# THERMOCHEMISTRY

# **Exercise-1**

### **PART - I : SUBJECTIVE QUESTIONS**

### Section (A) : Calculation $\Delta U$ , $\Delta H$ & W for chemical reaction

- A-1. For the reaction :  $C_2H_5OH(\Box) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(g)$ if  $\Delta U^0 = -1373$  kJ mol<sup>-1</sup> at 298 K. Calculate  $\Delta H^0$
- A-2. 2 mole of zinc is dissolved in HCl at 25°C. Calculate the work done in open vessel.

### Section (B) : Basics & Kirchoff's law

**B-1.** Diborane is a potential rocket fuel which undergoes combustion according to the reaction  $B_2H_6(g) + 3O_2(g) \longrightarrow B_2O_3(s) + 3H_2O(g)$ 

From the following data, calculate the enthalpy change for the combustion of diborane

$2B(s) + (3/2) O_2(g) \longrightarrow B_2O_3(s) \Delta H = -$	1273 kJ mol <sup>-1</sup>
$H_2(g) + (1/2)O_2(g) \longrightarrow H_2O(I)$	$\Delta H = -286 \text{ kJ mol}^{-2}$
$H_2O(I) \longrightarrow H_2O(g)$	$\Delta H = 44 \text{ kJ mol}^{-1}$
$2B(s) + 3H_2(g) \longrightarrow B_2H_6(g)$	$\Delta H = 36 \text{ kJ mol}^{-1}$

**B-2.** Predict the standard reaction enthalpy of 2 NO<sub>2</sub>(g)  $\rightarrow$  N<sub>2</sub>O<sub>4</sub>(g) at 100°C.  $\Delta$ H° at 25°C is -57.2 kJ.mol<sup>-1</sup> C<sub>p</sub>(NO<sub>2</sub>) = 37.2 J.mol<sup>-1</sup> K<sup>-1</sup> C<sub>p</sub>(N<sub>2</sub>O<sub>4</sub>) = 77.28 J.mol<sup>-1</sup> k<sup>-1</sup>.

### Section (C) : Enthalpy of formation & combustion

**C-1.** The heat of combustion of ethyl alcohol is -300 kcal. If the heats of formation of CO<sub>2</sub> (g) and H<sub>2</sub>O( $\Box$ ) are -94.3 and -68.5 kcal respectively, calculate the heat of formation of ethyl alcohol.

C-2.	If $H_2 + 1/2 O_2 \longrightarrow H_2O$ ,	$\Delta H = -68$ kcal
	$K + H_2O + water \longrightarrow KOH (aq) + 1/2 H_2,$	$\Delta H = -48$ kcal
	KOH + water $\longrightarrow$ KOH (aq),	$\Delta H = -14 \text{ kcal}$
	Find the heat of formation of KOH.	

- **C-3.** The standard enthalpy of decomposition of the yellow complex  $H_3NSO_2$  into  $NH_3$  and  $SO_2$  is + 40 kJ mol<sup>-1</sup>. Calculate the standard enthalpy of formation of  $H_3NSO_2$ .  $\Delta H^0_f(NH_3) = -46.17$  kJ mol<sup>-1</sup>,  $\Delta H^0_f(SO_2) = -296.83$ .
- **C-4.** When 12.0 g of carbon (graphite) reacted with oxygen to form CO and CO<sub>2</sub> at 25<sup>o</sup>C and constant pressure, 252 kJ of heat was released and no carbon remained. If  $\Delta H^{0_{f}}$  (CO, g) = 110.5 kJ mol<sup>-1</sup> and  $\Delta H^{0_{f}}$  (CO<sub>2</sub>,g) = 393.5 kJ mol<sup>-1</sup>, calculate the mass of oxygen consumed.

### Section (D) : Bond enthalpy method & Resonance energy

- **D-1.** Calcualte the bond energy of CI–CI bond from the following data :  $CH_4(g) + Cl_2(g) \longrightarrow CH_3CI(g) + HCI(g); \Delta H = -100.3 \text{ kJ}.$  Also the bond enthalpies of C–H, C–CI, H–CI bonds are 413, 326 and 431 kJ mol<sup>-1</sup> respectively.
- **D-2.** Calculate  $\Delta H^{0}_{r}$  for the reaction  $CH_{2}Cl_{2}(g) \longrightarrow C(g) + 2H(g) + 2Cl(g)$ . The average bond enthalpies of C–H and C–Cl bonds are 414 kJ mol<sup>-1</sup> and 330 kJ mol<sup>-1</sup>.
- **D-3.** Calculate the enthalpy change ( $\Delta$ H) of the following reaction  $2C_2H_2(g) + 5O_2(g) \longrightarrow 4CO_2(g) + 2H_2O(g)$  given average bond enthalpies of various bonds, i.e., C–H, C=C, O=O, C=O, O–H as 414, 814, 499, 724 and 640 kJ mol<sup>-1</sup> respectively.

- D-4. Calculate change in enthalpy for the reaction at 27°C H<sub>2</sub>(g) + C□<sub>2</sub>(g) → 2H−C□(g) by using the bond energy and energy data Bond energies of H−H, C□−C□ and H−C□ bonds are 435 kJ mol<sup>-1</sup>, 240 kJ mol<sup>-1</sup> and 430 kJ mol<sup>-1</sup> respectively.
- **D-5.** Estimate the average S−F bond enthalpy in SF<sub>6</sub>. The values of standard enthalpy of formation of SF<sub>6</sub>(g), S(g) and F(g) are : −1100, 274 and 80 kJ mol<sup>-1</sup> respectively.

#### Section (E) : Enthalpy of solution & Born Haber's cycle

- **E-1.** Calculate the standard enthalpy of solution of AgCl(s) in water  $\Delta H^{0}_{f}$  (AgCl,s) = 127.07 kJ mol<sup>-1</sup>,  $\Delta H^{0}_{f}$  (Ag<sup>+</sup>, aq) = 105.58 kJ mol<sup>-1</sup>,  $\Delta H^{0}_{f}$  (Cl<sup>-</sup>, aq) = -167.35 kJ mol<sup>-1</sup>.
- **E-2.** Enthalpies of solution of BaCl<sub>2</sub> (s) and BaCl<sub>2</sub>.2H<sub>2</sub>O (s) are 20 kJ/mole and 8.0 kJ/mole respectively. Calculate heat of hydration of BaCl<sub>2</sub> (s).
- E-3. Setup of Born-Haber cycle; calculate lattice energy of MgO<sub>(s)</sub>. The given that enthalpy of formation of MgO<sub>(s)</sub> = −602, sublimation of Mg<sub>(s)</sub> = 148 ; 1<sup>st</sup> & 2<sup>nd</sup> ionization energy of Mg = 738 & 1450 respectively. For Oxygen bond dissociation energy = 498; 1<sup>st</sup> & 2<sup>nd</sup> electron gain enthalpy = −141 & 844 respectively (all unit in kJmole<sup>-1</sup>).

