YISHUN INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION

CANDIDATE NAME: **SUGGESTED ANSWERS**

CLASS

DATE

H2 CHEMISTRY 9729/04

Paper 4 Practical Paper

23 August 2022
2 hours 30 minutes

Candidates answer on question paper.
Additional Materials: As listed in the Confidential Instructions Insert

READ THESE INSTRUCTIONS FIRST

Write your name and class in the spaces at the top of this page.
Give details of the practical shift and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
Qualitative Analysis Notes are printed on pages 23 and 24.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's use	
1	
2	
3	
4	
Total	55

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

1 Determination of a value for the solubility product, K_{sp}, of calcium iodate(V), $Ca(IO_3)_2$

The solubility in water of solid calcium iodate(V), $Ca(IO_3)_2$, is low. When a sample of this salt is mixed with water, a small amount dissolves and an equilibrium between the solid salt and its aqueous ions is established.

$$Ca(IO_3)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2IO_3^-(aq)$$

If separate aqueous solutions containing Ca^{2+} ions and IO_3^- ions are mixed, some of the solid salt is formed and, again an equilibrium is established.

When specified volumes of potassium iodate and calcium nitrate are mixed, some calcium iodate(V) is formed as a white solid. The mixture should be left to stand for some time.

After the solid is removed by filtration, the amount of iodate(V) ions left in the filtrate is determined as described below.

When excess potassium iodide, KI, is added to an acidified solution containing iodate(V) ions, iodine is liberated as follows.

reaction 1 $IO_3^-(aq) + 5I^-(aq) + 6H^+ \rightarrow 3I_2(aq) + 3H_2O(l)$

The liberated iodine is then titrated with a standard solution of sodium thiosulfate.

reaction 2 $2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

In this question, you will perform a titration to determine the solubility product, K_{sp}, of calcium iodate(V).

You are provided with:

- **FA 1**, 0.200 mol dm^{-3} potassium iodate, KIO_3
- **FA 2**, 1.00 mol dm^{-3} calcium nitrate, $Ca(NO_3)_2$
- **FA 3**, 0.0400 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$
- **FA 4**, aqueous solution of potassium iodide, KI
- **FA 5**, dilute hydrochloric acid, HC*l*

You are also provided with starch solution.

(a) Preparation of the reaction mixture

1. Use a measuring cylinder to transfer 50 cm^3 of **FA 1** to the beaker labelled **reaction mixture**.

2. Use a measuring cylinder to transfer 20 cm^3 of **FA 2** to the same beaker.

3. A precipitate will form, stir the mixture thoroughly. Leave this mixture to stand for 15 minutes to allow equilibrium to be reached.

While you are waiting for the mixture to reach equilibrium, proceed with Question 2(a).

(b) (i) Analysing the filtrate

1. Filter the reaction mixture through a **dry** filter paper into a **dry** conical flask, labelled **FA 6**. This is the filtrate, **FA 6**. Do not wash the white precipitate with water.

2. Fill a burette with **FA 3**.

3. Use a pipette to transfer 10.0 cm^3 of **FA 6** into a 250 cm^3 conical flask.

4. Use a measuring cylinder to add about 10 cm^3 of **FA 4** to the conical flask.

5. Use a measuring cylinder to add about 2 cm^3 of **FA 5** to the conical flask.

6. Run **FA 3** from the burette into the conical flask until the brown colour of the iodine fades to a pale yellow colour.

7. Add about 5 drops of starch solution to the conical flask. Continue adding **FA 3** until the blue-black colour **just** disappears.

8. Record your titration results, to an appropriate level of precision, in the space provided below.

9. Repeat points 3 to 7 until consistent results are obtained.

   Rinse the conical flask thoroughly between each titration.

