Key



APChem Unit 11

NMSI: Entropy & Free Energy

(#1) A) Solid Sugar + $H_2O$ → Soln  solid → Soln

- more disorder

ΔS positive

B) $I_{2(g)} \longrightarrow I_{2(s)}$

Vapor → Crystals

∴ Less disorder

∴ ΔS is Negative

(#2) $2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$

$248.1\ \frac{J}{mol\ K}$  $205.3\ \frac{J}{mole}$  $256.6\ \frac{J}{mol\ K}$

$$\Delta S^\circ_{rxn} = \Sigma \Delta S^\circ_{products} - \Sigma S^\circ_{reactants}$$

$$= \left[\frac{2\ mole}{mole\ rxn}\left(\frac{256.6\ J}{mole\ K}\right)\right] - \left[\frac{2\ mole}{mole\ rxn}\left(\frac{248.1\ J}{mole\ K}\right) + \frac{1\ mole}{mole\ rxn}\left(\frac{205.3\ J}{mole\ K}\right)\right]$$

$$\boxed{\Delta S^\circ_{rxn} = -188.3\ \frac{J}{mol\ rxn\ K}}$$

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#3

$Sb_2S_{3(s)} + 3Fe_{(s)} \rightarrow 2Sb_{(s)} + 3FeS_{(s)}$ $\Delta H = -125 \frac{kJ}{mol_{rxn}}$ Exo

$Sb_4O_{6(s)} + 6C_{(s)} \rightarrow 4Sb_{(s)} + 6CO_{(g)}$ $\Delta H = 778$ kJ/mol rxn Endo

$\Delta S_{surr} = ?$ @ 25°C & 1 atm

$\Delta S_{surr} = \frac{-\Delta H_{system}}{T}$

$\Delta S_{surr} = -\left(\frac{-125{,}000\ J}{1\ mol_{rxn}}\right) / 298\ K$

$\Delta S_{surr} = 419\ J/mol_{rxn} \cdot K$

$\Delta S_{surr} = \frac{-\Delta H_{system}}{T}$

$= -\left(\frac{778{,}000\ J}{mol_{rxn}}\right) / 298\ K$

$\Delta S_{surr} = -2.61 \times 10^3 \frac{J}{mol_{rxn} \cdot K}$

#4 $2H_2O_{(\ell)} + O_{2(g)} \rightarrow 2H_2O_{2(\ell)}$

$-56.7 \frac{kcal}{mol}$ $0 \frac{kcal}{mol}$ $-27.2 \frac{kcal}{mol}$ $\Delta G° = ?$

$\Delta G°_{rxn} = \Sigma \Delta G°_p - \Sigma \Delta G°_R$

$= 2(H_2O_2) - [2(H_2O) + \cancel{O_2}^{0}]$

$= \frac{2\ mol}{mol_{rxn}}\left(-27.2 \frac{kcal}{mol}\right) - \left[\frac{2\ mol}{mol_{rxn}}\left(-56.7 \frac{kcal}{mol}\right)\right]$

$= -54.4 \frac{kcal}{mol_{rxn}} - \left(-113.4 \frac{kcal}{mol_{rxn}}\right)$

$\Delta G°_{rxn} = 59.0$ kcal/mol rxn

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#5 $2\,SO_{2(g)} + O_{2(g)} \rightarrow 2\,SO_{3(g)}$ $\Delta H^\circ = ?$ $\Delta S^\circ = ?$ $\Delta G^\circ = ?$

$\Delta H^\circ = \Sigma \Delta H^\circ_P - \Sigma \Delta H^\circ_R$

$= \frac{2\,mol}{mol\,rxn}\left(-396\ KJ/mol\right) - \left[\frac{2\,mol}{mol\,rxn}\left(-297\ \frac{KJ}{mol}\right) + 0^\circ\right]$

$= -792\ \frac{KJ}{mol\,rxn} + 594\ \frac{KJ}{mol\,rxn}$

$\boxed{\Delta H^\circ = -198\ KJ/mol\,rxn}$

$\Delta S^\circ = \Sigma \Delta S^\circ_P - \Sigma \Delta S^\circ_R$

$= \frac{2\,mol}{mol\,rxn}\left(257\ J/K.mol\right) - \left[\frac{2\,mol}{mol\,rxn}\left(248\ \frac{J}{mol\,K}\right) + \frac{1\,mole}{1\,mol\,rxn}\left(205\ \frac{J}{mol\,K}\right)\right]$

$= 514\ \frac{J}{K\,mol\,rxn} - 701\ \frac{J}{K\,mol\,rxn}$

$\boxed{\Delta S^\circ = -187\ \frac{J}{K\,mol\,rxn}}$

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

$= -198\ \frac{KJ}{mol\,rxn} - (298\,K)\left(-187\ \frac{J}{K\,mol\,rxn}\right)\left(\frac{1\,KJ}{1000\,J}\right)$ $T = 25^\circ + 273 = 298\ K$

$= -198\ \frac{KJ}{mol\,rxn} + 55.7\ \frac{KJ}{mol\,rxn}$

$\boxed{\Delta G^\circ = -142\ KJ/mol\,rxn}$

#6 Given: $C_{dia\,(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta G^\circ = -397\ KJ$

$C_{Graph\,(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta G^\circ = -394\ KJ$

Find: $\Delta G^\circ$ $C_{dia\,(s)} \rightarrow C_{Graph}$

Soln:

$C_{dia\,(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $-397\ KJ$

R $CO_{2(g)} \rightarrow C_{Graph}^{0k} + O_{2(g)}$ $+394\ KJ$

$C_{dia\,(s)} \rightarrow C_{graph\,(s)}$ $-3\ KJ$

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(#8) Given: $H_2O_{(l)} \rightarrow H_2O_{(g)}$ $\Delta H_{vap} = 44\ kJ/mol\ rxn$

$\Delta S_{vap} = 118.8\ J/K \cdot mol\ rxn$

Boiling pt = ?

Soln: $\Delta G^\circ = 0$ @ phase change, Because system is @ Equilibrium (Key Point!)

$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ $\Delta G^\circ = 0$ @ Equilibrium

$$T = \frac{\Delta H^\circ}{\Delta S^\circ} = \frac{44\ kJ/mol\ rxn}{\left(\frac{118.8\ J}{K \cdot mol\ rxn}\right)\left(\frac{1\ kJ}{1000\ J}\right)}$$

$\boxed{T = 370\ K}$

(#9) Given: $2\,CO_{2(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$ $\Delta G^\circ = -257.2\ \frac{kJ}{mol\ rxn}$ @ 25°C

Find: $K = ?$

Soln:

$T = 25°C + 273$

$T = 298\ K$

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

$$-257.2\ \frac{kJ}{mol\ rxn} = -\left(8.3145\ \frac{J}{mol\ K}\right)\left(\frac{1\ kJ}{1000\ J}\right)(298\ K) \ln K$$

$$-257.2\ \frac{kJ}{mol\ rxn} = -2.48\ \frac{kJ}{mol\ rxn} \ln K$$

$$\ln K = 104$$

$$K_c = 1.47 \times 10^{45}$$

$K_p = K_c(RT)^{\Delta n}$ $\Delta n = \#\ moles\ p - \#\ moles\ R$

$\Delta n = 2 - 3$

$\Delta n = -1$