CH1012 Tutorial 5 Answers

1. The vapour pressure of *n*-butane is 3.41 x 10^5 Pa at 30°C and 8.95 x 10^5 Pa at 70°C. Calculate ΔH_{vap} (*n*-butane) in this temperature range.

$$\ell n\left(\frac{P_2}{P_1}\right) = \frac{-H_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$\left[-R \text{ x } \ell n\left(\frac{P_2}{P_1}\right)\right] \text{ x}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)^{-1} = \Delta H_{vap}$$

$$\left[-8.314 \text{ x } \ell n\left(\frac{8.95}{3.41}\right)\right] \text{ x}\left(\frac{1}{343} - \frac{1}{303}\right)^{-1} = \Delta H_{vap}$$

-8.0225 x -2598.225 = ΔH_{vap}

20844.316 J = ΔH_{vap}

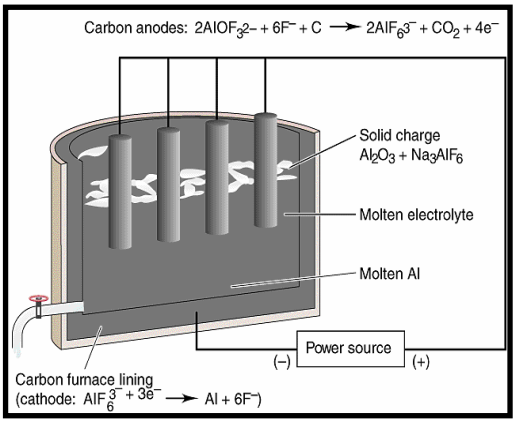
ΔH_{vap} = **20.8 kJ / mol**

2. Describe the main features of the **Hall-Heroult process** for the production of aluminium metal from alumina.

Cathode: $Al_2O_3 + 6e \rightarrow 2Al + 3O^{2-}$
Anode: $C + 2O^{2-} \rightarrow CO_2 + 4e$
Overall: $2Al_2O_3 + 3C \rightarrow 4Al + 3CO_2$

The electrolyte is cryolite (Na_3AlF_6) and alumina. At 1000°C this is molten.

The cells operate at 4.7 volts but have huge Currents > 100kA
The carbon anode is consumed



3. Explain the characteristics of **interstitial alloys** and **heterogenous alloys** using examples to illustrate your answer.

Interstitial alloy - one atom type is much smaller (typically main group) and fits in the interstices of the bulk structure. eg. Fe / C where the C content in the steel varies from <0.2% mild steel to > 1% in carbon steel.

Heterogeneous alloys - components not dispersed uniformly. eg. Pearlite Steel,
phase 1 pure iron, phase 2 cementite Fe_3C

$3Fe + C \rightarrow Fe_3C$ ΔH +ve at >1000 ^oC most of C is present as Fe_3C

4. What are the physical properties of an azeotropic mixture?

An **azeotropic mixture** is a constant boiling mixture of two liquids where the composition of the vapour phase and liquid phase are the same $x_1:x_2$ vapour = $x_1:x_2$ liquid. The azeotropic mixture is arrived at by removal of the volatile components during distillation and is either a minimum or maximum on a temperature vs composition diagram.

5. The **van der Waal's equation** accounts for the behaviour of a real gas. What are the van der Waal's forces and how do they relate to this equation?

The van der Waal's Forces are the weak intermolecular forces between molecules (atoms). They include forces such as (i) hydrogen bonding, (ii) dipole-dipole, (iii) dispersion forces (instaneous dipoles).
They relate to the van der Waals equation in that the pressure in a real gas is lower than that of an ideal gas due to the intermolecular forces, therefore the extra term (na^2/V^2) is added to the pressure to correct for the effect of these forces.

6. Which **quantum numbers** define the energy of a $3dz^2$ orbital?
What is the value of the azimuthal quantum number for this orbital?

$3dz^2$ The energy is defined by the principal quantum number n and the azimuthal quantum number l.
The values for $3dz^2$ are n = 3, **l = 2**