INSTRUCTIONS

- Answer all questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do not use an erasable pen or correction fluid.
- Do not write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.
1 (a) A list of compounds is shown.

- aluminium oxide
- calcium bromide
- calcium oxide
- ethane
- ethene
- hydrogen chloride
- methane
- nitrogen dioxide
- potassium iodide
- potassium manganate(VII)
- sodium chloride

Answer the following questions using only the compounds in the list. Each compound may be used once, more than once or not at all.

Which compound:

(i) when in acidified solution, is used to test for sulfur dioxide

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

(ii) is the main constituent of natural gas

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

(iii) when dissolved in water, gives a yellow precipitate on addition of acidified aqueous silver nitrate

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

(iv) is used in flue gas desulfurisation to neutralise acidic gases

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

(v) is a reactant used in the manufacture of ethanol?

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

(b) What is the meaning of the term *compound*?

.................................................................................................................................................... [2]
(c) Complete the electronic structure of a molecule of hydrogen chloride.

Show only the outer shell electrons.

\[
\text{H} \quad \text{Cl}
\]
Iron is extracted by heating a mixture of coke (carbon), limestone and iron ore in air in a blast furnace.

A diagram of the blast furnace is shown.

(a) Name the ore of iron added to the blast furnace.  
.................................................................................................................................................................................. [1]

(b) The impurities in the iron ore are removed as slag.

(i) What information in the diagram shows that slag is less dense than molten iron?  
.................................................................................................................................................................................. [1]

(ii) Which one of the substances added to the blast furnace helps to remove the impurities? Explain how it does this.

substance .............................................................................................................................................................................

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

(c) Hot air is blown into the blast furnace.

Explain why.
..................................................................................................................................................................................
.................................................................................................................................................................................. [1]
(d) The chemical equation for one of the reactions in the blast furnace is shown.

\[
\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2
\]

(i) How does this equation show that \( \text{Fe}_2\text{O}_3 \) has been reduced?

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

(ii) When 16.0 g of \( \text{Fe}_2\text{O}_3 \) react with excess carbon monoxide, 11.2 g of iron are produced.

Calculate the mass of iron produced when 4.0 g of \( \text{Fe}_2\text{O}_3 \) react with excess carbon monoxide.

mass of iron = ......................................... g [1]

(e) An isotope of iron is shown.

\(^{58}\text{Fe}^{26}\)

Deduce the number of electrons, protons and neutrons in an atom of this isotope of iron.

number of electrons .................................................................[3]

number of protons .................................................................[3]

number of neutrons .................................................................[3]

(f) Iron is a transition element.

Which two of these statements about iron are correct?

Tick two boxes.

Iron forms coloured compounds. [ ]

Iron can act as a catalyst. [ ]

Iron is brown when freshly cut. [ ]

Iron has a low density. [ ]

Iron has a low melting point. [ ]

[Total: 13]
3 Water is essential for many industrial processes.

(a) State one use of water in industry.
.................................................................................................................................................. [1]

(b) What is the pH of pure water?

Draw a circle around the correct answer.

\[
\begin{array}{cccc}
\text{pH 0} & \text{pH 6} & \text{pH 7} & \text{pH 14} \\
\end{array}
\]

[1]

(c) Filtration and chlorination are two of the steps used in water treatment.

Describe the purpose of each of these steps.

filtration ........................................................................................................................................
...........................................................................................................................................................

chlorination ..................................................................................................................................
...........................................................................................................................................................

[2]

(d) The changes of state of water are shown.

Give the names of the changes of state represented by A and B.

A ................................................................................................................................................

B ................................................................................................................................................

[2]
(e) The table compares the reactions of four metals with both steam and dilute hydrochloric acid.

<table>
<thead>
<tr>
<th>metal</th>
<th>reaction with steam at 200°C</th>
<th>observation with dilute hydrochloric acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>copper</td>
<td>no reaction</td>
<td>no bubbles formed</td>
</tr>
<tr>
<td>magnesium</td>
<td>rapid reaction</td>
<td>bubbles form rapidly</td>
</tr>
<tr>
<td>nickel</td>
<td>no reaction</td>
<td>bubbles form slowly</td>
</tr>
<tr>
<td>zinc</td>
<td>rapid reaction</td>
<td>bubbles form slowly</td>
</tr>
</tbody>
</table>

Put the four metals in order of their reactivity. Put the least reactive metal first.

least reactive: [ ] [ ] [ ] [ ]

most reactive: [ ] [ ] [ ] [ ]

[2]

[Total: 8]
4 Angelic acid and ethanoic acid are both carboxylic acids.

The structure of angelic acid is shown.

![Structure of Angelic Acid]

(a) (i) On the structure of angelic acid, draw a circle around the functional group that shows that it is a carboxylic acid. [1]

(ii) Deduce the formula of angelic acid to show the number of carbon, hydrogen and oxygen atoms.

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

(iii) Angelic acid is an unsaturated compound.

Describe a chemical test to distinguish between an unsaturated and a saturated compound.

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

result with unsaturated compound ......................................................................................................................

result with saturated compound ...................................................................................................................... [3]

(b) The formula of ethanoic acid is \( \text{C}_2\text{H}_4\text{O}_2 \).

Complete the table to calculate the relative molecular mass of ethanoic acid.

Use the Periodic Table to help you.

<table>
<thead>
<tr>
<th>type of atom</th>
<th>number of atoms</th>
<th>relative atomic mass</th>
<th>( \text{relative molecular mass} = ) ................. [2]</th>
</tr>
</thead>
<tbody>
<tr>
<td>carbon</td>
<td>2</td>
<td>12</td>
<td>( 2 \times 12 = 24 )</td>
</tr>
<tr>
<td>hydrogen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>oxygen</td>
<td>1</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>
(c) Ethanoic acid can be reduced to ethanol.

