Chemical Equations: Reacting Masses

Question Paper

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Chemistry Lab Skills 1
Sub Topic	Chemical Equations: Reacting Masses
Booklet	Question Paper

Time Allowed: **74 minutes**

Score: **/61**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 Washing soda is hydrated sodium carbonate, $Na_2CO_3.xH_2O$, where the number of moles of water of crystallization, x, can vary.

A sample of washing soda is analysed. Two methods are used to determine the value of x in the sample.

Method 1: Heating

2.50 g of the washing soda is placed in a crucible. The crucible is gently heated for three minutes and then heated strongly for five minutes. The mass of the solid after heating is 1.06 g.

$$Na_2CO_3.xH_2O(s) \rightarrow Na_2CO_3(s) + xH_2O(g)$$ **Equation 1**

(a) Suggest why the crucible is heated gently for the first three minutes.

(1)

....

....

(b) What additional step after heating strongly for five minutes is needed to make sure that all of the water of crystallization has been removed?

(1)

....

....

(c) What is the correct chemical term for sodium carbonate without water of crystallization?

(1)

....

(d) (i) Calculate the number of moles of sodium carbonate that remain after heating the sample, assuming that all of the water of crystallization has been removed.

(2)

(ii) Calculate the number of moles of water lost from the sample of washing soda on heating.

(1)

(iii) Hence deduce the value of x in the sample of washing soda, $Na_2CO_3.xH_2O$, obtained using Method 1.

(1)

x = ...

Method 2: Titration

Sodium carbonate reacts with hydrochloric acid as follows:

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$$ **Equation 2**

A 2.50 g sample of the washing soda is placed in a beaker and dissolved in deionized water. This solution is poured into a 250 cm^3 volumetric flask, made up to the mark and mixed thoroughly.

A pipette is then used to transfer 25.00 cm^3 of the washing soda solution to each of three conical flasks. A burette is filled with hydrochloric acid, of concentration 0.100 mol dm^{-3}, and titrations are carried out. The results are shown in the table.

Titration numbers	1	2	3
Burette reading (final) / cm^3	17.00	33.55	16.45
Burette reading (initial) / cm^3	0.00	17.00	0.00
Titre / cm^3	17.00	16.55	16.45

(e) What should be done to make sure that all of the washing soda is transferred to the volumetric flask?

(1)

....

....

(f) Explain why only titrations 2 and 3 are used to calculate the mean titre.

(1)

....

....

(g) (i) Calculate the mean titre, and then calculate the number of moles of hydrochloric acid in the mean titre.

(1)

(ii) Using your answer to part (g)(i) and **Equation 2**, calculate the number of moles of sodium carbonate present in 25 cm^3 of the washing soda solution.

(1)

(iii) Hence calculate the total number of moles of sodium carbonate present in 250 cm^3 of the washing soda solution.

(1)

(iv) Calculate the molar mass of the hydrated washing soda, $Na_2CO_3.xH_2O$. Hence deduce the value of x in the sample of washing soda from the data in Method 2.

(2)

x = ...

(h) A student carrying out Method 2 overshot the end-point of each titration.

Explain how this would affect the calculated value of x.

(2)

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....

(Total for Question 1 = 16 marks)

2 A white powder is the carbonate of an element in Group 2. Its formula can be written XCO_3.

0.150 g of the pure carbonate was mixed with excess dilute hydrochloric acid.

The following reaction occurred.

$$XCO_3(s) + 2HCl(aq) \rightarrow XCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) Describe the test for carbon dioxide.

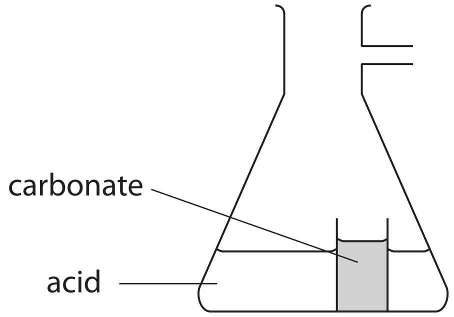
(1)

Test ....

