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

(A) $H_2(g) + I_2(g) \longrightarrow 2HI(g)$ (B) $HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l)$

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

Q.2 Which of the following equations represents a reaction that provides the heat of formation of CH_3Cl?

(A) $C(s) + HCl(g) + H_2(g) \rightarrow CH_3Cl(g)$ (B) $C(s) + 3/2\ H_2(g) + 1/2\ Cl_2(g) \rightarrow CH_3Cl(g)$

(C) $C(s) + 3\ H(g) + Cl(g) \rightarrow CH_3Cl(g)$ (D) $CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$

Q.3. Use the given standard enthalpies of formation to determine the heat of reaction of the following reaction:

$TiCl_4(g) + 2\ H_2O(g) \rightarrow TiO_2(g) + 4\ HCl(g)$

$\Delta H^\circ_f\ TiCl_4(g) = -763.2$ kJ/mole $\Delta H^\circ_f\ TiO_2(g) = -944.7$ kJ/mole

$\Delta H^\circ_f\ H_2O(g) = -241.8$ kJ/mole $\Delta H^\circ_f\ HCl(g) = -92.3$ kJ/mole

(A) – 278.1 (B) + 369.2 (C) + 67.1 (D) – 67.1

Q.4 Using the following information calculate the heat of formation of CH_4.

$$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$$

$\Delta H^\circ = -890.4$ kJ

$\Delta H^\circ_f\ CO_2(g) = -393.5$ kJ/mole $\Delta H^\circ_f\ H_2O(l) = -285.9$ kJ/mole

(A) – 98.6 (B) – 65.5 (C) – 74.9 (D) – 43.5

Q.5 The heats of formation of $CO_2(g)$ and $H_2O(l)$ are –394 kJ/mole and –285.8 kJ/mole respectively Using the data for the following combustion reaction, calculate the heat of formation of $C_2H_2(g)$.

$$2\ C_2H_2(g) + 5\ O_2(g) \rightarrow 4\ CO_2(g) + 2\ H_2O(l)$$

$\Delta H^\circ = -2601$ kJ

(A) – 238.6 (B) 253.2 (C) 238.7 (D) 226.7

Q.6 The heats of formation of $CO_2(g)$ and $H_2O(l)$ are –394 kJ/mole and –285.8 kJ/mole respectively & $\Delta H^\circ_{Combustion}\ [C_3H_8(g)] = -2221.6$ kJ. Then calculate the heat of formation of $C_3H_8(g)$.

(A) 212.2 (B) – 143.3 (C) 185.4 (D) – 103.6

Q.7 The standard enthalpy of formation of ammonia gas is -

Given : $N_2H_4(g) + H_2(g) \longrightarrow 2NH_3(g)$; $\Delta H^\circ_r = -40$kJ / mol

$\Delta H^\circ_f[N_2H_4(g)] = -120$kJ / mol

(A) –60 (B) –180 (C) 40 (D) –80

Q.8 $2NO_2(g) \rightarrow N_2O_4(g)$

$\Delta U^\circ_f\ [N_2O_4(g)] = 2$kcal/ mole

and $\Delta U^\circ_{reaction} = -16$ kcal /mol then calculate $\Delta H^\circ_{formation}$ of NO_2 at 727°C

(A) 9 kcal /mol (B) 4.5 kcal /mol (C) 8 kcal /mol (D) 10 kcal /mol

Q.9 Study the following thermochemical equations :

$A \rightarrow B$; $\Delta H = +100$kcal

$B \rightarrow C$; $\Delta H = -80$kcal

The correct order of enthalpies of formation of A, B and C is -

(A) A < B < C (B) A < C < B (C) C < A < B (D) B < C < A

Q.10 What amount of heat energy (kJ) is released in the combustion of 12.0 g of C_3H_4 at 1atm constant pressure.

(Atomic weights: C = 12, H = 1, O = 16).

$$C_3H_4(g) + 4\,O_2(g) \rightarrow 3\,CO_2(g) + 2\,H_2O(l)$$

$\Delta H^\circ = -1939.1$ kJ

(A) 725 (B) 504 (C) 783 (D) 581.73

Q.11 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 :-

(A) –44.0 kcal (B) –22.0 kcal (C) 22.0 kcal (D) 44.0 kcal

Q.12 The enthalpy change for the following reaction is 513 kJ. Calculate the average Cl – F bond energy.

$$ClF_3(g) \rightarrow Cl(g) + 3\,F(g)$$

(A) 1542 (B) 88 (C) 171 (D) 514

Q.13 The reaction $CH_4(g) + Cl_2(g) \longrightarrow CH_3Cl(g) + HCl(g)$ has $\Delta H = -25$ kCal.

