**Exercise-1** 

Marked Questions may have for Revision Questions.

## **OBJECTIVE QUESTIONS**

#### Section (A) : Basic definition

A-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		
A-2.	Among the following, a	an intensive property is :		[AFMC 2004]		
	(1) mass	(2) volume	(3*) surface tension	(4) enthalpy		
A-3.	Out of boiling point (I),	entropy (II), pH (III) and	d e.m.f. of a cell (IV), inte	ensive properties are -		
	(1) I, II	(2) I, II, III	(3*) I, III, IV	(4) All of the above		
A-4.	Thermodynamic equilil	orium involves				
	(1) Chemical equilibriu	m	(2) Thermal equilibriur	n		
	(3) Mechanical		(4*) All the above			
A-5.	A tightly closed thermo	flask contains some ice	cubes. This constitutes			
	(1) closed system	(2) open system (3	*) isolated system (4) No	on-thermodynamic system		
A-6.	An isolated system is t	hat system in which				
	(1) there is no exchang	ge of energy with the sur	roundings			
	(2) there is exchange of	of mass and energy with	the surrounding			
	(3*) There is no exchar	nge of mass and energy	with the surrounding			
	(4) There is exchange	of mass with surroundin	gs.			
Sectio	on (B): First law o	f thermodynamics,	, calculations of $\Delta E$	, W & Q.		
B-1.	The first law of thermo	dynamics is represented	by the equation :	[AFMC 2000]		
	(1) $\Delta E = Q - W$	$(2^*) \Delta E = Q + W(3) W$	= Q + ΔE (4) Q	$= W + \Delta E$		
B-2.	An ideal gas receives	10 J of heat in a reversib	le 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
- B-3. P-V plot for two gases (assuming ideal) during adiabatic processes are given in the figure. Plot A and plot B should correspond respectively to :



(4)  $H_2$  and  $Cl_2$ 

B-4. 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

(1) He and H<sub>2</sub>

- (3) Entropy of the universe remains constant (4\*) Energy of the universe remains constant
- **B-5.** 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 :



# Section (C) : Calculation of $\Delta E$ , $\Delta H$ , w and q in different type of physical processes on an idel gas, solid and on liquids

C-1.	Heat exchanged in a chemical reaction at the constant temprature and pressure is known as :					
				[AFMC	C 99]	
	(1) Internal energy	(2) entropy	(3*) enthalpy	(4) free energy	,	
C-2.	The relation of internal	energy, enthalpy and wo	ork done can be represe	nted by :	[AFMC 99]	
	(1) $\Delta E = \Delta H + W$	(2) $\Delta E = W - \Delta H$	(3*) $\Delta H = \Delta E + W$	(4) W = $\Delta E - A$	7H	
C-3.	The internal energy of	a substance :			[AFMC 2001]	
	(1*) increases with incr	ease in temprature	(2) decreases with incl	rease in tempratu	ıre	
	(3) remains constant		(4) calculated by $E = n$	nc <sup>2</sup>		
C-4.	A gas expands isother volume of 20 dm <sup>3</sup> . It al	mally against a constant	external pressure of 1 at	tm from a volume ngs. The ΛU is :	e of 10- dm <sup>3</sup> to a [AIIMS 991	
	(1) 212 1	(2) + 102	(2*) 212 1	(4) + 224	[/	
	(1) - 312 J	(2) + 123 J	$(3^{\circ}) = 213 \text{ J}$	(4) + 231 J		
C-5.	One mole of a non-ide	al gas undergoes a chan	ge of state (1.0 atm, 3.0	L, 200 K) to (4.0	atm, 5.0 L, 250	
	K) with a change in inte	ernal energy (ΔU) = 40 L·	atm. The change in enth	halpy of the proce	ess in L-atm ;	
	(1) 43	(2*) 57	(3) 42	(4) None of the	se	
	(1)	(- ) -	(-)	(),		
C-6.	The work done in adial	batic process on ideal ga	s by a constant external	pressure would	be :	
	(1) Zero	(2*) ΔE	(3) ΔH	(4) ΔG		
C-7.	A certain amount of zin	nc is dissolved in HCl at 2	5⁰C in an open vessel. 1	The type of proce	ss and the work	
	done by the system respectively would be:					
	(1) isothermal, positive	(2*) isobaric, negative	(3) isochoric, zero	(4) None		
C-8.	Inter mixing of ideal ga	ses (at the same temper	ature) is an example of:			
	(1) reversible isotherm	al	(2*) irrerversible isothermal and adiabatic			
	(3) reversible adiabatic	;	(4) none of these			
C-9.	Two molecules of an ic	leal gas expand spotane	ously into a vaccum. The	e work done is :	[AFMC 2001]	

	(1) 2 J	(2) 4 J	(3) 8 J	(4*) zero	
C-10.	The process carried out	t in perfect insulation is			[RPMT 2003]
	(1) isothermal	(2) isobaric	(3) isochoric	(4*) adiabatic	
C-11.	Adiabatic process involves				[RPMT 2003]
	(1*) Q = 0	(2) ΔE = 0	(3) ∆W = 0	(4) $\Delta V = 0$	

Section (D) :  $II_{nd}$  Law of thermodynamics : Basics of entropy, Entropy calculation for different types of physical process on an ideal gas, solid and liquid, chemical reaction

I. 
$$Ag^+ (aq) + CI^- (aq) \longrightarrow AgCI (s)$$
  
II.  $NH_4CI (s) \longrightarrow NH_3 (g) + HCI (g)$   
III.  $2NH_3 (g) \longrightarrow N_2 (g) + 3H_2 (g)$   
(1) I and II (2) III (3\*) II and III (4) II

D-2. 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) $\longrightarrow$ 2CO(g)	$(4^*) \ 3C_2H_2 \ (g) \longrightarrow C_6H_6 \ (\ \boldsymbol{\ell})$

- D-3. The entropy of vaporization of benzene is 85 JK<sup>-1</sup> mol<sup>-1</sup>. When 117 g benzene vaporizes at it's normal boiling point, the entropy change of surrounding is (assuming reversible process) :
  (1) -85 JK<sup>-1</sup>
  (2\*) -85 × 1.5 JK<sup>-1</sup>
  (3) 85 × 1.5 JK<sup>-1</sup>
  (4) None of these
- **D-4.** The entropy change when two moles of ideal monoatomic gas is heated from 200°C to 300 °C reversibly and isochorically ?
  - $(1) \frac{3}{2}_{R \ln} \left( \frac{300}{200} \right) \qquad (2) \frac{5}{2}_{R \ln} \left( \frac{573}{273} \right) \qquad (3^*) 3R \ln^{\left( \frac{573}{473} \right)} \qquad (4) \frac{3}{2}_{R \ln} \left( \frac{573}{473} \right)$
- **D-5.** If one mole of an ideal gas  $\begin{pmatrix} C_{p,m} = \frac{5}{2}R \end{pmatrix}$  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

**D-6.** Calculate the entropy change (J/mol K) of the given reaction. The molar entropies [J/K-mol] are given in brackets after each substance.