Observation ....

(b) The carbonate and dilute hydrochloric acid were mixed in a conical flask with a side arm. Complete the diagram below to show how to collect the carbon dioxide and measure its volume.

(2)



(c) The volume of carbon dioxide, measured at room temperature and pressure, was 41 cm^3. Calculate the number of moles of gas formed.

[The molar volume of a gas under these conditions is 24 $dm^3\,mol^{-1}$.]

(1)

(d) Use your answer to (c), and the mass of the carbonate used, to calculate the molar mass of XCO_3.

(2)

(e) Deduce the value which this experiment gives for the relative atomic mass of **X**. Suggest which Group 2 metal is most likely to be **X**.

(1)

(f) Suggest why less gas is collected than expected. You should assume that the reaction is complete and no gas escapes.

(1)

....

....

(g) What would be observed when a flame test is carried out on XCO_3?

(1)

....

(h) A student attempted to determine the molar mass of other carbonates of Group 2 by the method used in this question.

The student measured the volume of gas produced by each carbonate, but replaced hydrochloric acid with sulfuric acid.

Explain why the results of the student's experiments would give very inaccurate values for the molar mass of some carbonates of Group 2.

(2)

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....

(Total for Question 2 = 11 marks)

3 Cyclohexene, C_6H_{10}, can be prepared by dehydrating cyclohexanol, $C_6H_{11}OH$, with phosphoric acid.

$$C_6H_{11}OH \xrightarrow{H_3PO_4} C_6H_{10} + H_2O$$

Procedure

Step 1 12.0 cm^3 of cyclohexanol was put into a small flask. 5 cm^3 of concentrated phosphoric acid, an excess, was added slowly to the cyclohexanol using a dropping pipette. Some anti-bumping granules were added to the mixture and the flask was set up for distillation.

Step 2 The portion of the distillate collected between 80 °C and 90 °C contained only cyclohexene and water.

Step 3 The distillate of cyclohexene and water was transferred to a separating funnel and a saturated solution of sodium chloride was added. Most of the water which was in the distillate went into the saturated sodium chloride layer.

Step 4 The crude cyclohexene was run out of the separating funnel and dried with anhydrous calcium chloride.

Step 5 The calcium chloride was removed by filtration through glass wool, and the liquid was redistilled to collect pure cyclohexene.

Cyclohexene has an unpleasant smell and irritates the eyes, so the entire experiment was carried out in a fume cupboard. In **Step 1**, tubing was connected to carry any uncondensed cyclohexene to a drain.

(a) The chemicals involved in this reaction are all hazardous if they make contact with the eyes, or if swallowed or inhaled.

Other than their effect on the eyes or their toxicity, state **two** different hazards of the chemicals involved in this reaction. Name the chemical associated with each hazard.

(2)

Chemical	Hazard

(b) Calculate the number of moles of cyclohexanol used in this experiment. The density of cyclohexanol is 0.962 g cm^{-3}.

(2)

(c) Draw a labelled diagram showing how to distil the reaction mixture in **Step 1** and collect the distillate boiling between 80 °C and 90 °C.

(4)

(d) Explain the difference between a 'dehydrating agent', such as the phosphoric acid used in **Step 1**, and a 'drying agent', such as the anhydrous calcium chloride used in **Step 4**.

(2)

....

....

....

....

(e) Suggest **one** advantage of using glass wool, rather than filter paper, when removing the calcium chloride in **Step 5**.

(1)

....

....

(f) Calculate the mass of cyclohexanol needed to obtain 10.0 g cyclohexene if the yield is 75%.

(3)

(g) The cyclohexene was tested by mixing it with bromine dissolved in an organic solvent.

(i) What colour change would be observed?

(1)

....

(ii) Give the **displayed** formula for the organic product of this reaction.

