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.

This document has 12 pages. Blank pages are indicated.
This question is about elements X, Y and Z.

(a) An atom of element X is represented as $^{34}_{16}X$.

(i) Name the different types of particles found in the nucleus of this atom of X.

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

(ii) What is the term for the total number of particles in the nucleus of an atom?

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

(iii) What is the total number of particles in the nucleus of an atom of $^{34}_{16}X$?

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

(iv) What is the electronic structure of the ion $X^{2-}$?

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

(v) Suggest the formula of the compound formed between aluminium and X.

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

(b) (i) What term is used to describe atoms of the same element with different numbers of particles in the nucleus?

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

(ii) Identify the atom against which the relative masses of all other atoms are compared.

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

(iii) What is the name of the amount of any substance that contains $6.02 \times 10^{23}$ particles?

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

(iv) The constant $6.02 \times 10^{23}$ has a name. What is the name of this constant?

............................................................................................................................................. [1]
(c) Part of the definition of relative atomic mass is 'the average mass of naturally occurring atoms of an element'.

Some relative atomic masses are not whole numbers.

Element $Y$ has only two different types of atom, $^{69}Y$ and $^{71}Y$.

The ratio of atoms present in element $Y$ is shown.

$^{69}Y : ^{71}Y = 3 : 2$

- Calculate the relative atomic mass of element $Y$ to one decimal place.

relative atomic mass = .........................

- Identify element $Y$.

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

(d) Element $Z$ is in Period 3 and Group V.

(i) Identify element $Z$.

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

(ii) Explain in terms of electron transfer why $Z$ behaves chemically as a non-metal.

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

[Total: 16]
Magnesium is a metal.

(a) Name and describe the bonding in magnesium.

name ..........................................................................................................................................

description of bonding .............................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
[4]

(b) Magnesium oxide, MgO, is formed when magnesium burns in oxygen.

(i) Complete the dot-and-cross diagram to show the electron arrangement of the ions in magnesium oxide.
    The inner shells have been drawn.
    Give the charges on the ions.

    

[3]

(ii) Write the chemical equation for the reaction that occurs when magnesium burns in oxygen.

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

(c) Magnesium oxide also forms when magnesium nitrate, Mg(NO₃)₂, is heated strongly. This is an endothermic reaction.

(i) Write the chemical equation for this reaction.

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

(ii) What type of reaction is this?

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

(iii) Name two other compounds of magnesium that form magnesium oxide when heated.

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

[Total: 14]
3 Sulfur dioxide, \( \text{SO}_2 \), is used in the manufacture of sulfuric acid.

(a) In the first stage of the process, sulfur dioxide is obtained from sulfur-containing ores.

Name one of these ores.

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

(b) The next stage of the process is a reaction which can reach equilibrium.

The equation for this stage is shown.

\[
2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})
\]

(i) Describe two features of an equilibrium.

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

(ii) Name the catalyst used in this stage.

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

(iii) Why is a catalyst used?

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

(iv) Explain, in terms of particles, why a high temperature increases the rate of this reaction.

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

(v) In this stage, only a moderate temperature of 450 °C is used.

What does this suggest about the forward reaction?

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

(vi) Calculate the percentage by mass of sulfur in sulfur trioxide, \( \text{SO}_3 \).

percentage = ..............................   [2]
(c) Concentrated sulfuric acid is a dehydrating agent which can chemically remove water from substances.

Both hydrated copper(II) sulfate crystals and sucrose (a sugar), \( \text{C}_{12}\text{H}_{22}\text{O}_{11} \), can be completely dehydrated by concentrated sulfuric acid.

Name the solid product formed in each case.

hydrated copper(II) sulfate crystals .................................................................
sucrose ................................................................................................................ [2]

(d) When propan-1-ol is heated with concentrated sulfuric acid as a catalyst an unsaturated hydrocarbon of relative molecular mass 42 is formed and one other product.

(i) What is meant by the term unsaturated?

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

(ii) Write the chemical equation for this reaction.

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

(iii) Name the unsaturated hydrocarbon formed.

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

[Total: 17]
4 This question is about reactions of bases and acids.

(a) Ammonia is a gas at room temperature.

What is the test for ammonia gas? Describe the positive result of this test.

