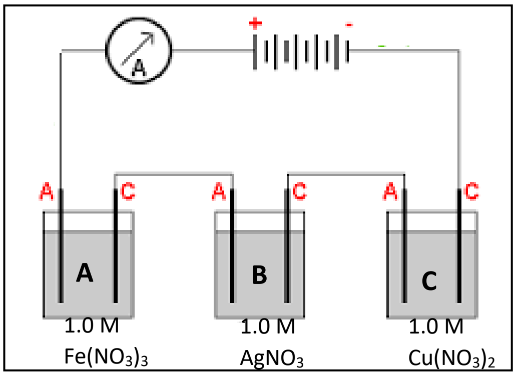
Revision – Electrolysis, rates and equilibrium.



1. An electric charge of 1.30 X 10^5 Coulomb was passed through three electrolytic cells connected in series as shown in diagram 1. The solutions are 1.0 $Fe(NO_3)_3$, 1.0 M $Cu(NO_3)_2$ and 1.0 M $AgNO_3$.

a. On which electrodes is solid metal deposited? Explain.

Formation of metal is a reduction reaction which occurs at the cathode. In an electrolytic cell the cathode is the negative electrode "C".

b. What mass of metal forms in each cell

The mol of electrons that flow through the cell is
=> 130,000 / 96500 = 1.347 mol

In cell A
=> Fe^{3+} (aq) + 3e → Fe(s)
=> mol of Fe deposited = 1.347 /3 mol = 0.449
=> mass of Fe = 0.449 X 55.845 = 25.1g

In cell B
=> Ag^{+} (aq) + e → Ag(s)
=> mol of Ag deposited = 1.347
=> mass of Ag = 1.347 X 107.9 = 145g

In cell C
=> Cu^{2+} (aq) + 2e → Cu(s)
=> mol of Cu deposited = 1.347 / 2 = 0.674
=> mass of Cu = 0.674X 63.6 = 42.8g

c. What current, in amps, is passed through each cell if it operates for 12.50 hours?

Q = It
=> 130000 = I X 12.50 X 60 X 60
=> 130000 / (150) = I = 2.89 A

2. Consider the reaction below at equilibrium.

$$3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g) \ \Delta H = -92.4 \text{ kJ/mol}$$

a. For the chemical system described above, which statements is/are true? Explain

i. The reaction below represents the reverse reaction to the Haber process.
$NH_3(g) \rightarrow 1½\, H_2(g) + ½\, N_2(g)$ ΔH = +92.4 kJ/mol
False
$NH_3(g) \rightarrow 1½\, H_2(g) + ½\, N_2(g)$ ΔH = +46.2 kJ/mol
Multiply the ΔH by ½ .

ii. If the activation energy for the reverse reaction is 126kJ/mol then the activation energy for the forward reaction, **<u>at equilibrium</u>**, is also 126kJ/mol

False
When a system reached equilibrium the rates of the forward and reverse reactions are equal. The activation energy does not change for the forward and reverse reactions does not change. A temperature increase, increases the proportion of particles with the necessary activation energy for the reverse and forward reactions.

iii. The rate of the forward reaction is greater than the rate of the reverse reaction as the system approaches equilibrium.

False.
As the system approaches equilibrium the reaction moves forward to produce product. During this phase the forward rate of reaction is higher than the reverse rate of reaction because the number of reactant particles is at its highest while the number of product particles is at its lowest.

b. Exothermic reactions proceed quickly at higher temperatures but are plagued, by uneconomical low yields. Using an energy profile for the above reaction and the Maxwell-Boltzmann energy distribution curves explain why, at high temperatures, the rate of reaction is high but the equilibrium yield is low. Solution (Video)

c. The rate of the reaction above is given by the expression ($\Delta[NH_3]/\Delta t$), where t is time in seconds. Which one of the expressions below is a valid expression for the rate of formation of NH_3? Explain

i. $½\, \Delta[H_2]/\Delta t = \Delta[NH_3]/\Delta t$
ii. $3 \times \Delta[H_2]/\Delta t = \Delta[NH_3]/\Delta t$
iii. $-\Delta[N_2]/\Delta t = \Delta[NH_3]/\Delta t$
iv. $-2\Delta[N_2]/\Delta t = \Delta[NH_3]/\Delta t$
v. $-3\Delta[H_2]/2\Delta t = \Delta[NH_3]/\Delta t$

Nitrogen is used up at half the rate (mol/time) as NH_3 is being formed. This is according to the stoichiometry of the equation. The rate of nitrogen use has a negative sign as it is decreasing so we multiply it by -2 to get the positive rate of NH_3 formation.