SL & HL Questions on Oxidation & reduction (3)

1. The following procedure was used to determine the percentage of copper in a coin.

Step 1. A coin with a mass of 3.03 g was completely dissolved in excess concentrated nitric acid, $HNO_3(aq)$. After the excess nitric acid had been neutralised and the oxides of nitrogen removed all the solution of copper(II) nitrate obtained was transferred into a volumetric flask and the total volume made up to 100 cm^3 with distilled water.

Step 2. 10.0 cm^3 of this diluted copper(II) nitrate solution was pipetted into a conical flask and excess potassium iodide solution was added. The following reaction occurred:

$$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$$

Step 3. The mixture was then titrated with 2.00 x 10^{-1} mol dm^{-3} sodium thiosulfate solution, $Na_2S_2O_3(aq)$. 21.4 cm^3 of this thiosulfate solution were required to react with all the iodine produced in the preceding reaction.

The reaction between iodine and thiosulfate ions is:

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

(a) One of the products formed when copper, Cu(s) reacted with concentrated nitric acid, $HNO_3(aq)$ in **Step 1** is nitrogen dioxide, $NO_2(g)$.

i. Deduce the balanced equation for this reaction.

ii. Identify which species has been oxidised and which species has been reduced during this reaction.

(b) **i.** Identify the reducing agent in the reaction between copper ions and iodide ions in **Step 2**.

ii. State the change in oxidation state that occurs for the copper ions.

(c) Identify the reducing agent in the reaction between iodine and thiosulfate ions in **Step 3**.

(d) Calculate the mass of copper in the coin.

(e) Calculate the percentage of copper in the coin.

2. Some domestic heating fuel contains sulfur.

To determine the sulfur content of a domestic fuel, a 10.0 g sample of the fuel was burnt completely in oxygen. The products of the combustion, which consisted solely of carbon dioxide, $CO_2(g)$, sulfur dioxide, $SO_2(g)$, and water vapour, $H_2O(g)$, were bubbled through water.

It can be assumed that all the sulfur dioxide produced dissolved completely in the water whereas that the amount of carbon dioxide that dissolved was negligible.

The solution formed was titrated with an acidified solution of 2.50×10^{-2} mol dm^{-3} potassium manganate(VII), $KMnO_4(aq)$.The titration was complete after 12.0 cm^3 of the potassium rmanganate(VII) solution had been added.

i. Describe how the end point of the titration was indicated during the titration.

ii. Knowing that $SO_4^{2-}(aq)$ ions are formed, deduce the balanced oxidation and reduction half-equations for the titration reaction and hence determine the overall equation for the reaction.

iii. Calculate the percentage by mass of sulfur in the domestic fuel used.