
(*d*) hydrocarbon with more branching

29. Antiseptics and disinfectants either kill or prevent growth of microorganisms. Identify which of the following is not true?
(*a*) A 0.2% solution of phenol is an antiseptic while 1% solution acts as a disinfectant
(*b*) Chlorine and iodine are used as strong disinfectants
(*c*) Dilute solutions of boric acid and hydrogen peroxide are strong antiseptics
(*d*) Disinfectants harm the living tissue

30. Match the following Column I with Column II.

Column I	Column II
A. Sucralose	1. Antioxidant
B. Iodine	2. Artificial sweetener
C. Sodium benzoate	3. Antacid
D. Ranitidine	4. Antiseptic
	5. Food preservative

Select the correct option.
Codes

	A	B	C	D		A	B	C	D
(*a*)	2	4	1	3	(*b*)	2	4	5	3
(*c*)	2	3	5	1	(*d*)	2	1	3	4

31. The bacteriostatic antibiotic among the following is
(*a*) erythromycin (*b*) penicillin
(*c*) aminoglycoside (*d*) ofloxacin

32. Which of the following analgesics are toxic to liver?
(*a*) Aspirin (*b*) Naproxen
(*c*) Both (a) and (b) (*d*) None of these

33. Which of the following is soft and biodegradable detergent?
(*a*) ABS (*b*) LAS
(*c*) Both (a) and (b) (*d*) None of these

34. Aspartame is a dipeptide of
(*a*) aspartic acid (*b*) phenyl alanine
(*c*) Both (a) and (b) (*d*) None of these

35. Aspirin is used to cure Alzheimer's disease which is caused by
(*a*) Al^{3+} (*b*) Mg^{2+}
(*c*) Fe^{3+} (*d*) All of these

36. One of the artificial sweetener has same functional group as urea. This artificial sweetener is
(*a*) saccharin (*b*) duclin (*c*) sucralose (*d*) cyclamate

37. Which of the following is not the correct matching of medicine with its disease/activity?
(*a*) Aspirin-pain reliever
(*b*) Equanil-hypertension
(*c*) Chloramphenicol-typhoid
(*d*) 0.2 per cent phenol-disinfectant

38. Which of the following soaps decolourise Br_2 water and alkaline $KMnO_4$?
(*a*) $C_{17}H_{35}COONa$ (*b*) $C_{15}H_{31}COONa$
(*c*) $C_{17}H_{33}COONa$ (*d*) All of these

39. Which of the following is/are antioxidants added to preserve food from autoxidation and spoilage?
(*a*) BHT (*b*) BHA
(*c*) Both (a) and (b) (*d*) None of these

40. In 1970, the US Food and Drug Administration (FDA) banned the sale of saccharin because
(*a*) it was bitter in taste
(*b*) it was insoluble in water and at high temperature of cooking, it decomposed
(*c*) it was found to be carinogenic
(*d*) it was not pollutant free

41. Iodex is pain reliever applied externally. It is
(*a*) ethyl salicylate (*b*) acetyl salicylic acid
(*c*) methyl salicylic acid (*d*) methyl salicylate

42. Select the correct statement(s) about cimetidine and ranitidine.
(*a*) These are antihistamine drugs.
(*b*) These prevent the excess production of HCl in the stomach.
(*c*) Both prevent the interaction between histamine and receptor of stomach wall.
(*d*) All of the above are correct.

43. Which of the following group or class has not the correct examples of drugs/medicines?
(*a*) Tranquilisers Barbiturates, Equanil, Valium
(*b*) Antibiotics Sulphanilamide, Sulphadiazine, Sulphaguanidine
(*c*) Antacids Omeprazole, Lansoprazole, Sodium bicarbonate
(*d*) Anaesthetics Nitrogen dioxide, Ether, Halothane

44. Which one of the following is employed as antihistamine (anti-allergic)?
(*a*) Diphenylhydramine (*b*) Chlorpheniramine
(*c*) Promethazine (*d*) All of the above

45. Select the correct statement(s).
(*a*) The antibiotics which are effective mainly against gram-positive or gram-negative bacteria are called narrow-spectrum antibiotics.
(*b*) The antibiotics which kill or inhibit a wide range of gram-positive or gram-negative bacteria are called broad-spectrum antibiotics.
(*c*) Penicillin G is a narrow-spectrum antibiotics while ofloxacin is a broad-spectrum antibiotics.
(*d*) All of the above

To be Continued at Page 92

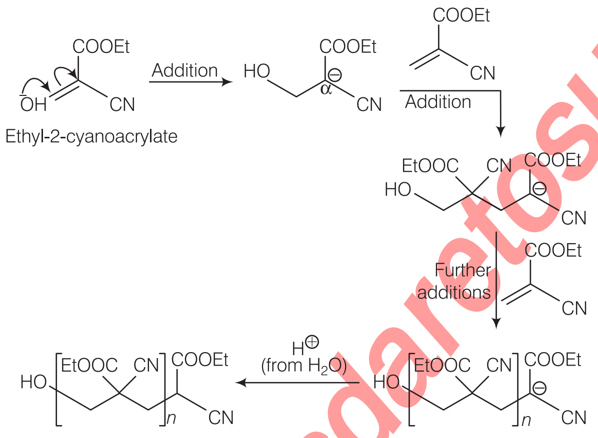
DO YOU KNOW

- **Do you know how criminals are identified from their fingerprints left at the objects?**

To identify criminals from their fingerprints left at the objects you need a method of making fingerprints visible. Mostly fingerprints are deposits of sweat, grease and various amino acids and sugars. One way to show up a fingerprint is to spray it with ethyl-2-cyanoacrylate, the monomer of superglue.

Hydroxide ions produced from water in the air start the polymerisation of the cyanoacrylate. A white polymer forms along the ridges of the fingerprint to give an image of the fingerprint that can be photographed and identified.

Mechanism of this reaction is as follows:



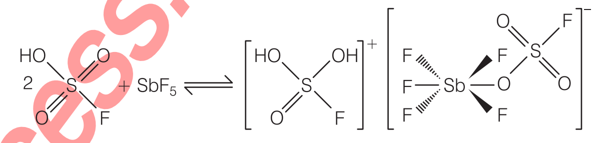
Poly(superglue ethyl-2-cyanoacrylate)

- **Do you know super acid which is also known as magic acid is stronger than 100% sulphuric acid?**

Super acid is an acid which is stronger than 100% sulphuric acid. Super acids were developed by the Hungarian-American chemist George Olah, who won the Nobel prize for his work in 1994. A super acid is formed by dissolving a powerful Lewis acid such as antimony pentafluoride (SbF_5) in a Bronsted-Lowry acid such as hydrofluoric acid (HF) or fluorosulphuric acid (HSO_3F).

The combination of SbF_5 and HSO_3F is known as magic acid because it can dissolve candle wax. Magic acid is 1×10^{18} times stronger than 100% sulphuric acid. Super acids are very strong because the Bronsted-Lowry acid donates a lone pair to the Lewis acid. The H—X bond is broken and the proton becomes attached to another molecule of the Bronsted-Lowry acid.

This leads to high concentrations of cations such as $H_2\overset{+}{F}$ and $H_2SO_3\overset{+}{F}$ in which the proton is extremely weakly bound.



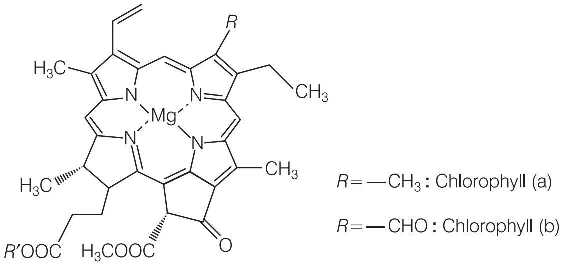
Magic acid

Super acids are strong enough to protonate hydrocarbons giving carbocations such as $\overset{+}{C}H_3$ and $\overset{+}{C}_2H_5$. Protonation is the first step in dissolving candle wax, which is made from long-chain hydrocarbons such as $C_{30}H_{62}$.

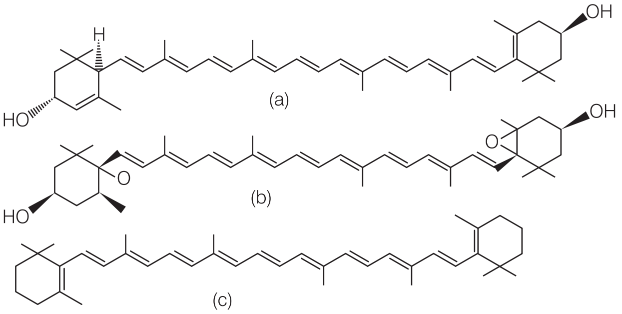
Carbocations are intermediate in many organic reactions but it was only through the use of super acids that they could be produced in large enough quantities to be directly observed and characterised using IR and NMR spectroscopy.

- **Do you know, how bell peppers go through a series of colour changes as they ripen?**

The initial green colour of the bell peppers is due to the chlorophylls, the universal leaf pigments. Beside chlorophylls, bell peppers also contain carotenoids which imparts yellow colour but in the presence of chlorophylls, the yellow colour by small amount of carotenoids is completely masked by the green colour.



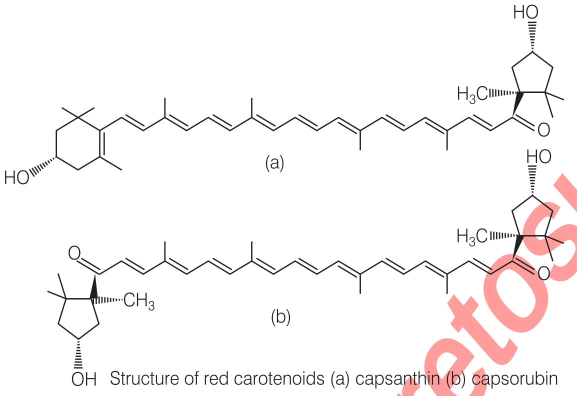
Structure of chlorophylls (a) and (b)



Structure of carotenoids (a) Lutein (b) Violaxanthin (c) β-carotene

But as the pepper ripens, chlorophyll starts decomposing alongwith synthesis of newer amounts of carotenoids, which imparts yellow and orange hues to the capsicum. The prominent types of the carotenoids found are, lutein, violaxanthin and β-carotene. The yellow colour is primarily due to the presence of violaxanthin. Lutein is also known to provide yellow colour to the egg yolks. The orange colour is mainly due to β-carotene which is also responsible for the orange colour of carrots.

Further, ripening is associated with the synthesis of carotenoids like capsanthin and capsorubin which gives red colour to the pepper. Synthesis of the carotenoids (also called paprika ketones) involves **pinacol rearrangement**.

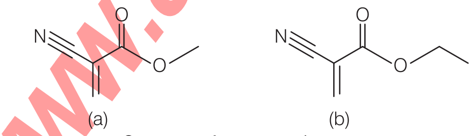


Structure of red carotenoids (a) capsanthin (b) capsorubin

The pinacol rearrangement reaction requires an acid catalyst on a sophisticated laboratory. The peppers showing presence of these rearrangement reaction at room temperature in neutral condition, with the help of an unknown enzyme is a matter of interest, on which researches are on going.

Do you know, how superglues fix things almost instantly?

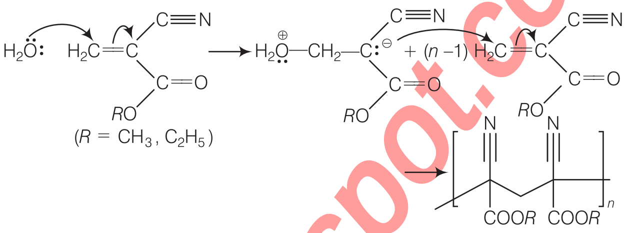
The magical capability of a superglue (like feviquick) is an upshot of polymerisation of cyanoacrylates. The cyanoacrylates were discovered during the second world war, but their high stickiness led them soon be discarded. Their potential as a superglue was recognised only after their rediscovery few years later.



(a) (b)

Structure of cyanoacrylates
(a) Methyl cyanoacrylate (b) Ethyl cyanoacrylate

Functioning of superglue involves reaction of the acrylates with water. Even a small amount of water present as vapour in air is sufficient to start the polymerisation which concludes almost instantly.



Polymerised product
acting as a fixer

The polymerised product has large adhesive forces mainly due to the van der Waals' forces of the highly branched chains of the polymer.

Do you know, how bonding helps in the repair of out broken bones?

Bones consists both inorganic and organic materials. The inorganic material is chiefly hydroxyapatite, $Ca_5(PO_4)_3OH$, which makes up about 70% of bone by dry mass. Among the organic components, the chief components are collagen fibres, which thread through inorganic matrix, providing extra strength and allowing bone to flex under stress. Also, weaving through the hydroxyapatite-collagen framework are blood vessels that supply nutrients.

For a minor fracture, few weeks are required in the process of bone growth to repair the damaged area.

For severe fractures, especially those involving bone loss, a bone graft (transplanting the bone tissues) may be needed. An alternative to a bone graft is an implant of synthetic bone material. One such material, called **Pro Osteon** is derived by heating coral (calcium carbonate) with ammonium hydrogen phosphate to form a hydroxyapatite similar to that of bone.

Throughout the heating process, the porous structure of the coral, which resembles that of bone is retained.

$$\underset{\text{Coral}}{5CaCO_3} + 3(NH_4)_2HPO_4 \xrightarrow[24\text{ - }65\text{ h}]{200°C} \underset{\text{Hydroxyapatite}}{Ca_5(PO_4)_3OH} + 3(NH_4)_2CO_3 + 2H_2CO_3$$

The surgeon can shape a piece of this material to match the bone void, implant it, stabilising the area by inserting metal plates and/or screw and let new bone tissue grow into the pores of implant.

You might have seen the use of peanuts as food items in direct or processed forms but do you know, peanuts are also used as an ingredient in explosive dynamite.

Dynamite is an explosive material which has nitroglycerine as one of the major ingredient. Nitroglycerine is an oily explosive liquid made from glycerol. Peanuts contain oil, this oil is extracted from peanuts and it is used in the process of making glycerol. Glycerol is one of the main ingredient of nitroglycerine. Nitroglycerine is an extremely unstable explosive. It is so unstable that even on shaken it explodes. However, glycerol can be made from different sources as well.

MEDI QUEST

Comprehensive Simulator Test Series for NEET & AIIMS

NEET PREP UP

Mock Questions from Complete Syllabus with Complete Solutions

FULL TEST 5

(COMPLETE SYLLABUS) WITH SOLUTIONS

INSTRUCTIONS

- This test consists of 45 questions and each question is allotted 4 marks for correct response.
- Candidates will be awarded marks as stated above for correct response of each question. 1/4 marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
- There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted according as per instructions.

1. If a platinum wire is dipped in a solution of 0.1M of Sn^{2+} and 0.01M of Sn^{4+}, then E_{cell} is

(a) $E^\circ_{cell} - \frac{0.059}{2}$
(b) $E^\circ_{cell} + 0.059$
(c) E°_{cell}
(d) $E^\circ_{cell} + \frac{0.059}{2}$

2. For the equilibrium,

$$2NO_2(g) \rightleftharpoons N_2O_4(g) + 14.6 \text{ kcal}$$

The increase in temperature

(a) stops the reaction
(b) does not affect equilibrium
(c) favours the decomposition of N_2O_4
(d) favours the formation of N_2O_4

3. Which of the following statements regarding photochemical smog is not correct?

(a) It cause irritation in eyes and throat
(b) It is formed through photochemical reaction involving solar energy
(c) It contains components which are reducing in nature
(d) CO does not play any role in photochemical smog formation

4. Consider the following chemical equations,

I. $S + O_2 \longrightarrow SO_2;\ \Delta H_1 = -298.2$ kJ
II. $SO_2 + \frac{1}{2}O_2 \longrightarrow SO_3;\ \Delta H_2 = -98.7$ kJ
III. $SO_3 + H_2O \longrightarrow H_2SO_4;\ \Delta H_3 = -130.2$ kJ
IV. $H_2 + \frac{1}{2}O_2 \longrightarrow H_2O;\ \Delta H_4 = -287.3$ kJ

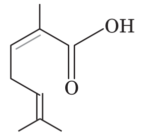
Based on the above equations, predict the enthalpy of formation of H_2SO_4.

(a) –814.4 kJ
(b) –715.4 kJ
(c) –554.0 kJ
(d) –455.3 kJ

5. Fluorine has low electron affinity than chlorine. This is because of

(a) bigger radius of fluorine and less density
(b) smaller radius of fluorine and high density
(c) smaller radius of chlorine and high density
(d) smaller radius of chlorine and less density

6. The IUPAC name of the following compound is

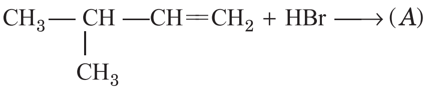


(a) 2,3-dimethyl epoxy ethane
(b) 2,6-dimethyl hepta -2,5-dienoic acid
(c) 2,5-dimethylhepta -2,6-dienoic acid
(d) 2-ethyl-3-methylcyclohexa -1,3-diene

7. Which of the following is not correctly matched ?

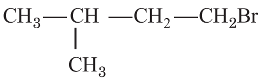
(a) ClF_3 — T-shaped
(b) PCl_5 — Trigonal bipyramidal
(c) IF_5 — Square pyramidal
(d) CCl_4 — Square planar

8. Consider the following reaction,

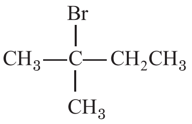


$$CH_3-\underset{\underset{CH_3}{|}}{CH}-CH=CH_2 + HBr \longrightarrow (A)$$

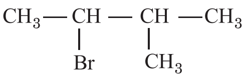
The major product *A* formed in above reaction is

(*a*)


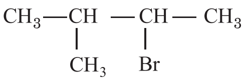
$CH_3-\underset{\underset{CH_3}{|}}{CH}-CH_2-CH_2Br$

(*b*)


$CH_3-\overset{\overset{Br}{|}}{\underset{\underset{CH_3}{|}}{C}}-CH_2CH_3$

(*c*)


$CH_3-\underset{\underset{Br}{|}}{CH}-\underset{\underset{CH_3}{|}}{CH}-CH_3$

(*d*)


$CH_3-\underset{\underset{CH_3}{|}}{CH}-\underset{\underset{Br}{|}}{CH}-CH_3$

9. Match Column I with Column II and mark the correct option using the codes that follow.

Column I (Crystal systems)	**Column II** (Edge lengths)
A. Triclinic	1. $a = b = c$
B. Tetragonal	2. $a = b \neq c$
C. Cubic	3. $a \neq b \neq c$
D. Monoclinic	

Codes

	A	B	C	D		A	B	C	D
(*a*)	3	2	1	3	(*b*)	1	2	3	2
(*c*)	2	2	1	3	(*d*)	3	2	3	1

10. Consider the following statements.

I. The boiling point of water decreases at high altitudes because of the low atmospheric pressure.

II. Liquids with stronger intermolecular attractive forces are more viscous than those with weaker intermolecular forces.

III. Cleaning action of soaps and detergents is due to lowering of interfacial tension between water and greasy substances.

