Surname	Centre Number	Candidate Number
Other Names		2

GCE A LEVEL

A410U10-1

S18-A410U10-1

CHEMISTRY – A level component 1
Physical and Inorganic Chemistry

TUESDAY, 5 JUNE 2018 – AFTERNOON

2 hours 30 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 8.**	**15**	
Section B	**9.**	**11**	
	10.	**16**	
	11.	**11**	
	12.	**12**	
	13.	**14**	
	14.	**23**	
	15.	**18**	
	Total	**120**	

A410U101
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 (15 marks)** and **Section B (105 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 120.

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**_(a)_(i) and **Q.14**_(c)_(ii)II.

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.

Examiner only

SECTION A

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

1. *(a)* Give the electronic structure of an atom of phosphorus. [1]

....

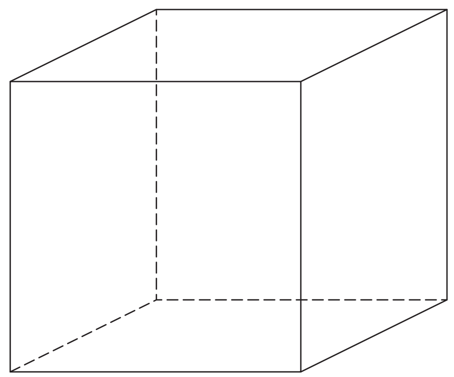
(b) Explain why the first ionisation energy of phosphorus is greater than that of sulfur. [2]

....

....

....

2. Draw the arrangement of ions in the structure of CsCl. [1]



3. State what is meant by a buffer solution. [1]

....

....

....

Examiner only

4. Draw a dot and cross diagram of the ammonium ion and use it to explain the difference between covalent and coordinate bonds. [2]

....

....

....

5. Calcium metal reacts slowly with water. Write an equation for this reaction. [1]

....

A410U101 03

6. Using the principles of valence shell electron pair repulsion (VSEPR) state and explain the shape of a molecule of H_2S. [2]

....

....

....

....

Examiner only

7. Chlorine and sodium hydroxide can react together in a disproportionation reaction.

(a) Balance the equation. [1]

.... Cl_2 + ... NaOH ⟶ .... NaCl + ... $NaClO_3$ + ... H_2O

(b) Use oxidation states to explain why this is a disproportionation reaction. [2]

....

....

....

....

8. Standard electrode potentials are measured by comparison with the standard hydrogen electrode.

Describe the standard hydrogen electrode. You may include a diagram as part of your answer. [2]

....

....

....

....

