Pearson Edexcel

Additional Assessment Materials

Summer 2021

Pearson Edexcel GCE in Chemistry 9CH0

Resource Set 1 – Topic Group 6

Questions based on practical work taken from any topic

(Public release version)

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Additional Assessment Materials, Summer 2021

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General guidance to Additional Assessment Materials for use in 2021

Context

- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an **optional** part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional Assessment Materials have been drawn from previous examination materials, namely past papers.
- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.

Purpose

- The purpose of this resource to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the mapping guidance which will map content and/or skills covered within each set of questions.
- These materials are only intended to support the summer 2021 series.

4 Compound **C** is a pink crystalline solid containing two cations and one anion.

(a) Three tests were carried out on **C**. The observation made for each test was recorded in the table.

(i) Complete the statements in the inference column by writing the names or formulae of the species.

(6)

Test	Observation	Inference
Test 1 Aqueous sodium hydroxide was added to solid **C** and the mixture warmed The gas evolved was tested with damp red litmus paper	The red litmus paper turned blue	The gas evolved was ammonia gas One of the cations in **C** is ammonium ion
Test 2 Concentrated hydrochloric acid was added to an aqueous solution of **C**	The pink solution turned blue	The other cation in **C** is cobalt ion The formula of the complex ion in the blue solution is $[CoCl_4]^{2-}_{(aq)}$
Test 3 Dilute hydrochloric acid and aqueous barium chloride were added to an aqueous solution of **C**	A white precipitate formed	The white precipitate is barium sulfate The anion in **C** is sulfate ion

(ii) Use the results of the tests in (a)(i) to give a formula of **C**.
Do not include water of crystallisation.

(1)

$Co(NH_4)_2(SO_4)_2$

(b) Write the **ionic** equation for the reaction between the cation in **C** and sodium hydroxide producing the gas in **Test 1**.
State symbols are not required.

(1)

$NH_4^+ + OH^- \rightarrow NH_3 + H_2O$

(c) State the type of reaction occurring in **Test 2**.

(1)

ligand substitution

(d) Give a reason why dilute hydrochloric acid is needed in **Test 3**.

(1)

to remove other elements in the compound that interfere with the test by forming their own unwanted precipitate

(Total for Question 4 = 10 marks)

5 This question is about extracting benzoic acid from a mixture of benzoic acid, C_6H_5COOH, and phenol, C_6H_5OH.

The following steps were carried out.

Step 1 A suitable mass of the mixture was placed in a separating funnel and some ether added. The funnel was shaken to dissolve the mixture.

Step 2 Aqueous sodium hydrogencarbonate was added to the separating funnel, and the contents shaken.

Step 3 Once the reaction was complete, the two layers were allowed to separate.

Step 4 The lower aqueous layer was removed and placed in a beaker.

Step 5 The ether layer in the separating funnel was washed with deionised water and the washings added to the beaker.

Step 6 Hydrochloric acid was added to the aqueous solution in the beaker to precipitate the benzoic acid.

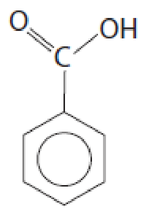
Step 7 The impure benzoic acid was filtered under reduced pressure.

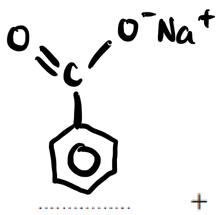
Step 8 The impure benzoic acid was purified by recrystallisation.

Step 9 The melting temperature of the purified benzoic acid was measured and compared with the literature value of 122 °C.

(a) Complete the equation for the reaction between benzoic acid and sodium hydrogencarbonate.

(2)



+ $NaHCO_3$ → 

+ H_2O + CO_2

(b) In Step **2** there is a pressure build-up in the separating funnel.

Describe how you would lower the pressure.

(1)

open the stopper on top of funnel often

(c) State why, in Step **4**, the aqueous layer was the lower of the two layers.