Choose the correct statement(s) and mark the correct option that are given below.

(*a*) Only I
(*b*) Only II
(*c*) Both I and III
(*d*) I, II and III

11. Consider the following statements.

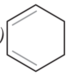
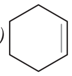
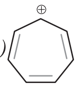
I. The chemical formula of litharge is PbO

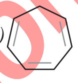
II. $(SiO_3^{2-})_n$ anions is present in the chain structure of silicates.

Choose the correct statement and mark the correct option.

(*a*) Only I
(*b*) Both I and II
(*c*) Only II
(*d*) Neither I nor II

12. Which of the following compound is aromatic ?

(*a*) 
(*b*) 
(*c*) 

(*d*) 

13. At high pressure, Langmuir adsorption isotherm takes the form,

(*a*) $\dfrac{m}{x} = \dfrac{b}{a} + \dfrac{1}{ap}$ (*b*) $\dfrac{x}{m} = \dfrac{a}{b}$

(*c*) $\dfrac{x}{m} = ap$ (*d*) $\dfrac{x}{m} = \dfrac{ap}{(1 + bp)}$

(Where respective symbols have their usual meaning)

14. Which of the following statements is incorrect ?

(*a*) The slag formed in the extraction of copper is $Cu_2O + FeS$
(*b*) The ore that is concentrated by froth-floatation process is cinnabar
(*c*) In the metallurgy of iron, the flux used is CaO
(*d*) Hydrogen is used to reduce NiO

15. Choose the incorrect statement.

(*a*) SO_3 and SO_3^{2-} both have trigonal planar geometry
(*b*) SF_4 exist but OF_4 does not
(*c*) S_8 ring is not planar
(*d*) Oxygen is more electronegative than sulphur

16. Which of the following compound of Xenon is square planar?

(*a*) XeF_2 (*b*) XeO_3F (*c*) XeO_2F_2 (*d*) XeF_4

17. Which of the following constitute a group of the isoelectronic species ?

(*a*) $BO_3^{3-}, CO_3^{2-}, NO_3^-$ (*b*) $C_2^{2-}, CO_3^{2-}, PO_4^{3-}$
(*c*) $CN^-, N_2, SO_3^{2-}, ClO_4^-$ (*d*) $C_2^{2-}, N_2, BO_3^{3-}, NO_3^-$

18. Two moles of an ideal gas is expanded isothermally and reversibly from 1L to 10L at 300K. The enthalpy change (in kJ) for the process is

(*a*) Zero (*b*) 4.8 (*c*) –11.8 (*d*) 11.4

19. Choose the correct statements regarding the electronic displacement in a covalent bond ?

(*a*) Inductive effect operates through π-bond
(*b*) Inductive effect operates through σ-bond
(*c*) Resonance effect operates through π-bond
(*d*) Both resonance and inductive effects operate through π-bond

20. The ease of adsorption of the hydrated alkali metal ions on an ion-exchange resin follows the order.

(*a*) $Li^+ < K^+ < Na^+ < Rb^+$ (*b*) $Na^+ < Li^+ < K^+ < Rb^+$
(*c*) $Rb^+ < K^+ < Na^+ < Li^+$ (*d*) $K^+ < Na^+ < Rb^+ < Li^+$

21. Different structures are generated due to rotation along C—C axis of butane. Which of the conformation is the most stable?

(*a*) Methyl — methyl *eclipse*
(*b*) Staggered — *gauche*
(*c*) Hydrogen — hydrogen *eclipse*
(*d*) Staggered — *anti*

22. A buffer solution is prepared in which the concentration of NH_3 is 0.30M and the concentration of NH_4^+ is 0.20M. If the equilibrium constant, pK_b for NH_3 is equal to 4.74, what is the pH of this solution? [$\log 2 = 0.301$, $\log 3 = 0.477$]

(a) 8.73 (b) 9.08 (c) 9.44 (d) 11.72

23. XY crystallises in a body-centred cubic lattice with edge length 'a' equal to 487 pm. The distance between two oppositely charged ions in the lattice is

(a) $\frac{\sqrt{3} \times 487}{2}$ pm
(b) $\frac{\sqrt{2} \times 487}{2}$ pm
(c) $\frac{2 \times 487}{\sqrt{2}}$ pm
(d) $\frac{2 \times 487}{\sqrt{3}}$ pm

24. Which of the following azeotropic solutions has the boiling point less than the boiling points of the constituents ?

(a) CS_2 and CH_3CHO
(b) CH_3COCH_3 and CH_3CH_2OH
(c) CH_3COCH_3 and CS_2
(d) $CHCl_3$ and CH_3COCH_3

25. Consider a hypothetical electrochemical cell, $X \mid X^+ (aM) \mid\mid Y^+ (bM) \mid Y$

The emf measured is +0.30 V. The cell reaction is

(a) $X^+ + Y \longrightarrow X + Y^+$
(b) $X^+ + e^- \longrightarrow X \,;\, Y^+ + e^- \longrightarrow Y$
(c) the cell reaction cannot be predicted
(d) $X + Y^+ \longrightarrow X^+ + Y$

26. For the reaction, $A + B \longrightarrow$ Products, it is observed that

I. On doubling the initial concentration of A only, the rate of reaction is also doubled.

II. On doubling the initial concentration of both A and B respectively, there is a change by a factor of 8 in the rate of reaction.

The rate of this reaction is given by

(a) rate $= k[A]^2[B]$
(b) rate $= k[A][B]$
(c) rate $= k[A][B]^2$
(d) rate $= k[A]^2[B]^2$

27. Acidified $K_2Cr_2O_7$ solution turns green when Na_2SO_3 is added to it. This is due to the formation of

(a) $CrSO_4$ (b) $Cr_2(SO_4)_3$ (c) CrO_4^{2-} (d) $Cr_2(SO_3)_3$

28. Which of the following complexes has a magnetic moment of 5.9 BM?

(a) $Ni(CO)_4$
(b) $[Fe(H_2O)_6]^{2+}$
(c) $[Co(NH_3)_6]^{2+}$
(d) $[MnBr_4]^{2-}$

29. The correct order for the wavelength of absorption for the given complexes in the visible region is

(a) $[Ni(NO_2)_6]^{4-} < [Ni(NH_3)_6]^{2+} < [Ni(H_2O)_6]^{2+}$
(b) $[Ni(NO_2)_6]^{4-} < [Ni(H_2O)_6]^{2+} < [Ni(NH_3)_6]^{2+}$
(c) $[Ni(H_2O)_6]^{2+} < [Ni(NH_3)_6]^{2+} < [Ni(NO_2)_6]^{4-}$
(d) $[Ni(NH_3)_6]^{2+} < [Ni(H_2O)_6]^{2+} < [Ni(NO_2)_6]^{4-}$

30. The reaction of toluene with Cl_2 in the presence of $FeCl_3$ gives X and reaction in presence of light gives Y. Thus, X and Y are

(a) X = benzal chloride ; Y = o-chlorotoluene
(b) X = benzyl chloride ; Y = m-chlorotoluene
(c) X = m-chlorotoluene ; Y = p-chlorotoluene
(d) X = o and p-chlorotoluene; Y = trichloro methyl benzene

31. A bromoalkane X reacts with magnesium in dry ether to form compound Y. The reaction of Y with methanal followed by hydrolysis yield a straight chain alcohol having molecular formula, $C_4H_{10}O$. The compound X is

(a) 2-bromopropane
(b) bromoethane
(c) 1-bromopropane
(d) bromomethane

32. The alcohol that produces turbidity immediately with Lucas reagent at room temperature is

(a) 1-hydroxy 2-methyl propane
(b) 2-hydroxy-2-methyl propane
(c) 2-hydroxy butane
(d) 1-hydroxy butane

33. Consider the following statements.

I. Conversion of ethyl alcohol into aldehyde is an example of hydrolysis.

II. Boiling point of ethyl alcohol is higher than ether due to polarity.

III. Among $KMnO_4$, $K_2Cr_2O_7$ and PCC, the most suitable reagent for the conversion of ethyl alcohol to acetaldehyde is PCC.

Choose the correct statement(s) and mark the correct option.

(a) Only I
(b) Both I and II
(c) Only III
(d) I, II and III

34. Arrange the following polymers in increasing order of their intermolecular forces

(I) Nylon -6,6; (II) Buna-S; (III) Polythene

(a) II < I < III
(b) III < II < I
(c) I < II < III
(d) II < III < I

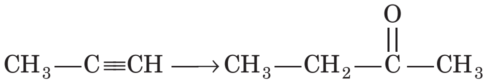
35. Match the following column I with column II and mark the correct code that are given below.

Column I (Name of reaction)	**Column II** (Major product formed in the reaction)
A. Hell-Volhard -Zelinsky reaction	1. Alkane
B. Williamson synthesis	2. Ether
C. Wurtz reaction	3. α-bromo acid

Codes

	A	B	C
(a)	3	2	1
(b)	2	1	3
(c)	1	2	3
(d)	1	3	2

36. Choose the correct reagents to carry out the following conversion.



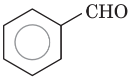
$$CH_3—C\equiv CH \longrightarrow CH_3—CH_2—\overset{\overset{O}{||}}{C}—CH_3$$

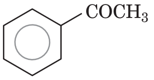
(a) $NaNH_2 / CH_3I, HgSO_4$ / dil.H_2SO_4
(b) O_SO_4, HIO_4
(c) $BH_3, H_2SO_4 / NaOH$
(d) $HgSO_4$ / dil $\cdot H_2SO_4$

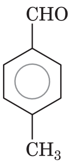
37. Acetamide and ethylamine can be distinguished by reacting with
(a) aqueous HCl and heat
(b) aqueous NaOH and heat
(c) acidified $KMnO_4$
(d) bromine water

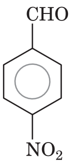
38. Sucrose on treatment with conc. HCl produces
(a) glucose
(b) glucose + fructose
(c) fructose
(d) laevunilic acid

39. Which one of the following compounds is the most reactive towards nucleophilic addition reaction?

(a)


(b)


(c)


(d)


40. Which of the following compounds undergoes both Cannizzaro and Aldol reaction?
(a) $(CH_3)_2CH.CHO$
(b) HCHO
(c) C_6H_5CHO
(d) CH_3CHO

41. Activation energy (E_a) and rate constants (K_1 and K_2) of a chemical reaction at two different temperatures (T_1 and T_2) are related as

(a) $\log_{10}\frac{K_2}{K_1} = \frac{E_a}{2.303\,R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$

(b) $\ln\frac{K_2}{K_1} = \frac{E_a}{2.303\,R}\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$

(c) $\ln\frac{K_2}{K_1} = \frac{-E_a}{R}\left[\frac{1}{T_1} + \frac{1}{T_2}\right]$

(d) $\ln\frac{K_2}{K_1} = \frac{-E_a}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$

42. Consider the following statements.
I. The kinetic energy of an element is inversely proportional to square of its momentum.
II. de-Broglie wavelength associated with a particle is directly proportional to its mass.
III. The wavelength associated with an electron is directly proportional to square root of accelerating potential.
IV. The kinetic energy of an electron is directly proportional to accelerating potential.

Choose the correct statement(s) and mark the correct option that are given below.
(a) I and II
(b) II and III
(c) III and IV
(d) Only IV

43. 50 g of N_2 (g) reacts with 10 g of H_2 (g) to form $NH_3(g)$ in Haber's process. Calculate the amount of ammonia formed in the process.
(a) 34.0 g
(b) 28.33 g
(c) 17.0 g
(d) 56.66 g

44. The angular momentum for an electron present in p-subshell is
(a) 0
(b) $\frac{\sqrt{2}h}{2\pi}$
(c) $\frac{2h}{\sqrt{2}\pi}$
(d) $2h$

45. In which of the following arrangements the given sequence is/are strictly according to the property indicated in the bracket?
(a) $CO_2 < SiO_2 < SnO_2 < PbO_2$ (Oxidising power)
(b) $H_2O < H_2S < H_2Se < H_2Te$ (K_a value)
(c) $HF < HCl < HBr < HI$ (Acidic strength)
(d) All of the above

Answers with Explanation

1. **(d)** $E_{cell} = E^\circ_{cell} - \frac{0.059}{n}\log\frac{[\text{Product}]}{[\text{Reactant}]}$

$$Sn^{2+}(0.1\,M) \longrightarrow Sn^{4+}(0.01\,M) + 2e^-$$

$$E_{cell} = E^\circ_{cell} - \frac{0.059}{2}\log\frac{[Sn^{4+}]}{[Sn^{2+}]}$$
$$= E^\circ_{cell} - \frac{0.059}{2}\log\left[\frac{0.01}{0.1}\right]$$
$$= E^\circ_{cell} - \frac{0.059}{2}\log[0.1]$$
$$= E^\circ_{cell} - \frac{0.059}{2}\times(-1)$$
$$= E^\circ_{cell} + \frac{0.059}{2}$$

2. **(c)** The given reaction is exothermic and according to Le-Chatelier's principle, high temperature will shift the equilibrium in backward direction. In other words, high temperature will favour the decomposition of N_2O_4.

3. **(c)** Photochemical smog is formed in warm and sunny climate during day time by the action of sunlight on primary pollutants. It contains nitrogen oxides, ozone, PAN etc., which are oxidising in nature. So, photochemical smog is an oxidising agent in character. It causes irritation in eyes and throat.

4. ***(a)*** The equation for the formation of H_2SO_4 can be written as

$$H_2 + S + 2O_2 \longrightarrow H_2SO_4;\ \Delta H = \Delta_f H^{\circ}_{(H_2SO_4)}$$

The above equation is the sum of the four equations given in the question.

Thus, from Hess' Law,

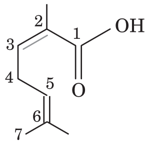
$$\Delta_f H^{\circ}_{(H_2SO_4)} = \Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4$$

$$= -298.2 + (-98.7) + (-130.2) + (-287.3)$$

$$= -814.4 \text{ kJ}$$

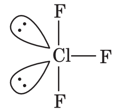
5. ***(b)*** Fluorine has low electron affinity than chlorine because of smaller size of fluorine and compact 2*p*-orbital where interelectronic repulsion is more.

6. ***(b)***

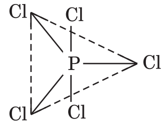


2, 6-dimethylhepta-2, 5-dienoic acid

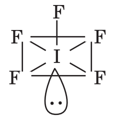
7. ***(d)***



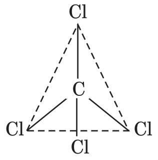
ClF_3-T-shaped



PCl_5-trigonal bipyramidal

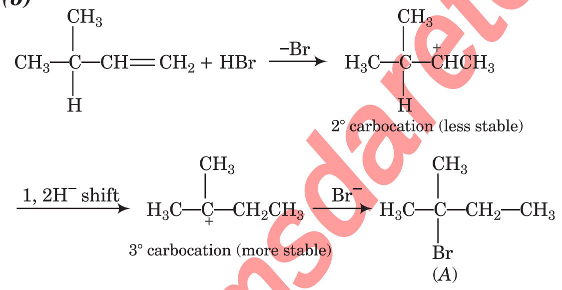


IF_5-square pyramidal



CCl_4-tetrahedral

8. ***(b)***

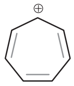


9. ***(a)*** A → 3; B → 2; C → 1; D → 3.

10. ***(d)*** The boiling point of a liquid is the temperature at which its vapour pressure becomes equal to the atmospheric pressure. At high altitudes, the atmospheric pressure becomes low hence, the boiling point of water decreases.

11. ***(b)*** I. Litharge is chemically, PbO. It is an amphoteric oxides and is used in making flint glass, as a drier in paints, varnishes, etc.

II. $[SiO_3^{2-}]_n$ and $[Si_4O_{11}^{6-}]$ are the units of chain silicates. Thus, $[SiO_3^{2-}]_n$ is present in chain structure of silicates.

12. ***(c)***  is aromatic in nature because this compound is cyclic and obeys the Huckel's rule, $(4n + 2)\pi$-electrons. It has planar structure. Thus, it follows all the essential conditions for aromaticity.

13. ***(b)*** According to Langmuir adsorption isotherm,

$$\frac{x}{m} = \frac{ap}{1 + bp}$$

At high pressure, $1 + bp \approx bp$

$$\Rightarrow \quad \frac{x}{m} = \frac{ap}{bp} = \frac{a}{b}$$

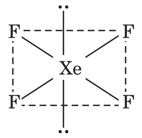
14. ***(a)*** In the extraction of copper, the impurities of iron oxide combine with silica (flux) and form insoluble slag.

Froth floatation process is used to concentrated the sulphide ores only. Thus, cinnabar i.e. HgS is concentrated by this method. Bauxite ($Al_2O_3 . 2H_2O$), malachite ($CuCO_3 . Cu(OH)_2$) and zincite (ZnO) cannot be concentrated by this method.

CaO acts as a flux as it combines with silica present as an impurity (gangue) to form slag ($CaSiO_3$).

15. ***(a)*** SO_3 is trigonal planar due to sp^2-hybridised sulphur. SO_3^{2-} is sp^3-hybridised, but pyramidal due to presence of lone pair of electron.

16. ***(d)*** XeF_4 has square planar structure. It involves sp^3d^2 hybridisation of xenon which possess octahedral geometry in which two positions are occupied by lone pairs.



17. ***(a)***

Species	Electron in central atom + other Element	Charge	Total electron
BO_3^{3-}	5 + 24 = 29	–3	32
CO_3^{2-}	6 + 24 = 30	–2	32
NO_3^-	7 + 24 = 31	–1	32
SO_3^{2-}	16 + 24 = 40	–2	42
CN^-	6 + 7 = 13	–1	14
N_2	7 + 7 = 14	0	14
C_2^{2-}	6 + 6 = 12	–2	14
PO_4^{3-}	15 + 32 = 47	–3	50
ClO_4^-	17 + 32 = 49	–1	50

Thus, BO_3^{3-}, CO_3^{2-}, NO_3^- are isoelectronic.

18. ***(a)*** We know that, $\Delta H = nC_p \Delta T$

The given process is isothermal therefore, $\Delta H = 0$

19. ***(b)*** Inductive effect is a permanent effect operates on σ-electrons while resonance involves delocalisation of π-electrons.

20. ***(c)*** Ease of adsorption of the hydrated alkali metal ions on an ion-exchange resin decreases as the size of alkali metal ion increases. The order of size of alkali metal ions increases down the group. Thus, the ease of adsorption decreases down the group. The order of size of alkali metal ions is

$$Li^+ < Na^+ < K^+ < Rb^+$$

Order of adsorption

$$Rb^+ < K^+ < Na^+ < Li^+$$

21. ***(d)*** From the given options of conformation of butane staggered-*anti* conformation is the most stable.