#### Section (F) : Enthalpy of neutralization

- **F-1.** 10 mL of each 1 M HCl and 1M H<sub>2</sub>SO<sub>4</sub> are neutralized by 1 M NaOH solution that liberate the heat of a & b kJ/mol respectively. What is relation between a and b ?
- **F-2.** The enthalpy of neutralization of 1M HCl by 1M NaOH is 57 kJ/mole. The enthalpy of formation of water is 285 kJ/mole. The enthalpy of formation of OH<sup>-</sup> ion is :
- **F-3.** The standard enthalpy of neutralization of KOH with HCN and HCl in dilute solution is –2480 cal.mol<sup>-1</sup> and –13.68 kcalmol<sup>-1</sup> respectively. Find the enthalpy of dissociation of HCN at the same temperature.

### PART - II : ONLY ONE OPTION CORRECT TYPE

#### Section (A) : Calculation $\Delta U$ , $\Delta H$ & W for chemical reaction

A–1. The free energy change for a reversible reaction at equilibrium is : (A) Positive (B) Negative (C) Zero (D) Cannot say  $\Delta H^{\circ}$  for the reaction  $X_{(g)} + Y_{(g)} \longrightarrow Z_{(g)}$  is - 4.6 Kcal, the value of  $\Delta U^{\circ}$  of the reaction at 227°C is A-2.  $(R = 2 \text{ cal.mol}^{-1} \text{ K}^{-1})$ : (A) -3.6 kcal (B) -5.6 kcal (C) -4.6 kcal (D) -2.6 kcal A-3.2 Determine which of the following reactions at constant pressure represent surrounding that do work on the system :  $4NH_3(g) + 7O_2(g) \longrightarrow 4NO_2(g) + 6H_2O(g)$ I. II. CO (g) + 2H<sub>2</sub> (g)  $\longrightarrow$  CH<sub>3</sub>OH ( $\ell$ ) III. C (s, graphite) +  $H_2O(g) \longrightarrow CO(g) + H_2(g)$ IV.  $H_2O(s) \longrightarrow H_2O(\ell)$ (A) III, IV (B) II and III (C) II, IV (D) I and II, IV Consider the reaction at 300 K A-4.  $H_2(g) + Cl_2(g) \longrightarrow 2HCl(g);$  $\Delta H^{\circ} = -185 \text{ kJ}$ If 2 mole of H<sub>2</sub> completely react with 2 mole of Cl<sub>2</sub> to form HCl. What is  $\Delta U^0$  for this reaction ? (B) – 185 kJ (C) 370 kJ (A) 0 (D) - 370 kJ A mixture of 2 mole of CO and 1 mole of  $O_2$ , in a closed vessel is ignited to convert the CO to  $CO_2$ . If A-5.  $\Delta H$  is the enthalpy change and  $\Delta U$  is the change in internal energy then : (A)  $\Delta H < \Delta U$ (B)  $\Delta H > \Delta U$ (C)  $\Delta H = \Delta U$ (D)  $\Delta H = 2\Delta U$ 

Therm	nodynamics & Thermochemistry		
Section	on (B) : Basics & Kirchoff's law		
B-1.	For which of the following change $\Delta H \neq \Delta E$ ? (A) H <sub>2</sub> (g) + I <sub>2</sub> (g) $\longrightarrow$ 2HI(g) (C) C(s) + O <sub>2</sub> (g) $\longrightarrow$ CO <sub>2</sub> (g)	(B) HCl(aq) + NaOH(ao (D) N₂(g) + 3H₂(g) →→	q) —→ NaCl(aq) + H₂O(⊟) • 2NH₃(g)
B-2.	Calculate the Standard internal energy of for standard enthalpy of formation, which is $-442.8$ (A) $-433$ (B) $+433$	mation of liquid methyl a 91 kJ mole <sup>−1</sup> at 25ºC. (C) –452.82	acetate (CH <sub>3</sub> COOCH <sub>3</sub> ) from its (D) 452.82
B-3.	$2C + O_2 \longrightarrow 2CO$ ; $\Delta H = -220 \text{ kJ}$ Which of the following statement is correct for t (A) Heat of combustion of carbon is 110 kJ (C) Reaction needs no initiation	this reaction (B) Reaction is exother (D) All of these are corr	mic ect
B-4.১	$C(s) + O_2(g) \longrightarrow CO_2, (g); \qquad \Delta H = -$	–94.3 kcal/mol	
	$CO(g) + \frac{1}{2}O_2(g) \longrightarrow CO_2(g); \qquad \Delta H = -$	– 67.4 kcal/mo!	
	$\begin{array}{l} O_2(g) \longrightarrow 2O \ (g); & \Delta H = \\ CO \ (g) \longrightarrow C \ (g) + O(g); & \Delta H = \\ Calculate \ \Delta H \ for \ C \ (s) \longrightarrow C \ (g) \ in \ kcal/mol. \end{array}$	117.4 kcal/mol 230.6 kcal/mol	
0	(A) $1/1$ (B) $154$	(C) 117	(D)145
Sectio	on (C) : Enthalpy of formation & com	Dustion	
C-1.	In the reaction, $CO_2(g) + H_2(g) \longrightarrow CO(g) + H$ (A) heat of reaction (B) heat of combustion	$_2O(g); \Delta H = 2.8 \text{ kJ}, \Delta H \text{ reg}$ (C) heat of formation	oresents (D) heat of solution
C-2.১	Given, $H_2(g) + Br_2(g) \longrightarrow 2HBr(g)$ , $\Delta H^{o_1}$ and standard enthalpy of formation of HBr at 25°C (A) $\Delta H^{o_1}/2$ (B) $\Delta H^{o_1}/2 + \Delta H^{o_2}$	l standard enthalpy of co is (C) ΔH <sup>0</sup> 1/2 – ΔH <sup>0</sup> 2	ndensation of bromine is $\Delta H^{0}_{2}$ , (D) ( $\Delta H^{0}_{1}-\Delta H^{0}_{2}$ ) / 2
C-3.	For the following reaction, C (diamond) + C (graphite) + The heat required to change 1 g of C (graphite (A) 1.59 kcal (B) 0.1375 kcal	+ $O_2 \longrightarrow CO_2(g)$ ; $\Delta H = -S_2 \longrightarrow CO_2(g)$ ; $\Delta H = -S_2 \longrightarrow C(g)$ ; $\Delta H = -S_2 \longrightarrow C$ (diamond) is (C) 0.55 kcal	-94.3 kcal/mol 97.6 kcal/mol (D) 0.275 kcal
C-4.	The standard heat of combustion of solid boror (A) $\Delta H^{\circ}_{f}$ (B <sub>2</sub> O <sub>3</sub> ) (B) 1/2 $\Delta H^{\circ}_{f}$ (B <sub>2</sub> O <sub>3</sub> )	n is equal to : (C) 2∆H° <sub>f</sub> (B₂O₃)	(D) 4∆H° <sub>f</sub> (B₂O <sub>3</sub> )
C-5.24	The heat of combustion of sucrose $(C_{12}H_{22}O_{12})$ when 17.1 g of sucrose is burnt?	(C) 40 5 kcal/mol. How	much of heat will be liberated
C-6.	If $S + O_2 \longrightarrow SO_2$ , $\Delta H = -$ $SO_2 + 1/2 O_2 \longrightarrow SO_3$ , $\Delta H = -$ $SO_3 + H_2O \longrightarrow H_2SO_4$ , $\Delta H = -$ $H_2 + 1/2 O_2 \longrightarrow H_2O$ , $\Delta H = -$ the enthalpy of formation of $H_2SO_4$ at 298 K wi (A) - 814.4 kJ mol <sup>-1</sup> (B) + 814.4 kJ mole <sup>-1</sup>	- 298.2 kJ mole <sup>-1</sup> - 98.7 kJ mole <sup>-1</sup> - 130.2 kJ mole <sup>-1</sup> - 287.3 kJ mole <sup>-1</sup> II be : (C) - 650.3 kJ mole <sup>-1</sup>	(D) – 433.7 kJ mole <sup>-1</sup>
C-7.১	When a certain amount of ethylene was combinethylene is 1411 kJ, the volume of O <sub>2</sub> (at NTP) (A) 268.8 ml (B) 268.8 L	usted, 5644 kJ heat was e that entered into the reac (C) 6226 × 22.4 L	volved. If heat of combustion of tion is : (D) 22.4 L
C-8.	The values of heat of combustion of ethan respectively. Then which of the following is bet (A) $C_2H_2$ (B) $C_2H_6$	e (C <sub>2</sub> H <sub>6</sub> ) and ethyne (C ter fuel on mass basis : (C) Both (A) & (B)	<sub>2</sub> H <sub>2</sub> ) are –341 and –310 Kcal (D) None of these

