Surname	StemUp Model Solution	Centre Number	Candidate Number
Other Names			2

GCE AS

B410U10-1

S19-B410U10-1

CHEMISTRY – AS component 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 7.**	**10**	
Section B	**8.**	**12**	
	9.	**10**	
	10.	**10**	
	11.	**17**	
	12.	**8**	
	13.	**13**	
	Total	**80**	

B410U101
01

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.

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.8***(b)*(i).

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.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

SECTION A

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

1. Complete the electronic structure for the Br^- ion. [1]

$1s^2 2s^2 2p^6 3s^2$ $3p^6 4s^2 3d^{10} 4p^6$

2. Complete the equation to show what happens when $^{28}_{15}P$ decays by positron emission. [1]

$^{28}_{15}P \longrightarrow {}^{0}_{+1}\beta + {}^{28}_{14}Si$

3. *(a)* State why some covalent bonds are polar but others are not. [1]

Bonds are polar when the bonded atoms have different electronegativities (different tendencies to attract the bonded pair of electrons).

(b) On the formulae below show any dipoles. [1]

F—F

$\overset{\delta-}{F}—\overset{\delta+}{Cl}$

4. Halogens and their compounds are used in water treatment.

State **one** halogen and **one** halide that are commonly used in water treatment. In **each** case give a reason for their use. [2]

Halogen chlorine

Reason for use sterilisation of water (kills bacteria)

Halide fluoride

Reason for use added to water supply / toothpaste to prevent tooth decay

© WJEC CBAC Ltd.

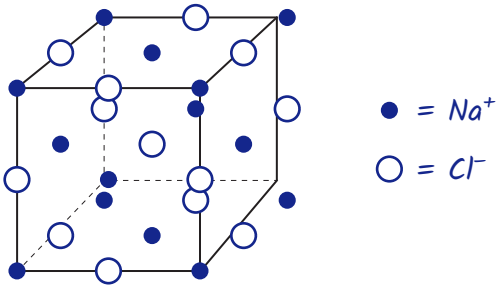
stemup.co.uk

Examiner only

5. An element absorbs green light with a wavelength of 500 nm. Another element absorbs red light. Suggest a value for the wavelength of this absorption. [1]

700 nm

6. Complete the diagram below to show the arrangement of ions in a sodium chloride lattice. [1]



7. A and B react according to the equation shown.

$$A(g) + 2B(g) \rightleftharpoons AB_2(g)$$

The equilibrium constant, K_c, for this reaction is 1.47 $dm^6 mol^{-2}$. At equilibrium the concentration of A was 0.2 mol dm^{-3}, and that of AB_2 was 0.4 mol dm^{-3}. Calculate the concentration of B. [2]

$$K_c = \frac{[AB_2]}{[A][B]^2} \quad \text{so} \quad 1.47 = \frac{0.4}{0.2 \times [B]^2}$$

$[B]^2 = 0.4 \div (1.47 \times 0.2) = 1.361$

$[B] = \sqrt{1.361}$

Concentration of B = 1.17 mol dm^{-3}

10

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

SECTION B

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

8. *(a)* A student said that the Periodic Table was a list of the elements arranged in order of increasing mass.

Another student said that this was not the case since it did not apply, for example, to argon and potassium.

Discuss whether the first student was correct and explain why the masses quoted in the Periodic Table for argon and potassium do not follow the general trend of increase in mass. [3]

The first student is not correct: the Periodic Table arranges the elements in order of increasing atomic number (number of protons), not mass.

The atomic masses are due to protons and neutrons (averaged over isotopes).

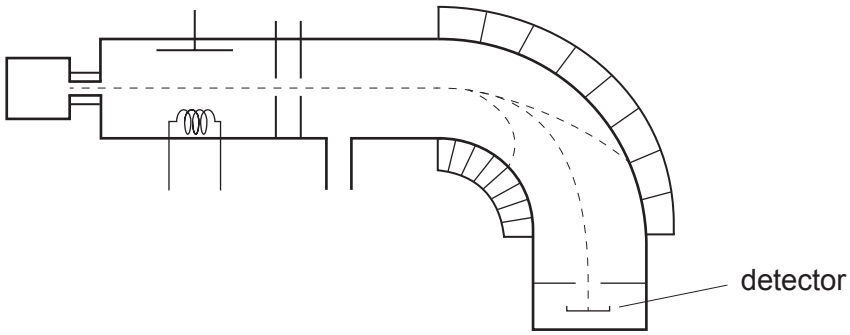
Argon has one proton fewer than potassium, but naturally occurring argon contains more atoms with a greater number of neutrons (mainly argon-40 vs potassium-39), so A_r(Ar) 39.9 > A_r(K) 39.1.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(b) (i) The relative atomic mass of a sample of an element can be found using a mass spectrometer. The diagram shows the main parts of a mass spectrometer.