22. ***(c)*** $pOH = pK_b + \log\frac{[salt]}{[base]}$

$$= 4.74 + \log\frac{0.20}{0.30}$$
$$= 4.74 + (0.301 - 0.477)$$
$$= 4.74 - 0.176$$
$$= 4.56$$

$\therefore \quad pH = 14 - 4.56 \quad [\because pH + pOH = 14]$

$$= 9.44$$

23. ***(a)*** For a body centred cubic lattice,

$$2(r^+ + r^-) = \sqrt{3}a$$
$$(r^+ + r^-) = \frac{\sqrt{3}}{2}a$$
$$= \frac{\sqrt{3} \times 487}{2}$$
$$= 421.7 \text{ pm}$$

24. ***(b)*** When the new interaction is weaker than those in the constituents, the boiling point of the resultant solution is less than those of constituents. Such condition is found in case of non-ideal solution showing positive deviation from Raoult's law. Among the given solution, CH_3CH_2OH and CH_3COCH_3 is non-ideal solution and exhibit positive deviation. Hence, it has lesser boiling point or higher vapour pressure.

25. ***(d)*** The emf of the given hypothetical electrochemical cell is +0.30 V. So, cell reaction is possible.

The half-cell reactions are as follows

(i) At anode : $X \longrightarrow X^+ + e^-$ (Oxidation)

(ii) At cathode : $Y^+ + e^- \longrightarrow Y$ (Reduction)

Hence, the overall cell reaction is

$$X + Y^+ \longrightarrow X^+ + Y;\ E^\circ_{cell} = +0.30 \text{ V}.$$

26. ***(c)*** I. On doubling the initial concentration of *A* only, the rate of reaction is doubled. Thus, the order of reaction with respect to *A* is 1.

II. On doubling the initial concentration of both *A* and *B*, there is a change in the rate of reaction by a factor of 8. Thus, rate of reaction with respect to *B* is 2.

$\therefore$ Overall rate $= k[A][B]^2$

27. ***(b)*** $K_2Cr_2O_7 + 3Na_2SO_3 + 4H_2SO_4 \longrightarrow 3Na_2SO_4 + K_2SO_4 + 4H_2O + Cr_2(SO_4)_3$

28. ***(d)*** We know that, magnetic moment $(\mu) = \sqrt{n(n+2)}$

where, n = number of unpaired electrons

$$5.9 = \sqrt{n(n+2)}$$
$$(5.9)^2 = n^2 + 2n$$

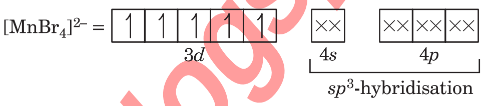
The square of 5.9 = 34.81 ≃ 35

$$\therefore \quad 35 = n^2 + 2n \Rightarrow n^2 + 2n - 35 = 0$$
$$\Rightarrow \quad n^2 + 7n - 5n - 35 = 0$$
$$n(n+7) - 5(n+7) = 0$$
$$(n+7)(n-5) = 0$$
$$n = 5, -7$$

$n = -7$ is not possible. Hence, required complex must possess 5 unpaired electrons.

In $[MnBr_4]^{2-}$, Mn is present in +2 oxidation state as

$$x + 4(-1) = -2$$
$$x = -2 + 4$$
$$x = +2$$
$$Mn^{2+}\ (Z = 25)\ ;\ [Ar]\ 3d^5$$



Hence, in $[MnBr_4]^{2-}$, five unpaired electrons are present, thus it has magnetic moment (μ) equal to 5.9 BM.

29. ***(a)*** When the central metal ion is same (here Ni^{2+}), the absorption of colour depends on the ligand. According to spectrochemical series, the strength of various ligands are as follows:

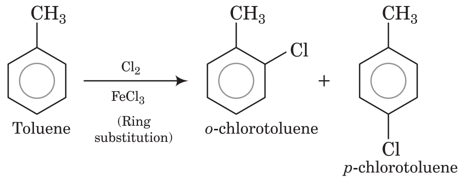
$$I^- < Br^- < Cl^- < NO_3^- < F^- < H_2O < NH_3 < NO_2^- < CN^- < CO$$

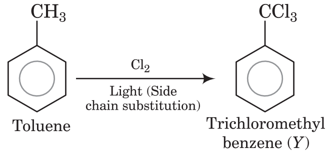
Thus, H_2O is the weakest ligand among the given options therefore, the energy of absorption will be lowest in $[Ni(H_2O)_6]^{2+}$, so it will have highest wavelength of absorption i.e. red light. $\left(\because E \propto \frac{1}{\lambda}\right)$

$\therefore$ The order of increasing wavelength is

$$[Ni(NO_2)_6]^{4-} < [Ni(NH_3)_6]^{2+} < [Ni(H_2O)_6]^{2+}$$

30. ***(d)***





31. ***(c)*** $\underset{\substack{\text{1-bromopropane} \\ (X)}}{CH_3—CH_2—CH_2—Br} + Mg \xrightarrow{\text{Dry ether}}$

$$\underset{(Y)}{CH_3CH_2CH_2MgBr} \xrightarrow{HCHO}$$

$$CH_3CH_2CH_2CH_2—O—MgBr \xrightarrow{H_2O}$$

$$\underset{\substack{\text{1–butanol} \\ (C_4H_{10}O)}}{CH_3CH_2CH_2CH_2—OH} + Mg\begin{matrix} Br \\ OH \end{matrix}$$

32. ***(b)*** Tertiary (3°) alcohol gives turbidity immediately with Lucas reagent. 2-hydroxy-2-methyl propane is a tertiary alcohol.

33. ***(c)*** I. The conversion of ethyl alcohol into acetaldehyde is an example of oxidation.

II. The boiling point of ethanol is higher than ether due to extensive intermolecular hydrogen bonding.

III. Pyridinium chlorochromate (PCC) prevents further oxidation of aldehydes to carboxylic acid

$$R\text{CH}_2\text{OH} \xrightarrow[\text{(solvent)}]{\text{PCC}}_{\text{CH}_2\text{Cl}_2} R\text{CHO} + \text{H}_2\text{O}$$

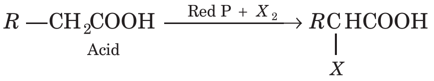
34. ***(d)*** Nylon-6,6 is a fibre in which strong intermolecular forces like hydrogen bonds are present between the chains. Buna-S is an elastomer and has weak van der Waal's forces. Polythene is thermoplastic and has intermediate intermolecular forces, which is stronger than elastomer but weaker than fibre. Thus, the order of intermolecular forces is

$$\underset{\text{(II)}}{\text{Buna-S}} < \underset{\text{(III)}}{\text{Polythene}} < \underset{\text{(I)}}{\text{Nylon-6,6}}.$$

35. ***(a)***

A. **Hell-Volhard-Zelinsky reaction**

α-chloro or α-bromo acids are usually prepared by first converting the acid into its chloride and bromide and then carrying out chlorination or bromination.



$$\underset{\text{Acid}}{R-\text{CH}_2\text{COOH}} \xrightarrow{\text{Red P} + X_2} R\underset{\underset{X}{|}}{\text{C}}\text{HCOOH}$$

where, $X \rightarrow$ Cl or Br

B. **Williamson synthesis**

It is the laboratory preparation of ether.

$$\underset{\text{Sodium alkoxide}}{R\text{ONa}} + \underset{\text{Alkyl halide}}{XR'} \xrightarrow{\Delta} \underset{\text{Ether}}{ROR'} + \text{Na}X$$

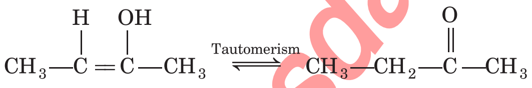
C. **Wurtz reaction**

Alkyl halide when heated with metallic sodium in ether gives alkane by joining two alkyl groups.

$$2RX + 2\text{Na} \xrightarrow{\text{Dry ether}} R-R + 2\text{Na}X$$

36. ***(a)*** $\text{CH}_3-\text{C}\equiv\text{CH} \xrightarrow[-\text{NH}_3]{\text{NaNH}_2} \text{CH}_3-\text{C}\equiv\overset{-}{\text{C}}-\overset{+}{\text{Na}} \xrightarrow[-\text{NaI}]{\text{CH}_3\text{I}}$

$$\text{CH}_3-\text{C}\equiv\text{C}-\text{CH}_3 \xrightarrow[\text{dil}\cdot\text{H}_2\text{SO}_4]{\text{HgSO}_4}$$



$$\text{CH}_3-\overset{\overset{\text{H}}{|}}{\text{C}}=\overset{\overset{\text{OH}}{|}}{\text{C}}-\text{CH}_3 \xrightleftharpoons{\text{Tautomerism}} \text{CH}_3-\text{CH}_2-\overset{\overset{\text{O}}{\|}}{\text{C}}-\text{CH}_3$$

37. ***(b)*** Acetamide and ethylamine can be distinguished by heating with NaOH solution. As acetamide liberates NH_3 but ethylamine does not liberates NH_3.

$$\text{CH}_3\text{CONH}_2 + \text{NaOH} \xrightarrow{\Delta} \text{CH}_3\text{CO}\overset{-}{\text{O}}\overset{+}{\text{N}}\text{a} + \text{NH}_3$$

$$\text{CH}_3\text{CH}_2\text{NH}_2 + \text{NaOH} \longrightarrow \text{No reaction}$$

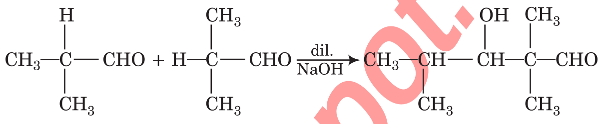
38. ***(d)*** Sucrose on reacting with conc. HCl forms laevunilic acid.

$$\underset{\text{Sucrose}}{\text{C}_{12}\text{H}_{22}\text{O}_{11}} \xrightarrow{\text{conc. HCl}} \underset{\text{Laevunilic acid}}{\text{CH}_3\text{COCH}_2\text{CH}_2\text{COOH}}$$

$$\text{C}_{12}\text{H}_{22}\text{O}_{11} \xrightarrow{\text{Enzyme}} \underset{\text{Glucose}}{\text{C}_6\text{H}_{12}\text{O}_6} + \underset{\text{Fructose}}{\text{C}_6\text{H}_{12}\text{O}_6}$$

39. ***(d)*** Reactivity of carbonyl compounds towards nucleophilic addition reactions depends upon the presence of substituted group. Electron withdrawing groups increases the reactivity towards nucleophilic addition reactions.

40. ***(a)*** 2-methylpropanol contain one α-H-atom, hence it undergoes Aldol condensation.



$$\text{CH}_3-\overset{\overset{\text{H}}{|}}{\underset{\underset{\text{CH}_3}{|}}{\text{C}}}-\text{CHO} + \text{H}-\overset{\overset{\text{CH}_3}{|}}{\underset{\underset{\text{CH}_3}{|}}{\text{C}}}-\text{CHO} \xrightarrow[\text{NaOH}]{\text{dil.}} \text{CH}_3-\underset{\underset{\text{CH}_3}{|}}{\text{CH}}-\overset{\overset{\text{OH}}{|}}{\text{CH}}-\overset{\overset{\text{CH}_3}{|}}{\underset{\underset{\text{CH}_3}{|}}{\text{C}}}-\text{CHO}$$

It also undergoes Cannizzaro's reaction.

$$2(\text{CH}_3)_2\text{CH}\cdot\text{CHO} \xrightarrow[473\text{ K}]{\text{NaOH}} (\text{CH}_3)_2-\text{CHCO}\overset{-}{\text{O}}\overset{+}{\text{Na}} + (\text{CH}_3)_2\text{CHCH}_2\text{OH}$$

41. ***(a)*** $\ln\dfrac{K_2}{K_1} = \dfrac{-E_a}{R}\left[\dfrac{1}{T_2} - \dfrac{1}{T_1}\right]$; $\log_{10}\dfrac{K_2}{K_1} = \dfrac{E_a}{2.303\,R}\left[\dfrac{1}{T_1} - \dfrac{1}{T_2}\right]$

42. ***(d)*** The kinetic energy of an electron is directly proportional to accelerating potential.

$$\therefore \quad \frac{1}{2}mv^2 = \text{eV}$$

$$\therefore \quad \text{KE} \propto V \quad (\text{where}\,; V = \text{potential difference})$$

43. ***(d)*** In Haber's process,

$$\underset{28\text{g}}{\text{N}_2(g)} + \underset{6\text{g}}{3\text{H}_2(g)} \rightleftharpoons \underset{34\text{g}}{2\text{NH}_3(g)}$$

6g of hydrogen requires = 28 g of nitrogen

$10\text{g of H}_2 \text{ requires} = \dfrac{28 \times 10}{6} = 46.66 \text{ g of nitrogen}$

∴ Hydrogen is limiting regent.

6g of hydrogen produces 34g of ammonia.

$10\text{g of hydrogen produces} = \dfrac{34 \times 10}{6} = 56.6 \text{ g of ammonia}$

44. ***(b)*** Orbital angular momentum $(\mu) = \sqrt{l\,(l+1)}\,\dfrac{h}{2\pi}$

For p-subshell, $l = 1$

$$\therefore \quad \mu = \sqrt{1\,(1+1)}\,\frac{h}{2\pi}$$

$$= \sqrt{2}\,\frac{h}{2\pi}$$

45. ***(d)*** (a) On moving from top to bottom, oxidising power of oxides increases. Thus, order of oxidising power of oxides of IVA group elements is

$$\text{CO}_2 < \text{SiO}_2 < \text{SnO}_2 < \text{PbO}_2$$

(b) As we move from top to bottom in a group, acidic nature (K_a) increases. Therefore, $\text{p}K_a$ value decreases. Thus, order of $\text{p}K_a$ values of hydrides of IVA group element is

$$\text{H}_2\text{O} > \text{H}_2\text{S} > \text{H}_2\text{Se} > \text{H}_2\text{Te}$$

and order of K_a values of hydrides is

$$\text{H}_2\text{O} < \text{H}_2\text{S} < \text{H}_2\text{Se} < \text{H}_2\text{Te}$$

(c) As we move from top to bottom in a group, acidic strength of hydrides increases. Therefore, order of acidic strength of hydrides of VIIA group element is

$$\text{HF} < \text{HCl} < \text{HBr} < \text{HI}.$$

MEDI QUEST

Comprehensive Simulator Test Series for NEET & AIIMS

NEET SCALE UP

Mock Questions from Complete Syllabus with Answer key.

FULL TEST 6

(Complete Syllabus)
WITH ANSWER KEY

INSTRUCTIONS

- This test consists of 45 questions and each question is allotted 4 marks for correct response.
- Candidates will be awarded marks as stated above for correct response of each question. 1/4 marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
- There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted according as per instructions.

1. Resistance of a salt solution is 32 ohm. Distance between its electrodes and cross-sectional area are 1.80 cm and 54 cm^2, respectively. The equivalent conductivity of solution is
(a) 105 ohm^{-1}cm^2.eq^{-1}
(b) 104.2 ohm^{-1}cm^2.eq^{-1}
(c) 140.2 ohm^{-1}cm^2.eq^{-1}
(d) 110.5 ohm^{-1}cm^2.eq^{-1}

2. The electron affinity of halogens are F = 322, Cl = 349, Br = 324, I = 295 kJ mol^{-1}. The higher value for Cl as compared to that of F is due to
(a) weaker electron-electron repulsion in Cl
(b) higher atomic radius of F
(c) smaller electronegativity of F
(d) more vacant *p*-subshell in Cl

3. For producing the effective collisions, the colliding molecules must have
(a) proper orientation with energy lesser than threshold energy
(b) improper orientation with energy equal to threshold energy
(c) proper orientation with energy equal to or greater than threshold energy
(d) a certain minimum amount of energy

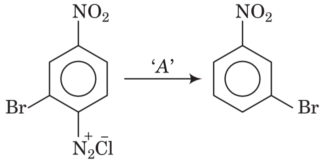
4. During electrolysis of a solution of $AgNO_3$, 96500 C charge pass through the electroplating bath. The mass of silver deposited on the cathode is
(a) 10.8 g (b) 108 g (c) 1.08 g (d) 21.6 g

5. When $CH_2=CH-COOH$ is reduced with $LiAlH_4$, the compound obtained will be
(a) CH_3CH_2COOH
(b) $CH_2=CH-CH_2OH$
(c) $CH_3CH_2CH_2OH$
(d) CH_3CH_2CHO

6. An alkene on vigorous oxidation with $KMnO_4$ gives only acetic acid. The alkene is
(a) $CH_3CH_2CH=CH_2$
(b) $CH_3CH=CHCH_3$
(c) $(CH_3)_2C=CH_2$
(d) $CH_3CH=CH_2$

7. For mixing of two ideal gases at 30°C and 2 atm pressure, which of the following is correct.
(a) $\Delta G_{mix}=0, \Delta S_{mix}=0, \Delta H_{mix}=0,$
(b) $\Delta G_{mix}=0, \Delta S_{mix}=0, \Delta V_{mix}=0,$
(c) $\Delta G_{mix}=0, \Delta S_{mix}>0, \Delta H_{mix}=0,$
(d) $\Delta G_{mix}=0, \Delta S_{mix}=0, \Delta H_{mix}>0,$

8. In the reaction,



The reagent '*A*' is
(a) H_3PO_2 (b) Cu_2Cl_2
(c) $HgSO_4/H_2SO_4$ (d) H^+/H_2O

9. A compound containing only carbon,hydrogen and oxygen has a molecular weight of 44 g mol^{-1}. On complete oxidation it is converted into a compound of molecular weight 60 g mol^{-1}. The original compound is an

(a) aldehyde *(b)* acid *(c)* alcohol *(d)* ether

10. A substance is completely trimerised on dissolution in a solvent. The van't Hoff factor (*i*) for such change is

(a) 1 *(b)* 2 *(c)* $\frac{1}{3}$ *(d)* 3

11. For adsorption of gas on solid surface, the plots of $\log\ x/m$ *vs* $\log\ p$ is linear with a slope of

(a) $\log\ k$ *(b)* $\frac{1}{n}$ *(c)* k *(d)* $\frac{1}{nk}$

12. A solution is given which is a mixture of 0.05 M NaCl and 0.05 M NaI. The concentration of iodide ion in the solution when AgCl just starts precipitating is equal to

(K_{sp} of AgCl $= 1\times10^{-10}\ M^2$, K_{sp} of AgI $= 4\times10^{-16}\ M^2$)

(a) 2×10^{-7} M *(b)* 2×10^{-9} M
(c) 2×10^{-8} M *(d)* 4×10^{-6} M

13. Ionic solids with Schottky defects contain in their structure

(a) cation vacancies only
(b) cation vacancies and interstitial cations
(c) equal number of cations and anion vacancies
(d) interstitial anions and anion vacancies

14. Which of the following representation is correct for the cell reaction occurring at equilibrium in an electrochemical cell?

(a) $E^\circ_{cell} = \frac{2.303RT}{nF}\log\ K_{eq}$ *(b)* $\Delta G^\circ = -\ 2.303RT\log\ K_{eq}$
(c) $-\Delta G^\circ = RT\ln K_{eq}$ *(d)* All of these

15. If the solubility of lead chloride is '*k*', then the number of moles of Cl ions in 1000 mL of saturated lead chloride solution will be

(a) $\frac{k}{2}$ *(b)* $\left(\frac{k}{4}\right)^{\frac{1}{3}}$ *(c)* $(2k)^{\frac{1}{3}}$ *(d)* $k^{\frac{1}{2}}$

16. The frequency of radiation emitted when the electron falls from $n = 4$ to $n = 1$ in a hydrogen atom will be (given, ionisation energy of H $= 2.18\times10^{-18}$ J $atom^{-1}$ and $h = 6.625\times10^{-34}$ Js).

