Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A LEVEL

2410U10-1

S19-2410U10-1

CHEMISTRY – AS unit 1

The Language of Chemistry, Structure of Matter and Simple Reactions

MONDAY, 20 MAY 2019 – MORNING

1 hour 30 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 8.**	**10**	
Section B	**9.**	**16**	
	10.	**14**	
	11.	**12**	
	12.	**14**	
	13.	**14**	
	Total	**80**	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- **Data Booklet** supplied by WJEC.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions in the spaces provided.
Section B Answer **all** questions in the spaces provided.

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in **Q.12***(c)*.

If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

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SECTION A

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

1. Using **outer** electrons only, draw a dot and cross diagram to show the formation of the bonding in magnesium fluoride. [2]

2. In some areas, fluoride ions are added to drinking water.

State **one** benefit of adding fluoride ions to water. [1]

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.....

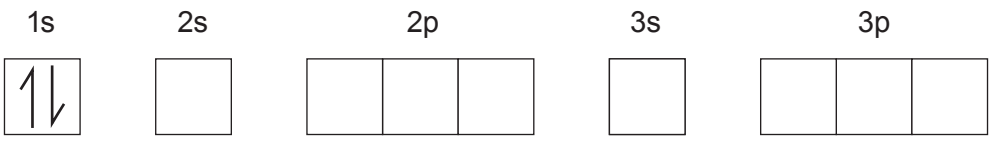
3. Complete the following definition of relative atomic mass. [1]

The relative atomic mass of an element is the average mass of one atom of the element

relative to .....

.....

4. Sodium forms only one stable ion. By inserting arrows to represent electrons, complete the electronic structure of this ion. [1]



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5. Give the oxidation number of vanadium in $VOCl_3$. [1]

.....

6. Phosphoric acid has the formula H_3PO_4. Write the formula of magnesium phosphate. [1]

.....

7. Cooking fuel for outdoor camping contains butane, which reacts with oxygen according to the following equation.

$$C_4H_{10}(g) + 6\tfrac{1}{2}O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(g)$$

If 1.00 mol of butane reacts in this way, calculate the number of **molecules** of carbon dioxide that will be formed. [1]

Molecules of CO_2 = ...

8. 9.60 g of titanium reacts completely with 3.68 dm^3 of oxygen gas at 298 K and 1 atm to form an oxide.

Calculate the empirical formula of this oxide. [2]

Empirical formula .....

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SECTION B

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

9. *(a)* Consider the elements labelled **A**-**G**. **These are not chemical symbols.**

A $1s^2\ 2s^2\ 2p^1$
B $1s^2\ 2s^2\ 2p^3$
C $1s^2\ 2s^2\ 2p^6$
D $1s^2\ 2s^2\ 2p^6\ 3s^2$
E $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$
F $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$
G $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

(i) Give the letter (**A**-**G**) of the element with the largest **first** ionisation energy.

Give **two** reasons for your answer. [3]

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(ii) Give the letter (**A**-**G**) of the element with the largest **last** ionisation energy.

Give a reason for your answer. [2]

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(iii) Give the letters (**A**-**G**) of **all** the elements above that are metals. [2]

.....

(iv) Give the letters (**A**-**G**) of **all** the elements above that form basic oxides. [1]

.....

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(b) Magnesium exists as three naturally-occurring stable isotopes. They can be identified using a mass spectrometer.

(i) State how magnesium ions are formed in a mass spectrometer. [1]

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.....

(ii) State how magnesium ions are separated in a mass spectrometer. [1]

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(c) Magnesium-28 is an unstable radioactive isotope that decays by β-emission.

(i) Give the mass number and symbol of the element formed as a product of the radioactive decay of magnesium-28. [1]

.....

(ii) If it takes 84 hours for the activity of the isotope to decay to $\frac{1}{16}$ th of its original activity, calculate its half-life. [1]

Half-life = ... hours

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(d) Magnesium is a typical metal. Describe the bonding in magnesium and explain why it is ductile. You may include a diagram as part of your answer. [3]

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(e) According to the label on the bottle, the concentration of magnesium ions in a sample of Welsh mineral water is 15 mg / litre.

