Surname	StemUp Model Solution	Centre Number	Candidate Number
Other Names			2

GCE AS

B410U10-1

S18-B410U10-1

CHEMISTRY – AS component 1
The Language of Chemistry, Structure of Matter and Simple Reactions

TUESDAY, 22 MAY 2018 – MORNING

1 hour 30 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 7.**	**10**	
Section B	**8.**	**9**	
	9.	**10**	
	10.	**13**	
	11.	**12**	
	12.	**14**	
	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.9***(a)*.

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.*

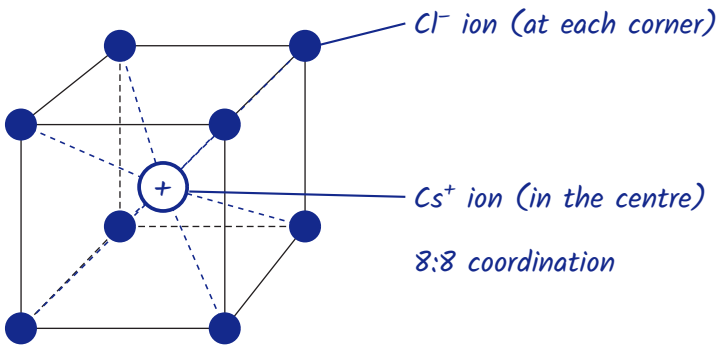
1. Complete the electronic structure of a bromine atom, Br. [1]

$1s^2\ 2s^2\ 2p^6$ $3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^5$

2. Give the oxidation state of chromium in the dichromate ion, $Cr_2O_7^{2-}$. [1]

+6

3. Complete the diagram to show the structure of caesium chloride, CsCl. [1]



4. Using the formula of calcium sulfate, calculate the number of **oxygen** atoms present in 0.1 mol of calcium sulfate. [2]

$CaSO_4$: 1 mol of calcium sulfate contains 4 mol of O atoms

moles of O atoms = $0.1 \times 4 = 0.4$ mol

number = $0.4 \times 6.02 \times 10^{23} = 2.41 \times 10^{23}$

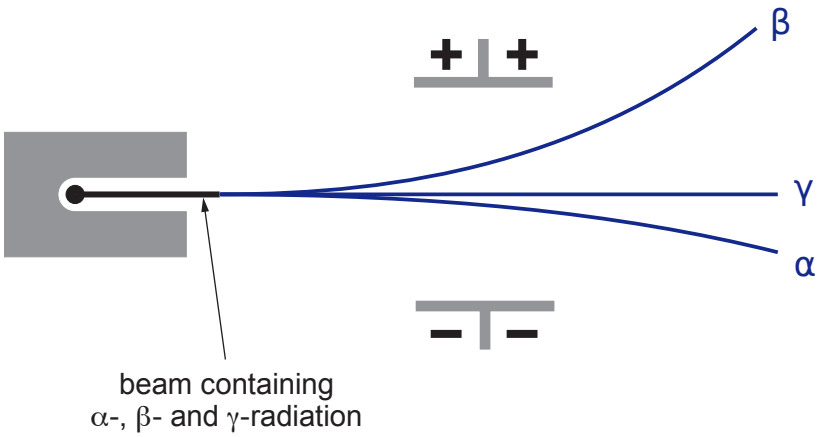
Number of oxygen atoms = 2.41×10^{23}

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5. Complete the diagram to show how α-, β- and γ-radiation are affected by an electric field. [2]



6. Complete the equation. [1]

2 CH_3COOH + ... ZnO ⟶ ..... $(CH_3COO)_2Zn$ + H_2O

7. Ethanol, C_2H_5OH, can be made by the fermentation of glucose, $C_6H_{12}O_6$.

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$$

Calculate the atom economy of this reaction. [2]

M_r $C_6H_{12}O_6$ = 6(12.0) + 12(1.01) + 6(16.0) = 180.12

M_r of $2C_2H_5OH$ = 2 × 46.06 = 92.12

atom economy = 92.12/180.12 × 100 = 51.1%

Atom economy = 51 %

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SECTION B

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

8. Using ideas that you have studied in your Chemistry course comment on and explain the following observations.

(a) Ice floats on water. [3]

Ice is less dense than liquid water because its molecules are further apart. In ice the water molecules are held in an open lattice by hydrogen bonds. On melting this hydrogen-bonded lattice is partially broken down, so the molecules move closer together in water.

(b) The mass spectrum of naturally-occurring chlorine, Cl_2, contains three lines of different heights in the molecular ion region. [3]

Chlorine has two isotopes, chlorine-35 and chlorine-37, in a 3:1 ratio. Cl_2 molecules give lines at m/z 70 ($^{35}Cl^{35}Cl$), 72 ($^{35}Cl^{37}Cl$) and 74 ($^{37}Cl^{37}Cl$) with relative heights 9:6:1.

