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ENGR145 HW3

5.1) $N = \frac{N_A \rho}{A} = \frac{6.02\times10^{23}\,\text{atoms/mol}\,(10.35\,g/cm^3)}{107.87\,g/mol} = 5.778\times10^{22}$ atoms/cm^3

$2\times10^{-6} = \frac{N_v}{N} \Rightarrow N(2\times10^{-6}) = N_v$

$(5.778\times10^{22})(2\times10^{-6}) = 1.1556\times10^{17}$ atoms/cm^3

1.1556×10^{17} atoms/$cm^3 \times \frac{1000000\,cm^3}{1\,m^3} = 1.1556\times10^{23}$ atoms/m^3

5.46) 6.5×10^{21} atoms/m^3 P $\times \frac{1\text{ mol P}}{6.02\times10^{23}\text{ atoms}} \times \frac{30.974\,g}{1\text{ mol P}} = 0.334\,g/m^3$

$0.334\,g/m^3$ P $\quad \rho_{Si} = 2.33\,g/cm^3 \times \frac{1000000\,cm^3}{1\,m^3} = 2.33\times10^6\,g/m^3$

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$2.33\times10^{6}\,g/m^3$ Si

a) $C_1 = \frac{m_1}{m_1+m_2}\times100 \Rightarrow C_P = \frac{m_P}{m_P+m_{Si}}\times100 = \frac{0.334}{0.334+2.33\times10^6}\times100 = 1.43\times10^{-5}\%$

weight percent of Phosphorus = $1.43\times10^{-5}\%$

b) $C_1' = \frac{C_1A_2}{C_1A_2+C_2A_1}\times100 \Rightarrow C_P' = \frac{C_PA_{Si}}{C_PA_{Si}+C_{Si}A_P}\times100$

$C_P = 1.43\times10^{-7}$

$C_{Si} = .999999857$

$A_P = 30.974\,g$

$A_{Si} = 28.086\,g$

$C_P' = \frac{(1.47\times10^{-7})(28.086)(100)}{(1.47\times10^{-7})(28.086)+(.999999857)(30.947)} = 1.30\times10^{-5}\%$

atom percent of Phosphorus = $1.30\times10^{-5}\%$

6.6) Steady state diffusion involves diffusion in a single direction, where flux is proportional to the concentration gradient times the diffusion constant. If fluid is independent of time, then it is said to be steady state diffusion, and can be represented by the relationship stated above, also known as Fick's first law.

6.8) 6mm Sheet of Palladium

0.25 m^2 area at 600°C or 873 K

Diffusion Coef 1.7×10^{-8} m^2/s

2.0 kg high pressure

0.4 kg low pressure

Steady-State

Number of kg/hour

$t = 3600s$

$$J = \frac{M}{A \cdot t} \quad M = J \cdot A \cdot t \quad J = -D\frac{dC}{dx}$$

$$M = -D\frac{dC}{dx} \cdot A \cdot t \quad \frac{dC}{dx} = \frac{\Delta C}{\Delta x} = \frac{C_A - C_B}{x_A - x_B}$$

$$\frac{dc}{dx} = \frac{2 - 0.4}{0 - 6 \times 10^{-3}} = -266.67$$

$$M = (-1.7 \times 10^{-8})(-266.67)(0.25)(3600)$$

$$= 0.00408 = 4.08 \times 10^{-3} \text{ kg/h}$$

3.103) Predominantly ionic materials would be less likely to form non-crystalline structures because ionic bonds are strongly attracted to each other and can form ordered structures very easily when cooling. Their strong attraction to each other allows them to form planes quickly. Covalent bonds do not have as strong intramolecular attractions, so it takes them longer to order themselves in planar configurations when cooling.

Thought question: blackboard chalk has typically been a form of calcium carbonate or limestone, deposited by micro-organisms. Some blackboard chalk is based on gypsum, or calcium sulfate. Suppose that you have a piece of blackboard chalk. Propose an experiment to tell if it is primarily calcium carbonate or calcium sulfate.

To test to see what type of material the chalk is made of, I would start by dissolving two pieces of chalk in two separate glasses of water. The calcium carbonate and calcium sulfate are both ionic so they would break up into their ions in their respective bodies of water. The carbonate in the water would form H2CO3, a weak acid. Taking the pH of this solution would tend to be lower, or more acidic. The sulfate, however, would be unable to create H2SO4 due to the properties of strong acids. Because the ions would just be floating in the water for the calcium sulfate solution, a pH test would reveal that the solution would tend to be more basic than the other. These two pH tests would reveal the chemical composition of the chalks, with the calcium carbonate being more acidic than the calcium sulfate. Necessary materials would be two glasses, distilled water, two different types of chalk that are unknown, and litmus paper slips.