Q1. (a) One isotope of sodium has a relative mass of 23.

(i) Define, in terms of the fundamental particles present, the meaning of the term *isotopes*.

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(ii) Explain why isotopes of the same element have the same chemical properties.

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(iii) Calculate the mass, in grams, of a single atom of this isotope of sodium. (The Avogadro constant, L, is 6.023×10^{23} mol^{-1})

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(5)

(b) Give the electronic configuration, showing all sub-levels, for a sodium atom.

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(1)

(c) Explain why chromium is placed in the d block in the Periodic Table.

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(1)

(d) An atom has half as many protons as an atom of ^{28}Si and also has six fewer neutrons than an atom of ^{28}Si. Give the symbol, including the mass number and the atomic number, of this atom.

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(2)
(Total 9 marks)

Q2. (a) The equation for the reaction between magnesium carbonate and hydrochloric acid is given below.

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$$

When 75.0 cm^3 of 0.500 mol dm^{-3} hydrochloric acid were added to 1.25 g of impure $MgCO_3$ some acid was left unreacted. This unreacted acid required 21.6 cm^3 of a 0.500 mol dm^{-3} solution of sodium hydroxide for complete reaction.

(i) Calculate the number of moles of HCl in 75.0 cm^3 of 0.500 mol dm^{-3} hydrochloric acid.

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(ii) Calculate the number of moles of NaOH used to neutralise the unreacted HCl.

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(iii) Show that the number of moles of HCl which reacted with the $MgCO_3$ in the sample was 0.0267

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(iv) Calculate the number of moles and the mass of $MgCO_3$ in the sample, and hence deduce the percentage by mass of $MgCO_3$ in the sample.

Moles of $MgCO_3$ .....

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Mass of $MgCO_3$ .....

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Percentage of $MgCO_3$ .....

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(8)

(b) A compound contains 36.5% of sodium and 25.5% of sulphur by mass, the rest being oxygen.

(i) Use this information to show that the empirical formula of the compound is Na_2SO_3

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(ii) When Na_2SO_3 is treated with an excess of hydrochloric acid, aqueous sodium chloride is formed and sulphur dioxide gas is evolved. Write an equation to represent this reaction.

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(4)
(Total 12 marks)

Q3. Which one of the following contains the greatest number of moles of methanol? (The Avogadro number (L) is 6.02 × 10^{23}, the relative molecular mass (M_r) of methanol is 32.)

A 6.6 × 10^{22} molecules

B 3.3 g of methanol

C 2.5 × 10^{-3} m^3 of methanol vapour at 300 K and 100 kPa

D 70 cm^3 of 1.5 M aqueous methanol

(Total 1 mark)

Q4. Use the information below to answer this question.

A saturated solution of magnesium hydroxide, $Mg(OH)_2$, contains 0.1166 g of $Mg(OH)_2$ in 10.00 dm^3 of solution. In this solution the magnesium hydroxide is fully dissociated into ions.

Which one of the following is the concentration of $Mg^{2+}(aq)$ ions in the saturated solution?

A 2.82 × 10^{-2} mol dm^{-3}

B 2.00 × 10^{-3} mol dm^{-3}

C 2.82 × 10^{-3} mol dm^{-3}

D 2.00 × 10^{-4} mol dm^{-3}

(Total 1 mark)

Q5. (a) A sample of ethanol vapour, C_2H_5OH (M_r = 46.0), was maintained at a pressure of 100 kPa and at a temperature of 366K.

(i) State the ideal gas equation.

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(ii) Use the ideal gas equation to calculate the volume, in cm^3, that 1.36 g of ethanol vapour would occupy under these conditions.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

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(5)

(b) Magnesium nitride reacts with water to form magnesium hydroxide and ammonia.

(i) Balance the equation, given below, for the reaction between magnesium nitride and water.

$$Mg_3N_2 + H_2O \rightarrow Mg(OH)_2 + NH_3$$

(ii) Calculate the number of moles, and hence the number of molecules, of NH_3 in 0.263 g of ammonia gas.
(The Avogadro constant $L = 6.02 \times 10^{23}$ mol^{-1})

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(4)

(c) Sodium carbonate is manufactured in a two-stage process as shown by the equations below.

$$NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 + NH_4Cl$$

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

Calculate the maximum mass of sodium carbonate which could be obtained from 800 g of sodium chloride.

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(4)
(Total 13 marks)