15

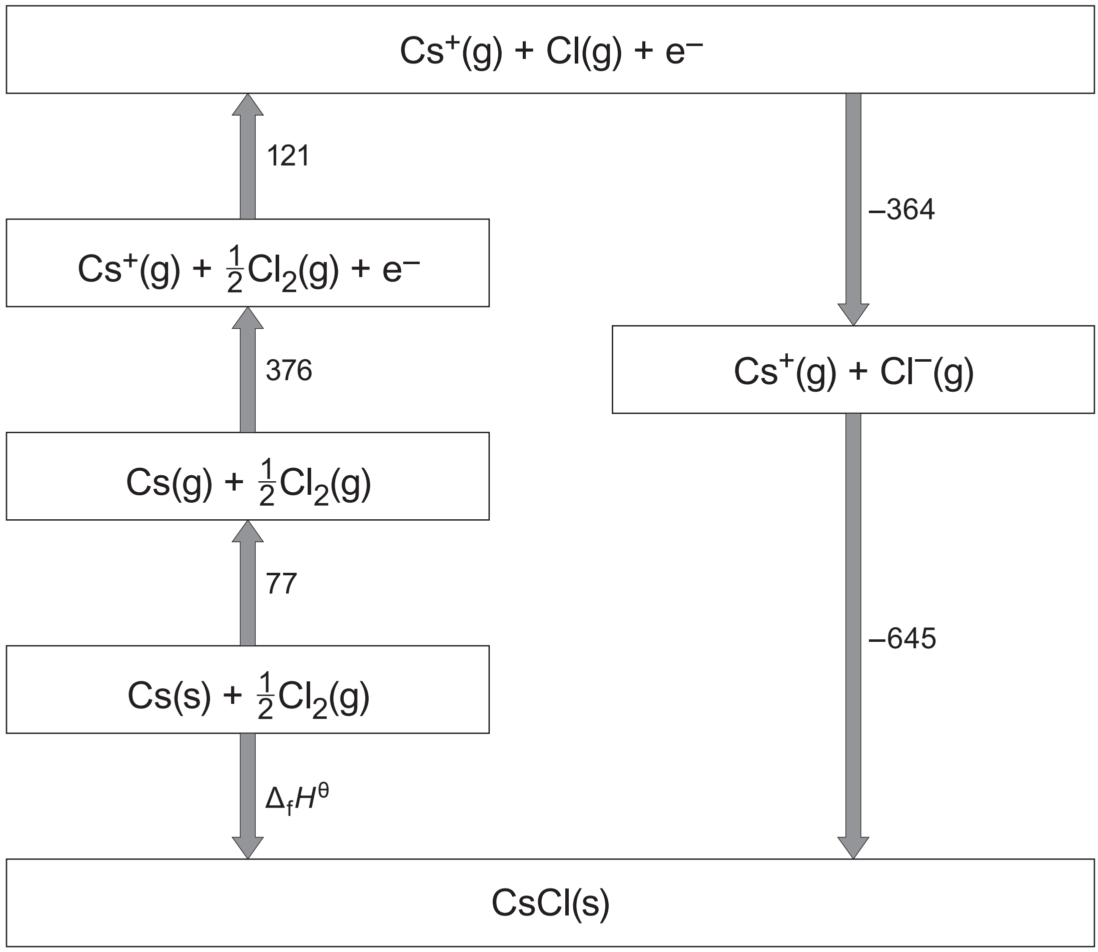
Examiner only

SECTION B

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

9. Caesium chloride is an ionic solid that is transparent to a wide range of frequencies of electromagnetic radiation, from infrared to ultraviolet.

(a) The Born-Haber cycle below shows the formation of caesium chloride from its elements. All values shown are standard values in kJ mol^{-1}.



(i) State the value of the standard enthalpy change of lattice breaking of CsCl. [1]

.... kJ mol^{-1}

A410U101 05

Examiner only

(ii) Calculate the standard enthalpy of formation of CsCl, $\Delta_f H^\theta$. [2]

$\Delta_f H^\theta$ = ... kJ mol^{-1}

(iii) The standard enthalpy change of solution of CsCl is +18 kJ mol^{-1} and the enthalpy of hydration of a chloride ion is –364 kJ mol^{-1}.

I. Calculate the enthalpy change of hydration of a caesium ion. [2]

$\Delta_{hyd} H^\theta$ = ... kJ mol^{-1}

II. A student says "Caesium chloride must be insoluble as the enthalpy change of solution is endothermic. Endothermic reactions do not occur readily."

The teacher shows the student that caesium chloride is soluble.

State what other factor(s) must be considered when deciding whether a reaction is feasible and explain why these would favour the formation of the solution. [3]

....

....

....

....

....

....

Examiner only

(b) The first ionisation energy of caesium is 376 $kJ\,mol^{-1}$. This value can be found from the frequency of a line in the atomic spectrum of caesium. Calculate the frequency of this line in THz. [3]

(1 THz = 1000 GHz)

Frequency = ... THz

11

A410U101
07

Examiner only

10. Industrial processes are designed to give the maximum yield of the pure product in the shortest time at the lowest possible cost. The choice of temperature, pressure and catalyst are all key factors of designing an industrial process.

(a) (i) The Wacker process is used to produce ethanal from ethene. It is a reaction catalysed by a mixed catalyst containing chlorides of copper and palladium. The reaction may be carried out in the gas phase according to the equation below.

$$C_2H_4(g) + \tfrac{1}{2}O_2(g) \rightleftharpoons CH_3CHO(g) \qquad \Delta H^\theta = -218\ \text{kJ mol}^{-1}$$

Outline the factors that would need to be considered when selecting conditions for this process, applying these to suggest appropriate conditions. You should include a full explanation of why catalysts are very important for exothermic equilibria such as this. [6 QER]

....

....

....

....

....

....

....

....

....

....

....

....