(c) Universal indicator is red when placed in 0.1 mol dm^{-3} hydrochloric acid and it is orange when placed in 0.1 mol dm^{-3} propanoic acid, C_2H_5COOH. [3]

Red in HCl as it has a very low pH (about 1); orange in propanoic acid as it has a higher pH (about 3).

HCl is a strong acid that is fully dissociated, but C_2H_5COOH is a weak acid that only partially dissociates, so at the same concentration it gives a much lower $[H^+]$.

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9. *(a)* A student was studying the boiling temperatures of different substances including those listed in the table.

Substance	Boiling temperature / °C
hydrogen, H_2	–253
bromine, Br_2	59
hydrogen bromide, HBr	–66

The student suggested that the boiling temperature could be predicted by considering the strength of the covalent bonds in the molecules.

State why the student is **incorrect**. Explain your reasoning and the factors that govern the boiling temperatures of these substances. [6 QER]

The student is incorrect because no covalent bonds are broken when these substances boil. Boiling only overcomes the intermolecular forces between the molecules.

In H_2 and Br_2 the only intermolecular forces are van der Waals forces, caused by temporary dipole to induced dipole attractions. Br_2 has many more electrons than H_2, so its temporary dipoles are larger and its van der Waals forces are much stronger; more energy is needed to separate the molecules, so Br_2 boils at 59 °C but H_2 at −253 °C.

HBr is polar (Br is more electronegative than H), so it has permanent dipole to permanent dipole attractions as well as van der Waals forces. Permanent dipole attractions are stronger than van der Waals forces, so we might expect HBr to boil higher than Br_2. However Br_2 boils higher, so here the larger size (number of electrons) of Br_2 has more effect than the polarity of HBr.

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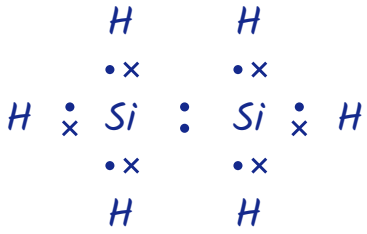
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(b) (i) Silicon and hydrogen can form a series of compounds called silanes.

Draw a dot and cross diagram to show the electron arrangement in the silane, Si_2H_6. Show outer electrons only. [2]



(ii) Predict the H—Si—H bond angle in Si_2H_6. Explain your answer. [2]

109.5°. Each Si atom has four bonding pairs and no lone pairs; these electron pairs repel equally and get as far apart as possible (tetrahedral).

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10. Cerrusite is a naturally-occurring crystalline ore that contains a high percentage of insoluble lead(II) carbonate, $PbCO_3$.

(a) One method of finding the percentage of lead in the ore is by forming lead ions in solution and then precipitating them as lead(II) sulfate.

(i) Suggest how the ore could be treated to form lead(II) ions in solution. [1]

Add dilute nitric acid (to dissolve the $PbCO_3$).

(ii) Name a solution which could be added to the lead(II) solution to form lead(II) sulfate. [1]

Sodium sulfate solution

(iii) Write an **ionic** equation for the reaction used to form lead(II) sulfate. Include state symbols. [2]

$Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$

(iv) Describe how the lead(II) sulfate precipitate should be treated to obtain results for quantitative analysis. Explain your answer. [3]

Filter off the precipitate (in a weighed filter crucible).

Wash it with distilled water to remove soluble impurities.

Dry it in an oven and reweigh, repeating until constant mass, to make sure all the water has been removed.

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(b) (i) 4.52 g of cerrusite were investigated by the method outlined in part *(a)* and the following results were obtained.

	Mass / g
Empty container	21.47
Container + lead(II) sulfate	25.03

Calculate the percentage by mass of **lead** in the cerrusite. [3]

mass $PbSO_4$ = 25.03 − 21.47 = 3.56 g

moles $PbSO_4$ = 3.56/303.3 = 0.0117 mol

mass Pb = 0.0117 × 207.2 = 2.43 g

% Pb = 2.43/4.52 × 100 = 53.8%

Percentage = 54 %

(ii) The balance used in the experiment could be read to 2 decimal places. **Two** weighings were made to find the mass of lead(II) sulfate. Calculate the maximum percentage error in the mass of lead(II) sulfate. Show your working. [1]

max error = 2 × 0.005 = 0.01 g

% error = 0.01/3.56 × 100 = 0.281%

Maximum percentage error = 0.281 %

(c) Some samples of cerrusite are thought to contain other carbonates in addition to the lead(II) carbonate. Suggest how this hypothesis could be investigated in a school or college laboratory. [2]

Add excess acid to a weighed sample and measure the volume of CO_2 produced (gas syringe). If other carbonates are present there will be more moles of carbonate (CO_2) than calculated from the mass of $PbCO_3$.

