Question 37 **(18 marks)**

The copper cycle is a series of reactions involving copper.

Step 1: 2.54 g of copper is added to excess concentrated nitric acid to produce copper(II) nitrate, nitrogen dioxide and water.

(a) Write balanced half-equations for the oxidation and reduction reactions and a balanced overall redox equation for the reaction in Step 1. (5 marks)

Oxidation half-equation	
Reduction half-equation	
Overall redox equation	

Step 2: Copper(II) nitrate is added to excess sodium hydroxide solution, according to the following equation:

$$Cu(NO_3)_2(aq) + 2\ NaOH(aq) \rightarrow Cu(OH)_2(s) + 2\ NaNO_3(aq)$$

(b) Describe all the observations for this reaction, including colour changes. (2 marks)

Step 3: Copper(II) hydroxide is heated to produce copper(II) oxide and water vapour.

(c) Write an equation for Step 3, including state symbols. (3 marks)

Step 4: Copper(II) oxide is added to excess dilute sulfuric acid solution.

(d) Write an equation for this reaction. (2 marks)

Step 5: Excess magnesium metal is added to the copper(II) sulfate solution.

(e) Write an equation for this reaction. (2 marks)

(f) If 0.616 g of magnesium was required to react with the copper(II) sulfate, calculate the mass of copper produced and, therefore, the percentage yield of copper from the series of reactions. (4 marks)