(1)

has lower density as dissolved in low density water

(d) Give a reason why, in Step **5**, the ether layer was washed with deionised water.

(1)

to ensure all of aqueous layer has been completely removed from it

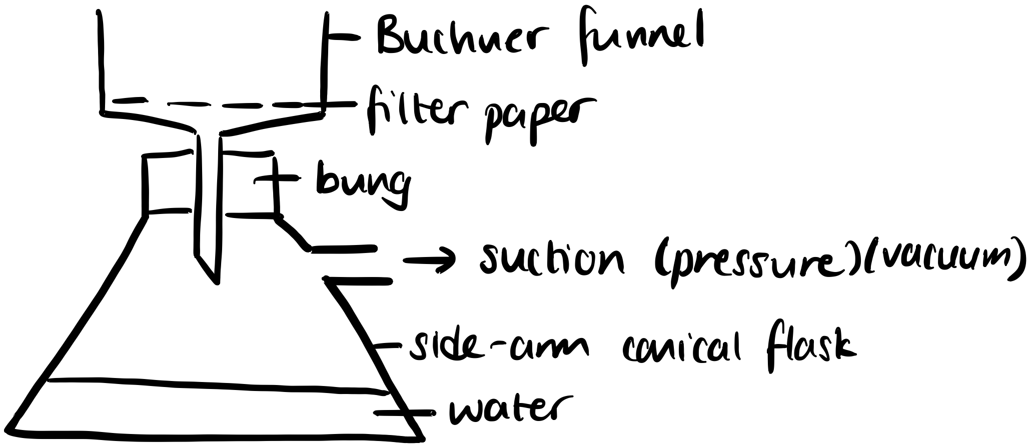
(e) Explain why the addition of hydrochloric acid in Step **6** results in the precipitation of benzoic acid.

(2)

HCl is a strong acid which is able to convert sodium benzoate to benzoic acid and as benzoic acid is insoluble in water, it will precipitate and recrystallise out

(f) Draw a diagram of the apparatus used in Step **7** to filter under reduced pressure.

(2)



(g) Benzoic acid can be purified in Step **8** because of its high solubility in hot water and low solubility in cold water.

Calculate the maximum number of benzoic acid molecules that can dissolve in 50.0 cm^3 of cold water if the solubility is 1.70 g per 1000 cm^3.

(3)

$$\frac{1.70g}{1000cm^3} \xrightarrow{\div 20} \frac{0.085g}{50\ cm^3}$$

Mr of Benzoic acid: $(7 \times 12) + (2 \times 16) + (1 \times 6) = 122$

$$\frac{Mass}{Mr} = \frac{0.085g}{122} = 6.97 \times 10^{-4}\ mol$$

Mol x Avogadro's Constant $= 6.97 \times 10^{-4}\ mol \times 6.022 \times 10^{23}\ mol^{-1} = 4.20 \times 10^{20}$ molecules

(h) The melting temperature range of the purified benzoic acid in Step **9** was 116–121 °C.

Compare this result with the literature value, giving a reason for any differences.

(2)

lower melting temperature obtained due to impure substances still present, water in this case, as purified benzoic acid in a crystalline solid disrupt forces holding solid together so less energy required to melt.

Range of temperature also indicates impurities in the substance.

(Total for Question 5 = 14 marks)

