Name: ..... ( ) Class: .....

MONTFORT SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2025

Secondary 4 Express

CHEMISTRY
Paper 1

6092/01
29 Aug 2025 (Fri)
1 hour

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, glue or correction fluid.

There are **forty** questions in this section. 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.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **20** printed pages.

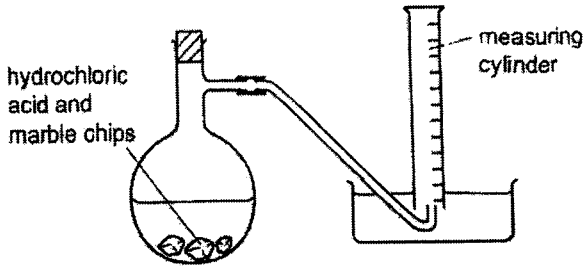
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1 A student wants to carry out an experiment to follow the rate of the reaction between hydrochloric acid and marble chips.

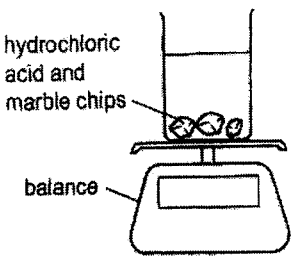
$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

Which diagrams show apparatus that is suitable for this experiment?

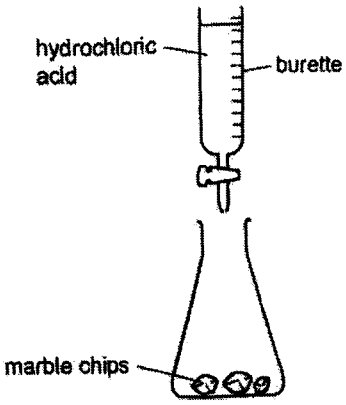
1



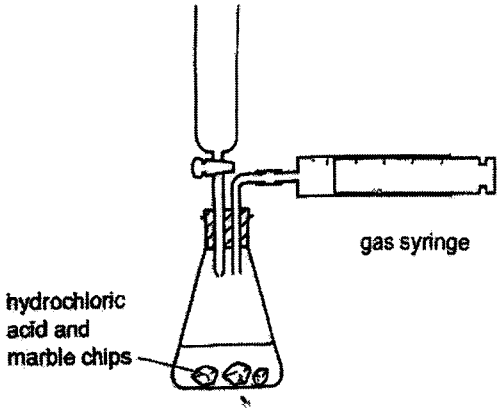
2



3



4



A 1 and 2 only

B 1 and 3 only

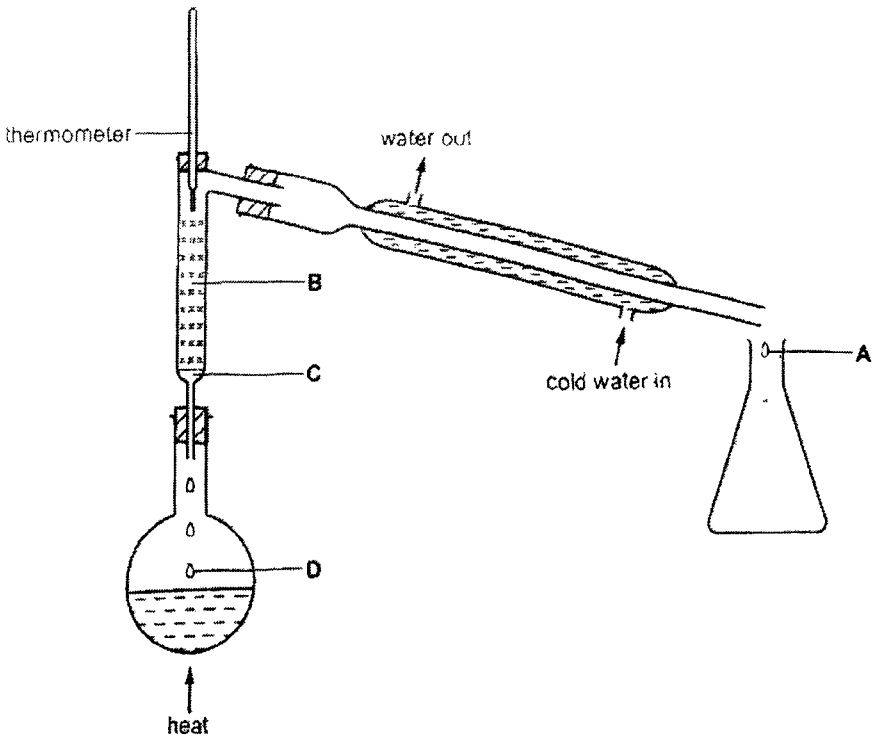
C 1 and 4 only

D 1, 2 and 4

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2 A mixture containing equal volumes of two liquids that mix completely but do not react together is placed in the apparatus shown and heated until the thermometer first shows a steady reading.

At which position will there be the highest proportion of the liquid with the higher boiling point?



3 In which pair of particles is:

- the sum of their charges equal to zero
- the sum of their masses almost the same as $\frac{1}{12}$ of the mass of an atom of ^{12}C?

A one electron and one neutron

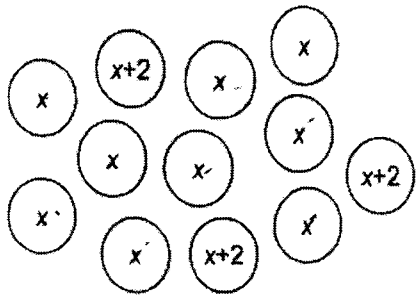
B one electron and one proton

C one neutron and one proton

D two neutrons

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4 An element has two isotopes of relative isotopic masses x and $x+2$. The diagram shows the composition of atoms in a sample of the element.



What is the relative atomic mass of this element?

A $x + 0.5$
B $x + 1.0$
C $x + 1.5$
D $x + 2.0$

5 X and Y are both elements, one of which is a non-metal.

1 mole of X is added to 1 mole of Y and they are heated together.

X and Y react completely to form substance Z.

Substance Z cannot be easily separated to form X and Y.

Three statements are given.

1 Y must be the non-metal.
2 X and Y formed a compound on heating.
3 Substance Z has the empirical formula XY.

Which statements are correct?

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

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6 Which molecule has only four electrons involved in covalent bonds?

A
B
C
D

A. Cl2
B. CO2
C. H2S
D. N2

7 The melting points and boiling points of four compounds, W, X, Y and Z, are given in the table.

	melting point /°C	boiling point /°C
W	63	354
X	–7	59
Y	1728	2230
Z	–183	–89

The four compounds are silicon(IV) oxide, ethane, bromine and a carboxylic acid of formula $C_{16}H_{32}O_2$.

Which row identifies W, X, Y and Z?

	silicon(IV) oxide	ethane	bromine	carboxylic acid $C_{16}H_{32}O_2$
A	W	X	Z	Y
B	W	Y	Z	X
C	Y	Z	W	X
D	Y	Z	X	W

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8 The formula of ammonium metavanadate is NH_4VO_3. It consists of NH_4 ions and VO_3 ions.

