CONVENT OF THE HOLY INFANT JESUS SECONDARY
Preliminary Examination in preparation for
the General Certificate of Education Ordinary Level 2023

CANDIDATE NAME

CLASS

REGISTER NUMBER

CHEMISTRY (Pure)

Paper 1 Multiple Choice

6092/01

15 September 2023

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class and register number on the Multiple Choice Answer Sheet provided.

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 on the question paper.
A copy of the Periodic Table is printed on page 18.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **17** printed pages and **1** blank page.

[Turn over

1   A mixture of three liquids is separated by fractional distillation.

Which statements are correct?

1   The mixture boils at constant temperature when each liquid is being distilled.

2   The temperature at which the mixture boils increases throughout distillation.

3   The liquid with the highest boiling point is collected first.

4   The liquid with the lowest boiling point is collected first.

A   1 and 3

B   1 and 4

C   2 and 3

D   2 and 4

2   Sodium chloride was accidentally added to oil in a beaker.

What is the correct sequence of steps to recover pure and dry sample of sodium chloride from the mixture?

A   dissolve in water → distillation → evaporation

B   dissolve in water → add mixture into a separating funnel → evaporation

C   filtration → dissolve residue in water → distillation

D   filtration → dissolve residue in water → evaporation

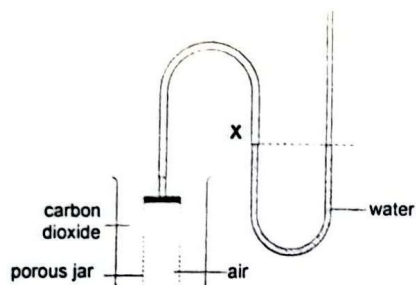3   Diagrams of the three states of matter for carbon dioxide are shown.
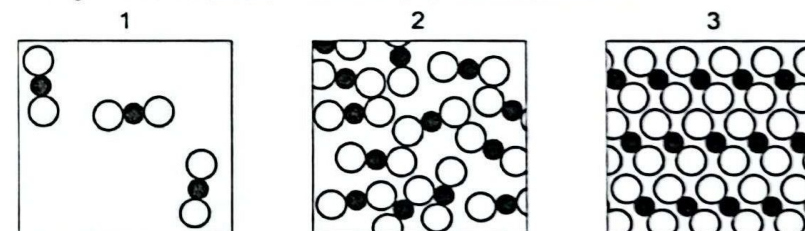
Which two diagrams show the states of matter before and after the sublimation of carbon dioxide?

A   2 to 1   B   2 to 3   C   3 to 1   D   3 to 2

4 The apparatus shown in the diagram was set up.

A porous pot containing air was placed in a beaker of carbon dioxide.

Which row shows both the correct observation and explanation for the observation initially?

	observation	explanation
A	Initially the water level at X gradually moved down the mark.	Air inside the porous jar diffused out faster than the carbon dioxide diffuse in.
B	Initially the water level at X gradually moved down the mark.	Carbon dioxide outside the porous jar diffused in faster than air which diffused out.
C	Initially the water level at X gradually moved up above the mark.	Air inside the porous jar diffused out faster than the carbon dioxide diffused in.
D	Initially the water level at X gradually moved up above the mark.	Carbon dioxide outside the porous jar diffused in faster than air which diffused out.

5 Magnesium has three naturally occurring stable isotopes, ^{24}Mg, ^{25}Mg and ^{26}Mg, with relative abundance of 78.99%, 10.00% and 11.01%, respectively.

What is the relative atomic mass of naturally occurring magnesium?

A 24.1

B 24.3

C 24.4

D 24.5

[Turn over

6 A metal X and a non-metal Y react together to form an ionic compound XY_2.

Which statement is correct when this compound is formed?

A Each atom of X gives away one electron.

B Each atom of X receives two electrons.

C Each atom of Y gives away one electron.

D Each atom of Y receives one electron.

7 Iodine is a black solid which produces violet vapour when warmed.

Which statement is true about iodine?

A Iodine has a giant molecular structure.

B Iodine molecules are bonded to one another by covalent bonds.

C Iodine molecules are easily separated from one another by gentle heating.

D The purple vapour consists of iodine atoms moving randomly and colliding with one another.

8 The structures of four substances P, Q, and R at room conditions, are represented as follows.

P Q R
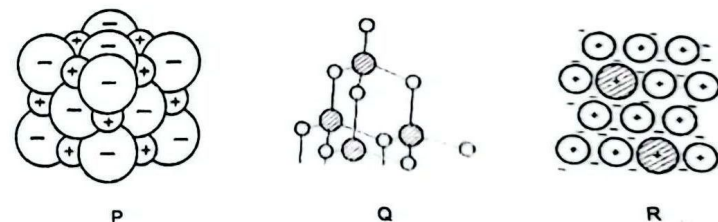
Which row shows the correct identities for the four substances P, Q and R?

	P	Q	S
A	calcium chloride	diamond	calcium oxide
B	sodium chloride	silicon dioxide	bronze
C	sodium chloride	diamond	bronze
D	sodium oxide	silicon dioxide	calcium oxide

9 Urea is produced when ammonia reacts with carbon dioxide.

$$2NH_3(g) + CO_2(g) \rightarrow CON_2H_4(s) + H_2O(l)$$

What is the mass of urea formed when 72 dm³ of ammonia is reacted with 48 dm³ of carbon dioxide?

A   60 g

B   90 g

C   120 g

D   180 g

10 An experiment was conducted to find the percentage of iron by mass in a nail.

Step 1: Nail was weighed.

     Mass of nail = 0.800 g

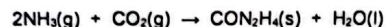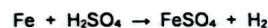Step 2: The nail was completely dissolved in excess dilute sulfuric acid.

     $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

Step 3: The resulting solution from step 2 was titrated with 0.100 mol/dm³ acidified potassium manganate(VII) .

     Average volume of acidified potassium manganate(VII) used = 26.00 cm³

     $MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$
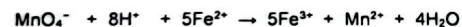
     What is the percentage by mass of iron in the nail?