Examiner only

(ii) This industrial process has a yield of 95.0%. Calculate the mass of ethanal, in kg, that would be produced from 2.00 tonnes of ethene. [3]

Mass of ethanal = ... kg

(b) This process uses a catalyst mixture that contains $CuCl_2$.

When copper(II) compounds are dissolved in water they appear pale blue, whilst copper(I) compounds are not coloured.

(i) Give the formula of the complex ion present in dilute aqueous solutions of copper(II) compounds. [1]

....

(ii) Explain why copper(I) compounds are not coloured. [2]

....

....

....

(iii) State the colour change that occurs when concentrated ammonia solution is added to copper(II) compounds in aqueous solution, drawing the structure of the copper-containing ion present. Explain why the addition of ammonia solution causes the colour to change. [4]

....

....

....

....

A410U101 09

16

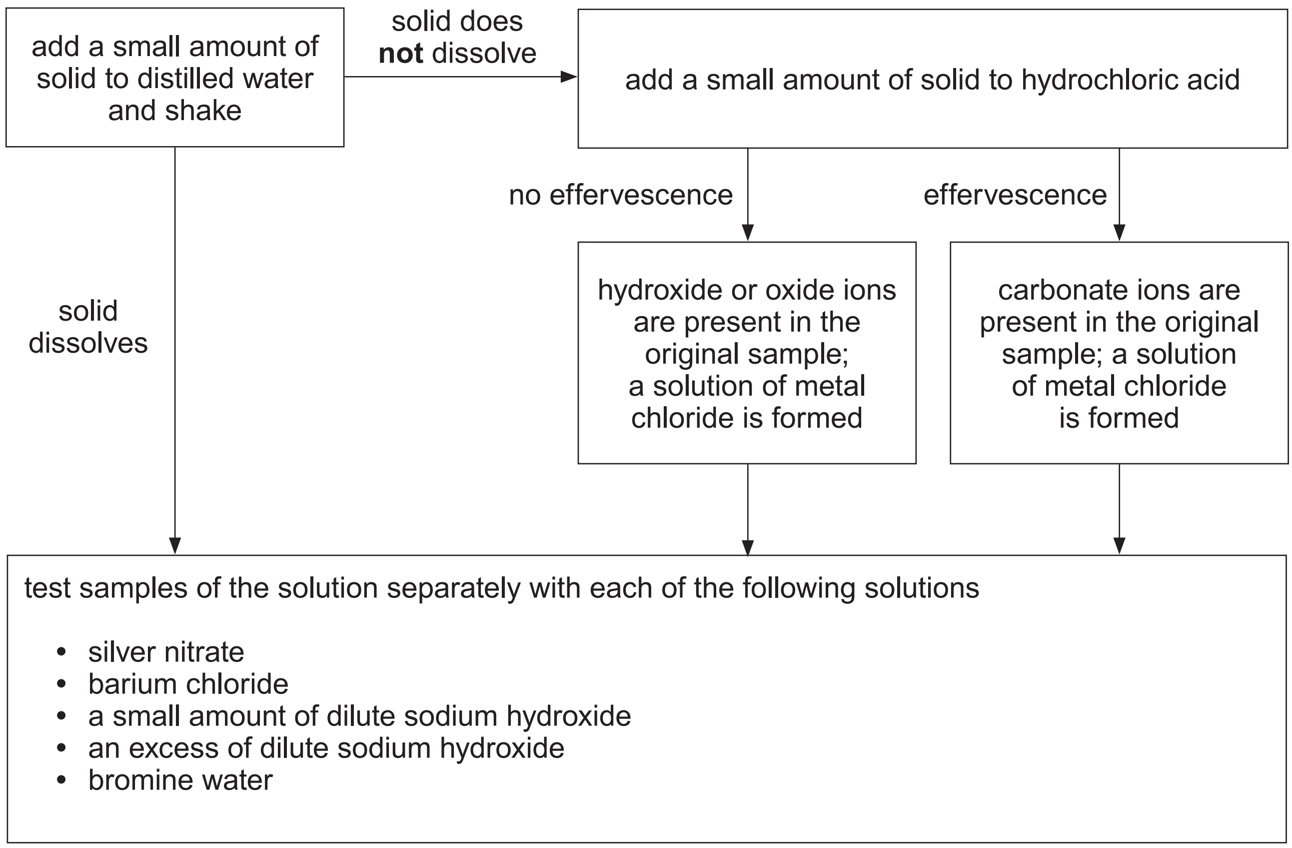
Examiner only

11. A student is provided with a set of unknown ionic solids. She is told that the compounds could be any **four** of the following.