What are the charges on these ions?

	NH_4 ion	VO_3 ion
A	1+	1–
B	2+	2–
C	3+	3–
D	4+	4–

9 When a strip of copper is placed in aqueous silver nitrate, a displacement reaction takes place.

What is the ionic equation for the reaction which takes place?

A $Ag^+(aq) + Cu(s) \rightarrow Ag(s) + Cu^{2+}(aq) + e^-$

B $2Ag^+(aq) + Cu(s) \rightarrow 2Ag(s) + Cu^{2+}(aq)$

C $2AgNO_3(aq) + Cu(s) \rightarrow 2Ag(s) + Cu(NO_3)_2(aq)$

D $2Ag(s) + Cu^{2+}(aq) \rightarrow 2Ag^+(aq) + Cu(s)$

10 Which statement is correct?

A If the relative formula mass of hydrated sodium carbonate, $Na_2CO_3 \cdot xH_2O$, is 286, then x is 10.

B Phosphoric(V) acid, H_3PO_4, has a relative molecular mass of 50.

C The relative atomic mass of a sample of an element with isotopes of masses 20 and 22 can only be equal to 21.

D The relative atomic mass of an element is the average mass of atoms of isotopes of the element compared with the mass of a hydrogen atom.

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11 Two aqueous solutions, Q and R, have the same concentration in mol / dm^3 .

Solution Q contains 4.0 g of NaOH in 500 cm^3 of solution.

Which solution could be solution R?

[A_r: Na, 23; O, 16; H, 1]

A 0.2 mol of $Ca(OH)_2$ in 250 cm^3 of solution

B 0.2 mol of HCl in 100 cm^3 of solution

C 0.05 mol of H_2SO_4 in 250 cm^3 of solution

D 0.1 mol of KOH in 1000 cm^3 of solution

12 The equation for the reaction between magnesium and dilute hydrochloric acid is shown.

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

Which mass of magnesium chloride is formed when 48.0 g of magnesium completely reacts with excess dilute hydrochloric acid?

A 23.8 g

B 47.5 g

C 95.0 g

D 190 g

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13 Three compounds are listed.

copper(II) nitrate, $Cu(NO_3)_2$

zinc sulfate, $ZnSO_4$

sodium thiosulfate, $Na_2S_2O_3$

Which row shows the element that is present in the greatest percentage by mass in each compound?

[relative formula masses, M_r: $Cu(NO_3)_2$, 188; $ZnSO_4$, 161; $Na_2S_2O_3$, 158]

	copper(II) nitrate	zinc sulfate	sodium thiosulfate
A	copper	oxygen	oxygen
B	copper	oxygen	sulfur
C	oxygen	zinc	sodium
D	oxygen	zinc	sulfur

14 Samples of two hydrated compounds are weighed and then dehydrated by heating.

The anhydrous compounds are weighed and the results are shown.

3.97 g $FeSO_4 \cdot xH_2O$ gives 2.17 g anhydrous $FeSO_4$.

2.88 g $CaSO_4 \cdot yH_2O$ gives 2.27 g anhydrous $CaSO_4$.

What are the values of x and y?

[M_r: $FeSO_4$, 152; $CaSO_4$, 136; H_2O, 18]

	x	y
A	5	2
B	5	5
C	7	5
D	7	2

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15 Aqueous copper(II) sulfate is electrolysed with copper electrodes.

What is the equation for the reaction occurring at the anode?

A $Cu \rightarrow Cu^{2+} + 2e^-$

B $Cu^{2+} + 2e^- \rightarrow Cu$

C $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

D $2SO_4^{2-} + 2H_2O \rightarrow 2H_2SO_4 + O_2 + 4e^-$

16 Three statements about fuel cells are given.

1 A hydrogen-oxygen fuel cell requires a continuous input of fuel and oxygen.
2 In a hydrogen-oxygen fuel cell, hydrogen is burned in oxygen to produce electricity.
3 When a hydrogen-oxygen fuel cell is operating, water is the only chemical product.

Which statements are correct?

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

17 Which statements about the energy changes during a chemical reaction are correct?

1 The activation energy, Ea, is the maximum energy the colliding particles must have in order to react.
2 During an endothermic reaction, thermal energy is taken in from the surroundings leading to a decrease in the temperature of the surroundings.
3 The making of chemical bonds is an exothermic process.

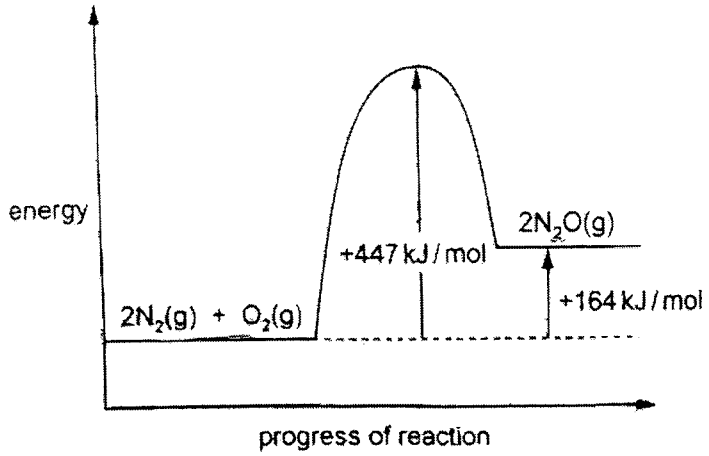
A 1, 2 and 3
B 1 and 2 only
C 1 and 3 only
D 2 and 3 only

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18 Under certain conditions, nitrogen reacts with oxygen to form N_2O.

$$2N_2(g) + O_2(g) \rightarrow 2N_2O(g)$$

The reaction pathway diagram is shown.



What is the activation energy of the reverse reaction?

A – 447kJ / mol

B – 283 kJ /mol

C + 141.5 kJ /mol

D + 283 kJ / mol

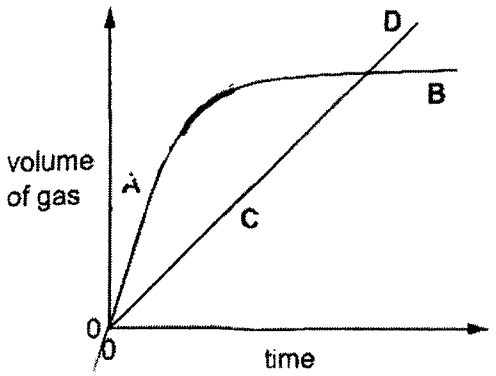
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19 Two reactions each produce a gaseous product.

The reactions are performed separately using the same conditions of temperature and pressure.

The volume of gas formed in each experiment is measured over time and the results are plotted in the graph shown.

At which point is the rate of production of gas the greatest?



20 Copper forms a red oxide, Cu_2O, and a black oxide, [illegible]

In the presence of a catalyst, aqueous hydrogen peroxide, H_2O_2, decomposes to form water.

