THERMOCHEMISTRY

1. For the reaction $A_{(g)} \rightarrow (B)_{(g)}$, the value of the equilibrium constant at 300 K and 1 atm is equal to 100.0. The value of $\Delta_r G$ for the reaction at 300 K and 1 atm in J mol^{-1} is – xR, where x is ______ (Rounded off to the nearest integer) (R = 8.31 J mol^{-1} K^{-1} and ln 10 = 2.3)

2. The ionization enthalpy of Na^+ formation from $Na_{(g)}$ is 495.8 kJ mol^{-1}, while the electron gain enthalpy of Br is –325.0 kJ mol^{-1}. Given the lattice enthalpy of NaBr is –728.4 kJ mol^{-1}. The energy for the formation of NaBr ionic solid is (–) _______ × 10^{-1} kJ mol^{-1}.

3. For a chemical reaction $A + B \rightleftharpoons C + D$

($\Delta_r H^0$ = 80kJ mol^{-1}) the entropy change $\Delta_r S^0$ depends on the temperature T (in K) as ($\Delta_r S^0$ = 2T (J K^{-1} mol^{-1}).

Minimum temperature at which it will become spontaneous is ______K.(Integer)

4. The average S–F bond energy in kJ mol^{-1} of SF_6 is ______.(Rounded off to the nearest integer)

[Given : The values of standard enthalpy of formation of SF_6(g), S(g) and F(g) are –1100, 275 and 80 kJ mol^{-1} respectively.]

5. The standard enthalpies of formation of Al_2O_3 and CaO are –1675 kJ mol^{-1} and –635 kJ mol^{-1} respectively.

For the reaction

$3CaO + 2Al \rightarrow 3Ca + Al_2O_3$ the standard reaction enthalpy $\Delta_r H^0$= _______ kJ.

(Round off to the Nearest Integer).

6. For the reaction $C_2H_6 \rightarrow C_2H_4 + H_2$

the reaction enthalpy $\Delta_r H$ = ______ kJ mol^{-1}.

(Round off to the Nearest Integer).

[Given : Bond enthalpies in kJ mol^{-1} : C–C : 347, C=C : 611; C–H : 414, H–H : 436]

7. The Born-Haber cycle for KCl is evaluated with the following data :

$\Delta_f H^\ominus$ for KCl = –436.7 kJ mol^{-1};

$\Delta_{sub} H^\ominus$ for K = 89.2 kJ mol^{-1};

$\Delta_{ionization} H^\ominus$ for K = 419.0 kJ mol^{-1}; $\Delta_{electron\ gain} H^\ominus$ for $Cl_{(g)}$ = –348.6 kJ mol^{-1}; $\Delta_{bond} H^\ominus$ for Cl_2 = 243.0 kJ mol^{-1}

The magnitude of lattice enthalpy of KCl in kJ mol^{-1} is _______ (Nearest integer)

8. For water $\Delta_{vap} H$ = 41 kJ mol^{-1} at 373 K and 1 bar pressure. Assuming that water vapour is an ideal gas that occupies a much larger volume than liquid water, the internal energy change during evaporation of water is_____kJ mol^{-1}

[Use : R = 8.3 J mol^{-1} K^{-1}]

9. 200 mL of 0.2 M HCl is mixed with 300 mL of 0.1 M NaOH. The molar heat of neutralization of this reaction is –57.1 kJ. The increase in temperature in °C of the system on mixing is x × 10^{-2}. The value of x is _______ . (Nearest integer)

[Given : Specific heat of water = 4.18 J g^{-1} K^{-1} Density of water = 1.00 g cm^{-3}]

(Assume no volume change on mixing)

10. Data given for the following reaction is as follows:

$FeO_{(s)} + C_{(graphite)} \longrightarrow Fe_{(s)} + CO_{(g)}$

Substance	ΔH° (kJ mol^{-1})	ΔS° (J mol^{-1}K^{-1})
$FeO_{(s)}$	–266.3	57.49
$C_{(graphite)}$	0	5.74
$Fe_{(s)}$	0	27.28
$CO_{(g)}$	–110.5	197.6

The minimum temperature in K at which the reaction becomes spontaneous is _______ .

(Integer answer)

11. The **incorrect** expression among the following is:

(1) $\frac{\Delta G_{System}}{\Delta S_{Total}} = -T$(at constant P)

(2) $\ln K = \frac{\Delta H^\circ - T\Delta S^\circ}{RT}$

(3) $K = e^{-\Delta G^\circ/RT}$

(4) For isothermal process $w_{reversible}$

$= -\ nRT \ln \frac{V_f}{V_i}$

12. For the reaction $2NO_2(g) \rightleftharpoons N_2O_4(g)$, when $\Delta S = -176.0\ JK^{-1}$ and $\Delta H = -57.8\ kJ\ mol^{-1}$, the magnitude of ΔG at 298 K for the reaction is_____ kJ mol^{-1}. (Nearest integer)

SOLUTION

1. Official Ans. by NTA (1380)

Sol. $\Delta G^o = -RT \ln Kp$

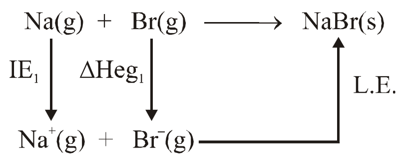
$= -R(300)\ (2)\ \ln(10)$

$= -R(300 \times 2 \times 2.3)$

$\Delta G^o = -1380\ R$

2. Official Ans. by NTA (5576)

Sol.



