Surname	StemUp Model Solution	Centre Number	Candidate Number
Other Names			2

GCE AS – NEW

B410U10-1

S17-B410U10-1

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

FRIDAY, 26 MAY 2017 – MORNING

1 hour 30 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 8.**	**10**	
Section B	**9.**	**13**	
	10.	**15**	
	11.	**15**	
	12.	**13**	
	13.	**14**	
	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.10***(b)*.

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 configuration for the ion Ni^{2+}. [1]

$1s^2\ 2s^2$ $2p^6\ 3s^2\ 3p^6\ 3d^8$

2. The half-life of a radioactive isotope is 12 days. If a 3.0 g sample of the isotope is left for 24 days, what mass of the isotope will remain? [1]

24 days = 2 half-lives: 3.0 → 1.5 → 0.75 g

Mass = 0.75 g

3. *(a)* Define *electronegativity*. [1]

The tendency of an atom in a covalent bond to attract the bonded pair of electrons towards itself.

(b) On each of the diagrams of molecules below label any permanent dipoles. [1]

Cl—Cl
(no permanent dipole)

δ− δ+
F—Cl

stemup.co.uk

Examiner only

4. Dinitrogen tetroxide, N_2O_4, and nitrogen dioxide, NO_2, can exist in equilibrium.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

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

$K_c = \dfrac{[NO_2]^2}{[N_2O_4]}$

(b) A 1 dm^3 volume of an equilibrium mixture contained 0.2 mol of N_2O_4 and 1.6 mol of NO_2. Calculate the value of K_c. Include the unit. [1]

$K_c = [NO_2]^2 \div [N_2O_4] = 1.6^2 \div 0.2 = 2.56 \div 0.2$

K_c = 12.8

Unit $mol\ dm^{-3}$

5. Calcium carbonate, $CaCO_3$, decomposes significantly at temperatures above 800 °C. Suggest a temperature at which barium carbonate, $BaCO_3$, would decompose significantly. Give a reason for your suggestion. [1]

About 1000 °C (above 900 °C): thermal stability of Group 2 carbonates increases down the group, and Ba is below Ca.

6. Give the oxidation state of vanadium in the ion VO_3^-. [1]

+5

7. Name **two** substances whose aqueous solutions can be mixed to produce the insoluble compound copper(II) hydroxide. [1]

copper(II) sulfate and sodium hydroxide

8. Balance the equation below. [1]

3Cu(s) + 8 HNO_3(aq) → 3 $Cu(NO_3)_2$(aq) + 2 NO(g) + 4 H_2O(l)

B410U101 03

10

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

SECTION B

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

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

(a) The conductivity of aluminium is different from that of sodium. [2]

Both metals conduct because of the delocalised (free) electrons in the sea of electrons between the positive ions.

Aluminium has a greater conductivity: each Al atom contributes 3 delocalised electrons but each Na atom only 1, so Al has more free electrons.

(b) When solid iodine is heated gently a purple vapour is seen but, even at high temperatures, diamond does not melt. [4]

Iodine has a simple molecular structure but diamond is giant molecular (giant covalent).

To change state, iodine molecules only overcome weak temporary dipole (Van der Waals) forces, so gentle heating is enough.

To melt diamond, strong covalent bonds between C atoms must be broken: not possible even at high temperatures.

(c) The melting temperature of magnesium oxide is much higher than the melting temperature of sodium chloride. [3]

Both are ionic, and melting involves overcoming the electrostatic attraction between the positive and negative ions.

This attraction is greater in magnesium oxide than in sodium chloride, because the ions in MgO are Mg^{2+} and O^{2-} (more highly charged) whereas in NaCl they are Na^{+} and Cl^{-}.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(d) In two separate experiments aqueous chlorine was added to aqueous sodium bromide and aqueous bromine was added to aqueous sodium chloride.

In each case an orange/brown solution was seen at the end of the addition. [4]

The orange/brown solution is bromine in both cases.

Chlorine is a better oxidising agent than bromine (Cl is smaller, so it attracts electrons more strongly), so chlorine takes electrons from bromide ions: $Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$

Bromine cannot react with (oxidise) chloride ions, so the orange/brown colour in the second experiment is just the added bromine water.