Titration results

initial burette reading	/ cm^3	0.00	2.00
final burette reading	/ cm^3	36.50	38.50
volume of FA 3 used	/ cm^3	36.50	36.50

[3]

(ii) From your titrations, obtain a suitable volume of **FA 3** to be used in your calculations. Show clearly how you obtained this volume. [3]

Volume of **FA 3** used = (36.50 + 36.50) ÷ 2 = 36.50 cm^3

(c) (i) Calculate the amount of $S_2O_3^{2-}$ ions present in the volume of **FA 3** recorded in **(b)(ii)**. [1]

Amount of $S_2O_3^{2-}$ ions = (36.50 × 10^{-3}) × 0.0400 = **1.46 × 10^{-3} mol**

(ii) Calculate the amount of IO_3^- ions present in 10.0 cm^3 of the filtrate, **FA 6**. [1]

$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

Amount of I_2 = ½ × Amount of $S_2O_3^{2-}$ = ½ × (1.46 × 10^{-3}) = 7.30 × 10^{-4} mol

$IO_3^-(aq) + 5I^-(aq) + 6H^+ \rightarrow 3I_2(aq) + 3H_2O(l)$

Amount of IO_3^- in 10.0 cm^3 = 1/3 × Amount of I_2 = 1/3 × 7.30 × 10^{-4} = **2.4333 × 10^{-4}** mol

(iii) Calculate the total amount of IO_3^- ions present in the filtrate, **FA 6**. [1]

Amount of IO_3^- in 70.0 cm^3 = (2.4333 × 10^{-4}) × 7 = **1.70 × 10^{-3} mol**

(d) (i) Using the initial amount of IO_3^- ions in the reaction mixture prepared in **(a)**, and your answer from **(c)(iii)**, calculate the amount of IO_3^- ions precipitated as $Ca(IO_3)_2$. [1]

Initial amount of IO_3^- ions in the reaction mixture prepared = 0.200 × 50.0 × 10^{-3} = 0.0100 mol
Amount of IO_3^- precipitated = 0.0100 – 1.70 × 10^{-3} = **8.30 × 10^{-3} mol**

(ii) Deduce the amount of Ca^{2+} ions removed by precipitation in **(a)**, point 3, and hence, calculate the amount of Ca^{2+} ions left in **FA 6**. [2]

$Ca(IO_3)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2IO_3^-(aq)$

Amount of Ca^{2+} removed by precipitation = ½ × Amount of IO_3^- precipitated
= ½ × 8.2966×10^{-3} mol
= **4.15×10^{-3} mol**

Initial amount of Ca^{2+} added = $1.00 \times 20.0 \times 10^{-3}$ = 0.0200 mol
Amount of Ca^{2+} left in **FA 6** = $0.0200 - (4.15 \times 10^{-3})$ = **0.0159 mol**

(e) **(i)** Write an expression for the solubility product, K_{sp}, of calcium iodate(V). [1]

$K_{sp} = [Ca^{2+}][IO_3^-]^2$

(ii) Use this expression, together with your answers to parts **(c)(iii)** and **(d)(ii)** to calculate a value for this solubility product. Include units in your answer. [1]

$[Ca^{2+}] = 0.0159 \div (70 \div 1000) = 0.227$ mol dm^{-3}
$[IO_3^-] = (1.70 \times 10^{-3}) \div (70 \div 1000) = 0.024285$ mol dm^{-3}

$K_{sp} = 0.227 \times (0.024285)^2$ = **1.34×10^{-4} mol^3 dm^{-9}**

(f) A student added solid calcium nitrate to his filtrate, **FA 6**.

Predict, qualitatively, the effect of such an addition on the filtrate, and on the magnitude of the mean titre, in part **(b)(ii)**. Explain your answer. [2]

Predictions:
More precipitate will form and the titre value will be lower.

Explanation:
The addition of $Ca(NO_3)_2$ increases the concentration of Ca^{2+} and to remove some of the Ca^{2+}, the equilibrium moves the equilibrium towards the solid.
Hence, IO_3^- ions are removed from the solution causing the concentration of IO_3^- to be lower so less $S_2O_3^{2-}$ needed.

(g) In part **(b)(i)**, point **1**, you are told to use **dry** apparatus and to avoid washing the residue with water. Suggest and explain the likely consequences on your mean titre value in part **(b)(ii)** if you failed to follow these instructions. [1]

Water would be added to the filtrate, causing **FA 6** to be diluted and the mean titre value would be lower.