 $\begin{array}{c} \mbox{2PbS (s) [91.2] + 3O_2 (g) [205.1] \longrightarrow 2PbO (s) [66.5] + 2SO_2 (g) [248.2] \\ (1) -113.5 & (2^*) -168.3 & (3) +72.5 & (4) -149.2 \end{array}$ 

# Section (E) : $\Delta$ G calculation, Spontanity of chemical reaction significance of $\Delta$ G and III<sub>rd</sub> Law of thermodynamics

E-1.	Which of the following conditions regarding a chemical process ensures its spontanlity at all temperature ?				
	(1) $\Delta H > 0$ , $\Delta G < 0$	(2*) ΔH < 0, ΔS > 0	(3) $\Delta H < 0, \Delta S < 0$	(4) ΔH > 0, ΔS < 0	
E-2.	For isothermal expans (1) $\Delta G = \Delta S$	ion in case of an ideal ga (2) ΔG = ΔH	is : (3*) ΔG = -Τ.ΔS	(4) None of these	
E-3.	A reaction has $\Delta H = -$ (1) spontaneous below (3) spontaneous above	33 kJ and $\Delta S = +58 J/K$ a certain temperature a certain temperature	This reaction would be (2) non-spontaneous a (4*) spontaneous at al	: at all temperatures I temperature	
E-4.	For the gas - phase de (1) $\Delta H < 0$ , $\Delta S < 0$	ecomposition, PCl₅ ( (2*) ΔH > 0, ΔS > 0	g) $\stackrel{\Delta}{\longleftarrow}$ PCl <sub>3</sub> (g) + Cl <sub>2</sub> (g) (3) $\Delta$ H > 0, $\Delta$ S < 0	: (4) ΔH < 0, ΔS > 0	
E-5.	What is the free energ into steam at 100ºC ar	y change ( $\Delta G$ ) when 1.0 nd 1 atm pressure ?	mole of water at 100°C	and 1 atm pressure is converted	
	(1) 80 cal	(2) 540 cal	(3) 620 cal	(4*) Zero	
Section	on (F) : Thermoche	emistry : Enthalpy c	ontents and Kircho	off's equation	
F-1.	In the exothermic reac (1) zero	tion the enthalpy of react (2) positive	ion is always : (3*) negative	[AIIMS 2001] (4) none of these	
F-2.	Which of the reaction of	defines molar $\Delta H_f^{\circ}$ ?	1	1	
	(1) CaO(s) + CO <sub>2</sub> (g) -	──→ CaCO₃(s) 3	(2) $\frac{1}{2}$ Br <sub>2</sub> (g) +	$\frac{1}{2}$ H <sub>2</sub> (g) $\longrightarrow$ HBr(g)	
	$(3^{*}) N_{2}(g) + 2H_{2}(g) +$	$\frac{1}{2}O_2(g) \longrightarrow NH_4 NO_3$	(s) (4) $I_2(s) + H_2(s)$	′g) —→ 2HI (g)	
F-3.	In the reaction, CO <sub>2</sub> (g) (1*) heat of reaction	+ H <sub>2</sub> (g) → CO(g) + H <sub>2</sub> O (2) heat of combustion	(g) ; $\Delta H = 2$ (3) heat of formation	2.8 kJ, ΔH represents (4) heat of solution	
F-4.	Enthalpy of formation of $NH_3(g)$ is equal to: (1) Sum of the enthalpy contents of 0.5 mol $N_2(g)$ and 1.5 mol $H_2(g)$ (2) Enthalpy content of $NH_3(g)$ (3) Sum of the enthalpy contents of 1.0 mol $N_2(g)$ and 3.0 mol $H_2(g)$ (4*) None of the above				
F-5.	The enthalpy of formation	tion of ammonia is = 46.0	kJ mol⁻¹. The enthalpy	change for following reaction is :	
	2NH₃	l₂ + 3H₂ (2) 64.0 kJ	(3) 86.0 kJ	<b>[AIIMS 2002]</b> (4*) 92.0 kJ	
F-6.	The difference betwee would be :	n ΔH and ΔE on a molar	basis for the combustio	n of Methane gas at T K (kelvin)	
	(1) zero	(2) –RT	(3*) –2RT	(4) –3RT	
				no situ of water yen over 1 of y and	

**F-7** 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:

	MISTRY FOR JE	E TH			
	(1) x = y	(2*) x > y	(3) x < y	(4) cannot be determined	
Sect	ion (G) : Enthalpy	/ of combustion and	neutralisation		
G-1.	The standard heat of	of combustion of solid bord	n is equal to -		
	(1) ΔH° <sub>f</sub> (B <sub>2</sub> O <sub>3</sub> )	(2*) 1/2 ΔH° <sub>f</sub> (B <sub>2</sub> O <sub>3</sub> )	(3) 2∆H° <sub>f</sub> (B <sub>2</sub> O <sub>3</sub> )	(4) 1/2 ΔH° <sub>f</sub> (B <sub>2</sub> O <sub>3</sub> )	
G-2.	The enthalpy of cor open vessel, the an	nbustion of $C_6H_6$ is – 3250 nount of heat envolved is :	kJ when 0.39g of C $_6$ H	l₀ is burnt in excess of oxgyen in an [AFMC 2000]	
	(1) 8.32 kJ	(2) 12.36 kJ	(3*) 16.25 kJ	(4) 20.74 kJ	
G-3.	Enthalpy of neutral strong acid with Na	isation of CH₃COOH by N OH is – 55.9 kJ/mol. The v	laOH is – 50.6 kJ/mol alue of ΔH for the ionis	and the heat of neutralisation of a sation of CH <sub>3</sub> COOH is :	
	(1) 3.5 kJ / mol	(2) 4.6 kJ / mol	(3*) 5.3 kJ / mol	(4) 6.4 kJ / mol	
Sect	ion (H) : Bond En	thalpies and Resona	ince Energy		
H-1.	The bond dissocia respectively. The er	ation energy of gaseous hthalpy of formation for HC	$H_2$ , $CI_2$ and $HCI$ a	re 104, 58 and 103 kcal mol <sup>_1</sup>	
	(1) – 44.0 kcal	(2*) – 22.0 kcal	(3) 22.0 kcal	(4) 44.0 kcal	
H-2.	AB, $A_2$ and $B_2$ ar 1 : 1 : 0.5 and enthat $A_2$ .	e diatomic molecules. If alpy of formation of AB fron	the bond enthalpies $h_2$ and $B_2$ is – 100 kJ,	of A <sub>2</sub> , AB & B <sub>2</sub> are in the ratio $/mol^{-1}$ . What is the bond enthalpy of	
	(1*) 400 kJ/mol	(2) 200 kJ/mol	(3) 100 kJ/mol	(4) 300 kJ/mol	

Exercise-2

Marked Questions may have for Revision Questions.

# **OBJECTIVE QUESTIONS**

- 3 (1) 2 Fe(s) +  $\overline{2}$  O<sub>2</sub>(g)  $\longrightarrow$  Fe<sub>2</sub>O<sub>3</sub>(s) 1. If  $\Delta G = -177$  K cal for (2) 4 Fe<sub>2</sub>O<sub>3</sub>(s) + Fe(s)  $\longrightarrow$  3 Fe<sub>3</sub>O<sub>4</sub>(s) and  $\Delta G = -19$  K cal for What is the Gibbs free energy of formation of Fe<sub>3</sub>O<sub>4</sub>? (1) + 229.6 kcal/mol (2\*) – 242.3 kcal/mol (3) – 727 kcal/mol (4) - 229.6 kcal/mol 2. In the reaction  $CS_2(\ell) + 3O_2(g) \longrightarrow CO_2(g) + 2SO_2(g) \Delta H = -265$  kcal The enthalpies of formation of CO<sub>2</sub> and SO<sub>2</sub> are both negative and are in the ratio 4:3. The enthalpy of formation of CS<sub>2</sub> is +26kcal/mol. Calculate the enthalpy of formation of SO<sub>2</sub>. (1) - 90 kcal/mol (2) - 52 kcal/mol (3) - 78 kcal/mol (4\*) - 71.7 kcal/mol 3. 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

