1. The relative molecular mass of aluminium chloride is 267 and its composition by mass is 20.3% Al and 79.7% chlorine. Determine the empirical and molecular formulas of aluminium chloride.

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    (Total 4 marks)

2. Sodium reacts with water as follows.

    $$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$
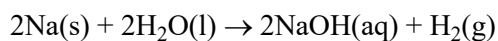
    1.15 g of sodium is allowed to react completely with water. The resulting solution is diluted to 250 cm^3. Calculate the concentration, in mol dm^{-3}, of the resulting sodium hydroxide solution.

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    (Total 3 marks)

3. (i) Calcium carbonate is added to separate solutions of hydrochloric acid and ethanoic acid of the same concentration. State **one** similarity and **one** difference in the observations you could make.

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(ii) Write an equation for the reaction between hydrochloric acid and calcium carbonate.

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(iii) Determine the volume of 1.50 mol dm^{-3} hydrochloric acid that would react with exactly 1.25 g of calcium carbonate.

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(iv)   Calculate the volume of carbon dioxide, measured at 273 K and
        1.01×10^5 Pa, which would be produced when 1.25 g of calcium carbonate reacts
        completely with the hydrochloric acid.

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        (2)
        (Total 9 marks)

4.   An organic compound, **A**, containing only the elements carbon, hydrogen and oxygen was
        analysed.

(a)   **A** was found to contain 54.5% C and 9.1% H by mass, the remainder being oxygen.
        Determine the empirical formula of the compound.

        (3)

(b)   A 0.230 g sample of **A**, when vaporized, had a volume of 0.0785 dm^3 at 95° C and 102
        kPa. Determine the relative molecular mass of **A**.

        (3)

(c) Determine the molecular formula of **A** using your answers from parts (a) and (b).

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(1)
(Total 7 marks)

5. An organic compound **A** contains 62.0% by mass of carbon, 24.1% by mass of nitrogen, the remainder being hydrogen.

(i) Determine the percentage by mass of hydrogen and the empirical formula of **A**.

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(3)

(ii) Define the term relative molecular mass.

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(2)

(iii) The relative molecular mass of **A** is 116. Determine the molecular formula of **A**.

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(1)
(Total 6 marks)

6. An organic compound A contains 62.0% by mass of carbon, 24.1% by mass of nitrogen, the remainder being hydrogen.

(i) Determine the percentage by mass of hydrogen and the empirical formula of **A**.

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(3)

(ii) Define the term *relative molecular mass*.

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(2)

(iii) The relative molecular mass of **A** is 116. Determine the molecular formula of **A**.

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(1)
(Total 6 marks)

7.   Propane and oxygen react according to the following equation.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$
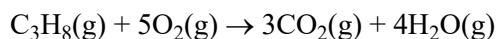
Calculate the volume of carbon dioxide and water vapour produced and the volume of oxygen remaining, when 20.0 dm^3 of propane reacts with 120.0 dm^3 of oxygen. All gas volumes are measured at the same temperature and pressure.

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(Total 3 marks)

8.   State and explain what would happen to the pressure of a given mass of gas when its absolute temperature and volume are both doubled.

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(Total 3 marks)

9. (i) Crocetin consists of the elements carbon, hydrogen and oxygen. Determine the empirical formula of crocetin, if 1.00 g of crocetin forms 2.68 g of carbon dioxide and 0.657 g of water when it undergoes complete combustion.

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(6)

(ii) Determine the molecular formula of crocetin given that 0.300 mole of crocetin has a mass of 98.5 g

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(2)
(Total 8 marks)

10. A solution containing ammonia requires 25.0 cm^3 of 0.100 mol dm^{-3} hydrochloric acid to reach the equivalence point of a titration.

(i) Write an equation for the reaction of ammonia with hydrochloric acid

(1)

(ii) Calculate the amount (in mol) of hydrochloric acid and ammonia that react.

(2)

(iii) Calculate the mass of ammonia in the solution.

(2)
(Total 5 marks)

11. A toxic gas, A, consists of 53.8% nitrogen and 46.2% carbon by mass. At 273 K and 1.01×10^5 Pa, 1.048 g of A occupies 462 cm^3. Determine the empirical formula of A. Calculate the molar mass of the compound and determine its molecular structure.

(Total 3 marks)

12. 100 cm^3 of ethene, C_2H_4, is burned in 400 cm^3 of oxygen, producing carbon dioxide and some liquid water. Some oxygen remains unreacted.

(a) Write the equation for the complete combustion of ethene.

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(2)

(b) Calculate the volume of carbon dioxide produced and the volume of oxygen remaining.

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(2)
(Total 4 marks)

13. (a) Write an equation for the formation of zinc iodide from zinc and iodine.