(a) $1.54\times10^{15}\ s^{-1}$ *(b)* $1.03\times10^{15}s^{-1}$
(c) $3.08\times10^{15}s^{-1}$ *(d)* $2\times10^{15}s^{-1}$

17. Consider the following reaction,

$$C_2H_5\overset{-}{O}\overset{+}{K}+C_2H_5I\xrightarrow{\Delta}X\text{ (pleasant smelling liquid)}$$

Which of the following reagents converts ethyl bromide to *X*?

(a) Sodium *(b)* Dry silver oxide
(c) Ethyl chloride *(d)* Dry silver powder

18. Which one of the following statement regarded to borax is incorrect?

(a) It produces alkaline solution when dissolved in water
(b) It is prepared from colemanite ore
(c) All boron atoms are present in same hybridisation state
(d) It produces B_2O_3, $NaBO_2$ and H_2O on strong heating

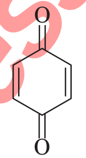
19. In which of the following complex, magnetic moment changed when all the ligands are replaced by CN^- ion to form cyano complex ion?

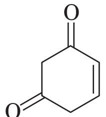
(a) $[Co(H_2O)_6]^{3+}$ *(b)* $[NiCl_4]^{2-}$
(c) $[Fe(NO_2)_6]^{4-}$ *(d)* $[Ni(H_2O)_6]^{2+}$

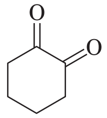
20. Which one of the following statements related to the chemical properties of lanthanoids (Ln) is incorrect?

(a) It reacts with water at room temperature to produce $Ln(OH)_3$ and H_2
(b) At elevated temperature, (Ln) reacts with nitrogen to produce Ln_3N_2 type salt
(c) They produce H_2 gas with dil. acid
(d) They produce Ln_2O_3 type oxides when burn in O_2

21. Which among the following given molecules can exhibit tautomerism?


I


II


III

(a) Only I *(b)* II and III
(c) I and II *(d)* I and III

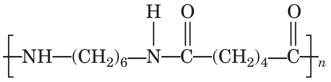
22. The *d*-orbital involved in the hybridisation of the PCl_5 molecule is

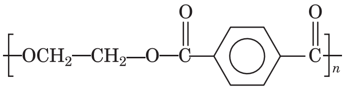
(a) $3d_{x^2-y^2}$ *(b)* $3d_{z^2}$ *(c)* $3d_{xy}$ *(d)* $4d_{x^2-y^2}$

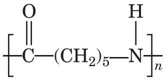
23. Aluminium reacts with NaOH and forms compound '*X*'. If the coordination number of aluminium in '*X*' is 6, the correct formula of '*X*' is

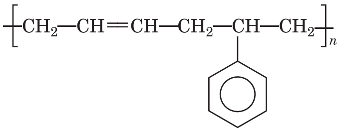
(a) $[Al(H_2O)_4(OH)_2]^+$ *(b)* $[Al(H_2O)_3(OH)_3]$
(c) $[Al(H_2O)_2(OH)_4]^-$ *(d)* $[Al(H_2O)_6](OH)_3$

24. Which one of the following structures represents dacron polymer?

(a)

$$\left[NH-(CH_2)_6-\overset{H}{\overset{|}{N}}-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}\right]_n$$

(b)


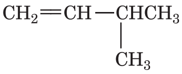
(c)

$$\left[\overset{O}{\overset{\|}{C}}-(CH_2)_5-\overset{H}{\overset{|}{N}}\right]_n$$

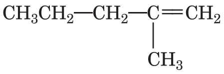
(d)


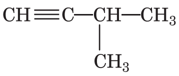
25. The molality of a 1 L solution with X % by mass of H_2SO_4 is equal to 10. The mass of the solvent present in the solution is 900 g. The value of X is

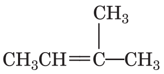
(a) 85.5 *(b)* 80.2
(c) 88.2 *(d)* 57.5

26. A hydrocarbon reacts with HI to give *(A)* which on further reacting with aqueous KOH forms (B). (B) on oxidation gives 3-methyl-2-butanone. The hydrocarbon is

(a)

$CH_2{=}CH{-}CH(CH_3)CH_3$

(b)

$CH_3CH_2{-}CH_2{-}C(CH_3){=}CH_2$

(c)

$CH{\equiv}C{-}CH(CH_3){-}CH_3$

(d)

$CH_3CH{=}C(CH_3){-}CH_3$

27. $E°$ of $Mg^{2+}|Mg$, $Zn^{2+}|Zn$ and $Fe^{2+}|Fe$ are –2.37 V, –0.76 V and – 0.44 V, respectively. Which of the following statement is correct?

(a) Zn will oxidises Fe

(b) Zn will reduces Fe^{2+}

(c) Mg will oxidises Fe

(d) Zn will reduces Mg^{2+}

28. Anhydrous $AlCl_3$ cannot be obtained from which of the following reactions

(a) By passing dry Cl_2 over a hot mixture of alumina and coke
(b) Heating $AlCl_3.6H_2O$
(c) By passing dry HCl over hot aluminium
(d) By passing dry Cl_2 over hot aluminium powder

29. Which one of the following statements concerning properties of solution, describes a colligative effect?

(a) Boiling point of pure water decreases by the addition of ethanol
(b) Vapour pressure of pure water decreases by the addition of nitric acid
(c) Vapour pressure of pure benzene decreases by the addition of naphthalene
(d) Boiling point of pure benzene increases by the addition of toluene

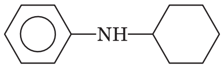
30. For an octahedral complex, which of the following d-electronic configuration will give maximum CFSE value?

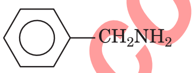
(a) High spin d^7 *(b)* High spin d^6
(c) Low spin d^5 *(d)* Low spin d^4

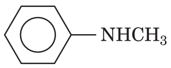
31. Which one of the following statement is not true for standard hydrogen electrode?

(a) Pressure of hydrogen is 1 atmosphere
(b) It contains a metallic conductor which does not adsorb hydrogen
(c) Temperature is 25°C
(d) The hydrogen ion concentration is 1 M

32. Which one of the following amines yields N-nitroso amine on treatment with $NaNO_2$ / HCl ?

(a)


(b)


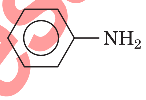
(c)


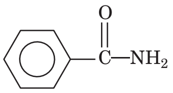
(d)

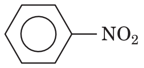

33. Which one of the following statements is incorrect?

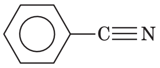
(a) $(CH_3)_2CH \cdot CH(NH_2)COOH$ can exist as Zwitter ion
(b) RNA contains thymine
(c) $H_2\overset{+}{N}CH_2COOH$ is more acidic than RCH_2COOH
(d) The energy in the cells of a living body is stored in the form of ATP

34. An organic compound (X) on reduction gives a compound (Y) which on further reaction with $CHCl_3$ and NaOH form (Z). The compound (Y) on catalytic reduction gives N-methylaniline.
The compound (X) is

(a)


(b)


(c)


(d)


35. One mole of a substance (A) on reacting with excess of water, gives two mole of readily combustible gas and an alkaline solution. The alkaline solution gives white turbidity with SO_2. The substance (A) is

(a) NaH *(b)* $CaCO_3$
(c) $Be(OH)_2$ *(d)* CaH_2

36. Which one of the following statements is correct?

(a) Hybridised orbitals always form σ-bonds

(b) sp^2-hybridised orbitals have equal s-and p-character

(c) $\overset{+}{C}H_3$ shows sp^2-hybridisation whereas $\overset{-}{C}H_3$ shows sp-hybridisation

(d) $\overset{+}{N}H_4$ has a distorted tetrahedral geometry

37. Arrange the following $\overset{+}{N}H_4, H_3\overset{+}{O}, HF, H_2O$ and $\overset{-}{O}H$ in decreasing order of acidic nature.

(a) $\overset{+}{N}H_4 > HF > H_3\overset{+}{O} > H_2O > \overset{-}{O}H$

(b) $H_3\overset{+}{O} > HF > \overset{+}{N}H_4 > H_2O > \overset{-}{O}H$

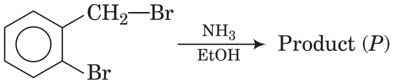
(c) $H\overset{-}{O} > H_2O > \overset{+}{N}H_4 > HF > H_3\overset{+}{O}$

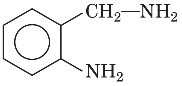
(d) $H_3\overset{+}{O} > \overset{+}{N}H_4 > HF > \overset{-}{O}H > H_2O$

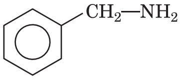
38. In which of the following pairs the two molecules have identical bond order?

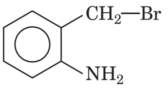
(a) N_2^-, O_2 *(b)* N_3^+, O_2
(c) N_2, O_2^{2+} *(d)* O_2^+, N_2

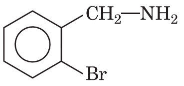
39. What is the major product (*P*) obtained in the following reaction?



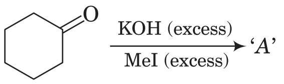
(a) 

(b) 

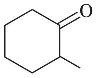
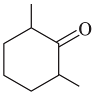
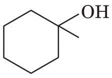
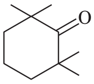
(c) 

(d) 

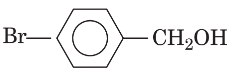
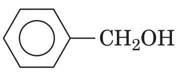
40.

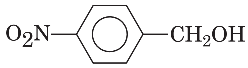
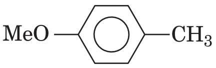


The product (*A*) of the above reaction is

(a) 
(b) 
(c) 
(d) 

41. Consider the following compounds,

I.  II. 

III.  IV. 

The decreasing order of their reactivity for nucleophilic substitution with HBr is

(a) IV > III > II > I (b) IV > II > I > III
(c) III > I > II > IV (d) I > II > IV > III

42. Which of the following is the correct order for the acidic strength of the given compounds?

I. $CH_3C \equiv CCOOH$ II. $CH_3CH_2CH_2COOH$
III. $CH_3CH_2CH_2CH_2OH$ IV. $CH_3CH = CHCOOH$

(a) II < III < I < IV (b) I < IV < III < II
(c) III < II < IV < I (d) I < II < III < IV

43. Bleaching powder loses its effect on keeping for a long time because

(a) it absorbs moisture
(b) it changes into calcium hypochlorate
(c) it changes into calcium chloride and calcium chlorate.
(d) it changes into calcium chloride and calcium hydroxide.

44. In which of the following reactions, H_2O_2 acts as a reducing agent?

(a) $Ag_2O + H_2O_2 \longrightarrow 2Ag + H_2O + O_2$
(b) $PbS + 4H_2O_2 \longrightarrow PbSO_4 + 4H_2O$
(c) $H_2O_2 + SO_2 \longrightarrow H_2SO_4$
(d) $2KI + H_2O_2 \longrightarrow 2KOH + I_2$

45. A compound has magnetic moment of 1.73 BM. Select the possible configuration of central metal and geometry, respectively.

(a) d^5 (low spin), octahedral (b) d^9, tetrahedral
(c) d^7 (low spin), octahedral (d) All of the above

Answers

1. (b)	**2.** (a)	**3.** (c)	**4.** (a)	**5.** (b)
6. (b)	**7.** (c)	**8.** (a)	**9.** (a)	**10.** (c)
11. (b)	**12.** (a)	**13.** (c)	**14.** (d)	**15.** (c)
16. (c)	**17.** (b)	**18.** (c)	**19.** (b)	**20.** (b)
21. (b)	**22.** (b)	**23.** (c)	**24.** (b)	**25.** (c)
26. (a)	**27.** (b)	**28.** (b)	**29.** (c)	**30.** (c)
31. (b)	**32.** (c)	**33.** (b)	**34.** (c)	**35.** (d)
36. (a)	**37.** (b)	**38.** (c)	**39.** (d)	**40.** (d)
41. (b)	**42.** (c)	**43.** (c)	**44.** (a)	**45.** (d)

Continued from Page 37

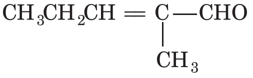
The product obtained in the first test tube can be converted into product which is identical in all respect with that obtained in the second test tube.

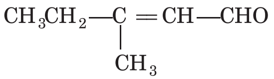
17. The respective reactions involved in the two test tubes are

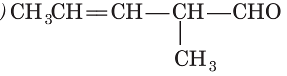
(a) Aldol condensation and Cannizzaro reaction
(b) Aldol condensation and Perkin reaction
(c) Aldol condensation and Knoevenagel reaction
(d) Aldol condensation and Claisen condensation

18. What would have been the final product when ethanal of the first test tube is replaced by propanal?

(a) $CH_3CH_2CH = CHCH_2CHO$

(b) 
$CH_3CH_2CH = \underset{\displaystyle CH_3}{\underset{|}{C}}-CHO$

(c) 
$CH_3CH_2-\underset{\displaystyle CH_3}{\underset{|}{C}} = CH-CHO$

(d) 
$CH_3CH{=}CH-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CHO$

Answers

Paper 1

1. (b)	**2.** (b)	**3.** (a)	**4.** (b)	**5.** (a)	**6.** (b,c)	**7.** (a,b,d)	**8.** (a,b,c,d)	**9.** (a,d)	**10.** (b,c)
11. (b,c,d)	**12.** (a,b,c,d)	**13.** (b,d)	**14.** (1)	**15.** (6)	**16.** (7)	**17.** (8)	**18.** (0)		

Paper 2

1. (d)	**2.** (b)	**3.** (a)	**4.** (b)	**5.** (a)	**6.** (b)	**7.** (a,b,c)	**8.** (a,b,c)	**9.** (a,b,c)	**10.** (b,d)
11. (b,c)	**12.** (a,b,c)	**13.** (a,b,c,d)	**14.** (a,c,d)	**15.** (a)	**16.** (a)	**17.** (c)	**18.** (b)		

QUALITATIVE AND QUANTITATIVE ANALYSIS

Stepwise Learning and Practice through Selective Problems

① In Duma's method for estimation of nitrogen, 0.3 g of an organic compound gave 50 cm^3 of nitrogen collected at 300 K and 715 mm pressure. Calculate the percentage of nitrogen in the compound (vapour pressure of water or aqueous tension of water at 300 K is 15mm).

(a) 17.46 (b) 19.31
(c) 25.12 (d) 28.01

(a) **Step I** *Convert the volume at experimental conditions to volume at STP.*

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

$$\frac{700\,\text{mm} \times 50\,\text{cm}^3}{300\text{ K}} = \frac{760\,\text{mm} \times V_2\,\text{cm}^3}{273\text{K}}$$

[∵ Actual pressure of the gas (dry gas) $= 715 - 15 = 700$ mm Hg]

$$V_2 = \frac{273 \times 700 \times 50}{300 \times 760} = 41.9\,\text{cm}^3$$

Step II *Convert the volume at STP into mass.*

According to the definition of gram molar volume, 22400 cm^3 of nitrogen at STP weigh = 28g

∴ 41.9 cm^3 of nitrogen at STP weigh

$$= \frac{28 \times 41.9}{22400}\text{g}$$

Step III *Finally, write the equation for percentage of nitrogen and substitute the above calculated values.*

Percentage (%) of nitrogen

$$= \frac{\text{Mass of } N_2 \text{ at STP}}{\text{Mass of the substance taken}} \times 100$$

$$= \frac{28 \times 41.9}{22400 \times 0.3} \times 100$$

$$= 17.46$$

TRY THESE!

1. In estimation of nitrogen by Duma's method, 1.18 g of an organic compound gave 224 mL of N_2 at NTP. The percentage of nitrogen in the compound is

(a) 20 (b) 11.8
(c) 47.7 (d) 23.7

2. In the Duma's method of estimation of nitrogen, the nitrogen in the organic compound is finally converted into

(a) NO_2 (b) N_2
(c) HNO_3 (d) $NaNO_3$

1. (d) **2.** (b)

② In Carius method of estimation of halogens, 250 mg of an organic compound gave 141 mg of AgBr. The percentage of bromine in the compound is (atomic mass Ag = 108, Br = 80)

[JEE Main 2015]

(a) 24 (b) 36
(c) 48 (d) 60

(a) **Step I** *Write the expression for % of bromine by Carius method.*

$$\%\text{ of Br} = \frac{\text{Atomic weight of Br}}{\text{Molecular weight of AgBr}} \times \frac{\text{Weight of AgBr}}{\text{Weight of organic bromide}} \times 100$$

Step II *Substitute all the known values in the expression obtained in step-I.*

$$\%\text{ of Br} = \frac{80}{188} \times \frac{\text{Weight of AgBr}}{\text{Weight of organic bromide}} \times 100$$

Step III *Finally, substitute all the values which is given in the question.*

$$\%\text{ of Br} = \frac{80}{188} \times \frac{141}{250} \times 100$$

$$= \frac{1128000}{47000} = 24\%$$

TRY THESE!

1. In Carius method containing 0.099 g of organic compound gave 0.287g AgCl. The percentage of chlorine in the compound will be

(a) 28.6
(b) 71.7
(c) 35.4
(d) 64.2

2. 0.197 g of an organic substance when heated with excess of strong nitric acid and silver nitrate gave 0.3525 g of silver iodide. The percentage of iodine in the compound is

(a) 84.6%
(b) 38.6%
(c) 96.68%
(d) 53.86%

3. An organic compound weighing 0.31g gave 0.444 g of magnesium pyrophosphate in the estimation of phosphorus by Carius method. The percentage of P in the compound is

(a) 20 (b) 60
(c) 40 (d) 30

1. (b) **2.** (c) **3.** (c)

③ For the estimation of nitrogen, 1.4 g of an organic compound was digested by Kjeldahl's method and the evolved ammonia was absorbed in 60 mL of $M/10$ sulphuric acid. The unreacted acid required 20 mL of $M/10$ sodium hydroxide for the complete neutralisation. The percentage of nitrogen in the compound is [JEE Main 2014]

(a) 6% (b) 10% (c) 3% (d) 5%

(b) **Step I** *Write the balanced chemical reaction for the conversion of N present in organic compound to ammonia, ammonia to ammonium sulphate and neutralisation of acid by* NaOH.

$$\text{Organic compound} \longrightarrow NH_3$$
$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4 \qquad \text{...(i)}$$
$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O \qquad \text{...(ii)}$$

Step II *Calculate the millimoles (mmol) of* N *present in organic compound followed by mass of* N *present in organic compound using the concept of stoichiometry.*

Initially mmoles of H_2SO_4 taken = 6, mmoles of H_2SO_4 reacted in Eqn. (ii) = 1

$\therefore$ mmoles of H_2SO_4 reacted from Eqn. (i) $= 6 - 1 = 5$ mmol

mmoles of NH_3 in Eqn. (i) $= 2 \times 5 = 10$ mmol

mmoles of N-atom in organic compound = 10 mmol

Mass of N $= 10 \times 10^{-3} \times 14 = 0.14$ g

Step III *Write the expression for estimation of % of* N *in an organic compound using Kjeldahl's method.*

$$\% \text{ of N} = \frac{\text{Mass of N} \times 100}{\text{Mass of organic compound}}$$

Step IV *Substitute the values to calculate % of* N *in an organic compound.*

$$\% \text{ of N} = \frac{0.14}{1.4} \times 100 = 10\%$$

TRY THESE!