	If $S + O_2 \longrightarrow SO_2$ ,	$\Delta H = -298.2 \text{ kJ mole}^{-1}$		
	$SO_2 + 1/2 O_2 \longrightarrow 3$	SO₃ ΔH =  – 98.7 kJ mole	-1	
	$SO_3 + H_2O \longrightarrow H_2$	SO4, ΔH = – 130.2 kJ ma	ble <sup>-1</sup>	
	$H_2 + 1/2 O_2 \longrightarrow H_2$	2O, ΔH = – 287.3 kJ mole	<b>j</b> -1	
	the enthalpy of forma	tion of $H_2SO_4$ at 298 K w	ill be -	
	(1*) – 814.4 kJ mol –	1 (2) + 814.4 kJ mole <sup>-1</sup>	(3) – 650.3 kJ mole	<sup>-1</sup> (4) – 433.7 kJ mole <sup>-1</sup>
5.	An athelete is given 1 of this gained energy he would need to per (1*) 319 gm	00 g of glucose (C <sub>6</sub> H <sub>12</sub> O in the event and rest is r spire ? (The enthalpy of (2) 422 gm	s) with energy equivale eleased in the form of r evaporation of water is (3) 293 gm	nt to 1560 kJ. He utilises 50 percent respiration. Find the weight of water 44 kJ/mole.) (4) 378 gm
6.	In the reaction $AB_2(\ell)$	+ 3X <sub>2</sub> (g) AX <sub>2</sub> (g)	⊦ 2BX₂(g) ΔH = – 270 k	cal per mol. of $AB_2(\ell)$
	the enthalpies of form of $\Delta H_f^0$ (AB <sub>2</sub> ( $\ell$ )) = + 30	nation of AX <sub>2</sub> (g) & BX <sub>2</sub> (g) 0 kcal/mol. Then	are in the ratio of 4 : 3	and have opposite sign. The value
	(1) $\Delta H_{f^0}(AX_2) = -96$	kcal /mol	(2) $\Delta H_{f^0}(BX_2) = +4$	80 kcal /mol
	(3*) $K_p = K_c \& \Delta H_f^0$ (A	X <sub>2</sub> ) = + 480 kcal /mol	(4) $K_p = K_c RT \& \Delta H_f$	$h^{0}(AX_{2}) + \Delta H_{f}^{0}(BX_{2}) = -240 \text{ kcal /mol}$
7.	Enthalpy of polymeris	sation of ethylene, as rep ethylene. Given bond en	resented by the reaction rhalpy of C=C bond is 6	on, $nCH_2=CH_2 \rightarrow (-CH_2-CH_2)_n$ is 600 kJ mol <sup>-1</sup> , enthalpy of C-C bond
	(III KJ IIIOI) WIII DE .			
	(1) 116.7	(2*) 350	(3) 700	(4) indeterminate
8.	(i) KJ filol) will be . (1) 116.7 For the hypothetical r If $\Delta_r G^o$ and $\Delta_r S^o$ are 2	(2*) 350 reaction A <sub>2</sub> (g) + B <sub>2</sub> (g) $=$ 0 kJ/mol and -20 JK <sup>-1</sup> m	(3) 700 → 2AB(g). ol <sup>-1</sup> respectively at 200	(4) indeterminate
8.	(i) KJ fillor) will be . (1) 116.7 For the hypothetical r If $\Delta_r G^o$ and $\Delta_r S^o$ are 2 $\Delta_r C_p$ is 20 JK <sup>-1</sup> mol <sup>-1</sup> (1*) 20 kJ/mol	(2*) 350 reaction A₂(g) + B₂(g) <del>~</del> 0 kJ/mol and −20 JK <sup>-1</sup> m then Δ <sub>r</sub> H <sup>o</sup> at 400 K is : (2) 7.98 kJ/mol	<ul> <li>(3) 700</li> <li>⇒ 2AB(g).</li> <li>ol<sup>-1</sup> respectively at 200</li> <li>(3) 28 kJ/mol</li> </ul>	<ul><li>(4) indeterminate</li><li>) K.</li><li>(4) None of these</li></ul>
8.	(1) 116.7 For the hypothetical r If $\Delta_r G^o$ and $\Delta_r S^o$ are 2 $\Delta_r C_p$ is 20 JK <sup>-1</sup> mol <sup>-1</sup> (1*) 20 kJ/mol	(2*) 350 reaction A₂(g) + B₂(g) 0 kJ/mol and –20 JK <sup>-1</sup> m then Δ <sub>r</sub> H⁰ at 400 K is : (2) 7.98 kJ/mol	<ul> <li>(3) 700</li> <li>⇒ 2AB(g).</li> <li>ol<sup>-1</sup> respectively at 200</li> <li>(3) 28 kJ/mol</li> </ul>	<ul><li>(4) indeterminate</li><li>) K.</li><li>(4) None of these</li></ul>
8. 9.	(1) 116.7 For the hypothetical r If $\Delta_r G^o$ and $\Delta_r S^o$ are 2 $\Delta_r C_p$ is 20 JK <sup>-1</sup> mol <sup>-1</sup> (1*) 20 kJ/mol 50 Ltr. of a certain lice is suddenly released liquid increases by 1 (1*) 41 etc.	(2*) 350 reaction $A_2(g) + B_2(g) =$ 0 kJ/mol and -20 JK <sup>-1</sup> m then $\Delta_r H^o$ at 400 K is : (2) 7.98 kJ/mol quid is confined in a pisto and liquid is expanded a Ltr. and the final pressur	<ul> <li>(3) 700</li> <li>⇒ 2AB(g).</li> <li>ol<sup>-1</sup> respectively at 200</li> <li>(3) 28 kJ/mol</li> <li>In system at the extern against the constant at the on the liquid is 10 atr</li> </ul>	<ul> <li>(4) indeterminate</li> <li>(4) None of these</li> <li>(4) None of these</li> <li>(4) None of these</li> <li>(4) Pressure 100 atm. This pressure tmospheric pressure, volume of the mospheric pressure, volume of the m. Find the workdone.</li> </ul>
8. 9.	(1) 116.7 For the hypothetical r If $\Delta_r G^o$ and $\Delta_r S^o$ are 2 $\Delta_r C_p$ is 20 JK <sup>-1</sup> mol <sup>-1</sup> (1*) 20 kJ/mol 50 Ltr. of a certain lic is suddenly released liquid increases by 1 (1*) 1L.atm	(2*) 350 reaction A <sub>2</sub> (g) + B <sub>2</sub> (g) $\overline{}$ to kJ/mol and -20 JK <sup>-1</sup> m then $\Delta_r$ H <sup>o</sup> at 400 K is : (2) 7.98 kJ/mol quid is confined in a pisto and liquid is expanded a Ltr. and the final pressur (2) 5 L.atm	<ul> <li>(3) 700</li> <li>⇒ 2AB(g).</li> <li>ol<sup>-1</sup> respectively at 200</li> <li>(3) 28 kJ/mol</li> <li>In system at the extern against the constant at e on the liquid is 10 atr (3) 500 L.atm</li> </ul>	<ul> <li>(4) indeterminate</li> <li>(4) None of these</li> <li>(4) None of these</li> <li>(4) None of these</li> <li>(4) none of the vorkdone.</li> <li>(4) 50 L.atm</li> </ul>
8. 9. 10.	(1) 116.7 For the hypothetical r If $\Delta_r G^o$ and $\Delta_r S^o$ are 2 $\Delta_r C_p$ is 20 JK <sup>-1</sup> mol <sup>-1</sup> (1*) 20 kJ/mol 50 Ltr. of a certain lic is suddenly released liquid increases by 1 (1*) 1L.atm Consider the reaction	(2*) 350 reaction A <sub>2</sub> (g) + B <sub>2</sub> (g) $\overline{}$ 0 kJ/mol and -20 JK <sup>-1</sup> m then $\Delta_r$ H <sup>o</sup> at 400 K is : (2) 7.98 kJ/mol quid is confined in a pisto and liquid is expanded a Ltr. and the final pressur (2) 5 L.atm	<ul> <li>(3) 700</li> <li>⇒ 2AB(g).</li> <li>ol<sup>-1</sup> respectively at 200</li> <li>(3) 28 kJ/mol</li> <li>In system at the extern against the constant at e on the liquid is 10 atr (3) 500 L.atm</li> </ul>	<ul> <li>(4) indeterminate</li> <li>(4) None of these</li> <li>(4) None of these</li> <li>(4) None of these</li> <li>(4) none of the vorkdone.</li> <li>(4) 50 L.atm</li> </ul>
8. 9. 10.	(1) 116.7 For the hypothetical r If $\Delta_r G^o$ and $\Delta_r S^o$ are 2 $\Delta_r C_p$ is 20 JK <sup>-1</sup> mol <sup>-1</sup> (1*) 20 kJ/mol 50 Ltr. of a certain lice is suddenly released liquid increases by 1 (1*) 1L.atm Consider the reaction H <sub>2</sub> (g) + Cl <sub>2</sub> (g)	(2*) 350 reaction A <sub>2</sub> (g) + B <sub>2</sub> (g) $$ 10 kJ/mol and -20 JK <sup>-1</sup> m then $\Delta_r$ H <sup>o</sup> at 400 K is : (2) 7.98 kJ/mol quid is confined in a pisto and liquid is expanded a Ltr. and the final pressur (2) 5 L.atm in at 300 K g) $\longrightarrow$ 2HCl (g) ;	<ul> <li>(3) 700</li> <li>⇒ 2AB(g).</li> <li>ol<sup>-1</sup> respectively at 200</li> <li>(3) 28 kJ/mol</li> <li>(3) 28 kJ/mol</li> <li>against the constant at the extern against the constant at the iquid is 10 atr (3) 500 L.atm</li> </ul>	<ul> <li>(4) indeterminate</li> <li>(4) None of these</li> <li>(4) None of these</li> <li>(4) None of these</li> <li>(4) so the workdone.</li> <li>(4) 50 L.atm</li> </ul>
8. 9. 10.	(1) KJ file) will be : (1) 116.7 For the hypothetical r If $\Delta_r G^o$ and $\Delta_r S^o$ are 2 $\Delta_r C_p$ is 20 JK <sup>-1</sup> mol <sup>-1</sup> (1*) 20 kJ/mol 50 Ltr. of a certain lice is suddenly released liquid increases by 1 (1*) 1L.atm Consider the reaction H <sub>2</sub> (g) + Cl <sub>2</sub> (g) If 2 mole of H <sub>2</sub> completing	(2*) 350 reaction $A_2(g) + B_2(g) $ to kJ/mol and $-20 \text{ JK}^{-1} \text{ m}$ then $\Delta_r H^o$ at 400 K is : (2) 7.98 kJ/mol quid is confined in a pistor and liquid is expanded a Ltr. and the final pressur (2) 5 L.atm the at 300 K g) $\longrightarrow$ 2HCl (g) ; etely react with 2 mole of	<ul> <li>(3) 700</li> <li>2AB(g).</li> <li>ol<sup>-1</sup> respectively at 200</li> <li>(3) 28 kJ/mol</li> <li>(3) 28 kJ/mol</li> <li>an system at the extern against the constant at the on the liquid is 10 atr (3) 500 L.atm</li> <li>ΔH<sup>0</sup> = − 185 kJ</li> <li><sup>4</sup> Cl<sub>2</sub> to form HCI. What</li> </ul>	<ul> <li>(4) indeterminate</li> <li>(4) indeterminate</li> <li>(4) None of these</li> <li>(4) None of these</li> <li>(4) None of these</li> <li>(5) L.atm</li> <li>(4) 50 L.atm</li> </ul>
8. 9. 10.	(1) KJ file) will be : (1) 116.7 For the hypothetical r If $\Delta_r G^o$ and $\Delta_r S^o$ are 2 $\Delta_r C_p$ is 20 JK <sup>-1</sup> mol <sup>-1</sup> (1*) 20 kJ/mol 50 Ltr. of a certain lice is suddenly released liquid increases by 1 (1*) 1L.atm Consider the reaction H <sub>2</sub> (g) + Cl <sub>2</sub> (g) If 2 mole of H <sub>2</sub> complet (1) 0	(2*) 350 reaction A <sub>2</sub> (g) + B <sub>2</sub> (g) $$ 10 kJ/mol and -20 JK <sup>-1</sup> m then $\Delta_r$ H <sup>o</sup> at 400 K is : (2) 7.98 kJ/mol quid is confined in a pistor and liquid is expanded a Ltr. and the final pressur (2) 5 L.atm in at 300 K g) $\longrightarrow$ 2HCl (g) ; etely react with 2 mole or (2) - 185 kJ	(3) 700 $\rightarrow$ 2AB(g). ol <sup>-1</sup> respectively at 200 (3) 28 kJ/mol (3) 28 kJ/mol In system at the extern against the constant at e on the liquid is 10 atr (3) 500 L.atm $\Delta H^0 = -185 \text{ kJ}$ <sup>c</sup> Cl <sub>2</sub> to form HCl. What (3) 370 kJ	(4) indeterminate (4) indeterminate (4) None of these (4) None of these all pressure 100 atm. This pressure tmospheric pressure, volume of the m. Find the workdone. (4) 50 L.atm is $\Delta U^{0}$ for this reaction ? (4*) – 370 kJ
8. 9. 10. 11.	(1) KJ file) will be . (1) 116.7 For the hypothetical r If $\Delta_r G^o$ and $\Delta_r S^o$ are 2 $\Delta_r C_p$ is 20 JK <sup>-1</sup> mol <sup>-1</sup> (1*) 20 kJ/mol 50 Ltr. of a certain life is suddenly released liquid increases by 1 (1*) 1L.atm Consider the reaction H <sub>2</sub> (g) + Cl <sub>2</sub> (g) If 2 mole of H <sub>2</sub> complet (1) 0 For a reaction A (g) = partial pressure of A.	(2*) 350 reaction A <sub>2</sub> (g) + B <sub>2</sub> (g) $$ to kJ/mol and -20 JK <sup>-1</sup> m then $\Delta_r$ H <sup>o</sup> at 400 K is : (2) 7.98 kJ/mol quid is confined in a pisto and liquid is expanded a Ltr. and the final pressur (2) 5 L.atm at 300 K g) $\longrightarrow$ 2HCl (g) ; etely react with 2 mole of (2) – 185 kJ B(g) at equilibrium The value of $\Delta$ G° of the	(3) 700 $\rightarrow$ 2AB(g). ol <sup>-1</sup> respectively at 200 (3) 28 kJ/mol (3) 28 kJ/mol In system at the extern against the constant at e on the liquid is 10 atr (3) 500 L.atm $\Delta H^0 = -185 \text{ kJ}$ f Cl <sub>2</sub> to form HCl. What (3) 370 kJ I. The partial pressure a reaction A $\rightarrow$ B is	(4) indeterminate (4) indeterminate (4) None of these (4) None of these all pressure 100 atm. This pressure tmospheric pressure, volume of the m. Find the workdone. (4) 50 L.atm is $\Delta U^{0}$ for this reaction ? (4*) – 370 kJ of B is found to be one fourth of the

