Exercise-1

✍ **Marked Questions may have for Revision Questions.**

ONLY ONE OPTION CORRECT TYPE

Section (A) : Basic definitions

1. Warming ammonium chloride with sodium hydroxide in a test tube is an example of :
(1) Closed system (2) Isolated system (3) Open system (4) None of these

2.✍ Out of boiling point (I), entropy (II), pH (III) and e.m.f. of a cell (IV), intensive properties are :
(1) I, II (2) I, II, III (3) I, III, IV (4) All of the above

3.✍ Predict the total number of intensive properties :
(i) Free energy (ii) Critical density (iii) Viscosity (iv) Specific heat capacity
(v) molar heat capacity (vi) Kinetic energy (vii) Specific gravity (viii) Dielectric constant
(ix) pH
(1) 9 (2) 8 (3) 7 (4) 6

4. Which of the following is an intensive property ?
(1) Temperature (2) Viscosity (3) Surface tension (4) All of these

5 A tightly closed thermoflask contains some ice cubes. This constitutes
(1) closed system (2) open system (3) isolated system (4) Non-thermodynamic system

6. An isolated system is that system in which
(1) there is no exchange of energy with the surroundings
(2) there is exchange of mass and energy with the surrounding
(3) There is no exchange of mass and energy with the surrounding
(4) There is exchange of mass with surroundings.

Section (B) : Thermodynamic functions & Thermodynamic processes

1. Which has maximum internal energy at 290 K ?
(1) Neon gas (2) Nitrogen gas (3) Ozone gas (4) Equal

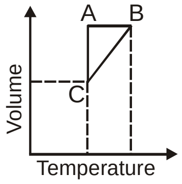
2. The internal energy of a substance :
(1) increases with increase in temprature (2) decreases with increase in temprature
(3) remains constant (4) calculated by $E = mc^2$

3. Which is correct for an adiabatic process ?
(1) $\Delta T= o$ (2) $q = 0$ (3) $\Delta V = 0$ (4) $\Delta P = 0$

4. Freezing up liquid in a system then :
(1) $q = 0$ (2) $q > 0$
(3) $q < 0$ (4) $q > 0$ or $q < 0$ (depending on the nature of liquid)

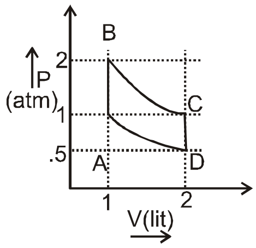
5. A gaseous system changes from state A (P_1, V_1, T_1) to B (P_2, V_2, T_2), B to C (P_3, V_3, T_3) and finally from C to A. The whole process may be called :
(1) Reversible process (2) Cyclic process (3) Isobaric process (4) Spontaneous process

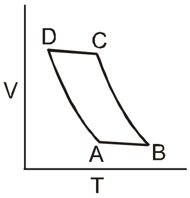
6. Five moles of a gas is put through a series of changes as shown graphicallay in a cyclic process the A → B, B → C and C → A respectively are

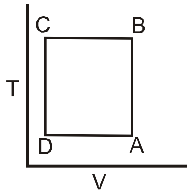


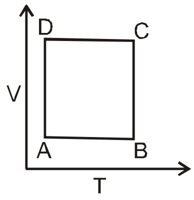
(1) Isochoric, Isobaric, Isothermal (2) Isobaric, Isochoric, Isothermal
(3) Isothermal, Isobaric, Isochoric (4) Isochoric, Isothermal, Isobaric

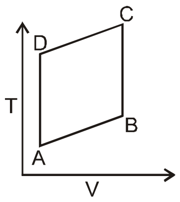
7. A cycle process ABCD is shown in P-V diagram for an ideal gas which of the diagram represent the same process.



(1) 

(2) 

(3) 

(4) 

8. In a laboratory, liquid in a thermally insulated container is stirred for one hr, by a mechanical linkage to a in surrounding, for this process :

(1) $W < 0; q = 0$ (2) $W < 0; q > 0$ (3) $W < 0; q > 0$ (4) $W > 0 ; q = 0$

9. A thermodynamic system goes from states (i) P_1, V to $2P_1$, V (ii) P, V_1 to P, $2V_1$. Then work done in the two cases is

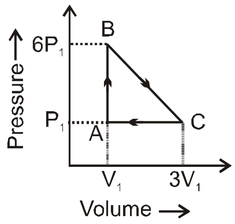
(1) Zero, Zero (2) Zero, $-PV_1$ (3) $-PV_1$, Zero (4) $-PV_1, -P_1V_1$

10. The work done in ergs for the reversible expansion of one mole of an ideal gas from a volume of 10 litres to 20 litres at 25^{0}C is :

(1) $-2.303 \times 298 \times 0.082 \log 2$ (2) $-298 \times 10^7 \times 8.31 \times 2.3031 \log 2$

(3) $-2.303 \times 298 \times 0.082 \log 0.5$ (4) $-8.31 \times 10^7 \times 298 \times 2.303 \log 0.5$

11. An ideal gas is taken around the cycle ABCA as shown in P-V diagram. The net work done by the gas during the cycle is equal to :



(1) $12P_1V_1$ (2) $5P_1V_1$ (3) $-5P_1V_1$ (4) P_1V_1

Section (C) : First law of thermodynamics

1. As per the First Law of thermodynamics, which of the following statement would be appropriate:

(1) Energy of the system remains constant (2) Energy of the surroundings remains constant

(3) Entropy of the universe remains constant (4) Energy of the universe remains constant

2. The first law of thermodynamics is represented by the equation :

(1) $\Delta E = q - W$ (2) $\Delta E = q + W$ (3) $W = q + \Delta E$ (4) $q = W + \Delta E$

3. A system absorb 600J of heat and work equivalent to 300J on its surroundings. The change in internal energy is

(1) 300 J (2) 400 J (3) 500 J (4) 600 J

4. In an isochoric process the increase in internal energy is

(1) Equal to the heat absorbed (2) Equal to the heat evolved

(3) Equal to the work done (4) Equal to the sum of the heat absorbed and work done

5. An ideal gas receives 10 J of heat in a reversible isothermal expansion. Then the work done by the gas:
(1) would be more than 10 J (2) 10 J
(3) would be less than 10 J (4) cannot be determined

6. A sample of liquid in a thermally insulated container (a calorimeter) is stirred by a motor. Taking liquid as a system for this process choose the appropriate option:
(1) $w < 0; q = 0; \Delta U = 0$ (2) $w > 0; q > 0; \Delta U > 0$ (3) $w < 0; q > 0; \Delta U = 0$ (4) $w > 0; q = 0; \Delta U > 0$

7. The internal energy change when a system goes from state A to B is 40 kJ/mol. If the system goes from A to B by a reversible path and returns to state A by an irreversible path, what would be the net change in internal energy ?
(1) 40 kJ (2) > 40 kJ (3) < 40 kJ (4) Zero

Section (D) : Calculation of ΔE, ΔH, w and q in different type of physical processes

1. Heat exchanged in a chemical reaction at the constant temprature and pressure is known as :
(1) Internal energy (2) entropy (3) enthalpy (4) free energy

2. For the isothermal expansion of an ideal gas
(1) U and H increases (2) U increases but H decreases
(3) H increases but U decreases (4) U and H are unaltered

3. A gas expands isothermally against a constant external pressure of 1 atm from a volume of 10- dm^3 to a volume of 20 dm^3. It absorbs 800 J of thermal energy from its surroundings. The ΔU is :
(1) – 312 J (2) + 123 J (3) – 213 J (4) + 231 J

4. One mole of a non-ideal gas undergoes a change of state (1.0 atm, 3.0 L, 200 K) to (4.0 atm, 5.0 L, 250 K) with a change in internal energy (ΔU) = 40 L-atm. The change in enthalpy of the process in L-atm ;
(1) 43 (2) 57 (3) 42 (4) None of these

5. For the real gases reaction $2CO (g) + O_2 (g) \longrightarrow 2CO_2 (g)$; $\Delta H = – 560$ kJ. In 10 litre rigid vessel at 500 K the initial pressure is 70 bar and after the reaction it becomes 40 bar. The change in internal energy is :
(1) – 557 kJ (2) – 530 kJ (3) – 563 kJ (4) None of these

6. A vessel contains 100 litres of a liquid X. Heat is supplied to the liquid in such a fashion that, Heat given = change in enthalpy. The volume of the liquid increases by 2 litres. If the external pressure is one atm, and 202.6 Joules of heat were supplied then, [U - total internal energy]
(1) $\Delta U = 0$, $\Delta H = 0$ (2) $\Delta U = + 202.6$J , $\Delta H = + 202.6$ J
(3) $\Delta U = – 202.6$J, $\Delta H = – 202.6$J (4) $\Delta U = 0$, $\Delta H = + 202.6$J

7. The work done in adiabatic process on ideal gas by a constant external pressure would be equal to :
(1) Zero (2) ΔE (3) ΔH (4) ΔG

8. A certain amount of zinc is dissolved in HCl at 25ºC in an open vessel. The type of process and the work done by the system respectively would be:
(1) isothermal, positive (2) isobaric, negative (3) isochoric, zero (4) None

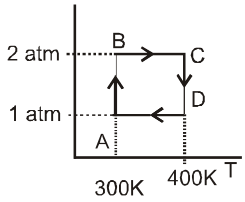
9. Two moles of an ideal gas expand spontaneously into a vaccum. The work done is :
(1) 2 J (2) 4 J (3) 8 J (4) zero

10. An ideal gas filled at pressure of 2 atm and temp of 300 K, in a balloon is kept in vacuum with in a large insulated container wall of balloon is punchtured then container temperature :
(1) Decreases (2) Increases (3) Remain constant (4) Unpredictable

11. If 1 mole of an ideal gas expands isothermally at 37ºC from 15 litres to 25 litres, the maximum work obtained is :

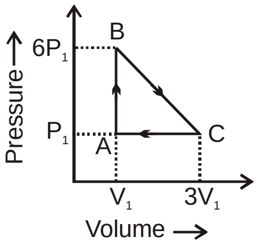
(1) 1303.73 J (2) 1603.26 J (3) 1235.30 J (4) 1396.26 J

12. Two moles of Helium gas undergo a reversible cyclic process as showin in figure. Assuming gas to be ideal. What is the work for the process C to D?



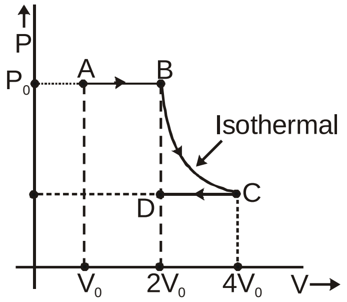
(1) – 800 Rℓn2 (2) zero (3) +200Rℓn2 (4) –600Rℓn2

13. Two moles of Helium gas undergo a reversible cyclic process as showin in figure. Assuming gas to be ideal. What is the total amount of heat invoved in the process?



(1) $5P_1V_1$ (2) zero (3) $-5P_1V_1$ (4) $12P_1V_1$

14. Work for the following process ABCD on a monoatomic gas is :



(1) $w = -2P_0V_0 \ln 2$, (2) $w = -P_0V_0 \ln 2$,

(3) $w = -P_0V_0(1 + \ln 2)$, (4) $w = -P_0V_0 \ln 2$,

15. The temperature of the system decreases in an

(1) Adiabatic compression (2) Isothermal compression

(3) Isothermal expansion (4) Adiabatic expansion

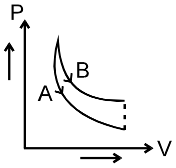
16. 1 mole of NH_3 gas at 27°C is expanded in reversible adiabatic condition to make volume 8 times ($\gamma = 1.33$). Final temperature and work done respectively are :

(1) 150 K, 900 cal (2) 150 K, 400 cal (3) 250 K, 1000 cal (4) 200 K, 800 cal

17.✍ One mole of an ideal gas $\left(C_{v,m} = \frac{5}{2}R\right)$ at 300 K and 5 atm is expanded adiabatically to a final pressure of 2 atm against a constant pressure of 2 atm. Final temperature of the gas is :

(1) 270 K (2) 273 K (3)248.5 K (4) 200 K

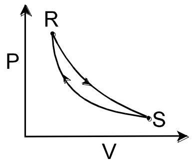
18.✍ In figure, A and B are two adiabatic curves for two different gases. Then A and B corresponds to :



(1) Ar and He respectively (2) He and H_2 respectively
(3) O_2 and H_2 respectively (4) H_2 and He respectively

19. If W_1 ; W_2 & W_3 are magnitude of work done of an ideal gas in isothermal, adiabatic & isobaric reversible expansion process from same initial stage to same final volume. Then correct order will be :
(1) $W_3 > W_1 > W_2$ (2) $W_3 > W_2 > W_1$ (3) $W_2 > W_1 > W_3$ (4) $W_1 > W_2 > W_3$

20. Consider the cyclic process R → S → R as shown in the Fig. You are told that one of the path is adiabatic and the other one isothermal. Which one of the following is(are) true?