1. In Kjeldahl's method, ammonia from 5 g of food neutralises 30 cm^3 of 0.1N acid. The percentage of nitrogen in the food is
   (a) 0.84 (b) 16.8 (c) 1.68 (d) 8.4
2. 1.2 g of organic compound on Kjeldalisation liberates ammonia which consumes 30 cm^3 of 1 N HCl. The percentage of nitrogen in the organic compound is
   (a) 30 (b) 17.45 (c) 35 (d) 46.67

1. (a) **2.** (c)

④ Organic compound '*A*' ⟶ Lassaigne's extract

$$\begin{tikzcd}
\text{Organic compound 'A'} \arrow[r] & \text{Lassaigne's extract} \arrow[dl, "\text{Path 'I'}"', "Na_2[Fe(CN)_5NO]"] \arrow[d, "\text{Path 'II'}"', "\text{(i) }Fe^{2+}\text{ (ii) }H_2SO_4"] \\
\text{Violet coloured complex} & \text{Prussian blue coloured complex}
\end{tikzcd}$$

The above Lassaigne's extract on treatment with Fe^{2+} does not give blood red colour because of the

(a) absence of S in the organic compound
(b) presence of halogen in the organic compound
(c) dissociation of NaSCN into Na_2S and NaCN
(d) conversion of NaSCN into HSCN

(c) **Step I** *Write the interpretation obtained by path*-I.

Lassaigne's extract give violet colour complex, which clearly confirms the presence of sulphur.

$$Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow \underset{\text{Violet colour}}{Na_4[Fe(CN)_5NOS]}$$

Step II *Write the interpretation obtained by path*-II.

The formation of prussian blue coloured complex confirms the presence of nitrogen.

Step III *Since, the Lassaigne's extract doesn't give red colour complex it means excess of Na metal is present.*

Excess of Na metal caused dissociation of NaSCN into Na_2S and NaCN

$$2Na + NaSCN \xrightarrow{\Delta} Na_2S + NaCN$$

TRY THESE!

1. Which of the following compounds gives blood red colouration when its Lassaigne's extract is treated with alkali and ferric chloride?
   (a) Thiourea (b) Diphenyl sulphide (c) Phenyl hydrazine (d) Benzamide.
2. The sodium extract of an organic compound on boiling with HNO_3 and addition of ammonium molybdate solution gives a yellow precipitate. The compound contains
   (a) nitrogen (b) phosphorus (c) sulphur (d) chlorine

1. (a) **2.** (b)

⑤ For a following given reaction which of the statement(s) is/are correct.

$$K_3[Fe(CN)_6] + \underset{\text{Excess}}{KI} \xrightarrow[H_2SO_4]{\text{dilute}}$$

$$\text{Brownish yellow solution} + \text{Brownish yellow ppt}$$

$$\downarrow ZnSO_4 \qquad\qquad \downarrow Na_2S_2O_3$$

$$\text{White ppt} \qquad\qquad \text{Colourless solution}$$

(a) The first reaction is a redox reaction
(b) White precipitate is $Zn_3[Fe(CN)_6]_2$
(c) Addition of filtrate to starch solution gives blue colour
(d) White precipitate is soluble in NaOH solution

(a,c,d) **Step I** *Write the equation of the reaction between* $K_3[Fe(CN)_6]$ *and* KI *which is present in excess.*

$$K_3[Fe(CN)_6] + \underset{\text{Excess}}{3KI} \xrightarrow{\text{dil. }H_2SO_4} \underset{\text{Brownish yellow solution}}{K_4[Fe(CN)_6]} + \underset{\text{Brownish yellow ppt.}}{2KI_3}$$

It is a redox reaction.

Step II Write the equation of the reaction between $K_4[Fe(CN)_6]$ with $ZnSO_4$ in which white ppt is obtained.

$$K_4[Fe(CN)_6] + ZnSO_4 \longrightarrow \underset{\text{White ppt}}{K_2Zn[Fe(CN)_6]} + K_2SO_4$$

Step III *Write the equation for the reaction of filtrate to starch solution.*

$$\underset{\text{Brownish yellow filtrate}}{I_3^-} + 2Na_2S_2O_3 \longrightarrow \underset{\text{Clear solution}}{Na_2S_4O_6} + NaI + \underset{\text{Turns starch solution blue}}{I_2}$$

Step IV *Write the equation for the reaction of* $K_2Zn[Fe(CN)_6]$ *(white ppt) with* NaOH

$$K_2Zn[Fe(CN)_6] + NaOH \longrightarrow [Zn(OH)_4]^{2-} + [Fe(CN)_6]^{4-}$$

TRY THESE!

1. $[X] + H_2SO_4 \longrightarrow [Y]$ a colourless gas with irritating smell. $[Y] + K_2Cr_2O_7 + H_2SO_4 \longrightarrow$ green solution. $[X]$ and $[Y]$ are [IIT JEE 2013]
   (a) SO_3^{2-}, SO_2 (b) Cl^-, HCl (c) S^{2-}, H_2S (d) CO_3^{2-}, CO_2
2. A solution of colourless salt H on boiling with excess of NaOH produces a non-flammable gas. The gas evolution ceases after sometime. Upon addition of Zn dust to the same solution, the gas evolution restarts. The colourless salt(s) H is [IIT JEE 2008]
   (a) NH_4NO_3 (b) NH_4NO_2 (c) NH_4Cl (d) $(NH_4)_2SO_4$

1. (a) **2.** (a, b)

SOLID STATE

FOR CLASS XII

Topicwise Collection of Best Subjective Problems

Very Short Answer Type [1 Mark]

1. Why crystalline solids are anisotropic in nature?

2. What are end-centred unit cells?

3. Calculate the radius ratio of calcium oxide (CaO) when radii of calcium ion and oxide ion are 94 pm and 146 pm, respectively?

4. Define *p*-type semiconductors.

5. An element '*X*' with atomic radius 0.414nm crystallises in body centred unit cell. What is the edge length of the unit cell?

6. What are the cell parameters in hexagonal crystal system?

Short Answer Type [2 Marks]

7. Why density of crystal decreases in Schottky defect?

8. Inspite of long range order in the arrangement of particles why are the crystals usually not perfect. [NCERT Exemplar]

9. Define the term doping and how conductivity of intrinsic semiconductors increases by doping?

10. An atom crystallises in bcc arrangement. What is the packing efficiency of the arrangement?

11. Why crystals of NaCl appears yellow in colour?

12. Give one point of difference between ferromagnetic and ferrimagnetic substances with an example of each?

13. What is the coordination number of the solid XY if the radii of X and Y are 0.98 pm, and 1.81 pm respectively?

Short Answer Type [3 Marks]

14. (a) (i) What are conductors?
(ii) How metallic conductors differ from electrolytic conductors?
(b) Why insulators does not conduct electricity?

15. Calculate the radius of lead atom if it crystallises in fcc unit cell? (Density of lead = 11.35 g/cm^3, atomic mass = 207 g/mol)

16. (i) What are non-stoichiometric defects?
(ii) Why LiCl acquires pink colour when heated in Li vapours.

17. What is the effect of temperature on conductivity of semiconductors? Illustrate with the diagram.

18. In a cubic close packed structure of a mixed oxide, one-eighth of tetrahedral voids are occupied by divalent ions, X^{2+} and one half of the octahedral voids are occupied by trivalent ions, Y^{3+}. What is the formula of compound? [NCERT Exemplar]

19. (a) How ionic solids differ from covalent solids?
(b) Although both diamond and graphite are allotropes of carbon, but diamond is an insulator while graphite is a conductor of electricity. Give reasons.

20. A compound AB has a face-centred crystal structure in which 'A' atoms are present at the corners and 'B' atoms at face centres. If one atom of A and two atoms of B are missing from corners and face centres respectively, what is the formula of the compound AB?

21. (a) What are amorphous solids? Give one example.
(b) Why is the glass of window panes of very old buildings are thicker at the bottom?

22. An element 'X' crystallises in ccp structure with metallic radius of 256 pm.
(i) What is the edge length of the unit cell?
(ii) How many unit cells are present in 2 cm^3 of element 'X'?

23. (a) What is the Bohr magneton? Write its magnitude?
(b) Fe_3O_4 (magnetite) is a ferrimagnetic substance. What happens when temperature is raised to 850 K?

24. Calculate the cationic vacancies of the crystal of sodium chloride which is doped with 0.5×10^{-3} mole percent of $SrCl_2$?

25. X-ray diffraction studies shows that silver crystallises in fcc lattice. If the edge length of unit cell is 4.077×10^{-8} cm and density is 10.5 g/cm^3, determine the atomic mass of silver?

Value Based Type [4 Marks]

26. Rohan wants to purchase a glass for window pane. He is confused between transparent and milky coloured glasses shown by shopkeeper. His friend Manan, a student of chemistry adviced him to purchase a transparent glass.

Answer the following questions using the above passage

(a) Why Manan adviced Rohan to buy transparent glass?

(b) What phenomenon is associated with milky coloured glass?

(c) What values are associated with the Manan?

Long Answer Type [5 marks]

27. (a) Define voids. Name the different types of voids present in crystal structure?

(b) Give the diagram of different types of voids.

(c) Determine the total number of voids present in 0.25 moles of compound which crystallises in hcp structure?

28. (a) What are Schottky and Frenkel defects? Give one example of each.

(b) What type of defects are observed in crystal of sodium chloride?

(c) What happens when molten NaCl contains small amount of strontium chloride?

29. A sample of ferrous oxide has actual formula $Fe_{0.93}O_{1.00}$. In this sample, what fractions of metal ions are Fe^{2+} ions. What type of non-stoichiometric defect is present in the sample? [NCERT Exemplar]

30. (a) (i) What are extrinsic semiconductors?

(ii) What are the different types of extrinsic semiconductors?

(b) (i) How conductivity of silicon crystal is increased when doped with arsenic?

(ii) What are the applications of *n*-type and *p*-type semiconductors?

Solutions

1. Crystalline solids are anisotropic in nature as their physical properties like refractive index, electrical resistance show different values in different directions.

2. Unit cells in which one constituent particle is present at the centre of any two opposite faces in addition to the particles present at the corners are called end-centred unit cells.

3. $\text{Radius ratio} = \dfrac{\text{Radius of positive ion}}{\text{Radius of negative ion}} = \dfrac{94}{146} = 0.644 \text{ pm}$

4. When silicon (Si) or germanium (Ge) crystal is doped with elements of group 13 such as Al, Ga which contains only three valence electrons, are known as *p*-type semiconductors.

5. For body-centred unit cell, egde length (a)

$$= \frac{4r}{\sqrt{3}} = \frac{4 \times 0.414}{\sqrt{3}} = 0.956 \text{ nm}$$

6. In hexagonal crystal system, edge length : $a = b \neq c$

axial angles : $\alpha = \beta = 90°, \gamma = 120°$. e.g. graphite, ZnO, CdS.

7. Schottky defect is a vacancy defect in ionic solids which arises when equal number of cations and anions are missing from the crystal lattice. Hence, density of crystal decreases.

8. Crystals have long range repeated pattern of arrangement of constituent particles but in the process of crystallisation some deviations from the ideal arrangement may be introduced, therefore, crystals are usually not perfect. Moreover, the particles keep on oscillating from the mean position.

9. Doping is a process by which impurity is introduced in semiconductors. It can be done with an impurity which is electron rich or electron deficient as compared to intrinsic semiconductors which produces electronic defects in the semiconductors. Thus, increases the conductivity.

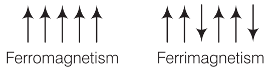
10. Since, the atom crystallises in bcc arrangement, number of atoms per unit cell $= 8 \times \dfrac{1}{8} + 1 = 2$

$$\text{Edge length } (a) = \frac{4r}{\sqrt{3}}$$

$$\therefore \text{Packing efficiency} = \frac{Z \cdot \frac{4}{3}\pi r^3}{a^3} \times 100 = \frac{2 \times \frac{4}{3}\pi r^3}{\left(\frac{4r}{\sqrt{3}}\right)^3} \times 100 = 68\%$$

11. Yellow colour in NaCl is due to metal excess defect result of which is that upaired electrons occupy anionic sites, known as F-centres. These electrons absorb energy from the visible region for the excitation which makes crystal appears yellow.

12. Ferromagnetic substances are permanently magnetised substances. When placed in strong magnetic field, all the domains are oriented in same direction producing strong magnetic effect. e.g. CrO_2. In ferrimagnetic substances, magnetic moments of domains are aligned in parallel and anti-parallel directions in unequal number. e.g. Fe_3O_4.



13. Radius of X (cation) = 0.98 pm

Radius of Y (anion) = 1.81 pm

$\text{Radius ratio} = \dfrac{\text{Radius of cation}}{\text{Radius of anion}} = \dfrac{0.98}{1.81} = 0.541 \text{ pm}$

Radius ratio lies between 0.414 and 0.732.

$\therefore$ Coordination number = 6.

14. (a) (i) Solid substances which conducts electricity are known as conductors. Their range of conductivity is 10^4 to $10^7\,\Omega^{-1}\ \text{cm}^{-1}$. These generally include metals.

(ii) In metallic conductors, the flow of electricity is due to free electrons, which decreases with increase in temperature.

In electrolytic conductors, electricity is conducted by movement of ions under applied electric field, which increases with increase in temperature.

(b) Due to large difference in energy of valence band and conduction band, electrons cannot jump from valence band to conduction bands. Thus, do not conduct electricity and are called insulators.

15. Density of unit cell $(d) = \dfrac{MZ}{a^3 \cdot N_A}$

where, $Z = 4$ (for $f$cc unit cell)

$M = 207\,g\ \text{mol}^{-1}$

$d = 11.35\ \text{g cm}^{-3}$

$N_A = 6.023 \times 10^{23}\ \text{mol}^{-1}$

On substituting all the values we get,

$$11.35\ \text{g/cm}^3 = \frac{4 \times 207\ \text{g/mol}}{a^3 \times 6.023 \times 10^{23}\text{mol}^{-1}}$$

$$a^3 = \frac{4 \times 207\ \text{g / mol}}{11.35\ \text{g / cm}^3 \times 6.023 \times 10^{23}\text{mol}^{-1}}$$

$$a^3 = 12.114 \times 10^{-23}\ \text{cm}^3$$

$$a = 4.948 \times 10^{-8}\ \text{cm}$$

For fcc structure, $r = \dfrac{a}{2\sqrt{2}}$

$$\therefore \quad r = \frac{4.948 \times 10^{-8}}{2\sqrt{2}}$$

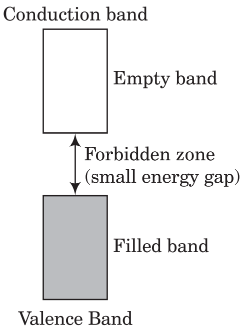
$$r = 1.7494 \times 10^{-8}\text{cm}$$

16. (a) (i) Imperfections which lead to change in composition of solids are called non-stoichiometric defects. These defects are of two types.

- Metal excess defect
- Metal deficiency defect

(ii) The Cl^- ions diffuse to the surface and forms LiCl. An electron is released which diffuses into the crystal and occupies the anionic site. Such sites are called F-centres. These impart pink colour to the crystal. The colour results by the excitation of the electrons when they absorb energy from visible light falling on the crystals.

17. Semiconductors are the substances which have smaller energy gap between valence band and conduction band. On increasing the temperature, this energy gap further reduces and more electrons can jump from valence band to conduction band. Thus, increases the conductivity of semiconductors.



18. Let, the number of O^{2-} ions in crystal = N

$\therefore$ Number of tetrahedral voids = $2N$

Number of octahedral voids = N

$\therefore$ Number of X^{2+} ions $= \dfrac{1}{8} \times 2N = \dfrac{N}{4}$

Number of Y^{3+} ions $= \dfrac{1}{2} \times N = \dfrac{N}{2}$

$\therefore$ Ratio of the ions

$$= X^{2+} : Y^{3+} : \text{O}^{2-} = \frac{N}{4} : \frac{N}{2} : N$$

$$= 1 : 2 : 4$$

$\therefore$ the formula of compound is $XY_2\text{O}_4$

19. (a) Ionic solids are the solids formed by three dimensional arrangement of ions bounded by strong coulombic forces. These are electrical insulators in the solid state but conduct electricity in molten state.

The solids formed by covalent bonds between non-metals are called covalent solids. These are insulators and do not conduct electricity.

(b) Both diamond and graphite are allotropes of carbon but graphite conducts electricity while diamond does not. This is because in graphite atoms are arranged in different layers and each atom is covalently bonded to three of its neighbouring atoms in same layer. The fourth valence electron is present between three layers and is free to move. This mobile electron makes graphite a good conductor of electricity.

20. In face-centred crystal structure, 8 atoms are present at the corners and 6 atoms at face centres.

Since, one atom of A and two atoms of B are missing, therefore,

Number of atoms of A at corners = 7

Number of atoms of B at face centres = 4.

$$A_{\text{eff}} = 7 \times \frac{1}{8} = \frac{7}{8}\ \text{atoms/unit cell}$$

$$B_{\text{eff}} = 4 \times \frac{1}{2} = 2\ \text{atoms/unit cell}$$

Hence, formula of compound $AB = A_{\frac{7}{8}}B_2 = A_7B_{16}$

21. (a) Solids which consists particles of irregular shape i.e. arrangement of particles has only short range order are called amorphous solids. e.g. quartz glass.

(b) Amorphous solids have tendency to flow but very slowly. Therefore, also called as supercooled liquids or pseudo solids. Because of this, glass of window panes of very old buildings are thicker at the bottom. Glass flows down very slowly and makes the bottom of window pane slightly thicker.

22. (i) ccp structure is same as that of face centred structure (fcc).

$\therefore$ Edge length $(a) = 2\sqrt{2}r = 2\sqrt{2}(256) = 724$ pm

(ii) Volume of unit cell = a^3

$$= (724 \times 10^{-8}\ \text{cm})^3 = 3.79 \times 10^{-16}\ \text{cm}^3$$

Number of unit-cells in 2 cm^3 of element X

$$= \frac{2}{3.79 \times 10^{-16}\ \text{cm}^3}$$

$$= 5.28 \times 10^{15}\ \text{unit cells}$$

23. (a) Every substance has magnetic properties due to presence of electrons. Electron behaves as a tiny magnet due to its orbital motion around the nucleus and its spin around its own axis.

Thus, each electron possess permanent spin and an orbital magnetic moment. Magnitude of this magnetic moment is measured in unit called Bohr magneton (μ_B) whose magnitude is 9.27×10^{-24} Am^2.