12. One mole of an ideal diatomic gas ( $C_v = 5$  cal) was transformed from initial 25°C and 1 L to the state when temperature is 100°C and volume 10 L. The entropy change of the process can be expressed as (R = 2 calories/mol/K)

	298	373		373	1	373	_1
	(1) 3 ln 373 + 2 ln 10	(2*) 5 In 298 +	2 ln 10 (3) 7 lr	298 + 2 ln	10 (4) 5 lr	298 + 2	In 10
13.	For the following reacti	on, C <sub>Diamon</sub>	d + O <sub>2</sub> (g)	CO <sub>2</sub> (g) ; Δ	H = –94.0 ko	cal	
		CGraphite	$_{e}$ + O <sub>2</sub> (g) $\longrightarrow$	CO <sub>2</sub> (g) ; ΔН	H = −97.6 kc	al	
	The heat required to ch	nange 1 g of C <sub>diar</sub>	$_{\text{mond}} \longrightarrow C_{graph}$	<sub>nite</sub> is			
	(1) 3.6 kcal	(2) 43.2 kcal	(3) 191	l.6 kcal	(4*) 0.3	3 kcal	
14.	$C(s) + O_2(g) \longrightarrow C$	CO <sub>2</sub> , (g);	∆H = –94.3 kca	al/mol			
	CO (g) + 2 O <sub>2</sub> (g)	→ CO₂ (g);	ΔH = – 67.4 kc	al/mo!			
	$O_2(g) \longrightarrow 2O(g);$		ΔH = 117.4 kca	al/mol			
	$CO(g) \longrightarrow C(g) + C$	D(g) ;	ΔH = 230.6 kca	al/mol			
	Calculate $\Delta H$ for C (s)	$\longrightarrow$ C (g) in kc	al/mol.				
	(1) 171	(2)154	(3)117		(4*)14	5	

**15.** Assertion : The enthalpy of formation of  $H_2O(\ell)$  is greater than of  $H_2O(g)$  in magnitude.

Reason : Enthalpy change is negative for the condensation reaction

 $H_2O(g) \longrightarrow H_2O(\ell)$ 

- (1\*) Both assertion and reason are correct; and the reason is the correct explanation for the assertion.
- (2) Both assertion and reason are correct; but the reason is not the correct explanation for the assertion.
- (3) Assertion is incorrect, reason is correct.
- (4) Both the assertion and reason are incorrect.
- **16.** Assertion : Heat of neutralisation of perchloric acid, HCIO<sub>4</sub>, with NaOH is same as that of HCI with NaOH. Reason : Both HCI and HCIO<sub>4</sub> are strong acids.
  - (1\*) Both assertion and reason are correct; and the reason is the correct explanation for the assertion.
  - (2) Both assertion and reason are correct; but the reason is not the correct explanation for the assertion.
  - (3) Assertion is incorrect, reason is correct.
  - (4) Both the assertion and reason are incorrect.
- **17.** Assertion : In the following reaction :  $C(s) + O_2(g) \longrightarrow CO_2(g)$ ;  $\Delta H = \Delta U RT$  **Reason :**  $\Delta H$  is related to  $\Delta U$  by the equation,  $\Delta H = \Delta U + \Delta n_g RT$ 
  - (1) Both assertion and reason are correct; and the reason is the correct explanation for the assertion.
  - (2) Both assertion and reason are correct; but the reason is not the correct explanation for the assertion.
  - (3\*) Assertion is incorrect, reason is correct.
  - (4) Both the assertion and reason are incorrect.
- **18. Assertion :** Entropy change in reversible adiabatic expansion of an ideal gas is zero.