$\Delta H_{formation} = IE_1 + \Delta Heg_1 + LE$

$= 495.8 + (-325) + (-728.4)$

$= -557.6$

$= -5576 \times 10^{-1}$ KJ/mol.

Note: The above calculation is not for $\Delta H_{formation}$ but for $\Delta H_{Reaction}$.

But on the basis of given data it is the best ans.

3. Official Ans. by NTA (200)

Sol. $\Delta G^0 = \Delta H^0 - T \times \Delta S^0$

$\Delta G^0 = \Delta H^0 - T \times (2T)$

T = 200K

4. Official Ans by NTA (309)

Sol. $SF_6(g) \rightarrow S(g) + 6F(g)$

If $\in$ - bond enthalpy

$\Delta_r H = 6 \times \in_{S-F}$

$= \Delta_f H(S,g) + 6 \times \Delta_f H(F,g) - \Delta_f H(SF_6, g)$

$= 275 + 6 \times 80 - (-1100)$

= 1855 kJ

$\in_{S-F} = \frac{1855}{6} = 309.16$ kJ/mol.

5. Official Ans. by NTA (230)

Sol. Given reaction :

$3CaO + Al \rightarrow Al_2O_3 + 3Ca$

Now, $\Delta_r H^\circ = \Sigma\ \Delta_f H^\circ_{Products} - \Sigma \Delta_f H^\circ_{Reactants}$

$= [1 \times (-1675) + 3 \times 0] - [3 \times (-635) + 2 \times 0]$

$= +230$ kJ mol^{-1}

6. Official Ans. by NTA (128)

Sol. $\Delta_r H = [\in_{C-C} + 2\in_{C-H}] - [\in_{C=C} + \in_{H-H}]$

$= [347 + 2 \times 414] - [611 + 436]$

= 128

7. Official Ans. by NTA (718)

Sol. $\Delta_f H^\ominus_{KCl} = \Delta_{sub} H^\ominus_{(K)} + \Delta_{ionization} H^\ominus_{(K)} + \frac{1}{2}\Delta_{bond} H^\ominus_{(Cl_2)}$

$+ \Delta_{electron\ gain} H^\ominus_{(Cl)} + \Delta_{lattice} H^\ominus_{(KCl)}$

$\Rightarrow -436.7 = 89.2 + 419.0 +$

$\frac{1}{2}(243.0) + \{-348.6\} + \Delta_{lattice} H^\ominus_{(KCl)}$

$\Rightarrow \Delta_{lattice} H^\ominus_{(KCl)} = -717.8$ kJ mol^{-1}

The magnitude of lattice enthalpy of KCl in kJ mol^{-1} is 718 (Nearest integer).

8. Official Ans. by NTA (38)

Sol. Given equation is

$$H_2O(\ell) \longrightarrow H_2O(g) : \Delta H = 41\ \frac{kJ}{mol}$$

$\Rightarrow$ From the relation : $\Delta H = \Delta U + \Delta n_g RT$

$$\Rightarrow 41\frac{kJ}{mol} = \Delta U + (1) \times \frac{8.3}{1000} \times 373$$

$\Rightarrow$ DU = 41 – 3.0959

= 38 kJ/mol

9. Official Ans. by NTA (82)

Sol. ⇒ Millimoles of HCl = 200 × 0.2 = 40

⇒ Millimoles of NaOH = 300 × 0.1 = 30

⇒ Heat released = $\left(\frac{30}{1000}\times 57.1\times 1000\right)$ = 1713 J

⇒ Mass of solution = 500 ml × 1 gm/ml = 500 gm

$$\Rightarrow \Delta T = \frac{q}{m\times C} = \frac{1713J}{500g\times 4.18\frac{J}{g-K}} = 0.8196K$$

$= 81.96 \times 10^{-2}$ K

10. Official Ans. by NTA (964)

Sol. $T_{min} = \left(\frac{\Delta^0 H}{\Delta^0 S}\right)$

$$\Delta^0 H_{rxn} = \left[\Delta_f^0 H(Fe) + \Delta_f^0 H(CO)\right] -$$

$$= \left[\Delta_f^0 H(FeO) + \Delta_f^0 H(C_{(graphite)})\right]$$

= [0 – 110.5] – [–266.3+0] = 155.8 kJ/mol

$$\Delta^0 S_{rxn} = \left[\Delta^0 S(Fe) + \Delta^0 S(CO)\right] -$$

$$\left[\Delta^0 S(FeO) + \Delta^0 S(C_{(graphite)})\right]$$

= [27.28 + 197.6] – [57.49 + 5.74]

= 161.65 J/mol-K

$$T_{min} = \frac{155.8\times 10^3 J/mol}{161.65 J/mol-K} = 963.8K$$

≃ 964 k (nearest integer)

11. Official Ans. by NTA (2)

Sol. Option (2) is incorrect

$\Delta G^\circ = -RT\ \ell n\ K$

$\Delta H^\circ - T\Delta S^\circ = -RT\ \ell n\ K$

$$\ell nK = -\left[\frac{\Delta H^\circ - \Delta S^\circ}{RT}\right]$$

12. Official Ans. by NTA (5)

Sol. $\Delta G = \Delta H - T\Delta S$

$$\Delta G = 57.8 - \frac{298(-176)}{1000}$$

$\Delta G = -5.352$ kJ/mole

|Nearest integer value| = 5