Therm	odynamics & Thermo	chemistry				
Section	on (D) : Bond entha	Ipy method & Reso	onance energy			
D-1.a	If enthalpy of dissociati	ion of $CH_4$ and $C_2H_6$ are	320 and 600 calories re	espectively then bond energy of		
	(A) 80 cal	(B) 40 cal	(C) 60 cal	(D) 120 cal		
D-2.	The bond dissociation respectively. The enthal $(A) - 44.0$ kcal (E	n energy of gaseous Ipy of formation for HCI ( 3) – 22.0 kcal	H <sub>2</sub> , Cl <sub>2</sub> and HCl are gas will be (C) 22.0 kcal	104, 58 and 103 kcal mol <sup>-1</sup> (D) 44.0 kcal		
D-3.	AB, $A_2$ and $B_2$ are d 1 : 1 : 0.5 and enthalpy of $A_2$ .	iatomic molecules. If the of formation of AB from	he bond enthalpies of $A_2$ and $B_2$ is – 100 kJ/n	A <sub>2</sub> , AB & B <sub>2</sub> are in the ratio $nol^{-1}$ . What is the bond enthalpy		
	(A) 400 kJ/mol	(B) 200 kJ/mol	(C) 100 kJ/mol	(D) 300 kJ/mol		
Section	on (E) : Enthalpy of	Solution & Born Ha	aber's cycle			
E-1.	One mole of anhydrous 30 cal/mol. Heat of diss	MgCl <sub>2</sub> dissolves in wate solution of MgCl <sub>2</sub> .H <sub>2</sub> O is	er and librates 25 cal/mo	I of heat. $\Delta H_{hydration}$ of MgCI <sub>2</sub> = –		
	(A) +5 cal/mol	(B) –5 cal/mol	(C) 55 cal/mol	(D) –55 cal/mol		
E-2.	The enthalpy of solution the temperature of wate	n of NaOH (s) in water is er :	= 41.6 kJ/mole. When I	NaOH is dissolved in water then		
	(A) Increase	(B) Decrease	(C) Does not change	(D) Fluctuates		
E-3.24	The enthalpy change for $\Delta H = -0.5 \text{ kJ}$ . The value (A) $-1.25 \text{ kJ}$	or the reaction of 5 liter le of ∆U will be : (1 atm L (B) + 1.25 kJ	of ethylene with 5 liter c .t = 100 J) (C) 0.25 kJ	of H <sub>2</sub> gas at 1.5 atm pressure is (D) – 0.25 kJ		
E-4.	For which one of the f	ollowing reaction does th	ne molar enthalpy chang	ge of a reaction corresponds to		
	(A) KBr(s) $\longrightarrow$ K(s) + 1 (C) KBr(s) $\longrightarrow$ K <sup>+</sup> (g) +	∕₂Br₂(g) Br ⁻(g)	(B) KBr(g) $\longrightarrow K(g) + Br(g)$ (D) KBr(g) $\longrightarrow K^{+}(g) + Br^{-}(g)$			
E-5.১	Calculate the lattice en Li <sup>+</sup> (g) + Cl <sup>-</sup> (g) -	ergy for the reaction $\longrightarrow \text{LiCl}(s)$				
	$\Delta H_{sub}$ (Li) = 160 ; $\Delta H_{diss}$ E <sub>A</sub> (Cl) = -365 and $\Delta H_{f}$ (A) -837	(Cl <sub>2</sub> ) = 244 ; IP(Li) = 520 (LiCl) = - 400 (all in kJ n (B) -959	; nole <sup>-1</sup> ) (C) –1567	(D) –37		
Section	on (F) : Enthalpy of	neutralization				
F-1.১	<ul> <li>The enthalpy of neutralization of which of the following acid &amp; base is nearly – 13.6 kcal.</li> <li>(A) HCN and NaOH</li> <li>(B) CH<sub>3</sub>COOH and NH<sub>4</sub>OH</li> <li>(C) HCl and KOH</li> <li>(D) HCl and NH<sub>4</sub>OH</li> </ul>					
F-2.	If heat of dissociation o CHCl <sub>2</sub> COOH + KOH — (A) $-$ 13 kcal	f CHCl <sub>2</sub> COOH is 0.7 kca $\rightarrow$ CHCl <sub>2</sub> COOK + H <sub>2</sub> O (B) + 13 kcal	l/mole then $∆H$ for the re (C) – 14.4 kcal	action : (D) – 13.7 kcal		
		PART - III : MATC	CH THE COLUMN	N		

1. Match the column :

	Columm-I		Columm-II
(A)	C (s, graphite) + $O_2(g) \longrightarrow CO_2(g)$	(p)	$\Delta {\sf H}^{\sf 0}_{\sf combustion}$
(B)	$C(s, graphite) \longrightarrow C(g)$	(q)	$\Delta H^{o}_{formation}$
(C)	$CO(g) + \frac{1}{2}O_2(g) \longrightarrow CO_2(g)$	(r)	$\Delta H^{0}_{atomization}$
(D)	$CH_4(g) \longrightarrow C(g) + 4H(g)$	(s)	$\Delta {\sf H}^{\sf 0}_{\sf sublimation}$