(b) When temperature is raised to 850 K, Fe_3O_4 loses ferrimagnetism and becomes paramagnetic in nature.

24. NaCl crystal is doped with 0.5×10^{-3} mole percent of $SrCl_2$, thus, 100 moles of NaCl is doped with 0.5×10^{-3} moles of $SrCl_2$, or 1 mole of NaCl is doped with 0.5×10^{-5} moles of $SrCl_2$. Due to the addition of $SrCl_2$, each Sr^{2+} ion replaces $2Na^+$ ions, but occupies only one Na^+ lattice point. This creates cation vacancy.

$\therefore$ Cation vacancies = Number of Sr^{2+} ion added

$= 0.5 \times 10^{-5} \times 6.023 \times 10^{23}$

$= 3.011 \times 10^{18}$ mol^{-1}

25. Edge length of unit cell = 4.077×10^{-8} cm

Since, silver crystallises in fcc lattice, therefore, $Z = 4$

Density of unit cell $(d) = \dfrac{MZ}{a^3 N_A}$

On substituting the given values, we get

$$10.5 \text{ g cm}^{-3} = \frac{M \cdot 4}{(4.077 \times 10^{-8} \text{ cm})^3 \times (6.023 \times 10^{23} \text{ mol}^{-1})}$$

$M = 107.143$ g/mol

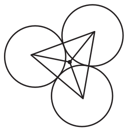
26. (a) Transparent glass is crystalline in nature while milky coloured glass is amorphous. The transparent glass is stronger and more tempered than milky glass.

(b) Since, amorphous solids have ability to flow, thus, crystallisation of glass is the phenomenon associated with it.

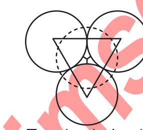
(c) Values associated with Manan are kind, helpful and the will to share knowledge with the underprivileged.

27. (a) Empty space in close packed structures is called voids. Different types of voids present in crystal structure are trigonal voids which is present in two dimensional packing while, tetrahedral voids and octahedral voids are present in three dimensional packing. Number of tetrahedral voids are twice the number of octahedral voids.

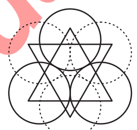
(b)



Trigonal void



Tetrahedral void



Octahedral void

(c) In hexagonal close packed (hcp) structure, there are 6 atoms per unit cell.

Thus, number of octahedral voids = 6

Number of tetrahedral voids = 2 × 6 = 12

$\therefore$ Total number of voids per atom $= \dfrac{12 + 6}{6} = 3$

Total number of voids in 1 mole $= 3 \times 6.023 \times 10^{23}$

Total number of voids in 0.25 mole

$= 3 \times 0.25 \times 6.023 \times 10^{23}$

$= 4.52 \times 10^{23}$

28. (a) The stoichiometric point defects in ionic solids in which equal number of cations and anions are missing from their lattice site, are known as Schottky defect. e.g. KCl. When smaller ion (usually cations) of lattice is dislocated from its normal site and occupies an interstitial site. This is called Frenkel defect. e.g. AgI.

(b) Sodium chloride (NaCl) shows Schottky defect as cation and anion are of almost similar sizes.

(c) When molten NaCl contains small amount of $SrCl_2$, some of the sites of Na^+ ions are occupied by Sr^{2+} ions. Each Sr^{2+} replaces the two Na^+ ions. Thus, it occupies site of one ion and other site remains vacant creating cationic vacancies. This is also known as impurity defect.

29. Let, the formula of sample be $(Fe^{2+})_x (Fe^{3+})_y$

$\therefore \quad x + y = 0.93 \quad$ ...(i)

Total positive charge on ferrous and ferric ions should balance the two units of negative charge on oxygen.

Therefore, $2x + 3y = 2 \Rightarrow x + \dfrac{3}{2}y = 1 \quad$ ...(ii)

On subtracting equation (i) from (ii),

$$\frac{3}{2}y - y = 1 - 0.93 \Rightarrow \frac{1}{2}y = 0.07$$

$$y = 0.14$$

On substituting value of y in equation (i), we get,

$$x + 0.14 = 0.93 \Rightarrow x = 0.79$$

Fraction of Fe^{2+} ions present in the sample $= \dfrac{0.79}{0.93} = 0.849$

Metal deficiency defect is present in sample because iron is less in amount than that required for stoichiometric composition.

30. (a) (i) To increase the conductivity of pure silicon or germanium crystals, these substances are doped with small amount of impurities either from group 13 or 15 elements. These are called extrinsic semiconductor.

(ii) The different types of extrinsic semiconductors are n-type and p-type semiconductors.

(b) (i) When silicon crystal is doped with arsenic (group 15 element) which contains five valence electrons, they occupy some of the lattice sites in the crystal. Four out of five electrons are used in the formation of four covalent bonds with the four neighbouring silicon atoms.

The fifth electron is not used in bonding thus,it is free for delocalisation. Thus, increases conductivity of doped silicon.

(ii) Applications of n-type and p-type semiconductors are as rectifier which is a combination of n-type and p-type semiconductor called diode, in transistors and as photodiode.

TARGET BITSAT 2017

TEST RIDER

Comprehensive Simulator Test Series for BITSAT

BITSAT

(PAPER ONE PREP UP)

FULL TEST 1

(COMPLETE SYLLABUS) WITH HINTS

Mock Questions from Complete Syllabus with Hints

INSTRUCTIONS

- This test consists of 45 questions and each question is allotted 4 marks for correct response.
- Candidates will be awarded marks as stated above for correct response of each question. 1/4 mark will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
- There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted according as per instructions.

1. Among the electrolytes, Na_2SO_4, $CaCl_2$, $Al_2(SO_4)_3$ and NH_4Cl the most effective for coagulating Sb_2S_3 sol is

(a) Na_2SO_4 *(b)* $CaCl_2$
(c) $Al_2(SO_4)_3$ *(d)* NH_4Cl

2. For which of the following reaction, ΔH is less than ΔE?

(a) $HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l)$
(b) $H_2(g) + I_2(g) \longrightarrow 2HI(g)$
(c) $C(s) + O_2(g) \longrightarrow CO_2(g)$
(d) $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

3. A solution was prepared by mixing 50 mL of 0.2 M of HCl and 50 mL of 0.10 M NaOH. The pH of the resultant solution is

(a) 7.0 *(b)* 2.0 *(c)* 3.0 *(d)* 1.3

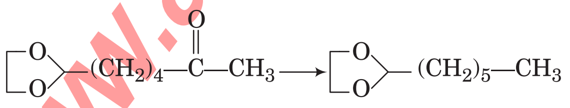
4. The byproduct produced in the manufacture of sodium hydroxide by Castner-Kellner process is

(a) Chlorine *(b)* Oxygen
(c) Sodium chloride *(d)* Sodium carbonate

5. The sum of protons, electrons and neutrons in the heaviest isotope of hydrogen is

(a) 3 *(b)* 5 *(c)* 4 *(d)* 6

6.



Which of the following reagents is suitable for above conversion?

(a) Zn—Hg / HCl *(b)* $LiAlH_4$
(c) $H_2N—NH_2 / OH^{\ominus}$ *(d)* $NaBH_4$

7. The colour of $KMnO_4$ is due to

(a) $M \rightarrow L$ charge transfer *(b)* $d \rightarrow d$ transition
(c) $L \rightarrow M$ charge transfer *(d)* $\sigma \rightarrow \sigma^*$ transition

8. Reduction of aromatic nitro compounds using Fe and HCl gives

(a) aromatic oxime
(b) aromatic hydrocarbon
(c) aromatic primary amine
(d) aromatic amide

9. The stabilisation of a dispersed phase in a lyophobic colloid is due to

(a) the absorption of charged substances on dispersed phase
(b) the large electro-kinetic potential developed in the colloid
(c) the formation of an electrical layer between two phases
(d) the viscosity of the medium

10. Which of the following reagent can be used to identify nickel ion?

(a) Resorcinol *(b)* Dimethylglyoxime
(c) Diphenyl benzidine *(d)* Potassium ferrocyanide

11. Which one of the following acts as an oxidising agent?

(a) Np^{4+} *(b)* Sm^{2+}
(c) Eu^{2+} *(d)* Yb^{2+}

12. Which of the following is the correct magnetic moment of $K_3[FeF_6]$?

(a) 3.87 BM *(b)* 4.89 BM
(c) 5.91 BM *(d)* 6.92 BM

13. On heating diethylether with excess of concentrated HI, it gives

(a) methyl iodide *(b)* *iso* propyl iodide
(c) ethyl iodide *(d)* *n*-propyl iodide

14. Which of the following is not a function of proteins?
(a) Nail formation
(b) Skin formation
(c) Muscle formation
(d) Providing energy for metabolism

15. The oxidation potential of a hydrogen electrode is decreased by
(a) increasing the $[H^+]$
(b) decreasing the p_{H_2}
(c) decreasing the pOH of the solution
(d) Both (a) and (b)

16. Which of the following will exhibit geometrical isomerism?
(a) Propene
(b) But-2-ene
(c) But-1-ene
(d) 1, 1-dichlorobutane

17. A reaction, $P \rightarrow Q$ has an activation energy of 25 kJ mol^{-1} and enthalpy change of – 5 kJ mol^{-1}. The activation energy for the reaction $Q \rightarrow P$ is
(a) 40 kJ mol^{-1}
(b) 20 kJ mol^{-1}
(c) 15 kJ mol^{-1}
(d) 30 kJ mol^{-1}

18. In which of the following pairs the difference in the oxidation number (ON) of the underlined elements is greatest?
(a) $\underline{N}O_2$ and $\underline{N}_2O_4$
(b) $\underline{P}_2O_5$ and $\underline{P}_4O_{10}$
(c) $\underline{N}_2O$ and $\underline{N}O$
(d) $\underline{S}O_2$ and $\underline{S}O_3$

19. The rate law for a reaction between the substances A and B is given by rate $= K[A]^n[B]^m$. On doubling the concentration of A and halving the concentration of B, the ratio of the new rate to the earlier rate of the reaction will be
(a) $\dfrac{1}{2^{m+n}}$
(b) $m + n$
(c) $n - m$
(d) 2^{n-m}

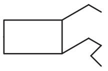
20. Which of the following statement is incorrect?
(a) The polar head of the detergent is positively charged
(b) Straight chain alkyl groups containing detergents are non-biodegradable
(c) Cetyl trimethyl ammonium bromide is a popular cationic detergent
(d) All of the above

21. The freezing point (in °C) of solution containing 0.1 g of $K_3[Fe(CN)_6]$ (mol. wt. 329) in 100 g of water ($K_f = 1.86$ K kg mol^{-1}) is
(a) -2.3×10^{-2}
(b) -5.7×10^{-2}
(c) -5.7×10^{-3}
(d) -1.2×10^{-2}

22. A metal oxide has the formula, A_2O_3. It can be reduced by hydrogen to give free metal and water. 0.1596 g of this metal oxide requires 6 mg of hydrogen for complete reduction. The atomic weight of metal is
(a) 53.6
(b) 55.8
(c) 62.7
(d) 51.6

23. Sodium metal crystallises in a body centred cubic lattice with a unit cell edge length of 4.29 Å. The radius of sodium atom is approximately.
(a) 1.86 Å
(b) 3.22 Å
(c) 5.72 Å
(d) 0.93 Å

24. The IUPAC name of the following compound,



is
(a) 1- butyl-2-ethyl cyclobutane
(b) 2, 2, 4-trimethyl pentane
(c) 3, 5-dimethyl heptane
(d) 1-nitrobutane

25. How many litres of ethene is required to prepare 90 g of ethane by the following method at STP?

$$CH_2{=}CH_2 \xrightarrow{HCl} P_1 \xrightarrow[Et_2O]{Mg} P_2 \xrightarrow{HCl} CH_3CH_3$$

(a) 22.4 L
(b) 44.8 L
(c) 67.2 L
(d) None of these

26. The complex ion which has no 'd'-electrons in the central metal atom is
(a) MnO_4^-
(b) $[Co(NH_3)_6]^{3+}$
(c) $[Fe(CN)_6]^{3-}$
(d) $[Cr(H_2O)_6]^{3+}$

27. What is the degeneracy of the nth level of hydrogen atom that has the energy $\left(\dfrac{-R_H}{16}\right)$?
(a) 4
(b) 9
(c) 16
(d) 12

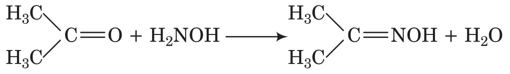
28. The standard Gibbs free energy change (ΔG°) for a reaction is – 41.8 kJ mol^{-1} at 700 K and 1 atm. The equilibrium constant of the reaction at 700 K is
(a) 1.312×10^{-3}
(b) 2.314×10^{-6}
(c) 4.16×10^{-6}
(d) 1.912×10^{-6}

29. Which of the following statement(s) regarding the advantage of roasting of the sulphide ore before reduction is incorrect?
(a) Roasting of the sulphide to the oxide is thermodynamically feasible
(b) Carbon and hydrogen are suitable reducing agents for metal sulphides
(c) The $\Delta_f G^\ominus$ of the sulphide is greater than those for CS_2 and H_2S
(d) The $\Delta_f G^\ominus$ is negative for roasting of sulphide ore to oxide.

30. Among the following, which element has the lowest electronegativity?
(a) Li
(b) F
(c) Cl
(d) Fe

31. Crystal field stabilisation energy for high spin d^4-octahedral complex is
(a) $-0.6\Delta_o$
(b) $-1.8\Delta_o$
(c) $-1.6\Delta_o + P$
(d) $-1.2\Delta_o$

32. Consider the following reaction,



$$(H_3C)_2C{=}O + H_2NOH \longrightarrow (H_3C)_2C{=}NOH + H_2O$$

It is an example of
(a) addition
(b) elimination
(c) substitution
(d) addition-elimination

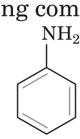
33. In the aluminothermic process, Al acts as a/an
(*a*) solder (*b*) oxidising agent
(*c*) reducing agent (*d*) flux

34. The molecule having one unpaired electron is
(*a*) NO (*b*) CO (*c*) $CN^{\ominus}$ (*d*) O_2

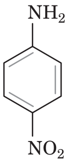
35. Which of the following has smallest number of molecules?
(*a*) 0.1 mole of CO_2 gas
(*b*) 11.2 L of CO_2 gas at NTP
(*c*) 22 g of CO_2 gas
(*d*) 22.4×10^3 mL of CO_2 at NTP

36. The correct increasing order of basic strength for the following compound is

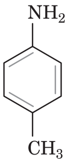
(I)



(II)



(III)



(*a*) II < III < I (*b*) III < I < II
(*c*) III < II < I (*d*) II < I < III

37. If the elevation in boiling point of a solution of 10 g of solute (mol. wt = 100) in 100 g of water is ΔT_b, the ebullioscopic constant of water is equal to
(*a*) 10 (*b*) $100\, T_b$
(*c*) ΔT_b (*d*) $\frac{\Delta T_b}{10}$

38. Consider the following reaction,
$$A(s) + 2B^+(aq) \longrightarrow A^{2+}(aq) + 2B$$
For the above reaction, K_C has been found to be 10^{12}. The E°_{cell} is
(*a*) 0.354 V (*b*) 0.708 V
(*c*) 0.0098 V (*d*) 1.36 V

39. What will be the molality of the solution containing 18.25 g of HCl gas in 500 g of water?
(*a*) 0.1 m (*b*) 0.6 m
(*c*) 0.5 m (*d*) 1 m

40. Enthalpy of sublimation of a substance is equal to
(*a*) enthalpy of fusion + enthalpy of vaporisation
(*b*) enthalpy of fusion
(*c*) enthalpy of vaporisation
(*d*) twice the enthalpy of vaporisation

Answers with Hints

1. **(*c*)** According to Hardy Schulze rule, greater the valency of cationic coagulating agent, higher will be its coagulating power.

2. **(*d*)** $\Delta H = \Delta E + \Delta n_g RT$
where, Δn_g = number of moles of gaseous products (n_p) − number of moles of gaseous reactants (n_r).

3. **(*d*)** 50 mL of 0.1 M NaOH = 5 millimoles
50 mL of 0.2 MHCl = 10 millimoles
$$\underset{1\text{ mol}}{NaOH} + \underset{1\text{ mol}}{HCl} \longrightarrow NaCl + H_2O$$
Molarity of HCl in resultant solution $= \frac{5}{100}$ M
Finally used the following relation to calculate pH.
$pH = -\log [H^+]$

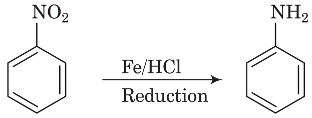
4. **(*a*)** At cathode : $Na^+ + e^- \xrightarrow{Hg}$ Na-amalgam
At anode : $Cl^- \longrightarrow \frac{1}{2} Cl_2 + e^-$
The amalgam is treated with water to give sodium hydroxide and hydrogen gas.
2Na-amalgam + $2H_2O \longrightarrow 2NaOH + 2Hg + H_2$

5. **(*c*)** Tritium is the heaviest isotope of hydrogen. ${}_1T^3$ has 3 nucleons (1 proton + 2 neutrons) and one electron.

6. **(*b*)** $LiAlH_4$ is used as a reducing agent in organic synthesis. It is used for the reduction of aldehydes and ketones.

7. **(*c*)** $KMnO_4 \longrightarrow K^+ + MnO_4^-$
In MnO_4^-, Mn has + 7 oxidation state.
It is considered that higher the oxidation state of metal, greater will be the tendency to $L \rightarrow M$ charge transfer.

8. **(*c*)**



9. **(*c*)** The stabilisation of a dispersed phase in a lyophobic colloid is due to formation of an electrical layer between two phases.

10. **(*b*)** Dimethylglyoxime is used as a chelating agent in the gravimetric analysis of nickel ion.

11. **(*a*)** All those inner-transition elements having + 2 oxidation state changes to + 3 and acts as reducing agents while those having + 4 oxidation state tend to change to + 3 oxidation state and acts as an oxidising agents.

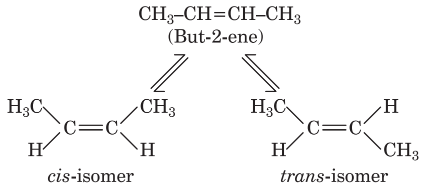
12. **(*c*)** For $K_3[FeF_6]$, Fe exist in + 3 oxidation state.
$Fe^{3+} = [Ar]5d^5 4s^0$
Magnetic moment $(\mu) = \sqrt{n(n+2)}$
where, n = number of unpaired electrons.

13. **(*c*)** With excess of HI, the reaction takes place as follows,
$$C_2H_5OC_2H_5 + \underset{\text{Excess}}{2HI} \xrightarrow[-\,H_2O]{373\text{ K}} \underset{\text{Ethyl iodide}}{2C_2H_5I}$$

14. **(*d*)** Proteins are insoluble in water, e.g. Keratin which is found in hair, skin, nails and myosin which is present in muscles.

15. **(*d*)** $E_{oxi} = -\frac{0.059}{1} \log \frac{[H^+]}{\sqrt{p_{H_2}}}$

16. ***(b)*** But-2-ene exhibit geometrical (i.e. *cis* or *trans*) isomerism.



