1 (a) Name the apparatus shown below.

..........................................................cm³ [2]

(b) What is the volume of the gas in the apparatus?

..........................................................cm³ [2]
2 A student added 150 cm$^3$ of 0.080 mol/dm$^3$ barium chloride to 100 cm$^3$ of 0.15 mol/dm$^3$ magnesium sulphate. A precipitate of barium sulphate was produced.

(a) Describe the colour of the precipitate.
..........................................................................................................................................................[1]

(b) How could the precipitate be removed from the mixture?
..........................................................................................................................................................[1]

(c) Calculate the number of moles of barium chloride and magnesium sulphate used in the experiment.

(i) barium chloride

............................................moles

(ii) magnesium sulphate

............................................moles

[2]

(d) Using your answers to part (c),

(i) deduce the number of moles of barium sulphate produced.

............................................moles

(ii) Give the formula of barium sulphate.

..........................................................................................................................................................

(iii) Calculate the mass of barium sulphate produced.

(A$_r$: Ba, 137; S, 32; O, 16)

..................................................g

[4]
A student electrolysed lead bromide and aqueous sodium chloride in the apparatus shown below.

Each of the electrodes is labelled with a letter.

(a) Why was it necessary for lead bromide to be molten?

......................................................................................................................................[1]

(b) (i) What was produced at electrode A?

......................................................................................................................................

(ii) What was the appearance of this product?

......................................................................................................................................

(iii) What was produced at electrode B?

......................................................................................................................................

(iv) Where did this product collect?

......................................................................................................................................[4]
(c) Gases were produced at electrodes C and D. In each case name the gas and give a test to confirm its presence.

(i) the gas produced at C .................................................................
    test for this gas .................................................................

(ii) gas produced at D .................................................................
    test for this gas .................................................................

(d) What change should be made so that sodium is produced at one of the electrodes?

.................................................................................................................[1]
For questions 4 to 8 inclusive, place a tick in the box against the best answer.

4 A student did a series of experiments in which a halogen was displaced from a salt by the addition of another halogen.

Which result was not correct?

<table>
<thead>
<tr>
<th></th>
<th>halogen</th>
<th>salt</th>
<th>halogen produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Br</td>
<td>KCl</td>
<td>Cl</td>
</tr>
<tr>
<td>(b)</td>
<td>Br</td>
<td>KI</td>
<td>I</td>
</tr>
<tr>
<td>(c)</td>
<td>Cl</td>
<td>KBr</td>
<td>Br</td>
</tr>
<tr>
<td>(d)</td>
<td>Cl</td>
<td>KI</td>
<td>I</td>
</tr>
</tbody>
</table>
Three test tubes each contained an aqueous solution into which a piece of metal was dipped.

Metal $X$ is an unknown metal.

After several minutes reactions were taking place in tubes I and II but not in III.

What did this indicate about the relative reactivities of these metals.

- Most reactive
- Least reactive

(a) Sn  Zn  $X$  
(b) Sn  $X$  Zn  
(c) $X$  Zn  Sn  
(d) Zn  Sn  $X$
6 Ammonia and hydrogen chloride cannot be collected by the displacement of water. They are collected by the methods shown below.

What deductions can be made about the properties of the two gases?

<table>
<thead>
<tr>
<th>ammonia</th>
<th>hydrogen chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>density</td>
<td>solubility in water</td>
</tr>
<tr>
<td>(a) more dense than air</td>
<td>insoluble</td>
</tr>
<tr>
<td>(b) less dense than air</td>
<td>soluble</td>
</tr>
<tr>
<td>(c) more dense than air</td>
<td>insoluble</td>
</tr>
<tr>
<td>(d) less dense than air</td>
<td>soluble</td>
</tr>
</tbody>
</table>
A student did some tests on ethanoic acid. Which result was incorrect?

<table>
<thead>
<tr>
<th>test</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) add sodium carbonate</td>
<td>effervescence</td>
</tr>
<tr>
<td>(b) litmus paper</td>
<td>turned red</td>
</tr>
<tr>
<td>(c) warm with ethanol together with two drops of concentrated sulphuric acid</td>
<td>a sweet smelling liquid</td>
</tr>
<tr>
<td>(d) warm with acidified potassium dichromate(VI)</td>
<td>solution turns green</td>
</tr>
</tbody>
</table>

A beaker of an unknown gas Y was inverted over a porous pot containing carbon monoxide as shown. The apparatus was left for a while but the water level did not change.

The gas Y could have been

(a) ammonia,
(b) carbon dioxide,
(c) chlorine,
(d) nitrogen.

\[A: \ N, \ 14; \ H, \ 1; \ C, \ 12; \ O, \ 16; \ Cl, \ 35.5.\]
Hydrated sodium carbonate has the formula \( \text{Na}_2\text{CO}_3\cdot x\text{H}_2\text{O} \) where \( x \) is a whole number.

A student determined the value of \( x \) in the formula by titrating an aqueous solution of sodium carbonate with 0.080 mol/dm\(^3\) hydrochloric acid (solution F).

A sample of \( \text{Na}_2\text{CO}_3\cdot x\text{H}_2\text{O} \) was placed in a previously weighed container, which was then reweighed.

\[
\text{Mass of container} + \text{Na}_2\text{CO}_3\cdot x\text{H}_2\text{O} = 5.71\text{g} \\
\text{Mass of container} = 3.73\text{g}
\]

(a) Calculate the mass of \( \text{Na}_2\text{CO}_3\cdot x\text{H}_2\text{O} \).

\[ \text{....................................g}[1] \]

The sample of \( \text{Na}_2\text{CO}_3\cdot x\text{H}_2\text{O} \) was dissolved in distilled water and made up to a 250 cm\(^3\) solution. This was solution G.

