

## GCE AS / A LEVEL – CHEMISTRY UNIT 1 SUPPLEMENTARY QUESTION PACK

Sourced from legacy 1092-02 (CH2) papers · New spec Unit 1 Topic 14 · AS unit, 80 marks, 1h 30min paper

REVISE.wales

# CHEMISTRY – UNIT 1 · GROUP 2 REACTIONS & TRENDS

Topic 1.6 – Group 2 (Be, Mg, Ca, Sr, Ba): reactions with water/oxygen/acids, oxides, hydroxides, carbonates, sulfates

*Reactions of Group 2 elements with water, oxygen and acids; trends in solubility of hydroxides and sulfates down the group; thermal stability of carbonates; industrial uses of CaO, Ca(OH)<sub>2</sub> and CaCO<sub>3</sub>.*

Legacy 2008 specification · CH2 source

**Estimated time for entire question pack: ~3 h 17 min**

*Derived from the legacy CH2 paper's pace of ~1.1 min/mark, padded for long-prose answers (123 marks over 12 questions).*

*You are advised to **not** attempt to complete all of this in one sitting.*

## ABOUT THIS QUESTION PACK

This is a **supplementary practice question pack** for new-spec Unit 1. It contains every legacy WJEC CH2 question (2008 modular spec, Jun 2009 – Jun 2016) that maps onto 2015 AS Unit 1 Topic 1.6 – bonding, intermolecular forces, solid structures and periodicity were assessed in the old CH2 module but now belong in Unit 1 under the 2015 specification.

Questions are ordered by source paper date.

## INSTRUCTIONS

Use black ink or black ball-point pen. Show all working – quality of written communication will affect marks. A calculator is allowed. You may need the WJEC Periodic Table / Data Booklet.

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Q	Source	Max	Mark
1	Jun 09 Q2	3	
2	Jan 10 Q11	19	
3	Jun 10 Q8	15	
4	Jan 11 Q2	1	
5	Jan 11 Q9	11	
6	Jun 11 Q3	1	

Q	Source	Max	Mark
7	Jan 12 Q7	14	
8	Jun 12 Q9	14	
9	Jan 13 Q1	1	
10	Jun 13 Q11	16	
11	Jan 14 Q10	16	
12	Jun 16 Q7	12	
<b>Total</b>		<b>123</b>	

## Group 2 Reactions & Trends – what the new spec asks

WJEC GCE AS / A Level Chemistry (from 2015) · Unit 1: The Language of Chemistry, Structure of Matter & Simple Reactions · Topic 1.6.

### Reaction with water

- $M + 2H_2O \rightarrow M(OH)_2 + H_2$  (M = Mg, Ca, Sr, Ba).
- Reactivity ↑ down the group: Mg slow with cold water (fast with steam → MgO); Ba vigorous.
- $Mg + H_2O(g) \rightarrow MgO + H_2$  (steam reaction, oxide product).

### Reactions with O<sub>2</sub> and acids

- $2M + O_2 \rightarrow 2MO$  (ionic oxides; basic).
- $M + 2HCl \rightarrow MCl_2 + H_2$ ;  $M + H_2SO_4 \rightarrow MSO_4 + H_2$ .
- BaSO<sub>4</sub> coating slows Ba dissolution in dilute H<sub>2</sub>SO<sub>4</sub>.

### Solubility trends down the group

- Hydroxides: solubility **increases** down the group (Mg(OH)<sub>2</sub> sparingly → Ba(OH)<sub>2</sub> soluble).
- Sulfates: solubility **decreases** down the group (MgSO<sub>4</sub> soluble → BaSO<sub>4</sub> insoluble – basis of test for SO<sub>4</sub><sup>2-</sup>).
- Carbonates: all insoluble; thermal stability ↑ down the group.

### Industrial & biological uses

- CaO (quicklime): cement, steelmaking, neutralising acidic soils.
- Ca(OH)<sub>2</sub> (slaked lime): agriculture, water treatment.
- CaCO<sub>3</sub> (limestone): building, glass, CaO production.
- Ca biologically essential (bone, teeth, signalling); Mg in chlorophyll.