Use this diagram to explain what happens to a sample of the element as it travels through the mass spectrometer. [6 QER]

The whole system is under a vacuum so ions do not collide with air molecules. The sample is first vaporised (turned into a gas).

In the ionisation chamber it is bombarded with high energy electrons from an electron gun; an electron is knocked off each atom, forming positive ions: $X(g) \rightarrow X^+(g) + e^-$.

The positive ions are accelerated by negatively charged plates (electric field) and pass through slits, which focus them into a narrow stream of fast ions.

In the curved tube the ions are deflected by the magnetic field of an electromagnet; the degree of deflection depends on m/z, lighter ions (lower m/z) being deflected more.

The magnetic field is varied (a range of fields) so ions of each m/z in turn hit the detector, which records their relative abundance as a mass spectrum.

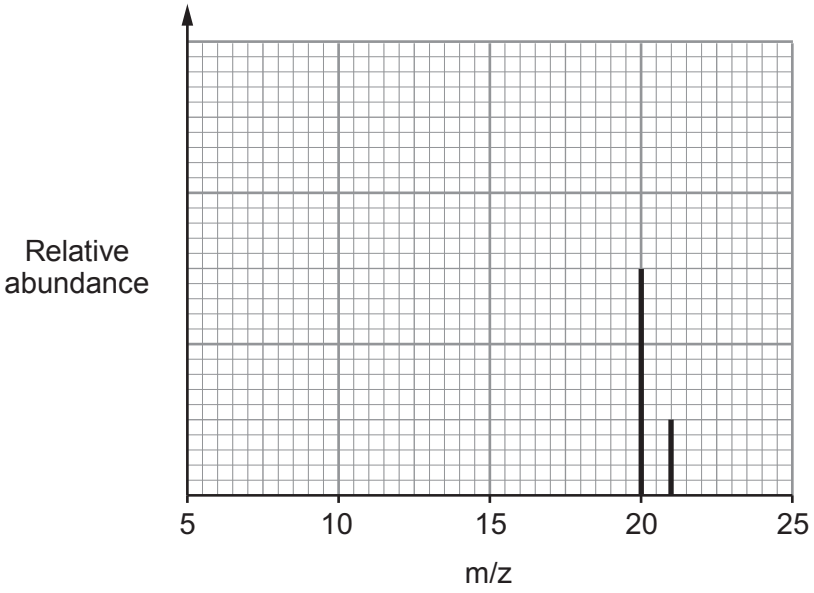
B410U101 05

stemup.co.uk

Examiner only

(ii) The mass spectrum of an element **T** is shown.

Use this to calculate the relative atomic mass, A_r, of the sample of **T**. [2]



$A_r = \dfrac{(20 \times 15) + (21 \times 5)}{15 + 5}$

$= (300 + 105) \div 20 = 405 \div 20$

$A_r =$ 20.25

(iii) The mass spectrum includes a very small peak at m/z 10 (not visible above). Suggest which particle is responsible for the presence of this peak. [1]

$^{20}T^{2+}$ (ion of mass 20 with a 2+ charge)