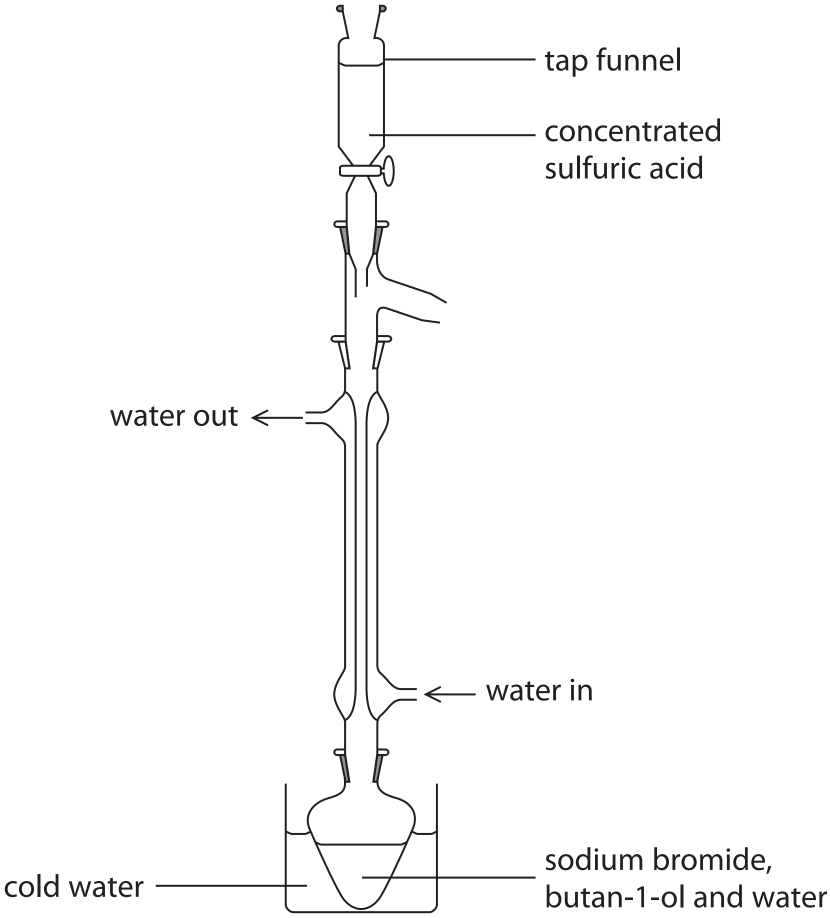
(1)

(Total for Question 3 = 16 marks)

4 One method of preparing 1-bromobutane from butan-1-ol is given below.

Procedure

Step 1 10 g of sodium bromide, 10 cm^3 of water and 7.5 cm^3 of butan-1-ol are placed in a flask. The flask is partially immersed in a large beaker of cold water. A condenser is fitted vertically in the neck of the flask as shown in the diagram.



Step 2 10 cm^3 of concentrated sulfuric acid is dripped slowly from the tap funnel into the reaction mixture. The flask is shaken gently.

Step 3 The tap funnel is removed from the top of the condenser and the flask is taken out of the cold water bath. The flask is then heated gently for about 45 minutes.

Step 4 The apparatus is then rearranged for distillation. The 1-bromobutane and water are distilled into a small beaker where they form two layers.

Step 5 The 1-bromobutane layer is separated from the water.

Step 6 The 1-bromobutane layer is washed with concentrated hydrochloric acid to remove unreacted butan-1-ol.

Step 7 The 1-bromobutane is then washed with dilute sodium carbonate solution.

You will need the following data to answer the questions.

Butan-1-ol, $CH_3CH_2CH_2CH_2OH$ $M_r = 74$

1-bromobutane, $CH_3CH_2CH_2CH_2Br$ $M_r = 137$

Liquid	Density / g cm^{-3}
butan-1-ol	0.81
water	1.0
concentrated hydrochloric acid	1.2
1-bromobutane	1.3

(a) The use of the beaker of cold water in **Step 1**, and the slow addition of concentrated sulfuric acid in **Step 2**, both prevent a reaction which gives unwanted **inorganic** products.

Identify **one** of these unwanted products. State the type of reaction occurring when these products form.

(2)

Product ....

Type of reaction ....

....

