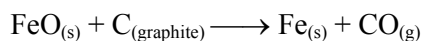


# THERMOCHEMISTRY

- 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  $\ln 10 = 2.3$ )
- 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  $(-)\ \_\_\_\_\_\_ \times 10^{-1}\ kJ\ mol^{-1}$ .
- For a chemical reaction  $A + B \rightleftharpoons C + D$  ( $\Delta_r H^0 = 80\ kJ\ mol^{-1}$ ) 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)
- 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.]
- 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).

- 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]
- 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)
- 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 :  $R = 8.3\ J\ mol^{-1}\ K^{-1}$ ]
- 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  $^\circ C$  of the system on mixing is  $x \times 10^{-2}$ . 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:



Substance	$\Delta H^\circ$ (kJ mol <sup>-1</sup> )	$\Delta S^\circ$ (J mol <sup>-1</sup> K <sup>-1</sup> )
FeO <sub>(s)</sub>	-266.3	57.49
C <sub>(graphite)</sub>	0	5.74
Fe <sub>(s)</sub>	0	27.28
CO <sub>(g)</sub>	-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)  $\frac{\Delta G_{\text{System}}}{\Delta S_{\text{Total}}} = -T(\text{at constant P})$

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

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

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

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

12. For the reaction  $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$ , when  $\Delta S = -176.0 \text{ JK}^{-1}$  and  $\Delta H = -57.8 \text{ kJ mol}^{-1}$ , the magnitude of  $\Delta G$  at 298 K for the reaction is \_\_\_\_\_ kJ mol<sup>-1</sup>. (Nearest integer)

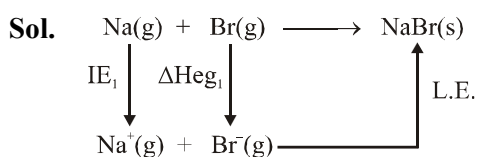
**SOLUTION**

**1. Official Ans. by NTA (1380)**

**Sol.**  $\Delta G^\circ = -RT \ln K_p$   
 $= -R(300)(2) \ln(10)$   
 $= -R(300 \times 2 \times 2.3)$

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

**2. Official Ans. by NTA (5576)**



$\Delta H_{\text{formation}} = \text{IE}_1 + \Delta H_{\text{eg}_1} + \text{L.E.}$   
 $= 495.8 + (-325) + (-728.4)$   
 $= -557.6$   
 $= -5576 \times 10^{-1} \text{ KJ/mol.}$

Note: The above calculation is not for  $\Delta H_{\text{formation}}$

but for  $\Delta H_{\text{Reaction}}$ .

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

**3. Official Ans. by NTA (200)**

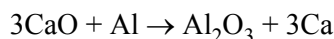
**Sol.**  $\Delta G^\circ = \Delta H^\circ - T \times \Delta S^\circ$   
 $\Delta G^\circ = \Delta H^\circ - T \times (2T)$   
 $T = 200\text{K}$

**4. Official Ans by NTA (309)**

**Sol.**  $\text{SF}_6(\text{g}) \rightarrow \text{S}(\text{g}) + 6\text{F}(\text{g})$   
 If  $\epsilon$  - bond enthalpy  
 $\Delta_r H = 6 \times \epsilon_{\text{S-F}}$   
 $= \Delta_f H(\text{S, g}) + 6 \times \Delta_f H(\text{F, g}) - \Delta_f H(\text{SF}_6, \text{g})$   
 $= 275 + 6 \times 80 - (-1100)$   
 $= 1855 \text{ kJ}$   
 $\epsilon_{\text{S-F}} = \frac{1855}{6} = 309.16 \text{ kJ/mol.}$

**5. Official Ans. by NTA (230)**

**Sol.** Given reaction :



Now,  $\Delta_r H^\circ = \sum \Delta_f H^\circ_{\text{Products}} - \sum \Delta_f H^\circ_{\text{Reactants}}$   
 $= [1 \times (-1675) + 3 \times 0] - [3 \times (-635) + 2 \times 0]$   
 $= +230 \text{ kJ mol}^{-1}$

**6. Official Ans. by NTA (128)**

**Sol.**  $\Delta_r H = [\epsilon_{\text{C-C}} + 2\epsilon_{\text{C-H}}] - [\epsilon_{\text{C=C}} + \epsilon_{\text{H-H}}]$   
 $= [347 + 2 \times 414] - [611 + 436]$   
 $= 128$

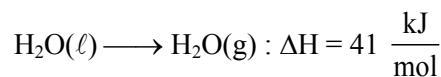
**7. Official Ans. by NTA (718)**

**Sol.**  $\Delta_f H^\circ_{\text{KCl}} = \Delta_{\text{sub}} H^\circ_{(\text{K})} + \Delta_{\text{ionization}} H^\circ_{(\text{K})} + \frac{1}{2} \Delta_{\text{bond}} H^\circ_{(\text{Cl}_2)}$   
 $+ \Delta_{\text{electron gain}} H^\circ_{(\text{Cl})} + \Delta_{\text{lattice}} H^\circ_{(\text{KCl})}$   
 $\Rightarrow -436.7 = 89.2 + 419.0 +$   
 $\frac{1}{2}(243.0) + \{-348.6\} + \Delta_{\text{lattice}} H^\circ_{(\text{KCl})}$   
 $\Rightarrow \Delta_{\text{lattice}} H^\circ_{(\text{KCl})} = -717.8 \text{ kJ mol}^{-1}$

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

**8. Official Ans. by NTA (38)**

**Sol.** Given equation is



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

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

$\Rightarrow \Delta U = 41 - 3.0959$

$= 38 \text{ kJ/mol}$

**9. Official Ans. by NTA (82)**

**Sol.**  $\Rightarrow$  Millimoles of HCl =  $200 \times 0.2 = 40$

$\Rightarrow$  Millimoles of NaOH =  $300 \times 0.1 = 30$

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

$\Rightarrow$  Mass of solution =  $500 \text{ ml} \times 1 \text{ gm/ml} = 500 \text{ gm}$

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

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

**10. Official Ans. by NTA (964)**

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

$$\Delta^0 H_{\text{rxn}} = [\Delta^0_f H(\text{Fe}) + \Delta^0_f H(\text{CO})] -$$

$$= [\Delta^0_f H(\text{FeO}) + \Delta^0_f H(\text{C}_{(\text{graphite})})]$$

$$= [0 - 110.5] - [-266.3 + 0] = 155.8 \text{ kJ/mol}$$

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

$$[\Delta^0 S(\text{FeO}) + \Delta^0 S(\text{C}_{(\text{graphite})})]$$

$$= [27.28 + 197.6] - [57.49 + 5.74]$$

$$= 161.65 \text{ J/mol-K}$$

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

$$\approx 964 \text{ k (nearest integer)}$$

**11. Official Ans. by NTA (2)**

**Sol.** Option (2) is incorrect

$$\Delta G^\circ = -RT \ln K$$

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

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

**12. Official Ans. by NTA (5)**

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

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

$$\Delta G = -5.352 \text{ kJ/mole}$$

$$|\text{Nearest integer value}| = 5$$