Surname	StemUp Model Solution	Centre Number	Candidate Number
First name(s)			2

GCE AS

B410U10-1

O20-B410U10-1

TUESDAY, 6 OCTOBER 2020 – AFTERNOON

CHEMISTRY – AS component 1

The Language of Chemistry, Structure of Matter and Simple Reactions

1 hour 30 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 7.**	**10**	
Section B	**8.**	**16**	
	9.	**10**	
	10.	**12**	
	11.	**9**	
	12.	**11**	
	13.	**12**	
	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)*.

If you run out of space, use the continuation 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 configuration of the Se^{2-} ion. [1]

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

2. What is the oxidation state of sulfur in the SO_4^{2-} ion? [1]

+6

3. Under certain conditions the following equilibrium exists.

$$2N_2O_5(g) \rightleftharpoons 4NO_2(g) + O_2(g)$$

(a) Write the expression for the equilibrium constant, K_c, for this equilibrium. [1]

$$K_c = \frac{[NO_2]^4\,[O_2]}{[N_2O_5]^2}$$

(b) State the unit, if any, for K_c in this equilibrium. [1]

$mol^3\ dm^{-9}$

4. A radioactive isotope has a half-life of 4 hours. Calculate the time needed for 4.0 g of the isotope to decay to 0.5 g. [1]

4.0 g → 2.0 g → 1.0 g → 0.5 g = 3 half-lives

3 × 4 hours = 12 hours

Time = 12 hours

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

5. Water gas is a mixture of carbon monoxide and hydrogen that is made by passing steam over heated carbon.

$$H_2O(g) + C(s) \longrightarrow H_2(g) + CO(g)$$

Calculate the atom economy of this process as a method for the production of hydrogen gas. [2]

$M_r(reactants) = M_r(H_2O) + A_r(C) = 18.02 + 12.0 = 30.02$

$M_r(H_2) = 2.02$

atom economy $= (2.02 \div 30.02) \times 100 = 6.73\ \%$

Atom economy = 6.73 %

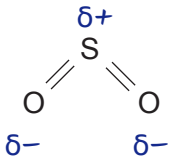
6. Balance the following equation. [1]

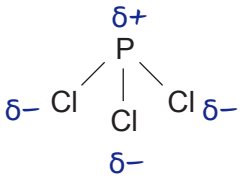
3 K_2CO_3 + 2 $AlCl_3$ + 3 H_2O ⟶ 6 KCl + 2 $Al(OH)_3$ + 3 CO_2

7. *(a)* State the meaning of the term *electronegativity*. [1]

The tendency of an atom to pull (attract) the shared pair of electrons in a covalent bond towards itself.

(b) On the diagrams below mark any permanent dipoles. [1]





10

© WJEC CBAC Ltd.

stemup.co.uk

B410U101
03

Examiner only

SECTION B

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

8. *(a)* State the meaning of the term *molar first ionisation energy*. [2]

The energy needed to remove one electron from each atom in one mole of gaseous atoms of the element: $X(g) \rightarrow X^+(g) + e^-$

(b) Students using a spectrometer observed lines from a hydrogen lamp in the visible part of the spectrum.

One student said that the frequencies of the lines could be used to calculate the molar first ionisation energy of hydrogen. The other student said that these were not the lines needed in this calculation.

Comment on these statements and explain how the molar first ionisation energy of hydrogen can be determined. [6 QER]

The second student is correct. The lines in the visible region form the Balmer series, produced when excited electrons fall back to the $n = 2$ energy level, so they cannot be used.

Ionisation removes the electron completely from the ground state, a transition from $n = 1$ to $n = \infty$. The lines needed are those of the Lyman series, where electrons fall to $n = 1$; these lines are in the ultraviolet region of the spectrum.

The Lyman lines get closer together as frequency increases and converge.

Measure the frequency of the convergence limit of the Lyman series: this corresponds to the movement of the electron from $n = 1$ to $n = \infty$.

Calculate the energy for one atom using $\Delta E = hf$ (h = Planck constant).

Multiply ΔE by Avogadro's constant (6.02×10^{23} mol^{-1}) to give the molar first ionisation energy, and divide by 1000 for kJ mol^{-1}.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(c) A line in a spectrum has a wavelength of 550 nm.

Calculate the energy change, in kJ mol^{-1}, that corresponds to this line. [4]

$\Delta E = hf = hc \div \lambda$

$\Delta E = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) \div (550 \times 10^{-9})$

$\Delta E = 3.62 \times 10^{-19}$ J per atom

$\times N_A$: $3.616 \times 10^{-19} \times 6.02 \times 10^{23} = 2.18 \times 10^{5}$ J mol^{-1}

$= 218$ kJ mol^{-1}

Energy change = 218 kJ mol^{-1}

(d) The table shows the first ionisation energy for some elements.