The black oxide has copper in a .....1..... oxidation state than in the red oxide.

In forming water, hydrogen peroxide is .....2..... .

Which words correctly complete gaps 1 and 2?

	1	2
A	higher	reduced
B	higher	oxidised
C	lower	reduced
D	lower	oxidised

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21 Universal indicator contains several dyes. The reversible reaction of one dye, IndOH, is shown.

$$\underset{\text{colour X}}{\text{IndOH(aq)}} + \text{H}^+\text{(aq)} \leftrightarrow \underset{\text{colour Y}}{\text{Ind}^+\text{(aq)}} + \text{H}_2\text{O}(l)$$

A few drops of Universal indicator solution are added to 50 cm^3 of water.

A few drops of dilute hydrochloric acid are added to the solution.

Which row describes what happens when the acid is added?

	pH	colour of solution shifts towards
A	decreases	colour X
B	decreases	colour Y
C	increases	colour X
D	increases	colour Y

22 Samples of HC*l* (aq) and HNO_3 (aq) are tested using Universal indicator paper.

The sample of HC*l* (aq) has a pH of 4 and the sample of HNO_3 (aq) has a pH of 2.

Which statement is correct?

A HC*l* (aq) is a weak acid and HNO_3 (aq) is a strong acid.

B HNO_3 (aq) has a lower formula mass than HC*l* (aq).

C The HNO_3 (aq) is more concentrated than the HC*l* (aq).

D The HC*l* (aq) has dissociated more than the HNO_3 (aq).

23 Which statement about oxides is correct?

A All acidic oxides are gases at room temperature.

B All basic oxides dissolve in water to give alkalis.

C Amphoteric oxides react with acids, alkalis and water.

D Potassium oxide is a basic oxide.

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24 A student is provided with suitable apparatus, distilled water and the following reagents.

solid magnesium hydroxide solid lead carbonate dilute nitric acid

aqueous sodium chloride aqueous sodium sulfate

Which salts can the student prepare as a pure dry sample?

A lead nitrate, magnesium nitrate, lead chloride, lead sulfate and magnesium sulfate
B lead nitrate, magnesium nitrate, lead chloride and lead sulfate only
C lead nitrate, magnesium nitrate and lead chloride only
D lead nitrate and magnesium nitrate only

25 One mole of compound X gives two moles of ions in aqueous solution.

X reacts with ammonium carbonate to give an acidic gas. What is compound X?

A calcium hydroxide
B ethanoic acid
C nitric acid
D sodium hydroxide

26 The elements are arranged in groups and periods in the Periodic Table.

Which row is correct?

	group determined by	period determined by	elements in the Periodic Table are arranged by
A	the number of electrons in the outer shell	the number of occupied shells	increasing proton number
B	the number of occupied shells	the number of electrons in the outer shell	increasing mass number
C	the number of electrons in the outer shell	the number of occupied shells	increasing mass number
D	the number of occupied shells	the number of electrons in the outer shell	increasing proton number

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27 Element X is in Group 1.

Some statements about element X are given.

- X is not the least dense element in Group 1.
- X is more reactive than potassium.
- X has an A_r value less than 100.

Which element is X?

A lithium
B sodium
C rubidium
D caesium

28 Three statements about the properties of metals are shown.

1 All metals conduct electricity.
2 All metals have two electrons in their innermost shell.
3 All metals have high melting points.

Which statements are correct?

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

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29 Group 1 elements and transition elements are metals.

Student X suggests that the Group 1 elements are above hydrogen in the reactivity series but that not all transition elements are above hydrogen.

Student Y suggests that the densities of Group 1 elements are lower than those of the transition elements.

Which students are correct?

A both X and Y

B X only

C Y only

D neither X nor Y

30 The equations for some of the reactions of metals Q, R and T are shown.

$$2QNO_3\,(aq) + Cu\,(s) \rightarrow 2Q\,(s) + Cu(NO_3)_2\,(aq)$$

$$R\,(s) + TSO_4\,(aq) \rightarrow T\,(s) + RSO_4\,(aq)$$

$$T\,(s) + H_2SO_4\,(aq) \rightarrow TSO_4(aq) + H_2(g)$$

Using the equations, what is the order of reactivity of Q, R and T?

	most reactive ⟶		least reactive
A	Q	T	R
B	R	Q	T
C	R	T	Q
D	T	R	Q

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31 Zinc is used to galvanise iron, which prevents the iron from rusting. Which statements are correct?

1 The layer of zinc forms a barrier between the iron and the oxygen and water in the atmosphere.
2 Zinc will oxidise before the iron does, even if the layer of zinc is scratched.
3 When iron rusts, atoms of iron gain electrons to form ions.

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

32 Some metals and the compounds in their ores are shown.

metal	Al	Ca	Pb	Na	Fe	Mg
compound in ore	Al_2O_3	$CaCO_3$	PbS	NaCl	Fe_2O_3	$MgCO_3$

Which type of reaction occurs in the extraction of each of these metals from its ore?

A decomposition by heat
B electrolysis
C precipitation
D reduction

33 What are the main products obtained by the fractional distillation of liquid air?

A carbon dioxide and oxygen
B carbon dioxide and water vapour
C nitrogen and oxygen
D nitrogen and water vapour

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34 Three statements about the carbon cycle are given.

1 The carbon cycle regulates the amount of carbon dioxide in the atmosphere.

2 During photosynthesis, carbon dioxide is produced.

3 Combustion of hydrocarbons requires oxygen.

Which statements are correct?

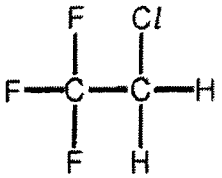
A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

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



Which element in this compound causes a depletion of ozone in the atmosphere?

A carbon

B chlorine

C fluorine

D hydrogen

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36 In the fractional distillation of petroleum, different fractions are obtained at the top and bottom of the fractionating column.

Which properties does the fraction obtained at the top of the fractionating column have, compared with the fraction obtained at the bottom?

1 higher viscosity
2 lower boiling point
3 lower volatility
4 shorter chain length

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

37 Compound Q is a hydrocarbon that has no structural isomers.

Compound Q does not decolourise bromine in the dark.

Which compound is Q?

A C_3H_6
B C_3H_8
C C_4H_8
D C_4H_{10}

38 Alkenes can be produced by the cracking of alkanes, such as decane, $C_{10}H_{22}$.

Which equation shows the cracking of decane to produce two different alkenes and at least one other product

A $C_{10}H_{22} \rightarrow 2C_2H_4 + C_3H_6 + C_4H_{10}$
B $C_{10}H_{22} \rightarrow H_2 + 2C_2H_4 + C_3H_6 + C_5H_{10}$
C $C_{10}H_{22} \rightarrow 2C_3H_6 + C_4H_{10}$
D $C_{10}H_{22} \rightarrow H_2 + 2C_2H_4 + 2C_3H_6$

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39 Two statements are shown.