Bond	Bond Enthalpy kCal
ε_{C-Cl}	84
ε_{H-Cl}	103
ε_{C-H}	x
ε_{Cl-Cl}	y
x : y = 9 : 5	

From the given data, what is the bond enthalpy of Cl—Cl bond

(A) 70 kCal (B) 80 kCal (C) 67.75 kCal (D) 57.75 kCal

Q.14 If x_1, x_2 and x_3 are enthalpies of H–H, O=O and O–H bonds respectively, and x_4 is the enthalpy of vaporisation of water, estimate the standard enthalpy of combustion of hydrogen

(A) $x_1 + \frac{x_2}{2} - 2x_3 + x_4$ (B) $x_1 + \frac{x_2}{2} - 2x_3 - x_4$ (C) $x_1 + \frac{x_2}{2} - x_3 + x_4$ (D) $2x_3 - x_1 - \frac{x_2}{2} - x_4$

Q.15 The enthalpy change at 298K for decomposition is given in following steps-

Step-1: $H_2O(g) \rightarrow H_{(g)} + OH(g)\ \Delta H = 498\ kJ/mol^{-1}$

Step-2: $OH(g) \rightarrow H_{(g)} + O(g)\ \Delta H = 428\ kJ/mol^{-1}$

Then value of mean bond enthalpy of O–H bond will be -

(A) 498 kJ/mol (B) 463kJ/mol (C) 428 kJ/mol (D) 70 kJ/mol

Q.16 $NH_3(g) + 3Cl_2(g) \rightarrow NCl_3(g) + 3HCl\ (g);\ -\Delta H_1$

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g);\ \Delta H_2$

$H_2(g) + Cl_2(g) \rightarrow 2HCl\ (g)\ ;\ \Delta H_3$

The enthalpy of formation of NCl_3 (g) in the terms of ΔH_1, ΔH_2 and ΔH_3 is

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

(C) $\Delta H_f = \Delta H_1 - \frac{\Delta H_2}{2} - \frac{3}{2}\Delta H_3$ (D) None

Q.17 The enthalpy changes of the following reactions at 27°C are

$Na(s) + \frac{1}{2}Cl_2(g) \longrightarrow NaCl(s)$ $\Delta_r H = -411$ kJ/mol

$H_2(g) + S(s) + 2O_2(g) \longrightarrow H_2SO_4(l)$ $\Delta_r H = -811$ kJ/mol

$2Na(s) + S(s) + 2O_2(g) \longrightarrow Na_2SO_4(s)$ $\Delta_r H = -1382$ kJ/mol

$\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \longrightarrow HCl(g)$ $\Delta_r H = -92$ kJ/mol;

from these data, the heat change of reaction at constant volume (in kJ/mol) at 27°C for the process (R = 8.3 J/K-mol)

$2NaCl(s) + H_2SO_4(l) \longrightarrow Na_2SO_4(s) + 2HCl(g)$ is

(A) 67 (B) 62.02 (C) 71.98 (D) None

Q.18 Find $\Delta_r U°$ for the reaction $4HCl(g) + O_2(g) \rightleftharpoons 2Cl_2(g) + 2H_2O(g)$ at 300 K. Assume all gases are ideal.

Given : $H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$ $\Delta_r H°_{300} = -184.5$ kJ/mole

$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$ $\Delta_r H°_{300} = -483$ kJ/mole (Use R = 8.3 J/mole)

(A) 111.5 kJ/mole (B) –109.01 kJ/mole (C) –111.5 kJ/mole (D) None

Q.19 Ethanol can undergoes decomposition to form two sets of products

$$C_2H_5OH(g) \longrightarrow \begin{cases} \xrightarrow{1} C_2H_4(g) + H_2O(g) & \Delta H° = 45.54 \text{ kJ} \\ \xrightarrow{2} CH_3CHO(g) + H_2(g) & \Delta H° = 68.91 \text{ kJ} \end{cases}$$

if the molar ratio of C_2H_4 to CH_3CHO is 8 : 1 in a set of product gases, then the enthalpy involved in the decomposition of 1 mole of ethanol is

(A) 65.98 kJ (B) 48.137 kJ (C) 48.46 kJ (D) 57.22 kJ

Q.20 $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

$\Delta G°_f[PCl_5(g)] = -74$ kcal /mol $\Delta G°_f[PCl_3(g)] = -60$ kcal /mol

then calculate value of equilibrium constant for dissociation of $PCl_5(g)$ at 727°C temperature ?