(h) A teacher performed this experiment and obtained a value for the solubility product, K_{sp}, of 2.77×10^{-5}. A literature value for this solubility product is 6.71×10^{-6} at 20 °C.

You should assume that apparatus of the same precision was used in each case.

Give a possible explanation for the higher value of K_{sp} obtained by the teacher. Suggest an improvement which might allow a value closer to the literature value to be obtained. [1]

Not all precipitate has had time to form/reaction has not reached equilibrium, so $[Ca^{2+}]$ and $[IO_3^-]$ too high.
Allow precipitate to form/equilibrium to establish by leaving the reaction mixture for a considerable time before filtering it.
or
The teacher's experiment is not carried out at 20 °C, so equilibrium position is displaced towards the aqueous ions/to the right (as the K_{sp} value is higher than actual).
Equilibrate the reaction mixture in a water bath at 20 °C for a considerable time before filtering it.

[Total: 18]

2 Qualitative Analysis

In this question, you will perform tests to

- investigate reactions involving vanadate(V) ion, VO_3^-
- deduce the functional groups present in four organic compounds.

You are provided with:

- **FA 7**, ammonium vanadate(V), NH_4VO_3
- zinc, Zn

Unless otherwise stated, the volumes given below are approximate and should be estimated rather than measured.

(a) (i) To a 2 cm depth of **FA7** in a test-tube, add a small spatula of zinc. Leave for approximately 4 minutes with occasional shaking. Record all your observations.

Keep the reaction mixture for use in **2(a)(ii)**. [2]

Effervescence which pops a lighted splint.
Yellow solution turns blue and then to green finally to lilac/violet/purple.

(ii) To 1 cm depth of the **solution** from **(a)(i)** in a test-tube, add 1 cm depth of sulfuric acid. Then add potassium manganate(VII) a few drops at a time until no further reaction occurs. At this stage, the solution is pink because unreacted $KMnO_4$ is present.

Record all the changes you observe. [2]

Solution turns from violet to blue then to green and finally to yellow
Purple $KMnO_4$ decolorises.

(iii) State the type of reaction occurring in the test in **(a)(ii)**. [1]

Redox

(b) You are provided with samples of **FA 8**, **FA 9**, **FA 10** and **FA 11**, each of which is an aqueous solution containing a different one of the following:

a carboxylic acid
a ketone
an alcohol
an aldehyde

You will perform the tests described in Table 2.1.

In addition to having access to the usual bench reagents, you are also provided with the following:

- iodine solution,
- solid sodium carbonate.

Perform the tests described in Table 2.1. Some of the observations have been completed for you. There is no need to carry those tests. Record your observations in Table 2.1.

Test and identify any gases evolved. If there is no observable change write **no observation change**.

Use a fresh sample of each solution in each test.

Table 2.1

	observations with **FA 8**	observations with **FA 9**	observations with **FA 10**	observations with **FA 11**
1. Add about 1 cm depth of **FA 8** in a test-tube. To this test-tube, add 6 drops of sodium hydroxide solution, followed by iodine solution, dropwise, until a permanent orange/red colour is present. Warm the mixture in a beaker of hot water for two minutes. Add sodium hydroxide solution using a teat pipette until no further change is seen. **Repeat using FA 10 instead of FA 8.**	no observable change	no observable change	pale yellow precipitate formed	pale yellow precipitate formed
Place about 2 cm depth of aqueous silver nitrate in a boiling tube. Then slowly add 1 cm depth of aqueous sodium hydroxide. Add aqueous ammonia slowly, with shaking, until the precipitate just dissolves. You can use a clean glass rod to stir the mixture and help dissolve the precipitate. Use this solution for test 2.				

2. Add about 1 cm depth of the solution prepared in a test-tube. Add 1 cm depth of **FA 8** to the test-tube, shake the tube and place it in the test-tube rack to stand. **Repeat using FA 9, instead of FA 8.**	no observable change	silver mirror formed	no observable change	no observable change

[2]

(ii) The observations in Table 2.1 are sufficient to identify the functional group present in **FA 9**.