lead(II) carbonate	lead(II) iodide	lead(II) nitrate
sodium carbonate	sodium iodide	potassium carbonate
calcium nitrate	magnesium hydroxide	magnesium sulfate

(a) All of the samples provided were white. State which one of the compounds from the list above could **not** be amongst the samples. Give a reason for your answer. [1]

(b) She planned to test each of the samples by following the steps below.



(i) Explain why the method as written would not conclusively identify all the unknown samples that contain carbonate ions. [1]

Examiner only

(ii) Her teacher says that hydrochloric acid is not the correct reagent to use in this method. Give **two** reasons why hydrochloric acid is not appropriate and suggest an alternative reagent that would avoid these problems. [3]

....

....

....

....

....

....

(iii) Another student starts her method with a flame test. State which s-block cations she could identify by this method, giving the colours expected for each. [2]

....

....

(iv) As time was short the teacher suggested the following simplified method.

- Look at the colour of the sample
- Carry out a flame test to identify s-block cations
- Try to dissolve the sample in water
- Add acid to the samples and look for effervescence

This method allowed seven of the nine compounds to be identified.

lead(II) carbonate	lead(II) iodide	lead(II) nitrate
sodium carbonate	sodium iodide	potassium carbonate
calcium nitrate	magnesium hydroxide	magnesium sulfate

Name the **two** compounds that could **not** be distinguished and suggest a test that would tell them apart. Give reagent(s) and observations for both compounds. [4]

....

....

....

....

....

....

A410U101
11

11

Examiner only

12. Radioisotopes of elements are often used in the study of biological molecules. One such radioisotope is fluorine-18.

(a) Give the numbers of protons and neutrons in the nucleus of a fluorine-18 atom. [1]

Protons .... Neutrons ....

(b) This radioisotope decays to form oxygen-18 only. Identify the type of radiation that must be emitted for this change to occur and identify any other type(s) of radiation that may also be emitted at the same time. [2]

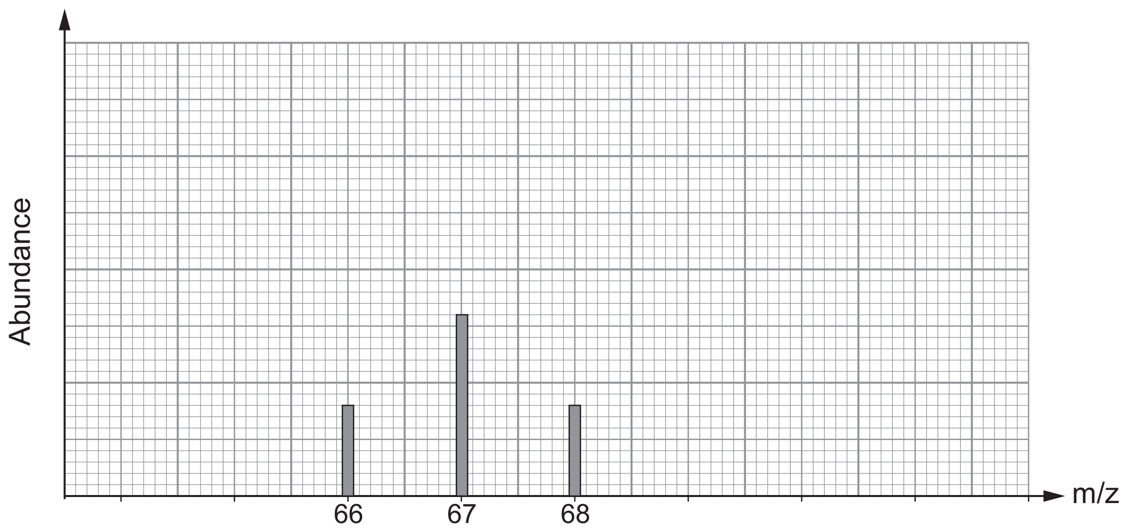
....

....

....

