A1 Choose from the following list of compounds to answer the questions below.

- calcium hydroxide
- carbon monoxide
- methane
- nitrogen dioxide
- potassium manganate(VII)
- silver nitrate
- sulfur dioxide

Each compound can be used once, more than once, or not at all.

Which compound

(a) is used as a bleach in the manufacture of paper,

(b) changes from purple to colourless when its acidified solution is used to oxidise ethanol,

(c) has an aqueous solution that reacts with aqueous sodium chloride to give a white precipitate,

(d) can be formed by the action of lightning on gases in the atmosphere,

(e) is formed by the decay of vegetable matter?

[Total: 5]
Sodium can react with compounds called crown ethers.

(a) A typical crown ether is shown below.

(b) When sodium reacts with crown ethers it forms Na\(^{+}\) and Na\(^{-}\) ions. Draw the structure of an Na\(^{-}\) ion. Show all the electrons.

Write the empirical formula for this crown ether.

........................................................................................................................................................................... [1]
(c) When sodium reacts with water, hydrogen is given off and an alkaline solution is formed.

(i) Describe two observations that can be made when sodium reacts with water.

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

(ii) Write an equation, including state symbols, for the reaction of sodium with water.

.................................................................................................................................... [3]

(d) Sodium is an alkali metal. Iron is a transition element.
State the differences between these two metals in terms of

(i) melting point ..........................................................................................................
............................................................................................................................. [1]

(ii) density ..................................................................................................................
............................................................................................................................. [1]

[Total: 9]
A3 Hydrogen peroxide is a colourless liquid.

An aqueous solution of hydrogen peroxide reacts with the iodide ions in acidified potassium iodide to form water and iodine.

\[
\text{H}_2\text{O}_2(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{I}^-(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{I}_2(\text{aq})
\]

(a) (i) Explain why iodide ions are acting as the reducing agent in this reaction.

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

(ii) What colour change would you observe in this reaction?

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

(b) The table shows how the speed of this reaction changes when different concentrations of potassium iodide and sulfuric acid are used. The hydrogen peroxide is always in excess and the temperature remains constant.

<table>
<thead>
<tr>
<th>experiment</th>
<th>concentration of potassium iodide in mol/dm³</th>
<th>concentration of sulfuric acid in mol/dm³</th>
<th>speed of reaction in mol/dm³/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.00017</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>0.1</td>
<td>0.00034</td>
</tr>
<tr>
<td>3</td>
<td>0.1</td>
<td>0.2</td>
<td>0.00017</td>
</tr>
<tr>
<td>4</td>
<td>0.3</td>
<td>0.1</td>
<td>0.00051</td>
</tr>
<tr>
<td>5</td>
<td>0.1</td>
<td>0.3</td>
<td>0.00017</td>
</tr>
</tbody>
</table>

Use the information in the table to describe how increasing the concentration of the following reagents affects the speed of reaction.

potassium iodide ..................................................................................................................................... [1]

sulfuric acid ............................................................................................................................................. [1]

(c) Explain, in terms of collisions between reacting particles, why decreasing the temperature decreases the speed of reaction between hydrogen peroxide and acidified potassium iodide.

.......................................................................................................................................................... [2]
(d) Iodine-127 has the symbol $^{127}\text{I}$. 

State the number of subatomic particles in an iodide ion $^{127}\text{I}^-$.

protons ........................................
electrons ......................................
neutrons ........................................... [2]

[Total: 8]
A4 A plant contains the coloured compounds chlorophyll and carotene.

(a) The mixture of coloured compounds is extracted with propanone to give a brown solution.

(i) Describe, with the aid of a labelled diagram, how you can show that there is more than one coloured compound in the brown solution.

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..................................................................................................................................
..................................................................................................................................
.................................................................................................................................. [3]

(ii) You are given a pure sample of chlorophyll. How can you show that the brown solution contains chlorophyll?
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..................................................................................................................................
..................................................................................................................................
.................................................................................................................................. [2]

(b) In green plants chlorophyll acts as a catalyst in photosynthesis.

(i) Complete the word equation which describes photosynthesis.