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(1) Process R → S is isothermal (2) Process S → R is adiabatic
(3) Process R → S is adiabatic (4) Such a graph is not possible

Section (E) : IInd Law of thermodynamics : Basics of entropy, Entropy calculation for different types of physical process on an ideal gas, solid and liquid, chemical reaction

1. $NH_4Cl\,(s) \longrightarrow NH_3\,(g) + HCl\,(g)$ when the above reaction occurs, the entropy
(1) remains same (2) decrease (3) increases (4) none of the above

2. Predict which of the following reaction (s) has a positive entropy change ?
I. $Ag^+\,(aq) + Cl^-\,(aq) \longrightarrow AgCl\,(s)$
II. $NH_4Cl\,(s) \longrightarrow NH_3\,(g) + HCl\,(g)$
III. $2NH_3\,(g) \longrightarrow N_2\,(g) + 3H_2\,(g)$
(1) I and II (2) III (3) II and III (4) II

3. Which of the following reactions is associated with negative change in entropy ?
(1) $2SO_3\,(g) \longrightarrow 2SO_2\,(g) + O_2\,(g)$ (2) $C_2H_6\,(g) \longrightarrow C_2H_4\,(g) + H_2\,(g)$
(3) 2C (s, graphite) + O_2 (g) 2CO(g) (4) $3C_2H_2\,(g) \longrightarrow C_6H_6\,(\ell)$

4. Which one of the following has ΔS° greater than zero ?
(1) $CaO\,(s) + CO_2\,(g) \rightleftharpoons CaCO_3\,(s)$ (2) $NaCl\,(aq) \rightleftharpoons NaCl\,(s)$
(3) $NaNO_3\,(s) \rightleftharpoons Na+\,(aq) + NO_3^-(aq)$ (4) $N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$

5. Mixing of non-reacting ideal gases is generally accompanied by
(1) Decrease in entropy (2) Increase in entropy
(3) Change in enthalpy (4) Increase in free energy

6. Which of the following reactions is associated with the most negative change in entropy ?
(1) $2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$ (2) $C_2H_4(g) + H_2(g) \longrightarrow C_2H_6(g)$
(3) C (s, graphite) + $O_2 \longrightarrow CO_2(g)$ (4) $3C_2H_2(g) \longrightarrow C_6H_6(\ell)$

7. For the gas - phase decomposition, $PCl_5\,(g) \overset{\Delta}{\rightleftharpoons} PCl_3\,(g) + Cl_2\,(g)$:

(1) $\Delta H < 0, \Delta S < 0$ (2) $\Delta H > 0, \Delta S > 0$ (3) $\Delta H > 0, \Delta S < 0$ (4) $\Delta H < 0, \Delta S > 0$

8. Which one of the following has ΔS^0 greater than zero.

(1) $CaO\,(s) + CO_2(g) \rightleftharpoons CaCO_3(s)$ (2) $NaCl\,(aq) \rightleftharpoons NaCl\,(s)$

(3) $NaNO_3(s) \rightleftharpoons Na^+\,(aq) + NO_3^-(aq)$ (4) $N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$

9.✍ For which reaction from the following, will be maximum entropy change :

(1) $Ca(s)+\frac{1}{2}O_2(g) \rightarrow CaO(s)$ (2) $CaCO_3(s) \rightarrow CaO(s)+CO_2(g)$

(3) $C(s)+O_2(g) \rightarrow CO_2(g)$ (4) $N_2(g)+O_2(g) \rightarrow 2NO(g)$

10. Which of the following statement is true. The entropy of the universe

(1) Increases and tends towards maximum value

(2) Decreases and tends to be zero

(3) Remains constant

(4) Decreases and increases with a periodic rate

11. When two mole of an ideal gas $\left(C_{p,m} = \frac{5}{2}R\right)$ heated from 300 K to 600 K at constant pressure. The change in entropy of gas (ΔS) is :

(1) $\frac{3}{2}$ R ln 2 (2) $-\frac{3}{2}$ R ln 2 (3) 5R ln 2 (4) $\frac{5}{2}$ R ln 2

12. The entropy change when two moles of ideal monoatomic gas is heated from 200ºC to 300 ºC reversibly and isochorically ?

(1) $\frac{3}{2}$ R ln $\left(\frac{300}{200}\right)$ (2) $\frac{5}{2}$ R ln $\left(\frac{573}{273}\right)$ (3) 3R ln $\left(\frac{573}{473}\right)$ (4) $\frac{3}{2}$ R ln $\left(\frac{573}{473}\right)$

13. If one mole of an ideal gas $\left(C_{p,m} = \frac{5}{2}R\right)$ is expanded isothermally at 300 K until it's volume is tripled, then change in entropy of gas is :

(1) zero (2) infinity (3) $\frac{5}{2}$ R ln 3 (4) R ln 3

14. 1 mole of a diatomic ideal gas at 25°C is subjected to expand reversibly and adiabatically to ten times of its initial volume. Calculate the change in entropy during expansion (in $JK^{-1}\,mol^{-1}$)

(1) R ln 10 (2) – R ln 10 (3) 2.5 R ln 10 (4) zero

15. When two mole of an ideal gas $\left(C_{p,m} = \frac{5}{2}R\right)$ is expande adiabatically and reversibly from 1 L to 8 L at . The change in entropy of univers is :

(1) 5R ln 2 (2) $\frac{3}{2}$ R ln 2 (3) 0 (4) –3R ln 2

16. Calculate the entropy change (J/mol K) of the given reaction. The molar entropies [J/K-mol] are given in brackets after each substance.

$2PbS\,(s)\,[91.2] + 3O_2\,(g)\,[205.1] \longrightarrow 2PbO\,(s)\,[66.5] + 2SO_2\,(g)\,[248.2]$

(1) –113.5 (2) –168.3 (3) +72.5 (4) –149.2

17. The change in entropy for the fusion of 1 mole of ice is [mp of ice = 273 K, molar enthalpy of fusion for ice = 6.0 kJ mol^{-1}].

(1) 11.73 JK^{-1} mol^{-1} (2) 18.84 JK^{-1} mol^{-1} (3) 21.97 JK^{-1} mol^{-1} (4) 24.47 JKI^{-1} mol^{-1}

Section (F) : ΔG calculation, Spontanity of chemical reaction significance of ΔG and IIIrd Law of thermodynamics

1. Which of the following conditions regarding a chemical process ensures its spontaneity at all temperature?

(1) $\Delta H > 0, \Delta S < 0$ (2) $\Delta H < 0, \Delta S > 0$ (3) $\Delta H < 0, \Delta S < 0$ (4) $\Delta H > 0, \Delta S < 0$

2. For isothermal expansion in case of an ideal gas :

(1) $\Delta G = \Delta S$ (2) $\Delta G = T\Delta S$ (3) $\Delta G = -T\Delta S$ (4) None of these

3. For the gas - phase decomposition, $PCl_5\,(g) \overset{\Delta}{\rightleftharpoons} PCl_3\,(g) + Cl_2\,(g)$:

(1) $\Delta H < 0, \Delta S < 0$ (2) $\Delta H > 0, \Delta S > 0$ (3) $\Delta H > 0, \Delta S < 0$ (4) $\Delta H < 0, \Delta S > 0$

4. In an irreversible process taking place at constant T and P and in which only pressure-volume work is being done, the change in Gibbs free energy (dG) and change in entropy (dS), satisfy the criteria :

(1) $(dS)_{V,\,E} < 0, (dG)_{T,\,P} < 0$ (2) $(dS)_{V,\,E} > 0, (dG)_{T,\,P} < 0$

(3) $(dS)_{V,\,E} = 0, (dG)_{T,\,P} = 0$ (4) $(dS)_{V,\,E} = 0, (dG)_{T,\,P} > 0$

5. Consider the ΔG^o_f and ΔH^o_f (kJ/mol) for the following oxides. Which oxide can be most easily decomposed to form the metal and oxygen gas ?

(1) ZnO ($\Delta G^o = -318.4, \Delta H^o = -348.3$) (2) Cu_2O ($\Delta G^o = -146.0, \Delta H^o = -168.8$)

(3) HgO ($\Delta G^o = -58.5, \Delta H^o = -90.8$) (4) PbO ($\Delta G^o = -187.9, \Delta H^o = -217.3$)

7. What is the free energy change (ΔG) when 1.0 mole of water at 100ºC and 1 atm pressure is converted into steam at 100ºC and 1 atm pressure ?

(1) 80 cal (2) 540 cal (3) 620 cal (4) Zero

8. The enthalpy change for a given reaction at 298 K is – x J mol^{-1} (x being positive). If the reaction occurs spontaneously at 298 K, the entropy change at that temperature

(1) can be negative but numerically larger than x/298

(2) can be negative but numerically smaller than x/298

(3) cannot be negative

(4) cannot be positive

9. A reaction has $\Delta H = -33$ kJ and $\Delta S = -58$ J/K. This reaction would be :

(1) spontaneous at all temperatures (2) non-spontaneous at all temperatures

(3) spontaneous above a certain temperature (4) spontaneous below a certain temperature

10.✍ $H_2O(s) \rightarrow H_2O(\ell)$

This phase transition is carried out at constant temp and pressure then work done during the process :

(1) W < 0 (2) W > 0 (3) W = 0 (4) can't detamined

11. At 1 atm pressure freezing of n mole of water liquid (0ºC) to ice(0ºC) then heat transfer :

(1) $n\Delta H_{fusion}$ (2) $-n\,\Delta H_{fusion}$ (3) $nC_{v,\,m}\Delta T$ (4) ΔH_{fusion}

Section (G) : Basics & Kirchoff's law

1. For which of the following change $\Delta H \neq \Delta E$?

(1) $H_2(g) + I_2(g) \longrightarrow 2HI(g)$ (2) $HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(\ell)$

(3) $C(s) + O_2(g) \longrightarrow CO_2(g)$ (4) $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

2. $2C + O_2 \rightarrow 2CO;\ \Delta H = -220$ kJ Which of the following statement is correct for this reaction

(1) Reaction is endothermic (2) Reaction is exothermic

(3) Reaction needs no initiation (4) All of these are correct

3. In the exothermic reaction the enthalpy of reaction is always :

(1) zero (2) positive (3) negative (4) none of these

4.✍ $C\,(s) + O_2\,(g) \longrightarrow CO_2,\,(g);$ $\Delta H = -94.3$ kcal/mol

$CO\,(g) + \frac{1}{2}\,O_2(g) \longrightarrow CO_2\,(g);$ $\Delta H = -\,67.4$ kcal/mo!

$O_2(g) \longrightarrow 2O\,(g);$ $\Delta H = 117.4$ kcal/mol

$CO\,(g) \longrightarrow C\,(g) + O(g)\,;$ $\Delta H = 230.6$ kcal/mol

Calculate ΔH for $C\,(s) \longrightarrow C\,(g)$ in kcal/mol.