**Exercise-2** 

## PART - I : ONLY ONE OPTION CORRECT TYPE

1. Look at the following diagram : Enthalpy(kJ) 51 51 В . . . . . . . . The enthalpy change for the reaction  $A \rightarrow B$  will be (D) – 65 kJ (A) - 25 kJ (B) - 40 kJ (C) + 25 kJ In Haber's process of manufacturing of ammonia : 2.  $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$ ;  $\Delta H^0_{25^{\circ}C} = -92.2 \text{ kJ}$ NH<sub>3</sub>(g) Molecule  $N_2(g)$  $H_2(a)$ C<sub>P</sub> JK<sup>-1</sup> mol<sup>-1</sup> 29.1 28.8 35.1 If C<sub>P</sub> is independent of temperature, then reaction at 100°C as compared to that of 25°C will be : (A) More endothermic (B) Less endothermic (C) More exothermic (D) Less exothermic In the reaction AB<sub>2</sub>( $\Box$ ) + 3X<sub>2</sub>(q)  $\rightleftharpoons$  AX<sub>2</sub>(q) + 2BX<sub>2</sub>(q)  $\Delta$ H = - 270 kcal per mol. of AB<sub>2</sub>( $\Box$ ), 3.2 the enthalpies of formation of  $AX_2(g) \& BX_2(g)$  are in the ratio of 4 : 3 and have opposite sign. The value of  $\Delta H_f^0$  (AB<sub>2</sub>( $\Box$ )) = + 30 kcal/mol. Then (A)  $\Delta H_{f^0}(AX_2) = -96$  kcal /mol (B)  $\Delta H_{f^0}$  (BX<sub>2</sub>) = + 480 kcal /mol (C)  $K_p = K_c \& \Delta H_f^0 (AX_2) = + 480 \text{ kcal /mol}$ (D)  $K_p = K_c RT \& \Delta H_f^0 (AX_2) + \Delta H_f^0 (BX_2) = -240 \text{ kcal /mol}$ The heat of formation of C<sub>2</sub>H<sub>5</sub>OH( $\Box$ ) is -66 kcal/mole. The heat of combustion of CH<sub>3</sub>OCH<sub>3</sub> (g) is 4. - 348 kcal/mole.  $\Delta$ H<sub>f</sub> for H<sub>2</sub>O and CO<sub>2</sub> are -68 kcal/mole and -94 kcal/mole respectively. Then, the  $\Delta$ H for the isomerisation reaction C<sub>2</sub>H<sub>5</sub>OH ( $\Box$ )  $\longrightarrow$  CH<sub>3</sub>OCH<sub>3</sub>(g) and  $\Delta$ E for the same are at T = 25°C (A)  $\Delta H = 18$  kcal/mole,  $\Delta E = 17.301$  kcal/mole (B)  $\Delta H = 22$  kcal/mole,  $\Delta E = 21.408$  kcal/mole (C)  $\Delta H = 26$  kcal/mole,  $\Delta E = 25.709$  kcal/mole (D)  $\Delta H = 30$  kcal/mole,  $\Delta E = 28.522$  kcal/mole 5. Cesium chlorides is formed according to the following equation  $Cs(s) + 0.5 Cl_2(g) \rightarrow CsCl(s)$ . The enthalpy of sublimation of Cs, enthalpy of dissociation of chlorine, ionization energy of Cs and electron affinity of chlorine are 81.2, 243.0, 375.7 and -348.3 kJ mol-1. The energy change involved in the formation of CsCl is -388.6 kJ mol<sup>-1</sup>. Calculate the lattice energy of CsCl. (A) 618.7 kJ mol<sup>-1</sup> (B) 1237.4 kJ mol<sup>-1</sup> (C) -1237.4 kJ mol-1 (D) -618.7 kJ mol-1 The enthalpies of neutralization of a weak base AOH and a strong base BOH by HCI are -12250 cal/ 6.2 mol and -13000 cal/ mol respecitively. When one mole of HCI is added to a solution containing 1 mole of AOH and 1 mole of BOH, the enthalpy change was -12500 cal/ mol. In what ratio the acid is distributed between AOH and BOH ? (A) 2:1 (B) 2:3 (C) 1:2 (D) None of these The enthalpy of neutralization of 40.0 g of NaOH by 60.0 g of CH<sub>3</sub>COOH will be : 7. (A) 57.1 kJ equiv<sup>-1</sup> (B) less than 57.1 kJ equiv<sup>-1</sup> (C) more than 57.1 kJ equiv<sup>-1</sup> (D) 13.7 kJ equiv-1 Given  $\Delta_{ioniz}$  H° (HCN) = 45.2 kJ mol<sup>-1</sup> and  $\Delta_{ioniz}$  H° (CH<sub>3</sub>COOH) = 2.1 kJ mol<sup>-1</sup>. Which one of the 8. following facts is true ? (A)  $pK_a$  (HCN) =  $pK_a$  (CH<sub>3</sub>COOH) (B)  $pK_a$  (HCN) >  $pK_a$  (CH<sub>3</sub>COOH) (C)  $pK_a$  (HCN) <  $pK_a$  (CH<sub>3</sub>COOH) (D) pK<sub>a</sub> (HCN) = (45.17/2.07) pK<sub>a</sub> (CH<sub>3</sub>COOH)