17. ***(d)*** For, $P \to Q, E_a$ (forward) and $Q \to P, E_a$ (reverse)

$$\Delta H = E_a \text{ (forward)} - E_a \text{ (reverse)}$$

$\therefore E_a(Q \to P)$ or E_a (reverse) = 30 kJ mol^{-1}

18. ***(d)*** (a) NO_2(ON = 4), N_2O_4(ON = 4)

(b) P_2O_5 (ON = 5) and P_4O_{10} (ON = 5)

(c) N_2O (ON = 1) and NO (ON = 2)

(d) SO_2 (ON = 4) and SO_3 (ON = 6)

19. ***(d)*** $\dfrac{\text{New rate}}{\text{Initial rate}} = \dfrac{K[2A]^n\,[1/2B]^m}{K[A]^n[B]^m} = 2^{n-m}$

20. ***(b)*** Straight chain alkyl groups containing detergents are biodegradable whereas branched chain alkyl groups containing detergents are non-biodegrable.

21. ***(a)*** van't Hoff factor $(i) = 4\{3K^+ + [Fe(CN)_6]^{3-}\}$

$$\text{Molality } (m) = \frac{\text{Moles of solute}}{\text{Mass of solvent (in kg)}} = \frac{0.1}{329} \times \frac{1000}{100}$$

$$\Delta T_f = i\,K_f \cdot m$$

where, ΔT_f = depression in freezing point

K_f = molal depression constant

Also, $T_{\text{solution}} = \Delta T_f^\circ - \Delta T_f$

22. ***(b)*** $\underset{0.1596\text{ g}}{A_2O_3} + \underset{0.006\text{ g}}{3H_2} \longrightarrow 2A + 3H_2O$

6g of H_2 will reduce $= \dfrac{0.1596 \times 6}{0.006} = 159.6$ g of A_2O_3

Let, atomic weight of $A = x$

$$2x + 3 \times 16 = 159.6$$

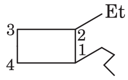
$$x = 55.8.$$

23. ***(a)*** For bcc unit cell,

$$\sqrt{3}a = 4r$$

$$r = \frac{\sqrt{3}}{4}a = \frac{\sqrt{3}}{4} \times 4.29\,\text{Å} = 1.86\,\text{Å}$$

24. ***(a)***



1-butyl-2-ethylcyclobutane

25. ***(c)*** $CH_2{=}CH_2 \xrightarrow{HCl} \underset{(P_1)}{CH_3{-}CH_2Cl}$

$$\xrightarrow[Et_2O]{Mg} \underset{(P_2)}{CH_3CH_2MgCl} \xrightarrow{HCl} CH_3CH_3$$

$$\text{Moles of ethane} = \frac{\text{Weight}}{\text{Molecular weight}}$$

$$= \frac{90}{30} = 3 \text{ moles}$$

3 moles of ethene will yield 3 moles of ethane.

$\therefore$ Volume of ethene at STP = 3 × 22.4 = 67.2 L

26. ***(a)*** In MnO_4^-, Mn^{+7} has $3d^0$ configuration.

27. ***(c)*** Energy of electron in the *n*th orbit is given as

$$E_n = \frac{-R_H Z^2}{n^2}$$

For H-atom, $Z = 1$ on comparing with $\dfrac{-R_H}{16}$ we get,

$$n = 4\,[4s, 4p, 4d \text{ and } 4f]$$

Degeneracy = total number of orbitals = 16

28. ***(a)*** $\Delta G^\circ = -RT\ln K = -2.303\,RT\log K$

$$-41800\text{ J mol}^{-1} = -2.303 \times (8.314\text{ JK}^{-1}\text{ mol}^{-1}) \times 700 \log K$$

$$\therefore \log K = \frac{41800}{13403} = 3.1187$$

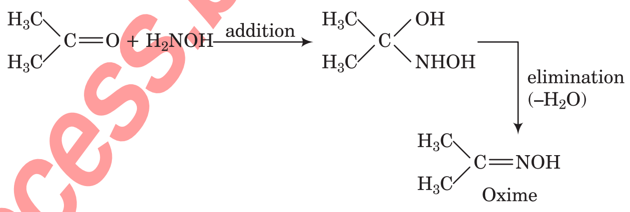
$$\Rightarrow \quad K = 1.312 \times 10^{-3}.$$

29. ***(b)***

30. ***(a)*** Li $(1s^2, 2s^1)$ donates one electron easily and hence, possess lowest electronegativity among the given options.

31. ***(a)*** CFSE = 3(– 0.4) + 1(0.6) = – $0.6\Delta_o$

32. ***(d)*** The reaction occurs as follows,



33. ***(c)*** In the aluminothermic process, aluminium reduces Fe_2O_3 or Cr_2O_3 to respective metals and acts as a reducing agent.

34. ***(a)*** NO has 15 electrons,

NO—$\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \pi 2p_x^2 \approx \pi 2p_y^2, \sigma 2p_z^2,$
$\pi 2^* p_x^1 = \pi^* 2p_y^0$

35. ***(a)*** One mole of any gas at NTP has volume equal to 22.4 L (22400 mL) and the number of molecules present in it is always 6.022×10^{23}.

36. ***(d)*** Presence of electron releasing group increases electron density over 'N' of —NH_2 group and hence, make it more basic while electron withdrawing group withdraws electron density. Hence, making it less basic.

37. ***(c)*** Elevation in boiling point, $\Delta T_b = \dfrac{1000 \times K_b \times W_{\text{solute}}}{W_{\text{solvent}} \times M_{\text{solute}}}$

where, K_b = molal boiling point elevation constant or ebullioscopic constant.

38. ***(a)*** $\Delta G^\circ = -2.303\,RT\log K_C = -2.303\,RT\log 10^{12}$

Also, $\Delta G^\circ = -nFE^\circ_{\text{cell}}$

$\therefore \quad -12 \times 2.303\,RT = -nFE^\circ_{\text{cell}}$

or $\quad E^\circ_{\text{cell}} = \dfrac{2.303\,RT}{nF} \times 12 = \dfrac{0.059}{2} \times 12 = 0.354$ V

39. ***(d)*** Molality $= \dfrac{\text{Number of moles of solute}}{\text{Mass of solvent (in kg)}}$

40. ***(a)*** The enthalpy change when one mole of a solid substance sublimes, i.e. converted into its vapours without melting at a temperature below its melting point is called enthalpy of sublimation.

TARGET BITSAT 2017

TEST RIDER

Comprehensive Simulator Test Series for BITSAT

BITSAT

(PAPER TWO SCALE UP)

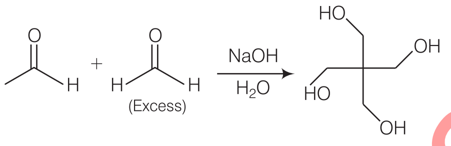
FULL TEST 2
(COMPLETE SYLLABUS)
WITH ANSWER KEY

Mock Questions from Complete Syllabus with Answer Key

INSTRUCTIONS

- This test consists of 40 questions and each question is allotted 4 marks for correct response.
- Candidates will be awarded marks as stated above for correct response of each question. 1/4 mark will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
- There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted according as per instructions.

1. The mechanism of the following transformation involves,



(a) Aldol reaction and Cannizzaro raction
(b) Aldol reaction and Claisen-Schmidt reaction
(c) Knoevenagel condensation and Canizzaro recaction
(d) Claisen-Schmidt reaction and Cannizzaro reaction

2. An electrochemical cell consists of two half-cell reaction,

$AgCl(s) \longrightarrow A\overset{+}{g}(s) + Cl^-(aq)$

$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$

The mass of copper (in grams) dissolved on passing 0.5 A of current for 1 h is

(a) 0.88 *(b)* 1.18
(c) 0.29 *(d)* 0.59

3. What volume of oxygen, entering the engine at 0.950 atm and 20°C is required to burn 1.00 g of benzene?

(a) 2.43 L *(b)* 4.24 L
(c) 3.62 L *(d)* 9.51 L

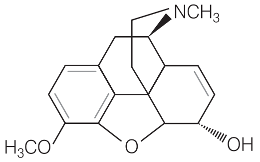
4. Consider a system containing ice, aqueous NaCl solution and solid NaCl in a bottle under a nitrogen atmosphere. Calculate the degree of freedom.

(a) 1 *(b)* 2
(c) 3 *(d)* 6

5. Which of the following statement(s) is correct regarding low density polythene (LDP)?

(a) LDP allow the polymer to undergo close packing
(b) It is used for manufacturing buckets, bottles, pipes, etc
(c) It is inert, smooth and good conductor of electricity
(d) It is obtained through the free-radical addition

6. The following structure represents,



(a) Morphine *(b)* Heroin *(c)* Codeine *(d)* Naproxen

7. Transition metals have a less tendency to form ions due to

(a) high ionisation energy
(b) low heat of hydration of ions
(c) high heat of sublimation
(d) All of the above

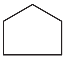
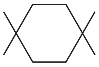
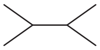
8. Consider the following, (A): $X \xrightarrow{k_1} P_1$; (B) $Y \xrightarrow{k_2} P_2$

k_1 and k_2 are the rate constants of the reactions (A) and (B), respectively. The ratio of time taken (t_1) when 10% of (X) has reacted to the time taken (t_2) when 80% of (Y) remained unreacted is

(a) $\dfrac{k_1(1-3\log 2)}{k_2(1-2\log 3)}$ *(b)* $\dfrac{k_2(1-2\log 3)}{k_1(1-3\log 2)}$

(c) $\dfrac{k_1(1-2\log 3)}{k_2(1-3\log 2)}$ *(d)* $\dfrac{k_2(1-3\log 2)}{k_1(1-2\log 3)}$

9. Choose alkane that gives more than one monochloro derivative upon reaction with chlorine in presence of sunlight

(a) 
(b) 
(c) 
(d) 

10. For silver metal, the threshold frequency v_o is 1.13×10^{17} Hz. What is the maximum kinetic energy of the photo electrons produced by shining ultraviolet light of 15.0 Å wavelength on the metal.

(a) 5.8×10^{17} J
(b) 5.8×10^{8} J
(c) 7.2×10^{17} J
(d) 6.1×10^{3} J

11. Assume hexagonal rings with equal carbon-carbon distances of $1 \cdot 40$Å, the length of the carbon skeleton in naphthalene is

(a) 2.68Å (b) 9.68Å (c) 7.22Å (d) 6.19Å

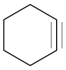
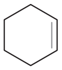
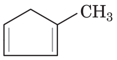
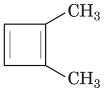
12. Ammonium carbamate dissociates as

$$NH_2COONH_4(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$$

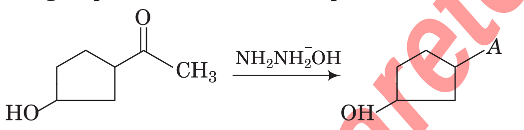
In a closed vessel containing ammonium carbamate, in equilibrium ammonia is added such that partial pressure of NH_3 become equal to the original total pressure. The ratio of partial pressure of CO_2 latter to the original pressure of CO_2 is

(a) 4 (b) 9 (c) 4/9 (d) 2/9

13. Compound (*X*) on oxidation with $OsO_4 / NaIO_4$ gives hexanedinal. The structure of (*X*) will be

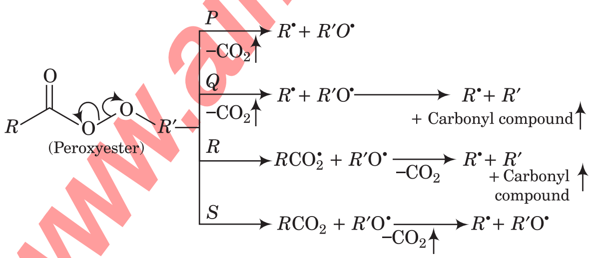
(a) 
(b) 
(c) 
(d) 

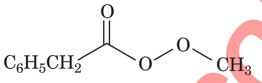
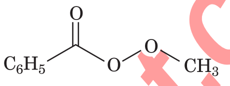
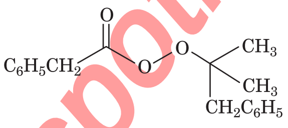
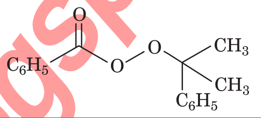
14. The group marked as '*A*' in the product is



(a) C_2H_5
(b) CH_3
(c) CH_3OH
(d) CH_3COOH

15. Different possible thermal decomposition pathways for peroxyesters are shown below. Match each pathway from Column I with an appropriate structure from Column II and select the correct answer using the code given below the lists.



Column I	Column II
P. Pathway *P*	1. 
Q. Pathway *Q*	2. 
R. Pathway *R*	3. 
S. Pathway *S*	4. 

Codes

	P	Q	R	S		P	Q	R	S
(a)	1	3	4	2	(b)	2	4	3	1
(c)	4	1	2	3	(d)	3	2	1	4

16. Considering the basic strength of amines in aqueous solution, which one of the following has the smallest pK_b value?

(a) $(CH_3)_2NH$
(b) CH_3NH_2
(c) $(CH_3)_3N$
(d) $C_6H_5NH_2$

17. A sodium salt of an unknown anion when treated with $MgCl_2$ gives white precipitate only on boiling. The anion is

(a) SO_4^{2-}
(b) HCO_3^-
(c) CO_3^{2-}
(d) NO_3^-

18. Iron is rendered passive by treatment with concentrated

(a) H_2SO_4
(b) H_3PO_4
(c) HCl
(d) HNO_3

19. Both $[Ni(CO_3)_4]$ and $[Ni(CN)_4]^{2-}$ are diamagnetic. The hybridisation of nickel in these complexes respectively, are

(a) sp^3, sp^3
(b) sp^3, dsp^2
(c) dsp^2, sp^3
(d) dsp^2, dsp^2

20. In context of green chemistry, which one of the following is considered as point source for water pollution?

(a) Factories
(b) Construction site
(c) Acid rain
(d) Field lawns

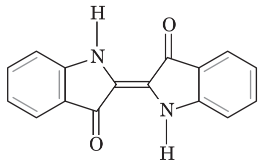
21. The value of '*x*' in $[Cu(CO)_x]^+$, such that it obeys the 18 electron rule is

(a) 6
(b) 5
(c) 4
(d) 3

22. As monomolecular adsorption, how much ammonia in mL at STP would be adsorbed on the surface of 25g charcoal? [Diameter of ammonia molecules is 0.3 nm]

(a) 15258.5 mL
(b) 13153.5 mL
(c) 15879.6 mL
(d) 15234.6 mL

23. Which of the following is incorrect statement(s) about the below compound ?



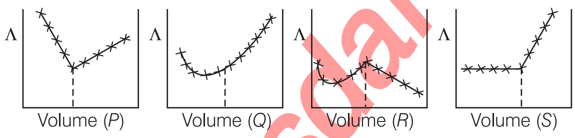
(a) It shows geometrical isomerism
(b) *trans* is more stable than *cis*
(c) *cis* is more stable than *trans*
(d) It is a planar compound

24. Toluene when refluxed with Br_2 in the presence of light mainly gives
(a) *o*-bromotoluene
(b) *p*-bromotoluene
(c) mixture of *o*-and *p*-bromotoluene
(d) benzyl bromide

25. For glucose anomers, $\alpha = +112°$, $\beta = +19°$ and for the constant equilibrium mixture $+52.7°$. The percent composition of the anomers in the equilibrium mixture is
(a) 63.8% (b) 42% (c) 10.9% (d) 93.3%

26. BeF_2 is highly soluble in water where as the fluorides of other alkaline earth metals are almost insoluble in water because
(a) only BeF_2 is ionic in nature
(b) BeF_2 is covalent in nature
(c) hydration energy of BeF_2 is much higher than its lattice energy.
(d) lattice energy of BeF_2 is much higher than that of its hydration energy.

27. $AgNO_3(aq)$ was added to an aqueous KCl solution gradually and the conductivity of the solution was measured. The plot of conductance (Λ) *versus* the volume of $AgNO_3$ is **[IIT JEE 2011]**



(a) (P) (b) (Q) (c) (R) (d) (S)

28. Which of the following is an example of network solid?
(a) Carbon dioxide (b) Silicon dioxide
(c) Sulphur dioxide (d) Nitrogen dioxide

29. Match the Column I with Column II and select correct answer by given codes.

Column I	Column II
A. Inert gas element	1. $(n-1)d^{1-10}ns^{1-2}$
B. Transition elements	2. ns^2 to ns^2np^6
C. Inner-transition elements	3. $(n-2)f^{1-14}(n-1)s^2p^6d^{0-1}ns^2$

Codes

	A	B	C		A	B	C
(a)	1	2	3	(b)	2	1	3
(c)	3	2	1	(d)	2	3	1

30. The volume of 2.5 M H_2SO_4 is required to neutralise a solution containing 2.5 g of NaOH is
(a) 10.2 mL (b) 18.4 mL
(c) 12.5 mL (d) 11.89 mL

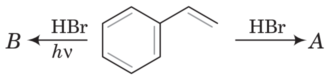
31. Which metal is used as a part of catalyst in Fischer-Tropsch method?
(a) Mn (b) Co (c) Fe (d) Pt

32. If the rate of effusion of helium at a pressure of 1000 Torr is 10 Torr min^{-1}. Find the rate of effusion of hydrogen gas at a pressure of 2000 Torr at the same temperature.
(a) 20 Torr min^{-1} (b) 10 Torr min^{-1}
(c) $30\sqrt{2}$ Torr min^{-1} (d) $20\sqrt{2}$ Torr min^{-1}

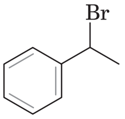
33. If the molecule of HCl was totally polar, the expected value of dipole moment was 6.12 Dq but the experimental value of dipole moment was 1.03 Dq. The percentage ionic character is
(a) 0 (b) 17 (c) 50 (d) 70

34. The species which can be serve as an initiator for the cationic polymerisation is
(a) $LiAlH_4$ (b) HNO_3
(c) $AlCl_3$ (d) BuLi

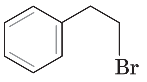
35. Predict the structure of *A* and *B*



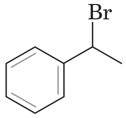
(a) Both *A* and *B* are



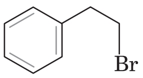
(b) Both *A* and *B* are



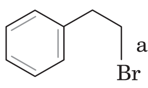
(c) *A* is



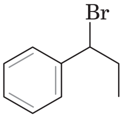
and *B* is



(d) *A* is



and *B* is



36. In acid rain, the correct order of different acid present in it is
(a) $H_2SO_4 > HNO_3 > HCl$
(b) $HNO_3 > HCl > H_2SO_4$
(c) $H_2SO_4 > HCl > HNO_3$
(d) $HCl > H_2SO_4 > HNO_3$

37. Carbon cannot be used in the reduction of Al_2O_3 because

(a) pure carbon is not easily available
(b) the enthalpy of formation of CO_2 is more than that of Al_2O_3
(c) the enthalpy of formation of Al_2O_3 is too high
(d) None of the above

