READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO NOT WRITE IN ANY BARCODES.

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 16.
Electronic calculators may be used.
1 A mixture of sand and sodium chloride can be separated in three steps. 
Step 1 is to add water to the mixture.
The diagram shows step 2 and step 3.
Where is pure sodium chloride collected?

2 The results of two tests on solution X are shown.

<table>
<thead>
<tr>
<th>reagent added</th>
<th>observation on adding a few drops of reagent</th>
<th>observation on adding an excess of reagent</th>
</tr>
</thead>
<tbody>
<tr>
<td>aqueous sodium hydroxide</td>
<td>white precipitate</td>
<td>precipitate dissolves</td>
</tr>
<tr>
<td>aqueous ammonia</td>
<td>white precipitate</td>
<td>precipitate remains</td>
</tr>
</tbody>
</table>

Which ion is present in solution X?
A \( \text{Al}^{3+} \)  B \( \text{Ca}^{2+} \)  C \( \text{Cu}^{2+} \)  D \( \text{Zn}^{2+} \)

3 Which diagram shows the arrangement of particles inside a balloon containing a mixture of the gases nitrogen and oxygen?

A  B  C  D

key
- nitrogen atom
- oxygen atom
A student follows the rate of the reaction between marble chips, CaCO$_3$, and dilute hydrochloric acid.

$$\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$$

Which diagrams show apparatus that is suitable for this experiment?

A 1 and 2 only  
B 1 and 3  
C 1 and 4 only  
D 1, 2 and 4
A chemist wishes to separate and identify a mixture of substances using paper chromatography. The diagram shows the apparatus used. The solvent is water.

The solvent front is allowed to reach the top of the paper before the chemist removes the paper from the solvent.

Which problem does this cause?

A This causes the spot nearest the bottom of the paper to catch up with the spot above it.
B This makes it impossible to calculate $R_f$ values.
C This makes it impossible to use a locating agent.
D This results in a safety hazard caused by solvent fumes.

Which particle contains the same number of both neutrons and electrons?

A $^{40}_{20}Ca^{2+}$  B $^{24}_{12}Mg^{2+}$  C $^{19}_{9}F^-$  D $^{32}_{16}S^{2-}$

Which statement is correct for all metals?

A They are hard and brittle.
B They are made up of a lattice of positive and negative ions.
C They conduct electricity by movement of electrons.
D They conduct electricity by movement of ions.
8 X represents the element of atomic number 8 and Y represents the element of atomic number 19.

The two elements react together to form a compound.

Which row is correct for the compound formed?

<table>
<thead>
<tr>
<th></th>
<th>formula</th>
<th>type of bonding</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Y₂X</td>
<td>covalent</td>
</tr>
<tr>
<td>B</td>
<td>Y₂X</td>
<td>ionic</td>
</tr>
<tr>
<td>C</td>
<td>X₂Y</td>
<td>covalent</td>
</tr>
<tr>
<td>D</td>
<td>X₂Y</td>
<td>ionic</td>
</tr>
</tbody>
</table>

9 The empirical formula of a liquid compound is C₂H₄O.

To find the empirical formula, it is necessary to know

A the density of the compound.
B the percentage composition by mass of the compound.
C the relative molecular mass of the compound.
D the volume occupied by 1 mole of the compound.

10 25.0 g of hydrated copper(II) sulfate crystals are heated to produce anhydrous copper(II) sulfate and water vapour.

\[ \text{CuSO}_4.5\text{H}_2\text{O(s)} \rightarrow \text{CuSO}_4(s) + 5\text{H}_2\text{O(g)} \]

What is the mass of anhydrous copper(II) sulfate formed?

\[ M_r: \text{CuSO}_4, 160; \text{H}_2\text{O}, 18 \]

A 9.0 g  B 16.0 g  C 22.5 g  D 25.0 g

11 Which sample contains the most atoms?

A 0.5 moles of water
B 1.0 moles of carbon dioxide
C 1.0 moles of methane
D 2.0 moles of hydrogen chloride

12 The relative atomic mass of chlorine is 35.5.

What is the mass of 2 moles of chlorine gas?

A 17.75 g  B 35.5 g  C 71 g  D 142 g
13 One mole of an organic compound, Q, is completely burnt in oxygen and produces exactly three moles of water.

Which compound is Q?
A butane, C₄H₁₀  
B ethanol, C₂H₅OH  
C propane, C₃H₈  
D propanol, C₃H₇OH

14 In an experiment, 1 mol of powdered copper and 1 mol of powdered zinc are placed in a flask. Dilute acid, containing 1 mol of acid, is added to the flask. The flask is left until all the reactions, if any, are complete.

Which diagram shows the result of the experiment?
A colourless neutral solution  
B blue neutral solution  
C blue neutral solution  
D colourless acidic solution
A simple cell can be made using two different metals as the electrodes and an aqueous solution as the electrolyte.