1 When ethanol is made from glucose by fermentation, each glucose molecule produces three molecules of ethanol.

2 When ethanoic acid is made from ethanol, the ethanol acts as an oxidising agent.

Which row about these statements is correct?

	statement 1	statement 2
A	✓	
B	✓	
C	×	
D	×	

key
✓ = true
× = false

40 An ester is formed from a carboxylic acid and an alcohol.

How does the number of carbon, hydrogen and oxygen atoms in an ester differ from the total number of these atoms in the carboxylic acid and alcohol from which the ester is formed?

	carbon atoms	hydrogen atoms	oxygen atoms
A	fewer	fewer	fewer
B	fewer	same	fewer
C	same	fewer	fewer
D	same	same	same

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Name: .... ( ) Class: .....

MONTFORT SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2025

Secondary 4 Express
CHEMISTRY
Paper 2

6092/02
25 Aug 2025 (Mon)
1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer all questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 24.

The use of an approved scientific calculator is expected, where appropriate.

FOR EXAMINERS' USE ONLY	
SECTION A	70
SECTION C	10
TOTAL	80

This document consists of **23** printed pages and 1 blank page.

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Section A

Answer all questions in the spaces provided.

1 Fig. 1.1 shows the structures of seven substances, **A**, **B**, **C**, **D**, **E**, **F** and **G**.

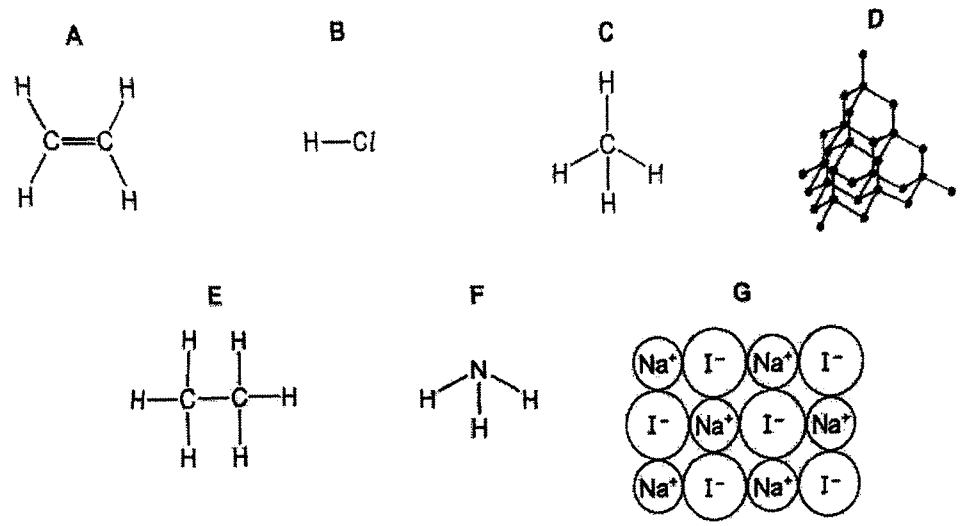


Fig. 1.1

(a) Answer the following questions using only the structures in Fig. 1.1.

Each structure may be used once, more than once or not at all.

State the structure that represents:

(i) a compound that is the main constituent of natural gas

..... [1]

(ii) the monomer used to produce poly(ethene)

..... [1]

(iii) a giant covalent structure

..... [1]

(iv) a compound that has a high melting point

..... [1]

(v) a waste gas from digestion in animals

..... [1]

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(vi) a solid at room temperature that conducts electricity when dissolved in water.

..... [1]

(b) Draw the dot-and-cross diagram for structure **B**.

Show the outer electron shells only.

[1]

[Total: 7]

[Turn Over

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2 Aluminium carbide, Al_4C_3, reacts with water to form methane, CH_4, and aluminium hydroxide.

(a) Construct a balanced chemical equation for this reaction.

..... [2]

(b) Methane is a saturated hydrocarbon.

(i) Explain why methane is a saturated hydrocarbon.

.....

..... [2]

(ii) Methane reacts with chlorine in the presence of ultraviolet light.

State the formulae of two products of this reaction.

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

(c) The equation for the complete combustion of methane is shown.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

This reaction is exothermic.

(i) Explain, using ideas about bond breaking and bond making, why this reaction is exothermic.

.....

.....

..... [2]

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(ii) Complete the reaction pathway diagram in Fig. 2.1 for the complete combustion of methane.

Label the:

- reactants
- products
- enthalpy change of the reaction, ΔH
- activation energy, E_a.

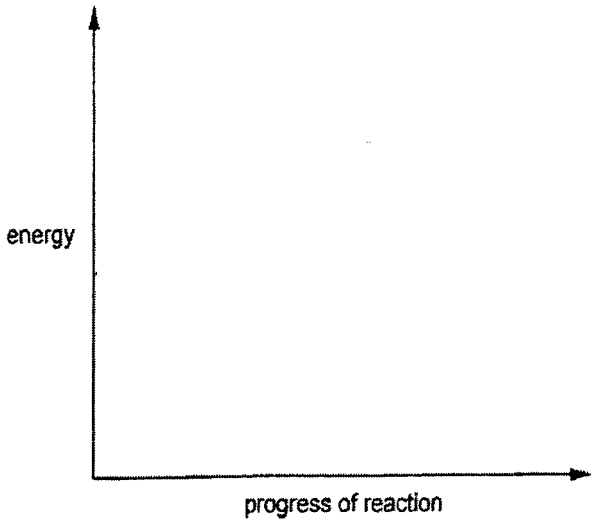


Fig. 2.1

[3]

[Total: 11]

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3 Nitrogen(V) oxide decomposes on heating to form nitrogen(IV) oxide and oxygen.

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

(a) The table shows how the rate of reaction varies with the concentration of N_2O_5.

concentration of $N_2O_5(g)$ in mol/dm^3	rate in $mol/dm^3/s$
3.2	6.39
1.6	3.15
0.8	1.63

(i) Describe how the rate of this reaction changes with the concentration of N_2O_5.

.....

..... [1]

(ii) Explain your answer to **(a)(i)** in terms of collision theory.

.....

.....

..... [2]

(iii) Describe and explain the effect of increasing the temperature on the rate of this reaction.

.....

.....

..... [2]

(b) Sulfur dioxide is an atmospheric pollutant.

(i) Describe one source of the sulfur dioxide in the atmosphere.

..... [1]

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(ii) The oxidation of sulfur dioxide to sulfur trioxide in the atmosphere is catalysed by nitrogen(IV) oxide.

$$SO_2 + NO_2 \rightarrow SO_3 + NO$$
$$NO + \tfrac{1}{2}O_2 \rightarrow NO_2$$

Nitrogen(IV) oxide speeds up the rate of reaction. Which other property of a catalyst is shown by these equations?

