READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and candidate number on the answer sheet in the spaces provided unless this has been done for you.

There are forty questions on this paper. Answer all questions.
For each question there are four possible answers A, B, C and D. Choose the one you consider correct and record your choice in soft pencil on the separate answer sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 20.
1  The experiment is set up as shown and left until there is no further change.

\[
\text{water} \quad \text{purple crystal of potassium manganate(VII)}
\]

What is observed?

A  a colourless layer below a purple layer
B  a colourless liquid with the purple crystal unchanged
C  a purple layer below a colourless layer
D  a uniformly purple solution

2  A student adds aqueous sodium hydroxide or aqueous ammonia to aqueous solutions of four different metal compounds.

Which solution contains Zn\(^{2+}\) ions?

<table>
<thead>
<tr>
<th>solution</th>
<th>add a few drops of NaOH(aq)</th>
<th>add excess NaOH(aq)</th>
<th>add a few drops of NH(_3)(aq)</th>
<th>add excess NH(_3)(aq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>ppt</td>
<td>ppt dissolves</td>
<td>ppt</td>
<td>ppt dissolves</td>
</tr>
<tr>
<td>B</td>
<td>ppt</td>
<td>ppt dissolves</td>
<td>ppt</td>
<td>ppt</td>
</tr>
<tr>
<td>C</td>
<td>ppt</td>
<td>ppt</td>
<td>no ppt</td>
<td>no ppt</td>
</tr>
<tr>
<td>D</td>
<td>no ppt</td>
<td>no ppt</td>
<td>no ppt</td>
<td>no ppt</td>
</tr>
</tbody>
</table>
A sample of a pure compound is heated until it is completely molten and the compound is then allowed to cool until it is completely solid again.

The graph shows how the temperature of the compound changes with time.

When are liquid and solid both present?

A  P to Q and R to S
B  P to Q
C  Q to R
D  R to S
4 A beaker of nitrogen is inverted over a porous pot containing carbon monoxide as shown. The water level does not change.

What is the reason for this?
A Both gases are diatomic.
B Nitrogen is an unreactive gas.
C The gas particles are too large to pass through the porous pot.
D The two gases have the same relative molecular mass.

5 Which statement about all the noble gases is correct?
A The number of protons in the atoms equals the number of neutrons.
B Their atoms each have a stable arrangement of electrons.
C Their atoms each have eight electrons in their outer shell.
D They exist as molecules containing two atoms.

6 A substance Q conducts electricity both when solid and molten.

What is Q?
A an alloy
B a hydrocarbon
C a metal oxide
D a salt
7 The diagrams show the structures of two forms of carbon.

![Diagram of carbon structures]

Which set of data is correct for these two structures?

<table>
<thead>
<tr>
<th></th>
<th>conducts electricity</th>
<th>very hard material</th>
<th>can be used as lubricant</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>T</td>
<td>T</td>
<td>S</td>
</tr>
<tr>
<td>B</td>
<td>S</td>
<td>T</td>
<td>S</td>
</tr>
<tr>
<td>C</td>
<td>S</td>
<td>S</td>
<td>T</td>
</tr>
<tr>
<td>D</td>
<td>T</td>
<td>S</td>
<td>T</td>
</tr>
</tbody>
</table>

8 Substance X has a melting point higher than 500 °C. It is insoluble both in water and in organic solvents. It conducts electricity when both solid and molten.

What is X?

A copper
B mercury
C poly(ethene)
D sodium chloride

9 How many moles per dm³ of gaseous carbon dioxide are there if 4.4 g occupies 500 cm³?

A 0.1 mol/dm³   B 0.2 mol/dm³   C 2.2 mol/dm³   D 8.8 mol/dm³

10 Which reactions take place during the electrolysis of aqueous copper(II) sulphate with copper electrodes?

<table>
<thead>
<tr>
<th></th>
<th>reaction at positive electrode</th>
<th>reaction at negative electrode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Cu²⁺ + 2e⁻ → Cu</td>
<td>Cu → Cu²⁺ + 2e⁻</td>
</tr>
<tr>
<td>B</td>
<td>4OH⁻ → 2H₂O + O₂ + 4e⁻</td>
<td>Cu²⁺ + 2e⁻ → Cu</td>
</tr>
<tr>
<td>C</td>
<td>Cu → Cu²⁺ + 2e⁻</td>
<td>2H⁺ + 2e⁻ → H₂</td>
</tr>
<tr>
<td>D</td>
<td>Cu → Cu²⁺ + 2e⁻</td>
<td>Cu²⁺ + 2e⁻ → Cu</td>
</tr>
</tbody>
</table>
The heat-reflecting shields of some space rockets are gold-plated, using electrolysis.