State the functional group present in **FA 9** and give evidence to support your answer.

functional group in **FA 9** aldehyde

evidence silver mirror formed shows that FA 9 is an aldehyde

[1]

(iii) Devise and perform simple tests to identify the functional groups in **FA 8**, **FA 10** and **FA 11**. Your test should use only the reagents provided. Record your test and observations in the space below.

Any test requiring heating MUST be performed using a beaker of hot water.

	FA 8	**FA 10**	**FA 11**
Place about 1 cm depth of **FA 8** in a test – tube. To this test – tube, add a few drops of potassium manganate and dilute sulfuric acid and place the test- tube in the hot water bath. Leave for a few minutes. **Repeat using FA 10 and FA 11.**	Purple solution remains.	Purple solution remains.	Purple solution decolourised.

Place about 1 cm depth of **FA 8** in a test – tube. To this test tube, add a small spatula of sodium carbonate power. **Repeat using FA 10 and FA 11.**	Effervescence observed. White ppt formed with limewater.	No effervescence observed.	No effervescence observed.

[4]

(iv) Complete Table 2.2 with the functional groups present in **FA 8**, **FA 10** and **FA 11**.

Give evidence from the observations in Table 2.1 and **(b)(ii)** to support your conclusions.

Table 2.2

	functional group present	evidence
FA 8	carboxylic acid	Effervescence with sodium carbonate which give white ppt with limewater shows that CO_2 is present. Only carboxylic acid is able to react with sodium carbonate.
FA 10	ketone	Pale yellow ppt formed show that $-COCH_3$ or $-CH(CH_3)OH$ is present but purple solution remains which shows that it cannot be oxidised so it must be ketone.
FA 11	alcohol	Pale yellow ppt formed show that $-COCH_3$ or $-CH(CH_3)OH$ is present and purple solution decolourise which shows that it can be oxidised so it must be alcohol.

[3]

[Total: 15]

3 Determination of a value for the activation energy of a reaction

FA 12 is 0.1 mol dm^{-3} solution of hydrated sodium thiosulfate, $Na_2S_2O_3.5H_2O$.

FA 13 is 2.0 mol dm^{-3} hydrochloric acid.

Solid sulfur is one of the products formed in the reaction between sodium thiosulfate and a strong acid, as shown in the equation 3.1. The presence of sulfur causes the solution to be opaque.

reaction 3 $S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow S(s) + SO_2(g) + H_2O(l)$

In order to determine the activation energy for this experiment, you will need to investigate the effect of temperature on its rate. The rate of this reaction is studied by measuring the time taken for the reaction to become opaque.

The activation energy, E_a, can be determined from the Arrhenius Equation, where T is the reaction temperature in Kelvin and k is the rate constant at temperature T. The frequency factor, A, can be regarded as a constant under the conditions of this experiment.

$$k = Ae^{-\frac{E_a}{RT}}$$

In this question, you will perform a series of five experiments, at different temperatures, T_K, each using the same volumes of **FA 12** and **FA 13**. Then, you will determine the value for the activation energy of the reaction graphically by plotting values of ln(1/t) on the y-axis against $1/T_K$ on the x-axis, a straight line of best fit may be drawn. The gradient of this line is $-E_a/R$, where R is the ideal gas constant.

For each experiment, you will note the temperature of the reaction, T, and the time taken, t, for the reaction mixture to become opaque.

You will then calculate values, to 3 significant figures, for

- $1/t$,
- ln(1/t),
- T in Kelvin, T_K (0.0 °C = 273.0 K)
- $1/T_K$

(a) Prepare a table in the space provided on page 16 in which to record, to an appropriate level of precision:

- all temperatures,
- all values of t,
- all calculated values of $1/t$, ln(1/t), T_K and $1/T_K$.

Notes: In each of these experiments, you will need to place the conical flask containing the reaction mixture on the printed page on page 2 of the insert. You will view the page by looking vertically down through the mixture. You will stop the stopwatch when the mixture **first** becomes opaque. This will be the first instant when you can no longer see the printed numbers on the page.

Under no circumstances should the equipment used to measure one solution be used to measure another solution.