**Reason :** The increase in entropy due to volume increase just componsate the decrease in entropy due to fall in temperature.

- (1\*) Both assertion and reason are correct; and the reason is the correct explanation for the assertion.
- (2) Both assertion and reason are correct; but the reason is not the correct explanation for the assertion.
- (3) Assertion is incorrect, reason is correct.
- (4) Both the assertion and reason are incorrect.
- Assertion : Enthalpy and entropy of any elementary substance in the standard states are taken as zero.
   Reason : At absolute zero, particles of the perfectly crysalline substance become completely motionless.
  - (1) Both assertion and reason are correct; and the reason is the correct explanation for the assertion.
  - (2) Both assertion and reason are correct; but the reason is not the correct explanation for the assertion.
  - (3\*) Assertion is incorrect, reason is correct.
  - (4) Both the assertion and reason are incorrect.
- **20.** Assertion : Many endothermic reactions that are not spontaneous at room temperatures become spontaneous at high temperature.

**Reason** :  $\Delta H^0$  of the endothermic reaction increases with increase in temperature.

- (1) Both assertion and reason are correct; and the reason is the correct explanation for the assertion.
- (2\*) Both assertion and reason are correct; but the reason is not the correct explanation for the assertion.
- (3) Assertion is incorrect, reason is correct.
- (4) Both the assertion and reason are incorrect.
- **21. Assertion :** Increase of free energy during the process under constant temperature and pressure provides a measure of its spontaneity.

**Reason** : A spontaneous change must have + ve sign of  $\Delta S_{system}$ .

- (1) Both assertion and reason are correct; and the reason is the correct explanation for the assertion.
- (2) Both assertion and reason are correct; but the reason is not the correct explanation for the assertion.
- (3) Assertion is incorrect, reason is correct.
- (4\*) Both the assertion and reason are incorrect.

**Exercise-3** 

#### **OFFLINE JEE-MAIN**

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

- 3. Assuming that water vapour is an ideal gas, the internal energy change ( $\Delta U$ ) 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 kJ mol<sup>-1</sup> and R = 8.3 J mol<sup>-1</sup> K<sup>-1</sup>) will be : [AIEEE 2007, 3/120] (1\*) 37.904 kJ mol<sup>-1</sup> (2) 41.00 kJ mol<sup>-1</sup> (3) 4.100 kJ mol<sup>-1</sup> (4) 3.7904 mol<sup>-1</sup>
- **4.** The standard enthalpy of formation ( $\Delta H_{f^o}$ ) at 398 K for methane,  $CH_{4(g)}$  is 74.8 kJ mol<sup>-1</sup>. 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  $H_{\rm 2}$  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<sub>2</sub>
- 5. Standard entropy of X<sub>2</sub>, Y<sub>2</sub> and XY<sub>3</sub> are 60, 40 and 50 JK<sup>-1</sup> mol<sup>-1</sup>, 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
- 6. On the basis of the following thermochemical data :  $(\Delta_f G^0 H^+_{(aq)} = 0)$  [AIEEE 2009, 8/144]  $H_2O(\ell) \rightarrow H^+(aq) + OH^-(aq.); \Delta H = 57.32 \text{ kJ}$   $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(\ell); \Delta H = -286.20 \text{ kJ}$ The value of enthalpy of formation of OH<sup>-</sup> ion at 25°C is :  $(1^*) -228.88 \text{ kJ}$  (2) +228.88 kJ (3) -343.52 kJ (4) -22.88 kJ
- 7. In a fuel cell methanol is used as fuel and oxygen gas is used as an oxidizer. The reaction is

 $CH_{3}OH(\ell) + \ \frac{3}{2}O_{2}\left(g\right) - \rightarrow CO_{2}(g) + 2H_{2}O(\ell)$ 

At 298 K, standard Gibb's energies of formation for CH<sub>3</sub>OH ( $\ell$ ), H<sub>2</sub>O( $\ell$ ) and CO<sub>2</sub> (g) are –166.2, –237.2 and

-394.4 kJ mol<sup>-1</sup> respectively. If standard enthalpy of combustion of methanol is -726kJ mol<sup>-1</sup>, efficiency of the fuel cell will be : [AIEEE 2009, 8/144]

$$CH_{3}OH(\ell) + \frac{3}{2}O_{2}(g) - \rightarrow CO_{2}(g) + 2H_{2}O(\ell)$$
(1) 87% (2) 90% (3\*) 97% (4) 80%

- 8. The standard enthalpy of formation of NH<sub>3</sub> is  $-46.0 \text{ kJ mol}^{-1}$ . If the enthalpy of formation of H<sub>2</sub> from its atoms is  $-436 \text{ kJ mol}^{-1}$  and that of N<sub>2</sub> is  $-712 \text{ kJ mol}^{-1}$ , the average bond enthalpy of N H bond in NH<sub>3</sub> is [AIEEE 2010, 4/144] (1)  $-964 \text{ kJ mol}^{-1}$  (2\*)  $+352 \text{ kJ mol}^{-1}$  (3)  $+1056 \text{ kJ mol}^{-1}$  (4)  $-1102 \text{ kJ mol}^{-1}$
- 9. For a particular reversible reaction at temperature T,  $\Delta H$  and  $\Delta S$  were found to be both +ve. If T<sub>e</sub> is the temperature at equilibrium, the reaction would be spontaneous when. [AIEEE 2010, 4/144]