13

© WJEC CBAC Ltd.

stemup.co.uk

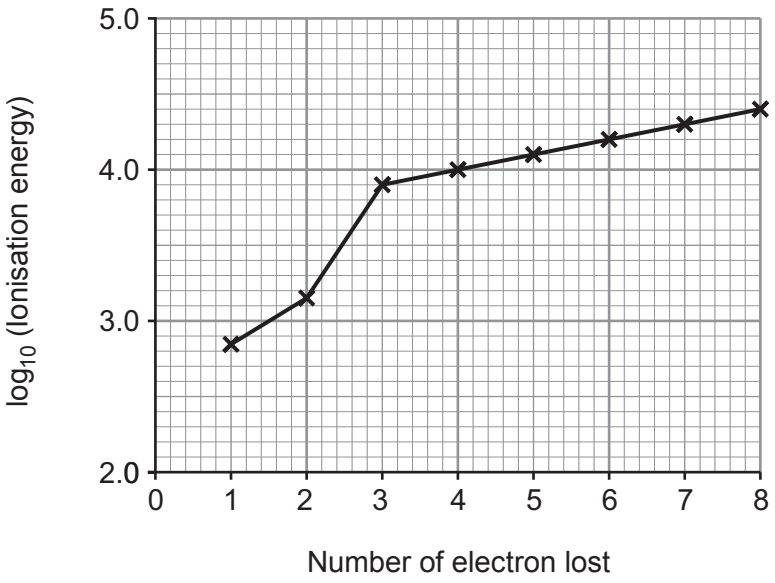
Examiner only

10. *(a)* Some students were discussing ionisation energies.

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

The energy needed to remove one electron from every atom in 1 mol of the element in the gaseous state, under standard conditions.

(ii) The graph below shows the logarithm of the first eight successive ionisation energies for element **X**.



I. Explain why successive ionisation energies increase. [2]

An electron must overcome the attraction of the nucleus. Each successive electron is removed from an increasingly positive ion (proton : electron ratio goes up).

II. Use the graph to determine in which group of the Periodic Table element **X** is found. Explain your answer. [2]

Group 2. There is a big jump between the 2nd and 3rd ionisation energies: after removal of two electrons a new shell (nearer the nucleus) is broken into.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(b) The students used a hydrogen discharge tube and observed some coloured lines. One said that these visible lines could be used to determine the value of the first ionisation energy of hydrogen.

(i) Discuss whether you agree with this student's suggestion. You should include an explanation of how spectral lines are produced and how they can be used to determine ionisation energy. [6 QER]

I disagree with the student. In the discharge tube, electrical energy excites electrons in the hydrogen atoms to higher energy levels. The excited electrons then fall back to lower levels and give off the energy as light of a definite frequency, $\Delta E = hf$. Only certain energies are allowed (energy levels are quantised), so lines are formed rather than a continuous spectrum.

The visible lines (Balmer series) come from transitions down to $n = 2$, so they cannot be used. For ionisation energy, transitions to $n = 1$ (the Lyman series, in the ultraviolet) must be used.

The lines get closer together at higher energy (frequency) since the energy levels get closer together, until they converge. The convergence limit is where the electron is removed completely from $n = 1$ ($n = \infty$), i.e. ionisation takes place. Its frequency is used in $E = hf$ and multiplied by the Avogadro constant to give the ionisation energy.

(ii) A spectral line with a frequency of 3.28×10^{15} Hz was formed when an atom of hydrogen was ionised.

Calculate the first ionisation energy of hydrogen in kJ mol^{-1}. Give your answer to the appropriate number of significant figures. [3]

$E = hf = 6.63 \times 10^{-34} \times 3.28 \times 10^{15} = 2.175 \times 10^{-18}$ J

per mole: $2.175 \times 10^{-18} \times 6.02 \times 10^{23} = 1.309 \times 10^{6}$ J mol^{-1}

$= 1309$ kJ mol^{-1} $= 1310$ kJ mol^{-1} (3 sig figs)

Ionisation energy = ... 1310 ..... kJ mol^{-1}

B410U101 07

15

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

11. *(a)* When acids are being used chemists often refer to the pH of the solution.

(i) State what is meant by pH. [1]

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

(ii) Calculate the pH of 0.50 mol dm^{-3} hydrochloric acid. [1]

$[H^+] = 0.50$ mol dm^{-3}; $pH = -\log 0.50$

pH = 0.30

(iii) Explain the observation that the pH of 0.10 mol dm^{-3} ethanoic acid, CH_3COOH, is higher than the pH of 0.10 mol dm^{-3} hydrochloric acid. [3]

Ethanoic acid is a weak acid but hydrochloric acid is a strong acid.