Before you prepare your experimental solutions,

- rinse the inside of the two boiling tubes labelled '1' with about 2 cm^3 of **FA 12**. Pour this **FA 12** into the waste bottle and place the boiling tubes in the test-tube rack until you need them.
- rinse the inside of the two boiling tubes labelled '2' with about 2 cm^3 of **FA 13**. Pour this **FA 13** into the waste bottle and place the boiling tubes in the test-tube rack until you need them.

Experiment **1** is performed at room temperature. This is the lowest temperature you will carry out. Experiment **2** is performed at 70 ^oC. This is the highest temperature you will carry out. The other three experiments are performed at different temperatures. You will use water baths to change the temperature of these reaction mixtures.

To prepare a hot water bath, you will mix tap water with the hot water provided until an appropriate temperature is reached.

1. Use a measuring cylinder to transfer 10 cm^3 of **FA 12** into the boiling tube labelled '**1**'. Place the boiling tube into a 250 cm^3 beaker containing hot water. This is the hot water bath.

2. Use another measuring cylinder to transfer 20 cm^3 of **FA 13** into the boiling tube labelled '**2**'. Place the boiling tube into the hot water bath.

3. Leave the boiling tubes in the hot water bath for use in **Experiment 2** and start **Experiment 1**.

Experiment 1

1. Use a measuring cylinder to transfer 20 cm^3 of **FA 13** into a 100 cm^3 conical flask.

2. Measure and record the temperature of **FA 13**.

3. Use another measuring cylinder to measure 10 cm^3 of **FA 12**.

   Note: Small amounts of SO_2 will be produced during the reaction.
   Minimise inhalation of SO_2.

4. Pour **FA 12** rapidly into the same conical flask. Start the stopwatch when about half of the **FA 12** solution has been added.

5. Swirl the conical flask once to mix the solutions. Then place the flask on the printed page of page 2 of the insert.

6. Stop the stopwatch when the solution **first** becomes opaque.

7. Record the time taken, *t*, to the nearest second in your table.

8. Discard the reaction mixture **immediately** down the sink. Wash out the conical flask and stand it upside down on a paper towel to drain.

Experiment 2

1. Measure and record the temperature of **FA 13** in boiling tube 2.

2. Remove the thermometer and carefully transfer the hot content of boiling tube 2 into a 100 cm^3 conical flask.

3. Pour rapidly the hot content of boiling tube 1 into the same conical flask. Start the stopwatch when about half of the **FA 12** solution has been added.

4. Swirl the conical flask once to mix the solutions. Then place the flask on the printed page of page 2 of the insert.

5. Stop the stopwatch when the solution **first** becomes opaque.

6. Record the time taken, *t*, to the nearest second in your table.

7. Discard the reaction mixture **immediately** down the sink. Wash out the conical flask and stand it upside down on a paper towel to drain.

Experiment 3, 4 and 5

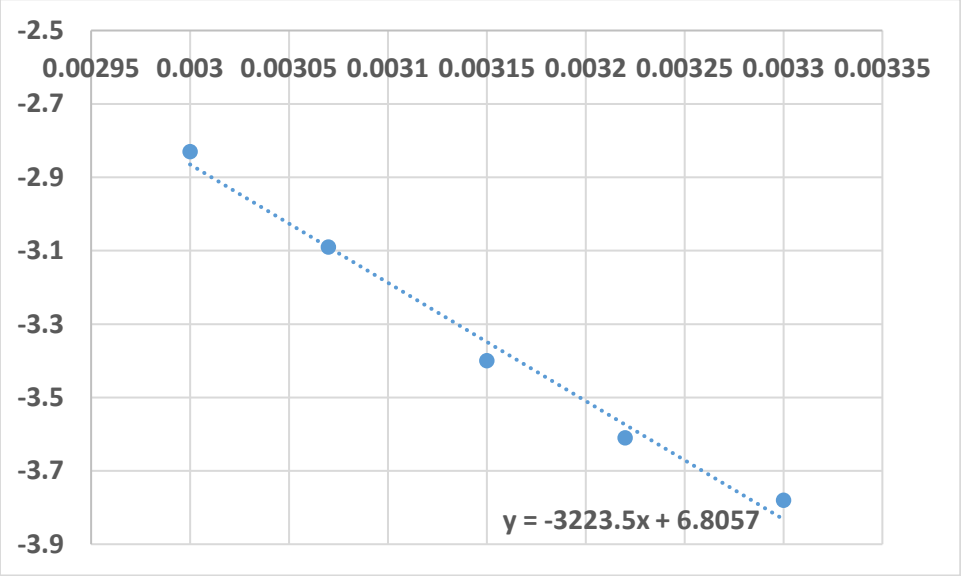
Repeat **Experiment 2** but at three different temperatures. Keep the temperature of **FA 13** between room temperature and 70 °C. Do not exceed 70 °C. You will use water baths to change the temperature of these reaction mixtures.