(c) A sample of fluorine gas contains four ^{18}F atoms for every ^{19}F atom. This was used to produce difluoromethanol, CHF_2OH.

A mass spectrum was taken as soon as the difluoromethanol had been synthesised. Part of the mass spectrum is shown below.



(i) Identify the species that gives rise to the peak at m/z 66. [1]

....

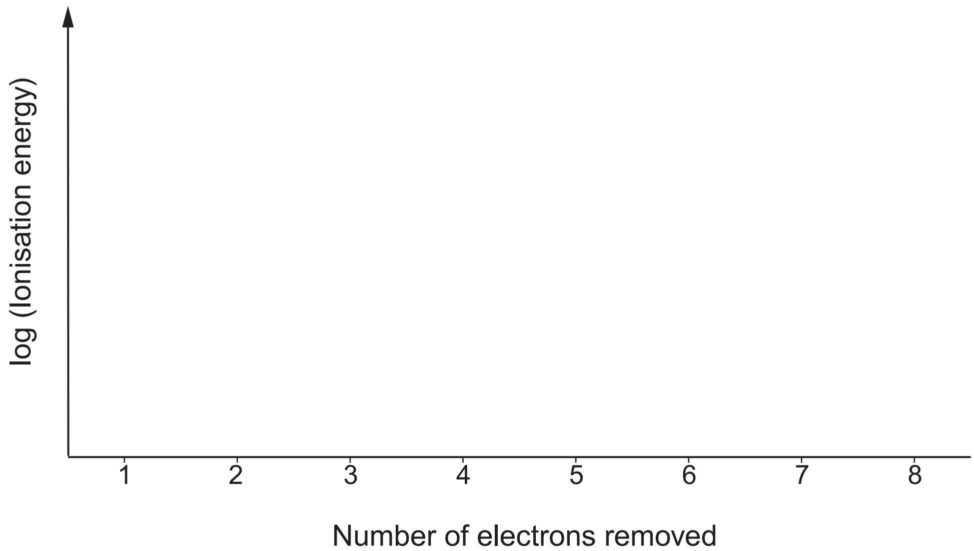
Examiner only

(ii) The half-life of the fluorine-18 isotope is 110 minutes, and the original fluorine sample contained four fluorine-18 atoms for every fluorine-19 atom. Find the time taken to synthesise the difluoromethanol. [4]

Time taken = ... minutes

(d) The electronic structure of the oxygen atoms produced in this decay process may be studied by measuring successive ionisation energies.

(i) Sketch a diagram showing the successive ionisation energies for oxygen.
Show all **eight** ionisation energies. [2]



(ii) Explain how this diagram gives information regarding the position of the element in the Periodic Table. [2]

....

....

....

....

A410U101
13

12

Examiner only

13. Brass is an alloy of copper and zinc only. The copper content of the alloy can be found by volumetric or gravimetric analysis. The brass is dissolved by adding highly acidic mixtures to the alloy which forms $Cu^{2+}(aq)$ and amphoteric $Zn^{2+}(aq)$.

(a) Redox titration is one method to find the mass of copper in a known mass of alloy.

A 2.877 g sample of alloy is dissolved in concentrated nitric acid. The mixture is neutralised and then made up to a volume of $250.0\,cm^3$.

Samples of the solution with a volume of $25.00\,cm^3$ are removed and excess potassium iodide solution added, before titration with $0.105\,mol\,dm^{-3}$ sodium thiosulfate solution. The mean volume of sodium thiosulfate needed to completely reduce the iodine in solution is $26.75\,cm^3$.

Calculate the percentage by mass of copper in this alloy. You **must** show your working. [4]

Percentage copper = ... %

Examiner only

(b) An alternative method is gravimetric analysis.

Another sample of alloy is dissolved in concentrated nitric acid. The solution is neutralised and aqueous sodium hydroxide is added until all the copper(II) and zinc(II) ions form metal hydroxide precipitates. This sample is then filtered, dried and weighed (weighing 1).

The solid sample is then treated with excess aqueous sodium hydroxide and the remaining solid is removed by filtration, dried and weighed (weighing 2).

The results are given below.