			<u> </u>						
9.2	The average O–H bond energy in H <sub>2</sub> O with the help of following data. (1) H <sub>2</sub> O( $\Box$ ) $\longrightarrow$ H <sub>2</sub> O(g) ; $\Delta$ H = + 40.6 KJ mol <sup>-1</sup> (2) 2H(g) $\longrightarrow$ H <sub>2</sub> (g) ; $\Delta$ H = - 435.0 KJ mol <sup>-1</sup> (3) O <sub>2</sub> (g) $\longrightarrow$ 2O(g) ; $\Delta$ H = + 489.6 KJ mol <sup>-1</sup> (4) 2H <sub>2</sub> (g) + O <sub>2</sub> (g) $\longrightarrow$ 2H <sub>2</sub> O( $\Box$ ) ; $\Delta$ H = - 571.6 KJ mol <sup>-1</sup> (A) 584.9 K L mol <sup>-1</sup> (C) 462.5 K L mol <sup>-1</sup>								
	(A) 584.9 KJ M	ol <sup>_1</sup> (B) 27	9.8 KJ MOI <sup>-</sup> '	(C) 462.5 KJ MOI	-' (D) 925 KJ mol <sup>-</sup> '				
10.১	Enthalpy of pol is –100 kJ per bond (in kJ mol	lymerisation of e mole of ethyler I) will be :	ethylene, as rep le. Given bond	resented by the rea enthalpy of C=C bo	action, $nCH_2=CH_2 \longrightarrow (-)$ and is 600 kJ mol <sup>-1</sup> , enthe	CH <sub>2</sub> -CH <sub>2</sub> -)n alpy of C-C			
	(A) 116.7	(B) 350	)	(C) 700	(D) indeterminate				
11.๖	The average er bond dissociati H bond energy (A) 85.2	nergy required to on energy of H <sub>2</sub> in kcal mol <sup>-1</sup> is (B) 57	o break a P – P (g) is 104.2 kca Neglect presen 6	bond in P₄ (s) into g l mol <sup>_1</sup> ; ∆Hf <sup>0</sup> of PH₃( ce of Van der Waals (C) 76.9	gaseous atoms is 53.2 kca g) from P₄(s) is 5.5 kcal m s forces in P₄(s)] (D) 63.3	al mol <sup>_1</sup> . The nol <sup>_1</sup> . The P-			
	PART	- II : SINGL	E AND DO	UBLE VALUE	INTEGER TYPE				
1.	If heat of reacti HA + NaOH — The heat of dis	on for the given $\rightarrow$ NaA + H <sub>2</sub> O ; sociation of HA	acid-base reaci ∆H =  – 4.7 kca is	ton :					
2.	The enthalpy o 3717 kJmole <sup>-1</sup> integer :	f combustion at respectively. T	25ºC of H <sub>2</sub> (g) he heat of hyd	cyclohexane and o drogenation of cycl	cyclohexene are – 241, – ohexene is (Kcal/mole) a	3920 and – approximate			
3.2	When 0.36g of rise by 10 K. Ca	f glucose was b alculate the star	urned in a bom dard molar entl	b calorimeter (Hea alpy of combustion	t capacity 600 JK <sup>-1</sup> ) the <sup>-</sup> (MJ/mole).	temperature			
4.	Calculate the e Ca <sup>+2</sup> (aq), CO <sup>-2</sup>	enthalpy change ₃(aq) and CaCO	when infinitely 3(s) are –129.80	dilute solution of C ), –161.7, –288.50 k	aCl₂ and Na₂CO₃ are mix cal mol <sup>_1</sup> respectively.	ked. $\Delta H^{0}_{f}$ for			
5.24	How many of th (i) Br <sub>2(□)</sub> (vi) F <sub>2(g)</sub> (xi) P <sub>(Black)</sub>	ne following hav (ii) CO (vii) F <sub>(g)</sub> (xii) P <sub>(red)</sub>	e standard heat <sup>2 (g)</sup> (iii) C (viii) I <sub>2(g)</sub> (xiii) CH <sub>4</sub>	of formation is zero graphite) (iv) Cl <sub>2(□)</sub> (ix) S <sub>(monoclinic)</sub> (	(v) Cl <sub>2(g)</sub> x) N <sub>2(g)</sub>				
6.	Standard enthat of formation of	alpy of combustic cyclopropane. If	on of cyclopropa $\Delta H^{o}_{f} (CO_{2}) = -$	ane is – 2091 kJ/mo 393.5 kJ/mole and	le at 25ºC then calculate t ∆H⁰ <sub>f</sub> (H₂O) =  – 285.8 kJ/m	the enthalpy lole.			
7.	Bond energies the following re N <sub>2</sub> (g) -	of N=N; H–H and a continued of N=N; H–H and a continued at the set of the se	nd N–H bonds a NH₃ (g)	are 945, 463 & 391	kJ mol <sup>-1</sup> respectively, the	enthalpy of			
8.	The reaction of nitrogen with hydrogen to make ammonia has $\Delta H = -92 \text{ kJ}$ N <sub>2</sub> (g) + 3H <sub>2</sub> (g) $\longrightarrow 2\text{NH}_3$ (g) What is the value of $\Delta U$ (in kJ) if the reaction is carried out at a constant pressure of 40 bar and the volume change is - 1.25 litre.								
9.	Calculate ∆U o Given that ∆H kcal/Mole	f reaction for the $f(H_2O) = -67.8$	hydrogenation kcal mole; ∆H	of acetylene at concloud $(C_2H_2) = -310$ .	stant volume and at 77°C. 1 kcal/mole, $\Delta H_{comb}(C_2H)$	4) = -337.2			
10.	Calculate the C	–C bond enthal	py from the follo	wing data :					
	(a) $C(s) \longrightarrow C$	C(g) ; ∆H = 170	Kcal	(b) $\frac{1}{2}$ H <sub>2</sub> (g) $\longrightarrow$	H(g) ; ∆H = 52 Kcal				
	(c) Heat of form	mation of ethane	e =  – 20 Kcal	(d) C–H bond ent	halpy = 99 Kcal.				

### **PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE**

1. Which of the following is(are) endothermic reaction : (A) Combustion of methane (B) Decomposition of water (C) Dehydrogenation of ethane to ethylene (D) Conversion of graphite to diamond 2. Heat of reaction depend upon : (A) Physical state of reactants and products (B) Whether the reaction is carried out at constant pressure or at constant volume (C) Method by which the final products are obtained from the reactants (D) Temperature of the reaction Which of the following reaction cannot be used to define the heat of formation of  $CO_2$  (g). 3. (B)  $C_6H_6(\Box) + \frac{7}{2}O_2(g) \longrightarrow 6CO_2(g) + 3H_2O(\Box)$   $O_2(g)$  (D) C (graphite) +  $O_2(G) \longrightarrow CO_2(G)$ (A) CO (g) +  $\frac{1}{2}$ O<sub>2</sub> $\longrightarrow$  CO<sub>2</sub> (g) (D) C (graphite) +  $O_2(g) \longrightarrow CO_2(g)$ (C) C (diamond) +  $O_2(g) \longrightarrow CO_2(g)$ Heat of formation of CH<sub>4</sub> are : 4. If given :  $C(s) + O_2(g) \longrightarrow CO_2(g)$  $\Delta H = -394 \text{ kJ}$  $\begin{array}{c} C(s) + O_2(g) \longrightarrow CO_2(g) \\ H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(\Box) \\ CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(\Box) \\ 0 \text{ kJ} \qquad (B) - 16.7 \text{ kcal} \qquad (C) \end{array}$ ∆H = – 284 kJ ∆H = – 892 kJ (A) – 70 kJ (C) – 244 kJ (D) - 50 kcal Heat of neutralization of the acid-base reaction is 57.32 kJ for : 5. (A) HCOOH + KOH (B) CH<sub>3</sub>COOH + NaOH (C) HNO<sub>3</sub> + LiOH (D) HCI + NaOH For which of the following reaction  $\Delta H^{o}_{reaction}$  is not equal to  $\Delta H^{o}_{f}$  of product. 6.2 (A)  $2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$ (B)  $N_2(g) + O_3(g) \longrightarrow N_2O_3(g)$ (C)  $CH_4(g) + 2Cl_2(g) \longrightarrow CH_2Cl_2(\Box) + 2HCl(g)$  (D)  $Xe(g) + 2F_2(g) \longrightarrow XeF_4(g)$ The following is (are) endothermic reaction(s) : 7. (A) Combustion of methane. (B) Decomposition of water (C) Dehydrogenation of ethane to ethylene. (D) Conversion of graphite to diamond. 8.2 Which of the reaction defines molar  $\Delta H_{f}^{\circ}$ ? (B)  $\frac{1}{2}$  Br<sub>2</sub>( $\Box$ ) +  $\frac{1}{2}$  H<sub>2</sub>(g)  $\longrightarrow$  HBr(g) (A)  $CaO(s) + CO_2(g) \longrightarrow CaCO_3(s)$ (C)  $N_2(g) + 2H_2(g) + \frac{3}{2}O_2(g) \longrightarrow NH_4 NO_3(s)$  (D)  $\frac{1}{2}I_2(s) + \frac{1}{2}H_2(g) \longrightarrow HI(g)$ 

## **PART - IV : COMPREHENSION**

#### Comprehension #1

Enthalpy of neutralization is defined as the enthalpy change when 1 mole of acid/base is completely neutralized by base/acid in dilute solution.