(1) 171 (2)154 (3)117 (4)145

5.✍ The enthalpy change for the reaction of 5 liter of ethylene with 5 liter of H_2 gas at 1.5 atm pressure is $\Delta H = -\,0.5$ kJ. The value of ΔU will be : (1 atm Lt = 100 J)

(1) – 1.25 kJ (2) + 1.25 kJ (3) 0.25 kJ (4) – 0.25 kJ

Section (H) : Enthalpy of formation & combustion

1. The species which by definition has **ZERO** standard molar enthalpy of formation at 298 K is :

(1) $Br_2(g)$ (2) $Cl_2(g)$ (3) $H_2O(g)$ (4) $CH_4(g)$

2. Which of the reaction defines molar $\Delta H_f°$?

(1) $CaO(s) + CO_2(g) \longrightarrow CaCO_3\,(s)$ (2) $\frac{1}{2}\,Br_2\,(g) + \frac{1}{2}\,H_2\,(g) \longrightarrow HBr(g)$

(3) $N_2\,(g) + 2H_2\,(g) + \frac{3}{2}\,O_2\,(g) \longrightarrow NH_4NO_3\,(s)$ (4) $I_2\,(s) + H_2\,(g) \longrightarrow 2HI\,(g)$

3. In the reaction, $CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g);$ $\Delta H = 2.8$ kJ, ΔH represents

(1) heat of reaction (2) heat of combustion (3) heat of formation (4) heat of solution

4. Thremodynamically, most stable form of phosphorus is :

(1) Red (2) Black (3) White (4) Yellow

5. The standard enthalpy of formation of ammonia is 46.0 kJ mol^{-1}. The standard enthalpy change for following reaction is :

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

(1) 46.0 kJ (2) - 46.0 kJ (3) - 92.0 kJ (4) 92.0 kJ

6. The heat of formation of CO(g) and $CO_2(g)$ are $\Delta H = -110$ and $\Delta H = -\,393$ kJ mol^{-1} respectively. What is the heat of reaction (ΔH) (in kJ mol^{-1}) for the following reaction ?

$$CO(g) + \frac{1}{2}\,O_2(g) \longrightarrow CO_2(g)$$

(1) – 504 (2) – 142.5 (3) – 283 (4) 504

7. The standard heat of combustion of solid boron is equal to :

(1) $\Delta H°_f\,(B_2O_3)$ (2) 1/2 $\Delta H°_f\,(B_2O_3)$ (3) $2\Delta H°_f\,(B_2O_3)$ (4) 1/3 $\Delta H°_f\,(B_2O_3)$

8. Given, $NH_3(g) + 3Cl_2(g) \rightleftharpoons NCl_3(g) + 3HCl(g);$ ΔH_1

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g);$ ΔH_2

$H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g);$ ΔH_3

The heat of formation of $NCl_3(g)$ in terms of ΔH_1, ΔH_2 and ΔH_3 is :

(1) $\Delta H_f = -\Delta H_1 + \frac{\Delta H_2}{2} - \Delta H_3$ (2) $\Delta H_f = \Delta H_1 + \frac{\Delta H_2}{2} - \frac{3}{2}\Delta H_3$

(3) $\Delta H_f = -\Delta H_1 - \frac{\Delta H_2}{2} - \frac{3}{2}\Delta H_3$ (4) None of the above

9.✍ For the following reaction, $C\ (diamond) + O_2 \longrightarrow CO_2(g)$; $\Delta H = -94.3$ kcal/mol

$C\ (graphite) + O_2 \longrightarrow CO_2(g)$; $\Delta H = -97.6$ kcal/mol

The heat required to change 1 g of C (diamond) $\longrightarrow$ C (graphite) is

(1) 1.59 kcal (2) 0.1375 kcal (3) 0.55 kcal (4) 0.275 kcal

10. If $S + O_2 \longrightarrow SO_2$, $\Delta H = -298.2$ kJ mole^{-1}

$SO_2 + 1/2\ O_2 \longrightarrow SO_3$ $\Delta H = -98.7$ kJ mole^{-1}

$SO_3 + H_2O \longrightarrow H_2SO_4$, $\Delta H = -130.2$ kJ mole^{-1}

$H_2 + 1/2\ O_2 \longrightarrow H_2O$, $\Delta H = -287.3$ kJ mole^{-1}

the enthalpy of formation of H_2SO_4 at 298 K will be -

(1) – 814.4 kJ mol^{-1} (2) + 814.4 kJ mole^{-1} (3) – 650.3 kJ mole^{-1} (4) – 433.7 kJ mole^{-1}

11. The values of heat of combustion of ethane (C_2H_6) and ethyne (C_2H_2) are – 341 and – 310 Kcal respectively. Then which of the following is better fuel on mass basis :

(1) C_2H_2 (2) C_2H_6 (3) Both (1) & (2) (4) None of these

12. The enthalpy of combustion of C_6H_6 is – 3250 kJ when 0.39g of C_6H_6 is burnt in excess of oxgyen in an open vessel, the amount of heat envolved is :

(1) 8.32 kJ (2) 12.36 kJ (3) 16.25 kJ (4) 20.74 kJ

13. The difference between ΔH and ΔE on a molar basis for the combustion of Methane gas at T K (kelvin) would be :

(1) zero (2) –RT (3) –2RT (4) –3RT

Section (I) : Enthalpy of Solution & Enthalpy of neutralization

1. The enthalpy of solution of NaOH (s) in water is – 41.6 kJ/mole when NaOH is dissolved in water then the temperature of water :

(1) Increase (2) Decrease (3) Does not change (4) Fluctuates

2. One mole of anhydrous $MgCl_2$ dissolves in water and librates 25 cal/mol of heat. $\Delta H_{hydration}$ of $MgCl_2$ = – 30 cal/mol. Heat of dissolution of $MgCl_2.H_2O$ is

(1) +5 cal/mol (2) –5 cal/mol (3) 55 cal/mol (4) –55 cal/mol

3.✍ The enthalpy of neutralization of which of the following acid & base is nearly – 13.6 kcal.

(1) HCN and NaOH (2) CH_3COOH and NH_4OH

(3) HCl and KOH (4) HCl and NH_4OH

4. Equal volume of HCOOH and NaOH are mixed. If x is the heat of neutralization of strong acid & strong base, then heat evolved of neutralization is :

(1) more than x (2) equal to x (3) twice of x (4) less than x

5. If heat of dissociation of $CHCl_2COOH$ is 0.7 kcal/mole then ΔH for the reaction :

$CHCl_2COOH + KOH \longrightarrow CHCl_2COOK + H_2O$

(1) – 13 kcal (2) + 13 kcal (3) – 14.4 kcal (4) – 13.7 kcal

6. Enthalpy of neutralisation of CH_3COOH by NaOH is – 50.6 kJ/mol and the heat of neutralisation of a strong acid with NaOH is – 55.9 kJ/mol. The value of ΔH for the ionisation of CH_3COOH is :

(1) 3.5 kJ / mol (2) 4.6 kJ / mol (3) 5.3 kJ / mol (4) 6.4 kJ / mol

Section (J) : Born-Haber Cycle

1. For which one of the following reaction does the molar enthalpy change of a reaction corresponds to Lattice energy of KBr ?

(1) $KBr(s) \longrightarrow K(s) + \frac{1}{2}Br_2(g)$ (2) $KBr(g) \longrightarrow K(g) + Br(g)$

(3) $KBr(s) \longrightarrow K^+(g) + Br^-(g)$ (4) $KBr(g) \longrightarrow K^+(g) + Br^-(g)$

2.✍ Calculate the lattice energy for the reaction

$Li^+(g) + Cl^-(g) \longrightarrow LiCl(s)$

given that

$\Delta H_{sub}(Li) = 160$; $\Delta H_{diss}(Cl_2) = 244$; IP(Li) = 520 ;

$E_A(Cl) = -365$ and $\Delta H_f(LiCl) = -400$ (all in kJ $mole^{-1}$)

(1) –837 (2) –959 (3) –1567 (4) –37

Section (K) : Bond Enthalpies and Resonance Energy

1. The bond energy (in **kcal mol^{-1}**) of a C–C single bond is approximately :

(1) 1 (2) 10 (3) 100 (4) 1000

2. The bond dissociation energy of gaseous H_2, Cl_2 and HCl are 104, 58 and 103 kcal mol^{-1} respectively. The enthalpy of formation for HCl gas will be

(1) – 44.0 kcal (2) – 22.0 kcal (3) 22.0 kcal (4) 44.0 kcal

3.✍ If enthalpy of dissociation of CH_4 (g) and C_2H_6 (g) into gaseous atoms are 320 and 600 calories respectively then bond energy of C–C bond is :

(1) 80 cal (2) 40 cal (3) 60 cal (4) 120 cal

4. AB, A_2 and B_2 are diatomic molecules. If the bond enthalpies of A_2, AB & B_2 are in the ratio 1 : 1 : 0.5 and enthalpy of formation of AB from A_2 and B_2 is – 100 kJ/mol^{-1}. What is the bond enthalpy of A_2.

(1) 400 kJ/mol (2) 200 kJ/mol (3) 100 kJ/mol (4) 300 kJ/mol

5. If at 298 K the bond energies of C–H, C–C, C=C and H–H bonds are respectively 414, 347, 615 and 435 kJ mol^{-1}, the value of enthalpy change for the reaction :

$H_2C{=}CH_2(g) + H_2(g) \longrightarrow H_3C{-}CH_3(g)$ at 298 K will be :

(1) + 250 kJ (2) – 250 kJ (3) + 125 kJ (4) – 125 kJ

6. Heat of hydrogenation of ethene is x_1 and that of benzene is x_2. Hence resonance energy is -

(1) $x_1 - x_2$ (2) $x_1 + x_2$ (3) $3x_1 - x_2$ (4) $x_1 - 3x_2$

Exercise-2

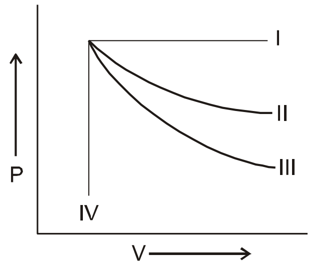
✍ **Marked Questions may have for Revision Questions.**

1.✍ In which one of the following sets, all the properties belong to same category (all extensive or all intensive)?

(1) Mass, volume, pressure (2) Temperature, pressure, volume

(3) Heat capacity, density, entropy (4) Enthalpy, internal energy, volume.

2.



The plots between P and V which represent isochoric and isobaric process respectively :

(1) I, II (2) IV, I (3) I, IV (4) II, III

3. In thermodynamics, a process is called reversible when -

(1) surroundings and system change into each other
(2) there is no boundary between system and surroundings
(3) the surroundings are always in equilibrium with the system
(4) the system changes into the surroundings spontaneously

4. Which one of the following statement is false :

(1) work is a state function
(2) temperature is a state function
(3) change in the state is completely defined when the initial and final states are specified
(4) work appears at the boundary of the system.

5. Which one of the following equations does not correctly represent the first law of thermodynamics for the given process in ideal gas ?

(1) Isothermal process : $q = -w$ (2) Cyclic process : $q = -w$
(3) Adiabatic process : $\Delta E = q$ (4) Expansion of a gas into vacuum : $\Delta E = q$

6.✍ Determine which of the following reactions at constant pressure represent surrounding that do work on the system :

I. $4NH_3(g) + 7O_2(g) \longrightarrow 4NO_2(g) + 6H_2O(g)$
II. $CO(g) + 2H_2(g) \longrightarrow CH_3OH(\ell)$
III. $C(s, \text{graphite}) + H_2O(g) \longrightarrow CO(g) + H_2(g)$
IV. $H_2O(s) \longrightarrow H_2O(\ell)$

(1) III, IV (2) II and III (3) II, IV (4) I and II, IV

7. Consider the reaction at 300 K

$H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$; $\Delta H^o = -185$ kJ

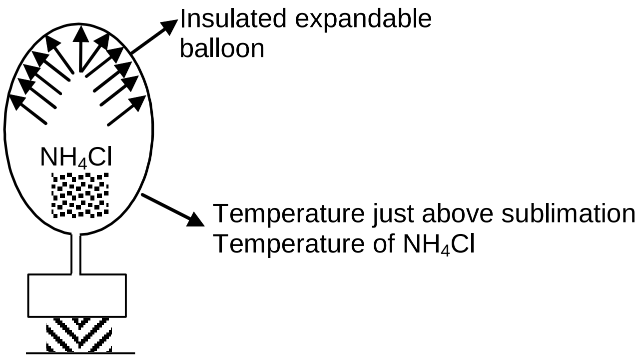
If 2 mole of H_2 completely react with 2 mole of Cl_2 to form HCl. What is ΔU^o for this reaction ?

(1) 0 (2) – 185 kJ (3) 370 kJ (4) – 370 Kj

8. A piece of NH_4Cl is kept inside a ballon filled with some air, having thermally insulated walls. The temperature is kept just above sublimation temperature of NH_4Cl.

$$NH_4Cl(s) \xrightarrow{\text{sublime}} NH_3(g) + HCl(g).$$

Which of the following is correct regarding this :



(1) q_{system} = positive (2) ΔU = negative (3) w = zero (4) ΔU = positive

9. 2 moles of ideal gas is expanded isothermally & reversibly from 1 litre to 10 litre. Find the enthalpy change in kJ mol^{-1}.

(1) 0 (2) 11.7 (3) – 11.7 (4) 25

10. The magnitudes of enthalpy changes for irreversible adiabatic expansion of a gas from 1L to 2L is ΔH_1 and for reversible adiabatic expansion for the same expansion is ΔH_2. Then

(1) $\Delta H_1 > \Delta H_2$

(2) $\Delta H_1 < \Delta H_2$

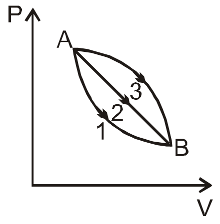
(3) $\Delta H_1 = \Delta H_2$, enthalpy being a state function ($\Delta H_1 = \Delta H_2$½

(4) $\Delta H_1 = \Delta E_1$ & $\Delta H_2 = \Delta E_2$ where ΔE_1 & ΔE_2 are magnitudes of change in internal energy of gas in these expansions respectively.

