Key

CHEMISTRY 114
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Worksheet 3

1. One mole of supercooled water at -10°C, in a heat-insulated container, crystallizes resulting in a mixture of ice and water at 0°C. What fraction of the mixture is ice? The molar enthalpy of fusion of ice at 0°C is 6.02 kJ mol^{-1}, the molar heat capacity of supercooled water is 75.3 J mol^{-1} K^{-1}.

$1\ H_2O_{(\ell,-10°C)} \xrightarrow[\Delta H_{tot}]{\text{irreversible}} x\ H_2O_{(s,0°C)} + (1-x) H_2O_{(\ell,0°C)}$

ΔH_1: $H_2O_{(\ell,-10°C)} \rightarrow H_2O_{(\ell,0°C)}$; ΔH_2: $H_2O_{(\ell,0°C)} \rightarrow$ products

adiabatic $\Rightarrow$ $q_{total} = 0 = q_1 + q_2 = \Delta H_1 + \Delta H_2$

$= n C_p \Delta T - x \Delta H_{fus}$

$\frac{x \Delta H_{fus}}{(\Delta H_{fus})} = \frac{n C_p \Delta T}{(\Delta H_{fus})}$

$x = \frac{n C_p \Delta T}{\Delta H_{fus}} = \frac{\left(75.3 \frac{J}{mol\,K}\right)(10\,K)(1\,mol)}{\left(6.02 \frac{kJ}{mol}\right)\left(\frac{1000\,J}{1\,kJ}\right)} = 0.125\,mol$

$x = \frac{0.125\,mol}{1\,mol} = \frac{1}{8}$

2. The enthalpy of vaporization of mercury is 58.51 kJ mol^{-1} and the entropy of vaporization is 92.92 J K^{-1} mol^{-1}. What is the normal boiling point of mercury?

$\Delta S = \frac{q_{rev}}{T} = \frac{\Delta H}{T} \Rightarrow T = \frac{\Delta H}{\Delta S} = \frac{\left(58.51 \frac{kJ}{mol}\right)}{\left(92.92 \frac{J}{mol\,K}\right)} \times \frac{1000\,J}{1\,kJ} = 629.68\,K$

3. For the reaction FeO (*s*) + CO (*g*) → Fe (*s*) + CO_2 (*g*), ΔG° is –5.8 kJ and ΔH° is – 11 kJ. S° (J mol^{-1} K^{-1}): Fe (27.3), CO (197.5), CO_2 (213.7)

a) What is ΔS_{surr} ?

$\Delta S = \frac{q}{T}$

$\Delta S_{surr} = \frac{q_{surr}}{T} = -\frac{q_{sys}}{T} = -\frac{\Delta H}{T} = \frac{(\Delta H^\circ \times 1000)}{T} = 36.89 \frac{J}{K}$

b) Is the reaction spontaneous under standard conditions? Explain

Yes $\Delta G^\circ < 0$

c) To react as much FeO(*s*) temperatures? Explain

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

lower temp

d) What is S° for FeO?

$\Delta S^\circ_{rxn} = S^\circ(Fe) + S^\circ(CO_2) - S^\circ(FeO) - S^\circ_{(s)}$

$S^\circ(FeO) = S^\circ(Fe) + S^\circ(CO_2) - S^\circ(CO) - \Delta S^\circ_{rxn} =$

4. For ammonia the enthalpy of fusion is 5.65 kJ mol^{-1} and the entropy of fusion is 28.9 J K^{-1} mol^{-1}.

a) Will ammonia spontaneously melt at 200 K. Why or why not?

$\Delta G = \Delta H - T\Delta S = \left(5.65 \frac{kJ}{mol}\right)\left(\frac{1000\,J}{1\,kJ}\right) - (200K)\left(28.9 \frac{J}{mol\,K}\right) = -130 \frac{J}{mol}$

$< 0 \Rightarrow$ spontaneous

b) What is the normal melting point of ammonia?

$\Delta S = \frac{q_{rev}}{T} = \frac{\Delta H}{T} \Rightarrow T = \frac{\Delta H}{\Delta S} = \frac{\left(5.65 \frac{kJ}{mol}\right)}{28.9 \frac{J}{mol\,K}} \times \frac{1000\,J}{1\,kJ} = 195.5K$

5. If you calculate a value for ΔG for a reaction using the values for ΔG°_f in the appendix, is it correct to state that the reaction is always spontaneous if the calculated value for ΔG is negative? Explain.

No, only at 298.15K

$p = 1\,atm$ or $[A] = 1M$

6. Bromine melts at -7°C and the molar enthalpy of fusion is 10.8 kJ mol^{-1}. What is the molar entropy of fusion?

$\Delta S = \frac{q_{fus}}{T} = \frac{\Delta H_{fus}}{T} = \frac{10.8 \frac{kJ}{mol}}{(273.15K - 7K)}\left(\frac{1000\,J}{1\,kJ}\right) = 40.57 \frac{J}{mol\,K}$