## Group 2 Reactions & Trends in one page

Quick-reference notes – revisit before each question.

### Reactivity trend

Be < Mg < Ca < Sr < Ba. Down group: atom larger, outer e<sup>-</sup> further & better screened ⇒ lose them more easily.

### With water

$\text{Mg} + 2\text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2 + \text{H}_2$  (slow, cold)  
*or*  $\text{Mg} + \text{H}_2\text{O} \rightarrow \text{MgO} + \text{H}_2$  (steam).  
Ca/Sr/Ba: vigorous fizzing with cold water.

### Hydroxide solubility ↑

$\text{Mg}(\text{OH})_2$  sparingly soluble (milk of magnesia) →  $\text{Ba}(\text{OH})_2$  soluble. Solution pH ↑ down group.

### Sulfate solubility ↓

$\text{MgSO}_4$  v. soluble →  $\text{BaSO}_4$  insoluble (white precipitate). Use acidified  $\text{BaCl}_2$  as the standard test for sulfate ions.

### Carbonate thermal stability ↑

$\text{MgCO}_3$  decomposes ~350°C;  $\text{BaCO}_3$  needs > 1300°C. Larger cation ⇒ less polarising ⇒  $\text{CO}_3^{2-}$  more stable.

### Key industrial reactions

$\text{CaCO}_3 \xrightarrow{\text{heat}} \text{CaO} + \text{CO}_2$  (limestone → quicklime).  
 $\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2$  (slaked lime, exothermic).  
 $\text{Ca}(\text{OH})_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$  (limewater test).

## SECTION A

Answer all questions in the spaces provided.

1. Complete the table below by putting a tick (✓) in the boxes that correctly describe graphite. [1]

Conducts electricity		Melting temperature		Bonding	
Yes	No	High	Low	Covalent	Ionic

2. (i) Give the equation for the reaction of barium metal with water. [1]

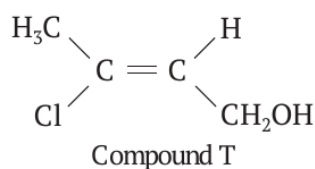
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- (ii) The solution obtained in (i) contains barium ions.  
State a reagent that would be added to this solution to show the presence of barium ions, giving the result of the test.

Reagent ..... [1]

Observation ..... [1]

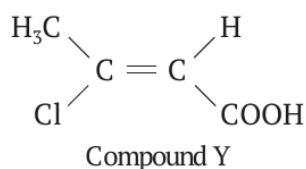
3. (i) Explain why Compound T has E-Z (trans-cis) isomers. [1]



.....

.....

- (ii) State a reagent, used in acid solution, that reacts with Compound T to give Compound Y. [1]



.....

Examiner  
only

11. (a) Edmund carries out two experiments with calcium.

(i) In the first experiment, he adds pieces of calcium to water.

I. State what he would **observe** in this reaction. [2]

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II. Write a balanced chemical equation for the reaction. [2]

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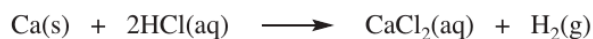
III. He repeats the experiment with strontium.

State whether you would expect strontium to be more or less reactive than calcium. Explain your answer clearly. [2]

.....

.....

(ii) In the second experiment, Edmund reacts pieces of calcium with 20.0 cm<sup>3</sup> of 2.00 mol dm<sup>-3</sup> hydrochloric acid.



I. Calculate the number of moles of acid used in the experiment. [1]

.....

.....

II. Calculate the minimum mass of calcium needed to react completely with the acid. [2]

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.....

.....

III. Give a test which would confirm the presence of calcium ions in aqueous calcium chloride, stating the result of the test. [2]

.....

.....

Examiner  
only

(b) Edmund wants to prepare aqueous sodium chloride using the same method as in (a)(ii) opposite. Explain why he should not use this method and state what reagents he could use to obtain aqueous sodium chloride. [2]

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.....