EMISTRY FOR J	EE T	THERMODYNAMICS & THERMOCHEMISTRY			
(1) T <sub>e</sub> > T	(2*) T > T <sub>e</sub>	(3) T <sub>e</sub> is 5 times T	(4) T = T <sub>e</sub>		
The entropy chang volume of 10 dm <sup>3</sup> t	je involved in the isother o a volume of 100 dm³ at	mal reversible expansion of t 27°C is :	of 2 moles of an ideal gas from a [AIEEE 2011, 4/120]		
(1*) 38.3 J mol⁻¹ K⁻	-1 (2) 35.8 J mol <sup>-1</sup> K <sup>-1</sup>	(3) 32.3 J mol <sup>-1</sup> K <sup>-1</sup>	(4) 42.3 J mol <sup>-1</sup> K <sup>-1</sup>		
The value of entha	lpy change ( $\Delta H$ ) for the re	eaction			
$C_2H_5OH_{(l)}$ -	+ $3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2(g)$	O <sub>(l)</sub>			
at 27°C is -1366.	.5 kJ mol <sup>-1</sup> . The value	of internal energy chang	e 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		
Consider the react	ion :				
4NO <sub>2(g)</sub> + 0	$D_{2(g)} \rightarrow 2N_2O_{5(g)}, \qquad \Delta_r H$	H = −111 kJ.			
If $N_2O_{5(s)}$ is formed	instead of $N_2O_{5(g)}$ in the a	above reaction, the $\Delta_r H$ val	lue will be:		
(given, ΔH of sublir	mation for N₂O₅ is 54 kJ r	nol−1)	[AIEEE 2011, 4/120]		
(1) + 54kJ	(2) + 219 kJ	(3) – 219 kJ	(4) – 165 kJ		
In veiw of the signs	s of $\Delta_r G^o$ for the following	reactions :			
PbO <sub>2</sub> + Pb	$\rightarrow$ 2PbO, $\Delta_r G^o < 0$				
SnO <sub>2</sub> + Sn	$\label{eq:alpha} \rightarrow \ 2SnO, \qquad \Delta_r G^o > 0,$				
which oxidation sta	ites are more characteris	tics for lead and tin?	[AIEEE 2011, 4/120]		
(1) For lead +2, for	tin +2	(2) For lead +4, for tir	n +4		
(3*) For lead +2, fo	r tin +4	(4) For lead +4, for tir	n +2		
The incorrect expre	ession among the followir	ng is :	[AIEEE 2012, 4/120]		
$\Delta G_{system}$			V <sub>f</sub>		
(1) $\Delta S_{\text{total}} = -T$		(2) In isothermal proc	cess, w <sub>reversible</sub> = −nRTℓn <sup>V</sup> i		
$\Delta H^{\circ} - T \Delta$	S°				
(3*) InK = RT		(4) $K = e^{-\Delta G^{\circ/RT}}$			
A piston filled with	0.04 mol of an ideal gas	s expands reversibly from	50.0 mL to 375 mL at a constant		
temperature of 37.0	0ºC. As it does so, it abso	orbs 208 J of heat. The val	ues of q and w for the process will		
(R = 8.314 J/mol K	) (ln 7.5 = 2.01)	[JEE	(Main) 2013, 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		
For complete com	bustion of ethanol, C₂H₅	$OH(l)$ + $3O_2(g) \rightarrow 2CO_2(g)$	g) + $3H_2O(l)$ , the amount of heat		
produced as meas	ured in bomb calorimeter	, is 1364.47 kJ mol⁻¹ at 25°	C. Assuming ideality the Enthalpy		
of combustion, $\Delta_{C}$ H	I, for the reaction will be :	: (R = 8.314 kJ mol <sup>-1</sup> ) <b>[JEE</b>	(Main) 2014, 4/120]		
	EMISTRY FOR JI (1) T <sub>e</sub> > T The entropy change volume of 10 dm <sup>3</sup> t (1*) 38.3 J mol <sup>-1</sup> K <sup>-1</sup> The value of entha $C_2H_5OH_{(1)}$ , at 27°C is -1366. temperature will be (1) -1369.0 kJ Consider the reacting 4NO <sub>2(g)</sub> + C If N <sub>2</sub> O <sub>5(s)</sub> is formed (given, $\Delta$ H of sublim (1) + 54kJ In veiw of the signs PbO <sub>2</sub> + Pb SnO <sub>2</sub> + Sn which oxidation stat (1) For lead +2, for (3*) InK = $\frac{\Delta H^o - T\Delta}{RT}$ A piston filled with temperature of 37.0 be: (R = 8.314 J/mol K (1*) q = +208 J, w = For complete comproduced as measing of combustion, $\Delta_{C}H^{-1}$	<b>EMISTRY FOR JEE</b> (1) T <sub>e</sub> > T (2*) T > T <sub>e</sub> The entropy change involved in the isother volume of 10 dm <sup>3</sup> to a volume of 100 dm <sup>3</sup> a (1*) 38.3 J mol <sup>-1</sup> K <sup>-1</sup> (2) 35.8 J mol <sup>-1</sup> K <sup>-1</sup> The value of enthalpy change (ΔH) for the r C <sub>2</sub> H <sub>5</sub> OH <sub>(1)</sub> + 3O <sub>2(g)</sub> → 2CO <sub>2(g)</sub> + 3H <sub>2</sub> / at 27°C is -1366.5 kJ mol <sup>-1</sup> . The value temperature will be : (1) -1369.0 kJ (2*) -1364.0 kJ Consider the reaction : 4NO <sub>2(g)</sub> + O <sub>2(g)</sub> → 2N <sub>2</sub> O <sub>5(g)</sub> , Δ <sub>t</sub> - If N <sub>2</sub> O <sub>5(s)</sub> is formed instead of N <sub>2</sub> O <sub>5(g)</sub> in the (given, ΔH of sublimation for N <sub>2</sub> O <sub>5</sub> is 54 kJ r (1) + 54kJ (2) + 219 kJ In veiw of the signs of Δ <sub>t</sub> G <sup>o</sup> for the following PbO <sub>2</sub> + Pb → 2PbO, Δ <sub>t</sub> G <sup>o</sup> > 0, which oxidation states are more characteris (1) For lead +2, for tin +2 (3*) For lead +2, for tin +4 The incorrect expression among the following $\frac{\Delta G_{system}}{\Delta S_{total}} = -T$ (3*) InK = $\frac{\Delta H^o - T\Delta S^o}{RT}$ A piston filled with 0.04 mol of an ideal gas temperature of 37.0°C. As it does so, it abso be: (R = 8.314 J/mol K) (In 7.5 = 2.01) (1*) q = +208 J, w = -208 J (3) q = -208 J, w = +208 J For complete combustion of ethanol, C <sub>2</sub> H <sub>5</sub> produced as measured in bomb calorimeter of combustion, Δ <sub>c</sub> H, for the reaction will be	THERMODYNAMICS 1(1) $T_e > T$ (2*) $T > T_e$ (3) $T_e$ is 5 times TThe entropy change involved in the isothermal reversible expansion volume of 10 dm³ to a volume of 100 dm³ at 27°C is :(1*) 38.3 J mol <sup>-1</sup> K <sup>-1</sup> (2) 35.8 J mol <sup>-1</sup> K <sup>-1</sup> (3) 32.3 J mol <sup>-1</sup> K <sup>-1</sup> The value of enthalpy change ( $\Delta$ H) for the reaction $C_2H_5OH_{(1)} + 3O_{2((g)} - 2CO_{2((g)} + 3H_2O_{(1)})$ at 27°C is -1366.5 kJ mol <sup>-1</sup> . The value of internal energy change temperature will be :(1) -1369.0 kJ(2') -1364.0 kJ(3) -1361.5 kJConsider the reaction : $4NO_{2(g)} + O_{2(g)} - 2N_2O_{5(g)}$ , $\Delta$ :H = -111 kJ.If N2O <sub>5(g)</sub> is formed instead of N2O <sub>5(g)</sub> in the above reaction, the $\Delta$ H value (given, $\Delta$ H of sublimation for N2O <sub>5</sub> is 54 kJ mol <sup>-1</sup> )(1) + 54kJ(2) + 219 kJ(3) -219 kJIn veiw of the signs of $\Delta$ :G <sup>0</sup> for the following reactions :PbO2 + Pb - 2PbO, $\Delta$ :G <sup>0</sup> SO $2 + Sn - 2SnO, \Delta:G0 SO 2 + Sn - 2SnO, \Delta:G0 $		

(1*) – 1366.95 kJ mol <sup>-1</sup>	(2) – 1361.95 kJ mol⁻¹
(3) – 1460.50 kJ mol⁻¹	(4) – 1350.50 kJ mol⁻¹