11. A certain mass of gas is expanded from (1L, 10 atm) to (4L, 5 atm) against a constant external pressure of 1 atm. If initial temperature of gas is 300 K and the heat capacity of process is 50 J/°C. Then the enthalpy change during the process is (1L atm $\simeq$ 100 J)

(1) ΔH = 15 kJ (2) ΔH = 15.7 kJ (3) ΔH = 14.4 kJ (4) ΔH = 14.7 kJ

12. A given mass of gas expands from the state A to the state B by three paths 1, 2 and 3 as shown in the figure. If w_1, w_2 and w_3 respectively be the magnitudes work done by the gas along three paths then :



(1) $w_1 > w_2 > w_3$ (2) $w_1 < w_2 < w_3$ (3) $w_1 = w_2 = w_3$ (4) $w_2 < w_3 < w_1$

13. One mole of a non-ideal gas undergoes a change of state (2.0 atm, 3.0 L, 95 K) → (4.0 atm, 5.0 L, 245 K) with a change in internal energy, ΔU = 30.0 L atm. The change in enthalpy (ΔH) of the process in L atm is -

(1) 40.0 (2) 42.3

(3) 44.0 (4) not defined, because pressure is not constant

14. One mole of an ideal monoatomic gas at temperature T and volume 1L expands to 2L against a constant external pressure of one atm under adiabatic conditions, then final temperature of gas will be :

(1) $T + \frac{2}{3\times0.0821}$ (2) $T - \frac{2}{3\times0.0821}$ (3) $\frac{T}{2^{5/3-1}}$ (4) $\frac{T}{2^{5/3+1}}$

15. Isoentropic process is

(1) adiabatic and irreversible process (2) isothermal and reversible process

(3) Adiabatic and reversible process (4) isothermal and reversible for which Q = 0

16. The direct conversion of A to B is difficult, hence it is carried out by the following shown path:

$$\begin{tikzcd} C \arrow[r] & D \arrow[d] \\ A \arrow[u] & B \end{tikzcd}$$

$\Delta S(A \longrightarrow C) = 50$; $\Delta S(C \longrightarrow D) = 30$; $\Delta S(B \longrightarrow D) = +20$

The entropy change for the process $A \longrightarrow B$ is

(1) 100 (2) – 60 (3) – 100 (4) + 60

17. An isolated system comprises the liquid in equilibrium with vapours. At this stage the molar entropy of the vapour is :

(1) Less than that of liquid (2) more than that of liquid

(3) Equal to zero (4) Equal to that of liquid

18. For the process, $H_2O(\ell) \rightarrow H_2O(g)$ at T = 100°C and 1 atmosphere pressure, the correct choice is :

(1) $\Delta S_{system} > 0$ and $\Delta S_{surroundings} > 0$ (2) $\Delta S_{system} > 0$ and $\Delta S_{surroundings} < 0$

(3) $\Delta S_{system} < 0$ and $\Delta S_{surroundings} > 0$ (4) $\Delta S_{system} < 0$ and $\Delta S_{surroundings} < 0$

19. $\Delta H = 30$ kJ mol^{-1} , $\Delta S = 75$ J / k / mol. Find boiling temperature at 1 atm.

(1) 400 K (2) 300 K (3) 150 K (4) 425 K

20. Spontaneous adsorption of a gas on a solid surface is exothermic process because

(1) enthalpy of the system increases. (2) entropy increases.

(3) entropy decreases. (4) free energy change increases.

21. A certain quantity of water is kept in freezer maintained at the freezing point of water. Which of the following observation would take place:

(1) ice will be formed

(2) water will cool down but no ice will be formed

(3) some part of water will be frozen

(4) water would freeze even before reaching freezing point

22. Given the following reactions :

I : $N_2(g) + 2O_2(g) \longrightarrow 2NO_2(g)$, $\Delta H_1 = 16.18$ kcal

II : $N_2(g) + 2O_2(g) \longrightarrow N_2O_4(g)$, $\Delta H_{II} = 2.31$ kcal

Based on the above facts :

(1) NO_2 is more stable than N_2O_4 at low temperature

(2) N_2O_4 is more stable than NO_2 at low temperature

(3) both are equally stable at low temperature

(4) none of the above

23. The value of $\log_{10}K$ for a reaction $A \rightleftharpoons B$ is :

(Given : $\Delta_r H^{\circ}_{298K} = -54.07$ kJ mol^{-1}, $\Delta_r S^{\circ}_{298K} = 10$ JK^{-1} mol^{-1} and R = 8.314 JK^{-1} mol^{-1} ; 2.303 x 8.314 x 298 = 5705)

(1) 5 (2) 10 (3) 95 (4) 100

24. For the process $H_2O(\ell)$ (1 bar, 373 K) $\rightarrow$ $H_2O(g)$ (1 bar, 373 K), the correct set of thermodynamic parameters is :

(1) $\Delta G = 0, \Delta S = +ve$ (2) $\Delta G = 0, \Delta S = -ve$ (3) $\Delta G = +ve, \Delta S = 0$ (4) $\Delta G = -ve, \Delta S = +ve$

25. For a reaction $A(g) \rightleftharpoons B(g)$ at equilibrium. The partial pressure of B is found to be one fourth of the partial pressure of A. The value of ΔG° of the reaction $A \rightarrow B$ is

(1) RT ℓn 4 (2) – RT ℓn 4 (3) RT log 4 (4) – RT log 4

26 Given that the molar heat capacity of ice is more than the molar heat capacity of water vapour. Let x and y be the magnitudes of the enthalpies of sublimation of ice at T_1 K and T_2 K such that $T_1 < T_2$. Choose the correct options:

(1) x = y (2) x > y (3) x < y (4) cannot be determined

27. For the hypothetical reaction $A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$.

If $\Delta_r G^o$ and $\Delta_r S^o$ are 20 kJ/mol and –20 JK^{-1} mol^{-1} respectively at 200 K.

$\Delta_r C_p$ is 20 JK^{-1} mol^{-1} then $\Delta_r H^o$ at 400 K is :

(1) 20 kJ/mol (2) 7.98 kJ/mol (3) 28 kJ/mol (4) None of these

28. Which of the following equation gives the values of heat of formation (ΔH_f^0)

(1) $C \text{ (diamond)} + O_2(g) \longrightarrow CO_2(g)$

(2) $\frac{1}{2}H_2(g) + \frac{1}{2}F_2(g) \rightarrow HF(g)$

(3) $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

(4) $H_2(g) + F_2(g) \rightarrow 2HF(g)$

29. From the following data of ΔH, of the following reactions,

$C(s) + \frac{1}{2}O_2(g) \longrightarrow CO(g)$ $\Delta H = -110$ kJ

$C(s) + H_2O(g)$ $CO(g) + H_2(g)$ $\Delta H = 132$ kJ

What is the molar ratio of steam and oxygen which on being passed over excess coke does not lead to the rise in temperature :

(1) 10 : 3 (2) 5 : 3 (3) 3 : 10 (4) None of these

30.✍ Given, $H_2(g) + Br_2(g) \longrightarrow 2HBr(g)$, ΔH^0_1 and standard enthalpy of condensation of bromine is ΔH^0_2, standard enthalpy of formation of HBr at 25°C is

(1) $\Delta H^0_1 / 2$ (2) $\Delta H^0_1 / 2 + \Delta H^0_2$ (3) $\Delta H^0_1 / 2 - \Delta H^0_2$ (4) $(\Delta H^0_1 - \Delta H^0_2) / 2$

31. The standard enthalpies of formation of $CO_2(g)$, $H_2O(l)$ and glucose(s) at 25°C are –400 kJ/mol, –300 kJ/mol and –1300 kJ/mol, respectively. The standard enthalpy of combustion per gram of glucose at 25°C is

(1) +2900 kJ (2) – 2900 kJ (3) –16.11 kJ (4) + 16.11 kJ

32.✍ When a certain amount of ethylene was combusted, 5644 kJ heat was evolved. If heat of combustion of ethylene is 1411 kJ, the volume of O_2 (at STP) that entered into the reaction is :

(1) 268.8 ml (2) 268.8 L (3) 6226 × 22.4 L (4) 22.4 L

33.✍ The heat of combustion of sucrose ($C_{12}H_{22}O_{11}$) is 1710 kcal/mol. How much of heat will be liberated when 17.1 g of sucrose is burnt ?

(1) 85.5kcal (2) 13.5 kcal (3) 40.5 kcal (4) 25.5 kcal

34. Enthalpy of polymerisation of ethylene, as represented by the reaction, $nCH_2{=}CH_2 \longrightarrow (-CH_2-CH_2-)_n$ is –100 kJ per mole of ethylene. Given bond enthalpy of C=C bond is 600 kJ mol^{-1}, enthalpy of C–C bond (in kJ mol) will be :

(1) 116.7 (2) 350 (3) 700 (4) indeterminate

35.✍ The average energy required to break a P – P bond in P_4 (s) into gaseous atoms is 53.2 kcal mol^{-1}. The bond dissociation energy of $H_2(g)$ is 104.2 kcal mol^{-1}; ΔH_f^0 of $PH_3(g)$ from $P_4(s)$ is 5.5 kcal mol^{-1}. The P-H bond energy in kcal mol^{-1} is [Neglect presence of Van der Waals forces in $P_4(s)$]

(1) 85.2 (2) 57.6 (3) 76.9 (4) 63.3

36. Using the data provided, calculate the multiple bond energy (kJ mol^{-1}) of a C≡C bond C_2H_2. That energy is (take the bond energy of a C–H bond as 350 kJ mol^{-1})

$2C(s) + H_2(g) \longrightarrow C_2H_2(g)$ $\Delta H = 225$ kJ mol^{-1}

$2C(s) \longrightarrow 2C(g)$ $\Delta H = 1410$ kJ mol^{-1}

$H_2(g) \longrightarrow 2H(g)$ $\Delta H = 330 \text{ kJ mol}^{-1}$

(1) 1165 (2) 837 (3) 865 (4) 815

Exercise-3

PART - I : NEET / AIPMT QUESTION (PREVIOUS YEARS)

1. In an endothermic reaction, the value of ΔH is : **[AIPMT 1999]**

(1) zero (2) positive (3) negative (4) constant

2. From the given reactions

$$S(s) + \frac{3}{2} O_2 (g) \longrightarrow SO_3(g) + 2x \text{ kcal}$$

and $$SO_2(g) + \frac{1}{2} O_2(g) \longrightarrow SO_3(g) + y \text{ kcal},$$

the heat of formation of SO_2 is : **[AIPMT 1999]**

(1) (x + y) (2) (x – y) (3) (2x + y) (4) (2x – y)

3. If ΔE is the heat of reaction for $C_2H_5OH (\ell) + 3O_2(g) \longrightarrow 2CO_2 (g) + 3H_2O (\ell)$ at constant volume, the ΔH (heat of reaction at constant pressure), then the correct relation is : **[AIPMT 2000]**

(1) $\Delta H = \Delta E + RT$ (2) $\Delta H = \Delta E - RT$ (3) $\Delta H = \Delta E - 2RT$ (4) $\Delta H = \Delta E + 2RT$

4. The entropy change in the fusion of one mole of a solid melting at 27°C (latent heat of fusion is 2930 J mol^{-1}) is: **[AIPMT 2000]**

(1) 9.77 $JK^{-1} mol^{-1}$ (2) 10.73 $JK^{-1} mol^{-1}$ (3) 2930 $JK^{-1} mol^{-1}$ (4) 108.5 $JK^{-1} mol^{-1}$

5. The factor of ΔG values is important in metallurgy. The ΔG values for the following reactions at 800ºC are given as : **[AIPMT 2000]**

$S_2(s) + 2O_2(g) \longrightarrow 2SO_2(g)$; $\Delta G = -544$ kJ

$2Zn(s) + S_2(s) \longrightarrow 2ZnS(s)$; $\Delta G = -293$ kJ

$2Zn(s) + O_2(g) \longrightarrow 2ZnO(s)$; $\Delta G = -480$ kJ

The ΔG for the reaction

$2ZnS(s) + 3O_2(g) \longrightarrow 2ZnO(s) + 2SO_2(g)$

will be :

(1) – 357 kJ (2) – 731 kJ (3) – 773 kJ (4) – 229 kJ

6. Change in enthalpy for reaction **[AIPMT 01]**

$2H_2O_2(\ell) \longrightarrow 2H_2O(\ell) + O_2(g)$

if heat of formations of $H_2O_2(\ell)$ and $H_2O(\ell)$ are – 188 and – 286 kJ/mol respectively is :