Which electrodes and electrolyte would be used to gold-plate the heat shield?

<table>
<thead>
<tr>
<th></th>
<th>negative electrode</th>
<th>positive electrode</th>
<th>electrolyte</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>carbon</td>
<td>heat shield</td>
<td>gold compound</td>
</tr>
<tr>
<td>B</td>
<td>gold</td>
<td>heat shield</td>
<td>copper compound</td>
</tr>
<tr>
<td>C</td>
<td>heat shield</td>
<td>carbon</td>
<td>copper compound</td>
</tr>
<tr>
<td>D</td>
<td>heat shield</td>
<td>gold</td>
<td>gold compound</td>
</tr>
</tbody>
</table>

The reaction \( \text{C}_2\text{H}_4 + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 2\text{H}_2\text{O} \) is exothermic because

A more bonds are broken than are formed.

B more bonds are formed than are broken.

C the energy needed to break the bonds is greater than that released on forming new bonds.

D the energy needed to break the bonds is less than that released on forming new bonds.
13 Which reaction profile shows the fastest exothermic reaction?
In two separate experiments, a substance is decomposed and the gas evolved is collected. The graph shows the total volume of gas collected against time for each experiment.

Which graph shows how the speed of reaction varies with time in each experiment?

A colourless gas is passed into each of three different solutions. The results are shown in the table.

<table>
<thead>
<tr>
<th>solution of</th>
<th>potassium iodide</th>
<th>acidified potassium dichromate(VI)</th>
<th>acidified potassium manganate(VII)</th>
</tr>
</thead>
<tbody>
<tr>
<td>result</td>
<td>stays colourless</td>
<td>orange to green</td>
<td>purple to colourless</td>
</tr>
</tbody>
</table>

What is the colourless gas?

A an acid
B an alkali
C an oxidising agent
D a reducing agent
Chlorine can be manufactured by using the reversible reaction between hydrogen chloride and oxygen.

\[4 \text{HCl}(g) + \text{O}_2(g) \rightleftharpoons 2 \text{H}_2\text{O}(g) + 2 \text{Cl}_2(g)\] \(\Delta H\) is negative

A mixture in dynamic equilibrium is present at 450°C.

Which change to the mixture will increase the amount of chlorine at equilibrium?

A adding a catalyst
B adding more HCl(g)
C decreasing the pressure
D increasing the temperature

Which pair of substances produce a precipitate when their aqueous solutions are mixed?

A sodium chloride and barium nitrate
B sodium nitrate and barium chloride
C sodium nitrate and silver nitrate
D sodium sulphate and barium chloride

Which statement about catalysts is correct?

A Catalysts are used in industry to reduce energy costs.
B Catalysts are used up during a reaction.
C Iron is used as a catalyst in the Contact Process.
D Transition metals do not make good catalysts.

Element X is a solid at room temperature.

It needs one electron per atom to gain the electronic structure of a noble gas.

It is the least reactive element in its group.

What is the element X?

A At B Cs C F D Li
20 Elements \( X \) and \( Y \) are in Group VII of the Periodic Table.

\( X \) is a liquid at room temperature. \( Y \) is a solid at room temperature.

1. Atoms of \( Y \) have more protons than atoms of \( X \).
2. Molecules of \( Y \) have more atoms than molecules of \( X \).
3. \( Y \) displaces \( X \) from aqueous solutions of \( X^- \) ions.

Which statements are correct?

A 1 only
B 2 only
C 3 only
D 1, 2 and 3

21 Metal \( M \) will displace copper from aqueous copper(II) sulphate solution, but will not displace iron from aqueous iron(II) sulphate solution. \( M \) is extracted from its oxide by heating the oxide with carbon.

What is the order of reactivity of these four metals?

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>sodium</td>
<td>metal ( M )</td>
<td>iron</td>
<td>copper</td>
</tr>
<tr>
<td>sodium</td>
<td>iron</td>
<td>metal ( M )</td>
<td>copper</td>
</tr>
<tr>
<td>copper</td>
<td>iron</td>
<td>metal ( M )</td>
<td>sodium</td>
</tr>
<tr>
<td>copper</td>
<td>metal ( M )</td>
<td>iron</td>
<td>sodium</td>
</tr>
</tbody>
</table>
22 The diagram shows the electrolytic production of aluminium.