38. Which of the following is not true about potash alum?

(a) Its aqueous solution is basic
(b) It is used in dyeing industries
(c) On heating, it melts to give water of crystallisation
(d) Its empirical formula is $K\,Al(SO_4)_2\cdot 12H_2O$

39. Haemoglobin contains 0.35% Fe. Each molecule contains four atoms of Fe (56 g-atoms/mol). The molecular weight of haemoglobin is

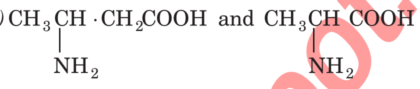
(a) 64×10^3 g/mol
(b) 74×10^2 g/mol
(c) 31×10^{10} g/mol
(d) 9.1×10^3 g/mol

40. Which of the following amino acids on heating separately gives an α,β unsaturated acid and α,γ-lactam?

(a) 
$\underset{NH_2}{CH_2}\cdot CH_2CH_2COOH$ and $CH_3\underset{NH_2}{CH_2}$

(b) 
$CH_3\underset{NH_2}{CH}\cdot COOH$ and $CH_3\underset{NH_2}{CH}CH_2\cdot COOH$

(c) 
$CH_3\underset{NH_2}{CH}\cdot CH_2COOH$ and $CH_3\underset{NH_2}{CH}CH_2\cdot CH_2COOH$

(d) 
$CH_3\underset{NH_2}{CH}\cdot CH_2COOH$ and $CH_3\underset{NH_2}{CH}\,COOH$

Answers

1. (a)	**2.** (d)	**3.** (a)	**4.** (a)	**5.** (d)
6. (c)	**7.** (d)	**8.** (b)	**9.** (c)	**10.** (a)
11. (b)	**12.** (c)	**13.** (b)	**14.** (a)	**15.** (a)
16. (a)	**17.** (b)	**18.** (d)	**19.** (b)	**20.** (a)
21. (c)	**22.** (b)	**23.** (c)	**24.** (d)	**25.** (a)
26. (c)	**27.** (b)	**28.** (b)	**29.** (b)	**30.** (c)
31. (b)	**32.** (d)	**33.** (b)	**34.** (c)	**35.** (c)
36. (a)	**37.** (c)	**38.** (a)	**39.** (a)	**40.** (c)

Continued from Page 65

46. Which of the following property about aspirin is not true?

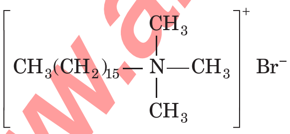
(a) A narcotic analgesics
(b) Effective in relieving pain
(c) Antiblood clotting action
(d) Neurologically active drug

47. What is the type of detergent (Z) formed in the following reactions?

$$3HCHO + CH_3CHO \xrightarrow{NaOH} X \xrightarrow{LiAlH_4} \xrightarrow{CH_3(CH_2)_{16}COOH} Z\text{(detergent)}$$

(a) Cationic
(b) Anionic
(c) Non-ionic
(d) Both cationic/anionic

48. Match structures given in Column I with their classifications given in Column II and select correct option from the codes given below.

	Column I		Column II
A.	$C_{17}H_{35}COO^-Na^+$	p.	Cationic detergent
B.	$CH_3(CH_2)_{10}CH_2SO_3^-Na^+$	q.	Anionic detergent
C.	 $\left[CH_3(CH_2)_{15}-\overset{CH_3}{\underset{CH_3}{N}}-CH_3\right]^+Br^-$	r.	Non-ionic detergent
D.	$CH_3(CH_2)_{16}COO(CH_2CH_2O)_xCH_2CH_2OH$	s.	Soap

Select the correct option.

Codes

	A	B	C	D		A	B	C	D
(a)	p	q	s	r	(b)	p	s	q	r
(c)	s	q	p	r	(d)	r	s	p	q

49. Which of the following statements is not correct?

(a) Disinfectants are antimicrobial drugs.
(b) Antiseptic medicines can be ingested.
(c) Dilute solutions of some disinfectants can be used as antiseptic.
(d) Some antiseptic can be added to soaps.

50. Veronal and luminal are the derivatives of barbituric acid which are

(a) tranquilisers
(b) neurologically active drugs
(c) Both (a) and (b)
(d) None of the above

Answers

1. (a)	**2.** (c)	**3.** (c)	**4.** (c)	**5.** (a)
6. (b)	**7.** (c)	**8.** (a)	**9.** (c)	**10.** (d)
11. (b)	**12.** (b)	**13.** (c)	**14.** (a)	**15.** (b)
16. (a)	**17.** (b)	**18.** (b)	**19.** (c)	**20.** (b)
21. (d)	**22.** (c)	**23.** (c)	**24.** (d)	**25.** (b)
26. (b)	**27.** (a)	**28.** (c)	**29.** (c)	**30.** (b)
31. (a)	**32.** (c)	**33.** (b)	**34.** (c)	**35.** (a)
36. (b)	**37.** (d)	**38.** (c)	**39.** (c)	**40.** (c)
41. (d)	**42.** (d)	**43.** (d)	**44.** (d)	**45.** (d)
46. (a)	**47.** (c)	**48.** (c)	**49.** (b)	**50.** (c)

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FUN ARCADE

PETER DEBYE

(24/03/1884 - 2/11/1966)

Petrus (Peter) **Josephus Wilhelmus Debye** was born on March 24, 1884 at Maastricht, Netherlands. He received his early education at the elementary and secondary schools in his hometown and from then his life has been devoted to a search for knowledge. He continued his studies at the Aachen Institute of Technology (Technische Hochschule) and gained a degree in electrical technology there, in 1905.

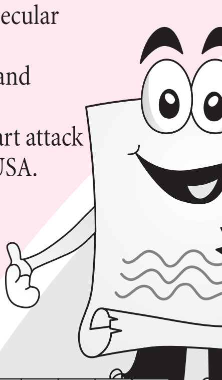
In 1906, Debye obtained a position in Theoretical Physics at Munich University, where he qualified as a University lecturer in 1910. In May 1914, he became member of the Royal Netherlands Academy of Arts and Science and in December of the same year he became foreign member.

His first major scientific contribution was the application of the concept of dipole moment to the charge distribution in asymmetric molecules. In 1912, he developed equations relating dipole moments to temperature and dielectric constant. The units of molecular dipole moments are termed 'debyes' in his honor.

In 1912, he extended Albert Einstein's theory of specific heat. In 1913, he extended Niels Bohr's theory of atomic structure, introducing elliptical orbits. In 1914-1915, he calculated the effect of temperature on X-ray diffraction patterns of crystalline solids with Paul Scherrer.

Peter Debye was awarded by Nobel Prize in chemistry in year 1936 "for his contributions to our knowledge of molecular structure through his investigations on dipole moments and on the diffraction of X-rays and electrons in gases.

He died on 2nd Nov. 1966 due to heart attack and buried in Ithaca, New York, USA.



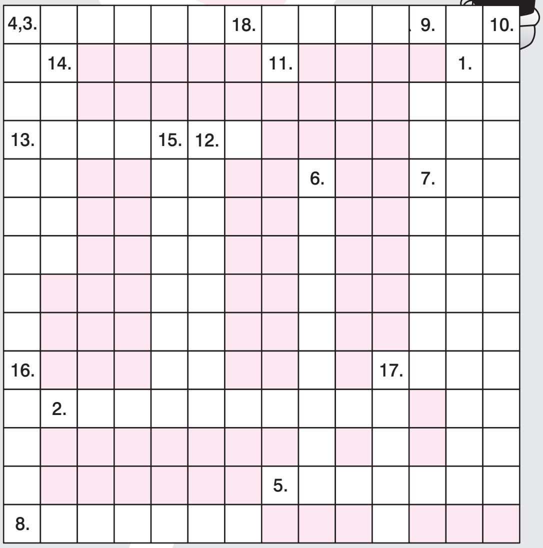
CROSSWORD

ACROSS

2. Preparation of oil gas or petrol gas from kerosene or petrol involves the principle of .... (9)
3. X-ray diffraction data reveals that benzene is a ... molecule. (6)
5. Flyash and slag from the steel industry are utilised by the ... industry. (6)
8. Nodal plane is an imaginary plane at which probability of finding an electron is .... (7)
11. It express the positions of substituents at opposite apexes on benzene ring. (4)
13. An enzyme which hydrolyse the sugar or starch (maltose) into glucose. (7)
16. A mixture of alkaloids mainly morphine, codeine and narcotine is ... . (5)
17. A space of very low electron density in an atom or molecule as predicted from wave equation is known as ... . (5)
18. Natural rubber consists mainly of a polymer of ... . (8)

DOWN

1. It is an old name for mercury. (11)
4. When constituent particles are present only on the corner positions of a unit cell, called as a .... unit cell. (9).
6. Compound of a metal containing —OH group is called ... . (9)
7. The ore which is usually contaminate with earthly or undesired materials. (6)
9. Organic compound containing alcoholic group attached to double bonded carbon atom. (4)
10. Naturally occurring alloy of gold and silver (upto 45% Ag) which resembles pure gold in appearance. (8)
12. Aggregation or group of orbitals of exactly similar energy which make an orbit. (8)
14. For an organic liquid, such as acetone, the intermolecular dipole-dipole interactions are significantly ....(6)
15. Optically inactive molecule is called .... molecule . (7)



Puzzles to Puzzle You

1. The reaction,

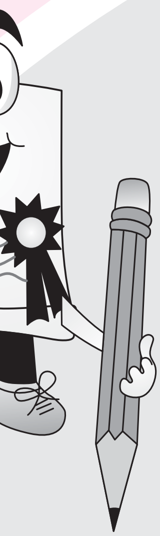
$$2A(g) + B(g) \rightleftharpoons 3C(g) + D(g)$$

is begin with the concentration of *A* and *B* both at an initial value of 1.00 M. When equilibrium is reached, the concentration of *D* is measured and found to be 0.25 M. What is the value of equilibrium constant for this reaction?

2. In a solid *AB* having the NaCl structure, *A* atoms occupy the corners of the cubic unit cell. If all the face centred atoms along one of the axis are removed, what is the resultant stoichiometry of the solid?

3. Glycine is a low molecular weight organic compound, yet is a high-melting crystalline solid and more soluble in water than in benzene. How?

4. Steam at 100°C is mixed with 1500 g of water at 15°C, such that the final temperature of the mixture is 80°C. What is the mass of steam?



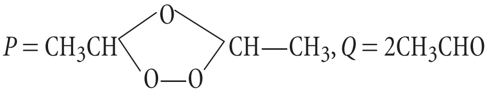
March 2017 Answers

Crossword

7P	Y	10R	A	N	O	18S	E				8K		
		A				P			3M		A		14F
		D			16L	I	T	H	O	4P	O	N	E
		I				N			N	I	L	12L	R
		A				E			D	P	I	A	R
		T				L				E	N	T	E
		I		5F	U	S	E	D		T	6Z	T	D
	11T	O	P	A	Z					T	Y	I	O
	13U	N	I	D	E	N	T	A	T	E	M	C	X
9, 17Q	U	I	N	I	N	E					A	E	I
U	2G	L	Y	C	O	G	E	N			S		N
1A	C	R	I	L	A	N					E		
R	15L	E	W	I	S	I	T	E					
K													

Puzzles to Puzzle you

1. $X = CH_3COCH_2CH_3$, $Y = CH_3—CH(OH)CH_2CH_3$, $Z = CH_3CH{=\!=}CHCH_3$



$P = CH_3CH\langle O, O—O\rangle CH—CH_3$, $Q = 2CH_3CHO$

2. Conjugated diene is more stable than alkyne

3. Path (b)

CHEMISTRY BEHIND SELF-CLEANING WINDOWS

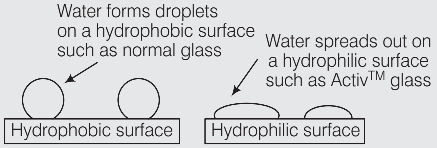
- Pilkington Activ^{TM}, launched in 2001 was the first type of glass to be produced that has the ability to clean itself.
- The glass contains a virtually transparent coating of titanium dioxide, 15 nm thick, which is deposited during the manufacturing process.
- The TiO_2 coating is durable, since it is bonded to the glass surface and has two functions that allow it to act as a self-cleaning glass.
- Firstly, TiO_2 absorbs ultraviolet photons from sunlight.
- On absorption of a photon, an electron is promoted from the filled valence band into the empty conduction band.
- The promoted electron is then able to interact with oxygen absorbed on the surface to produce a superoxide ion (O_2^-).

$$O_2 + e^- \longrightarrow O_2^-$$

- Once, it has been activated, the photoactive form of TiO_2 acts as an oxidising agent by accepting electrons into the vacancies in the valence band.
- It obtains these electrons by oxidation of water, converting H_2O into very reactive hydroxy radicals ($\bar{O}H$)

$$H_2O \longrightarrow \bar{O}H + H^+ + e^-$$

- This also takes the TiO_2 back to a ground state and completes the catalytic cycle.
- Both hydroxyl radicals and superoxide ions are strong oxidising agents and are able to oxidise most of the organic molecules present in dirt, converting them eventually to CO_2 and H_2O. This means that photoactivation of TiO_2 provides a means for getting rid of most organic dirt.
- The second way in which the TiO_2 coating leads to self-cleaning relates the interactions with water molecules.
- On the surface of the coating, the TiO_2 oxygen atoms are protonated, forming OH groups.
- These groups are hydrophilic and interact with water molecules through hydrogen bonds.
- As a result, rain water spreads out into a thin film on the glass surface and dirt is washed off the window in a sheet of water.



- The behaviour contrasts with that of normal glass which is hydrophobic.
- Water form droplets on most types of glass and these run off the surface in streams.
- The streams tend to concentrate the dirt and lead to smudges and drying marks.

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JUST SOLVE & SEND
KNOWLEDGE COEFFICIENT QUIZZER (NO. 29)

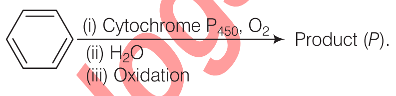
1. A coal fired electric power plant burns about 1.5 million tons of coal a year. Coal has an approximate composition of $C_{135}H_{96}O_9NS$. When coal burns, it releases about 30 kJ/g. We can approximate how much energy (kJ) is released by this plant in a year and the mass of CO_2 released in that year by burning 1.5 million tons of coal?

2. An organic compound has 52.17% C, 18.04% H and rest O. The compound does not react with either metallic sodium or PCl_5. It forms only one alkyl iodide when treated with HI. Alkyl iodide, so formed, has 89.13% iodine and 8.45% carbon. Find out the structure of the original compound.

3. Oxalate ion forms a complex ion with Mn^{2+} by coordinating at the oxygen lone pairs. How many atoms are in the ring formed between one oxalate ion and the central metal ion.

4. Formation of tritium in the atmosphere involves the nuclear reaction of ^{14}N with a neutron. Give the nuclear reaction for this process and identify the other product.

5. Give the product (*P*) in the following reaction,



Fill in the Blanks

6. The interplay between the hard, regular ...... regions and the elastic ...... regions gives spider silk its strength and ability to stretch.

7. Artificial grass is made from ...... which when worn down is often recycled.

8. ...... is used as an X-ray contrast agent in images of the digestive tract.

9. ...... can be used to decaffeinate coffee beans.

10. Corals are under major threat from rising acidity in the oceans and their structures largely consist of ....

KNOWLEDGE Coefficient Quizzer (No. 29)

Write your answers on separate sheets and send to us alongwith this coupon

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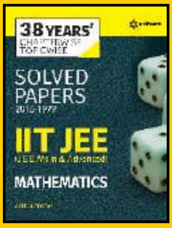

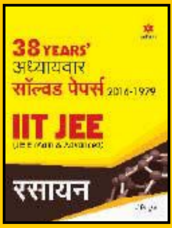


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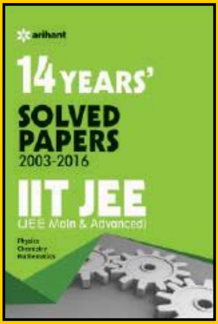



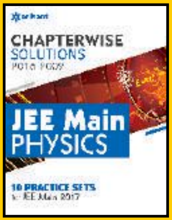
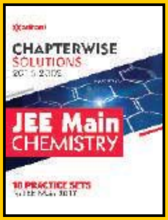
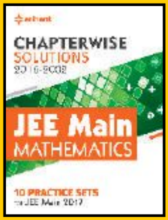

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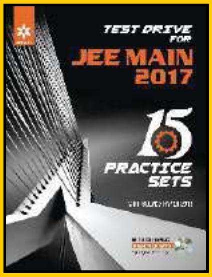

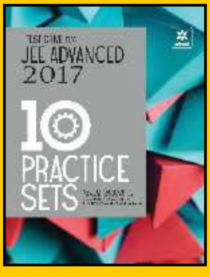

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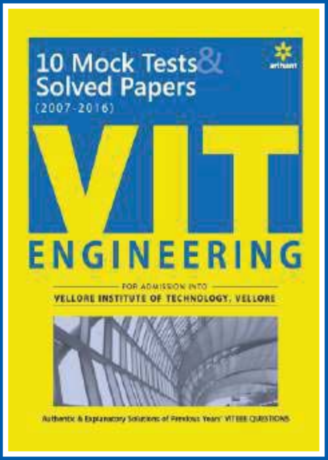

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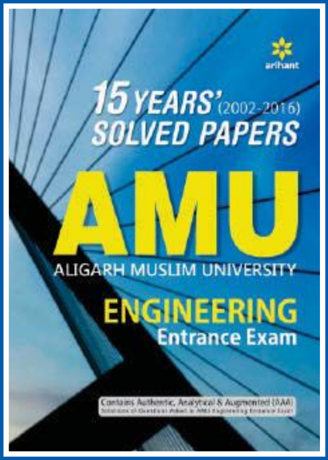

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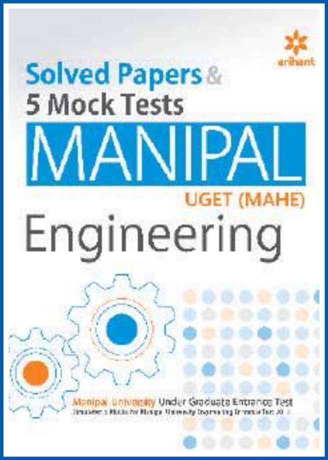

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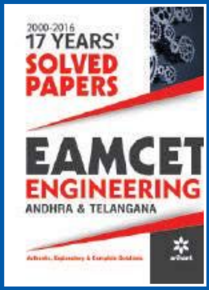

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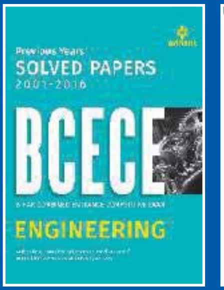

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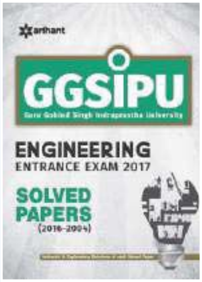

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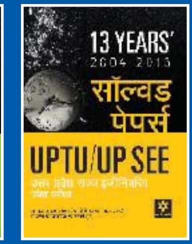

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