READ THESE INSTRUCTIONS FIRST

Write your centre number, candidate number and name on all the work you hand in.
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.
DO NOT WRITE IN ANY BARCODES.

Answer all questions.
Electronic calculators may be used.
A copy of the Periodic Table is printed on page 16.
You may lose marks if you do not show your working or if you do not use appropriate units.

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.
Atoms contain particles called electrons, neutrons and protons.

(a) Complete the table.

<table>
<thead>
<tr>
<th>particle</th>
<th>where the particle is found in an atom</th>
<th>relative mass</th>
<th>relative charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>orbiting the nucleus</td>
<td></td>
<td>$\frac{1}{12}$</td>
<td>+1</td>
</tr>
<tr>
<td>in the nucleus</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) How many electrons, neutrons and protons are there in the ion shown?

$^{44}_{20}\text{Ca}^{2+}$

number of electrons .............................................

number of neutrons .............................................

number of protons .............................................

[Total: 6]
2 Magnesium exists as three isotopes, $^{24}\text{Mg}$, $^{25}\text{Mg}$ and $^{26}\text{Mg}$.

(a) State, in terms of the total numbers of electrons, neutrons and protons, one difference and two similarities between these magnesium isotopes.

difference ........................................................................................................................................

similarity 1 ...................................................................................................................................

similarity 2 ....................................................................................................................................... [3]

(b) All isotopes of magnesium react with dilute hydrochloric acid to make hydrogen and a salt.

(i) Why do all isotopes of magnesium react in the same way?

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

(ii) Write a chemical equation for the reaction between magnesium and dilute hydrochloric acid.

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

(iii) Describe a test for hydrogen.

  test ................................................................................................................................................

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

(c) Magnesium is a metal.

Describe the structure and bonding of metals. Include a labelled diagram in your answer.

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........................................................................................................................................................ [3]
(d) Magnesium reacts with oxygen to form the ionic compound magnesium oxide.

(i) Complete the dot-and-cross diagrams to show the electronic structures of the ions in magnesium oxide. Show the charges on the ions.

\[
\begin{array}{c}
\text{Mg} \\
\text{O}
\end{array}
\] 

(ii) Magnesium oxide melts at 2853 °C.

Why does magnesium oxide have a high melting point?

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

(iii) Explain why molten magnesium oxide can conduct electricity.

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

[Total: 17]
3 (a) (i) Sodium is in Group I of the Periodic Table.

Describe two physical properties of sodium which are different from the physical properties of transition elements such as copper.

1 ..........................................................................................................................................
.............................................................................................................................................
2 ..........................................................................................................................................
.............................................................................................................................................

(ii) Sodium reacts rapidly with water.

Give one observation made when sodium is added to water.

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

(b) Some car airbags contain sodium azide.

When a car airbag is used the sodium azide, NaN₃, decomposes. The products are nitrogen and sodium.

The equation for the decomposition of sodium azide is shown.

\[ 2\text{NaN}_3(s) \rightarrow 2\text{Na}(l) + 3\text{N}_2(g) \]

Calculate the mass, in g, of sodium azide needed to produce 144 dm³ of nitrogen using the following steps.

- Calculate the number of moles in 144 dm³ of N₂ measured at room temperature and pressure.

  moles of N₂ = ......................... mol

- Determine the number of moles of NaN₃ needed to produce this number of moles of N₂.

  moles of NaN₃ = ......................... mol

- Calculate the relative formula mass, \( M_r \), of NaN₃.

  \( M_r = \) .........................

- Calculate the mass of NaN₃ needed to produce 144 dm³ of N₂.

  ......................... g [4]
(c) Some airbags contain silicon(IV) oxide. When the airbag is used sodium oxide is formed.

Oxides can be classified as acidic, amphoteric, basic or neutral.

Classify each of these oxides:

sodium oxide .................................................................

silicon(IV) oxide. .................................................................

[2]

(d) Lead(II) azide is insoluble in water. Solid lead(II) azide can be made in a precipitation reaction between aqueous lead(II) nitrate and aqueous sodium azide. Lead(II) azide has the formula Pb(N₃)₂.

(i) Deduce the formula of the azide ion.

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

(ii) Complete the chemical equation for the reaction between aqueous lead(II) nitrate and aqueous sodium azide to form solid lead(II) azide and aqueous sodium nitrate. Include state symbols.

Pb(NO₃)₂(aq) + ...... NaN₃(aq) → Pb(N₃)₂(.....) + ...... ..................(.....)

[2]

(iii) Describe how you could obtain a sample of lead(II) azide that is not contaminated with any soluble salts from the reaction mixture.

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(e) An organic compound made from sodium azide has the composition by mass: 49.5% carbon, 7.2% hydrogen and 43.3% nitrogen.

Calculate the empirical formula of the organic compound.

[3]

[Total: 17]
Question 4 starts on the next page.
Solutions of ionic compounds can be broken down by electrolysis.

(a) Concentrated aqueous copper(II) chloride was electrolysed using the apparatus shown.

