Cambridge AS & A Level

CHEMISTRY

Paper 2

Topical Past Paper Questions

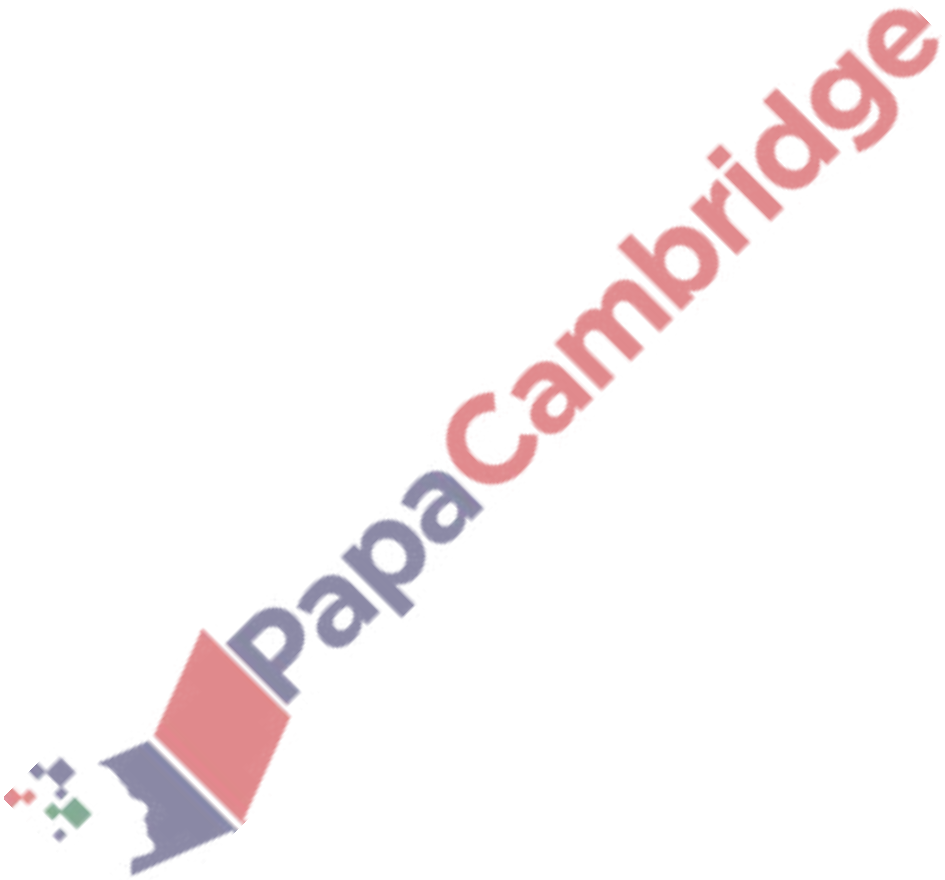
+ Answer Scheme

2015 - 2021

PapaCambridge

Chapter 1

Atoms, molecules and stoichiometry



1.1 Reacting masses and volumes (of solutions and gases)

1. 9701_s17_qp_21 Q: 1

Combustion data can be used to calculate the empirical formula, molecular formula and relative molecular mass of many organic compounds.

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

.....

.....

.....

..... [2]

(b) **T** is an alcohol, C_xH_yO. A gaseous sample of **T** occupied a volume of 20 cm^3 at 120 °C and 100 kPa.

The sample was completely burned in 200 cm^3 of oxygen (an excess). The final volume, measured under the same conditions as the gaseous sample, was 250 cm^3.

Under these conditions, all water present is vaporised. Removal of the water vapour from the gaseous mixture decreased the volume to 170 cm^3.

Treating the remaining gaseous mixture with concentrated alkali, to absorb carbon dioxide, decreased the volume to 110 cm^3.

The equation for the complete combustion of **T** can be represented as shown.

$$C_xH_yO + zO_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

(i) Use the data given to calculate the value of *x*.

x = ... [1]

(ii) Use the data given to calculate the value of *y*.

y = ... [1]

If you were unable to calculate values for x and y then use $x = 4$ and $y = 10$ for the remaining parts of this question. These are **not** the correct values.

(iii) Complete the equation for the complete combustion of the alcohol, **T**.

..... + ...O_2 → .....CO_2 + ...H_2O

[1]

(iv) Give the skeletal formulae for two possible structures of **T**.

Name each alcohol.

.....	.....

[2]

(v) Use the general gas equation to calculate the mass of **T** present in the original 20 cm^3 gaseous sample, which was measured at 120 °C and 100 kPa.

Give your answer to **three** significant figures. Show your working.

mass = ... g [3]

[Total: 10]

2. 9701_m16_qp_22 Q: 2

Spathose is an iron ore that contains iron(II) carbonate, $FeCO_3$. The percentage of iron(II) carbonate in spathose can be determined by titration with acidified potassium dichromate(VI) solution using a suitable indicator.

The ionic equation is shown below.

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$$

(a) A 5.00 g sample of spathose was reacted with excess concentrated hydrochloric acid and then filtered.
The filtrate was made up to 250 cm^3 in a volumetric flask with distilled water.