For strong acid and strong base neutralization net chemical change is

$$H^+(aq) + OH^-(aq) \longrightarrow H_2O(\Box); \quad \Delta_r H^0 = -55.84 \text{ kJ/mol}$$

 $\Delta H^{0}_{ionization}$  of aqueous solution of strong acid and strong base is zero. When a dilute solution of a weak acid or base is neutralized, the enthalpy of neutralization is some what less because of the absorption of heat in the ionization of the weak acid or base, for weak acid/base  $\Delta H^{0}_{neutrilization} = \Delta H^{0}_{ionization} + \Delta H^{0} (H^{+} + OH^{-} \longrightarrow H_{2}O)$ 

If enthalpy of neutralization of CH<sub>3</sub>COOH by NaOH is -49.86 kJ/mol then enthalpy of ionzation of 1.2 CH<sub>3</sub>COOH is: (A) 5.98 kJ/mol (B) –5.98 kJ/mol (C) 105.7 kJ/mol (D) None of these

What is  $\Delta H^0$  for complete neutralization of strong diacidic base A(OH)<sub>2</sub> by HNO<sub>3</sub>? 2.2 (A) –55.84 kJ (B) –111.68 kJ (C) 55.84 kJ/mol (D) None of these

3.>Under the same condition how many mL of 0.1 M NaOH and 0.05 M H<sub>2</sub>A (strong diprotic acid) solution<br/>should be mixed for a total volume of 100 mL produce the highest rise in temperature :<br/>(A) 25 : 75(B) 50 : 50(C) 75 : 25(D) 66.66 : 33.33

#### Comprehension # 2

Answer Q.4, Q.5 and Q.6 by appropriately matching the information given in the three columns of the following table.

All the given reaction are carried out at constant pressure and temperature conditions. Assuming ideal behavior of all the gases involved.

ĺ		Column-1	Column-2			Column-3					
	(I)	$2Ag_2O(s) \longrightarrow 4Ag(s) + O_2(g)$	(i)	Wrxn >	0	(P)	Reaction tempera	n is ture.	spontaneous	at	high
	(II)	$2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$	(ii)	Wrxn <	0	(Q	Reactior tempera	n is tures.	spontaneous	s at	all
	(III)	$2C(s) + O_2(g) \longrightarrow 2CO(g)$	(iii)	$\Delta_{\text{rxn}} H$	> 0	(R)	Reactan	t mixtur	e is diamagne	tic.	
	(IV)	$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$	(iv)	$\Delta_{rxn}S$ :	> 0	(S)	One of metallic	the reat oxide in	actant is used to metal.	l to re	duce
4	•	The only incorrect combination is (A) (I) (ii) (P) (B) (II) (	s – iii) (P)		(C)	(IV) (ii	i) (R)	(D	) (III) (ii) (Q)		
5	•	The only correct combination is - (A) (I) (iv) (Q) (B) (II) (	- i) (S)		(C)	(II) (iii	) (R)	(D	) (IV) (ii) (S)		
6	•	The only correct combination is (A) (III) (iv) (S) (B) (IV)	_ (i) (Q)		(C)	(II) (iii	) (S)	(D	9) (I) (i) (P)		
	Ń	Evercice 2									
	(										
*	Mark	ed Questions may have more th	an one	corre	ct opt	ion.					
	PA	RT - I : JEE (ADVANCI	ED) /	IIT-JI	EE F	RO	BLEMS	S (PR	EVIOUS \	<b>YEA</b> F	RS)
1		The species which by definition h	nas 7FF	RO star	ndard	molar	enthalov	of form:	ation at 298 K	is ·	
	•			<b>O</b> olur	laara	molai	onthopy	orionin	[JEE 20	)10, 3/ <sup>,</sup>	163]
		(A) $Br_2(g)$ (B) $Cl_2(g)$	g)		(C)	H <sub>2</sub> O(g	1)	(D	) CH₄(g)		
2		The bond energy (in <b>kcal mol</b> <sup>-1</sup> )	of a C-	-C singl	le bon	d is a	pproximat	ely :	[JEE 20	10, 3/1	63]
		(A) 1 (B) 10			(C)	100		(D	) 1000		
3	•	Match the transformation in colu	mn-l w	ith appr	ropriat	e opti	ons in <b>co</b> l	lumn-ll	. [JEE 20	11, 8/1	80]
	-	Column-I			Colu	Imn-II					
	-	$(A)  CO_2(s) \longrightarrow CO_2(g)$	$\mathbf{O}$	(p)	phas	e tran	Isition				
	-	(B) $CaCO_3(S) \longrightarrow CaO(S) + CaO(S)$	UU <sub>2</sub> (g)	(q) (r)			tive				
	-	$(D) \qquad P(white solid) \longrightarrow P(red solid)$		(s)		s posit	ive				
				(t)	∆S is	s nega	ative				
4		Using the data provided, calcu energy is (take the bond energy $2C(s) + H_2(g) \longrightarrow C_2H_2(g)$ $2C(s) \longrightarrow 2C(g)$ $H_2(g) \longrightarrow 2H(g)$	ate the of a C–	multip H bond $\Delta H = 2$ $\Delta H = 1$ $\Delta H = 3$	ole bo   as 35 225 kJ  410 k 330 kJ	nd en 50 kJ r   mol-´ kJ mol   mol-´	iergy (kJ mol <sup>-1</sup> ) -1	mol⁻¹)	of a C≡C bor <b>[JEE 20</b>	nd C <sub>2</sub> H 1 <b>2, 3/1</b>	l₂. That <b>36]</b>
		(A) 1165 (B) 837			(C)	865		(D	) 815		
5		The standard enthalpies of form	ation of	CO <sub>2</sub> (g	), H₂0	D( <i>I</i> ) ar	nd glucos	e(s) at 2	25ºC are -400	kJ/mc	ol, –300

he standard enthalpies of formation of CO<sub>2</sub>(g), H<sub>2</sub>O(*I*) 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