Which statements about simple cells are correct?

1. A greater voltage is produced using magnesium and silver than using magnesium and copper.
2. The electrolyte is an aqueous solution containing both positive and negative ions.
3. The more reactive metal will release electrons.

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

Magnesium can be produced by electrolysis of molten magnesium chloride, MgCl₂.

What are the equations for the reactions that occur at the positive electrode and at the negative electrode?

<table>
<thead>
<tr>
<th></th>
<th>positive electrode</th>
<th>negative electrode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2Cl⁻ → Cl₂ + 2e⁻</td>
<td>2H⁺ + 2e⁻ → H₂</td>
</tr>
<tr>
<td>B</td>
<td>Cl₂ + 2e⁻ → 2Cl⁻</td>
<td>Mg²⁺ + 2e⁻ → Mg</td>
</tr>
<tr>
<td>C</td>
<td>2Cl⁻ → Cl₂ + 2e⁻</td>
<td>Mg²⁺ + 2e⁻ → Mg</td>
</tr>
<tr>
<td>D</td>
<td>2Cl⁻ → Cl₂ + 2e⁻</td>
<td>Mg²⁺ + 2e⁻ → 2Mg</td>
</tr>
</tbody>
</table>

Three different solutions were electrolysed using inert electrodes.

solution 1  aqueous sodium chloride
solution 2  concentrated hydrochloric acid
solution 3  dilute sulfuric acid

Which solutions produce hydrogen at the negative electrode?

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

Compound Y reacts with oxygen. This reaction has a positive enthalpy change of reaction, ΔH.

What information can be deduced about Y and its reaction with oxygen?

A  Compound Y can be used as a fuel.
B  Compound Y could be a hydrocarbon.
C  In the reaction the energy needed to break bonds is greater than the energy released when bonds are made.
D  In the reaction the products are at a lower energy level than the reactants.
The formation of liquid water from hydrogen and oxygen may occur in three stages.

1. \[2\text{H}_2(g) + \text{O}_2(g) \rightarrow 4\text{H}(g) + 2\text{O}(g)\]
2. \[4\text{H}(g) + 2\text{O}(g) \rightarrow 2\text{H}_2\text{O}(g)\]
3. \[2\text{H}_2\text{O}(g) \rightarrow 2\text{H}_2\text{O}(l)\]

Which stages are endothermic?

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

Sulfur trioxide is produced by the following reaction.

\[2\text{SO}_2(g) + \text{O}_2(g) \rightarrow 2\text{SO}_3(g) \quad \Delta H = -195 \text{kJ}\]

Which change in conditions would produce a greater amount of \(\text{SO}_3\) at equilibrium?

A. adding a catalyst  
B. increasing the pressure  
C. increasing the temperature  
D. removing some \(\text{SO}_2\) and \(\text{O}_2\)
21 Magnesium reacts with dilute sulfuric acid.

\[ \text{Mg(s)} + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{MgSO}_4(\text{aq}) + \text{H}_2(\text{g}) \]

Two experiments were carried out.

experiment 1  24.0 g of magnesium was reacted with 100 cm\(^3\) of 1.0 mol/dm\(^3\) sulfuric acid.

experiment 2  24.0 g of magnesium was reacted with 50 cm\(^3\) of 2.0 mol/dm\(^3\) sulfuric acid.

In each experiment the volume of hydrogen was measured at various times. The results were plotted on a graph.

Which graph is correct?

![Graph options A, B, C, D with volume of hydrogen vs. time]

22 Which statement is correct for both aluminium and iron?

A  Both form 2+ ions.

B  Both have amphoteric oxides.

C  The manufacture of both metals involves the reduction of the metal ions.

D  They are both normally manufactured by electrolysis.
23 A household cleaning compound is used to remove calcium carbonate from bathroom surfaces. The compound reacts with the calcium carbonate to form a soluble salt, carbon dioxide and water.

What is the pH of this cleaning compound?
A pH 2  B pH 7  C pH 10  D pH 14

24 Dilute hydrochloric acid is added separately to samples of copper, copper(II) oxide and copper(II) carbonate.

Which row correctly shows whether copper(II) chloride is produced?

<table>
<thead>
<tr>
<th></th>
<th>Cu</th>
<th>CuO</th>
<th>CuCO₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>B</td>
<td>×</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>C</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
</tr>
<tr>
<td>D</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- ✓ = copper(II) chloride produced
- × = copper(II) chloride not produced

25 Which ions are present when hydrochloric acid has exactly neutralised aqueous sodium hydroxide?
A Na⁺, Cl⁻, H⁺ and OH⁻
B Na⁺, Cl⁻ and H⁺ only
C Na⁺ and Cl⁻ only
D H⁺ and OH⁻ only

26 Which experiment will result in the formation of a white precipitate?
A aqueous barium nitrate added to aqueous sodium chloride
B aqueous sodium carbonate added to aqueous calcium chloride
C carbon dioxide passed through aqueous potassium chloride
D dilute hydrochloric acid added to aqueous ammonia

27 Which statement about both the Group I and Group VII elements is correct?
A They conduct electricity when molten.
B They form covalent compounds when bonded to non-metals.
C They exist as diatomic molecules.
D When Group I elements combine with Group VII elements, ionic compounds form.
28 The elements helium, argon and neon are noble gases.

