GCE A LEVEL CHEMISTRY

S21-A410

Assessment Resource D

Physical and Inorganic Chemistry

1. Draw a dot-and-cross diagram to show the bonding of the compound magnesium fluoride. [2]

2. When blue crystals of $CuSO_4.5H_2O$ are heated they form a white solid. Upon addition of water they return to their original blue colour.

Explain these observations. [2]

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3. A sample of the element boron contains 22.10 % boron-10 and 77.90 % boron-11.

Calculate the relative atomic mass of this sample, giving your answer to **four** significant figures. [2]

A_r = ...

4. Many common acids donate one hydrogen ion during chemical reactions, however others can donate two or more hydrogen ions.

(a) Hydrochloric acid, HCl, and ethanoic acid, CH_3COOH, are examples of monobasic acids – these are acids that can donate only one hydrogen ion in chemical reactions.

Hydrochloric acid is a strong acid and ethanoic acid is a weak acid.

(i) Define pH. [1]

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(ii) Write an expression for the acid dissociation constant, K_a, for ethanoic acid. [1]

(iii) A student makes the following statements:

- when the concentration of any monobasic acid is doubled, the concentration of H^+ ions is also doubled; this applies to both strong acids and weak acids
- each time the concentration of an acid is doubled, the pH value increases by 0.3

Is the student correct? Explain your answer.

You should refer to both statements and the difference(s) between strong acids and weak acids in your answer. [6 QER]

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(b) Sulfuric acid is a dibasic acid as it can donate up to two hydrogen ions during chemical reactions.

When a small amount of sodium hydroxide is present the following reaction can occur.

$$H_2SO_4(aq) + NaOH(aq) \longrightarrow NaHSO_4(aq) + H_2O(l)$$

When more sodium hydroxide is present the following reaction can occur.

$$NaHSO_4(aq) + NaOH(aq) \longrightarrow Na_2SO_4(aq) + H_2O(l)$$

(i) The soluble salt $NaHSO_4$ can be prepared as a white solid using the first reaction above. Briefly outline how this preparation would be undertaken.

A detailed experimental procedure is not required. [4]

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(ii) The $NaHSO_4$ formed in this preparation is hydrated and has the formula $NaHSO_4.xH_2O$.

In an experiment a sample of $NaHSO_4.xH_2O$ was heated to constant mass. The sample lost 37.5 % of its mass.

Calculate the value of x in the formula $NaHSO_4.xH_2O$. [3]

x = ...

(iii) $NaHSO_4$ can also be formed by reaction of concentrated sulfuric acid with sodium halides such as sodium chloride, sodium bromide or sodium iodide.

When concentrated sulfuric acid is added to **one** of these halides several changes are observed, including a smell of rotten eggs.

Identify the halide used and explain why the smell is observed with this halide but not with the others. [2]

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(c) Many reactions of acids produce hydrogen gas. When an electrical discharge is passed through this gas certain frequencies of energy are emitted.

(i) Explain why this energy is emitted. [2]

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(ii) The first ionisation energy of hydrogen is 1316 kJ mol^{-1}.

Calculate the wavelength of the convergence limit of the Lyman series for hydrogen in nm. [3]

Wavelength = ... nm

5. It is possible to study the concentration dependence of rate by finding how the rate of a reaction changes over time. This is because the concentrations of the reactants change over time.

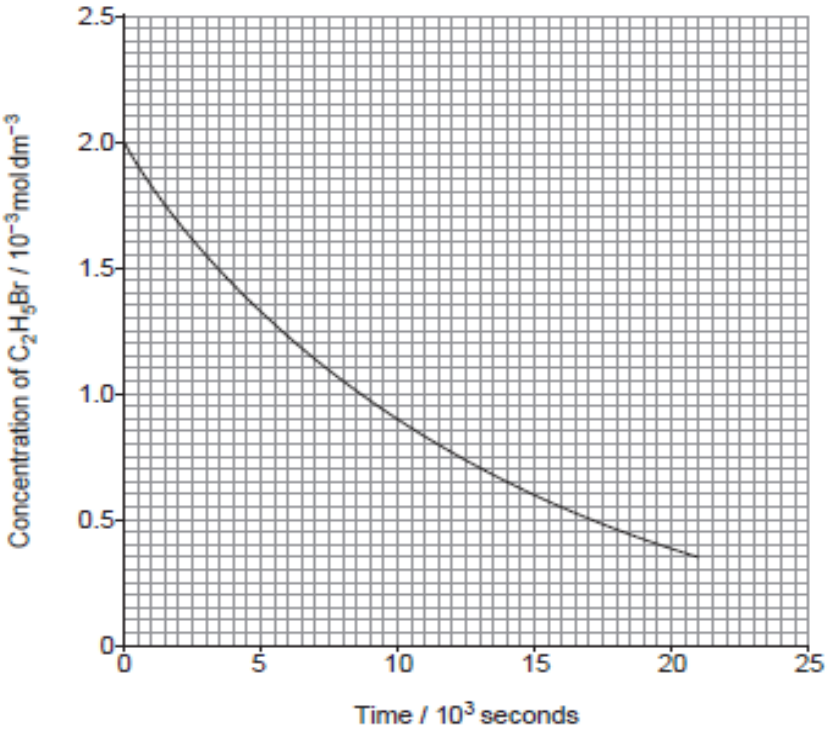
The reaction below occurs in non-aqueous solution in the presence of a small amount of water.

$$C_2H_5Br + OH^- + H_2O \longrightarrow C_2H_5OH + Br^- + H_2O$$

Three students carried out experiments to find how the concentration of each reactant affects the rate. Each one changed the concentration of a different reactant. They used the initial concentrations shown below and an automated sampling device to take measurements every 10 minutes for 6 hours.

	Initial concentration of each reactant / mol dm^{-3}		
	$[C_2H_5Br]$	$[OH^-]$	$[H_2O]$
George's experiment: Finding the effect of $[C_2H_5Br]$ on rate	2.00×10^{-3}	2.00	2.00
Hannah's experiment: Finding the effect of $[H_2O]$ on rate	2.00	2.00	2.00×10^{-3}
Jamal's experiment: Finding the effect of $[OH^-]$ on rate	2.00	2.00×10^{-3}	2.00

(a) The results obtained in George's experiment are shown on the graph below.



(i) Calculate the initial rate for the reaction, stating its unit. [3]

Initial rate = ...

Unit .....

(ii) Use the graph to show that the reaction is first order with respect to C_2H_5Br. [2]

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(b) Suggest why this method uses much lower concentrations of the reactants being studied than those of the other reactants involved. [1]

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(c) Hannah finds that the concentration of water does not change during her experiment.

(i) Give a reason why the concentration of water does not change. [1]

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(ii) The order of the reaction with respect to water is zero. Suggest how Hannah could confirm this. [1]

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(d) Jamal carried out his experiment at a slightly different temperature from George.

He found that the reaction is first order with respect to hydroxide ions. The final rate equation is therefore as follows.

$$\text{rate} = k[C_2H_5Br][OH^-]$$

The value of the rate constant is 4.07×10^{-5}.

(i) Give the unit of the rate constant. [1]

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(ii) The activation energy for this reaction is $89.5\,\text{kJ mol}^{-1}$ and its frequency factor, A, has a value of 4.30×10^{11}.

Calculate the temperature used for Jamal's experiment.

You **must** show your working. [3]

Temperature = ... K