(c) For both calcium chloride and calcium metal:

- state the conditions necessary for each to conduct electricity; [4]
- explain, in terms of bonding and structure, how this process occurs. QWC [2]

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Total [19]

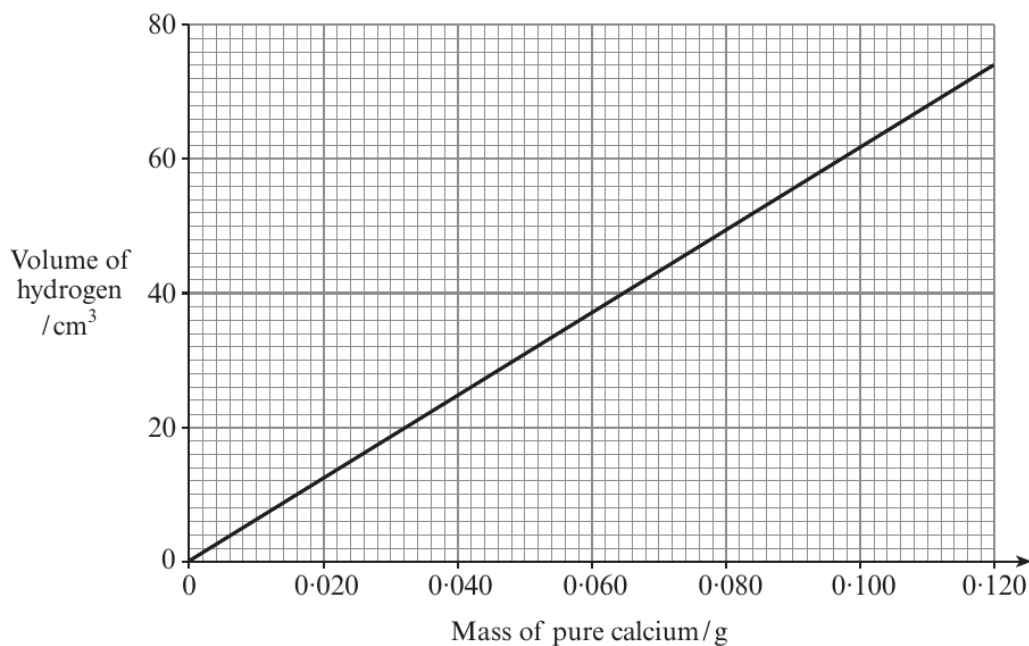
**Section B Total [70]**



Examiner  
only

8. (a) (i) 0.115 g of impure calcium metal was added to water. Hydrogen gas and calcium hydroxide were formed.  
Give the equation for this reaction. [1]

- (ii) All the hydrogen produced was collected and gave a volume of 64.0 cm<sup>3</sup>.



Use the graph to find the mass of pure calcium present and hence the percentage purity of the calcium used. [2]

- (iii) Jonathan added a piece of strontium metal to water. He noticed that the reaction was more vigorous than when using calcium. He said that one reason for this was that the strontium ion, Sr<sup>2+</sup>, was formed more easily than the calcium ion, Ca<sup>2+</sup>.

Explain why this statement is true, in terms of the electronic structures of the two metals. [2]

Examiner  
only

(b) A solution, giving an apple-green colour to a flame, was suspected to be aqueous barium hydroxide.

Describe **two** simple tests to confirm this conclusion, giving the result of each test. [2]

- 1. ....  
.....
- 2. ....  
.....

(c) Both solid strontium metal and solid graphite are conductors of electricity. Describe the structures of these two materials and explain how they are both able to conduct electricity. You may use diagrams in your answer. [5]

*QWC* [1]

Strontium

.....  
.....

Graphite

.....  
.....

(d) There is much interest in carbon nanotubes as drug delivery agents. Describe how the structure of carbon nanotubes is related to the structure of graphite. [2]

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.....  
.....