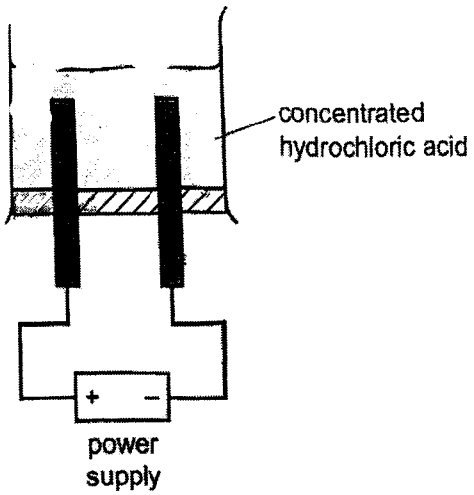
..... [1]

[Total: 7]

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4 When concentrated hydrochloric acid is electrolysed, gases are produced at the electrodes.

The incomplete apparatus is shown.



(a) (i) Complete the diagram by:

- labelling the anode and cathode
- showing how the gases are collected. [2]

(ii) Predict the products of this electrolysis at the:

positive electrode .....

negative electrode ..... [2]

(iii) Graphite (carbon) electrodes are used in this electrolysis.

Suggest **one** other element that can be used as an electrode and give a reason, other than that it can conduct electricity.

element .....

reason .....

[1]

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(b) Aqueous chlorine reacts with aqueous sodium iodide.

Using a balanced chemical equation for the reaction, explain why chlorine is more reactive than iodine.

.....

.....

.....

..... [2]

[Total: 7]

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5 Molybdenum is a transition element which is used to make steel that is extremely hard.

It exhibits variable oxidation states and can be manufactured by heating together molybdenum(IV) oxide, MoO_2, and aluminium.

(a) Construct the equation for this reaction.

..... [1]

(b) **(i)** Complete the table to show the oxidation states of molybdenum and aluminium.

element	oxidation state in reactants	oxidation state in products
molybdenum		
aluminium		

[2]

(ii) In terms of oxidation states, explain why this is a redox reaction.

.....

.....

..... [2]

(c) Suggest which metal, molybdenum or aluminium, is less reactive. Explain your answer.

.....

..... [1]

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(d) Molybdenum has a melting point of 2620 °C.

(i) With the help of a labelled diagram, describe the type of bonding that is present in molybdenum.

.....

.....

..... [2]

(ii) Suggest why molybdenum has a much higher melting point than aluminium.

..... [1]

[Total: 9]

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6 Calcium hydroxide is often added to acidic soil to increase its pH for healthy plant growth.

Fertilisers containing nitrogen, phosphorus, and potassium which are primary nutrients for healthy plant growth are often added as well.

Table 6.1 shows some commonly used fertilisers.

Table 6.1

fertiliser	formula
ammonium nitrate	
sodium phosphate	Na_3PO_4
	Ca(NO3)2
potassium sulfate	K_2SO_4

(a) Complete Table 6.1 by filling in the missing information. [2]

(b) **(i)** Write an ionic equation for the reaction between calcium hydroxide and the excess acid in the soil.

..... [1]

(ii) A common fertiliser, urea, contains the elements carbon, oxygen, nitrogen, and hydrogen.

It contains 46.7% nitrogen, 6.7% hydrogen and 20% carbon.

Calculate the empirical formula of urea.

[3]

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(c) Two farmers discovered that they have a plot of land that lacks nutrients and is too acidic for any healthy plant growth.

They wanted to add calcium hydroxide together with a fertiliser to the plot of land at the same time.

Farmer 1: Ammonium nitrate should be added together with calcium hydroxide to provide nitrogen for healthy plant growth.

Farmer 2: Calcium nitrate should be added together with calcium hydroxide to provide nitrogen for healthy plant growth.

Which farmer is correct? Explain your reasoning.

.....

.....

.....

.....

..... [3]

[Total: 9]

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7 Ammonia is produced commercially via the catalytic reaction of nitrogen and hydrogen at high temperature and pressure.

Fig. 7.1 shows the graph of the reaction.

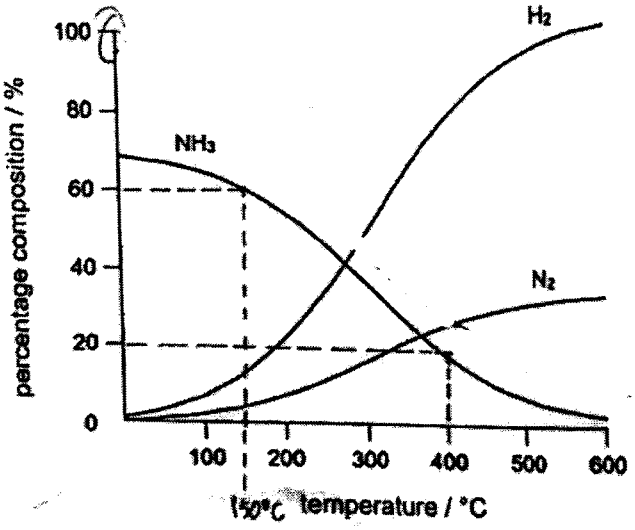


Fig. 7.1

(a) Using the information from the graph, state the relationship between temperature and the percentage yield of ammonia obtained.

..... [2]

(b) Suggest why the percentage composition of hydrogen and nitrogen increases when temperature is high.

[1]

(c) Sketch on Fig. 7.1 the expected graph for the percentage yield of ammonia at a higher pressure for the stated temperatures. Label your graph as (c). [1]

(d) In terms of collision theory, describe how increasing the pressure affects the rate of production of ammonia.

[3]

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(e) Ammonia can be used to treat industrial waste gases containing nitrogen oxides.

The equation shows how the treatment converts nitrogen monoxide to nitrogen and water.

$$6NO + 4NH_3 \rightarrow 5N_2 + 6H_2O$$

(i) Use the equation provided, state the effect on the composition of the gases released into the atmosphere when an insufficient amount of ammonia was added to nitrogen monoxide.

.....

..... [1]

(ii) Describe how nitrogen monoxide affects the environment.

.....

.....

..... [2]

[Total: 10]

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8 **Fossil Fuels**

Fossil fuels like crude oil are known to be non-renewable and are limited in supply. They are still used as fuels because getting energy from their combustion is still considered an economical and convenient method. To ensure that the supply of crude oil lasts longer for our use, we need to conserve crude oil.

Alternative Energy Source - Biogas

Biogas is a renewable fuel that is produced when organic matter, such as food or animal waste, is broken down by bacteria in the absence of oxygen. Biogas, that can be derived from cow dung from farms, contains biomethane.

Table 8.1 shows a typical composition of biogas.

Table 8.1

compound	formula	percentage by volume	additional information
biomethane	CH_4	50 - 80	colourless, odourless
carbon dioxide	CO_2	15 - 50	colourless, odourless
nitrogen	N_2	0 - 10	colourless, odourless
hydrogen sulfide	H_2S	0 – 1	colourless, pungent, toxic

The biogas produced on the farm contains traces of hydrogen sulfide. To prolong the lifespan of the metal machinery parts, hydrogen sulfide must be removed from the biogas, otherwise when it is combusted, it produces sulfur dioxide and sulfuric acid.