![Diagram of electrolytic production of aluminium]

What is the physical state of the aluminium oxide and aluminium during this process?

<table>
<thead>
<tr>
<th></th>
<th>aluminium oxide</th>
<th>aluminium</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>liquid</td>
<td>liquid</td>
</tr>
<tr>
<td>B</td>
<td>liquid</td>
<td>solid</td>
</tr>
<tr>
<td>C</td>
<td>solid</td>
<td>liquid</td>
</tr>
<tr>
<td>D</td>
<td>solid</td>
<td>solid</td>
</tr>
</tbody>
</table>

23 Aluminium is used to make saucepans because of its apparent lack of reactivity.

Which property of aluminium explains its unreactivity?

A It has a high electrical conductivity.
B It has a low density.
C It has a surface layer of oxide.
D It is in Group III of the Periodic Table.

24 Alloys are usually harder than the metals from which they are made.

Which difference between the metals explains the greater hardness of alloys?

A atomic radii
B densities
C electrical conductivities
D relative atomic masses
25 Which gas **cannot** be removed from the exhaust gases of a petrol powered car by its catalytic converter?

A carbon dioxide  
B carbon monoxide  
C hydrocarbons  
D nitrogen dioxide

26 Which gas, present in pond water, decreases in concentration during eutrophication?

A carbon dioxide  
B methane  
C nitrogen  
D oxygen

27 The results of tests carried out on compound X are shown.

<table>
<thead>
<tr>
<th>test</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>dilute hydrochloric acid added</td>
<td>gas given off which turned limewater cloudy</td>
</tr>
<tr>
<td>warm with aqueous sodium hydroxide</td>
<td>gas evolved which turned red litmus blue</td>
</tr>
</tbody>
</table>

What is compound X?

A ammonium carbonate  
B ammonium nitrate  
C calcium carbonate  
D calcium nitrate

28 Aluminium sulphate can be obtained as shown in the equation.

$$2Al(OH)_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 6H_2O$$

How many moles of sulphuric acid are needed to produce 0.5 mol of aluminium sulphate?

A 0.5  
B 1.0  
C 1.5  
D 3.0
29 Ammonium sulphate is an important fertiliser. During which stage in the manufacture of ammonium sulphate does a reaction with water occur?

- sulphur (stage A)
- sulphur dioxide (stage B)
- sulphur trioxide (stage C)
- sulphuric acid (stage D)
- ammonium sulphate

30 The diagram shows the colours of the indicators, methyl orange and methyl red, at different pH values.

<table>
<thead>
<tr>
<th>pH</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>colour of methyl orange</td>
<td>red</td>
<td></td>
<td>yellow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>colour of methyl red</td>
<td>red</td>
<td></td>
<td>yellow</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table shows the pH of four solutions.

<table>
<thead>
<tr>
<th>solution</th>
<th>W</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

In which solutions will both indicators be yellow?

- A W and X
- B X and Y
- C Y and Z
- D Z only

31 The diagram shows some of the stages in the manufacture of ammonium sulphate.

From which connecting pipe would a major leak most increase the pH value of rain?

- nitrogen and hydrogen (pipe A)
- reaction vessel
- ammonia (pipe B)
- reaction vessel
- ammonium sulphate (pipe C)
- SO₂ + O₂ (pipe D)
32 Which graph shows the changes in pH as an excess of hydrochloric acid is added to aqueous sodium hydroxide?

A

B

C

D

33 Two tests are carried out on a solution of compound X.

<table>
<thead>
<tr>
<th>test</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>add nitric acid followed by aqueous silver nitrate</td>
<td>white precipitate formed</td>
</tr>
<tr>
<td>excess aqueous sodium hydroxide added</td>
<td>white precipitate formed that does not re-dissolve</td>
</tr>
</tbody>
</table>

What is compound X?

A aluminium chloride
B aluminium sulphate
C calcium chloride
D calcium sulphate
34 Which property of the alkanes does **not** increase as relative molecular mass increases?

A. boiling point  
B. flammability  
C. melting point  
D. viscosity

35 What is the structure of the product of the reaction between butene, \( \text{CH}_3-\text{CH}_2-\text{CH}=\text{CH}_2 \), and bromine, \( \text{Br}_2 \)?