25.0 cm\(^3\) of G was transferred to a conical flask.

(b) Which piece of apparatus is most suitable for this purpose?

\[ \text{......................................................................................................................................}[1] \]

Two drops of methyl orange indicator were added to G. Solution F was run in from a burette until an end point was reached.

(c) What was the colour change at the end point?

The colour changed from .........................to .........................at the end point. [1]

Three titrations were done. The diagrams below show parts of the burette with the liquid levels before and after each titration.
(d) Use the diagrams to complete the following table.

<table>
<thead>
<tr>
<th>titration</th>
<th>first</th>
<th>second</th>
<th>third</th>
</tr>
</thead>
<tbody>
<tr>
<td>final reading/cm³</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>initial reading/cm³</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>volume of solution F/cm³</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>best titration results (✔)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Summary

Tick (✔) the best titration results. Using these results, the average volume of F was ............... cm³. [4]

(e) Calculate the number of moles of hydrochloric acid in the average volume calculated in (d).

................................. moles [1]

Sodium carbonate reacts with hydrochloric acid according to the following equation.

\[ \text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{CO}_2 + \text{H}_2\text{O} \]

(f) Calculate the number of moles of sodium carbonate which reacts with the number of moles of hydrochloric acid calculated in (e).

................................. moles [1]

(g) Calculate the number of moles of sodium carbonate in 250 cm³ of solution G.

................................. moles [1]
(h) Calculate the relative molecular mass of sodium carbonate Na₂CO₃. 
\[ A_r: \text{Na, 23; C, 12; O, 16.} \]

..........................................

..........................................

(i) Using your answers to (g) and (h), calculate the mass of sodium carbonate, Na₂CO₃, in 250 cm³ of solution G.

..........................................

..........................................
g [1]

(j) By subtracting your answer in (i) from your answer in (a), calculate the mass of water in the original sample of hydrated sodium carbonate.

..........................................

..........................................
g [1]

(k) Using your answers in (i) and (j) in the following formula, calculate the value of \(x\) in Na₂CO₃·\(x\)H₂O.

\[
x = \frac{106 \times \text{answer (j)}}{18 \times \text{answer (i)}}
\]

..........................................

[1]
The following table shows the tests a student did on substance L and the conclusions made from the observations. Complete the table by describing these observations and suggest the test and observation that led to the conclusion in test 4.

<table>
<thead>
<tr>
<th>test</th>
<th>observation</th>
<th>conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L was dissolved in water and the solution divided into three parts for tests 2, 3 and 4.</td>
<td>L is a compound of a transition metal</td>
</tr>
<tr>
<td>2</td>
<td>(a) To the first part, aqueous sodium hydroxide was added until a change was seen. <em>(b) An excess of aqueous sodium hydroxide was added to the mixture from (a).</em></td>
<td>L may contain Fe$^{3+}$ ions.</td>
</tr>
<tr>
<td>3</td>
<td>(a) To the second part, aqueous ammonia was added until a change was seen. <em>(b) An excess of aqueous ammonia was added to the mixture from (a).</em></td>
<td>The presence of Fe$^{3+}$ ions is confirmed.</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>L contains NO$_3^-$ ions.</td>
</tr>
</tbody>
</table>

Conclusion: the formula for substance L is ........................................................................................................................................[10]
11 A student found the solubility of the salt potassium chlorate(V), in water using the apparatus shown below.

10 g of water was put into a boiling tube. To this 0.5 g of potassium chlorate(V) was added. The tube and its contents were heated until the solid dissolved. The tube was allowed to cool. At the first sign of solid appearing the temperature was taken. The experiment was repeated using 1.0, 2.0, 3.0, and 4.0 g of potassium chlorate(V).
Question 11 continues overleaf.
(a) The thermometer stems below show the temperature at which the solid appeared. Use these values to complete the table below.

<table>
<thead>
<tr>
<th>mass of potassium chlorate(V) in 10 g of water</th>
<th>0.5 g</th>
<th>1.0 g</th>
<th>2.0 g</th>
<th>3.0 g</th>
<th>4.0 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>temperature / °C at which potassium chlorate(V) appears</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The experiment was repeated for the salt potassium chloride, the results for which are shown in the table below.

<table>
<thead>
<tr>
<th>mass of potassium chloride in 10 g of water</th>
<th>3.5</th>
<th>4.0</th>
<th>4.5</th>
<th>5.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>temperature / °C at which potassium chloride appears</td>
<td>10</td>
<td>33</td>
<td>56</td>
<td>80</td>
</tr>
</tbody>
</table>

(b) Plot the results for both potassium chlorate(V) and for potassium chloride on the grid opposite. Join the points for potassium chlorate(V) with a smooth curved line and those for potassium chloride with a straight line.

Extend each line in both directions, so that at the lower ends each line crosses the vertical axis and at the upper ends the lines cross. Use the resulting lines to answer the following questions.
(c) What is the mass of each compound that dissolves in 10 g of water at 0 °C?

(i) Potassium chlorate(V) .......................................... g

Potassium chloride .......................................... g

(ii) At what temperature is the solubility of each salt the same?

.......................................... °C

(d) The solubility of a salt is defined as the maximum mass of salt that will dissolve in 100 g of water at a given temperature. Calculate the solubility of both potassium chlorate(V) and potassium chloride at the temperature you have given in (c)(ii).

.......................................... g [1]

(e) The student was given a boiling-tube containing 3.0 g of potassium chlorate(V) in 10.0 g of water at a temperature of 40 °C. Describe the appearance of the contents of the tube.

...................................................................................................................................... [1]