17.	The following reaction is performed at 298 K							
	2NO	(g) + O <sub>2</sub> (g	$) = 2NO_2(g)$	)				
	The standard	free ener	gy of formation o	f NO(g)	is 86.6 kJ/mol at 29	98 K. W	/hat is the standard f	ree energy
	of formation of	of NO <sub>2</sub> (g)	at 298 K ?	(Kp = 1	.6 × 10 <sup>12</sup> ) [.	JEE(M	ain) 2015, 4/120]	
	(1) R(298) in	$(1.6 \times 10^{-1})$	<sup>2</sup> ) – 86600	(2) 866	600 + R(298) ln (1.6	6 x 10 <sup>12</sup>	2)	
	I	$\ln(1.6 \times 10^{\circ})$	$(12)^{12}$					
	-	R (298	)	(4+) 0 5			(4.0.4.012)]	
40	(3) 86600 –	e e me h u e tiu	, 	(4 <sup>^</sup> ) 0.5	) [2 × 86,600 – R (2	298) In 2 5 ana	$(1.6 \times 10^{12})$ ]	an a ath call c
18.	The heats of f	compusition (	in k I) of carbon and	carbon	monoxide are -393	3.5 and	I –283.5 KJ MOI⁻', re [ IEE(Main) 2016 /	
	(1) 676 5	ormation (	(2) = 676.5	ΠΟΠΟΛΙΟ	(3*) –110 5		(4) 110 5	/120]
	(1) 07 0.0		(2) 070.0		(0) 110.0		(4) 110.0	
19.	ΔU equal to :						[JEE(Main) 2017	7, 4/120]
	(1) Isobaric w	vork	(2*) Adiabatic v	vork	(3) Isothermal wo	rk	(4) Isochoric work	
20.	Given :	C(graphit	$_{ie)} + O_2(g) \longrightarrow$	CO <sub>2</sub> (g)	; Δ <sub>r</sub> H <sup>o</sup> =  – 393.5 kJ	mol <sup>-1</sup> ;	;	
			1					
		H <sub>2</sub> (g) -	$+ \overline{2} O_2(g) \longrightarrow$	H <sub>2</sub> O(I) ;	$\Delta_{\rm r} {\rm H}^{\rm o} = - 285.8 ~{\rm kJ}$	mol <sup>-1</sup> ;	;	
		CO <sub>2</sub> (g	) + 2H₂O(I) →	CH <sub>4</sub> (g)	+ 2O <sub>2</sub> (g) ;Δ <sub>r</sub> H <sup>o</sup> = +	890.3	kJ mol⁻¹	
Based	on the above t	thermoche	emical equations.	the valu	Le of $\Delta_r H^0$ at 298 K	for the	reaction :	
	C	いい エ 2Ha	$(a) \longrightarrow CH^{(a)}$	will bo ·		r	IEE(Main) 2017 //1	201
	(1) +144.0 kJ	$ mol^{-1} $	(2*) –74.8 kJ m	$nol^{-1}$	(3) –144.0 kJ mol	_1 _1	(4) +74.8 kJ mol <sup>-1</sup>	20]
	(1)		(_ )		(,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		(1) 11 11 11 11 11 11	
			ON	ILINE、	JEE-MAIN			
1.	The standard	d enthalpy	of formation of	NH₃ is -	-46.0 kJ/mol. If the	e entha	Ipy of formation of	H <sub>2</sub> from its
	atoms is -43	6 kJ/mol a	and that of $N_2$ is –	-712 kJ/ı	nol, the average bo	ond tha	alpy of N–H bond in I	NH₃ is :
					[JEE(N	/lain) 2	014 Online (09-04-1	14), 4/120]
	(1) –1102 kJ/	'mol	(2) – 964 kJ/m	ol	(3*) + 352 kJ/mol		(4) +1056 kJ/mol	
2.	The molar he	at capacit	y (C <sub>p</sub> ) of CD <sub>2</sub> O is	10 cals	at 1000 K. The char	nge in e	entropy associated w	vith cooling
	of 32 g of CD	2O vapou	r from 1000 K to	100 K at	constant pressure	will be	e : (D = deuterium, at	t. mass = 2
	u)				[JEE(Main) 2014	Online	e (11-04-14), 4/120]	
	(1) 23.03 cal	deg <sup>-1</sup>	(2*) – 23.03 ca	l deg <sup>-1</sup>	(3) 2.303 cal deg-	-1	(4) – 2.303 cal deg⁻	1
3.	Then entropy	v (S⁰) of th	e following subst	ances a	re :			
	CH4(g) 186.2	JK <sup>-1</sup> mol	-1					
	O <sub>2</sub> (g) 205.0 J	IK <sup>-1</sup> mol <sup>-1</sup>						
	CO <sub>2</sub> (g) 213.6	5 JK <sup>−1</sup> mol <sup>-</sup>	-1					
	H₂O(ℓ) 69.9 J	JK <sup>-1</sup> mol <sup>-1</sup>						
	The entropy of	change (Δ	Sº) for the reaction	on CH₄(g	$g) + 2O_2(g) \rightarrow CO_2(g)$	(g) + 2l	H₂O(ℓ) is :	
					[JEE(Mai	in) 201	4 Online (12-04-14)	, 4/1201
	(1) –312.5 JK	K−1 mol−1	(2*) –242.3 JK⁻	<sup>-1</sup> mol <sup>-1</sup>	(3) –108.1 JK <sup>-1</sup> m	iol <sup>-1</sup>	(4) –37.6 JK <sup>-1</sup> mol <sup>-1</sup>	,

4.	<ul> <li>The standard enthalpy of formation (Δ<sub>f</sub>H<sup>0</sup><sub>298</sub>) for methane, CH<sub>4</sub> is -74.9 kJ mol<sup>-1</sup>. In order to calculate the average energy given out in the formation of a C–H bond from this it is necessary to know which one of the following ? [JEE(Main) 2014 Online (12-04-14), 4/120]</li> <li>(1) the dissocation energy of the hydrogen molecule, H<sub>2</sub>.</li> <li>(2) the first four ionisation energies of carbon.</li> <li>(3*) the dissociation energy of H<sub>2</sub> and enthalpy of sublimation of carbon (graphite).</li> <li>(4) the first four ionisation energies of carbon and electron affinity of hydrogen.</li> </ul>					
5.	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 :					
	(A vogadro number =	6.02 × 10 <sup>23</sup> , h = 6.62 × 10	D <sup>-34</sup> J s): [JEE(Main)	2015 Online (10-04-15), 4/120]		
	(1) 2.48 × 10 <sup>3</sup> nm	(2*) 1.49 × 10 <sup>3</sup> nm	(3) 2.49 × 10 <sup>4</sup> nm	(4) 2.48 × 10 <sup>4</sup> nm		
6.	For the reaction, $A(g) \cdot K^{-1}$ mol <sup>-1</sup> at 298 K. The	+ B(g) → C(g) + D(g), ΔH e equilibrium constant for	<sup>o</sup> and $\Delta$ S <sup>o</sup> are, respective the reaction at 298 K is:	ely, –29.8 kJ mol⁻¹ and –0.100 kJ		
			[JEE(Main) 20	016 Online (09-04-16), 4/120]		
	(1*) 1	(2) 10	(3) 1.0 × 10 <sup>-10</sup>	(4) 1.0 × 10 <sup>10</sup>		
7.	A reaction at 1 bar temperature. Identify the	is non-spontaneous at he correct statement abo	low temperature but I ut the reaction among th [JEE(Main) 20	becomes spontaneous at high e following: 016 Online (09-04-16), 4/120]		
	(1*) Both $\Delta H$ and $\Delta S$ a	re positive.	(2) $\Delta H$ is negative while	e $\Delta S$ is positive.		
	(3) $\Delta H$ is positive while	$\Delta S$ is negative.	(4) Both $\Delta H$ and $\Delta S$ are	e negative.		
8.	If 100 mole of H <sub>2</sub> O <sub>2</sub> deal	compose at 1 bar and 300 e is : [JEE(I	D K, the work done (kJ) by Main) 2016 Online (10-0	y one mole of O₂(g) as it expands 94-16), 4/120]		
	2H <sub>2</sub> O <sub>2</sub> ( <i>l</i> )	<sup>≥</sup> 2H <sub>2</sub> O( <i>l</i> ) + O <sub>2</sub> (g)	(R = 8.3 J K <sup>-1</sup> mol <sup>-1</sup> )			
	(1) 498.00	(2) 62.25	(3*) 124.50	(4) 249.00		
9.	For a reaction, A(g) $\rightarrow$	A (I); $\Delta H = -3RT$ . The c	orrect statement for the r	reaction is :		
			[JEE(Main) 20	017 Online (08-04-17), 4/120]		
	(1) ΔH = ΔU ≠ O	$(2^*)  \Delta H  >  \Delta U $	(3) $ \Delta H  <  \Delta U $	(4) $\Delta H =  \Delta U = O$		
10.	The enthalpy change of	on freezing of 1 mol of wa	ater at 5ºC to ice at –5ºC	is :		
	(Given ∆ <sub>fus</sub> H = 6 kJ mo	$D^{-1}$ at 0°C, $C_p(H_2O, I) = 75$	5.3 J mol <sup>_1</sup> K <sup>_1</sup> , C <sub>p</sub> (H₂O,s	sl) = 36.8 J mol <sup>-1</sup> K <sup>-1</sup> )		
	Υ.		[JEE(Main) 2017 Onli	ne (08-04-17), 4/120]		
	(1) 5.81 kJ mol⁻¹	(2) 5.44 kJ mol <sup>-1</sup>	(3) 6.00 kJ mol⁻¹	(4*) 6.56 kJ mol <sup>-1</sup>		
11.	A gas undergoes change from state A to state B. In this process, the heat absorbed and work done by the gas is 5 J and 8 J, respectively. Now gas is brought back to A by another process during, which 3 J of heat is evolved. In this reverse process of B to A : <b>[JEE(Main) 2017 Online (09-04-17), 4/120]</b>					

- (1) 10 J of the work will be done by the surrounding on gas.
- (2) 10 J of the work will be done by the gas.
- $(3^*)$  6 J of the work will be done by the surrounding on gas.
- (4) 6 J of the work will be done by the gas.