3 This question is about the identification of a Group 2 carbonate.

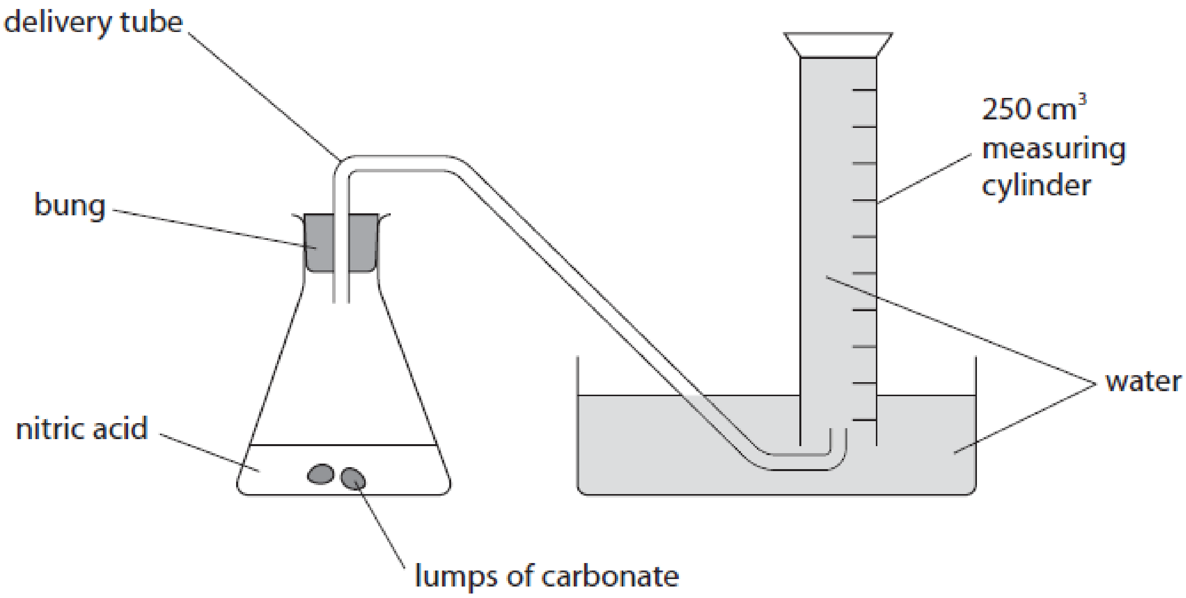
A chemistry teacher found a bottle containing lumps of a white solid. The original label was missing from the bottle. However, someone had written 'Group 2 carbonate' on the bottle. The lumps of the anhydrous white solid were pure and dry.

The chemistry teacher tried to identify the carbonate with the help of three students. The three students worked under identical conditions and shared the same weighing balance.

Student **1** recognised that if an acid is added to a carbonate, carbon dioxide is evolved. The student decided to measure the volume of carbon dioxide evolved when the Group 2 carbonate reacts with excess nitric acid.

The student knew that 1 mol of a Group 2 carbonate produces 1 mol of carbon dioxide.

Student **1** set up the apparatus shown below.



- Student **1** weighed out some of the Group 2 carbonate and added it to a 250 cm^3 conical flask.
- Student **1** then added 100 cm^3 of 0.200 $mol\,dm^{-3}$ nitric acid to the conical flask and replaced the bung.
- Student **1** measured the volume of gas collected in the inverted measuring cylinder at room temperature and pressure (r.t.p.) when all the Group 2 carbonate had reacted.
- Student **1** obtained the results shown in Table 1.

$$XCO_3 + 2HNO_3 \rightarrow X(NO_3)_2 + H_2O + CO_2$$

Measurement		Value
Mass of weighing bottle and carbonate	/ g	13.247
Mass of empty weighing bottle	/ g	12.431
Mass of carbonate used	/ g	0.816
Volume of acid used	/ cm^3	100
Volume of gas collected	/ cm^3	225

Table 1

(a) Complete Table 1 to show the mass of the carbonate used.

(1)

* 13.247 − 12.431 = 0.816g *

(b) Calculate the amount, in moles, of carbon dioxide collected in the measuring cylinder at r.t.p.

(1)

$24\ dm^3$ = 1 mole

$225 cm^3 = 0.225 dm^3 = 9.375 \times 10^{-3}$ mol

$\left(\frac{0.225}{24} = 9.375 \times 10^{-3}\right)$

(c) Calculate the molar mass of the Group 2 carbonate to an appropriate number of significant figures and hence deduce the identity of the Group 2 metal.