Complete the structure of ethanol to show all of the atoms and all of the bonds.

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

[1]

(d) Ethanol can be manufactured by fermentation.

Describe the process of fermentation to include:

- the names of the reactants and catalyst

- the conditions required

- the name of the process used to separate the ethanol from the rest of the reaction mixture.

[4]

[Total: 12]
The table shows some properties of four metals in Group I of the Periodic Table.

<table>
<thead>
<tr>
<th>metal</th>
<th>melting point / °C</th>
<th>boiling point / °C</th>
<th>relative electrical conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>sodium</td>
<td>98</td>
<td>883</td>
<td>........................</td>
</tr>
<tr>
<td>potassium</td>
<td>63</td>
<td>760</td>
<td>14</td>
</tr>
<tr>
<td>rubidium</td>
<td>..................</td>
<td>686</td>
<td>8</td>
</tr>
<tr>
<td>caesium</td>
<td>29</td>
<td>669</td>
<td>5</td>
</tr>
</tbody>
</table>

(a) Complete the table to estimate:
- the melting point of rubidium
- the relative electrical conductivity of sodium.

(b) What is the physical state of caesium at 20 °C?
Give a reason for your answer.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(c) Describe the trend in the boiling points of the Group I metals.

________________________________________________________________________

(d) When potassium reacts with water, a coloured flame is seen and a gas is produced that pops with a lighted splint.

(i) Complete the chemical equation for this reaction.

        ......K + 2H₂O → 2KOH + ..........

(ii) State the colour of the flame when potassium reacts with water.

________________________________________________________________________

(iii) The solution formed is alkaline.
Describe how you can use universal indicator solution to determine the pH of the solution.

________________________________________________________________________
________________________________________________________________________

[Total: 10]
6 This question is about the reactions of magnesium with nitric acid.

(a) The equation for the reaction of magnesium with concentrated nitric acid is shown.

\[ \text{Mg} + 4\text{HNO}_3 \rightarrow \text{Mg(NO}_3)_2 + 2\text{NO}_2 + 2\text{H}_2\text{O} \]

(i) The reaction is exothermic.

What is the meaning of the term *exothermic*? ................................................................. [1]

(ii) Which word best describes the compound \( \text{Mg(NO}_3)_2 \)?

Draw a circle around the correct answer.

\[ \text{acid} \quad \text{base} \quad \text{oxide} \quad \text{salt} \] [1]

(iii) Oxides of nitrogen are formed when fossil fuels are burned.

What type of chemical reaction occurs when fossil fuels are burned?

Draw a circle around the correct answer.

\[ \text{combustion} \quad \text{cracking} \quad \text{fermentation} \quad \text{neutralisation} \] [1]

(iv) Oxides of nitrogen dissolve in rain water to form acid rain.

State one adverse effect of acid rain on buildings.

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

(b) When very dilute nitric acid reacts with magnesium powder, hydrogen is produced.

(i) Describe a practical method for investigating the rate of this reaction.

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

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

............................................................................................................................................ [3]
(ii) What effect would each of the following have on the rate of this reaction?

- Larger pieces of magnesium are used instead of magnesium powder. All other conditions stay the same.

- The temperature of the reaction mixture is increased. All other conditions stay the same.

[Total: 9]
7 (a) The electrolysis of dilute sulfuric acid produces gases at both electrodes.

(i) The incomplete apparatus is shown.

Complete the diagram by:

- labelling the anode and cathode
- adding connecting wires
- showing how the gases are collected.

(ii) Name the products formed at each electrode.

positive electrode ................................................................................................................

negative electrode ............................................................................................................... 

(b) Carbon dioxide is produced when sulfuric acid reacts with sodium carbonate.

Name the two other products which are formed.

...................................................................... and ................................................................. 

(c) Describe the test for carbon dioxide.

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

observations ...........................................................................................................................
(d) Carbon dioxide is a greenhouse gas.

State one effect of greenhouse gases on the environment.

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

[Total: 10]
8 (a) The structures of four substances C, D, E and F, are shown.

(i) Which one of these substances, C, D, E or F, is a gas at room temperature?
............................................................................................................................................... [1]

(ii) What type of bonding is present in substance E?
............................................................................................................................................... [1]

(iii) Which one of these substances, C, D, E or F, is soluble in water?
............................................................................................................................................... [1]

(iv) Which one of these substances, C, D, E or F, conducts electricity when solid?
............................................................................................................................................... [1]

(b) The halogens have molecules containing two atoms.

What is the name for molecules containing only two atoms?
............................................................................................................................................... [1]
(c) The reaction of iodine with hydrogen is shown.

\[ I_2 + H_2 \leftrightharpoons 2HI \]

What is the meaning of the symbol \( \leftrightharpoons \)?

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

(d) Iodine is formed when chlorine reacts with aqueous potassium iodide.

(i) Complete the chemical equation for this reaction.

\[ \ldots + 2K\text{I} \rightarrow I_2 + \ldots..\text{KCl} \] [2]

(ii) When aqueous iodine is mixed with aqueous potassium chloride, there is no reaction.

Suggest, in terms of chemical reactivity, why there is no reaction.

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

[Total: 9]
The Periodic Table of Elements

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<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
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<td>6</td>
<td>7</td>
<td>8</td>
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<td>Li</td>
<td>Be</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>O</td>
<td>F</td>
<td>Ne</td>
<td>Na</td>
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<td>lithium</td>
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<td>oxygen</td>
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<td>cerium</td>
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<td>neodymium</td>
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<td>samarium</td>
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<td>samarium</td>
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<td>lutetium</td>
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</tbody>
</table>

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).