12.

	<ul><li>(1) enthalpy increases but entropy decreases.</li><li>(3) enthalpy decreases but entropy increases.</li></ul>	<b>[JEE(Main)</b> (2*) enthalpy remains (4) Both enthalpy and	<b>2017 Online (09-04-17), 4/120]</b> constant but entropy increases. entropy remain constant.	
F	PART - II : JEE (ADVANCED) / IIT-J	EE PROBLEMS (	PREVIOUS YEARS)	
1.	In thermodynamics, a process is called reversil (A) surroundings and system change into each (B) there is no boundary between system and s (C*) the surroundings are always in equilibrium (D) the system changes into the surroundings s	ble when - other surroundings with the system spontaneously	[JEE 2001, 1/35]	
2.	<ul> <li>Which one of the following statement is false :</li> <li>(A*) work is a state function</li> <li>(B) temperature is a state function</li> <li>(C) change in the state is completely defined w</li> <li>(D) work appears at the boundary of the system</li> </ul>	hen the initial and final s n.	[JEE 2001, 1/35] tates are specified	
3.	One mole of a non-ideal gas undergoes a char K) with a change in internal energy, $\Delta U = 30.0$ atm is - (A) 40.0 (C*) 44.0	nge of state (2.0 atm, 3.0) L atm. The change in e (B) 42.3 (D) not defined, becau	O L, 95 K) → (4.0 atm, 5.0 L, 245 enthalpy (ΔH) of the process in L [JEE 2002, 3/90] use pressure is not constant	
4.	Which of the following equation gives the value (A) C (diamond) $+ O_2(g) \longrightarrow CO_2(g)$ (C) N <sub>2</sub> (g) $+ 3H_2(g) \longrightarrow 2NH_3(g)$	es of heat of formation ( $\Delta$ (B*) $\frac{1}{2} \frac{1}{H_2(g)} + \frac{1}{2} \frac{1}{F_2(g)}$ (D) $H_2(g) + F_2(g) \rightarrow 20$	i heat of formation ( $\Delta H_f^0$ ) [JEE 2003, 3/84] (3*) $\frac{1}{2} \frac{1}{H_2(g)} + \frac{1}{2} \frac{1}{F_2(g)} \rightarrow HF(g)$ () $H_2(g) + F_2(g) \rightarrow 2HF(g)$	
5.	2 moles of ideal gas is expanded isothermally & in kJ mol <sup>-1</sup> . (A*) 0 (B) 11.7	reversibly from 1 litre to (C) – 11.7	10 litre. Find the enthalpy change [JEE 2004, 3/84] (D) 25	
6.	$\Delta H = 30 \text{ kJ mol}^{-1}$ , $\Delta S = 75 \text{ J} / \text{k} / \text{mol}$ . Find both (A*) 400 K (B) 300 K	iling temperature at 1 ati (C) 150 K	m. <b>[JEE 2004, 3/84]</b> (D) 425 K	
7.	Spontaneous adsorption of a gas on a solid su (A) enthalpy of the system increases. (C*) entropy decreases.	urface is exothermic process because [JEE 2004, 3/84] (B) entropy increases. (D) free energy change increases.		
8.	One mole of an ideal monoatomic gas at tempe	erature T and volume 1L e	expands to 2L against a constant	

An ideal gas undergoes isothermal expansion at constant pressure. During the process :

8. 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 :

[JEE 2005, 3/84]

$$(A) T_{+} + \frac{2}{3 \times 0.0821} \qquad (B^{*}) T_{-} - \frac{2}{3 \times 0.0821} \qquad (C) \frac{T}{2^{E/3-1}} \qquad (D) \frac{T}{2^{E/3-1}}$$
9. The ratio of P to V at any instant is constant and is equal to 1, for a monoatomic ideal gas under going a process. What is the molar heat capacity of the gas. [JEE 2006, 3/184]  

$$(A) \frac{3R}{2} \qquad (B^{*}) \frac{4R}{2} \qquad (C) \frac{5R}{2} \qquad (D) 0$$
10. The direct conversion of A to B is difficult, hence it is carried out by the following shown path:  

$$(A) \frac{1}{2} + (B^{*}) \frac{4R}{2} \qquad (C) \frac{5R}{2} \qquad (D) 0$$
10. The direct conversion of A to B is difficult, hence it is carried out by the following shown path:  

$$(A) \frac{1}{2} + (B^{*}) \frac{1}{2} + (C) \frac{1}{2} + (C) \frac{1}{2} + (C) \frac{1}{2} + (D) \frac{1}{2} +$$

$$(A^*) \Delta G = 0, \Delta S = +ve \quad (B) \Delta G = 0, \Delta S = -ve \quad (C) \Delta G = +ve, \Delta S = 0 \quad (D) \Delta G = -ve, \Delta S = +ve$$

- 14. Statement-1: For every chemical reaction at equilibrium, standard Gibbs energy of reaction is zero.
   Statement-2: At constant temperature and pressure, chemical reactions are spontaneous in the direction of decreasing Gibbs energy. [JEE 2008, 3/163]
   (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
  - (A) Statement-T is True, Statement-2 is True, Statement-2 is a correct explanation for Statement-T.
  - (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
  - (C) Statement-1 is True, Statement-2 is False

- (D\*) Statement-1 is False, Statement-2 is True
- **15. Statement-1**: There is a natural asymmetry between converting work to heat and converting heat to work.

Statement-2 : No process is possible in which the sole result is the absorption of heat form a reservoirand its complete conversion into work.[JEE 2008, 3/163](A\*) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

- **16.** The species which by definition has **ZERO** standard molar enthalpy of formation at 298 K is : (A)  $Br_2(g)$  (B\*)  $Cl_2(g)$  (C)  $H_2O(g)$  (D)  $CH_4(g)$
- 17.
   The bond energy (in kcal mol<sup>-1</sup>) of a C–C single bond is approximately :
   [JEE 2010, 3/163]

   (A) 1
   (B) 10
   (C\*) 100
   (D) 1000
- Using the data provided, calculate the multiple bond energy (kJ mol<sup>-1</sup>) of a C=C bond C<sub>2</sub>H<sub>2</sub>. That energy is (take the bond energy of a C–H bond as 350 kJ mol<sup>-1</sup>)
   [JEE 2012, 3/136]

The standard enthalpies of formation of CO<sub>2</sub>(g), H<sub>2</sub>O(*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
 (A) +2900 kJ
 (B) - 2900 kJ
 (C\*) -16.11 kJ
 (D) + 16.11 kJ

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

#### [JEE(Advanced) 2014, 3/120]

(A) $\Delta S_{system} > 0$ and $\Delta S_{surroundings} > 0$	(B*) $\Delta S_{system} > 0$ and $\Delta S_{surroundings} < 0$
(C) $\Delta S_{system} < 0$ and $\Delta S_{surroundings} > 0$	(D) $\Delta S_{system} < 0$ and $\Delta S_{surroundings} < 0$

21. One mole of an ideal gas at 300 K in thermal contact with surroundings expands isothermally from 1.0 L to 2.0 L against a constant pressure of 3.0 atm. In this process, the change in entropy of surroundings  $(\Delta S_{surr})$  in JK<sup>-1</sup> is : (1 L atm = 101.3 J) [JEE(Advanced) 2016, 3/124]