A   18.2%

B   40.5%

C   91.0%

D   95.8%

11 A piece of blue litmus paper was soaked in dilute aqueous potassium chloride and supported on a glass slide. The paper was connected to an electrical supply as shown in the diagram.

negative electrode   glass slide   positive electrode

blue litmus paper soaked in dilute aqueous potassium chloride
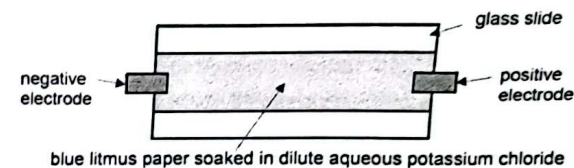
Which row shows the correct observations near each electrode **after some time**?

	negative electrode	positive electrode
A	remains blue	turns red
B	remains blue	turns red and then bleached
C	turns red	turns blue and then bleached
D	turns red and then bleached	remains blue

12 During the electrolysis of an aqueous solution of a chromium salt, 1.3 g of chromium is deposited at the cathode by the same amount of charge that deposits 4.8 g of copper.

What is the formula of the chromium ion?
[Ar Cr, 52]

A Cr^{2+} B Cr^{3+}

C Cr^{4+} D Cr^{6+}

13 Three electrochemical cells are set up using iron metal and three other unknown metals P, Q and R as electrodes.

metal tested	voltmeter reading / V	direction of electron flow
P	1.1	iron to metal P
Q	0.5	metal Q to iron
R	0.2	iron to metal R

Which option shows the three unknown metals in increasing order of reactivity?

A   P, Q, R

B   P, R, Q

C   Q, R, P

D   R, Q, P

[Turn over

14 Which two processes are endothermic?

A   combustion and cracking

B   combustion and fermentation

C   cracking and photosynthesis

D   respiration and photosynthesis

15 For the forward reaction of a reversible reaction, the enthalpy change of reaction, ΔH, is -30 kJ/mol and the activation energy, E_a, is $+70$ kJ/mol.

What is the activation energy of the reverse reaction?

A -100 kJ/mol

B -40 kJ/mol

C $+40$ kJ/mol

D $+100$ kJ/mol

16 A hydrogen fuel cell uses hydrogen and oxygen to produce electricity, heat and water.

The energy level diagram for the reaction is shown below.
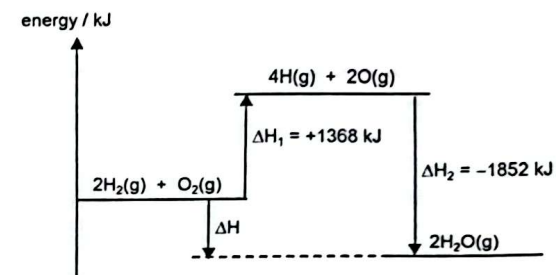
The bond energies of some bonds are given below.

bond	bond energy (kJ/mol)
O—O	150
O=O	496
O—H	460

What is the bond energy, in kJ/mol, of H–H bonds?

A   430 kJ/mol

B   436 kJ/mol

C   860 kJ/mol

D   872 kJ/mol

17 Zinc reacts very slowly with hydrochloric acid at room temperature. When substance X is added to the zinc/hydrochloric acid mixture, hydrogen gas is produced quickly.

Which statements about the addition of substance X are correct?

1   X provides an alternative pathway with a lower activation energy.

2   X increases the enthalpy change of the reaction.

3   X increases the rate of reaction.

4   X increases the yield of the reaction.

A   1 and 2 only   B   1 and 3 only

C   1, 2 and 4 only   D   3 and 4 only

[Turn over

18 The result of an experiment involving the decomposition of 20.0 cm³ of hydrogen peroxide of 1.5 mol/dm³ is represented by graph X below.
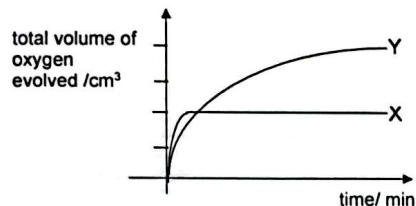
Which conditions produce graph Y?

	volume of hydrogen peroxide used /cm³	concentration of hydrogen peroxide used / mol/dm³
A	10	3.0
B	15	1.5
C	50	1.2
D	60	0.8

19 Study the reaction shown below.

$$2KMnO_4(aq) + 5SO_2(g) + 2H_2O(l) \rightarrow K_2SO_4(aq) + 2MnSO_4(aq) + 2H_2SO_4(aq)$$

Which row correctly shows the oxidising and reducing agent in the reaction?

	oxidising agent	reducing agent
A	H_2O	$MnSO_4$
B	$KMnO_4$	H_2O
C	$KMnO_4$	SO_2
D	SO_2	$KMnO_4$

20 In which reaction is the underlined substance reduced?

A $\quad CaCO_3 + 2\underline{HCl} \rightarrow CaCl_2 + H_2O + CO_2$

B $\quad CuSO_4 + \underline{Zn} \rightarrow Cu + ZnSO_4$

C $\quad \underline{N_2} + 3H_2 \rightarrow 2NH_3$

D $\quad \underline{C_2H_4} + Br_2 \rightarrow C_2H_4Br_2$

[Turn over

21 Which statement about acids is correct?

A All strong acids react with carbonates but all weak acids do not.

B Organic acids are strong acids.

C The pH of 1.0 mol/dm³ ethanoic acid, CH_3COOH, is higher than the pH of 1.0 mol/dm³ sulfuric acid, H_2SO_4.

D The pH of 1.0 mol/dm³ nitric acid, HNO_3, is lower than the pH of 1.0 mol/dm³ hydrochloric acid, HCl.