Burning biomethane releases greenhouse gases like carbon dioxide but allowing cow dung to degrade naturally also releases methane. Converting cow dung into biomethane to be used as biofuel instead of letting it degrade naturally is found to cut down greenhouse gases by 4%. This is because methane has a much greater global-warming power than carbon dioxide. To reduce the carbon impact, that source of destructive pollution must be transformed into a cleaner fuel. Most of the biomethane produced at the farm can be used to generate sufficient electricity to power several homes. The remaining is then used as fertiliser on the farm, allowing for a reduction in the use of synthetic fertilisers made from fossil fuels.

Biomethane produced from cow dung is a biofuel with high performance and high purity. Obtaining biomethane from cow dung starts right on the farm, where cow dung is collected and put into an on-site biodigester. A biodigester is a sealed container where the bacteria breaks down cow dung into biomethane and fertiliser through a natural process. The biomethane then spins a power generator to produce electricity. The fertiliser produced from the biodigester can also be readily used by farmers.

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Fig. 8.1 shows the process of obtaining biomethane.

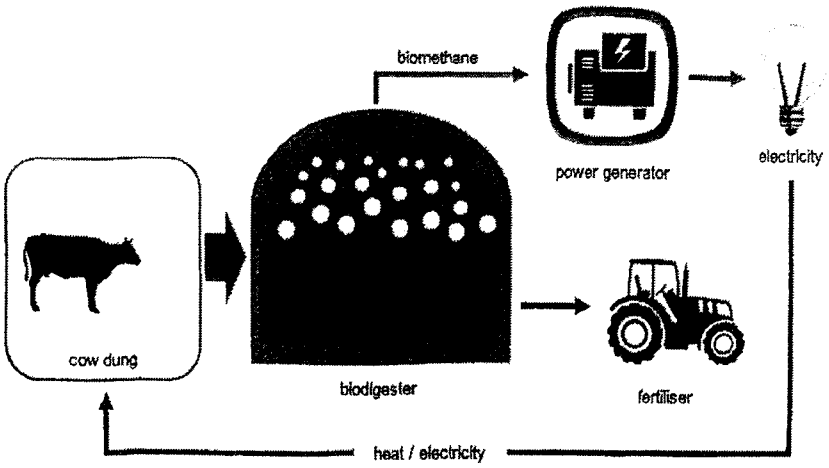


Fig. 8.1

Alternative Energy Source - Metal Powders

Using tiny metal particles to power external-combustion engines is novel. Unlike the internal-combustion engines used in petrol-powered cars, external-combustion engines use heat from an outside source to drive an engine. For decades, the idea of burning metal powders has been used in fireworks and in rocket propellants, such as the solid-fuel booster rockets of space shuttles.

The potential for metal powders to be used as a recyclable fuel in a wide range of applications has been largely overlooked by scientists. When metal powders are burned, they react with air to form a non-toxic solid oxide product that can be easily collected for recycling, unlike the carbon dioxide emission produced from the burning of fossil fuels that escape into the atmosphere. Iron could be the primary candidate for this purpose as millions of tonnes of iron powders are already produced annually for the chemical and electronic industries. However, more research needs to be done to avoid carbon dioxide emissions associated with traditional iron production using coal. While not perfected and commercialised yet, the use of low-cost metallic fuels, like iron powder, is a worthy alternative to petrol and diesel fuels.

(a) **(i)** Farmers can easily detect when levels of hydrogen sulfide in the biogas increase.

Explain why this is so.

.....

..... [1]

(ii) Explain why hydrogen sulfide must be removed from the biogas.

.....

.....

..... [2]

[Turn Over

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(b) Burning biomethane from cow dung also produces greenhouse gases.

However, many people still think that it is worth using cow dung to generate electricity on the farms.

Use the information provided to suggest **environmental** and **economical** reasons why many people think so.

.....

.....

.....

.....

.....

.....

..... [5]

(c) Iron powder burns in air to form iron(III) oxide, which can be easily collected and then converted back to iron.

(i) Suggest a reactant to convert iron(III) oxide back to iron.

..... [1]

(ii) Use the information provided to explain why iron powder is considered a recyclable fuel as compared to fossil fuels.

.....

..... [1]

[Total: 10]

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Section B

Answer **one** question from this section.

9 The table shows some properties of five esters.

name	structure	relative molecular mass	melting point °C	boiling point / °C
methyl ethanoate	CH_3COOCH_3	74	−98	57
ethyl ethanoate	$CH_3COOCH_2CH_3$	88	−84	77
propyl ethanoate	$CH_3COOCH_2CH_2CH_3$	102	−95	102
butyl ethanoate	$CH_3COOCH_2CH_2CH_2CH_3$	116	−78	126
pentyl ethanoate	$CH_3COOCH_2CH_2CH_2CH_2CH_3$	130	−71	148

(a) These esters are part of a homologous series.

Using the data given, state two characteristics of a homologous series.

1. .....

.....

2. .....

..... [2]

(b) The next member of the homologous series is hexyl ethanoate.

Explain why it is more difficult to predict the melting point than the boiling point of hexyl ethanoate.

.....

.....

.....

..... [2]

[Turn Over

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(c) At 25 °C, ethyl ethanoate is a liquid.

Explain how the data in the table shows this.

.....

.....

..... [2]

(d) (i) Methyl ethanoate can be made from an organic acid and compound **Y**.

Draw the structures of the two compounds from which methyl ethanoate is made.

organic acid	compound **Y**

[2]

(ii) Hence, calculate the maximum mass of methyl ethanoate that can be made from 1.20 g of organic acid and excess compound **Y**.

[2]

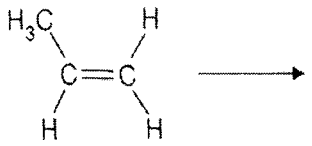
[Total: 10]

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10 Food packaging used in industries produces a lot of waste which includes both glass and plastic.

(a) One of the plastics that is commonly used in food packaging is polypropene which is formed by addition polymerisation.

(i) Complete the equation by drawing the structure of polypropene.

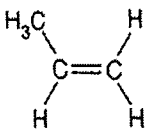


[1]

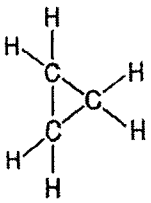
(ii) With the aid of an equation, calculate the percentage yield of carbon dioxide if 4800 dm^3 of carbon dioxide is released when 4.2 kg of propene is burnt.

[2]

(b) Propene and cyclopropane are isomers.



propene



cyclopropane

(i) Suggest how the structures of propene and cyclopropane show that they are isomers.

.....

..... [1]

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(ii) Describe a chemical test that can distinguish propene from cyclopropane.

.....

.....

..... [2]

(c) The glass waste from food packaging can be melted at high temperatures and then made into new objects.

(i) Using the movement of particles, describe the changes in movement and arrangement of the particles when melting occurs.

.....

.....

.....

..... [2]

(ii) Glass waste contains SiO_2.

