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 12. 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.
1 Substances can be classified as elements, compounds or mixtures.

(a) What is meant by the term *compound*?

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

(b) Mixtures can be separated by physical processes.

A sequence of physical processes can be used to separate common salt (sodium chloride) from a mixture containing sand and common salt only.

Give the order and the correct scientific term for the physical processes used to separate the common salt from the mixture.

1 .................................................................
2 .................................................................
3 ................................................................. [4]

The boiling points of four different alcohols, A, B, C and D, are shown.

<table>
<thead>
<tr>
<th>alcohol</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>boiling point/°C</td>
<td>56</td>
<td>78</td>
<td>122</td>
<td>160</td>
</tr>
</tbody>
</table>

(c) A student suggested that the apparatus shown could be used to separate the mixture of alcohols.
(i) Apparatus X needs to have cold water flowing through it.
   - Draw an arrow on the diagram to show where the cold water enters apparatus X.
   - Name apparatus X.

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

(ii) Part of the fractionating column is missing. This means that the experiment will not work.
   - Draw on the diagram the part of the fractionating column which is missing.
   - Explain why the experiment will not work with this part of the fractionating column missing.

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

(iii) Suggest why a Bunsen burner is not used to heat the flask.

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

(iv) A hot water bath cannot be used to separate alcohols C and D.
   Explain why.

............................................................................................................................................. ............................................................................................................................................. [2] [Total: 13]
Flerovium, Fl, atomic number 114, was first made in research laboratories in 1998.

(a) Flerovium was made by bombarding atoms of plutonium, Pu, atomic number 94, with atoms of element Z.

- The nucleus of one atom of plutonium combined with the nucleus of one atom of element Z.
- This formed the nucleus of one atom of flerovium.

Suggest the identity of element Z.

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

(b) In which period of the Periodic Table is flerovium?

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

(c) Predict the number of outer shell electrons in an atom of flerovium.

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

(d) Two isotopes of flerovium are $^{286}$Fl and $^{289}$Fl. The nuclei of both of these isotopes are unstable and emit energy when they split up.

(i) State the term used to describe isotopes with unstable nuclei.

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

(ii) Complete the table to show the number of protons, neutrons and electrons in the atoms of the isotopes shown.

<table>
<thead>
<tr>
<th>isotope</th>
<th>number of protons</th>
<th>number of neutrons</th>
<th>number of electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{286}$Fl</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{289}$Fl</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[2]

(e) Only a relatively small number of atoms of flerovium have been made in the laboratory and the properties of flerovium have not yet been investigated.

It has been suggested that flerovium is a typical metal.

(i) Suggest two physical properties of flerovium.

1 .................................................................................................................................................. [2]

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

(ii) Suggest one chemical property of flerovium oxide.

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

[Total: 9]
This question is about iron.

(a) Three of the raw materials added to a blast furnace used to extract iron from hematite are coke, hematite and limestone.

Name one other raw material added to the blast furnace.

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

(b) A series of reactions occurs in a blast furnace during the extraction of iron from hematite.

Describe these reactions.
Include:
- one chemical equation for the reduction of hematite
- one chemical equation for the formation of slag.

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.................................................................................................................................................... [5]

(c) The iron extracted from hematite using a blast furnace is impure.

Identify the main impurity in this iron and explain how it is removed in the steel-making process.
main impurity ........................................................................................................................................
how it is removed ................................................................................................................................
............................................................................................................................................................
............................................................................................................................................................
............................................................................................................................................................ [3]

[Total: 9]
This question is about masses, volumes and moles.

(a) Which term is defined by the following statement?

*The average mass of naturally occurring atoms of an element on a scale where the $^{12}$C atom has a mass of exactly 12 units.*

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

(b) Butane, $C_4H_{10}$, has a relative **molecular** mass of 58.

Potassium fluoride, KF, has a relative **formula** mass of 58.

Explain why the term relative molecular mass can be used for butane but **cannot** be used for potassium fluoride.

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

(c) A 0.095 g sample of gaseous element Y occupies 60.0 cm$^3$ at room temperature and pressure.

- Determine the number of moles of element Y in 60.0 cm$^3$.

  moles of element Y = .................................. mol

- Calculate the relative molecular mass of element Y and hence suggest the identity of element Y.

  relative molecular mass = ..................................

  identity of element Y = .................................. [3]
(d) A 1.68 g sample of phosphorus was burned and formed 3.87 g of an oxide of phosphorus.

Calculate the empirical formula of this oxide of phosphorus.

empirical formula = .................................. [4]

(e) Another oxide of phosphorus has the empirical formula $P_2O_3$.
One molecule of this oxide of phosphorus contains four atoms of phosphorus.

Calculate the mass of one mole of this oxide of phosphorus.

mass = ........................................ g [2]

[Total: 12]
5  (a) The table gives some chemical properties of transition elements and their compounds, and of Group I elements and their compounds.