Mass of empty vessel = 23.34 g

Mass of vessel and precipitate (weighing 1) = 25.12 g

Mass of vessel and precipitate (weighing 2) = 24.45 g

Calculate the percentage by mass of copper in this alloy. You **must** show your working. [4]

Percentage copper = ... %

(c) A student suggests that the alloys in parts *(a)* and *(b)* are the same. State and explain whether the evidence supports this statement and suggest what further evidence should be collected to confirm your conclusion. [2]

....

....

....

Examiner only

(d) (i) Concentrated nitric acid is used to dissolve the alloy in the experiments above. The pH of this strong acid is typically –1.2.

Calculate the concentration of this nitric acid. [2]

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

(ii) The acidic solution is neutralised using aqueous sodium hydroxide of concentration 2.00 mol dm^{-3}.

Calculate the pH of this sodium hydroxide solution. [2]

[ionic product of water, K_w = 1.00 × 10^{-14} mol^2 dm^{-6}]

pH = ...

14

BLANK PAGE

Examiner only

14. Materials are often classified according to their physical properties and chemists use their knowledge of their structures to explain these properties.

(a) One way to classify materials is according to their physical state.

The halogens chlorine, bromine and iodine have different physical states at room temperature. Give the physical state for each of these halogens and explain why they have different physical states. [3]

....

....

....

....

....

....

....

....

Examiner only

(b) Another way to classify materials is according to their solubility in water. The solubilities of four compounds were found in an online database.

Substance	Solubility in water at 20 °C / g dm^{-3}
$CaCl_2$ (anhydrous)	745
$CaCl_2.4H_2O$ (hydrated)	908
butan-1-ol ($CH_3CH_2CH_2CH_2OH$)	73
octan-1-ol ($CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2OH$)	0.46

(i) A student says that this shows that the concentration of calcium ions in a saturated solution of calcium chloride is the same for solutions formed by dissolving anhydrous and hydrated forms of $CaCl_2$. Is he correct? Give a reason for your answer. [2]

....

....

....

....

(ii) Explain why the alcohols butan-1-ol and octan-1-ol can dissolve in water, giving a reason why the solubility of octan-1-ol is lower than that of butan-1-ol. [3]

....

....

....

....

....

....

Examiner only

(c) The physical properties of materials can be modified by using additives. AIBN is an additive used to modify the properties of rubber.

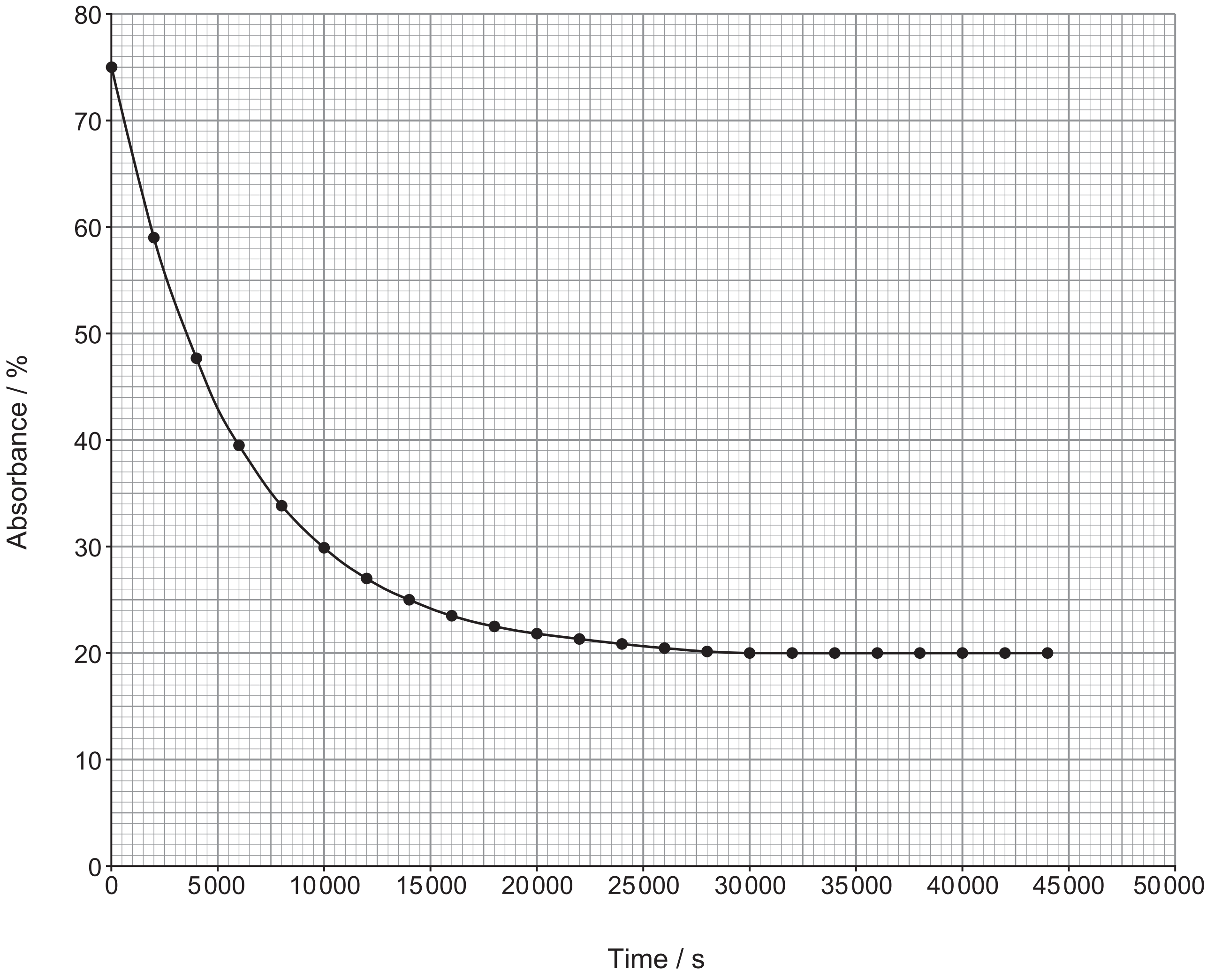
AIBN decomposes in solution in the solvent dioxane, shown as (sol) below, under standard conditions.