12

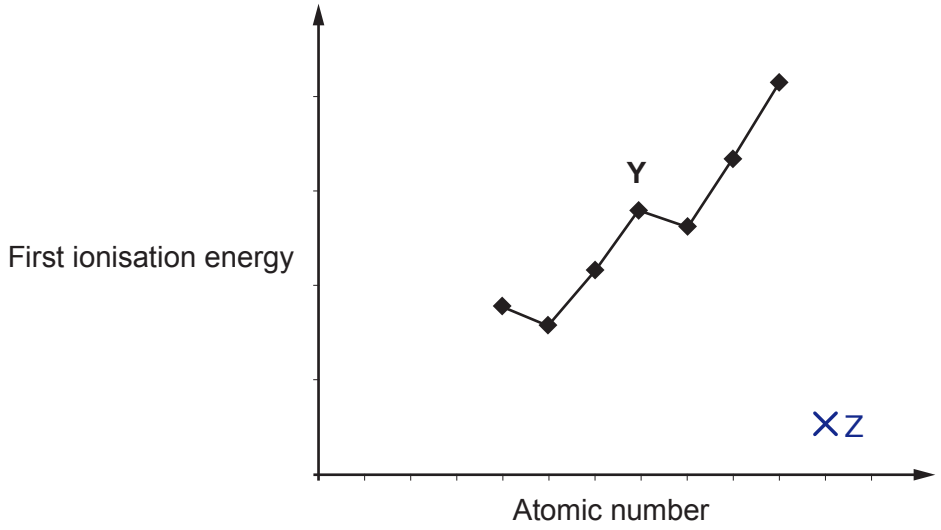
stemup.co.uk

Examiner only

9. *(a)* Write the equation that corresponds to the molar first ionisation energy of an element. Use **X** to represent the element. [1]

$X(g) \rightarrow X^{+}(g) + e^{-}$

(b) The graph shows the molar first ionisation energy for successive elements in part of the Periodic Table.



(i) Explain why first ionisation energies generally increase in value as a period is crossed from left to right. [2]

The number of protons increases, so there is greater nuclear charge (same shell); greater attraction for the outer electron, so more energy is needed to remove it.

(ii) In which group of the Periodic Table is the element shown as **Y**?

Explain how you reached this conclusion. [2]

Group 5.

The next element (Group 6) shows a small fall in first ionisation energy, because in Group 6 the electron removed is from a p orbital containing a paired electron; repulsion between the paired electrons makes it easier to remove.

(iii) **On the graph** plot the expected molar first ionisation energy for the next element in the Periodic Table. Label this point **Z**. [1]

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(c) (i) What is meant by the Avogadro constant? [1]

The number of particles in one mole of a substance (equal to the number of atoms in exactly 12 g of carbon-12), 6.02×10^{23} mol^{-1}.

(ii) Calculate the number of oxygen atoms in 34.23 g of aluminium sulfate, $Al_2(SO_4)_3$.

Show clearly how you carried out the calculation. [3]

M_r $Al_2(SO_4)_3 = (2 \times 27.0) + 3 \times (32.1 + 4 \times 16.0) = 342.3$

moles $= 34.23 \div 342.3 = 0.100$ mol

formula units $= 0.100 \times 6.02 \times 10^{23} = 6.02 \times 10^{22}$

each $Al_2(SO_4)_3$ contains $3 \times 4 = 12$ oxygen atoms

oxygen atoms $= 12 \times 6.02 \times 10^{22} = 7.22 \times 10^{23}$

Number of oxygen atoms = 7.22×10^{23}

10

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

10. Use ideas that you have studied in your Chemistry course to comment on and explain the following observations.

(a) When dilute sulfuric acid is added to aqueous magnesium chloride no visible change occurs but when it is added to aqueous barium chloride a white precipitate is observed.

Include an equation for any reaction that you describe. [3]

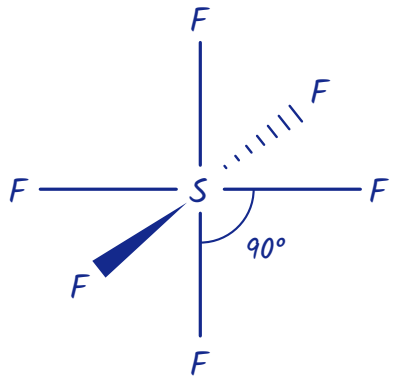
With barium chloride, a white precipitate of barium sulfate forms because barium sulfate is insoluble:

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

There is no visible change with magnesium chloride because magnesium sulfate is appreciably soluble, so no precipitate forms (solubility of the Group 2 sulfates decreases down the group).

(b) The bond angles in sulfur hexafluoride, SF_6, are 90°.

You should include a diagram in your explanation. [3]



octahedral

Sulfur has six outer electrons, each forming a bond to a fluorine atom, so there are six bonding pairs of electrons around S and no lone pairs.

The electron pairs repel each other as far apart as possible (minimum repulsion), so the six bonds are arranged octahedrally with all bond angles 90°.

B410U101 09

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(c) Street lights containing sodium vapour emit yellow light. [4]

Electricity passed through the sodium vapour gives energy to the electrons in the sodium atoms, so the electrons are excited: they are promoted from the ground state to a higher energy level.

The excited electrons are unstable and then fall back to a lower energy level, giving out the energy difference as light ($\Delta E = hf$).

The energy levels are fixed, so the energy emitted corresponds to a particular frequency; for sodium this is in the yellow part of the visible spectrum, so yellow light is seen.