(1) – 196 kJ/mol (2) + 196 kJ/mol (3) + 948 kJ/mol (4) – 948 kJ/mol

7. When 1 mole gas is heated at constant volume, temperature is raised from 298 to 308 K. Heat supplied to the gas is 500 J. Then, which statement is correct ? **[AIPMT 01]**

(1) $q = W = 500$ J, $\Delta E = 0$ (2) $q = \Delta E = 500$ J, $W = 0$

(3) $q = -W = 500$ J, $\Delta E = 0$ (4) $\Delta E = 0$, $q = W = -500$ J

8. Enthalpy of the reaction, $CH_4 + \frac{1}{2} O_2 \longrightarrow CH_3OH$ is negative. If enthalpy of combustion of CH_4 and CH_3OH are x and y respectively, then which relation is correct ? **[AIPMT 01]**

(1) $x > y$ (2) $x < y$ (3) $x = y$ (4) $x \geq y$

9. Unit of entropy is : **[AIPMT 02]**
(1) JK^{-1} mol^{-1} (2) J mol^{-1} (3) $J^{-1}K^{-1}$ mol^{-1} (4) JK mol^{-1}

10. In a closed insulated container a liquid is stirred with a paddle to increase the temperature, which of the following is true ? **[AIPMT 02]**
(1) $\Delta E = W \neq 0, q = 0$ (2) $\Delta E = W = 0, q \neq 0$ (3) $\Delta E = 0, W = q \neq 0$ (4) $W = 0, \Delta E = q \neq 0$

11. 2 moles of an ideal gas at 27ºC temperature is expanded reversibly from 2 L to 20 L. Find entropy change (R = cal/mol K). **[AIPMT 02]**
(1) 92.1 (2) 0 (3) 4 (4) 9.2

12. Heat of combustion ΔH^o for C(s), $H_2(g)$ and $CH_4(g)$ are – 94, – 68 and – 213 kcal/mol. Then, ΔH^o for $C(s) + 2H_2(g) \rightarrow CH_4(g)$ is : **[AIPMT 02]**
(1) – 17 kcal (2) – 111 kcal (3) – 170 kcal (4) – 85 kcal

13. The densities of graphite and diamond at 298 K are 2.25 and 3.31 g cm^{-3}, respectively. If the standard free energy difference (ΔG^o) is equal to 1895 J mol^{-1}, the pressure at which graphite will be transformed into diamond at 298 K is : **[AIPMT 03]**
(1) 9.92×10^6 Pa (2) 9.92×10^5 Pa (3) 9.92×10^8 Pa (4) 9.92×10^7 Pa

14. The molar heat capacity 'C' of water at constant pressure is 75 JK^{-1} mol^{-1}, when 1.0 kJ of heat is supplied to 100 g of water which is free to expand, the increase in temperature of water is : **[AIPMT 03]**
(1) 4.8 K (2) 6.6 K (3) 1.2 K (4) 2.4 K

15. What is the entropy change (in JK^{-1} mol^{-1}) when one mole of ice is converted into water at 0ºC ? (The enthalpy change for the conversion of ice to liquid water is 6.0 kJ mol^{-1} at 0ºC.) **[AIPMT 03]**
(1) 2.198 (2) 21.98 (3) 20.13 (4) 2.013

16. For which one of the following equation ΔH^o_r equal to ΔH^o_f for the product ? **[AIPMT 03]**
(1) $Xe(g) + 2F_2(g) \longrightarrow XeF_4(g)$ (2) $2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$
(3) $N_2(g) + O_3(g) \longrightarrow N_2O_3(g)$ (4) $CH_4(g) + 2Cl_2(g) \longrightarrow CH_2Cl_2(\ell) + 2HCl(g)$

17. For the reaction, $C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(\ell)$
at constant temperature, $\Delta H - \Delta E$ is : **[AIPMT 03]**
(1) + 3RT (2) – RT (3) + RT (4) – 3RT

18. If the bond energies of H–H, Br–Br and H–Br are 433, 192 and 364 kJ mol^{-1} respectively, then ΔH^o for the reaction $H_2(g) + Br_2(g) \longrightarrow 2HBr(g)$ is : **[AIPMT 04]**
(1) – 261 kJ (2) + 103 kJ (3) + 261 kJ (4) – 103 kJ

19. Standard enthalpy and standard entropy changes for the oxidation of ammonia at 298 K are – 382.64 kJ mol^{-1} and – 145.6 J K^{-1} mol^{-1}, respectively. Standard Gibb's energy change for the same reaction at 298 K is : **[AIPMT 04]**
(1) – 2221.1 kJ mol^{-1} (2) – 339.3 kJ mol^{-1} (3) – 439.3 kJ mol^{-1} (4) – 523.2 kJ mol^{-1}

20. Considering entropy (S) as a thermodynamic parameter, the criterion for the spontaneity of any process is : **[AIPMT 04]**
(1) $\Delta S_{system} + \Delta S_{surrounding} > 0$ (2) $\Delta S_{system} - \Delta S_{surrounding} > 0$
(3) $\Delta S_{system} > 0$ only (4) $\Delta S_{surrounding} > 0$ only

21. The work done during the expansion of a gas from a volume of 4 dm^3 to 6 dm^3 against a constant external pressure of 3 atm, is : **[AIPMT 04]**

(1) – 6 J (2) – 608 J (3) + 304 J (4) – 304 J

22. A reaction occurs spontaneously if : **[AIPMT 05]**

(1) $T\Delta S < \Delta H$ and both ΔH and ΔS are +ve (2) $T\Delta S > \Delta H$ and both ΔH and ΔS are +ve

(3) $T\Delta S = \Delta H$ and both ΔH and ΔS are +ve (4) $T\Delta S > \Delta H$ and ΔH is + ve and ΔS is –ve

23. Which of the following pairs of a chemical reaction is certain to result in a spontaneous reaction ? **[AIPMT 05]**

(1) Exothermic and decreasing disorder (2) Endothermic and increasing disorder

(3) Exothermic and increasing disorder (4) Endothermic and decreasing disorder

24. The absolute enthalpy of neutralisation of the reaction, **[AIPMT 05]**

$$MgO(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2O(\ell)$$

will be :

(1) less than – 57.33 kJ mol^{-1} (2) – 57.33 kJ mol^{-1}

(3) greater than – 57.33 kJ mol^{-1} (4) 57.33 kJ mol^{-1}

25. Identify the correct statement for change of Gibb's energy for a system (ΔG_{system}) at constant temperature and pressure. **[AIPMT 06]**

(1) If $\Delta G_{system} > 0$, the process is spontaneous.

(2) If $\Delta G_{system} = 0$, the system has attained equilibrium.

(3) If $\Delta G_{system} = 0$, the system is still moving in a particular direction.

(4) If $\Delta G_{system} < 0$, the process is not spontaneous.

26. Assume each reaction is carried out in an open container. For which reaction will $\Delta H = \Delta E$? **[AIPMT 06]**

(1) $H_2(g) + Br_2(g) \longrightarrow 2HBr(g)$ (2) $C(s) + 2H_2O(g) \longrightarrow 2H_2(g) + CO_2(g)$

(3) $PCl_5(g) \longrightarrow PCl_3(g) + Cl_2(g)$ (4) $2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$

27. The enthalpy and entropy change for the reaction, $Br_2(\ell) + Cl_2(g) \longrightarrow 2BrCl(g)$

are 30 kJ mol^{-1} and 105 Jk^{-1} mol^{-1} respectively. The temperature at which the reaction will be in equilibrium is: **[AIPMT 06]**

(1) 285.7 K (2) 273 K (3) 450 K (4) 300 K

28. The enthalpy of combustion of H_2, cyclohexene (C_6H_{10}) and cyclohexane (C_6H_{12}) are – 241, – 3800 and – 3920 kJ per mol respectively. Heat of hydrogenation of cyclohexene is : **[AIPMT 06]**

(1) – 121 kJ per mol (2) + 121 kJ per mol (3) + 242 kJ per mol (4) – 242 kJ per mol

29. Consider the following reactions : **[AIPMT 07]**

(i) $H^+ (aq) + OH^- (aq) = H_2O(\ell) - x_1$ kJ mol^{-1}

(ii) $H_2(g) + \frac{1}{2} O_2 (g) = H_2O(\ell) - x_2$ kJ mol^{-1}

(iii) $CO_2(g) + H_2(g) = CO(g) + H_2O (\ell) - x_3$ kJ mol^{-1}

(iv) $C_2H_2(g) + \frac{5}{2} O_2 (g) = 2CO_2(g) + H_2O(\ell) + x_4$ kJ mol^{-1}

Enthalpy of formation of $H_2O (\ell)$ is :

(1) + x_2 kJ mol^{-1} (2) + x_3 kJ mol^{-1} (3) – x_4 kJ mol^{-1} (4) + x_1 kJ mol^{-1}

30. Given that bond energies of H–H and Cl–Cl are 430 KJ mol^{-1} and 240 KJ mol^{-1} respectively and ΔH_f for HCl is – 90 KJ mol^{-1}. Bond enthalpy of HCl is **[AIPMT 07]**

(1) 245 KJ mol^{-1} (2) 290 KJ mol^{-1} (3) 380 KJ mol^{-1} (4) 425 KJ mol^{-1}

31. Which of the following are not state functions ? **[AIPMT 08]**

(I) q + W (II) q

(III) W (IV) H – TS

(1) (I) and (IV) (2) (II), (III) and (IV) (3) (I), (II) and (III) (4) (II) and (III)

32. For the gas phase reaction, **[AIPMT 08]**

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

which of the following conditions are correct ?

(1) $\Delta H = 0$ and $\Delta S < 0$ (2) $\Delta H > 0$ and $\Delta S > 0$ (3) $\Delta H < 0$ and $\Delta S < 0$ (4) $\Delta H > 0$ and $\Delta S < 0$

33. Bond dissociation enthalpy of H_2, Cl_2 and HCl are 434, 242 and 431 KJ mol^{-1} respectively. Enthalpy of formation of HCl is **[AIPMT 08]**

(1) 93 KJ mol^{-1} (2) – 245 KJ mol^{-1} (3) – 93 KJ mol^{-1} (4) 245 KJ mol^{-1}

34. From the following bond energies :

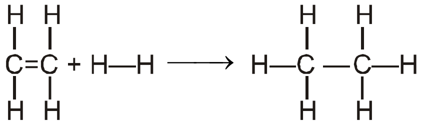
H—H bond energy : 431.37 kJ mol^{-1}

C=C bond energy : 606.10 kJ mol^{-1}

C—C bond energy : 336.49 kJ mol^{-1}

C—H bond energy : 410.50 kJ mol^{-1}

Enthalpy for the reaction,



$$H_2C{=}CH_2 + H{-}H \longrightarrow H_3C{-}CH_3$$

will be : **[AIPMT 09]**

(1) 1523.6 kJ mol^{-1} (2) – 243.6 kJ mol^{-1} (3) – 120.0 kJ mol^{-1} (4) 553.0 kJ mol^{-1}

35. The values of ΔH and ΔS for the reaction, $C_{(graphite)} + CO_2(g) \longrightarrow 2CO(g)$ are 170 kJ and 170 JK^{-1}, respectively. This reaction will be spontaneous at : **[AIPMT 09]**

(1) 710 K (2) 910 K (3) 1110 K (4) 510 K

36. Three moles of an ideal gas expanded spontaneously into vacuum. The work done wil be : **[AIPMT 10]**

(1) Infinite (2) 3 Joules (3) 9 Joules (4) Zero

37. For vaporization of water at 1 atmospheric pressure, the values of ΔH and ΔS are 40.63 kJ mol^{-1} and 108.8 JK^{-1} mol^{-1}, respectively. The temperature when Gibb's energy change (ΔG) for this transformation will be zero, is : **[AIPMT 10]**

(1) 273.4 K (2) 393.4 K (3) 373.4 K (4) 293.4 K

38. The following two reactions are known

$Fe_2O_{3(s)} + 3CO_{(g)} \longrightarrow 2Fe_{(s)} + 3CO_{2(g)}$; $\Delta H = -26.8$ kJ

$FeO_{(s)} + CO_{(g)} \longrightarrow Fe_{(s)} + CO_{2(g)}$; $\Delta H = -16.5$ kJ

The value of ΔH for the following reaction

$Fe_2O_{3(s)} + CO_{(g)} \longrightarrow 2FeO_{(s)} + CO_{2(g)}$ is : **[AIPMT 10]**