Element	First ionisation energy / kJ mol^{-1}
sodium, Na	496
magnesium, Mg	738
potassium, K	419

(i) Explain the difference in the values for sodium and magnesium. [2]

Sodium is lower than magnesium: they are both in the same period, so they have the same amount of shielding.

Sodium has fewer protons (smaller nuclear charge), so its outer electron is held less strongly.

(ii) Explain the difference in the values for sodium and potassium. [2]

Potassium is lower than sodium because potassium is in the next period down, so its outer electron is in a shell further out.

Potassium has a bigger atomic radius and more shielding, so the outer electron is attracted less strongly by the nucleus.

B410U101 05

© WJEC CBAC Ltd.

stemup.co.uk

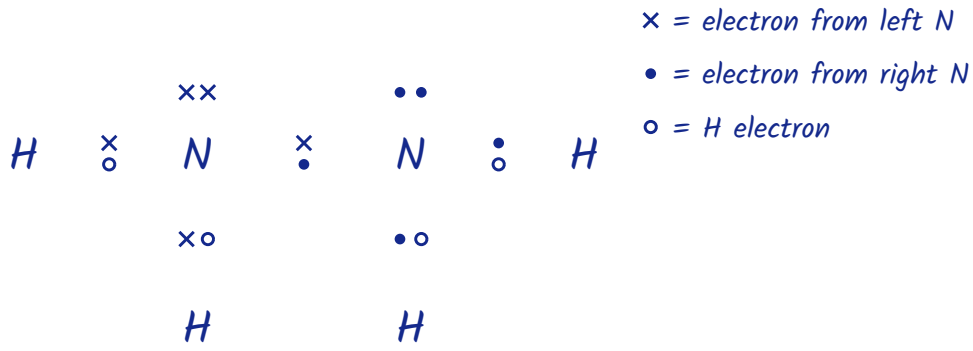
Examiner only

9. Hydrazine, N_2H_4, is a liquid that can be used as a rocket fuel. It reacts with oxygen in an exothermic reaction.

$$N_2H_4(l) + O_2(g) \longrightarrow N_2(g) + 2H_2O(g)$$

(a) (i) A molecule of hydrazine contains single bonds only.

Draw a dot and cross diagram to show the arrangement of the electrons in hydrazine. You should show outer electrons only. [2]



(ii) Suggest the bond angle for the H — N — H bonds in hydrazine. Explain your suggestion. [3]

About 107°. Each N atom has 3 bond pairs and 1 lone pair, so the pairs are arranged in a distorted tetrahedral (pyramidal) shape, and lone pair to bond pair repulsion is greater than bond pair to bond pair repulsion.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(b) Calculate the volume of nitrogen produced by the reaction of 20.0 cm^3 of liquid hydrazine with excess oxygen.

Assume that all measurements are taken at 273 K and 1 atm pressure, that the density of hydrazine is 1.02 g cm^{-3} and that the process has a 35 % yield. [4]

mass of N_2H_4 = 20.0 × 1.02 = 20.4 g

$n(N_2H_4)$ = 20.4 ÷ 32.04 = 0.637 mol

$n(N_2)$ = $n(N_2H_4)$ = 0.637 mol (1 : 1)

volume at 273 K, 1 atm = 0.637 × 22.4 = 14.26 dm^3

35 % yield: 14.26 × 35 ÷ 100 = 4.99 dm^3

Volume = 4.99 dm^3

B410U101
07

(c) Methane also reacts with oxygen in an exothermic reaction and could be used as a rocket fuel. Apart from conservation of fossil fuel reserves, suggest an environmental advantage of using hydrazine. [1]

The products (nitrogen and water) are non-toxic, and no CO_2 (greenhouse gas) is produced.