22 In an experiment 5 cm³ of 1.0 mol/dm³ sodium hydroxide is gradually added to 10 cm³ of 1.0 mol/dm³ hydrochloric acid containing methyl orange.
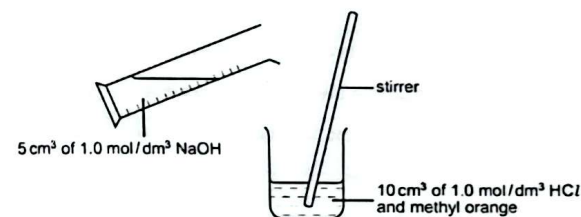
Which change occurs in the mixture?

A The concentration of the H^+ ions increases.

B The methyl orange changes colour.

C More water molecules are present.

D A precipitate is formed.

23 Element Y is in Period 2 of the Periodic Table. It forms a chloride that is a liquid at room temperature.

Which row shows correct information about the group number and the nature of the oxide of element Y?

	group number	nature of oxide
A	I	basic
B	II	acidic
C	IV	amphoteric
D	V	acidic

11

24 A student is given five reagents as shown below to make salts.

dilute hydrochloric acid
dilute sulfuric acid
dilute nitric acid
solid calcium oxide
solid lead(II) oxide

How many soluble salts can be prepared?

A 3

B 4

C 5

D 6

25 Which row correctly shows the salts that are prepared by each method?

	adding excess solid reactants	precipitation	titration
A	ammonium nitrate	barium sulfate	calcium chloride
B	calcium carbonate	lead(II) nitrate	sodium nitrate
C	magnesium sulfate	calcium carbonate	ammonium chloride
D	potassium sulfate	silver chloride	zinc sulfate

26 Sodium sulfate, Na_2SO_4, and sodium hydrogensulfate, $NaHSO_4$, can both be prepared using aqueous sodium hydroxide and sulfuric acid.

$NaOH(aq) + H_2SO_4(aq) \rightarrow NaHSO_4(aq) + H_2O(l)$

$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$
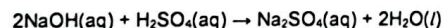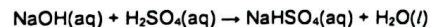
25.0 cm³ of 1 mol/dm³ sodium hydroxide is used each time.

Which row shows the correct volumes of 1 mol/dm³ sulfuric acid required to prepare a sample of sodium sulfate and a sample of sodium hydrogensulfate?

	volume of sulfuric acid required to make sodium hydrogensulfate / cm³	volume of sulfuric acid required to make sodium sulfate / cm³
A	12.5	12.5
B	12.5	25.0
C	25.0	12.5
D	25.0	50.0

[Turn over

12

27 Ammonia is manufactured by the Haber Process. The equation for the Haber process is given below.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\qquad$ $\Delta H = -92$ kJ/mol

Which statement about the Haber Process is true?

A Hydrogen used is obtained from the hydrogenation of alkenes.

B Nitrogen used is obtained from the fractional distillation of liquid air.

C The reaction is exothermic as energy is absorbed to break the strong N≡N bonds.

D The yield of the reaction is 100% as the reactants are recycled.

28 Which statement is correct?

A Going down Group I, the melting point of the elements increases.

B Going down Group I, the reactivity of the elements increases.

C Going down Group VII, the melting point of the elements decreases.

D Going down Group VII, the reactivity of the elements increases.

29 Three elements, X, Y and Z have consecutive increasing proton numbers.

If element Y is a noble gas, which statement is true?

A X reacts with water to form an alkaline solution.

B X and Z will react to form an ionic compound with low melting point.

C X and Z will share one electron each to form a compound XZ.

D Z transfers electrons to X to form ions having an electronic configuration identical to that of Y.

30 An element M reacts in the following ways.

1     $2M(s) + O_2(g) \rightarrow 2MO(s)$

2     $M(s) + 2HCl(aq) \rightarrow MCl_2(aq) + H_2(g)$

3     $M(s) + H_2O(l) \rightarrow$ no reaction

Which statement can be deduced about element M?

A   M can displace magnesium from a solution of magnesium nitrate.

B   M can be obtained from its oxide by reduction with carbon.

C   M forms a metal carbonate that will not decompose under strong heating.

D   M reacts more vigorously with hydrochloric acid than calcium.

31 Four steel spoons are treated before being placed in a beaker of water.

Which spoon rusts most quickly?

A   spoon attached to a piece of copper

B   spoon coated with grease

C   spoon dipped in paint and allowed to dry

D   spoon electroplated with zinc

32 Iron is obtained in the blast furnace from the ore haematite.

Which statement is **incorrect**?

A   Calcium carbonate is used to remove acidic impurities.

B   Coke is oxidised to form carbon dioxide.

C   Haematite is reduced by carbon monoxide.

D   Haematite undergoes thermal decomposition.

33 Some types of chemical reactions are listed.

1   acid-base

2   combustion

3   redox

4   thermal decomposition

Which types of reactions occur in a blast furnace during the extraction of iron?

A   1, 2, 3 and 4   B   1, 3 and 4 only

C   1 and 3 only   D   3 and 4 only

34 Which substance in polluted air damages stonework and harms aquatic life and trees?

A   carbon dioxide

B   carbon monoxide

C   methane

D   sulfur dioxide

35 Catalytic converters have proven to be reliable and effective in reducing harmful emissions from cars. However, they may have some adverse environmental impacts when used.

Which statement describes a negative impact of catalytic converters?

A   They emit acidic gases which lead to acid rain.

B   They emit CFCs which lead to depletion of the ozone layer.

C   They increase the emission of carbon particulates and soot.

D   They produce greenhouse gases which contribute to global warming

36 Kerosene and naphtha are two fractions obtained from petroleum.

What are the uses of these fractions?

	kerosene	naphtha
A	fuel for aircraft	making chemicals
B	fuel for cars	making plastics
C	fuel for lorries	making road surfaces
D	fuel for trains	making waxes

37 Heptane is an alkane with seven carbon atoms per molecule.

What is the molecular formula of heptane and how does its boiling point compare with that of butane?

	molecular formula of heptane	boiling point of heptane
A	C_7H_{14}	higher than butane
B	C_7H_{14}	lower than butane
C	C_7H_{16}	lower than butane
D	C_7H_{16}	higher than butane

38 A hydrocarbon has the molecular formula $C_{10}H_{16}$.

How many C=C bonds are there in one molecule of the hydrocarbon?