Total [15]

**Turn over.**

## SECTION A

Answer **all** questions in the spaces provided.

1. (a) Ethanol is present in many intoxicating drinks. Give **one** health problem associated with the consumption of excess ethanol. [1]

.....

- (b) Ethanol can be converted to ethanoic acid in an oxidation reaction. Give suitable reagents for this reaction. [1]

.....

2. Calcium compounds are important in many biological systems. Give an example of where a calcium compound is used in a living organism. [1]

.....

3. State which one of the following species has the smallest bond angle. [1]



.....

4. Write a chemical equation for the displacement reaction that occurs when chlorine gas is bubbled through a solution of sodium bromide, NaBr. [1]

.....

Examiner  
only

9. Calcium oxide is one of the most widely used industrial materials in the world, with worldwide production being in the region of 283 million tonnes every year.

(a) Most calcium oxide is produced from calcium carbonate by thermal decomposition. The chemical reaction occurring is:



Calculate the atom economy of this process. [2]

.....

.....

.....

(b) Draw a dot and cross diagram to show the formation of calcium oxide from atoms of calcium and oxygen. [2]

(c) Calcium oxide has the same crystal structure as sodium chloride.

(i) Draw the arrangement of ions in the structure of calcium oxide. [2]

(ii) Explain why calcium chloride cannot have the same crystal structure as sodium chloride and calcium oxide. [1]

.....

.....

Examiner  
only

(d) Calcium metal reacts quickly with a range of dilute acids.

(i) Write an equation for the reaction of calcium metal, Ca, with phosphoric acid,  $H_3PO_4$ , to produce calcium phosphate and hydrogen gas only. [2]

.....

(ii) A piece of calcium metal would react quickly with most dilute acids but would not react significantly with dilute sulfuric acid under the same conditions. Explain this lack of reactivity with dilute sulfuric acid. [2]

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Total [11]

## SECTION A

Answer **all** questions in the spaces provided.

1.           barium sulfate  
              calcium carbonate  
              magnesium hydroxide  
              sodium carbonate

From the list above, choose the compound that

(a) gives a brick-red flame test, [1]

.....

(b) is the **most** soluble in water. [1]

.....

2. Complete the table below to show the type or types of bonding present in the following solids. [2]

Solid	Type or types of bonding
calcium	
iodine	

3. Calcium phosphate is found widely in nature, e.g. in bones and in the leaves of plants. The formula for the phosphate ion is  $\text{PO}_4^{3-}$ . Write the formula for calcium phosphate. [1]

.....

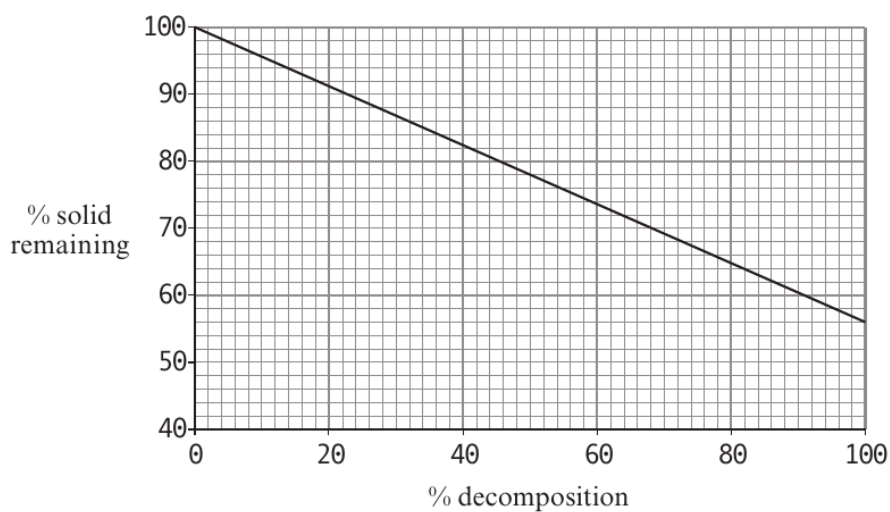
7. (a) In industry calcium oxide is made by heating limestone (a form of calcium carbonate) to a high temperature.