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11. Limewater is a saturated solution of calcium hydroxide, $Ca(OH)_2$. A student carried out an experiment to find the concentration of calcium hydroxide in a sample of limewater. The student had access to the apparatus and chemicals usually available in a school or college laboratory.

The teacher told the student that he needed to carry out a titration using 0.050 mol dm^{-3} hydrochloric acid.

(a) Describe how the student could prepare 0.050 mol dm^{-3} hydrochloric acid from 2.0 mol dm^{-3} hydrochloric acid. You should include details of any apparatus required. [3]

The acid must be diluted by a factor of 40 (2.0/0.050 = 40).

Use a 25.0 cm^3 pipette (with pipette filler) to transfer 25.0 cm^3 of the 2.0 mol dm^{-3} acid into a 1.00 dm^3 volumetric flask, make up to the mark with distilled water, then stopper and invert to mix.

(b) The student carried out the titration and used 19.60 cm^3 of the 0.050 mol dm^{-3} hydrochloric acid to neutralise 25.0 cm^3 of the calcium hydroxide solution.

Calculate the concentration of the calcium hydroxide solution in g dm^{-3}. [4]

moles HCl = $19.60 \times 0.050/1000 = 9.80 \times 10^{-4}$ mol

$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$

moles $Ca(OH)_2$ in 25.0 cm^3 = $9.80 \times 10^{-4}/2 = 4.90 \times 10^{-4}$ mol

conc = $4.90 \times 10^{-4} \times 1000/25.0 = 0.0196$ mol dm^{-3}

M_r $Ca(OH)_2$ = 74.1

conc = $0.0196 \times 74.1 = 1.45$ g dm^{-3}

Concentration = 1.45 g dm^{-3}

(c) The student left the bottle of calcium hydroxide solution overnight without its stopper in place. Explain what he observed when he returned next day. [2]

A white precipitate formed (it went cloudy) because CO_2 from the air was absorbed and insoluble $CaCO_3$ formed.

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(d) The student decided to repeat the titration using a saturated solution of barium hydroxide, $Ba(OH)_2$.

How would the volume of hydrochloric acid used in the titration be different? Explain your answer. [1]

A greater volume of acid is needed because $Ba(OH)_2$ is more soluble than $Ca(OH)_2$.

(e) The student did not label the solutions of calcium hydroxide and barium hydroxide. Describe a test he could use to determine which solution is which. Include the result of the test in each case. [2]

Flame test: calcium hydroxide gives a brick-red flame and barium hydroxide gives an apple-green flame.

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12. Carboxylic acids react with alcohols to make esters, using sulfuric acid as a catalyst. These reactions are reversible.

$$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

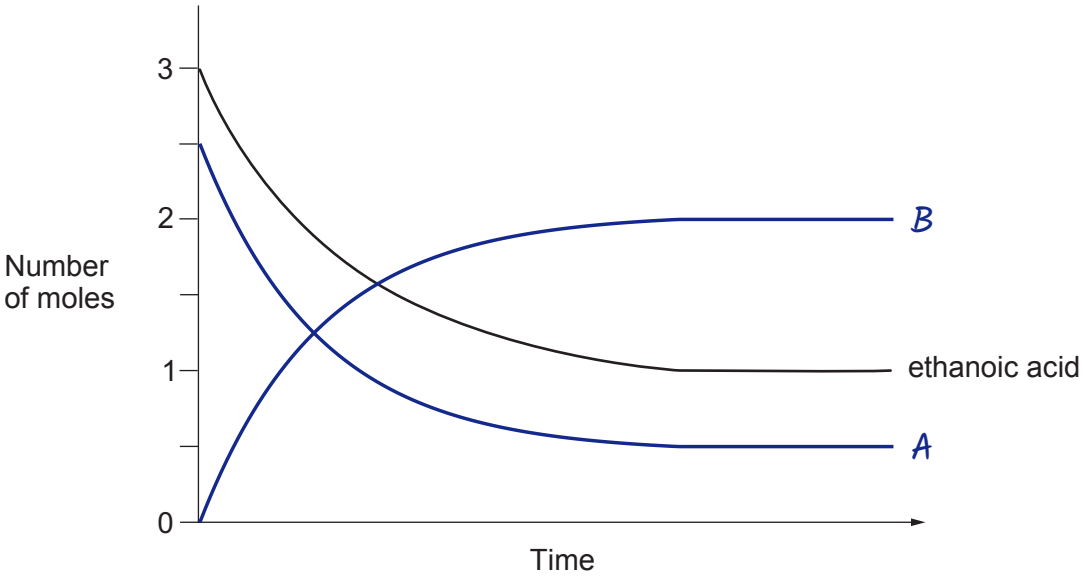
ethanoic acid ethanol ethyl ethanoate

(a) State what is meant by a *reversible* reaction. [1]

A reaction in which the products can react to re-form the reactants, as well as the reactants forming products.