A   1   B   2   C   3   D   4

39 The table gives some information about some esters and the fragrance they produce.

ester	fragrance
H—C(=O)—O—CH₂—CH₃	rum
CH₃—CH₂—CH₂—C(=O)—O—CH₃	apple
CH₃—C(=O)—O—CH₂—CH₂—CH₃	pear
H—C(=O)—O—CH₂—CH₂—CH₂—CH₃	plum

An ester is made from methanol and butanoic acid.

What fragrance would the ester have?

A   apple   B   pear   C   plum   D   rum

40 The monomers below are used to form polymers.

Which polymer **cannot** be formed from the monomers?
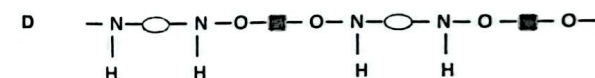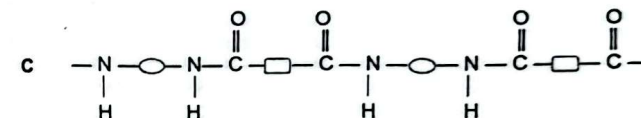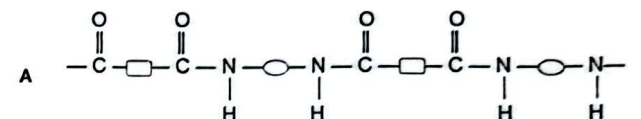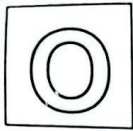
A

B

C

D

[Turn over

CANDIDATE NAME

CLASS

REGISTER NUMBER

CHEMISTRY

6092/02

Paper 2

30 August 2023

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

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.
A copy of the Periodic Table is printed on page 22.

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

This document consists of **21** printed pages and **1** blank page.

[Turn over

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1   Fig. 1.1 shows the structures of six organic compounds, **A, B, C, D, E** and **F**.

A

B

C

D

E

F
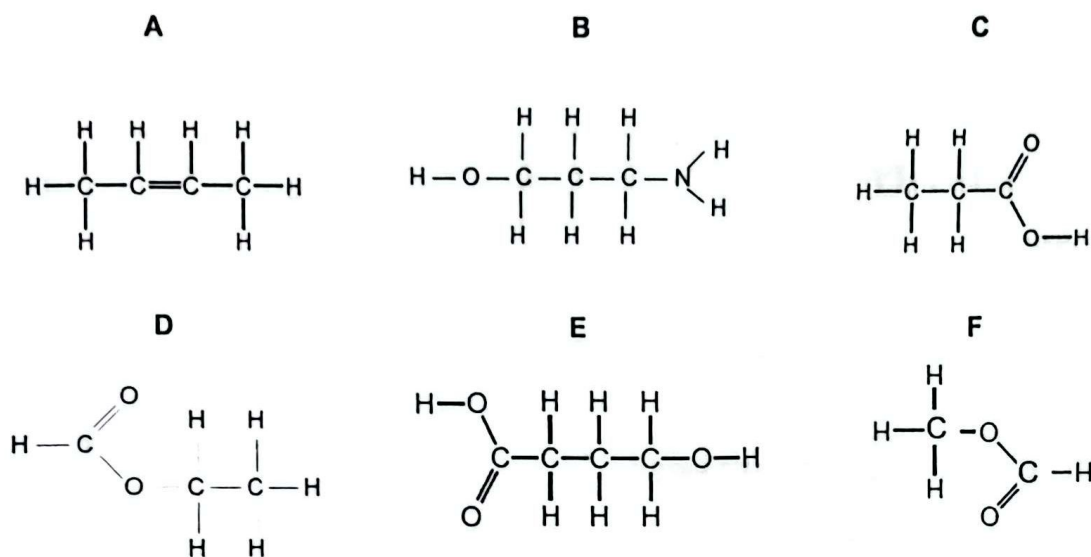
Fig. 1.1

(a)   Use the letters, **A, B, C, D, E** and **F** to answer the questions.

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

(i)   Which structure(s) represent esters?

.... [1]

(ii)   Which structure(s) can undergo condensation polymerisation with itself?

.... [1]

(iii)   Which structure(s) can undergo addition polymerisation?

.... [1]

(iv)   Which two structures are isomers?

.... [1]

(b)   Draw the full structural formula of the polymer formed from **(a)(iii)** showing 3 repeat units.

[1]

[Total: 5]

A2 **(a)** Table 2.1 shows the reactivity of four metals with cold water and with steam.

Table 2.1

metal	reactivity with cold water	reactivity with steam
cerium	slow	fast
nickel	none	very slow
rubidium	very fast	explosive
zinc	none	fast

Put the four metals in order of increasing reactivity.

least reactive   most reactive

[1]

(b) The full symbol of an ion of cerium is shown.

$$^{140}_{58}Ce^{3+}$$
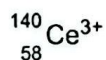
Deduce the number of electrons and neutrons in this ion.

number of electrons ....

number of neutrons ....

[2]

[Total: 3]

A3 **(a)** An aluminium–copper alloy consists mainly of aluminium and traces of copper.

(i) State what is meant by the term alloy.

....

.... [1]

(ii) With the aid of a labelled diagram, draw in Fig. 3.1 the arrangement of atoms in an aluminium–copper alloy.

Fig. 3.1

[3]

[Turn over
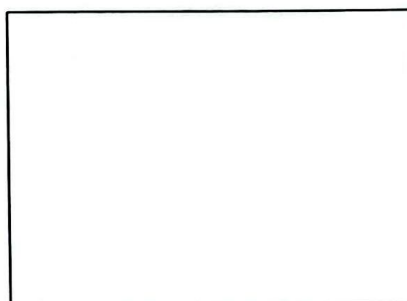
(iii) Explain whether the alloy can conduct electricity.