Which statement is correct?

A All these elements have eight electrons in their outer shell.
B Argon is used to react with impurities in the manufacture of steel.
C Helium is used in balloons as it is more dense than air.
D Neon is used in light bulbs to give an inert atmosphere.

29 Which row shows the correct catalyst for each industrial process?

<table>
<thead>
<tr>
<th></th>
<th>manufacture of sulfuric acid</th>
<th>manufacture of ammonia</th>
<th>manufacture of margarine</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>nickel</td>
<td>iron</td>
<td>vanadium(V) oxide</td>
</tr>
<tr>
<td>B</td>
<td>nickel</td>
<td>vanadium(V) oxide</td>
<td>iron</td>
</tr>
<tr>
<td>C</td>
<td>vanadium(V) oxide</td>
<td>iron</td>
<td>nickel</td>
</tr>
<tr>
<td>D</td>
<td>vanadium(V) oxide</td>
<td>nickel</td>
<td>iron</td>
</tr>
</tbody>
</table>

30 In the solid state, germanium has the same structure as diamond.

What is the likely melting point of germanium?

A above 800 °C
B between 100 °C and 800 °C
C 100 °C
D below 100 °C

31 Aluminium is a metal that is often used to make caps for bottles. When thrown away and buried in the soil, the caps do not corrode.

Why is this?

A Aluminium does not react with acids.
B Aluminium does not react with alkalis.
C Aluminium is alloyed with other metals.
D Aluminium is protected by a layer of oxide.
32 Which statement about Group I metals is correct?
   A They are hard compared with most other metals.
   B They form coloured compounds.
   C They have high densities compared with most other metals.
   D They only form ions with a charge of $+1$.

33 CFC compounds were used as aerosol propellants. The structure of one CFC compound is shown.

\[ \text{F} \text{CF} \text{C} \text{H} \text{Cl} \text{F} \]

Which element in this compound causes a depletion of ozone in the atmosphere?
   A carbon
   B chlorine
   C fluorine
   D hydrogen

34 Dry air is a mixture of gases of which 99% is nitrogen and oxygen.

What is the main constituent of the remaining 1%?
   A argon
   B helium
   C hydrogen
   D water vapour

35 Why is chlorine added to the water supply?
   A Chlorine is used to desalinate the water.
   B Chlorine kills bacteria that may be present in the water.
   C Chlorine precipitates solids that may be present in the water.
   D Chlorine removes tastes and odours from the water.
36 When the alcohol of molecular formula $\text{C}_4\text{H}_{10}\text{O}$ is oxidised, what is the molecular formula of the acid formed?

A $\text{C}_4\text{H}_{12}\text{O}_2$  B $\text{C}_4\text{H}_{10}\text{O}_2$  C $\text{C}_4\text{H}_8\text{O}_2$  D $\text{C}_4\text{H}_6\text{O}_2$

37 The diagrams show the structures of five hydrocarbons.

[Diagrams of hydrocarbons 1 to 5]

Which three hydrocarbons are isomers of each other?

A 1, 2 and 4  B 2, 3 and 5  C 2, 3 and 4  D 3, 4 and 5

38 Which alcohol and acid will react together to make the ester $\text{CH}_3\text{COOC}_2\text{H}_5$?

A $\text{CH}_3\text{OH}$ and $\text{CH}_3\text{COOH}$

B $\text{CH}_3\text{OH}$ and $\text{C}_2\text{H}_5\text{COOH}$

C $\text{C}_2\text{H}_5\text{OH}$ and $\text{CH}_3\text{COOH}$

D $\text{C}_2\text{H}_5\text{OH}$ and $\text{C}_2\text{H}_5\text{COOH}$
39 Which compound has a pH of less than 7 in aqueous solution?

A \[ \text{HOOC-CH-H} \]

B \[ \text{H-CO-CH-H} \]

C \[ \text{HO-C-OH} \]

D \[ \text{H-C-CO-C-CH-H} \]

40 Which statement about polymers is correct?

A Nylon and Terylene are produced by addition polymerisation.

B Nylon and Terylene both contain the amide linkage.

C Simple sugars can be produced by hydrolysing proteins.

D Starch contains the elements carbon, hydrogen and oxygen.
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>
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<tbody>
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</tr>
<tr>
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<tr>
<td>3</td>
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<td>B</td>
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<td>Sg</td>
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<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 dm$^3$ at room temperature and pressure (r.t.p.).