(b) In an experiment to prepare ethyl ethanoate, 3.0 mol of ethanoic acid were mixed with 2.5 mol of ethanol and a small amount of concentrated sulfuric acid. Water was added to make a total volume of 1.0 dm^3.

The number of moles of ethanoic acid present was measured as the reaction proceeded until equilibrium was reached. The results were then plotted.



On the grid sketch:

- the line that shows the number of moles of ethanol as the reaction proceeds to equilibrium. Label this line **A**.
- the line that shows the number of moles of ethyl ethanoate as the reaction proceeds to equilibrium. Label this line **B**. [3]

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(c) (i) Write the expression for the equilibrium constant, K_c, for the esterification reaction. Include the unit, if any. [2]

$$K_c = \frac{[CH_3COOC_2H_5][H_2O]}{[CH_3COOH][C_2H_5OH]}$$

Unit none (no units)

(ii) Under certain conditions the value of K_c was found to be 4. At a higher temperature, with all other factors being kept constant, this value remained almost the same. Explain what can be deduced from this information. [2]

ΔH for the reaction is approximately zero. By le Chatelier's principle, changing temperature only shifts the position of equilibrium (and changes K_c) if the reaction is exothermic or endothermic, so K_c stays the same.

(d) Esterification is catalysed by the addition of concentrated sulfuric acid. In an esterification the final pH of the solution was 2.4. Calculate the concentration of hydrogen ions present, in mol dm^{-3}. [2]

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

$[H^+] = 10^{-pH} = 10^{-2.4}$

$= 3.98 \times 10^{-3}$ mol dm^{-3}

$[H^+]$ = 3.98×10^{-3} mol dm^{-3}

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(e) 2.94 g of ethanoic acid were mixed with 2.07 g of ethanol and allowed to react. 2.73 g of ethyl ethanoate were produced. Calculate the percentage yield of this reaction. [4]

moles CH_3COOH = 2.94/60.06 = 0.0490 mol

moles C_2H_5OH = 2.07/46.07 = 0.0449 mol

reaction is 1:1, so ethanol is the limiting reagent

M_r $CH_3COOC_2H_5$ = 88.1

theoretical yield = 0.0449 × 88.1 = 3.96 g

% yield = 2.73/3.96 × 100 = 68.9%

Percentage yield = 68.9 %

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13. Compound **X** contains **only** carbon, hydrogen and oxygen. 6.57 g of **X** was burned in excess oxygen to form carbon dioxide and water. 12.57 g of carbon dioxide and 7.74 g of water were collected.

(a) Suggest how the mass of carbon dioxide and the mass of water could be measured in this experiment. [2]

Pass the gases first through a weighed tube of anhydrous calcium chloride (or conc. sulfuric acid) to absorb the water, then through a weighed tube of alkali (e.g. soda lime) to absorb the CO_2. The mass increase of each tube gives the mass.

(b) Find the percentage by mass of each element in **X**. [3]

mass C = 12.57 × 12.0/44.0 = 3.43 g

mass H = 7.74 × 2/18.02 = 0.86 g

% C = 3.43/6.57 × 100 = 52.2% % H = 0.86/6.57 × 100 = 13.1%

% O = 100 − (52.2 + 13.1) = 34.7%

Percentage carbon = 52.2 %

Percentage hydrogen = 13.1 %

Percentage oxygen = 34.7 %

(c) Calculate the empirical formula of **X**. [2]

C : H : O = 52.2/12.0 : 13.1/1.01 : 34.7/16.0

= 4.35 : 12.97 : 2.17

= 2 : 6 : 1

Empirical formula C_2H_6O

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(d) 9.20 g of **X**, measured at a pressure of 103 kPa and a temperature of 100 °C, had a volume of 6.02×10^3 cm^3. Calculate the relative molecular mass, M_r, of **X**. [4]

$pV = nRT$, so $n = pV/RT$

$p = 103 \times 10^3$ Pa, $V = 6.02 \times 10^{-3}$ m^3, $T = 373$ K

$n = (103 \times 10^3 \times 6.02 \times 10^{-3})/(8.31 \times 373) = 0.200$ mol

$M_r = 9.20/0.200 = 46.0$

Relative molecular mass = 46

(e) Use your answers to parts *(c)* and *(d)* to deduce the molecular formula of **X**. [1]

M_r of empirical formula C_2H_6O = 46.07, the same as the M_r found in (d), so the molecular formula = empirical formula

Molecular formula C_2H_6O

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END OF PAPER

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