- (i) This experiment can be repeated in the laboratory by strongly heating a marble chip. Unless the temperature is high enough the reaction is often incomplete. In an experiment the following results were obtained.

Mass of marble chip before heating = 3.24 g  
Mass of solid after heating = 2.01 g

Use the graph to help you calculate the percentage decomposition of the marble chip into calcium oxide and carbon dioxide. [2]



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Examiner  
only

- (ii) The solid from (i) was carefully added to cold distilled water in order to produce a solution of calcium hydroxide, together with unreacted solid calcium carbonate. The solubility of calcium hydroxide in water was found from the resulting solution. The instructions that were being followed stated
- add the solid to about 1200 cm<sup>3</sup> of distilled water
  - stir the mixture for ten minutes
  - filter the mixture

I. State why the solid was added to **distilled** water. [1]

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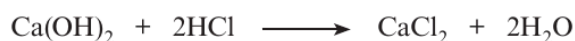
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II. State why the mixture was stirred for ten minutes. [1]

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.....

- (iii) 1.00 dm<sup>3</sup> of the solution, produced in (ii), was then titrated with hydrochloric acid of a known concentration.



It was found that 0.0450 mol of hydrochloric acid reacted with all the calcium hydroxide present in the solution.

I. State the number of moles of calcium hydroxide that reacted with the hydrochloric acid. [1]

.....

II. Calculate the solubility of calcium hydroxide in this solution in g dm<sup>-3</sup>. [1]  
[The molar mass of calcium hydroxide is 74.1 g mol<sup>-1</sup>]

.....

Solubility = ..... g dm<sup>-3</sup>

- (iv) Calcium carbonate will also react with hydrochloric acid. State why any unreacted calcium carbonate from the marble chip cannot interfere with the experiment in (iii). [1]

.....



Examiner  
only

(b) Dolomite,  $MgCO_3 \cdot CaCO_3$ , is a mineral found in Italy. State the colour given by dolomite in a flame test, giving a reason for your choice. [2]

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.....

(c) A solution of calcium hydroxide is reacted with aqueous sulfuric acid. A faint white precipitate is seen, as the calcium ions react with the sulfate ions. Give the **ionic** equation for this reaction. [1]

.....

(d) The hard mineral fluorapatite,  $CaF_2 \cdot 3Ca_3(PO_4)_2$ , is found in tooth enamel. One weakness with this material is that there are tiny holes between each ‘molecule’ of fluorapatite and these may be a cause of sensitive teeth. Recently a manufacturer has suggested that nano-sized fluorapatite particles in a toothpaste may help solve this problem by filling the holes. Suggest what should be done before this nano-sized material is licensed for use. [1]

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.....

(e) Fluorapatite occurs naturally as a rock and can be used to make the fertiliser ‘superphosphate’. 5.0 tonnes of fluorapatite give a maximum yield of 8.6 tonnes of superphosphate. Calculate the mass of superphosphate made from 5000 tonnes of fluorapatite if the percentage yield is 93%. [2]

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.....

.....

(f) Radium and calcium are elements in Group 2. Explain why radium carbonate,  $RaCO_3$ , has a similar formula to calcium carbonate,  $CaCO_3$ . [1]

.....

.....

.....

Total [14]



Examiner  
only

9. Calcium is present in teeth in the form of calcium phosphates. These do not react with water. The element calcium, however, reacts with water to produce calcium hydroxide and hydrogen gas.



- (a) A student investigated the reaction between calcium and cold water. He added 2.0 g of calcium to some water and collected the hydrogen gas formed.

Draw a labelled diagram of an apparatus that would be suitable for carrying out this reaction and measuring the volume of hydrogen produced. [2]

- (b) The student repeated the reaction using the same mass of barium. He noticed that the volume of gas, still at the same temperature and pressure, was less.

- (i) Give the reason why the volume of gas produced was less. [1]

.....  
 .....