Ethanoic acid is only partially dissociated, $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$,

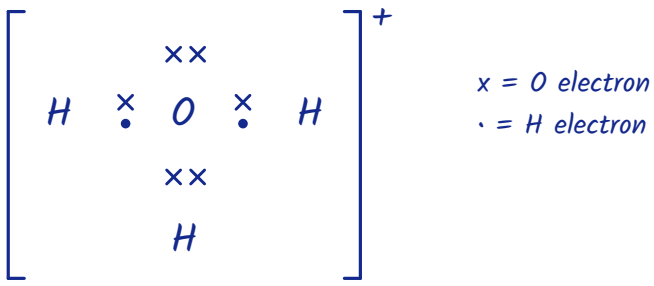
whereas HCl is fully dissociated.

So ethanoic acid has a lower concentration of H^+ ions, giving a higher

pH.

(b) Water is able to act as a base as it can accept H^+ to form H_3O^+.

(i) Draw a dot and cross diagram to show the arrangement of electrons in H_3O^+. Show outer electrons only. [2]



(ii) Name the type of bond present between H_2O and the H^+ added to form H_3O^+. [1]

co-ordinate (dative covalent) bond

(iii) Suggest a value for the bond angle between the O—H bonds in H_3O^+. Explain your answer. [3]

107° (106° to 108°). O has 3 bond pairs and 1 lone pair; lone pair to

bond pair repulsion is greater than bond pair to bond pair repulsion, so

the angle is less than 109.5°.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(c) An equilibrium exists, in aqueous solution, between chromate(VI) ions, CrO_4^{2-}, and dichromate(VI) ions, $Cr_2O_7^{2-}$.

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

yellow orange

(i) State le Chatelier's principle. [2]

If a change in conditions is applied to a system in equilibrium, the position of equilibrium moves in the direction that tends to minimise (oppose) the effect of the change.

(ii) Describe what is seen when aqueous sodium hydroxide is added to an orange solution containing dichromate(VI) ions. Explain your answer. [2]

The solution turns from orange to yellow.

The added OH^- ions remove H^+ ions (forming water), so the equilibrium moves to the left-hand side to replace H^+, forming yellow chromate(VI), CrO_4^{2-}.

15

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

12. *(a)* Caroline was investigating the number of moles of water of crystallisation, x, in hydrated barium chloride, $BaCl_2.xH_2O$. She was told that x is a whole number.

She followed an instruction sheet.

- Weigh an empty crucible with its lid.
- Add the hydrated salt to the crucible and weigh crucible, lid and salt.
- Place the lid on the crucible and heat salt for 3 minutes.
- Cool and reweigh the crucible, lid and contents.
- Heat for another 2 minutes and cool and reweigh again.

Caroline obtained the following results.

	Mass / g
Crucible + lid	13.132
Crucible + lid + $BaCl_2.xH_2O$	15.051
Crucible + lid + contents (after 1st heating)	14.787
Crucible + lid + contents (after 2nd heating)	14.777

(i) Use the data to determine the value of x in the formula $BaCl_2.xH_2O$. You **must** show your working. [4]

mass of water lost = 15.051 − 14.777 = 0.274 g

mass of anhydrous $BaCl_2$ = 14.777 − 13.132 = 1.645 g

M_r: $BaCl_2$ = 137.3 + 2(35.5) = 208; H_2O = 18

$BaCl_2 : H_2O$ = 1.645/208 : 0.274/18 = 0.00791 : 0.0152

= 1 : 1.92, x is a whole number so x = 2

x = 2

(ii) Why did the instructions say that the lid should be in place when the heating was carried out? [1]

To avoid loss of solid, e.g. by spitting (solid jumping out) during heating.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(iii) Ethan said that Caroline's method was inaccurate, even though she had carried out the experiment carefully and recorded all her results correctly.

Suggest **two** ways in which Caroline could make her experiment more accurate. Explain your answers. [4]

Suggestion 1

Use a greater mass of the hydrated solid. The masses measured are then larger, so the percentage error (uncertainty) in weighing is smaller.

Suggestion 2

Heat to constant mass (repeat heating, cooling and weighing until two masses agree). This ensures that all the water of crystallisation has been lost.

(iv) Caroline agreed that her experiment had been inaccurate but said that it gave the correct answer for x. Comment on why Caroline was correct and that accuracy need not be high in this experiment to determine the value of x. [1]

x must be a whole number, so a small variation in the calculated ratio (1.92) is irrelevant: it still rounds to 2.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(b) Caroline used the barium chloride as one of the reagents to identify the ions present in an aqueous solution **W**. Solution **W** contains only two ions.

The reagents were added to small volumes of solution **W** and the following observations were made.