(4)

$\frac{0.816g}{x + 12 + 16 \times 3} = 9.375 \times 10^{-3}$ mol as 1:1 ratio

$\frac{0.816g}{x + 60} = 9.375 \times 10^{-3}$ mol

$x + 60 = 87.04$

$x = 27.04$

X $M_r = 27.04$

magnesium

(as in Group 2)

(d) Student **2** carried out the same experiment as Student **1**, using the same mass of the Group 2 carbonate.
Student **2** made no errors in their measurements or calculations but obtained a value for the molar mass which was 10 g mol^{-1} greater than the value obtained by Student **1**.

(i) Explain **one** procedural error which could have resulted in Student **2** obtaining a molar mass greater than that of Student **1**.

(2)

some of carbon dioxide gas has escaped and wasn't collected in measuring cylinder so smaller volume recorded so smaller moles, leading to greater molar mass

(ii) It was later discovered that Student **2** had used 110 cm^3 of 0.200 mol dm^{-3} dilute nitric acid, instead of 100 cm^3 of 0.200 mol dm^{-3} dilute nitric acid.

Give a reason why this mistake would **not** have affected Student **2**'s result.

No calculation is required.

(1)

100 cm^3 was already an excess so adding more doesn't affect anything

(iii) The teacher noticed that Student **2** had used the Group 2 carbonate in powdered form rather than in lumps.
Explain how, if at all, this would affect the rate of reaction and the final volume of gas produced in the reaction.

(2)

greater surface area provided by powder so more particles of reactants can collide & react per unit time so greater rate of reaction and so final volume of gas recorded, that is unchanged, will be collected within a quicker time

(e) Student **3** suggested a different experiment.
Student **3** realised that, by heating the carbonate, carbon dioxide would be lost and an oxide would remain.
Student **3** decided to measure the change in mass of the carbonate and to use this information to calculate its molar mass.

- Student **3** weighed an empty test tube.
- Using a spatula, Student **3** added some of the carbonate to the test tube.
- The test tube containing the carbonate was then weighed.
- The test tube and its contents were heated to constant mass.
- The results obtained by Student **3** are shown in Table 2.

Measurement	Value
Mass of carbonate + test tube / g	20.447
Mass of oxide + test tube / g	20.205
Mass of empty test tube / g	19.996

MCO_3 0.451g
CO_2 0.242g
MO 0.209g

Table 2

(i) Write an equation, including state symbols, for the thermal decomposition of a Group 2 carbonate, MCO_3, where M represents the metal.

(1)

$$MCO_{3(s)} \rightarrow MO_{(s)} + CO_{2(g)}$$

(ii) Using Student **3**'s results, calculate the molar mass of the Group 2 carbonate.

(3)

	MCO_3	MO	CO_2
Mass	0.451g	0.209g	0.242g
Mr	x + 60	x + 16	44
Mol	5.5×10^{-3} mol	5.5×10^{-3} mol	5.5×10^{-3} mol
Ratio of mol	1 :	1 :	1

$\frac{Mass}{Mr} = \frac{0.242}{44} = 5.5 \times 10^{-3}$ mol

$\frac{0.209g}{x+16} = 5.5 \times 10^{-3}$ mol

$Mr = \frac{mass}{mol} = \frac{0.209}{5.5 \times 10^{-3}} = x + 16 = 38$ $\quad x = 22$ $\quad M_r = 22$

$38 - 16 = x$

(f) Student **3** used the same balance as Student **1**.

Give a reason why the mass of the carbonate measured by Student **3** has a greater percentage uncertainty than that measured by Student **1**.

(1)

Referring to the equation stated underneath, as the student are using the same balance, the absolute uncertainty is the same. However, student 1's measured value for the mass of carbonate is much bigger than student 3's value. (0.816g > 0.451g)

∴ Student 3's percentage uncertainty is much greater.

(Total for Question 3 = 16 marks)

Total for Test = 40 marks

$$\% \text{ uncertainty} = \frac{\text{absolute uncertainty}}{\text{measured value}} \times 100$$