....

.... [1]

(b) Aluminium reacts with dilute sulfuric acid to form aqueous aluminium sulfate.

Effervescence was observed.

(i) Construct the ionic equation, with state symbols, for the reaction between aluminium and dilute sulfuric acid.

....[2]

(ii) Describe how a pure and dry sample of hydrated aluminium sulfate, $Al_2(SO_4)_3 \cdot xH_2O$ can be prepared from the alloy.

....

....

....

....

....

.... [3]

(iii) The relative formula mass of hydrated aluminium sulfate is 630.

Calculate the value of x in the formula $Al_2(SO_4)_3 \cdot xH_2O$.

x = ... [2]

[Total: 12]

5

5

A4   A student investigates the reaction of large pieces of zinc carbonate with 0.1 mol/dm³ hydrochloric acid. The hydrochloric acid is in excess.

$$ZnCO_3 + 2HCl \rightarrow ZnCl_2 + CO_2 + H_2O$$
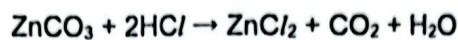
The rate of reaction is found by measuring the mass of the reaction mixture as time increases.

Fig. 4.1 shows the mass of reaction mixture plotted against time.
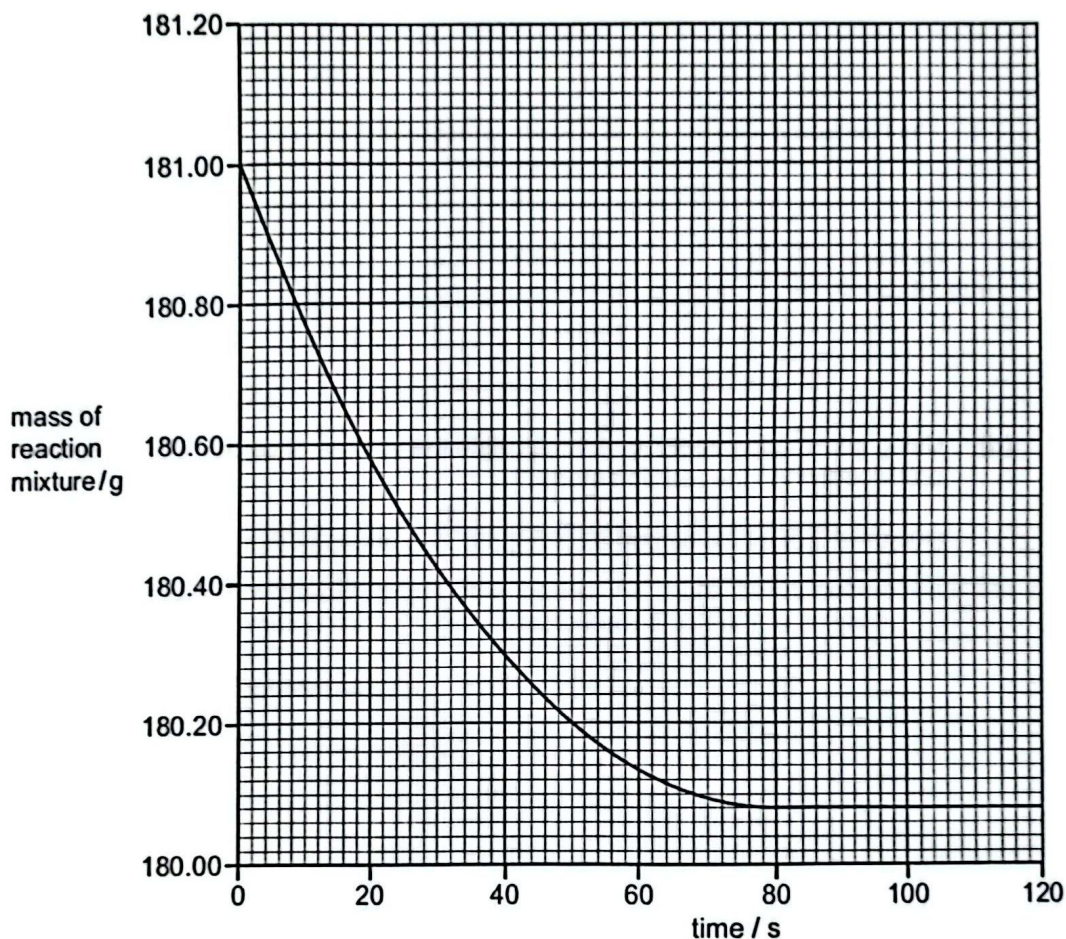
Fig. 4.1

(a) Deduce the mass of the reaction mixture at 36 s.

mass = ... g [1]

(b) The experiment is repeated using smaller pieces of zinc carbonate.
All other conditions stay the same.

Sketch, on the same graph, the graph you would expect to obtain if smaller pieces of zinc carbonate were used.

[1]

CHIJSec/2023/OLevelPrelim/6092/02

[Turn over

(c) Describe the effect each of the following has on the speed of reaction of zinc carbonate with dilute hydrochloric acid. Explain your answer in terms of reacting particles.

All other conditions stay the same.

(i) The reaction is carried out with 0.2 mol/dm³ hydrochloric acid.

....

....

.... [2]

(ii) The reaction is carried out at a lower temperature.

....

....

....

.... [3]

(d) Using information from Fig. 4.1, calculate the volume of carbon dioxide gas produced when the reaction stops.