(b) (i) Explain why the condenser is set up so that the water flows from bottom to top, as shown in the diagram.

(1)

....

....

....

(ii) Without the reflux condenser, the procedure in **Step 2** would become more hazardous. Explain why.

(1)

....

....

(c) To achieve the best possible yield of 1-bromobutane, the purification stages should involve the minimum number of transfers of the organic product from one piece of apparatus to another.

(i) How could the water layer be removed from the small beaker in **Step 5** without transferring the organic product?

(1)

....

(ii) Name the apparatus you would use to carry out the washing of the crude 1-bromobutane in **Step 6**.

Describe how you would obtain the organic layer from this mixture.

(2)

....

....

....

....

(d) What is the purpose of **Step 7**?

(1)

....

....

(e) After **Step 7**, the crude 1-bromobutane is washed with pure water and separated again. Two further steps are needed to obtain a pure sample of 1-bromobutane.

State what these steps are. Detailed experimental procedures are not required, but you should name any reagents which are needed.

(3)

Step 8 ....

....

....

....

Step 9 ....

....

(f) (i) Calculate the mass of butan-1-ol used in **Step 1**.

(1)

(ii) In this experiment, a student obtained 7.5 g of 1-bromobutane.

Calculate the percentage yield of 1-bromobutane. Assume that each mole of butan-1-ol can produce a maximum of one mole of 1-bromobutane.

Give your answer to **two** significant figures.

(3)

(Total for Question 4 = 15 marks)

5 Butanone, $CH_3COCH_2CH_3$, can be prepared from butan-2-ol, $CH_3CH(OH)CH_2CH_3$, using the procedure below.

An organic solvent suitable for this procedure has a low boiling temperature and is extremely flammable, so adequate safety precautions must be taken.

Procedure

1. Place about 10 g of sodium dichromate(VI) and 20 cm^3 of distilled water in a conical flask. Shake the flask to dissolve the solid. Then slowly add about 8 cm^3 of concentrated sulfuric acid.

2. Dissolve 5.00 g of butan-2-ol in the organic solvent in a round-bottom flask. Stand the flask in a large beaker containing ice and water. Slowly add the acidified sodium dichromate(VI) solution through a funnel to the butan-2-ol solution in the flask.

3. When the addition is finished, leave the mixture to cool and separate the organic layer, which contains the butanone, from the aqueous layer.

4. Wash the organic layer with sodium hydrogencarbonate solution, and then with water. Discard the aqueous layer.

5. Add some sodium sulfate, Na_2SO_4, to the organic layer and wait until this solution is clear.

6. Decant the solution into a flask, and add a few anti-bumping granules. Use distillation to remove the solvent, which has a **lower** boiling temperature than butanone. The solvent boils between 32°C and 36°C.

(a) What colour change will be seen when the acidified sodium dichromate(VI) reacts with the butan-2-ol?

(1)

From .... to ....

(b) The reaction is exothermic. Other than the risk of explosion, why is it important to cool the flask in a beaker of ice and water in **step 2**?

(1)

....

....

....

....

(c) State the purpose of washing the crude butanone in **step 4** with sodium hydrogencarbonate solution. Describe the method used to carry out this process, naming the piece of apparatus used.

(3)

Purpose ....

Method ....

....

....

....

....

....

(d) What is the purpose of adding sodium sulfate in **step 5**?

(1)

....

....

(e) Draw a labelled diagram of the apparatus used in **step 6** to distil off the solvent from the organic layer. The diagram should show at least one precaution which must be taken when distilling an extremely flammable liquid.

(4)

(f) (i) Calculate the volume, in cm^3, of 5.00 g of butan-2-ol.

The density of butan-2-ol is 0.805 g cm^{-3}.

(1)

(ii) Each mole of butan-2-ol can produce a maximum yield of one mole of butanone.

Calculate the mass of butan-2-ol that would be required to make 3.00 g of butanone if the yield is 64%.

Relative molecular masses:

butan-2-ol	74.1
butanone	72.1

(3)

(Total for Question 5 = 14 marks)