(1) + 10.3 kJ (2) – 43.3 kJ (3) – 10.3 kJ (4) + 6.2 kJ

39. Standard entropies of X_2, Y_2 and XY_3 are 60, 40 and 50 $JK^{-1}\ mol^{-1}$ respectively. For the reaction

$\frac{1}{2} X_2 + \frac{3}{2} Y_2 \rightleftharpoons XY_3$; $\Delta H = -30$ kJ, **[AIPMT 10]**

to be at equilibrium, the temperature should be:

(1) 750 K (2) 1000 K (3) 1250 K (4) 500 K

40. Consider the following processes : **[AIPMT 11]**

	ΔH (kJ/mol)
$1/2\ A \rightarrow B$	+150
$3B \rightarrow 2C + D$	–125
$E + A \rightarrow 2D$	+350

For $B + D \rightarrow E + 2C$, ΔH will be :

(1) 525 kJ/mol (2) –175 kJ/mol (3) –325 kJ/mol (4) 325 kJ/mol

41. If the enthalpy change for the transition of liquid water to steam is 30 kJ mol^{-1} at 27ºC, the entropy change for the process would be : **[AIPMT 11]**

(1) 10 J $mol^{-1}\ K^{-1}$ (2) 1.0 J $mol^{-1}\ K^{-1}$ (3) 0.1 J $mol^{-1}\ K^{-1}$ (4) 100 J $mol^{-1}\ K^{-1}$

42. Enthalpy change for the reaction, $4H_{(g)} \longrightarrow 2H_{2(g)}$ is – 869.6 kJ.
The dissociation energy of H–H bond is : **[AIPMT 11]**

(1) – 434.8 kJ (2) – 869.6 kJ (3) + 434.8 kJ (4) + 217.4 kJ

43. Which of the following is correct option for free expansion of an ideal gas under adiabatic condition ? **[AIPMT 11]**

(1) $q = 0, \Delta T \neq 0, w = 0$ (2) $q \neq 0, \Delta T = 0, w = 0$
(3) $q = 0, \Delta T = 0, w = 0$ (4) $q = 0, \Delta T < 0, w \neq 0$

44. Equal volumes of two monoatomic gases, A and B, at same temperature and pressure are mixed. The ratio of specific heats (C_p/C_v) of the mixture will be : **[AIPMT 12]**

(1) 0.83 (2)1.50 (3) 3.3 (4) 1.67

45. In which of the following reactions, standard reaction entropy change ($\Delta S°$) is positive and standard Gibb's energy change ($\Delta G°$) decreases sharply with increasing temperature ? **[AIPMT 12]**

(1) C graphite + $\frac{1}{2} O_2(g) \rightarrow CO(g)$ (2) $CO(g) + \frac{1}{2} O_2(g) \rightarrow CO_2(g)$

(3) $Mg(s) + \frac{1}{2} O_2(g) \rightarrow MgO(s)$ (4) $\frac{1}{2}$ C graphite + $\frac{1}{2} O_2(g) \rightarrow \frac{1}{2} CO_2(g)$

46. The enthalpy of fusion of water is 1.435 kcal/mol. The molar entropy change for the melting of ice at 0°C is :

(1) 10.52 cal / (mol K) (2) 21.04 cal / (mol K) **[AIPMT 12]**
(3) 5.260 cal / (mol K) (4) 0.526 cal / (mol K)

47. Standard enthalpy of vapourisation $\Delta_{vap} H^o$ for water at 100ºC is 40.66 kJ mol^{-1}. The internal energy of vaporisation of water at 100ºC (in $kJmol^{-1}$) is : **[AIPMT 12]**
(Assume water vapour to behave like an ideal gas).

(1) + 37.56 (2) – 43.76 (3) + 43.76 (4) + 40.66

48. A reaction having equal energies of activation for forward and reverse reaction has : **[NEET 13]**

(1) $\Delta G = 0$ (2) $\Delta H = 0$ (3) $\Delta H = \Delta G = \Delta S = 0$ (4) $\Delta S = 0$

49. Using the Gibbs change, $\Delta G^o = +63.3$ kJ, for the following reaction, $Ag_2CO_3(g) \rightleftharpoons 2Ag^+(aq) + CO_3^{2-}(aq)$ the K_{sp} of $Ag_2CO_3(s)$ in water at 25ºC is ($R = 8.314\ JK^{-1}\ mol^{-1}$) **[AIPMT 14]**

(1) 3.2×10^{-26} (2) 8.0×10^{-12} (3) 2.9×10^{-3} (4) 7.9×10^{-2}

50. For the reaction : **[AIPMT 14]**
$X_2O_4(l) \rightarrow 2XO_2(g)$
$\Delta U = 2.1$ k cal, $\Delta s = 20$ cal K^{-1} at 300 K
(1) 2.7 k cal (2) –2.7 k cal (3) 9.3 k cal (4) –9.3 k cal

51. The correct thermodynamic conditions for the spontaneous reaction at all temperatures is : **[NEET-1 16]**
(1) $\Delta H < 0$ and $\Delta S < 0$ (2) $\Delta H < 0$ and $\Delta S = 0$
(3) $\Delta H > 0$ and $\Delta S < 0$ (4) $\Delta H < 0$ and $\Delta S > 0$

52. For a sample of perfect gas when its pressure is changed isothermally from p_i to p_f, the entropy change is given by **[NEET-2 16]**
(1) $\Delta S = RT\ln\left(\frac{p_i}{p_f}\right)$ (2) $\Delta S = nR\ln\left(\frac{p_f}{p_i}\right)$
(3) $\Delta S = nR\ln\left(\frac{p_i}{p_f}\right)$ (4) $\Delta S = nRT\ln\left(\frac{p_f}{p_i}\right)$

53. For a given reaction $\Delta H = 35.5$ kJ mol^{-1} and $\Delta S = 83.6$ JK^{-1} mol^{-1}. The reaction is spontaneous at :
(Assume that ΔH and ΔS do not vary with temperature) **[NEET-17]**
(1) T < 425 K (2) T > 425 K (3) All temperatures (4) T > 298 K

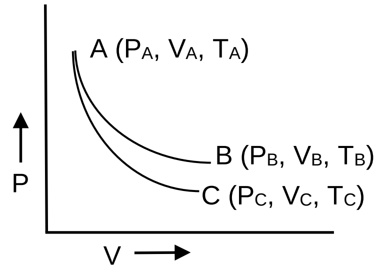
54. A gas is allowed to expand in a well insulated container against a constant external pressure of 2.5 atm from an initial volume of 2.50 L to a final volume of 4.50 L. The change in internal energy ΔU of the gas in joules will be: **[NEET-17]**
(1) 1136.25 J (2) –500 J (3) –505 J (4) +505 J

55. The bond dissociation energies of X_2, Y_2 and XY are in the ratio of 1 : 0.5 : 1. ΔH for the formation of XY is –200 kJ mol^{-1}. The bond dissociation energy of X_2 will be : **[NEET-18]**
(1) 200 kJ mol^{-1} (2) 400 kJ mol^{-1} (3) 800 kJ mol^{-1} (4) 100 kJ mol^{-1}

56. In which can change in entropy is negative **[NEET-1-19]**
(1) $2H(g) \rightarrow H_2(g)$ (2) Evaporation of water
(3) Expansion of a gas at constant temperature (4) Sublimation of solid to gas

57. An ideal gas expands isothermally from 10^{-3} m^3 to 10^{-2} m^3 at 300 K against a constant pressure of 10^5 Nm^{-2}. The work done on the gas is : **[NEET-2-19]**
(1) + 270 kJ (2) –900 J (3) + 900 kJ (4) –900 kJ

58. Reversible expansion of an ideal gas under isothermal and adiabatic conditions are as shown in the figure : **[NEET-2-19]**



AB $\longrightarrow$ Isothermal expansion
AC $\longrightarrow$ Adiabatic expansion

Which of the following options is not correct?
(1) $\Delta S_{isothermal} > \Delta S_{adiabatic}$ (2) $T_A = T_B$
(3) $W_{isothermal} > W_{adiabatic}$ (4) $T_C > T_A$

PART - II : AIIMS QUESTION (PREVIOUS YEARS)

1. For the reaction of one mole of zinc dust with one mole of suphuric acid in a bomb calriometer, ΔU and w corresponds to : **[AIIMS 2005]**
(1) $\Delta U < 0, w = 0$ (2) $\Delta U < 0, w < 0$ (3) $\Delta U > 0, w = 0$ (4) $\Delta U > 0, w > 0$

2. For a spontaneous process the correct statement is : **[AIIMS 2006]**
(1) Entropy of the system always increases (2) Free energy of the system always increases
(3) Total entropy change is always negative (4) Total entropy change is always positive.

3. For a phase $H_2O(l) \xrightleftharpoons[0°C,\ 1\ bar]{} H_2O\ (s)$ **[AIIMS 2006]**
(1) $\Delta G = 0$ (2) $\Delta S = 0$ (3) $\Delta H = 0$ (4) $\Delta U = 0$

4. The enthalpy change (ΔH) for the reaction, **[AIIMS 2006]**
$N_2\ (g) + 3H_2\ (g) \longrightarrow 2NH_3\ (g)$
is –92.38 kJ at 298 K. The internal energy change ΔU at 298 K is :
(1) – 92.238 k J (2) – 87.42 k J (3) – 97.34 k J (4) – 89.9 k J

5. **Assertion :** Water in liquid state is more stable than ice at room temprature.
Reason : Water in liquid form has higher entropy than ice. **[AIIMS 2006]**
(1) If both assertion and reason are true and reason is a correct explanation of assertion.
(2) If both assertion and reason are true but reason is not a correct explanation of assertion.
(3) If assertion is true but reason is false.
(4) If both assertion and reason are false.

6. The enthalpy of hydrogenation of cylohexene is – 119.5 kJ mol^{-1}. If resonance energy of benzne is – 150.4 kJ mol^{-1}, its enthaply of hyderogenation would be **[AIIMS 2007]**
(1) – 208.1 kJ mol^{-1} (2) – 269.9 kJ mol^{-1} (3) – 358.5 kJ mol^{-1} (4) – 508.9 kJ mol^{-1}

7. **Assertion :** For the combustion of methane,
$\Delta E > \Delta H$
Reason : ΔH is related by ΔE by the expression.
$\Delta H = \Delta E + \Delta nRT$ **[AIIMS 2007]**
(1) If both assertion and reason are true and reason is a correct explanation of assertion.
(2) If both assertion and reason are true but reason is not a correct explanation of assertion.
(3) If assertion is true but reason is false.
(4) If both assertion and reason are false.

8. For a reaction to be spotaneous at all tempratures **[AIIMS 2008]**
(1) ΔG –ve, ΔH +ve and ΔS +ve (2) ΔG +ve, ΔH –ve and ΔS +ve
(3) ΔG –ve, ΔH – ve and ΔS – ve (4) ΔG –ve, ΔH – ve and ΔS +ve

9. What will be the heat of formation of methane, if the heat of combustion of carbon is '–x' kJ, heat of formation of water is '–y' kJ and heat of combustion of methane is –z kJ ? **[AIIMS 2008]**
(1) (–x – y + z) kJ (2) (–z – x + 2y) kJ (3) (–x – 2y – z) kJ (4) (–x – 2y + z) kJ

10. **Assertion :** For a reaction
$2NH_3\ (g) \longrightarrow N_2\ (g) + 3H_2\ (g)$: $\Delta H > \Delta E$
Reason : Enthalpy change is always greater than internal energy change. **[AIIMS 2008]**
(1) If both assertion and reason are true and reason is a correct explanation of assertion.
(2) If both assertion and reason are true but reason is not a correct explanation of assertion.
(3) If assertion is true but reason is false.
(4) If both assertion and reason are false.

11. Enthalpy of combustion of methane and ethane are – 210 kcal/mol and – 368 kcal/mol respectively. The enthalpy of combustion of decane is **[AIIMS 2009]**

(1) – 158 kcal (2) – 1632 kcal (3) – 1700 kcal (4) Data is incomplete

12. **Assertion :** The enthalpy of formation of gaseous oxygen molecules at 298 K and under a pressure of one atmosphere is zero. **[AIIMS 2009]**
Reason : The entropy of formation of gaseous oxygen molecule under the same conditions is zero.
(1) If both assertion and reason are true and reason is a correct explanation of assertion.
(2) If both assertion and reason are true but reason is not a correct explanation of assertion.
(3) If assertion is true but reason is false.
(4) If both assertion and reason are false.

13. **Assertion :** The heat adsorbed during isothermal expansion of an ideal gas against vacuum is zero.
Reason : The volume occupied by the molecule is zero. **[AIIMS 2010]**
(1) If both assertion and reason are true and reason is the correct explanation of assertion.
(2) If both assertion and reason are true but reason is not the correct explanation of assertion.
(3) If Assertion is true but reason is false.
(4) If both assertion and reason are false.