Test	Observation
add aqueous sodium hydroxide	no visible reaction
add aqueous barium chloride	white precipitate formed
add dilute nitric acid	vigorous effervescence seen

(i) From these observations name **one** ion present in solution **W**. [1]

carbonate ion, CO_3^{2-}

(ii) The observations allowed Caroline to eliminate some metal ions as being present in **W**. Suggest **one** metal ion that she eliminated. [1]

Mg^{2+} (any non-Group 1 metal ion)

(iii) Write the **ionic** equation for the reaction between aqueous solutions of barium chloride and **W**. Include state symbols. [1]

$Ba^{2+}(aq) + CO_3^{2-}(aq) \rightarrow BaCO_3(s)$

13

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

13. A group of students was given a mineral sample that came from a region where both magnesite, $MgCO_3$, and dolomite, $CaMg(CO_3)_2$, were known to exist. They decided to analyse the sample by titration.

They added 4.77 g of the mineral to 100 cm^3 of 2.06 mol dm^{-3} hydrochloric acid. They titrated 25.0 cm^3 samples of the solution formed against 1.00 mol dm^{-3} sodium hydroxide. The results of these titrations are given in the table.

Titration number	1	2	3
Final burette reading / cm^3	23.20	24.50	23.00
Initial burette reading / cm^3	0.10	1.10	0.00
Titre / cm^3	23.10	23.40	23.00

(a) Explain why universal indicator is not used to show the end-point of a titration. [1]

There is no single sharp colour change at the end-point (it changes gradually through several colours).

(b) **Complete the table** and use the data to calculate a mean titre suitable for use in the calculation involved in the analysis of the sample. [1]

titres 1 and 3 are concordant: (23.10 + 23.00) ÷ 2

Mean titre = 23.05 cm^3

(c) Calculate the number of moles of hydrochloric acid that reacted with the mineral sample. [4]

moles HCl added = 100/1000 × 2.06 = 0.206 mol

moles NaOH in titration = 23.05/1000 × 1.00 = 0.0231 mol

moles HCl left in 25.0 cm^3 = 0.0231 mol (1 : 1)

moles HCl left in 100 cm^3 = 0.0231 × 4 = 0.0924 mol

moles HCl reacted = 0.206 − 0.0924 = 0.1136 mol

n(HCl) = 0.1136 mol

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(d) Complete the **ionic** equation for the reaction between carbonate ions and acid and hence calculate the number of moles of carbonate present in the mineral sample. [1]

CO_3^{2-} + ...2... H^+ ⟶ CO_2 + ...H_2O...

$n(CO_3^{2-}) = 0.1136 \div 2$

$n(CO_3^{2-})$ = ...0.0568... mol

(e) Calculate the relative formula mass of the carbonate and hence state whether the mineral is magnesite or dolomite. Assume that the mineral is a pure compound. [1]

$M_r = 4.77 \div 0.0568 = 84$ ($MgCO_3 = 84.3$, $CaMg(CO_3)_2 = 184.4$)

M_r = ...84...

$M_r = 84$ matches $MgCO_3$, so the mineral is magnesite.

(f) A burette can be read to an accuracy of ±0.05 cm^3.

Calculate the maximum percentage error in any of the **titres** in the table. [2]

maximum error in a titre (two readings) = $2 \times 0.05 = 0.1$ cm^3

smallest titre = 23.00 cm^3

% error = $0.1 \div 23.00 \times 100 = 0.435\%$

Percentage error = ...0.435... %

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(g) The students extended their investigation by measuring the volume of carbon dioxide released when a 4.59 g sample of the mineral reacted with an excess of acid. They collected 1.31 dm^3 of gas measured at 25 °C and at 1.01×10^5 Pa.

(i) Use the ideal gas equation, pV = nRT, to calculate the number of moles of carbon dioxide formed. Show your working. [3]

$n = pV \div RT$

$p = 1.01 \times 10^5$ Pa, $V = 1.31$ $dm^3 = 1.31 \times 10^{-3}$ m^3

$T = 25 + 273 = 298$ K

$n = (1.01 \times 10^5 \times 1.31 \times 10^{-3}) \div (8.31 \times 298) = 0.0534$

$n(CO_2)$ = 0.0534 mol

(ii) Show whether or not this extension confirms the conclusion reached in part *(e)*. [1]

Confirmed: 4.59 g magnesite = 4.59 ÷ 84 = 0.055 mol; 1 mol $MgCO_3$ gives 1 mol CO_2, and 0.053 mol CO_2 formed, which corresponds.

14

END OF PAPER

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

For continuation only.

© WJEC CBAC Ltd.

stemup.co.uk