A 25.0 cm^3 sample of the standard solution required 27.30 cm^3 of 0.0200 mol dm^{-3} dichromate(VI) solution for complete reaction.

(i) Calculate the amount, in moles, of dichromate(VI) ions used in the titration.

amount = ... mol [1]

(ii) Use your answer to **(i)** to calculate the amount, in moles, of Fe^{2+} present in the 25.0 cm^3 sample.

amount = ... mol [1]

(iii) Use your answer to **(ii)** to calculate the amount, in moles, of Fe^{2+} present in the 250 cm^3 volumetric flask.

amount = ... mol [1]

(iv) Use your answer to **(iii)** to calculate the mass of iron(II) carbonate present in the sample of spathose.

mass = ... g [2]

(v) Calculate the percentage of iron(II) carbonate in the sample of spathose.

percentage of iron(II) carbonate = ... % [1]

(b) Iron ores containing iron(III) compounds can be analysed using a similar method.

A standard solution of an aqueous iron(III) compound is reacted with aqueous tin(II) chloride. Aqueous tin(IV) chloride and aqueous iron(II) chloride are the products of this reaction.

(i) Write an **ionic** equation for this reaction. Do not include state symbols.

..... [2]

(ii) Any excess tin(II) chloride can be removed by reaction with $HgCl_2$(aq). A white precipitate of Hg_2Cl_2 is produced.

Complete the equation for this reaction.

.....(.....) + ...$HgCl_2$(aq) → $SnCl_4$(.....) + Hg_2Cl_2(.....)

[2]

[Total: 10]

3. 9701_w16_qp_21 Q: 1

A 0.17 g sample of a Group 14 chloride, **X**Cl_4, reacted with water to produce an oxide, **X**O_2, and HCl.

equation 1 **X**Cl_4(s) + $2H_2O$(l) → **X**O_2(s) + 4HCl(aq)

The HCl produced was absorbed in 100 cm^3 of 0.10 mol dm^{-3} sodium hydroxide solution (an excess).

In a titration, the unreacted sodium hydroxide solution required 30.0 cm^3 of 0.20 mol dm^{-3} hydrochloric acid for complete neutralisation.

(a) Calculate the amount, in moles, of hydrochloric acid used in the titration to neutralise the unreacted sodium hydroxide solution.

amount = ... mol [1]

(b) Write the equation for the reaction between hydrochloric acid and sodium hydroxide.

..... [1]

(c) Calculate the amount, in moles, of sodium hydroxide neutralised in the titration.

amount = ... mol [1]

(d) Calculate the amount, in moles, of sodium hydroxide that reacted with the HCl produced by the reaction in equation 1.

amount = ... mol [1]

(e) Calculate the amount, in moles, of HCl produced by the reaction in equation 1.

amount = ... mol [1]

(f) Calculate the amount, in moles, of **X**Cl_4 in the original 0.17 g sample.

amount = ... mol [1]

(g) Calculate the molecular mass, M_r, of **X**Cl_4.

M_r = ... [1]

(h) Calculate the relative atomic mass, A_r, of **X** and suggest its identity.

A_r of **X** = ...

identity of **X** .....
[2]

[Total: 9]

4. 9701_w16_qp_22 Q: 1

A 0.50 g sample of a Group 2 metal, **M**, was added to 40.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid (an excess).

equation 1 $\mathbf{M}(s) + 2HCl(aq) \rightarrow \mathbf{M}Cl_2(aq) + H_2(g)$

(a) Calculate the amount, in moles, of hydrochloric acid present in 40.0 cm^3 of 1.00 mol dm^{-3} HCl.

amount = ... mol [1]

(b) When the reaction had finished, the resulting solution was made up to 100 cm^3 in a volumetric flask.

A 10.0 cm^3 sample of the solution from the volumetric flask required 15.0 cm^3 of 0.050 mol dm^{-3} sodium carbonate solution, Na_2CO_3, for complete neutralisation of the remaining hydrochloric acid.

(i) Write the equation for the complete reaction of sodium carbonate with hydrochloric acid.

..... [1]

(ii) Calculate the amount, in moles, of sodium carbonate needed to react with the hydrochloric acid in the 10.0 cm^3 sample from the volumetric flask.

amount = ... mol [1]

(iii) Calculate the amount, in moles, of hydrochloric acid in the 10.0 cm^3 sample.

amount = ... mol [1]

(iv) Calculate the total amount, in moles, of hydrochloric acid remaining after the reaction shown in equation 1.

amount = ... mol [1]

(v) Use your answers to **(a)** and **(b)(iv)** to calculate the amount, in moles, of hydrochloric acid that reacted with the 0.50 g sample of **M**.

amount = ... mol [1]

(vi) Use your answer to **(v)** and equation 1 to calculate the amount, in moles, of **M** in the 0.50 g sample.

amount = ... mol [1]

(vii) Calculate the relative atomic mass, A_r, of **M** and identify **M**.

A_r of **M** = ...

identity of **M** = ...
[2]

[Total: 9]