14. The enthalpy of formation of $CO_{(g)}$, $CO_{2(g)}$, $N_2O_{(g)}$, and $N_2O_{4(g)}$ is –110, –393, +811 and 10 kJ/mol respectively. For the reaction,
$N_2O_{4(g)} + 3CO_{(g)} \rightarrow N_2O_{(g)} + 3CO_{2(g)}$. ΔH_r (kJ/mol) is : **[AIIMS 2011]**
(1) –212 (2) +212 (3) +48 (4) –48

15. For adiabatic process, which is correct ? **[AIIMS 2011]**
(1) $\Delta T = 0$ (2) $\Delta S = 0$ (3) $q = 0$ (4) $q_p = 0$

16. Which of the following is not a thermodynamic function ? **[AIIMS 2011]**
(1) Internal energy (2) Work done (3) Enthalpy (4) Entropy

17. Which of the following is intensive property ? **[AIIMS 2011]**
(1) Enthalpy (2) Entropy (3) Specific heat (4) Volume

18. **Assertion :** Entropy is always constant for a closed system.
Reason : Closed system is always reversible. **[AIIMS 2011]**
(1) If both assertion and reason are true and reason is the correct explanation of assertion.
(2) If both assertion and reason are true but reason is not the correct explanation of assertion.
(3) If Assertion is true but reason is false.
(4) If both assertion and reason are false.

19. AB, A_2 and B_2 are diatomic molecules. If the bond enthalpies of A_2, AB and B_2 are in the ratio 1 : 1 : 0.5 and enthalpy of formation of AB from A_2 and B_2 is – 100 kJ mol^{-1}. What is the bond energy of A_2 :
[AIIMS 2012]
(1) 200 kJ mol^{-1} (2) 100 kJ mol^{-1} (3) 300 kJ mol^{-1} (4) 400 kJ mol^{-1}

20. Which of the following condition favours the reduction of a metal oxide to metal ? **[AIIMS 2012]**
(1) ΔH = + ve, $T\Delta S$ = + ve at low temperature (2) ΔH = + ve, $T\Delta S$ = – ve at any temperature
(3) ΔH = – ve, $T\Delta S$ = – ve at high temperature (4) ΔH = – ve, $T\Delta S$ = + ve at any temperature

21. **Assertion :** Many endothermic reactions that are not spontaneous at room temperature become spontaneous at high temperature.
Reason : Entropy of the system increases with increase in temperature. **[AIIMS 2012]**
(1) If both Assertion and Reason are correct and Reasons is the correct explanation of Assertion.
(2) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(3) If Assertion is correct but Reason is incorrect.
(4) If Assertion is incorrect but Reason is correct.

22. The ΔH_{f^0} for CO_2 (g), CO(g) and H_2O (g), are –393.5,–110.5 and –241.8 KJ mol^{-1} respectively. The standard enthalpy change (in KJ) for the reaction **[AIIMS 2013]**

$CO_2(g) + H_2(g) + \rightarrow CO(g) + H_2O(g)$is

(1) 524.1 (2) 41.2 (3) –262.5 (4) –41.2

23. **Assertion:** For an isothermal reversible process Q =– W i.e.work done by the system equals the heat absorbed by the system. **[AIIMS 2013]**

Reason: Enthalpy change (ΔH) is zero for isothermal process.

(1) If both Assertion and Reason are correct and Reasons is the correct explanation of Assertion.
(2) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(3) If Assertion is correct but Reason is incorrect.
(4) If Assertion is incorrect but Reason is correct.

24. Assume each reaction is carried out in a open container. For which reaction $\Delta H = \Delta E$? **[AIIMS 2014]**

(1) $H_2(g) + Br_2(g) \rightarrow 2HBr(g)$ (2) $C(s) + 2H_2O(g) \rightarrow 2H_2(g) + CO_2(g)$
(3) $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$ (4) $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

25. The factor of ΔG values is important in metallurgy. The u values for the following reactions at 800ºC are given as : **[AIIMS 2015]**

$S_2(g) + 2O_2(g) \longrightarrow 2SO_2(g); \Delta G = -544$ kJ

$2Zn(s) + S_2(g) \longrightarrow 2ZnS(s); \Delta G = -293$ kJ

$2Zn(s) + O_2(g) \longrightarrow 2ZnO(s); \Delta G = -480$ kJ

The ΔG for the reaction,

$2ZnS(g) + 3O_2(g) \longrightarrow 2ZnO(g) + 2SO_2(g)$ will be :

(1) –731 kJ (2) –787 kJ (3) –534 kJ (4) –554 kJ

26. In a thermodynamics process helium gas obeys the law $T/P^{2/5}$ = constant. The heat given to n moles of He in orderto raise the temperature from T to 2T is : **[AIIMS - 2016]**

(1) 8 RT (2) 4 RT (3) 16 RT (4) Zero

27. **Assertion** : The enthalpy of both graphite and diamond is taken to be zero, being elementry substances. **[AIIMS - 2016]**

Reason : The enthalpy of formation of an elementary substance in any state is taken as zero.

(1) If both assertion and reason are true and reason is the correct explanation of assertion.
(2) If both assertion and reason are true but reason is not the correct explanation of assertion.
(3) If Assertion is true but reason is false.
(4) If both assertion and reason are false.

28. If at 298 K, the bond energies of C–H, C–C, C=C and H–H bonds are respectively 414, 347, 615 and 435 kJ mol^{-1}, the value of enthalpy change for the reaction ; **[AIIMS - 2017]**

$H_2C{=}CH_2 + H_2(g) \rightarrow H_3C{-}CH_3(g)$ at 298 K, will be

(1) + 250 kJ (2) – 250 kJ (3) + 125 kJ (4) – 125 kJ

29. One monoatomic gas is expanded adibatically from 2L to 10 L at 1 atm external pressure find ΔU (in atm L) ? **[AIIMS - 2018]**

(1) –8 (2) 0 (3) –66.7 (4) 58.2

30. Which are extensive properties **[AIIMS - 2018]**

(1) V & E (2) V & T (3) V & Cp (4) P and T

31. Ideal gas mole expand isothermally reversibly 2 lt. to 4lt and same gas 3 mole expand from 2 lt. to x lt and doing same work, what is 'x' **[AIIMS - 2018]**

(1) $(8)^{\frac{1}{3}}$ (2) $(4)^{\frac{2}{3}}$ (3) 2 (4) 4 lt

32. Which of following factor always increases for spontaneous process **[AIIMS - 2018]**

(1) ΔS (2) ΔH (3) $\Delta H - T\Delta S$ (4) $\Delta S - \frac{\Delta H}{T}$

PART - III : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. Assuming that water vapour is an ideal gas, the internal energy change (ΔU) when 1 mol of water is vapourised at 1 bar pressure and 100°C, (Given : Molar enthalpy of vapourization of water at 1 bar and 373 K=41 kJmol^{-1} and R = 8.3 J mol^{-1} K^{-1}) will be : **[AIEEE 2007, 3/120]**

(1) 37.904 kJ mol^{-1} (2) 41.00 kJ mol^{-1} (3) 4.100 kJ mol^{-1} (4) 3.7904 mol^{-1}

2. Identify the correct statement regarding a spontaneous process : **[AIEEE 2007, 3/120]**

(1) Exothermic processes are always spontaneous.
(2) Lowering of energy in the reaction process is the only criterion for spontaneity.
(3) For a spontaneous process in an isolated system, the change in entropy is positive.
(4) Endothermic processes are never spotaneous.

3. In conversion of lime-stone to lime, $CaCO_3$ (s) $\rightarrow$ CaO(s) + CO_2 (g) the values of ΔH^0 and ΔS^0 are + 179.1 kJ mol^{-1} and 160.2 J/K respectively at 298 K and 1 bar. Assuming that $\Delta H°$ and $\Delta S°$ do not change with temperature, temperature above which conversion of limestone to lime will be spontaneous is : **[AIEEE 2007, 3/120]**

(1) 845 K (2) 1118 K (3) 1008 (4) 1200 K

4. (ΔH–ΔU) for the formation of carbon monoxide (CO) from its elements at 298 K is **[AIEEE 2006]**
(R = 8.314 J K^{-1} mol^{-1})

(1) 1238.78 J mol^{-1} (2) -2477.57 J mol^{-1} (3) 2477.57 J mol^{-1} (4) –1238.78 J mol^{-1}

5. The standard enthalpy of formation ($\Delta H_f°$) at 398 K for methane, $CH_{4(g)}$ is 74.8 kJ mol^{-1}. The additional information required to determine the average energy for C - H bond formation would be : **[AIEEE 2007, 3/120]**

(1) the dissociation energy of H_2 and enthalpy of sublimation of carbon
(2) latent heat of vapourisation of methane
(3) the first four ionization energies of carbon and electron gain enthalpy of hydrogen
(4) the dissociation energy of hydrogen molecule, H_2

6. Standard entropy of X_2, Y_2 and XY_3 are 60, 40 and 50 JK^{-1} mol^{-1}, respectively. **[AIEEE 2008, 3/105]**

For the reaction, $\frac{1}{2} X_2 + \frac{3}{2} Y_2 \rightarrow XY_3$ $\Delta H = -30$ kJ. To be at equilibrium the temperature will be :

(1) 500 K (2) 750 K (3) 1000 K (4) 1250 K

7. In a fuel cell methanol is used as fuel and oxygen gas is used as an oxidizer. The reaction is

$$CH_3OH(\ell) + \frac{3}{2} O_2 (g) \longrightarrow CO_2(g) + 2H_2O(\ell)$$ **[AIEEE 2009, 8/144]**

At 298 K, standard Gibb's energies of formation for $CH_3OH(\ell)$, $H_2O(\ell)$ and CO_2 (g) are –166.2, –237.2 and–394.4 kJ mol^{-1} respectively. If standard enthalpy of combustion of methanol is –726kJ mol^{-1}, efficiency of the fuel cell will be :

(1) 87% (2) 90% (3) 97% (4) 80%

8. On the basis of the following thermochemical data : ($\Delta_f G^o H^+_{(aq)} = 0$) **[AIEEE 2009, 8/144]**

$H_2O(\ell) \longrightarrow H^+ (aq) + OH^- (aq.)$; $\Delta H = 57.32$ kJ

$H_2(g) + \frac{1}{2} O_2 (g) \longrightarrow H_2O (\ell)$; $\Delta H = -286.20$ kJ

The value of enthalpy of formation of OH^- ion at 25ºC is :

(1) –228.88 kJ (2) +228.88 kJ (3) –343.52 kJ (4) –22.88 kJ

9. The standard enthalpy of formation of NH_3 is – 46.0 kJ mol^{-1}. If the enthalpy of formation of H_2 from its atoms is – 436 kJ mol^{-1} and that of N_2 is – 712 kJ mol^{-1}, the average bond enthalpy of N – H bond in NH_3 is **[AIEEE 2010, 4/144]**

(1) – 964 kJ mol^{-1} (2) + 352 kJ mol^{-1} (3) + 1056 kJ mol^{-1} (4) – 1102 kJ mol^{-1}

10. For a particular reversible reaction at temperature T, ΔH and ΔS were found to be both +ve. If T_e is the temperature at equilibrium, the reaction would be spontaneous when. **[AIEEE 2010, 4/144]**

(1) $T_e > T$ (2) $T > T_e$ (3) T_e is 5 times T (4) $T = T_e$

11. The entropy change involved in the isothermal reversible expansion of 2 moles of an ideal gas from a volume of 10 dm^3 to a volume of 100 dm^3 at 27°C is : **[AIEEE 2011, 4/120]**

(1) 38.3 J mol^{-1} K^{-1} (2) 35.8 J mol^{-1} K^{-1} (3) 32.3 J mol^{-1} K^{-1} (4) 42.3 J mol^{-1} K^{-1}

12. In view of the signs of $\Delta_r G^o$ for the following reactions :

$PbO_2 + Pb \rightarrow 2PbO$, $\Delta_r G^o < 0$

$SnO_2 + Sn \rightarrow 2SnO$, $\Delta_r G^o > 0$,

which oxidation states are more characteristics for lead and tin ? **[AIEEE 2011, 4/120]**

(1) For lead +2, for tin +2 (2) For lead +4, for tin +4

(3) For lead +2, for tin +4 (4) For lead +4, for tin +2

13. The value of enthalpy change (ΔH) for the reaction, $C_2H_5OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$ at 27°C is –1366.5 kJ mol^{-1}. The value of internal energy change for the above reaction at this temperature will be **[AIEEE 2011, 4/120]**