The ionic half-equations for the reactions at the electrodes are shown.

negative electrode: \[ \text{Cu}^{2+}(aq) + 2e^- \rightarrow \text{Cu}(s) \]

positive electrode: \[ 2\text{Cl}^{-}(aq) \rightarrow \text{Cl}_2(g) + 2e^- \]

(i) Platinum is a solid which is a good conductor of electricity.

State one other property of platinum which makes it suitable for use as electrodes.

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

(ii) State what would be seen at the positive electrode during this electrolysis.

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

(iii) State and explain what would happen to the mass of the negative electrode during this electrolysis.

............................................................................................................................................. [2]
(iv) The concentrated aqueous copper(II) chloride electrolyte is green.

Suggest what would happen to the colour of the electrolyte during this electrolysis. Explain your answer.

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

(v) Identify the species that is oxidised during this electrolysis. Explain your answer.

species that is oxidised .............................................................................................................

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

(b) Metal objects can be electroplated with silver.

(i) Describe how a metal spoon can be electroplated with silver. Include:
- what to use as the positive electrode and as the negative electrode
- what to use as the electrolyte
- an ionic half-equation to show the formation of silver.

You may include a diagram in your answer.

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

ionic half-equation .............................................................................................................. [4]

(ii) Give one reason why metal spoons are electroplated with silver.

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

[Total: 13]
Carboxylic acids react with alcohols to form esters. The reaction is reversible. The equation for the reaction between ethanoic acid and ethanol is shown.

\[ \text{CH}_3\text{COOH} + \text{CH}_3\text{CH}_2\text{OH} \rightleftharpoons \text{CH}_3\text{COOCH}_2\text{CH}_3 + \text{H}_2\text{O} \]

(a) (i) What is the name of the ester formed in this reaction? 
............................................................................................................................................................................. [1]

(ii) Draw the structure of the ester formed. Show all of the atoms and all of the bonds.

(b) The reaction between ethanoic acid and ethanol is exothermic.

Draw an energy level diagram for this reaction.

On your diagram label:
- the reactants and products
- the energy change of the reaction, \( \Delta H \).

(c) Concentrated sulfuric acid is a catalyst for this reaction.

What is meant by the term catalyst?
............................................................................................................................................................................. [2]
(d) The rate of reaction can be increased by increasing the temperature.

Explain why increasing the temperature increases the rate of reaction.
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....................................................................................................................................................
....................................................................................................................................................
....................................................................................................................................................
....................................................................................................................................................
...............................................................................................................................................  [4]

(e) The reaction between ethanoic acid and ethanol reaches equilibrium.

(i) The reaction between ethanoic acid and ethanol is exothermic.

State and explain the effect, if any, of increasing the temperature on the amount of ester at equilibrium.
....................................................................................................................................................
....................................................................................................................................................
...............................................................................................................................................  [2]

(ii) State and explain the effect, if any, of removing water from the mixture on the amount of ester at equilibrium.
....................................................................................................................................................
....................................................................................................................................................
...............................................................................................................................................  [2]  

[Total: 15]
6 (a) Two hydrocarbons have the structures shown.

![Hydrocarbons A and B](image)

(i) Why are these two compounds hydrocarbons?

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

(ii) Hydrocarbon B reacts in the same way as a typical alkane.

Describe a chemical test to tell the difference between hydrocarbon A and hydrocarbon B.

State the name of the reagent you would use and the result you would obtain with hydrocarbon A and hydrocarbon B.

reagent ...........................................................................................................................................
result with hydrocarbon A ...........................................................................................................
result with hydrocarbon B ............................................................................................................. [3]

(b) Alkenes react with steam to form alcohols.

Compound C is an alcohol.

![Compound C](image)

Draw the structure of the alkene which could be reacted with steam to make compound C. Show all of the atoms and all of the bonds. [1]
(c) Alkenes can form polymers.

(i) What type of polymerisation occurs when alkenes form polymers? 
....................................................................................................................................... [1]

(ii) Part of the structure of a polymer is shown.

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

Draw the structure of the alkene from which this polymer can be made. Show all of the atoms and all of the bonds.

(iii) Polymers can undergo incomplete combustion to form carbon monoxide.

Complete the chemical equation for the incomplete combustion of poly(ethene). The only carbon-containing product is carbon monoxide.

\[
\begin{array}{c}
\text{H} & \text{H} \\
\text{C} & \text{C} \\
\text{H} & \text{H} \\
\end{array} + \text{...............O}_2 \rightarrow \text{...............} + 2n \text{H}_2\text{O}
\]

[2]

(d) Part of the structure of a polyamide is shown.

\[
\begin{array}{c}
\text{C} & \text{N} & \text{C} & \text{N} & \text{C} & \text{N} \\
\text{O} & \text{O} & \text{O} & \text{O} & \text{O} \\
\end{array}
\]

This polyamide is formed from identical monomers. Complete the diagram to show the structure of one monomer. Show all of the atoms and all of the bonds.

[2]
The volume of one mole of any gas is 24 dm$^3$ at room temperature and pressure (r.t.p.).