- (ii) Suggest another difference that the student would observe when barium was used in place of calcium. Explain your answer. [2]

.....  
 .....

- (c) The student did not label the flasks containing the solutions after the reactions with calcium and with barium.

Give a test that would distinguish between these solutions. Include the result of your test for both solutions. [2]

.....  
 .....



1 0

Examiner  
only

(d) Calcium oxide also reacts with water to produce calcium hydroxide. Draw a dot and cross diagram to show the bonding in calcium oxide. Show only the electrons in outer shells. [2]

(e) Barium, as barium sulfate, is used medicinally in barium meals since it is insoluble in water and shows on x-ray images.

(i) Starting from the solution of barium hydroxide the student produced in (b), describe how he could obtain a pure, dry sample of barium sulfate.

You should include an **ionic** equation for the reaction. [3]

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.....  
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.....

(ii) Calculate the maximum mass of barium sulfate that the student could make, starting with 2.0 g of barium. [2]

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.....

Mass = ..... g

Total [14]



## SECTION A

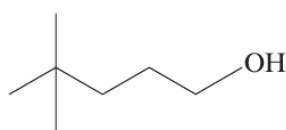
Answer **all** questions in the spaces provided.

1. Calcium and magnesium are essential elements in living things. Give **one** use of each element in biological systems. [1]

*Magnesium* .....

*Calcium* .....

2. Give the **systematic** name of the molecule shown below. [1]



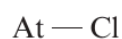
3. The electronegativity values of the halogens are listed below.

Atom	F	Cl	Br	I	At
Electronegativity value	4.0	3.0	2.9	2.6	2.2

- (a) Define the term *electronegativity*. [1]

.....  
.....

- (b) Use the data in the table to identify any dipoles present in the following bonds, marking their polarity clearly. [1]



Examiner  
only

11. Jennifer and Marged carry out some experiments with Group 2 metals.

(a) In the first experiment, Jennifer reacts calcium with oxygen to form calcium oxide.

(i) Write an equation for the reaction. [1]

.....

(ii) Using outer electrons only, draw a dot and cross diagram to show the transfer of electrons involved in the formation of calcium oxide. Show the charges on the ions formed. [2]

(b) Jennifer then adds water to the calcium oxide. Some of it reacts to form a solution of calcium hydroxide.

(i) Write the formula of calcium hydroxide. [1]

.....

(ii) Suggest the pH of this solution. [1]

.....

(c) Jennifer reacts the solution of calcium hydroxide with an aqueous solution of sodium carbonate and a white precipitate is seen. Write the **ionic** equation for this reaction. Include the relevant state symbols in the equation. [1]

.....



Examiner  
only

(d) Marged adds a strip of magnesium to dilute hydrochloric acid.



(i) State what she would **observe** as this reaction proceeds. [2]

.....

.....

(ii) If the mass of the magnesium strip is 0.503 g and the concentration of the acid is  $1.60 \text{ mol dm}^{-3}$ , calculate the minimum volume of acid required to react completely with the magnesium, giving your answer to **three** significant figures. [3]

*Volume of acid* = .....  $\text{cm}^3$

(iii) Calculate the volume at room temperature of the hydrogen produced in this reaction. [1]

[1 mol of gas occupies  $24.0 \text{ dm}^3$  at room temperature]

*Volume of hydrogen* = .....  $\text{dm}^3$

(iv) Give a test which would confirm the presence of chloride ions in aqueous magnesium chloride, stating the result of the test. [2]

.....

.....

**QUESTION 11 CONTINUES ON PAGE 18**



1 7

Examiner  
only

(e) Marged repeats the experiment with beryllium. State whether you would expect beryllium to be more or less reactive than magnesium. Explain your answer clearly. [2]

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.....

.....