Thermodynamics & Thermochemistry 6. The standard state Gibbs free energies of formation of C(graphite) and C(diamond) at T = 298 K are  $\Delta_f G^0[C(\text{graphite})] = 0 \text{ kJ mol}^{-1}$  $\Delta_f G^o[C(diamond)] = 2.9 \text{ kJ mol}^{-1}$ The standard state means that the pressure should be 1 bar, and substance should be pure at a given temperature. The conversion of graphite [C(graphite)] to diamond [C(diamond)] reduces its volume by  $2 \times 10^{-6}$  m<sup>3</sup> mol<sup>-1</sup>. If C(graphite) is converted to C(diamond) isothermally at T = 298 K, the pressure at which C(graphite) is in equilibrium with C(diamond), is : [JEE(Advanced) 2017, 3/122] [Useful information:  $1 J = 1 \text{ kg m}^2 \text{ s}^{-2}$ ,  $1 Pa = 1 \text{ kg m}^{-1} \text{ s}^{-2}$ ;  $1 \text{ bar} = 10^5 Pa$ ] (A) 58001 bar (B) 1450 bar (C) 14501 bar (D) 29001 bar PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS) **JEE-MAIN OFFLINE PROBLEMS**  $(\Delta H - \Delta U)$  for the formation of carbon monoxide (CO) from its elements at 298 K is [AIEEE 2006] 1.  $(R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1})$ (1) 1238.78 J mol-1 (2) -2477.57 J mol<sup>-1</sup> (3) 2477.57 J mol<sup>-1</sup> (4) -1238.78 J mol-1 The standard enthalpy of formation ( $\Delta H_f^{\circ}$ ) at 398 K for methane, CH<sub>4(0)</sub> is 74.8 kJ mol<sup>-1</sup>. The additional 2. 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<sub>2</sub> [AIEEE 2009, 8/144] 3. On the basis of the following thermochemical data :  $(\Delta_t G^{\circ} H^+_{(aq)} = 0)$  $H_2O(\Box) \longrightarrow H^+(aq) + OH^-(aq.); \Delta H = 57.32 \text{ kJ}$  $H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(\Box)$ ;  $\Delta H = -286.20 \text{ kJ}$ The value of enthalpy of formation of OH- ion at 25°C is : (1) -228.88 kJ (2) +228.88 kJ (3) -343.52 kJ (4) -22.88 kJ In a fuel cell methanol is used as fuel and oxygen gas is used as an oxidizer. The reaction is 4.  $CH_3OH(\Box) + \frac{3}{2}O_2(g) \longrightarrow CO_2(g) + 2H_2O(\Box)$ At 298 K, standard Gibb's energies of formation for CH<sub>3</sub>OH( $\Box$ ), H<sub>2</sub>O( $\Box$ ) and CO<sub>2</sub> (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 : [AIEEE 2009, 8/144] (2) 90% (4) 80% (1) 87% (3) 97% 5. The standard enthalpy of formation of NH<sub>3</sub> is -46.0 kJ mol<sup>-1</sup>. If the enthalpy of formation of H<sub>2</sub> from its atoms is - 436 kJ mol-1 and that of N2 is - 712 kJ mol-1, the average bond enthalpy of N-H bond in NH3 [AIEEE 2010, 4/144] is (1) – 964 kJ mol<sup>-1</sup> (2) + 352 kJ mol<sup>-1</sup> (3) + 1056 kJ mol<sup>-1</sup> (4) - 1102 kJ mol-1 The value of enthalpy change ( $\Delta H$ ) for the reaction,  $C_2H_5OH_{(1)} + 3O_{2(g)} \longrightarrow 2CO_{2(g)} + 3H_2O_{(1)}$  at 27°C is 6. -1366.5 kJ mol<sup>-1</sup>. The value of internal energy change for the above reaction at this temperature will be: [AIEEE 2011, 4/120] (3) –1361.5 kJ (1) -1369.0 kJ (2) –1364.0 kJ (4) -1371.5 kJ Consider the reaction :  $4NO_{2(g)} + O_{2(g)} \longrightarrow 2N_2O_{5(g)}$ , 7.  $\Delta_{\rm r}$ 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,  $\Delta H$  of sublimation for N<sub>2</sub>O<sub>5</sub> is 54 kJ mol<sup>-1</sup>) [AIEEE 2011, 4/120] (1) + 54kJ (2) + 219 kJ (3) – 219 kJ (4) - 165 kJ For complete combustion of ethanol,  $C_2H_5OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l)$ , the amount of heat 8. produced as measured in bomb calorimeter, is 1364.47 kJ mol-1 at 25°C. Assuming ideality the Enthalpy of combustion,  $\Delta cH$ , for the reaction will be : (R = 8.314 J mol<sup>-1</sup>) [JEE(Main) 2014, 4/120] (1) – 1366.95 kJ mol<sup>-1</sup> (2) – 1361.95 kJ mol<sup>-1</sup> (3) – 1460.50 kJ mol<sup>-1</sup> (4) – 1350.50 kJ mol<sup>-1</sup> The heats of combustion of carbon and carbon monoxide are -393.5 and -283.5 kJ mol<sup>-1</sup>, respectively. 9. [JEE(Main) 2016, 4/120] The heat of formation (in kJ) of carbon monoxide per mole is : (1) 676.5 (2) - 676.5(3) - 110.5(4) 110.5