$$\underset{\text{AIBN}}{NC{-}C(CH_3)_2{-}N{=}N{-}C(CH_3)_2{-}CN\ (sol)} \longrightarrow 2NC{-}C(CH_3)_2\bullet\ (sol) + N_2(g)$$

(i) Give the temperature and pressure used as standard conditions. [1]

....

(ii) The reaction can be followed by measuring the absorbance of the reactant in the solution at a wavelength of light of 350 nm. The dioxane solvent also absorbs a certain amount of light of this wavelength. The graph below shows the results of this experiment undertaken by two students, Anna and Megan.



Examiner only

I. State the percentage absorbance due to the solvent. Explain how you reached your conclusion. [2]

II. Describe and explain fully the shape of the graph. Use the graph to prove that the reaction is first order with respect to AIBN. [6 QER]

Examiner only

(iii) Upon heating, AIBN decomposes extremely rapidly. The rate equation for this process is as follows.

rate = k[AIBN]

The value of the rate constant k, can be found using the Arrhenius equation. Anna **incorrectly** writes the Arrhenius equation as

$$k = A\,e^{\frac{E_a}{T}}$$

I. State the correct Arrhenius equation. [2]

II. Anna uses the correct temperature, frequency factor and activation energy in her **incorrect** Arrhenius equation. The values of two of these are given below.

frequency factor, A = 6.92×10^9 s^{-1}
temperature = 600 K

Anna calculates that the rate constant is 4.89×10^{82} s^{-1}.

Megan says the true value should be much smaller. Find the value of the activation energy then use the **correct** Arrhenius equation to find the true value of the rate constant. State whether Megan is correct. [4]

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

k = ... s^{-1}

....

23

Examiner only

15. Ethyne, H—C≡C—H, is commonly known as acetylene and is burned as a fuel in oxy-acetylene welding torches. It is stored in cylinders where the gas is dissolved in propanone and this is adsorbed onto an inert substance and kept under pressure.

(a) Propanone is used to dissolve the ethyne as this gas is only slightly soluble in water. State why the solubility of ethyne in water is low. [1]

....

....

....