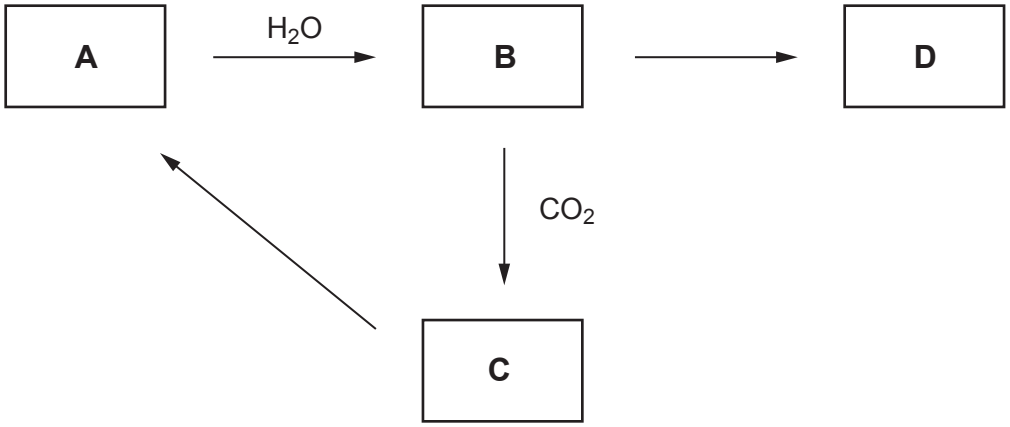
10

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

10. Some reactions of compounds of the same s-block metal are shown below.



A is a compound that reacts with water to give an aqueous solution of the sparingly soluble compound **B**.

B reacts with carbon dioxide to give a white precipitate of compound **C**.

D is an aqueous solution that gives a white precipitate with aqueous silver nitrate.

(a) Give the names of compounds **A** to **D**. [4]

A calcium oxide

B calcium hydroxide

C calcium carbonate

D calcium chloride

(b) Suggest a reagent that would convert **B** into **D**. [1]

hydrochloric acid, HCl(aq)

(c) State how the conversion of **C** into **A** could be carried out. [1]

by heating it strongly (thermal decomposition)

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(d) Write the **ionic** equation for the conversion of **A** into **B**. Include state symbols. [2]

$CaO(s) + H_2O(l) \rightarrow Ca^{2+}(aq) + 2OH^-(aq)$

(e) What would be observed, if anything, if aqueous sodium hydroxide were added dropwise and then to excess to solution **D**? [2]

Dropwise *a white precipitate forms*

Excess *the white precipitate is insoluble in excess (remains)*

(f) Suggest a test that would confirm the cation present in compounds **A** to **D**. Include the test and the expected result. [2]

Test *flame test*

Result *a brick red flame*

12

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

11. Explain the following statements.

(a) Bromine is a liquid at room temperature and iodine is a solid. [3]

To change state, the intermolecular forces between the molecules must be broken.

Iodine molecules have more electrons than bromine molecules, so there are more / stronger van der Waals forces (induced dipole attractions) between iodine molecules, needing more energy to overcome.

(b) Graphite conducts electricity but diamond does not. [3]

In diamond all the (valence) electrons of each carbon are involved in covalent bonds, so none are free to move.

In graphite each carbon uses only three electrons in bonding, so there are delocalised electrons between the layers. These delocalised electrons are free to move and carry charge.

(c) The molecular ion peaks are at m/z 158, 160 and 162 in the mass spectrum of bromine, Br_2. The areas of these peaks are in the ratio of 1 : 2 : 1. [3]

Bromine has two isotopes, ^{79}Br and ^{81}Br, in a 1 : 1 ratio (equal abundance).

The molecular ion peaks at 158, 160 and 162 are produced by $^{79}Br_2$, $^{79}Br^{81}Br$ and $^{81}Br_2$ respectively. There are two ways of forming $^{79}Br^{81}Br$, so the ratio is 1 : 2 : 1.

9

© WJEC CBAC Ltd.

stemup.co.uk

BLANK PAGE

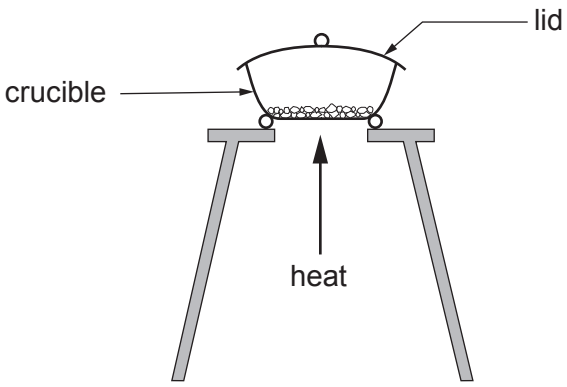
© WJEC CBAC Ltd.

stemup.co.uk

12. Barium chloride exists as a hydrated salt, $BaCl_2.xH_2O$, where x is the number of molecules of water of crystallisation. To determine the value of x, the hydrated salt is heated to remove the water of crystallisation.

The following method was carried out.