Calculate the concentration of magnesium ions in mol dm^{-3}. [1]

Concentration = ... mol dm^{-3}

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10. When an electrical discharge passes through gaseous hydrogen at low pressure, electromagnetic radiation is emitted.

(a) Describe the processes within a hydrogen atom that cause electromagnetic radiation to be emitted. [2]

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(b) If the electromagnetic radiation in part *(a)* is passed through a spectrometer, several series of converging lines are observed.

(i) Explain why there are several series of lines. [1]

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(ii) Explain why the lines within each series converge. [1]

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(c) The convergence limit of the Lyman series of lines occurs at a wavelength of 91.2 nm.

(i) State what the limit represents. [1]

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(ii) Calculate the energy, in kJ mol^{-1}, of the convergence limit. [4]

Energy = ... kJ mol^{-1}

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(d) Hydrogen forms when aluminium reacts with sulfuric acid.

$$2Al(s) + 3H_2SO_4(aq) \longrightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$$

(i) Calculate the volume of hydrogen, in cm^3, that would be produced if 0.131 g of aluminium were added to an excess of sulfuric acid at a temperature of 25 °C and a pressure of 1 atm. [3]

Volume = ... cm^3

(ii) Calculate the volume of hydrogen that would be produced if the same experiment were carried out at 50 °C and 1.6 atm. [2]

(If you do not have an answer in part (i), assume that the volume is 200 cm^3. This is **not** the correct answer.)

Volume = ... cm^3

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11. A student was asked to find the percentage of calcium carbonate in a sample of chalk. He used the following chemicals.

- Three chalk pieces of identical composition and mass 2.54 g
- Hydrochloric acid solution of concentration 1.00 mol dm^{-3}
- Sodium hydroxide solution of concentration 0.100 mol dm^{-3}

Method

- Use a burette to measure 50.00 cm^3 of hydrochloric acid (an excess) into a 100 cm^3 beaker.
- Put a piece of chalk into the beaker and leave until the reaction finishes.
- Filter the solution into a conical flask to remove any solid impurities.
- Add a few drops of indicator to the solution in the conical flask and titrate against the sodium hydroxide solution.
- Repeat the procedure using the other chalk pieces and calculate a mean titre.
- Use the mean titre to calculate the percentage of calcium carbonate in the chalk sample.

Results

Mass of each chalk piece = 2.54 g

Titration	1	2	3
Final reading / cm^3	16.80	33.05	16.70
Initial reading / cm^3	0.20	16.80	0.35
Titre / cm^3	16.60	16.25	16.35

Mean titre = $\frac{16.60 + 16.25 + 16.35}{3}$ = 16.40 cm^3

(a) State how the student would know that the reaction between the chalk and acid had finished. [1]

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(b) Suggest and explain **two** improvements to the student's method. [4]

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(c) The equation for the reaction between calcium carbonate and hydrochloric acid is as follows.

$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Use this and the student's results, including the mean titre of 16.40 cm^3, to calculate the percentage of calcium carbonate in the chalk sample. [4]

Percentage = ... %

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(d) Comment on the validity of the mean titre calculated. [1]

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(e) Another student follows the same procedure but filters the solution before the reaction is complete. State what effect, if any, this would have on the value of the titre. Justify your answer. [2]