(ln2 = 0.7)

(A) 2^{10} (B) 2^{-10} (C) 2^{-20} (D) 2^{+20}

Q.21 The lattice enthalpy of solid NaCl is 772 $kJmol^{-1}$ and enthalpy of solution is 2 $kJmol^{-1}$. If the hydration enthalpy of Na^+ & Cl^- ions are in the ratio of 3:2.5, what is the enthalpy of hydration of chloride ion?

(A) -140 $kJmol^{-1}$ (B) -350 $kJmol^{-1}$ (C) -351.81 $kJmol^{-1}$ (D) None

Q.22 ΔH_f^0 of water is – 285.8 kJ mol^{-1}. If enthalpy of neutralisation of monoacid strong base is -57.3 kJ mol^{-1}, ΔH_f^0 of OH^- ion will be

(A) -228.5 kJ mol^{-1} (B) 228.5 kJ mol^{-1} (C) 114.25 kJ mol^{-1} (D) -114.25 kJ mol^{-1}

Q.22 ΔH_f^0 of water is – 285.8 kJ mol^{-1}. If enthalpy of neutralisation of monoacid strong base is –57.3 kJ mol^{-1}, ΔH_f^0 of OH^- ion will be

(A) – 228.5 kJ mol^{-1} (B) 228.5 kJ mol^{-1} (C) 114.25 kJ mol^{-1} (D) –114.25 kJ mol^{-1}

Q.23 If bond enthalpy of C–C and C = C are 348 kJ /mole and 615 kJ/mole respectively then calculate enthalpy change (in kJ/mole) which occurs during the isomerisation of cyclopropane (g) into propene (g)

(A) 19 (B) 81 (C) 1 (D) 20

Q.24 The molar heat capacities at constant pressure (assume constant with respect to temperature) of A, B and C are in ratio of **1.5 : 3.0 : 2.0** . If enthalpy change for the exothermic reaction A + 2B ⟶ 3C at 300 K is – 10 kJ/mol & $C_{p,m}$ (B) is 300 J/mol then enthalpy change at 310 K is :

(A) – 8.5 kJ/mol (B) 8.5 kJ/mol (C) – 11.5 kJ/mol (D) none of these

Q.25 If enthalpy change for hydrogenation of ethylene is –132 kJ/mole and enthalpy of formation 1,3-butadiene (g) and butane (g) are 115 kJ and –140 kJ/mole respectively then calculate resonance energy of 1,3-budadiene (in kJ).

(A) 9 (B) 18 (C) 4 (D) 10

(19) $C_2H_5OH \longrightarrow C_2H_4(g) + H_2O(g)$ $\Delta n = 45.54$ kJ

n mol. n mol.

$C_2H_5OH \longrightarrow CH_3CHO(g) + H_2$ $\Delta n = 68.91$

1 – n = $\frac{1}{9}$ mol

$\frac{\Delta}{1-n} = \frac{8}{1} = n = \frac{8}{9}$ = $45.54 \times \frac{8}{9} + \frac{1}{9} \times 68.91$

(20) $PCl_5(g) \longrightarrow PCl_3(g) + Cl_2(g)$

$\Delta H^\circ = [\Delta H_f^\circ (PCl_3(g)] + \Delta H_f^\circ (Cl_2(g)) - \Delta H_f^\circ (PCl_5(g))$

$= -60 + 74 = 14$ Kcal/mol

$\Delta G^\circ = -RT \ln K_{eq}$

$14 = -\frac{2}{1000} \times 1000 \ln K_{eq}$ $\ln K_{eq} = -7$

$\log K_{eq} = \frac{2}{\log_2 e} = -7$ $(\log \frac{2}{e}) \log_2 K_{eq} = -7$

$0.7 \log_2 K_{eq} = -7$

$\log_2 K_{eq} = -10$

$K_{eq} = 2^{-10}$

(23) $6[C(C-H) + 3(C-C)] - [6[C(C-H)] + (C=C) + (C-C)]$

(24) Kirchoff eq

$A + 2B \longrightarrow 3C$

$\Delta r C_p = (3 \times 200) - (150 + 600)$

$\Delta H_{310} - \Delta H_{300} = \Delta r C_p (310 - 300)$

115 -140 -115 → -140

$C_4H_{6(g)} + 2H_2 \longrightarrow C_4H_{10(g)}$

R.E ↓ n ↗ 2(2 × (–132))

$C=C-C=C$