10

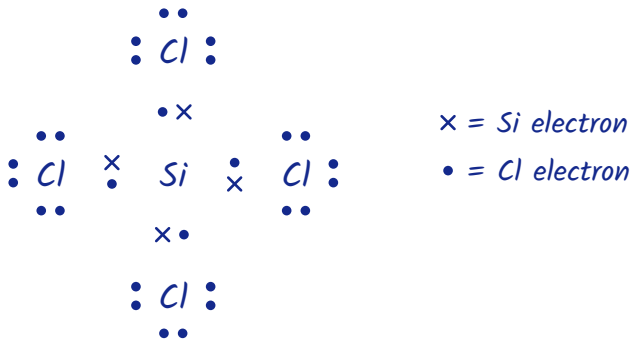
© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

11. *(a)* Both silicon oxide and silicon chloride are covalent compounds. Silicon has a valency of four in both compounds. At room temperature silicon chloride is a liquid whilst silicon oxide is a solid.

(i) Draw a dot and cross diagram to show the bonding in silicon chloride. Show outer electrons only. [2]



(ii) What is the bond angle in silicon chloride? [1]

109.5°

(iii) When silicon chloride is added to water, solid silicon oxide and a solution with a pH of less than 7 are formed.

Write the equation for this reaction. Include state symbols. [2]

$SiCl_4(l) + 2H_2O(l) \rightarrow SiO_2(s) + 4HCl(aq)$

(iv) Suggest why silicon oxide is a solid with a very high melting temperature whereas silicon chloride is a liquid at room temperature. [4]

$SiCl_4$ is a simple covalent molecule: only weak intermolecular forces (van der Waals) exist between the molecules, which need little energy to overcome, so it is a liquid.

SiO_2 is a giant covalent structure (macromolecule): to melt it many strong covalent bonds must be broken, which needs a lot of energy, so it has a very high melting temperature.

© WJEC CBAC Ltd.

Examiner only

(b) The acidity of solutions can be compared using the pH scale.

(i) Calculate the pH of 0.60 mol dm^{-3} nitric acid, HNO_3. [2]

HNO_3 is a strong acid, fully dissociated: $[H^+] = 0.60$ mol dm^{-3}

$pH = -\log[H^+] = -\log 0.60$

pH = 0.22

(ii) A student was told that the pH of water is 7.0. The student tested a sample of hot water and found the pH to be 6.9.

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

$[H^+] = 10^{-pH} = 10^{-6.9}$

Concentration = 1.26×10^{-7} mol dm^{-3}

(iii) The equilibrium for the dissociation of water is shown.

$$H_2O \rightleftharpoons H^+ + OH^-$$

Use the fact that the pH of the hot water in part (ii) was 6.9 to deduce whether this reaction is exothermic or endothermic. Explain your reasoning. [3]

A lower pH (6.9 instead of 7.0) means that $[H^+]$ is higher than expected in hot water.

So increasing the temperature has moved the equilibrium to the right hand side (more dissociation).

By Le Chatelier's principle a rise in temperature favours the endothermic direction, so the forward reaction must be endothermic.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(c) Magnesium reacts with hydrochloric acid.

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

A sample of magnesium of mass 5.00 g was reacted with excess hydrochloric acid. 4.31 dm^3 of hydrogen, measured at 273 K and 1 atm pressure, were produced.

Calculate the percentage purity of the sample of magnesium. [2]

moles Mg if pure = 5.00 ÷ 24.3 = 0.206 mol = moles H_2

theoretical volume H_2 = 0.2058 × 22.4 = 4.61 dm^3 (at 273 K, 1 atm)

percentage purity = 4.31 ÷ 4.61 × 100

Percentage purity = ... 93.5 ..... %

17

stemup.co.uk

Examiner only

12. *(a)* Several different compounds containing sodium, chlorine and oxygen exist. One of these decomposes on heating as shown in the equation.

$$2NaClO_3(s) \longrightarrow 2NaCl(s) + 3O_2(g)$$

(i) What is the oxidation state of chlorine in $NaClO_3$? [1]

+5

(ii) Calculate the maximum volume of gas, measured at 600 K and 1 atm pressure, that can be made by heating 88.0 g of $NaClO_3$. Give your answer to an **appropriate** number of significant figures. [3]