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

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

(b) Ammonia reacts with water to form ions.

\[ \text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^- \]

(i) How does this equation show that ammonia, \( \text{NH}_3 \), behaves as a base?

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

(ii) Aqueous ammonia is described as a weak base.

Suggest the pH of aqueous ammonia.

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

(iii) Describe what is seen when aqueous ammonia is added to aqueous copper(II) sulfate, until no further change is seen.

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

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

............................................................................................................................................. [3]
(c) Aqueous sodium hydroxide, NaOH(aq), is a strong alkali that reacts with dilute sulfuric acid exothermically.

(i) What type of reaction is this?

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

(ii) Complete the equation for the reaction between aqueous sodium hydroxide and dilute sulfuric acid.

\[ 2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{......................} + \text{......................} \] [2]

(d) A student wanted to find the concentration of some dilute sulfuric acid by titration. The student found that 25.0 cm\(^3\) of 0.0400 mol/dm\(^3\) NaOH(aq) reacted exactly with 20.0 cm\(^3\) of H\(_2\)SO\(_4\)(aq).

(i) Name a suitable indicator to use in this titration.

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

(ii) Calculate the concentration of the H\(_2\)SO\(_4\)(aq) in mol/dm\(^3\) using the following steps.

- Calculate the number of moles of NaOH in 25.0 cm\(^3\).

\[ \text{moles} = \text{.........................} \]

- Deduce the number of moles of H\(_2\)SO\(_4\) that reacted with the 25.0 cm\(^3\) of NaOH(aq).

\[ \text{moles} = \text{.........................} \]

- Calculate the concentration of H\(_2\)SO\(_4\)(aq) in mol/dm\(^3\).

\[ \text{concentration} = \text{......................... mol/dm}^3 \] [3]

(iii) Calculate the concentration of the 0.0400 mol/dm\(^3\) NaOH(aq) in g/dm\(^3\).

\[ \text{concentration} = \text{......................... g/dm}^3 \] [2]

[Total: 16]
5 Ethanol is manufactured by two different processes.

(a) For each process, name the organic reactant and state the type of reaction.

<table>
<thead>
<tr>
<th>Organic Reactant</th>
<th>Type of Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

(b) Alcohols can be oxidised to form carboxylic acids.

Name a suitable oxidising agent for this reaction.

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

(c) Alcohols can be partially oxidised to form aldehydes.

Aldehydes are a homologous series of organic compounds.

Partial oxidation is achieved by reacting an alcohol with the oxidising agent in distillation apparatus as shown.

(i) Name apparatus A.

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

(ii) On the diagram, use one arrow to show where water enters apparatus A.   [1]
(d) The table shows some information about aldehydes.

(i) Complete the table.

<table>
<thead>
<tr>
<th>name</th>
<th>ethanal</th>
<th>propanal</th>
<th>butanal</th>
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</thead>
<tbody>
<tr>
<td>molecular formula</td>
<td>CH₂O</td>
<td>C₂H₄O</td>
<td>C₃H₆O</td>
</tr>
</tbody>
</table>

(ii) Deduce the general formula of aldehydes.

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

(e) The structural formula of ethanal is shown.

The C=O group in aldehydes is at the end of the carbon chain. This is a reactive part of the molecule.

(i) What is the name given to the reactive part of any organic molecule?

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

(ii) Complete the dot-and-cross diagram to show the electron arrangement of a molecule of ethanal. Inner shells have been drawn.

....................................................................................................................................... [3]
(f) Propanone belongs to a homologous series called ketones. Ketones have the same C=O group as aldehydes but the C=O group is not at the end of the carbon chain. Propanone has the same molecular formula as propanal, $\text{C}_3\text{H}_6\text{O}$.

(i) What term is used to describe molecules with different structures but with the same molecular formula?

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

(ii) Suggest the structure of propanone, $\text{C}_3\text{H}_6\text{O}$. Show all of the atoms and all of the bonds.

[2]

[Total: 17]
The Periodic Table of Elements

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
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<td>Bh</td>
<td>Hs</td>
</tr>
</tbody>
</table>

Key
- **atomic number**
- **atomic symbol**
- **name**
- **relative atomic mass**

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