- Weigh an empty crucible with its lid.
- Place about 2.00 g of hydrated barium chloride in the crucible and re-weigh, with its lid.
- Place the lid on the crucible and heat gently at first, then remove the lid and heat strongly for about 2 minutes.



- Place the lid on the crucible and allow it to cool.
- Weigh the cooled crucible with its lid and residue.

The following results were recorded.

Mass of crucible + lid = 10.24 g

Mass of crucible + lid + hydrated barium chloride = 12.25 g

Mass of crucible + lid + residue after heating = 11.97 g

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(a) Calculate the mass of hydrated barium chloride and the mass of residue. Hence determine the value of x. [5]

mass of hydrated $BaCl_2$ = 12.25 − 10.24 = 2.01 g

mass of residue ($BaCl_2$) = 11.97 − 10.24 = 1.73 g

mass of water lost = 2.01 − 1.73 = 0.28 g

$M_r(BaCl_2) = 208$, $M_r(H_2O) = 18.02$

$n(BaCl_2) = 1.73 \div 208 = 8.32 \times 10^{-3}$ mol

$n(H_2O) = 0.28 \div 18.02 = 1.55 \times 10^{-2}$ mol

$x = 1.55 \times 10^{-2} \div 8.32 \times 10^{-3} = 1.86 \approx 2$

x = 2

(b) (i) Suggest why the crucible was heated initially with the lid in place. [1]

To avoid spitting (frothing), so that no solid is lost from the crucible.

(ii) Suggest why the lid was placed on the crucible when it was left to cool. [1]

To stop water being absorbed from the atmosphere by the residue as it cools.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(c) (i) When this experiment is carried out the value of x obtained is often less than the theoretical value. Suggest a reason for this, assuming that the compound contains no impurities. [1]

Not all the water of crystallisation was lost (heating was not long enough).

(ii) State an improvement that could be made to the practical procedure to overcome the problem you have identified in *(c)*(i). [1]

Heat, cool and reweigh repeatedly until a constant mass is obtained.

(d) If the error in each balance reading is ± 0.05 g, calculate the percentage error in the mass of hydrated barium chloride used in the experiment. [1]

two readings: error = 2 × 0.05 = 0.10 g

(0.10 ÷ 2.01) × 100 = 4.98 %

Percentage error = 4.98 %

(e) Apart from the improvement you identified in *(c)*(ii), suggest another change that could be made to improve the accuracy of the experiment. [1]

Use a larger mass of solid (or use a balance that reads to more decimal places).

11

© WJEC CBAC Ltd.

stemup.co.uk

BLANK PAGE

TURN OVER FOR QUESTION 13

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

13. *(a)* A compound of carbon, hydrogen and oxygen contains 40.0 % carbon and 6.7 % hydrogen by mass.

1.52 g of the gaseous compound has a volume of 1.76 dm^3 at a temperature of 150 °C and a pressure of 1 atm.

Use the data to determine the empirical formula and the molecular formula of this compound. You **must** show clearly how you carried out your calculations. [5]

C : H : O = 40.0/12.0 : 6.7/1.01 : 53.3/16.0

= 3.33 : 6.63 : 3.33 = 1 : 2 : 1, so empirical formula CH_2O

$pV = nRT$, so $n = pV \div RT$

$n = (1.01 \times 10^5 \times 1.76 \times 10^{-3}) \div (8.31 \times 423) = 0.0506$ mol

$M_r = m \div n = 1.52 \div 0.0506 = 30.0$

$M_r(CH_2O) = 30.0$, so the molecular formula is also CH_2O

Empirical formula CH_2O

Molecular formula CH_2O

(b) (i) State what is meant by an acid. [1]

A proton (H^+) donor.

(ii) Describe how ammonia, NH_3, is able to act as a base. [2]

Ammonia has a lone pair of electrons on the nitrogen atom, which it uses to accept a proton (H^+), forming a coordinate (dative) bond.

$NH_3 + H^+ \rightarrow NH_4^+$

(iii) Calculate the pH of 0.43 mol dm^{-3} hydrochloric acid. [2]

HCl is a strong acid, so $[H^+] = 0.43$ mol dm^{-3}

$pH = -\log[H^+] = -\log(0.43) = 0.37$

pH = 0.37

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(c) In the table below name the type of structure and bonding present in magnesium oxide, MgO, and chlorine dioxide, ClO_2. [2]

Compound	Structure	Bonding
MgO	giant ionic	ionic
ClO_2	simple molecular	covalent

12

END OF PAPER

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

For continuation only.

© WJEC CBAC Ltd.

stemup.co.uk

BLANK PAGE

© WJEC CBAC Ltd.

stemup.co.uk