A. \( \text{CH}_2\text{Br}-\text{CH}_2-\text{CH}_2-\text{CH}_2\text{Br} \)  
B. \( \text{CH}_2\text{Br}-\text{CH}_2-\text{CHBr}-\text{CH}_3 \)  
C. \( \text{CH}_3-\text{CHBr}-\text{CH}_2-\text{CH}_2\text{Br} \)  
D. \( \text{CH}_3-\text{CH}_2-\text{CHBr}-\text{CH}_2\text{Br} \)

36 Which formula represents a compound that will react with sodium carbonate to give off carbon dioxide?

A. \( \text{CH}_3\text{OH} \)  
B. \( \text{HCO}_2\text{CH}_3 \)  
C. \( \text{CH}_3\text{CO}_2\text{H} \)  
D. \( \text{CH}_3\text{CO}_2\text{C}_2\text{H}_5 \)

37 The displayed formulae of two compounds are shown.

![Chemical structures]

What are the similarities and differences between the two compounds?

<table>
<thead>
<tr>
<th></th>
<th>similarities</th>
<th>differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>molecular formulae</td>
<td>reactions</td>
</tr>
<tr>
<td>B</td>
<td>molecular formulae</td>
<td>relative molecular masses</td>
</tr>
<tr>
<td>C</td>
<td>structures</td>
<td>molecular formulae</td>
</tr>
<tr>
<td>D</td>
<td>structures</td>
<td>relative molecular masses</td>
</tr>
</tbody>
</table>
38 In which of the following are all the compounds members of the same homologous series?

A \( \text{CH}_4 \), \( \text{C}_2\text{H}_6 \), \( \text{C}_3\text{H}_8 \)
B \( \text{CH}_4 \), \( \text{C}_2\text{H}_6 \), \( \text{C}_3\text{H}_{10} \)
C \( \text{C}_2\text{H}_4 \), \( \text{C}_3\text{H}_6 \), \( \text{C}_4\text{H}_{10} \)
D \( \text{C}_3\text{H}_4 \), \( \text{C}_3\text{H}_6 \), \( \text{C}_3\text{H}_8 \)

39 Which polymer has the empirical formula \( \text{CH} \)?

A \[ \left( \begin{array}{c} \text{H} \\ \text{H} \\ \text{H} \\ \text{C} \\ \text{C} \\ \text{H} \\ \text{H} \\ \text{H} \\ \text{H} \end{array} \right)_n \]
B \[ \left( \begin{array}{c} \text{H} \\ \text{H} \\ \text{H} \\ \text{C} \\ \text{C} \\ \text{H} \\ \text{CH}_3 \\ \text{H} \\ \text{H} \end{array} \right)_n \]
C \[ \left( \begin{array}{c} \text{H} \\ \text{H} \\ \text{H} \\ \text{C} \\ \text{C} \\ \text{H} \\ \text{C}_2\text{H}_5 \end{array} \right)_n \]
D \[ \left( \begin{array}{c} \text{H} \\ \text{H} \\ \text{H} \\ \text{C} \\ \text{C} \\ \text{H} \\ \text{C}_6\text{H}_{15} \end{array} \right)_n \]

40 *Terylene* (a polyester) is made by condensation polymerisation of the two monomers shown.

\[ \text{HO} \overset{\text{O\ O\ O}}{\underset{\text{O\ O\ O}}{\text{C}}}-\text{CO-OH} \quad \text{and} \quad \text{HO} \overset{\text{O}}{\underset{\text{O}}{\text{C}}}\]

What is the repeat unit of the polymer?

A \[ \left( \begin{array}{c} \text{C} \\ \text{O} \\ \text{O} \end{array} \right)_n \]
B \[ \left( \begin{array}{c} \text{O} \\ \text{C} \end{array} \right)_n \]
C \[ \left( \begin{array}{c} \text{C} \\ \text{O} \\ \text{O} \end{array} \right)_n \]
D \[ \left( \begin{array}{c} \text{C} \\ \text{O} \end{array} \right)_n \]
DATA SHEET
The Periodic Table of the 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>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>1</td>
<td>Hydrogen</td>
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<td></td>
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<td>B</td>
<td>C</td>
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<td>F</td>
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<td>Cd</td>
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<td>Ac</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

*58-71 Lanthanoid series
90-103 Actinoid series

Key
- a = relative atomic mass
- X = atomic symbol
- b = proton (atomic number)

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