........................................ + water → ........................................ + oxygen [1]

(ii) During one stage in photosynthesis, electrons are removed from water to produce hydrogen ions and oxygen gas. Write an equation for this reaction.

............................................................................................................................................ [2]
(c) Chlorophyll and carotene can be made in the laboratory from isoprene.

\[
\begin{align*}
\text{CH}_3 \\
\text{CH}_2=\text{C} - \text{CH} - \text{CH}_2
\end{align*}
\]

isoprene

(i) Isoprene is an unsaturated compound.

What do you understand by the term unsaturated?

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

(ii) What would you observe when excess isoprene is added to aqueous bromine?

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

(d) In many plants, the alkene ethene promotes the ripening of fruits.

(i) Write the general formula for an alkene.

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

(ii) Draw the structure of an alkene containing four carbon atoms.

Show all atoms and bonds.

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

(iii) Describe how ethanol can be formed from ethene, stating the necessary reaction conditions.

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

[Total: 14]
A5 Three types of bonding are covalent, ionic and metallic.

(a) (i) Draw a labelled diagram to illustrate metallic bonding.

(ii) Use ideas about the structure of metals to explain why metals are malleable, .................................................................................................................. [1]

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

good conductors of electricity. ................................................................................

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

(b) Silicon dioxide has a similar structure to diamond.

Suggest why silicon dioxide does not conduct electricity, ................................................ [1]

is hard. ..................................................................................................................... [1]
(c) Part of the structure of palladium chloride is shown below.

\[
\begin{array}{c}
\text{palladium, Pd} \\
\text{chlorine, Cl}
\end{array}
\]

Deduce the empirical formula for palladium chloride.

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

(d) Sodium chloride has an ionic structure. Explain why sodium chloride conducts electricity when molten but does not conduct electricity when in the solid state.

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

[Total: 9]
Section B

Answer three questions from this section in the spaces provided.

The total mark for this section is 30.

B6 A student prepares some crystals of hydrated sodium sulfate by titrating aqueous sodium hydroxide with sulfuric acid.

(a) Describe how he can obtain pure dry crystals of sodium sulfate using this method.

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..........................................................................................................................................
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..........................................................................................................................................
..........................................................................................................................................
..........................................................................................................................................
....................................................................................................................................... [4]

(b) The student uses 25.0 cm$^3$ of 1.60 mol/dm$^3$ sodium hydroxide to prepare the crystals.

\[ 2\text{NaOH(aq)} + \text{H}_2\text{SO}_4(aq) + 8\text{H}_2\text{O(l)} \rightarrow \text{Na}_2\text{SO}_4\cdot10\text{H}_2\text{O(s)} \]

Calculate the maximum mass of hydrated sodium sulfate crystals that can be formed.

............................................................................................................................................... [4]

(c) When hydrated sodium sulfate crystals are heated gently, water is given off.

Describe a chemical test for water.

test ........................................................................................................................................ [2]

observation .........................................................................................................................

[Total: 10]
B7 The structure of glycollic acid is shown below.

\[ \text{\begin{tikzpicture}
\draw (0,0) -- (1,0) -- (1,1) -- (0,1) -- cycle;
\node at (0.5,0.5) {O};
\end{tikzpicture}} \]

(a) Name the two functional groups present in glycollic acid.

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

(b) Glycollic acid undergoes similar reactions to ethanoic acid. Complete the equation for the reaction of glycollic acid with sodium carbonate.

\[ \ldots \text{HOCH}_2\text{CO}_2\text{H} + \text{Na}_2\text{CO}_3 \rightarrow \ldots + \ldots + \ldots \] [2]

(c) Glycollic acid can be prepared from oxalic acid.

\[ \begin{array}{c}
\text{CO}_2\text{H} \\
\text{CO}_2\text{H}
\end{array} + 2\text{H}_2 \rightarrow \begin{array}{c}
\text{CH}_2\text{OH} \\
\text{CO}_2\text{H}
\end{array} + \text{H}_2\text{O} \]

How does this equation shows that oxalic acid has been reduced?

