Q1. (a) An unknown metal carbonate reacts with hydrochloric acid according to the following equation.

$$M_2CO_3(aq) + 2HCl(aq) \rightarrow 2MCl(aq) + CO_2(g) + H_2O(l)$$

A 3.44 g sample of M_2CO_3 was dissolved in distilled water to make 250 cm^3 of solution. A 25.0 cm^3 portion of this solution required 33.2 cm^3 of 0.150 mol dm^{-3} hydrochloric acid for complete reaction.

(i) Calculate the amount, in moles, of HCl in 33.2 cm^3 of 0.150 mol dm^{-3} hydrochloric acid. Give your answer to 3 significant figures.

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(1)

(ii) Calculate the amount, in moles, of M_2CO_3 that reacted with this amount of HCl. Give your answer to 3 significant figures.

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(1)

(iii) Calculate the amount, in moles, of M_2CO_3 in the 3.44 g sample. Give your answer to 3 significant figures.

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(1)

(iv) Calculate the relative formula mass, M_r, of M_2CO_3 Give your answer to 1 decimal place.

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(1)

(v) Hence determine the relative atomic mass, A_r, of the metal M and deduce its identity.

A_r of M .....

Identity of M .....

(2)

(b) In another experiment, 0.658 mol of CO_2 was produced. This gas occupied a volume of 0.0220 m^3 at a pressure of 100 kPa.
Calculate the temperature of this CO_2 and state the units.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

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(3)

(c) Suggest **one** possible danger when a metal carbonate is reacted with an acid in a sealed flask.

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(1)

(d) In a different experiment, 6.27 g of magnesium carbonate were added to an excess of sulfuric acid. The following reaction occurred.

$$MgCO_3 + H_2SO_4 \rightarrow MgSO_4 + CO_2 + H_2O$$

(i) Calculate the amount, in moles, of $MgCO_3$ in 6.27 g of magnesium carbonate.

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(2)

(ii) Calculate the mass of $MgSO_4$ produced in this reaction assuming a 95% yield.

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(3)
(Total 15 marks)

Q2. In an experiment to determine the concentration of a solution of sodium hydroxide, 25.0 cm^3 of 0.100 mol dm^{-3} hydrochloric acid were transferred to a conical flask. An indicator was added to the flask. The solution of sodium hydroxide was then added to the flask from a burette.

(a) State a suitable amount of indicator solution that should be added to the flask.

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(1)

(b) State why it is important to fill the space below the tap in the burette with alkali before beginning the titration.

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(1)
(Total 2 marks)

Q3. Hydrogen peroxide is sold commercially as an aqueous solution containing approximately 60 g dm^{-3} of hydrogen peroxide.

(a) Use data from the Periodic Table to calculate the M_r of hydrogen peroxide. Give your answer to the appropriate precision.

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(1)

(b) Calculate the concentration, in mol dm^{-3}, of a solution containing 60.0 g dm^{-3} of hydrogen peroxide.

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(1)

(c) The concentration of hydrogen peroxide in a hair bleach is 0.050 mol dm^{-3}. Use your answer from (b) to calculate the dilution factor needed to make the commercial hydrogen peroxide solution suitable for use in this hair bleach. Show your working.

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(2)
(Total 4 marks)

Q4. Hydrogen peroxide is used as an oxidising agent in the preparation of transition metal complexes.

(a) Consider the following reaction scheme. All the complexes are in aqueous solution.

$$[Co(H_2O)_6]^{2+} \xrightarrow{\text{Reaction 1}} \text{cobalt(II) complex} \xrightarrow[H_2O_2]{\text{Reaction 2}} [Co(NH_3)_6]^{3+}$$

(i) Identify a reagent for Reaction **1** and describe the colour change that occurs.

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(3)

(ii) State the colour of the final solution formed in Reaction **2**.

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(1)

(b) Consider the following reaction scheme. All the complexes are in aqueous solution.

$$[Cr(H_2O)_6]^{3+} \xrightarrow[\text{Excess NaOH(aq)}]{\text{Reaction 3}} \text{chromium(III) complex} \xrightarrow[H_2O_2]{\text{Reaction 4}} CrO_4^{2-}$$

(i) For Reaction **3**, state the colour of the initial and of the final solution and write an equation for the reaction.

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(4)

(ii) Write a half-equation for the reduction of hydrogen peroxide to hydroxide ions.

Deduce an overall equation for Reaction **4** and state the colour of the final solution.

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(4)

(c) The concentration of a hydrogen peroxide solution can be determined by titration with acidified potassium manganate(VII) solution. In this reaction the hydrogen peroxide is oxidised to oxygen gas.

A 5.00 cm^3 sample of the hydrogen peroxide solution was added to a volumetric flask and made up to 250 cm^3 of aqueous solution. A 25.0 cm^3 sample of this diluted solution was acidified and reacted completely with 24.35 cm^3 of 0.0187 mol dm^{-3} potassium manganate(VII) solution.

Write an equation for the reaction between acidified potassium manganate(VII) solution and hydrogen peroxide.
Use this equation and the results given to calculate a value for the concentration, in mol dm^{-3}, of the original hydrogen peroxide solution.

(If you have been unable to write an equation for this reaction you may assume that 3 mol of $KMnO_4$ react with 7mol of H_2O_2. This is **not** the correct reacting ratio.)

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(5)
(Total 17 marks)

Q5.(a) Sodium hydrogencarbonate ($NaHCO_3$) can also be used to neutralise ethanoic acid spillages. The equation for this reaction is shown below.

$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2$$

State the ideal gas equation.

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(1)

(b) There are several methods by which ethanoic acid is synthesised on an industrial scale. One method is the oxidation of butane in the presence of metal ion catalysts. Balance the equation given below which summarises this reaction.

$$.....C_4H_{10} + ...O_2 \longrightarrow .....CH_3COOH + ...H_2O$$

(1)

(c) A second method by which ethanoic acid is synthesised involves the oxidative fermentation of ethanol in the presence of bacteria. The equation representing this

reaction is given below.

$$C_2H_5OH + O_2 \longrightarrow CH_3COOH + H_2O$$

In a small scale experiment using this second method it was found that 23.0 g of ethanol produced only 4.54 g of ethanoic acid. Calculate the percentage yield for this experiment.

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(2)
(Total 4 marks)

Q6.(a) The manufacturer of vinegar buys concentrated ethanoic acid as a 15.0 mol dm^{-3} solution. In case of an accidental spillage of this ethanoic acid the manufacturer always has sodium carbonate readily available to neutralise the acid. The equation for this reaction is shown below.

$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + H_2O + CO_2$$

(i) Calculate the amount, in moles, of ethanoic acid in 10.0 cm^3 of a 15.0 mol dm^{-3} solution.

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(1)

(ii) Use your answer from part (i) to calculate the amount, in moles, of sodium carbonate needed to react completely with this amount of ethanoic acid.

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(1)

(iii) Use data from the Periodic Table to calculate the relative formula mass of sodium carbonate. Give your answer to the appropriate precision.

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(1)

(iv) Use your answers from parts (ii) and (iii) to determine the minimum mass of sodium carbonate needed to react completely with 10.0 cm^3 of the 15.0 mol dm^{-3} solution of ethanoic acid.

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(1)

(b) State **one** hazard when using concentrated ethanoic acid and **one** safety precaution you would take to minimise this hazard.

Hazard .....

Precaution .....

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(1)

(Total 5 marks)