(1) –1369.0 kJ (2) –1364.0 kJ (3) –1361.5 kJ (4) –1371.5 kJ

14. Consider the reaction : $4NO_{2(g)} + O_{2(g)} \rightarrow 2N_2O_{5(g)}$, $\Delta_r H = -111$ kJ.

If $N_2O_{5(s)}$ is formed instead of $N_2O_{5(g)}$ in the above reaction, the $\Delta_r H$ value will be:

(given, ΔH of sublimation for N_2O_5 is 54 kJ mol^{-1}) **[AIEEE 2011, 4/120]**

(1) + 54kJ (2) + 219 kJ (3) – 219 kJ (4) – 165 kJ

15. The incorrect expression among the following is : **[AIEEE 2012, 4/120]**

(1) $\frac{\Delta G_{system}}{\Delta S_{total}} = -T$ (2) In isothermal process, $w_{reversible} = -nRT \,\ell n \frac{V_f}{V_i}$

(3) $\ln K = \frac{\Delta H^o - T\Delta S^o}{RT}$ (4) $K = e^{-\Delta G^o/RT}$

16. A piston filled with 0.04 mol of an ideal gas expands reversibly from 50.0 mL to 375 mL at a constant temperature of 37.0ºC. As it does so, it absorbs 208 J of heat. The values of q and w for the process will be:

(R = 8.314 J/mol K) (ln 7.5 = 2.01) **[JEE 2013, (Main), 4/120]**

(1) q = +208 J, w = – 208 J (2) q = –208 J, w = – 208 J
(3) q = –208 J, w = + 208 J (4) q = +208 J, w = + 208 J

17. For complete combustion of ethanol, $C_2H_5OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l)$, the amount of heat produced as measured in bomb calorimeter, is 1364.47 kJ mol^{-1} at 25°C. Assuming ideality the Enthalpy of combustion, Δ_CH, for the reaction will be : (R = 8.314 kJ mol^{-1}) **[JEE(Main) 2014, 4/120]**

(1) – 1366.95 kJ mol^{-1} (2) – 1361.95 kJ mol^{-1} (3) – 1460.50 kJ mol^{-1} (4) – 1350.50 kJ mol^{-1}

18. The following reaction is performed at 298 K

$2NO(g) + O_2(g) \quad 2NO_2(g)$

The standard free energy of formation of NO(g) is 86.6 kJ/mol at 298 K. What is the standard free energy of formation of $NO_2(g)$ at 298 K ? ($K_P = 1.6 \times 10^{12}$) **[JEE(Main) 2015, 4/120]**

(1) R(298) in (1.6×10^{12}) – 86600 (2) 86600 + R(298) ln (1.6 x 10^{12})
(3) 86600 – (4) 0.5 [2 × 86,600 – R (298) ln (1.6×10^{12})]

19. The heat of atomixation of methane and ethane are 360 kJ/mol and 620 kJ/mol, respectively. The longest wavelength of light capable of breaking the C–C bond is :
(Avogadro number = 6.02×10^{23}, h = 6.62×10^{-34} J s) **[JEE(Main, Online) 2015, 4/120]**

(1) 2.48×10^3 nm (2) 1.49×10^3 nm (3) 2.49×10^4 nm (4) 2.48×10^4 nm

20. The heats of combustion of carbon and carbon monoxide are –393.5 and –283.5 kJ mol^{-1}, respectively. The heat of formation (in kJ) of carbon monoxide per mole is : **[JEE(Main) 2016, 4/120]**

(1) 676.5 (2) – 676.5 (3) –110.5 (4) 110.5

21. Given : $C_{(graphite)} + O_2(g) \rightarrow CO_2(g)$; $\Delta_rH^o = -393.5$ kJ mol^{-1} ; **[JEE(Main) 2017, 4/120]**

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$; $\Delta_rH^o = -285.8$ kJ mol^{-1} ;

$CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g)$; $\Delta_rH^o = +890.3$ kJ mol^{-1}

Based on the above thermochemical equations, the value of Δ_rH^o at 298 K for the reaction

$C_{(graphite)} + 2H_2(g) \rightarrow CH_4(g)$ will be :

(1) +144.0 kJ mol^{-1} (2) –74.8 kJ mol^{-1} (3) –144.0 kJ mol^{-1} (4) +74.8 kJ mol^{-1}

22. ΔU equal to : **[JEE(Main) 2017, 4/120]**

(1) Isobaric work (2) Adiabatic work (3) Isothermal work (4) Isochoric work

23. The combustion of benzene (l) gives $CO_2(g)$ and $H_2O(l)$. Given that heat of combustion of benzene at constant volume is –3263.9 kJ mol^{-1} at 25ºC; heat of combustion (in kJ mol^{-1}) of benzene at constant pressure will be : (R = 8.314 JK^{-1} mol^{-1}) **[JEE(Main) 2018, 4/120]**

(1) 3260 (2) –3267.6 (3) 4152.6 (4) –452.46

24. A process has ΔH = 200 J mol^{-1} and ΔS = 40 JK^{-1} mol^{-1}. Out of the values given below, choose the minimum temperature above which the process will be spontaneous : **[JEE(Main) 2019, 4/120]**

(1) 5 K (2) 12 K (3) 4 K (4) 20 K

25. An ideal gas undergoes isothermal compression from 5 m^3 to 1 m^3 against a constant external pressure of 4 Nm^{-2}. Heat released in this process is used to increase the temperature of 1 mole of Al. If molar heat capacity of Al is 24 J $mol^{-1}K^{-1}$, the temperature of Al increases by: **[JEE(Main) 2019, 4/120]**

(1) $\frac{3}{2}$K (2) $\frac{2}{3}$ K (3) 1 K (4) 2 K

26. For the chemical reaction X $\rightleftharpoons$ Y, the standard reaction Gibbs energy depends on temperature T (in K) as $\Delta_rG°$(in kJ mol^{-1}) = $120 - \frac{3}{8}T$. The major component of the reaction mixture at T is :

[JEE(Main) 2019, 4/120]

(1) Y is T = 280 K (2) Y is T = 300 K (3) X if T = 315 K (4) X if T = 350 K

27. The standard reaction Gibbs energuy for a chemical reaction at an absolute temperature T is given by $\Delta G° = A - BT$

Where A and B are non-zero constants. Which of the following is TRUE about this reaction ?

[JEE(Main) 2019, 4/120]

(1) Endothermic if A > 0 (2) Exothermic if B < 0

(3) Exothermic if A > 0 and B < 0 (4) Endothermic if A < 0 and B > 0

28. The reaction, $MgO(s) + C(s) \rightarrow Mg(s) + CO(g)$, for which $\Delta_rH° = +491.1$ kJ mol^{-1} and $\Delta_rS° = 198.0$ JK^{-1} mol^{-1}, is not feasible at 298 K. Temperature above which reaction will be feasible is :

[JEE(Main) 2019, 4/120]

(1) 2380.5 K (2) 1890.0 K (3) 2040.5 K (4) 2480.3 K

29. Given : **[JEE(Main) 2019, 4/120]**

(i) $C(graphite) + O_2(g) \rightarrow CO_2(g)$; $\Delta rH^- = x$kJ mol^{-1}

(ii) $C(graphite) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$; $\Delta rH^- = y$kJ mol^{-1}

(iii) $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$; $\Delta rH^- = z$kJ mol^{-1}

Based on the above thermochemical equations, find out which one of the following algebraic relationship is correct?

(1) x = y – z (2) y = 2z – x (3) x = y + z (4) z = x + y

Answers

EXERCISE - 1

SECTION (A)

1. (3) **2.** (3) **3.** (3) **4.** (4) **5** (3) **6.** (3)

SECTION (B)

1. (3) **2.** (1) **3.** (2) **4.** (3) **5.** (2) **6.** (1) **7.** (3)

8. (4) **9.** (2) **10.** (2) **11.** (3)

SECTION (C)

1. (4) **2.** (2) **3.** (1) **4.** (1) **5.** (2) **6.** (4) **7.** (4)

SECTION (D)

1. (3) **2.** (4) **3.** (3) **4.** (2) **5.** (2) **6.** (4) **7.** (2)

8. (2) **9.** (4) **10.** (3) **11.** (1) **12.** (1) **13.** (1) **14.** (1)

15. (4) **16.** (1) **17.** (3) **18.** (2) **19.** (1) **20.** (4)

SECTION (E)

1. (3) **2.** (3) **3.** (4) **4.** (3) **5.** (2) **6.** (4) **7.** (2)

8. (3) **9.** (2) **10.** (1) **11.** (3) **12.** (3) **13.** (4) **14.** (4)

15. (3) **16.** (2) **17.** (3)

SECTION (F)

1. (2) **2.** (3) **3.** (2) **4.** (2) **5.** (3) **7.** (4) **8.** (2)

9. (4) **10.** (2) **11.** (2)

SECTION (G)

1. (4) **2.** (2) **3.** (3) **4.** (4) **5.** (3)

SECTION (H)

1. (2) **2.** (3) **3.** (1) **4.** (2) **5.** (4) **6.** (3) **7.** (2)

8. (2) **9.** (4) **10.** (1) **11.** (1) **12.** (3) **13.** (3)

SECTION (I)

1. (1) **2.** (1) **3.** (3) **4.** (4) **5.** (1) **6.** (3)

SECTION (J)

1. (3) **2.** (1)

SECTION (K)

1. (3) **2.** (2) **3.** (4) **4.** (1) **5.** (4) **6.** (3)

EXERCISE - 2

1.	(4)	**2.**	(2)	**3.**	(3)	**4.**	(1)	**5.**	(3)	**6.**	(4)	**7.**	(4)
8.	(2)	**9.**	(1)	**10.**	(2)	**11.**	(2)	**12.**	(2)	**13.**	(3)	**14.**	(2)
15.	(3)	**16.**	(4)	**17.**	(2)	**18.**	(2)	**19.**	(1)	**20.**	(3)	**21.**	(2)
22.	(2)	**23.**	(2)	**24.**	(1)	**25.**	(1)	**26**	(2)	**27.**	(1)	**28.**	(2)
29.	(2)	**30.**	(4)	**31.**	(3)	**32.**	(2)	**33.**	(1)	**34.**	(2)	**35.**	(3)
36.	(4)												

EXERCISE - 3

PART-I

1.	(2)	**2.**	(4)	**3.**	(2)	**4.**	(1)	**5.**	(2)	**6.**	(1)	**7.**	(2)
8.	(2)	**9.**	(1)	**10.**	(1)	**11.**	(4)	**12.**	(1)	**13.**	(3)	**14.**	(4)
15.	(2)	**16.**	(1)	**17.**	(4)	**18.**	(4)	**19.**	(2)	**20.**	(1)	**21.**	(2)
22.	(2)	**23.**	(3)	**24.**	(1)	**25.**	(2)	**26.**	(1)	**27.**	(1)	**28.**	(1)
29.	(1)	**30.**	(4)	**31.**	(4)	**32.**	(2)	**33.**	(3)	**34.**	(3)	**35.**	(3)
36.	(4)	**37.**	(3)	**38.**	(4)	**39.**	(1)	**40.**	(2)	**41.**	(4)	**42.**	(3)
43.	(3)	**44.**	(4)	**45.**	(1)	**46.**	(3)	**47.**	(1)	**48.**	(2)	**49.**	(2)
50.	(2)	**51.**	(4)	**52.**	(3)	**53.**	(2)	**54.**	(3)	**55.**	(3)	**56.**	(1)
57.	(2)	**58.**	(4)										

PART-II

1.	(1)	**2.**	(4)	**3.**	(1)	**4.**	(2)	**5.**	(2)	**6.**	(1)	**7.**	(1)
8.	(4)	**9.**	(4)	**10.**	(3)	**11.**	(2)	**12.**	(3)	**13.**	(3)	**14.**	(4)
15.	(3)	**16.**	(2)	**17.**	(3)	**18.**	(4)	**19.**	(4)	**20.**	(4)	**21.**	(2)
22.	(2)	**23.**	(2)	**24.**	(1)	**25.**	(1)	**26.**	(4)	**27.**	(4)	**28.**	(4)
29.	(1)	**30.**	(1)	**31.**	(2)	**32.**	(4)						

PART-III

1.	(1)	**2.**	(3)	**3.**	(2)	**4.**	(1)	**5.**	(1)	**6.**	(2)	**7.**	(3)
8.	(1)	**9.**	(2)	**10.**	(2)	**11.**	(1)	**12.**	(3)	**13.**	(2)	**14.**	(3)
15.	(3)	**16.**	(1)	**17.**	(1)	**18.**	(4)	**19.**	(2)	**20.**	(3)	**21.**	(2)
22.	(2)	**23.**	(2)	**24.**	(1)	**25.**	(2)	**26.**	(3)	**27.**	(1)	**28.**	(4)
29.	(3)												