(b) (i) When used in an oxy-acetylene torch the ethyne is released at a pressure of 135 kPa at 20 °C. Find the number of moles of ethyne in 1 cm^3 and hence calculate the density of ethyne gas, in $g\,cm^{-3}$, at this pressure at 20 °C. [4]

density = mass ÷ volume

Density = ... $g\,cm^{-3}$

(ii) The density of dry air at 0 °C and 135 kPa is 1.27×10^{-3} $g\,cm^{-3}$. A student says that this shows that a vessel of negligible mass filled with ethyne will float in air. Calculate the density of dry air at 20 °C and 135 kPa and show whether the student is correct.

[2]

Density = ... $g\,cm^{-3}$

....

....

Examiner only

(c) A student wrote the equation below for the standard enthalpy of combustion ($\Delta_c H^\theta$) of ethyne.

$$2C_2H_2(g) \;+\; 5O_2(g) \longrightarrow 4CO_2(g) \;+\; 2H_2O(g)$$

(i) Identify **two** errors that the student has made. [2]

....

....

....

....

Examiner only

(ii) The student found the following data in a reference source. He wanted to calculate the most accurate value for the enthalpy change for his reaction.

	Standard enthalpy values / $kJ\,mol^{-1}$
$\Delta_f H^\theta$ [C_2H_2(g)]	227
$\Delta_f H^\theta$ [CO_2(g)]	–394
$\Delta_f H^\theta$ [H_2O(l)]	–242
$\Delta_{vaporisation} H^\theta$ [H_2O(l)]	41

Bond	Bond energy / $kJ\,mol^{-1}$
C—H	412
C≡C	837
C═O	743
O—H	463
O═O	496

Select appropriate data to calculate the **most accurate** value you can for the enthalpy change for the reaction below. Explain your choice of method. [4]

$$2C_2H_2(g) \;+\; 5O_2(g) \longrightarrow 4CO_2(g) \;+\; 2H_2O(g)$$

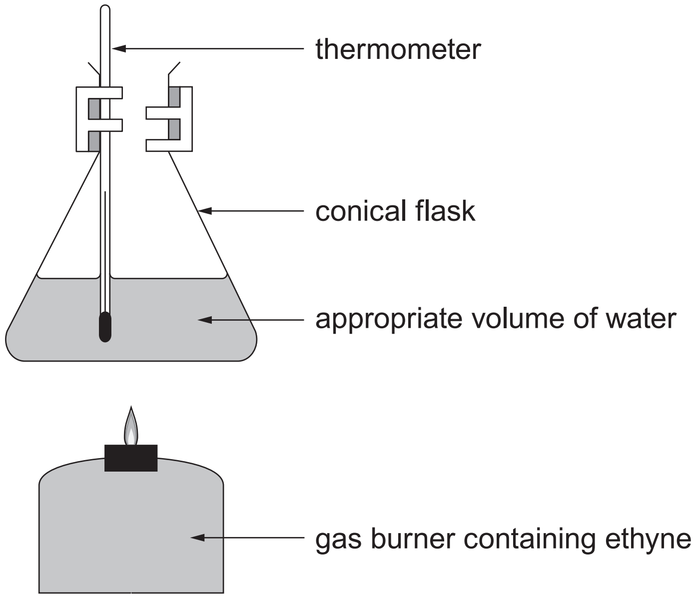
Enthalpy change of reaction = ... $kJ\,mol^{-1}$

....

....

....

(iii) The student decided to compare his value with one obtained experimentally. He used the apparatus and method given below.



Method

Measure an appropriate volume of water into the conical flask.

Measure the mass of the gas burner containing the ethyne on a 3 decimal place balance.

Select a thermometer that has 0.2 °C as its smallest division and place this in the conical flask.

Record the temperature of the water and then immediately light the gas burner.

Heat the water for 2 minutes.

Extinguish the gas burner and record the temperature of the water and the mass of the gas burner.

Examiner only

I. The difference between the initial and final temperature readings is 37.4 °C. Calculate the percentage error in this value. [1]

Percentage error = ... %

II. An appropriate volume of water was selected for the experiment. Explain why a volume which was **much** smaller or **much** greater than this would give results which were of a lower accuracy. [2]

Much smaller volume of water ....

....

....

Much greater volume of water ....

....

....

III. Suggest **two** improvements to the method and explain how these would lead to improved results. [2]

....

....

....

....

18

END OF PAPER

Examiner only

For continuation only.