Ther	modynamics &	Thermochemistry				
10.	Given :	$C_{(graphite)} + O_2(g) \longrightarrow CO_2$	(g); $\Delta_r H^0 = -393.5 \text{ kJ mol}^{-1}$ ;			
		$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O$	(I); $\Delta_r H^o = -285.8 \text{ kJ mol}^{-1}$ ;			
	Based on the (1) +144.0 kJ	$CO_2(g) + 2H_2O(I) \longrightarrow CH$ above thermochemical equal $C_{(graphite)} + 2H_2(g) \longrightarrow CH$ mol <sup>-1</sup> (2) -74.8 kJ mol <sup>-1</sup>	$\begin{array}{ll} {}_{4}(g) + 2O_{2}(g) \hspace{0.2cm} ; \hspace{0.2cm} \Delta_{r} H^{o} = + \hspace{0.2cm} 890.3 \hspace{0.2cm} \text{kJ mol}^{-1} \\ \text{tions, the value of } \hspace{0.2cm} \Delta_{r} H^{o} \hspace{0.2cm} \text{at } 298 \hspace{0.2cm} \text{K for the reaction :} \\ {}_{4}(g) \hspace{0.2cm} \text{will be :} \hspace{0.2cm} [\textbf{JEE(Main) 2017, 4/120}] \\ {}_{(3)} \hspace{0.2cm} -144.0 \hspace{0.2cm} \text{kJ mol}^{-1} \hspace{0.2cm} (4) + 74.8 \hspace{0.2cm} \text{kJ mol}^{-1} \end{array}$			
		JEE-MAIN	ONLINE PROBLEMS			
1.	The standard atoms is -436	enthalpy of formation of NI $_{5}$ kJ/mol and that of N <sub>2</sub> is $-7$	H <sub>3</sub> is –46.0 kJ/mol. If the enthalpy of formation of H <sub>2</sub> from its 712 kJ/mol, the average bond thalpy of N–H bond in NH <sub>3</sub> is : [JEE(Main) 2014 Online (09-04-14), 4/120]			
	(1) –1102 kJ/r	nol (2) – 964 kJ/mol	(3) + 352 kJ/mol (4) +1056 kJ/mol			
2.	The standard the average e one of the folle (1) the dissoca (2) the first fou (3) the dissoca (4) the first fou	enthalpy of formation $(\Delta_f H^0, H^0)$ nergy given out in the form owing ? ation energy of the hydroger ir ionisation energies of carb ation energy of H <sub>2</sub> and entha ir ionisation energies of carb	<ul> <li><sup>298</sup>) for methane, CH<sub>4</sub> is -74.9 kJ mol<sup>-1</sup>. In order to calculate ation of a C–H bond from this it is necessary to know which [JEE(Main) 2014 Online (12-04-14), 4/120] in molecule, H<sub>2</sub>.</li> <li><sup>100</sup> molecule, H<sub>2</sub>.</li> <li><sup>100</sup> and electron of carbon (graphite).</li> <li><sup>100</sup> on and electron affinity of hydrogen.</li> </ul>			
3.	The heat of a longest wavel (A vogadro nu (1) 2.48 × 10 <sup>3</sup>	atomixation of methane and ength of light capable of brea mber = $6.02 \times 10^{23}$ , h = $6.62$ nm (2) 1.49 × $10^3$ nm	d ethane are 360 kJ/mol and 620 kJ/mol, respectively. The aking the C-C bond is : 2 × 10 <sup>-34</sup> J s): [JEE(Main) 2015 Online (10-04-15), 4/120] (3) 2.49 × 10 <sup>4</sup> nm (4) 2.48 × 10 <sup>4</sup> nm			
4.	For a reaction (1) $\Delta H = \Delta U \neq$	A(g) → A (I); $\Delta$ H = −3RT. T O (2)   $\Delta$ H  >   $\Delta$ U	The correct statement for the reaction is : [JEE(Main) 2017 Online (08-04-17), 4/120] (3)  ΔH  <  ΔU  (4) ΔH =  ΔU = O			
5.	For which of tl (1) N <sub>2</sub> (g) + 3H (3) 2SO <sub>2</sub> (g) +	the following reactions, $\Delta H$ is $_2(g) \rightarrow 2NH_3(g)$ $O_2(g) \rightarrow 2SO_3(g)$	al to ΔU ? [JEE(Main) 2018 Online (15-04-18), 4/120] (2) 2HI(g) → H <sub>2</sub> (g) + I <sub>2</sub> (g) (4) 2NO <sub>2</sub> (g) → N <sub>2</sub> O <sub>4</sub> (g)			
6.	Given :	(i) C(graphite) + $O_2(g) \rightarrow 0$	CO₂(g); ∆rH⁻ = xkJ mol⁻¹			
		(ii) C(graphite) + $\frac{1}{2}O_2(g)$	$\rightarrow$ CO <sub>2</sub> (g); $\Delta$ rH <sup>-</sup> = ykJ mol <sup>-1</sup>			
		(iii) CO(g) + $\frac{1}{2}$ O <sub>2</sub> (g) $\rightarrow$ C	$O_2(g); \Delta rH^- = zkJ mol^{-1}$			
	Based on th	e above thermochemical	equations, find out which one of the following algebraic			
	relationship is $(1) x = y - z$	correct? (2) $y = 2z - x$	[JEE(Main) 2019 Online (12-01-19), 4/120] (3) $x = y + z$ (4) $z = x + y$			

	Δηςω	ere								
				EXER	CISE	-1				
				PA	RT – I					
A-1.	–1368 kJ mol⁻	-1	A-2.	–4.955 kJ		B-1.	- 203	5 kJ mol <sup>-1</sup>		
B-2.	– 56.98 kJ ma	o <b>∣</b> −1	C-1.	(–94.1 kcal)		C-2.	-102 l	kcal		
C-3.	– 383 kJ mol-	1	C-4.	24 g		D-1.	243.7	kJ mol⁻¹		
D-2.	1488 kJ mol <sup>-1</sup>		D-3.	– 2573 kJ/mo	le	D-4.	–185 l	кJ		
D-5.	309 kJ mol <sup>-1</sup>		E-1.	– 65.3 kJ mol <sup>-</sup>	-1	E-2.	– 28 k	J/mole		
E-3.	3890 kJmole-	1	F-1.	2a = b		F-2.	- 228	kJ/mole.		
F-3.	11.2 Kcal									
				PA	RT – II					
A–1.	(C)	A-2.	(A)	A-3.	(D)		A-4.	(D)	A-5.	(A)
B-1.	(D)	B-2.	(A)	B-3.	(B)		B-4.	(D)	C-1.	(A)
C-2.	(D)	C-3.	(D)	C-4.	(B)		C-5.	(A)	C-6.	(A)
C-7.	(B)	C-8.	(A)	D-1.	(D)		D-2.	(B)	D-3.	(A)
E-1.	(A)	E-2.	(A)	E-3.	(C)		E-4.	(C)	E-5.	(A)
F-1.	(C)	F-2.	(A)							
				PAF	RT – III					
1.	$(A) \rightarrow (p, q);$	$(B) \to (q$	, r, s) ; (0	C)  ightarrow (p) ; (D) $ ightarrow$	· (r)					
				EXER	CISE	- 2				
				PA	RT – I					
1.	(A)	2.	(C)	3.	(C)		4.	(B)	5.	(A)
6.	(A)	7.	(B)	8.	(B)		9.	(C)	10.	(B)
11.	(C)									
				PA	RT – II					
1.	9	2.	9 Kcal	/mole <b>3.</b>	3		4.	3	5.	5
6.	53	7.	– 12 k	J <b>8.</b>	-87		9.	40	10. 7	78 Kcal
				ΡΔϜ	RT – III					
1.	(BCD)	2.	(ABCF	)) <u>3</u>	(ABC)		4	(AB)	5	(CD)
6	(ABC)	7	(BCD)	8	(BCD)			()		(32)

The	rmodynamic	s & Therm	ochemistry						
				PAF	RT – IV				
1.	(A)	2.	(B)	3.	(B)	4.	(B)	5.	(AD)
6.	(A)								
				EXER	CISE –	3			
				РА	RT – I				
1.	(B)	2.	(C)	3.	(A – p, r,	s) ; (B – r, s)	; (C – t) ; (C	0 – p, q, t)	
4.	(D)	5.	(C)	6.	(C)				
				ΡΑ	RT – II				
			JEE-N		LINE PRO	BLEMS			
1.	(1)	2.	(1)	3.	(1)	4.	(3)	5.	(2)
6.	(2)	7.	(3)	8.	(1)	9.	(3)	10.	(2)
			JEE-	MAIN ON	LINE PRO	BLEMS			
1.	(3)	2.	(3)	3.	(2)	4.	(2)	5.	(2)
6.	(3)								