Total [16]

**Total Section B [70]**

**END OF PAPER**









**GCE AS/A level**

1092/01-A

**CHEMISTRY – DATA SHEET  
FOR USE WITH CH2**

P.M. TUESDAY, 4 June 2013

**Infrared Spectroscopy characteristic absorption values**

<b>Bond</b>	<b>Wavenumber / cm<sup>-1</sup></b>
C—Br	500 to 600
C—Cl	650 to 800
C—O	1000 to 1300
C=C	1620 to 1670
C=O	1650 to 1750
C≡N	2100 to 2250
C—H	2800 to 3100
O—H	2500 to 3550
N—H	3300 to 3500

Examiner  
only

10. (a) A solution of calcium chloride was obtained by adding 0.40 g of calcium metal to 80 cm<sup>3</sup> of hydrochloric acid of concentration 0.20 mol dm<sup>-3</sup>. The equation for the reaction is



- (i) Use the information given to show that an excess of calcium metal was used. [3]
- (ii) State **one** observation made during the reaction apart from the mixture becoming warm. [1]
- .....
- (b) A sample of a calcium compound **E** of mass 1.50 g was added to 200 cm<sup>3</sup> of cold water and the mixture heated until it all dissolved.

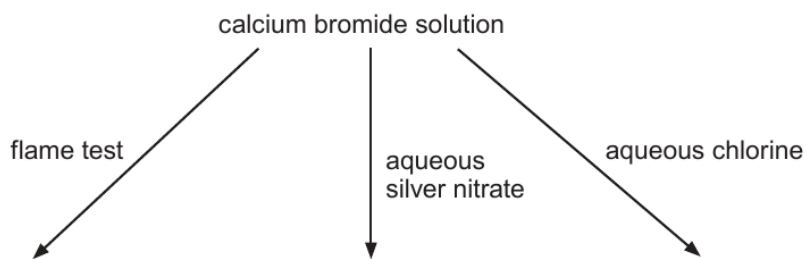
Use relevant information from the table to calculate the mass of compound **E** that crystallised when the solution was cooled to 0 °C. [2]

Solubility of compound <b>E</b> /g per 100 g of water	Temperature / °C
0.13	0
0.75	50
1.22	100

Mass that crystallised = ..... g

Examiner only

(c) A student was given a solution of calcium bromide and asked to carry out the reactions shown in the diagram below.



(i) State the colour given in the flame test. [1]

(ii) State what was seen when aqueous silver nitrate was added. [1]

(iii) Give the **ionic** equation for the reaction occurring in (ii). [1]

(iv) State what was seen when aqueous chlorine was added to the solution of calcium bromide. [1]

(v) Explain why chlorine reacted as described in (iv).  
Your answer should include

- the type of bonding and the species present in calcium bromide
- the type of reaction occurring
- why chlorine is able to react in this way
- an appropriate equation

[5]  
QWC [1]

Total [16]

Examiner  
only

4. (a) Place the following elements in order of their increasing first ionisation energy. [1]

sodium      magnesium      aluminium      silicon      chlorine

Lowest ..... Highest

- (b) Place the following elements in order of their increasing melting temperature. [1]

sodium      magnesium      aluminium      silicon      chlorine

Lowest ..... Highest

5. Decane (C<sub>10</sub>H<sub>22</sub>) may be used to produce ethene in a cracking reaction. Write an equation for this process. [1]

.....

6. Give the reagent(s) required for the oxidation of ethanol to form ethanoic acid. [1]

.....

7. A saturated solution of calcium sulfate at 20 °C was cooled to 0 °C and 0.11 g of solid calcium sulfate was obtained. Use the data below to calculate the volume of the calcium sulfate solution. [2]

Temperature / °C	Solubility of CaSO <sub>4</sub> / g dm <sup>-3</sup>
0	2.10
20	2.39

Volume = ..... dm<sup>3</sup>

**Total Section A [10]**

**END OF QUESTION PACK**

12 questions · 123 marks · ~3 h 17 min  
Source: WJEC CH2 (2008 modular spec, Jun 2009 – Jun 2016)  
Curated for WJEC Chemistry 2015 spec AS Unit 1 – Topic 14 (1.6)

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