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

(d) Glycollic acid polymerises to form poly(glycollic acid). The diagram shows a section of this polymer.

\[ \ldots \text{O} - \text{CH}_2 - \text{C} - \text{O} - \text{CH}_2 - \text{C} - \text{O} - \text{CH}_2 - \text{C} \ldots \]

(i) Is poly(glycollic acid) an addition polymer or a condensation polymer? Give a reason for your answer.

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

(ii) Name another polymer with the same linkage as poly(glycollic acid).

.............................................................................................................................. [1]
(e) Poly(glycollic acid) is biodegradable whereas poly(ethene) is non-biodegradable.

(i) Suggest two environmental advantages of using biodegradable polymers.

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

(ii) State one use of poly(ethene).

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

(iii) The diagram shows the repeat unit of poly(propene).

\[
\begin{array}{c}
\text{CH}_3 \quad \text{H} \\
\text{C} \quad \text{C} \\
\text{H} \quad \text{H} \\
\end{array}
\]

Draw the structure of the monomer used to make poly(propene).
Aluminium is extracted from bauxite ore.

(a) One stage in purifying bauxite to obtain pure aluminium oxide involves mixing the crushed ore with concentrated aqueous sodium hydroxide. The products of the reaction are aqueous sodium aluminate, NaAlO₂, and water.

(i) What type of oxide is aluminium oxide? Give a reason for your answer.
..................................................................................................................................
..................................................................................................................................... [1]

(ii) Write an equation for the reaction of aluminium oxide with aqueous sodium hydroxide.
..................................................................................................................................... [1]

(iii) The impurities in the ore are insoluble in water.
Suggest how the impurities are separated from the aqueous sodium aluminate.
..................................................................................................................................... [1]

(b) Pure aluminium oxide is electrolysed in the presence of cryolite to produce aluminium.

(i) Aluminium forms at the cathode and oxygen at the anode.
Write ionic equations for the reaction at
the cathode ............................................................................................................... [1]
The anode .................................................................................................................... [2]

(ii) Explain why cryolite is added to the aluminium oxide.
..................................................................................................................................... [1]

(c) (i) Aluminium is higher in the metal reactivity series than iron.
Apart from differences in malleability, explain why fizzy drinks cans are made from aluminium rather than iron.
..................................................................................................................................... [2]

(ii) Aluminium is often used in the form of alloys.
What do you understand by the term alloy?
..................................................................................................................................... [1]

[Total: 10]
B9 Hydrogen fluoride, hydrogen chloride and hydrogen iodide are all acidic gases.

(a) A student makes hydrogen chloride by reacting sodium chloride with excess concentrated sulfuric acid at room temperature and pressure.

\[
\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{NaHSO}_4 + \text{HCl}
\]

(i) Calculate the maximum volume of hydrogen chloride that can be made from 0.2 moles of sodium chloride at room temperature and pressure.

[1]

(ii) Draw a ‘dot-and-cross’ diagram for hydrogen chloride. Show only the outer electrons.

[1]

(b) Hydrogen fluoride is made by heating calcium fluoride, CaF$_2$, with concentrated sulfuric acid. Give an equation for this reaction.

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

(c) Hydrogen chloride dissolves in water to form hydrochloric acid. Hydrogen fluoride dissolves in water to form hydrofluoric acid.

A 0.1 mol/dm$^3$ solution of hydrochloric acid is completely ionised.

A 0.1 mol/dm$^3$ solution of hydrofluoric acid is only 10% ionised.

Use this information to compare and explain

the strength of each acid, .................................................................

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

the pH of each of these solutions. ..................................................

................................................................. [2]
(d) When hydrogen and iodine are heated in a sealed container an equilibrium is reached with the product, hydrogen iodide.

\[
\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g}) \quad \Delta H = -9.6 \text{ kJ/mol}
\]

(i) Predict the effect of the following on this equilibrium:

increasing the temperature,

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

decreasing the concentration of hydrogen iodide.

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

(ii) At 400 °C the equilibrium mixture contains 0.4000 moles of hydrogen, 0.07560 moles of iodine and 1.344 moles of hydrogen iodide.

Calculate the percentage of iodine molecules, \(\text{I}_2\), by mass in this equilibrium mixture.

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

[Total: 10]
The volume of one mole of any gas is 24 dm$^3$ at room temperature and pressure (r.t.p.).