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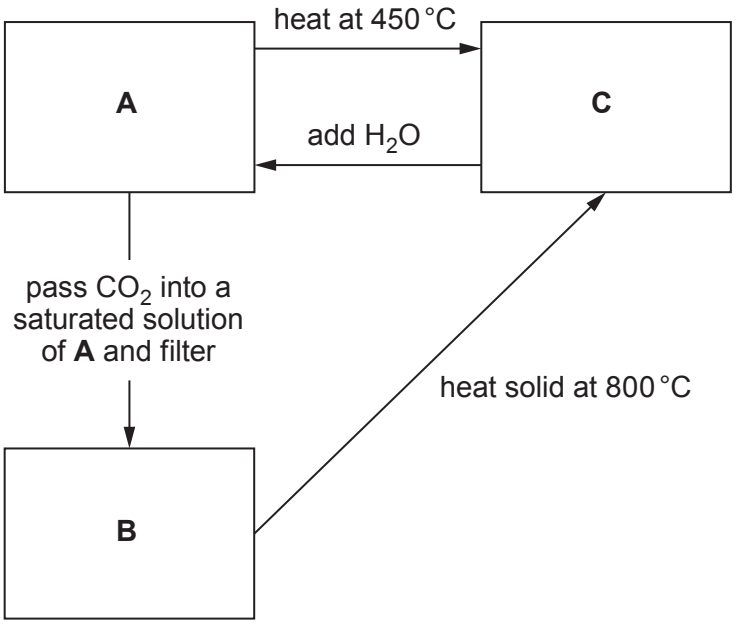
12. *(a)* A series of experiments is performed on three white solids, **A**, **B** and **C**. All contain the same Group 2 metal ion. Compound **A** is the metal hydroxide.

The experiment is summarised below.



- The compounds give a definite colour in a flame test
- Compound **A** is only slightly soluble in water
- Compound **B** is insoluble in water

(i) A student correctly identified the metal ion as calcium. Give **two** reasons why she came to that conclusion. [2]

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(ii) Name compound **B**. [1]

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(iii) 0.110 g of compound **C** was completely neutralised by 26.10 cm^3 of 0.150 mol dm^{-3} hydrochloric acid.

Given that 1 mol of compound **C** reacts with 2 mol of acid, calculate the relative formula mass of compound **C** and hence confirm that the metal ion is calcium.

You **must** show your working. [2]

(b) Group 2 metals are not the only elements that form 2+ ions.

A sample of an element has two isotopes, one with 70 neutrons and the other 72 neutrons. This element forms a 2+ ion containing 48 electrons. The relative abundances of the isotopes are 57.9 % and 42.1 % respectively.

Calculate the relative atomic mass of the element. Give your answer to **four** significant figures. [3]

A_r = ...

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(c) Describe, giving **brief** experimental details, how you would obtain the maximum amount of magnesium carbonate from a known mass of magnesium, in a **two-stage** process. Include appropriate chemical / ionic equations in your answer. [6 QER]

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13. *(a)* During the 2016 Olympic games, the diving pool had to be closed after the water turned green. A report in the media incorrectly suggested that there was too much chlorine in the pool.

When chlorine gas dissolves in cold water, a pale green solution is formed. In this solution, the following equilibrium is established.

$$Cl_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + Cl^-(aq) + HClO(aq)$$

pale green colourless

(i) Chemical equilibria are often described as dynamic equilibria.

Explain the term *dynamic equilibrium*. [1]

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(ii) Use Le Chatelier's principle to explain why the pale green colour disappears if sodium hydroxide solution is added. [2]

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(b) Chlorine can react directly with metals to form chlorides.

(i) I. Calcium chloride can exist as an anhydrous salt or as a hydrated salt, $CaCl_2.xH_2O$.

In an experiment to determine the extent of hydration a sample of hydrated calcium chloride, $CaCl_2.xH_2O$, with a mass of 3.29 g was heated to remove all water of crystallisation. The solid remaining had a mass of 1.67 g.

Calculate the value of x in the formula $CaCl_2.xH_2O$.

You **must** show your working. [3]

x = ...

II. Suggest how a student doing this experiment would ensure that all the water had been removed. [1]

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(ii) The melting temperature of sodium chloride is 1074 K but sodium iodide has a melting temperature of 934 K.

Suggest why the melting temperature of sodium iodide is lower than that of sodium chloride. [1]

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(c) Chlorine forms molecules and ions with other halogens.

(i) While chlorine has a boiling temperature of 238 K, the boiling temperature of iodine monochloride, ICl, is 371 K.

Suggest why the boiling temperature of iodine monochloride is higher than that of chlorine. [2]

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(ii) Name the shape of the $[ClF_6]^+$ ion. [1]

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(iii) $[ClF_2]^+$ and $[ClF_2]^-$ are two other ions containing a chlorine atom.

A student said that their shapes must be different.

Is he correct? Justify your answer using VSEPR theory. [3]

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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