Results

experiment	t / s	$1/t$ / s^{-1}	ln $(1/t)$	T / °C	T_K / K	$1/T_K$ / K^{-1}
1	44	0.0228	–3.78	30.0	303	0.00330
2	37	0.0270	–3.61	38.0	311	0.00322
3	30	0.0333	–3.40	44.0	317	0.00315
4	22	0.0455	–3.09	53.0	326	0.00307
5	17	0.0588	–2.83	60.0	333	0.00300

[4]

(b) (i) Plot a graph of ln(1/t) on the y-axis against $1/T_K$ on the x-axis. Draw the best-fit straight line taking into account all of your plotted points.



[3]

(ii) Calculate the value of the gradient of the line to three significant figures, showing clear how you did this. [1]

Taking two points which are more than 3 big squares apart in both horizontal and vertical directions,

Gradient = $\frac{\Delta y}{\Delta x} = -2950$

(iii) Calculate the activation energy, E_a, for reaction 3.
[R = 8.314 J K^{-1} mol^{-1}] [4]

$-E_a/R$ = gradient
$E_a = -2950 \times (-8.314) =$ **2.45×10^4 J mol^{-1}**

(c) In **Experiment 1**, you are told to start the stopwatch when about half of the **FA 12** solution has been added.

Suggest why this method is likely to be more accurate than starting the stopwatch after all the **FA 12** has been added. [1]

The experiment time will be longer which results in a smaller percentage error.

(d) When you performed this experiment, you were instructed to wash and drain the conical flask before using it again.

State and explain the likely effect on ***t*** of not draining a flask before it is reused. [1]

effect on ***t***:
t will increase

explanation:
Presence of undrained water left in the conical flask would result in dilution of the reactants and hence rate of reaction decreases, resulting in a longer *t*.

(e) A student repeated the experiment but chose to use burettes to measure the volumes of **FA 12** and **FA 13**.

State and explain, in terms of percentage error, whether the student was wise to use a burette, rather than a 100 cm^3 measuring cylinder, to measure the volume of **FA 12**. [1]

% error with burette = $\frac{2 \times 0.05}{10} \times 100 = 1.00\%$

% error with measuring cylinder = $\frac{0.5}{10} \times 100 = 5.00\%$

The student was wise as the use of a burette gives a smaller percentage error.

[Total: 15]

4 Planning

(a) Relative atomic mass of an element is the the average mass of one atom of that element as compared to $\frac{1}{12}$ of the mass of a ^{12}C atom.

Magnesium is a reactive metal and appears dull because the metal on the surface is oxidised by air. The metal reacts with hydrochloric acid according to the following equation.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Plan an investigation to determine the relative atomic mass of magnesium.

You should make use of the water displacement method for collection of gas in your plan. In addition, you should plan to prepare a solution of hydrochloric acid of a suitable concentration and to collect a suitable volume of gas in your investigation.

You may assume that you are provided with:
- one piece of magnesium strip
- 0.50 mol dm^{-3} hydrochloric acid
- a piece of sandpaper
- the equipment normally found in a school or college laboratory

Your plan should include brief details of:
- the apparatus you would use
- the quantities of the reactants and conditions that you would use
- the procedure that you would follow
- the measurements you would make (you may find it useful to label measurements in your plan as M1, M2 etc)
- an outline of how you would use your results to determine the *relative atomic mass* of magnesium.