(Assume that all the carbon dioxide produced escapes to the environment.)

volume of carbon dioxide gas = ... cm³ [2]

[Total: 9]

A5 Fig. 5.1 shows a few pieces of aluminium foil warmed in a mixture of aqueous lead(II) nitrate and aqueous sodium hydroxide.
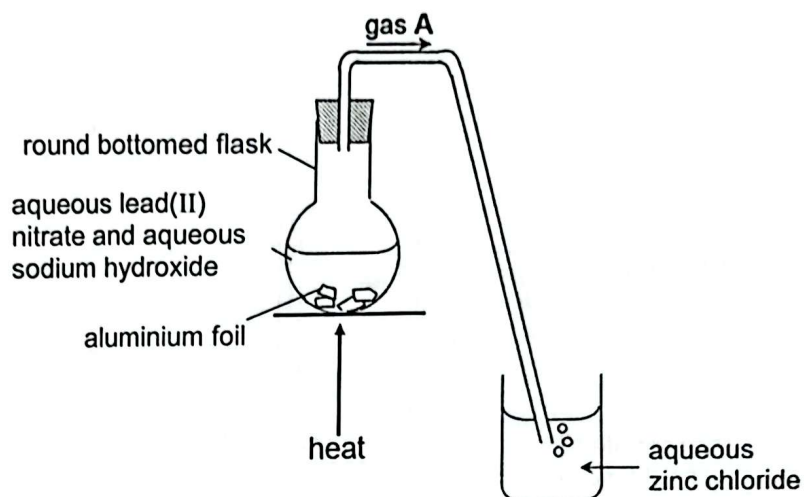
Fig. 5.1

(a) Name gas **A**.

.... [1]

(b) Gas **A** is bubbled into aqueous zinc chloride until there is no further change.

Initially a white precipitate was formed. As more gas is bubbled into the zinc chloride solution, white precipitate dissolved to form a colourless solution.

Explain the observations.

....

....

....

....

....

.... [3]

(c) A grey deposit is formed on the pieces of aluminium foil.

Explain this observation.

....

....

.... [2]

[Total: 6]

[Turn over

A6 The electrolysis of concentrated aqueous hydrochloric acid was carried out using the apparatus as shown in Fig. 6.1.
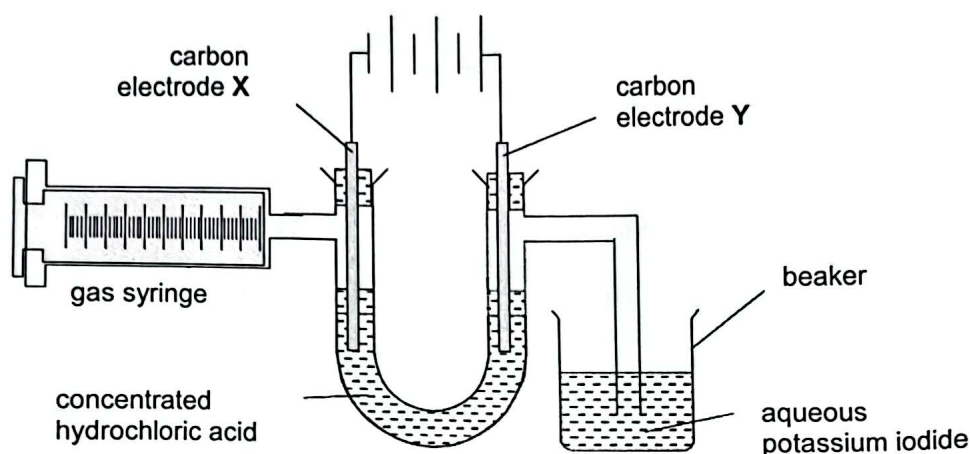
Fig. 6.1

(a) Construct the half equations with state symbols for the reactions at the electrodes.

electrode **X** ....

electrode **Y** .... [2]

(b) As shown in Fig. 6.1, the gas produced at electrode **Y** is bubbled into a beaker containing aqueous potassium iodide.

(i) Name the type of reaction that takes place in the beaker.

.... [1]

(ii) Describe what is observed in the beaker after some time.

....

.... [1]

(c) After the electrolysis was allowed to proceed for a longer period of time, it was observed that a new gas **Z** was formed at carbon electrode **Y**.

(i) State the identity of gas **Z** and explain why it is formed.

....

....

.... [2]

[Total:6]

A7 Fig. 7.1 shows the structure of cyclobutane, C_4H_8. Cyclobutane is a colourless gas and is commercially available as a liquefied gas.
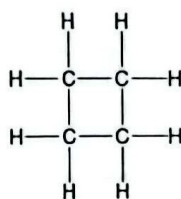
Fig. 7.1

(a) State the evidence from the structure that indicates cyclobutane is a saturated compound.

....

....[1]

(b) Draw the structural formulae of two other isomers of C_4H_8.

[2]

(c) Explain why the structures drawn in **(b)** and cyclobutane are isomers.

....

.... [1]

(d) Cyclobutane and its isomers exist as gases at room temperature and pressure.

Describe a chemical test that distinguishes cyclobutane from its isomers.

....

....

....

.... [2]

[Turn over

(e) Alkenes are manufactured by the cracking of long chain hydrocarbons.

The equation for the cracking of $C_{14}H_{30}$ is shown.

$$C_{14}H_{30} \rightarrow 2X + C_8H_{18}$$

(i) State why the cracking of long chain hydrocarbons is important.

....

.... [1]

(ii) Draw a 'dot-and-cross' diagram to show the bonding in **X**.

Show outer electrons only.

[2]

[Total: 9]

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8   Ionisation Energy

Ionisation energy (IE) is the minimum energy required to remove the most loosely bound electron of an atom or ion in the gaseous state.