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(1)

(b) 100.0 g of zinc is allowed to react with 100.0 g of iodine producing zinc iodide. Calculate the amount (in moles) of zinc and iodine, and hence determine which reactant is in excess.

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(3)

(c) Calculate the mass of zinc iodide that will be produced.

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(1)
(Total 5 marks)

14. An oxide of copper was reduced in a stream of hydrogen as shown below.
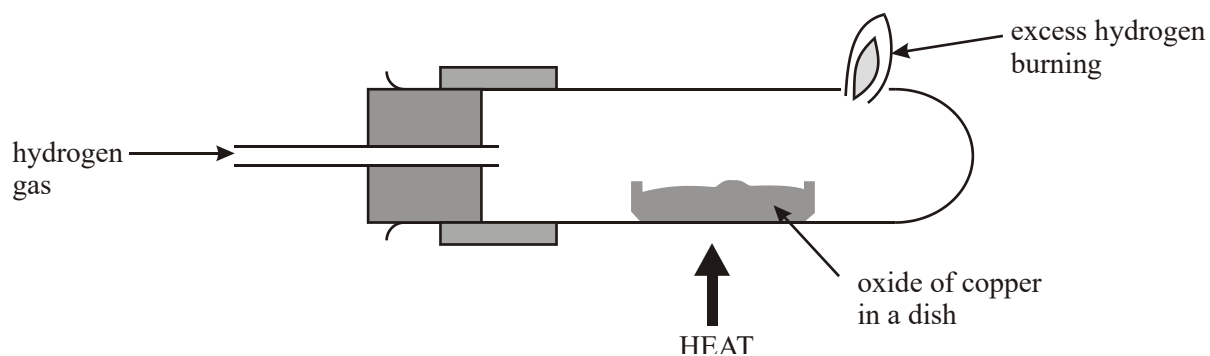
After heating, the stream of hydrogen gas was maintained until the apparatus had cooled.

The following results were obtained.

Mass of empty dish = 13.80 g
Mass of dish and contents before heating = 21.75 g
Mass of dish and contents after heating and leaving to cool = 20.15 g

(a) Explain why the stream of hydrogen gas was maintained until the apparatus cooled.

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(1)

(b) Calculate the empirical formula of the oxide of copper using the data above, assuming complete reduction of the oxide.

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(3)

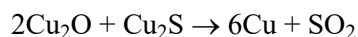(c) Write an equation for the reaction that occurred.

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(1)

(d)   State **two** changes that would be observed inside the tube as it was heated.

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(2)
(Total 7 marks)

15.   Copper metal may be produced by the reaction of copper(I) oxide and copper(I) sulfide according to the below equation.

$$2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$$

A mixture of 10.0 kg of copper(I) oxide and 5.00 kg of copper(I) sulfide was heated until no further reaction occurred.

(a)   Determine the limiting reagent in this reaction, showing your working.

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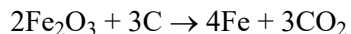**(3)**

(b)   Calculate the maximum mass of copper that could be obtained from these masses of reactants.

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(2)
(Total 5 marks)

16.   The reaction below represents the reduction of iron ore to produce iron.

$$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$$

A mixture of 30 kg of Fe_2O_3 and 5.0 kg of C was heated until no further reaction occurred. Calculate the maximum mass of iron that can be obtained from these masses of reactants.

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(Total 5 marks)

17. 0.502 g of an alkali metal sulfate is dissolved in water and excess barium chloride solution, $BaCl_2$(aq) is added to precipitate all the sulfate ions as barium sulfate, $BaSO_4$(s). The precipitate is filtered and dried and weighs 0.672 g.

(a) Calculate the amount (in mol) of barium sulfate formed.

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(2)

(b) Determine the amount (in mol) of the alkali metal sulfate present.

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(1)

(c) Determine the molar mass of the alkali metal sulfate and state its units.

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(2)

(d) Deduce the identity of the alkali metal, showing your workings.

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(2)

(e)   Write an equation for the precipitation reaction, including state symbols.

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(2)
(Total 9 marks)

18.   0.600 mol of aluminium hydroxide is mixed with 0.600 mol of sulfuric acid, and the following reaction occurs:

$$2Al(OH)_3(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 6H_2O(l)$$
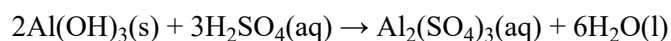
(a)   Determine the limiting reactant.

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(2)

(b)   Calculate the mass of $Al_2(SO_4)_3$ produced.

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(2)

(c)   Determine the amount (in mol) of excess reactant that remains.

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(1)

(Total 8 marks)