$M_r(NaClO_3) = 23.0 + 35.5 + 48.0 = 106.5$

$n(NaClO_3) = 88.0 \div 106.5 = 0.826$ mol

$n(O_2) = 0.826 \times 3/2 = 1.239$ mol

$V = nRT \div p = 1.239 \times 8.31 \times 600 \div 1.01 \times 10^5$

$= 0.0612\ m^3$

Volume = 61.2 dm^3

(b) The active component of bleach is sodium chlorate(I), NaClO. This is prepared by passing chlorine into aqueous sodium hydroxide.

$$2NaOH(aq) + Cl_2(g) \longrightarrow NaClO(aq) + NaCl(aq) + H_2O(l)$$

Calculate the atom economy of this process when used to prepare sodium chlorate(I). [2]

$M_r(NaClO) = 23.0 + 35.5 + 16.0 = 74.5$

total M_r of reactants $= 2(40.0) + 71.0 = 151.0$

atom economy $= 74.5 \div 151.0 \times 100$

Atom economy = 49.3 %

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(c) Another compound containing sodium, chlorine and oxygen has the following composition by mass.

Na 18.8 % Cl 29.0 % O 52.2 %

Calculate its empirical formula.

[2]

Na : Cl : O = 18.8/23.0 : 29.0/35.5 : 52.2/16.0

= 0.817 : 0.817 : 3.26

= 1 : 1 : 4

Empirical formula ..... $NaClO_4$ .....

8

Examiner only

13. A sample of witherite, an ore of barium, contains barium carbonate, $BaCO_3$. A geologist investigated the ore to determine the percentage of barium carbonate present by adding a sample of ore to excess acid and then finding how much acid had been neutralised.

He followed these instructions.

Stage 1

Add a known mass of ore to about 100 cm^3 of 0.500 mol dm^{-3} hydrochloric acid in a beaker. Stir until no further reaction occurs.

The geologist used 19.15 g of ore.

Stage 2

Filter and then add more acid to make the total volume of the solution up to exactly 250 cm^3.

Stage 3

Titrate 25.0 cm^3 samples of this solution against 0.100 mol dm^{-3} sodium hydroxide using a suitable indicator.

The geologist used a mean volume of 27.80 cm^3 of the sodium hydroxide to neutralise the acid.

(a) Explain why the geologist filtered the mixture in **Stage 2** of the process. [1]

To remove the insoluble (solid) impurities from the ore.

(b) State which piece of apparatus the geologist would use to make exactly 250 cm^3 of solution in **Stage 2**. [1]

A 250 cm^3 volumetric flask.

(c) State why an indicator is used in **Stage 3**. [1]

To show the end point (when the acid has just been neutralised).

(d) State how many titrations the geologist should carry out in **Stage 3**.
Give a reason for your choice. [1]

As many as needed until at least two concordant titres (within 0.10 cm^3) are obtained, to ensure an accurate, reliable mean.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(e) Write the equation for the reaction of barium carbonate with hydrochloric acid. [1]

$BaCO_3(s) + 2HCl(aq) \rightarrow BaCl_2(aq) + CO_2(g) + H_2O(l)$

(f) Calculate the total number of moles of hydrochloric acid **added** to the sample of ore. [1]

total volume of 0.500 mol dm^{-3} HCl = 250 cm^3

$n(HCl) = 250 \times 0.500 \div 1000$

Number of moles added = 0.125 mol

(g) Calculate the number of moles of hydrochloric acid neutralised in each titration and hence the number of moles neutralised by the original sample of ore. [3]

each titration: $n(NaOH) = n(HCl) = 27.80 \times 0.100 \div 1000$

$= 2.78 \times 10^{-3}$ mol

HCl left in 250 $cm^3 = 2.78 \times 10^{-3} \times 10 = 2.78 \times 10^{-2}$ mol

neutralised by ore = 0.125 − 0.0278

Number of moles neutralised by ore = 0.0972 mol

QUESTION 13 CONTINUES ON PAGE 18.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(h) State the number of moles of barium carbonate present in the original sample of ore and hence calculate the percentage by mass of barium in the ore. [3]

$n(BaCO_3) = 0.0972 \div 2 = 0.0486$ mol

mass of barium $= 0.0486 \times 137.3 = 6.67$ g

percentage $= 6.67 \div 19.15 \times 100$

Percentage barium in the ore = 34.8 %

(i) The true value for the percentage of barium present in the ore is higher than that calculated in part *(h)*. Suggest a possible reason for this. [1]

An insoluble barium compound (e.g. barium sulfate) may have been present in the ore; it does not react with the acid and is filtered off.

13

END OF PAPER

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

Additional page.

© WJEC CBAC Ltd.

stemup.co.uk