The first ionisation of an atom can be expressed as:

$$X(g) \rightarrow X^+(g) + e^-$$
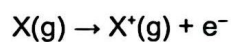
Fig. 8.1 shows the first ionisation energies (1st IE) of the first 20 elements in the Periodic Table.
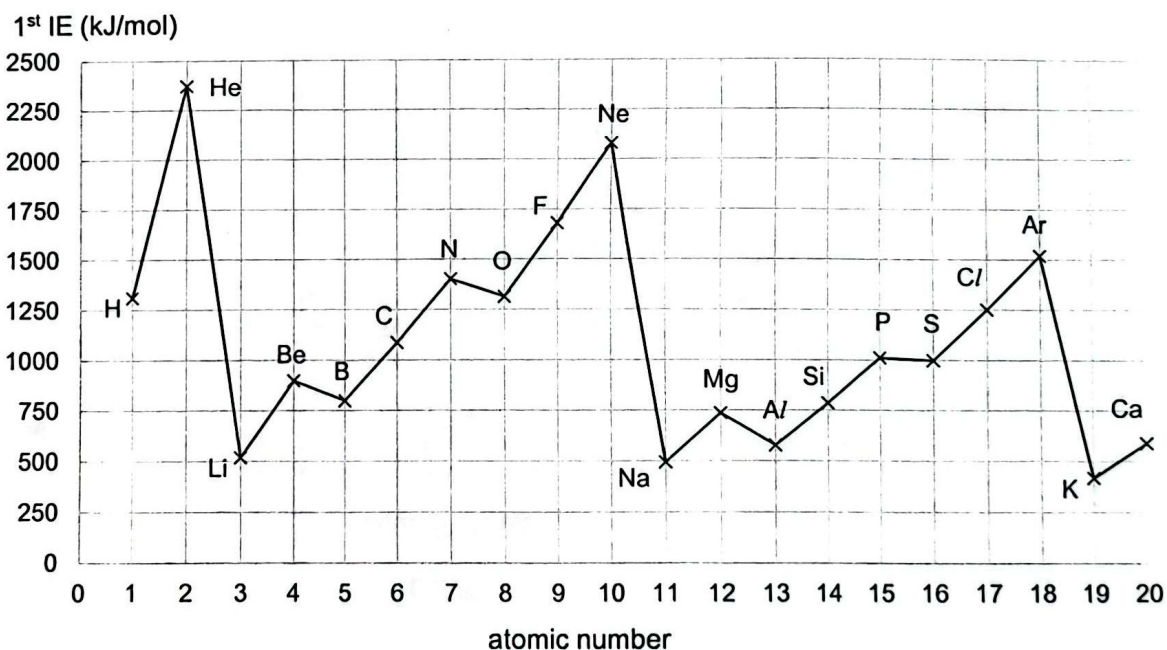
Fig. 8.1

Table 8.2 shows the first and second ionisation energies of the Group I elements.

Table 8.2

element	1st IE (kJ/mol)	2nd IE (kJ/mol)
Li	520	7298
Na	495	4562
K	418	3052

Electronegativity

Electronegativity is a measure of an atom's ability to attract electrons to itself. The term "electronegativity" was introduced by Jöns Jacob Berzelius in 1811, and was further developed in 1932 by Linus Pauling, who proposed an accurate electronegativity scale. The higher the electronegativity, the higher the tendency of an atom to attract electrons. Electronegativity is dependent on factors such as the attractive force of the nucleus and the number of electrons in an atom.

Fig. 8.3 shows the electronegativities of the first 20 elements in the Periodic Table.
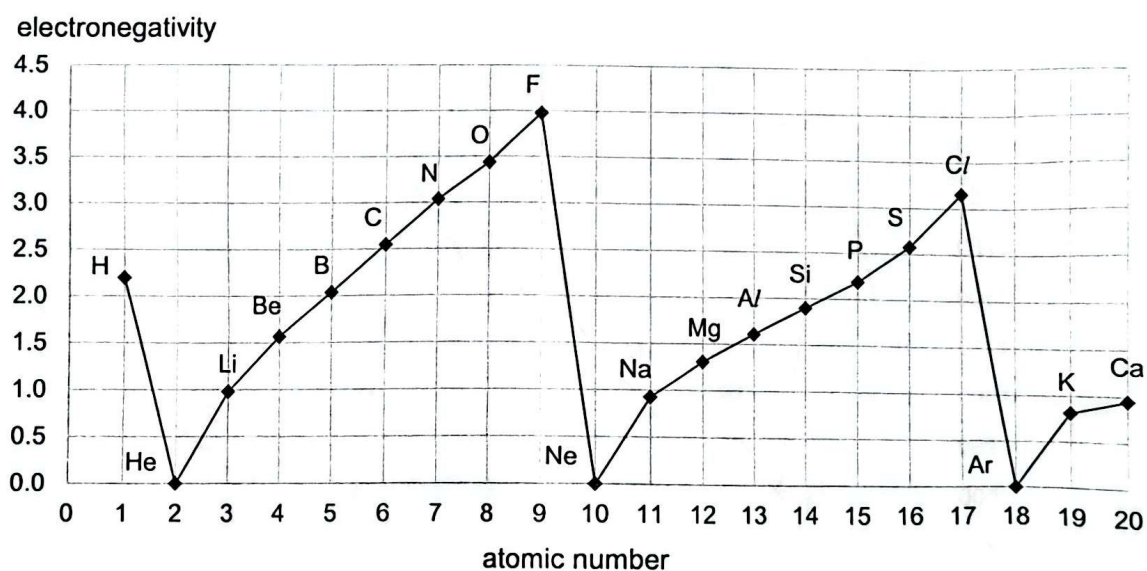
Fig. 8.3

(a) With reference to Fig. 8.1 and Fig. 8.3,

(i) describe the relationship between the first ionisation energy and electronegativity across the period from Group I to Group VII.

....

.... [1]

(ii) suggest why the elements in Group 0 do not follow the relationship described in (a)(i).

....

....

....

....

.... [2]

(b) The first ionisation of lithium can be represented by the equation:

$$Li(g) \rightarrow Li^+(g) + e^-$$

(i) Draw the dot-and-cross diagram for the resulting lithium ion that is formed.

[1]

(ii) Write the equation that represents the second ionisation for lithium, and draw the dot-and-cross diagram for the resulting ion, showing all electron shells.

equation for second ionisation:

....

dot-and-cross diagram of resulting ion:

[2]

[Turn over

(iii) Hence, by using ideas about atomic structure, explain the difference between the first and second ionisation energies of the Group I elements as shown in Table 8.2.

....

....

....

....

....

....