In terms of structure and bonding, explain why this melting takes place at high temperatures.

.....

.....

.....

..... [2]

[Total: 10]

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The Periodic Table of Elements

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9	proton (atomic) number atomic symbol name relative atomic mass										5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).
The Avogadro constant, $L = 6.02 \times 10^{23}\ mol^{-1}$

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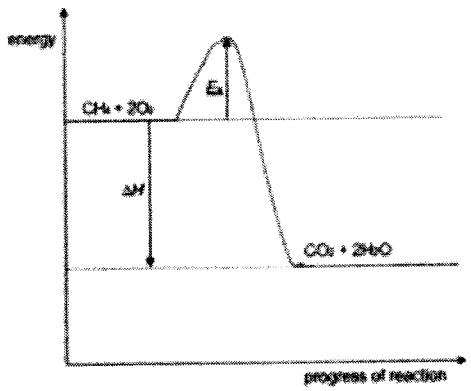
2025 Montfort Secondary School S4 G3 Chem Prelim Answer Key

PAPER 1

Q1	Q2	Q3	Q4	Q5
D	D	B	A	C
Q6	**Q7**	**Q8**	**Q9**	**Q10**
C	D	A	B	A
Q11	**Q12**	**Q13**	**Q14**	**Q15**
C	D	D	D	A
Q16	**Q17**	**Q18**	**Q19**	**Q20**
C	D	D	A	A
Q21	**Q22**	**Q23**	**Q24**	**Q25**
B	C	D	B	C
Q26	**Q27**	**Q28**	**Q29**	**Q30**
A	C	B	A	C
Q31	**Q32**	**Q33**	**Q34**	**Q35**
B	D	C	C	B
Q36	**Q37**	**Q38**	**Q39**	**Q40**
C	B	D	D	C

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PAPER 2

Q	ANSWER	Mark	REMARK
1ai	C	1	
1aii	A	1	
1aiii	D	1	
1aiv	G	1	
1av	C	1	
1avi	G	1	
1b	bonding pair of electrons between C*l* and H 6 non-bonding electrons on chlorine atom and no extra electrons on the H atom(s) (1)	1	
2a	$Al_4C_3 + 12H_2O \rightarrow 4Al(OH)_3 + 3CH_4$ formula for aluminium hydroxide as product (1) balanced equation (1)	2	
2bi	contains only carbon and hydrogen contains single bonds only	2	
2bii	Any two from: HC*l* (1) CH_3Cl (1) CH_2Cl_2 (1) $CHCl_3$ (1) CCl_4 (1)	2	
2ci	bond breaking endothermic AND bond making exothermic / energy absorbed to break bonds in CH4 & O2 AND energy released on making bonds in CO2 & H2O (1) more energy released than absorbed (1)	2	
2cii	 **M1** products to right of reactants AND reactant level above product level (1) **M2** enthalpy change shown as downward arrow AND labelled as enthalpy change or Δ H (1) **M3** activation energy drawn to maximum of energy hump with an upward arrow AND labelled (1)	3	

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<table>
<tr><td>3ai</td><td>Rate doubles as concentration doubles (or reverse argument) (1)</td><td>1</td><td></td></tr>
<tr><td>3aii</td><td>Particles closer together / more particles in a given volume (or reverse argument) (1)
Higher frequency of effective collision / more effective collisions per second (or reverse argument) (1)</td><td>2</td><td></td></tr>
<tr><td>3aiii</td><td>Increasing temperature increases rate (no marks)
Particles move faster / particles have greater kinetic energy (1)
Number of particles with energy greater than the activation energy is increased / higher frequency of effective collisions / more effective
collisions per second (1)</td><td>2</td><td></td></tr>
<tr><td>3bi</td><td>Burning fossil fuels / burning named fossil fuel / volcanoes (1)</td><td>1</td><td></td></tr>
<tr><td>3bii</td><td>It is reformed / it is not used up / it is unchanged at the end of the reaction (1)</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>4ai</td><td>anode (on left) and cathode (on right) correctly labelled (1)
test tubes / measuring cylinders over each electrode with open ends dipping into the electrolyte (1)</td><td>2</td><td></td></tr>
<tr><td>4aii</td><td>positive electrode: chlorine / Cl_2 (1)
negative electrode: hydrogen / H_2 (1)</td><td>2</td><td></td></tr>
<tr><td>4aiii</td><td>platinum (no marks)
inert / unreactive</td><td>1</td><td></td></tr>
<tr><td>4b</td><td>$Cl_2 + 2NaI \rightarrow I_2 + 2NaCl$ (1)

chlorine has displaced iodine in sodium iodide
/ chlorine has taken the place of iodine in sodium iodide (1)</td><td>2</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>5a</td><td>$3MoO_2 + 4Al \rightarrow 2Al_2O3 + 3Mo$ (1)</td><td>1</td><td></td></tr>
<tr><td>5bi</td><td><table><tr><th>element</th><th>oxidation state in reactants</th><th>oxidation state in products</th></tr><tr><td>molybdenum</td><td>+4</td><td>0 (1 for correct row)</td></tr><tr><td>aluminium</td><td>0</td><td>+3 (1 for correct row)</td></tr></table></td><td>2</td><td></td></tr>
<tr><td>5bii</td><td>molybdenum(IV) oxide has been reduced as the oxidation state of molybdenum has decreased from +4 in MoO_2 to 0 in Mo. (1)

aluminium has been oxidised as the oxidation state has increased from 0 in Al to +3 in Al_2O_3. (1)

Since oxidation and reduction occur simultaneously, this is a redox reaction. (no mark)</td><td>2</td><td></td></tr>
<tr><td>5c</td><td>molybdenum is less reactive (no mark)
as it has been displaced from its oxide / molybdenum(IV) oxide has</td><td>1</td><td></td></tr>
</table>

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<table>
<tr><td></td><td>been reduced by alumnium (1)</td><td></td><td></td></tr>
<tr><td>5di</td><td>metallic bonding (1)

structure drawn to show cations in a 'sea' of delocalised electrons. (1)</td><td>2</td><td></td></tr>
<tr><td>5dii</td><td>stronger electrostatic forces of attraction (1) due to higher number of electrons and protons present in Mo.</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>6a</td><td><table><tr><th>fertiliser</th><th>formula</th></tr><tr><td>ammonium nitrate</td><td>NH_4NO_3 (1)</td></tr><tr><td>sodium phosphate</td><td>Na_3PO_4</td></tr><tr><td>calcium nitrate (1)</td><td>$Ca(NO_3)_2$</td></tr><tr><td>potassium sulfate</td><td>K_2SO_4</td></tr></table></td><td>2</td><td></td></tr>
<tr><td>6bi</td><td>$H^+ + OH^- \rightarrow H_2O$ (1)</td><td>1</td><td></td></tr>
<tr><td>6bii</td><td><table><tr><th></th><th>N</th><th>H</th><th>C</th><th>O</th></tr><tr><td>% by mass</td><td>46.7</td><td>6.7</td><td>20</td><td>100 – (46.7+6.7+20) = 26.6 (1)</td></tr><tr><td>no. of moles / mol (1)</td><td>46.71446.714

