Answer on the question #63394, Chemistry / Physical Chemistry

Question:

1 dm3 of a solution of 2.0 M CuSO4 is electrolysed using platinum electrodes by passing (5) 4.50 A current for 9000 s. Calculate 1) the mass of Cu deposited, and 2) the amount of Cu2+ in the solution at the end of electrolysis.

Solution:

Faraday's law of electrolysis tells that the mass of the substance, liberated at the electrode in grams is proportional to the quantity of electricity Q passed through the solution:

$$m = \left(\frac{Q}{F}\right)\left(\frac{M}{z}\right)$$

where M is the molar lass of the substance, z is the charge of the ion and F is Faraday's constant $F = 96485\ C\ mol^{-1}$.

During the electrolysis in the solution of $CuSO_4$, the following reaction takes place:

$$Cu^{2+} + 2e^- \rightarrow Cu^0$$

Thus, the charge of ion is +2. Molar mass of Cu is 63.546 g mol^{-1}. Quantity of electricity, of simply charge is the product of current and time:

$$Q = It = 4.50(A) \cdot 9000(s) = \ 4.05 \cdot 10^4(C)$$

Getting the mass of copper deposited on the electrode:

$$m = \left(\frac{4.05 \cdot 10^4(C)}{96485\ (C\ mol^{-1})}\right)\left(\frac{63.546\ (g\ mol^{-1}}{2}\right) = 13.34\ (g)$$

Also, we get the amount of copper reduced and left in the solution:

$$n_{red} = \frac{m}{M} = \frac{13.34(g)}{63.546\ (g\ mol^{-1})} = 0.210\ (mol)$$

$$n_{all} = cV = 2(M) \cdot 1(L) = 2\ (mol)$$

$$n_{left} = \ n_{all} - n_{red} = 2 - 0.210 = 1.790\ (mol)$$

And the concentration of copper is finally

$$c = \frac{n_{left}}{V} = \frac{1.790(mol)}{1(L)} = 1.790\ (mol\ L^{-1})$$

Answer: 1) 13.34g, 2) 1.790 mol L-1

Remark: The solubility of $CuSO_4$ in water at 30o is 1.502 mol L^{-1}. This raises a question about the reality of the exercise case.