.... [3]

(c) Suggest the electronegativity of bromine. Explain your reasoning using ideas about atomic structure.

electronegativity of Br ....

reason ....

....

....

....

.... [3]

[Total: 12]

B9 The global energy crisis began in the aftermath of the COVID-19 pandemic in 2021, with several countries facing severe shortages and increased prices in fuels. The main fuel that is in low supply worldwide is natural gas.

Table 9.1 shows some information about methane and two other common fuels ethanol and hydrogen.

Table 9.1

fuel	structural formula	enthalpy of combustion (kJ/mol)
methane	H—C—H with H above and H below (CH₄ structure)	−890
ethanol	H—C—C—O—H with H atoms (CH₃CH₂OH structure)	−1367
hydrogen	H — H	−509

(a) **(i)** Write the chemical equations for the complete combustion reactions of methane and ethanol. State symbols are not required.

methane:

....

ethanol:

....

[2]

(ii) In terms of bonds broken and formed, explain the difference in the enthalpy of combustion of ethanol and methane.

....

....

....

....

....

....

.... [3]

[Turn over

(b) By calculation, identify the fuel in Table 9.1 that produces the most energy per gram.

[2]

(c) Besides supply and cost, suggest an advantage of using ethanol as an alternative fuel to methane.

....

.... [1]

[Total: 8]

EITHER

B10 Titanium is a metal that is extracted from rutile, which contains 50% titanium(IV) oxide.

Fig. 10.1 shows the flowchart of the extraction of titanium.

Step 1: | Chunks of titanium(IV) oxide are reacted with chlorine and coke at 1000°C to produce titanium(IV) chloride and carbon monoxide.

Step 2: | Titanium(IV) chloride is cooled and reacted with magnesium at 1100°C in a sealed reactor for 3 days to obtain titanium.

Step 3: | The reactor is slowly cooled, and the titanium is separated from the other product, magnesium chloride.
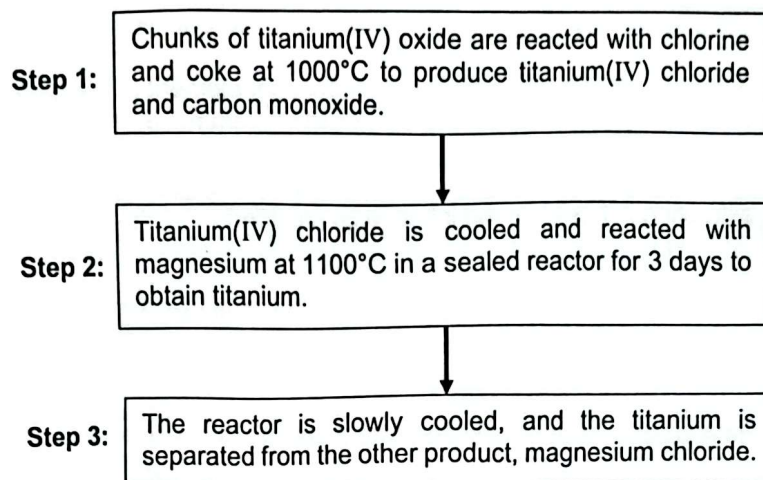
Fig. 10.1

(a) The titanium(IV) chloride produced in **Step 1** exists as a colourless liquid at room temperature and pressure, and boils at 136°C.

(i) Write the balanced chemical equation for the reaction taking place in **Step 1**. Include state symbols.

.... [2]

(ii) Based on the information provided, deduce the structure and bonding present in titanium(IV) chloride. Explain your reasoning.

....

....

....

.... [2]

(b) In **Step 3**, the slow cooling of the reactor allows the two products to separate due to the difference in their melting points.

product	melting point (°C)
titanium	1668
magnesium chloride	714

(i) Write the ionic equation for the reaction taking place in **Step 2**.

.... [2]

[Turn over

(ii) The reactor in **Step 2** and **Step 3** has an atmosphere of argon.

Suggest why an atmosphere of argon is necessary in this process.

....

.... [1]

(c) Although titanium is the tenth most abundant element in the Earth's crust, it is mainly obtained by recycling rather than extraction from rutile.

Discuss the economic and environmental advantages of recycling titanium rather than extracting it, based on the information provided.

....

....

....

....

....

.... [3]

[Total: 10]

OR

B10 A student investigated the reaction between 1.0 mol/dm^3 sodium hydroxide solution and two different strong acids of 1.0 mol/dm^3 concentration, acid A and acid B, using titration.

Table 10.1 shows the average volume of each acid used in each experiment. In both experiments, 25.0 cm^3 of sodium hydroxide solution was pipetted into the conical flask.

**Table 10.1**

	acid A	acid B
average volume of acid used (cm^3)	12.30	24.85

(a) Write the ionic equation for the reaction between sodium hydroxide and an acid.

.... [1]

(b) Using the information provided, suggest the identities of acid A and acid B. Explain your reasoning.

acid A ....

acid B ....

....

....

....

....

.... [4]

(c) Acid C is a weak acid comprising 41.4% carbon, 55.2% oxygen, with the remainder being hydrogen.

(i) Given that the relative molecular mass of acid C is 116, deduce its molecular formula.

[3]

[Turn over

(ii) Acid **C** exists as a solid at room temperature. It can be dissolved in water as shown in the set-up below.
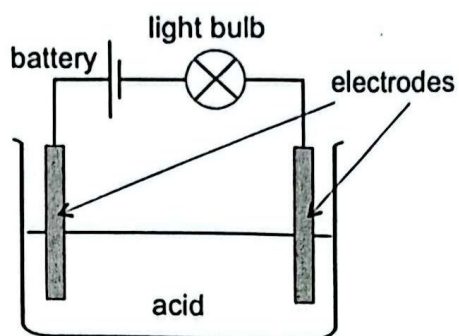
Explain why the bulb lights up in the set-up shown, but not when acid **C** is in the solid state.

....

....

....

.... [2]

[Total: 10]

End of Paper