= 3.33571</td><td>6.716.71

= 6.7</td><td>20122012

= 1.66667</td><td>26.61626.616

= 1.6625</td></tr><tr><td>simplest ratio</td><td>3.335711.662
53.335711.66
25

= 2.01</td><td>6.71.66256
.71.6625

= 4.03</td><td>1.666671.66251.
666671.6625

= 1.00</td><td>1.66251.66251.
66251.6625

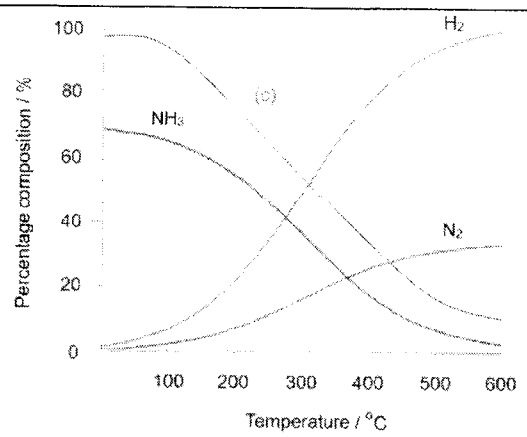
=1.00</td></tr><tr><td>empirical formula</td><td colspan="4">N_2H_4CO (1)</td></tr></table></td><td>3</td><td></td></tr>
<tr><td>6c</td><td>farmer 2 is correct. (no marks)

the nitrate ions from calcium nitrate provides the nitrogen content for healthy plant growth. (1)

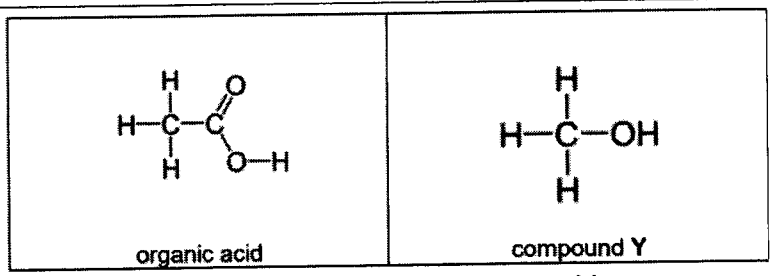
ammonium nitrate will react with calcium hydroxide to form ammonia gas (1) ;
which will escape from the soil and causes a loss in the nitrogen content (1) required for healthy plant growth</td><td>3</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>7a</td><td>at 150 °C, 60 % of ammonia is formed. at 400 °C, 20 % of ammonia is formed. / any correct evidence data from Fig. 7.1 (1)

as the temperature increases, the percentage of ammonia formed decreases. (1)</td><td>2</td><td></td></tr>
<tr><td>7b</td><td>at high temperature, the ammonia decomposes to form hydrogen and nitrogen. (1)</td><td>1</td><td></td></tr>
<tr><td>7c</td><td></td><td>(1)</td><td></td></tr>
</table>

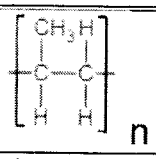
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7d	when the pressure of gaseous reactants increases, there are more reacting particles per unit volume. (1) this increases the frequency of collision and hence increases the frequency of effective collision (1) between the reacting particles and thus, the rate of reaction increases. (1)	3	
7ei	there will be unreacted or more or excess nitrogen monoxide released into the atmosphere together with less nitrogen and water vapour/steam produced (1)	1	
7eii	NO will react with air/oxygen to form NO_2 which reacts with moisture and air (or water and oxygen) to form nitric acid (1) which reacts/dissolves in water; to form acid rain which corrodes limestone buildings/kills aquatic life (1) OWTTE;	2	
8ai	has a pungent smell (1)	1	
8aii	when hydrogen sulfide is combusted, it produces sulfur dioxide and sulfuric acid; which will corrode the metal machinery parts. (1) hydrogen sulfide is toxic (1)	2	
8b	environmental: (any three) • if cow dung is not used, the cow dung will also degrade naturally to release methane which is a greenhouse gas; • converting cow dung into biomethane to be used as biofuel instead of letting it degrade naturally cuts down greenhouse gases by 4%. this is because methane has a much greater global-warming power than carbon dioxide; • conserves use of the limited/non-renewable fossil fuels/crude oil or • the fertiliser made on the farm can reduce the synthetic fertilisers made from fossil fuels/ crude oil;	5	

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	economical: (any two) • cow dung is produced and/or collected directly on the farm or on-site and biodigester is on-site so farmers save on transportation costs and/or time; (reject easy to use) • also cuts costs on using fossil fuels/crude oil for electricity; • biomethane is a biofuel with high performance and high purity; • the fertiliser produced from the biodigester can be readily used by farmers, saving costs from purchasing synthetic fertilisers;		
8ci	carbon or hydrogen or carbon monoxide	1	
8cii	iron(III) oxide is a solid product which can be collected more easily for recycling than the gaseous (or escaped) product, carbon dioxide, produced from the burning fossil fuels, which easily escapes into the atmosphere.	1	
9a	they have the (any 1 for 1 mark) • same general formula of CnH2n+2COO where n is ≥2 • same functional group of COO • Mr between successive members differ by 14 / molecular formula between successive members differ by a −CH2	2	
9b	the melting point increases then decreases (no clear trend) (1) but the boiling point increases as the molecular size / Mr increases (1)	2	
9c	The melting point is below 25 °C and (1) the boiling point is above 25 °C (1) OR 25 °C is between (1) its melting and boiling point (1)	2	
9di	 organic acid compound Y (1) correct structural formula of organic acid (1) correct structural formula of compound Y	2	
9dii	no. of moles of acid = 1.20 g / 60 = 0.02 mol no. of moles of methyl ethanoate = 0.02 mol (1) mass of methyl ethanoate = 0.02 x 74 = 1.48 g (1)	2	

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10ai		1	
10aii	$2C_3H_6 + 9O_2 \rightarrow 6CO_2 + 6H_2O$ no. of moles of propene = (4.2x1000)/42 = 100 mol volume of carbon dioxide produced = 3 x 100 x 24 = 7200 dm3 (1) percentage yield = 4800/7200 x 100% = 66.7 % (1) ECF allowed for incorrectly balanced equation	2	
10bi	both have the molecular formula C_3H_6 but the arrangement of atoms is different (needs to explain the difference fully in their own words) (1)	1	
10bii	reagent: Br_2 (aq) (1) reddish brown bromine decolourises when added to propene but remains unchanged when added to cyclopropane (1)	2	
10ci	movement: from vibrate about fixed position to move throughout the liquid (1) arrangement: from very close, orderly arrangement to close but disorderly arrangement (1)	2	
10cii	has a giant molecular structure and strong covalent bonds between atoms. (1) a lot of energy is needed to overcome the bonds. (1)	2	

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