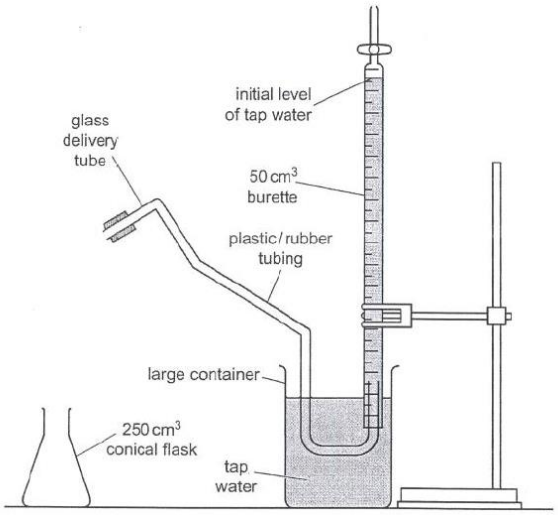
[A_r: H, 1.0; Cl: 35.5]

You may assume that 1 mole of a gas has a volume of approximately 24 dm^3 at 293 K and 1 atm.

1. Assuming 40 cm^3 of $H_2(g)$ is to be collected,
   Amount of H_2 produced = $40 \div 24000 = 1.6666 \times 10^{-3}$ mol
   Amount of HC*l* needed = $1.6666 \times 10^{-3} \times 2 = 3.333 \times 10^{-3}$ mol
   Volume of HC*l* needed = $(3.333 \times 10^{-3}) / 0.50 = 6.6666 \times 10^{-3}$ dm^3
   $= 6.67$ cm^3

2. Using a 25.0 cm^3 pipette (or 50.00 cm^3 burette), transfer 25.0 cm^3 of the 0.50 mol dm^{-3} hydrochloric acid into a 250 cm^3 volumetric flask. Make up the solution to 250 cm^3 with deionised water and mix thoroughly.

3. Set up the experiment as shown below and place the beaker of tap water in a thermostatically controlled water bath at 20 °C.



4. Using a 100 cm^3 measuring cylinder, transfer 70 cm^3 of the diluted hydrochloric acid into a 250 cm^3 conical flask.
5. Remove the layer of oxide on the Mg strip using the sandpaper and weigh the Mg strip (M1)
6. Add the Mg strip into the conical flask and insert the bung into the conical flask.
7. Read and record the initial water level (M2) in the burette. Hold the flask by its neck and gently swirl it continuously.
8. Read and record the final water level (M3) in the burette when no more $H_2(g)$ is produced.
9. *Wipe dry and reweigh the Mg strip if there's leftover when no more effervescence is present.*
10. Volume of $H_2(g)$ collected = M2 – M3 (initial burette reading – final burette reading) = M4
    Amount of $H_2 = (M4 \div 24 \times 10^{-3})$ mol
    Amount of Mg = $(M4 \div 24 \times 10^{-3})$ mol
    A_r of Mg = $M1 \div (M4 \div 24 \times 10^{-3})$ (Assuming that Mg is the limiting reagent)

(b) Identify one safety issue, relating to the properties of chemicals used or produced, in this procedure. Explain the precaution you would take to minimise the issue. [1]

Keep naked flame away from the apparatus as hydrogen is flammable.

[Total: 7]

Qualitative Analysis Notes

[ppt. = precipitate]

(a) Reactions of aqueous cations

cation	***reaction with***	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	ammonia produced on heating	−
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq),	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt., rapidly turning brown on contact with air insoluble in excess	off-white ppt., rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

(b) Reactions of anions

ions	***reaction***
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq))
bromide, Br^-(aq)	gives pale cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq))
nitrate, NO_3^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (insoluble in excess dilute strong acids)
sulfite, SO_3^{2-}(aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in dilute strong acids)

(c) Test for gases

ions	***reaction***
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	“pops” with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns aqueous acidified potassium manganate(VII) from purple to colourless

(d) Colour of halogens

halogen	***colour of element***	***colour in aqueous solution***	***colour in hexane***
chlorine, Cl_2	greenish yellow gas	pale yellow	pale yellow
bromine, Br_2	reddish brown gas / liquid	orange	orange-red
iodine, I_2	black solid / purple gas	brown	purple