<table>
<thead>
<tr>
<th>chemical property</th>
<th>transition elements</th>
<th>Group I elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>ability to act as catalysts</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>exist as coloured compounds</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

(i) What is meant by the term catalyst?
............................................................................................................................................
............................................................................................................................................
............................................................................................................................................ [2]

(ii) Give one other chemical property shown by transition elements which is not shown by Group I elements.
............................................................................................................................................ [1]

(b) Give two physical properties shown by transition elements which are not shown by Group I elements.
1 ................................................................................................................................................ [2]
2 ................................................................................................................................................

(c) The energy level diagram shows the energy profile for the reaction between zinc and dilute sulfuric acid.

(i) Complete the diagram by adding the formulae of the products. Include state symbols. [3]

(ii) Draw an arrow on the diagram to represent the activation energy. [1]

(iii) Is the reaction endothermic or exothermic? Explain your answer.
............................................................................................................................................ [1]
(d) The reaction between zinc and dilute sulfuric acid can be catalysed by the addition of aqueous copper(II) sulfate.

On the diagram, add the energy profile for the catalysed reaction.

![Energy profile diagram](image)

(e) A student electrolyses aqueous copper(II) sulfate using the apparatus shown.

![Apparatus diagram](image)

Oxygen gas forms at the positive electrode (anode).

(i) Write an ionic half-equation for the reaction at the negative electrode (cathode). Include state symbols.

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

(ii) Describe what the student observes at the negative electrode.

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

(iii) Give two other observations which the student makes during the electrolysis.

1 ...........................................................................................................................................

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

(iv) What difference would the student observe at the positive electrode if the aqueous copper(II) sulfate were replaced by concentrated aqueous copper(II) chloride?

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

[Total: 18]
6 The table shows the structures of four hydrocarbons.

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>Q</th>
<th>R</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CH₃–CH₃</td>
<td>CH₂=CH₂</td>
<td>CH₂=CH–CH₃</td>
<td>CH₂=CH–CH₂–CH₃</td>
</tr>
</tbody>
</table>

(a) Why are compounds P, Q, R and S known as hydrocarbons?
.............................................................................................................................................. [2]

(b) Compound P is saturated.
What is meant by the term saturated?
.............................................................................................................................................. [1]

(c) Compound P undergoes a substitution reaction with chlorine.
   (i) What is meant by the term substitution reaction?
.............................................................................................................................................. [1]
   (ii) State a condition required for this reaction to occur.
.............................................................................................................................................. [1]
   (iii) Write a chemical equation for this reaction.
.............................................................................................................................................. [2]

(d) Compound R undergoes an addition reaction with bromine.
   (i) Why is this reaction an addition reaction?
.............................................................................................................................................. [1]
   (ii) A compound containing bromine is formed in this reaction.
   Draw the structure of this compound. Show all of the atoms and all of the bonds.

.............................................................................................................................................. [1]
(e) Draw the structure of an unbranched isomer of compound S. Show all of the atoms and all of the bonds. Name this unbranched isomer of compound S.

structure

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

(f) Compound Q undergoes polymerisation.

(i) Name the polymer formed.

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

(ii) Complete the chemical equation to show the polymerisation of compound Q.

\[ n \text{CH}_2=\text{CH}_2 \rightarrow \]

[2]

(g) Amino acids undergo polymerisation to form proteins. Part of a protein molecule with the linkages missing is shown.

Draw the linkages on the diagram. Show all of the atoms and all of the bonds.

[2]

(h) The structure shows an ester.

\[ \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{C}=\text{O} \]
\[ \text{O}-\text{CH}_2-\text{CH}_3 \]

Write the word equation for a reaction which could be used to make this ester.

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

[Total: 19]
The Periodic Table of Elements

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>He</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ne</td>
</tr>
<tr>
<td>atomic number</td>
<td>atomic symbol</td>
<td>name</td>
<td>relative atomic mass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li 7</td>
<td>Be 4</td>
<td>B 5</td>
<td>C 6</td>
<td>N 7</td>
<td>O 8</td>
<td>F 9</td>
<td>Ne 10</td>
<td></td>
</tr>
<tr>
<td>Na 11</td>
<td>Mg 12</td>
<td>Al 13</td>
<td>Si 14</td>
<td>P 15</td>
<td>S 16</td>
<td>Cl 17</td>
<td>Ar 18</td>
<td></td>
</tr>
<tr>
<td>K 19</td>
<td>Ca 20</td>
<td>Sc 21</td>
<td>Ti 22</td>
<td>V 23</td>
<td>Cr 24</td>
<td>Mn 25</td>
<td>Fe 26</td>
<td>Co 27</td>
</tr>
<tr>
<td>Rb 37</td>
<td>Sr 38</td>
<td>Y 39</td>
<td>Zr 40</td>
<td>Nb 41</td>
<td>Mo 42</td>
<td>Tc 43</td>
<td>Ru 44</td>
<td>Rh 45</td>
</tr>
<tr>
<td>Cs 55</td>
<td>Ba 56</td>
<td>La 57</td>
<td>Ce 58</td>
<td>Pr 59</td>
<td>Nd 60</td>
<td>Pm 61</td>
<td>Sm 62</td>
<td>Eu 63</td>
</tr>
<tr>
<td>Fr 87</td>
<td>Ra 88</td>
<td>89–103 actinoids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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