DUNMAN SECONDARY SCHOOL

CANDIDATE NAME			
CLASS		**INDEX NUMBER**	

PRELIMINARY EXAMINATION 2026
SECONDARY 4 EXPRESS

CHEMISTRY

6092/02

Paper 2

26 August 2026
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

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 an HB 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 23.

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

Section A

Answer **all** questions.

1 The formulae of some ions are shown below.

Al^{3+}	Ag^{+}	Ca^{2+}
Cl^{-}	CO_3^{2-}	H^{+}
H^{-}	I^{-}	K^{+}
Li^{+}	OH^{-}	O^{2-}

Fill in the blanks with the formulae of the correct ion(s). Each formula may be used once, more than once, or not at all.

(a) a cation which has the same arrangement of electrons as neon,

Formula of ion : ……..

(b) an anion which has only two electrons,

Formula of ion : ……..

(c) ions which react together to produce a gas which gives a white precipitate in limewater,

Formulae of ions: …… and ……..…….....

(d) ions responsible for the formation of a yellow precipitate when aqueous silver nitrate is added to aqueous solution of a sodium salt,

Formulae of ions: …… and ……..…….....

(e) ions responsible for the formation of a white precipitate which remained unchanged when aqueous sodium hydroxide was added in excess to an aqueous nitrate.

Formulae of ions: …… and ……..…….....

[Total: 5]

2 Graphene and diamond are allotropes (different forms) of carbon. Stacked layers of graphene form graphite.

Fig. 2.1 shows structures of graphene and diamond.

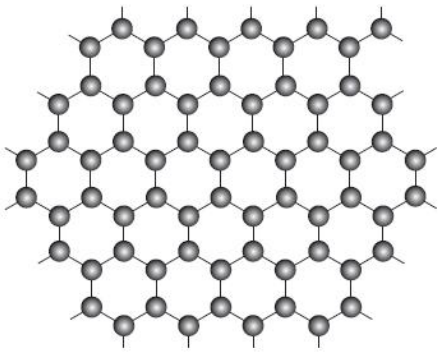
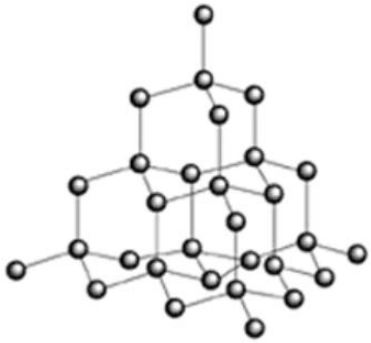
	
graphene	diamond

Fig. 2.1

(a) Describe the similarities and differences between the bonding and structure in graphene and diamond.

……..

……..

……

……..

……..

……. [3]

(b) When graphene and diamond are heated in air, both allotropes combust to produce carbon dioxide.

The solubility of graphene, diamond and carbon dioxide in water are shown in the table.

	graphene	diamond	carbon dioxide
solubility in water	insoluble	insoluble	soluble to form a weakly acidic solution

Use your knowledge of structure and bonding to explain the difference in solubility between graphene, diamond and carbon dioxide.

……..

……..

……..

……..

……..

..... [3]

[Total: 6]

3 Suggest explanations for the following observations:

(a) When dilute sulfuric acid is exactly neutralised by aqueous potassium hydroxide, the resulting mixture is a good conductor of electricity but when the same acid is exactly neutralized by aqueous barium hydroxide, the resulting mixture is a very poor conductor of electricity.

……..

……..

……..

……..

..... [2]

(b) When dilute hydrochloric acid and dilute sulfuric acid are electrolysed separately using inert electrodes, the ratio of the volume of gases obtained at the cathode and anode is 2:1.

……..

……..

……..

……..

..... [2]

[Total: 4]

4 Lead(II) iodide salt may be made by the reaction between aqueous potassium iodide and aqueous lead(II) nitrate.

A student added 50 cm^3 of 1.0 mol/dm^3 potassium iodide to 50 cm^3 of 1.0 mol/dm^3 lead(II) nitrate.

$$2KI(aq) + Pb(NO_3)_2(aq) \rightarrow 2KNO_3(aq) + PbI_2(s)$$

(a) Name this method of salt preparation.

…… [1]

(b) The experiment yielded *x* g of lead(II) iodide.

The student did another experiment to make lead(II) chloride by adding 50 cm^3 of 1.0 mol/dm^3 potassium chloride to 50 cm^3 of 1.0 mol/dm^3 lead(II) nitrate.

Compare the amount of lead(II) chloride with the amount of lead(II) iodide.

Explain your answer.

……

…… [1]

(c) Potassium nitrate is also a product of the reaction between aqueous potassium iodide and aqueous lead(II) nitrate.

(i) Explain why the student's method is not suitable for obtaining a pure sample of potassium nitrate.

……

…… [1]

(ii) By naming a suitable pair of reagents, suggest how potassium nitrate can be prepared.

…… [1]

[Total: 4]

5 Zinc reacts slowly with dilute sulfuric acid. In order to speed up the reaction, aqueous copper(II) sulfate was added to a mixture of zinc and dilute sulfuric acid. The result is a displacement of copper metal which catalyses the reaction between zinc and dilute sulfuric acid.

The graph below shows the volume of hydrogen gas obtained when various volumes of 1.0 mol/dm^3 aqueous copper(II) sulfate were added to mixtures of the same mass of zinc and excess dilute sulfuric acid.

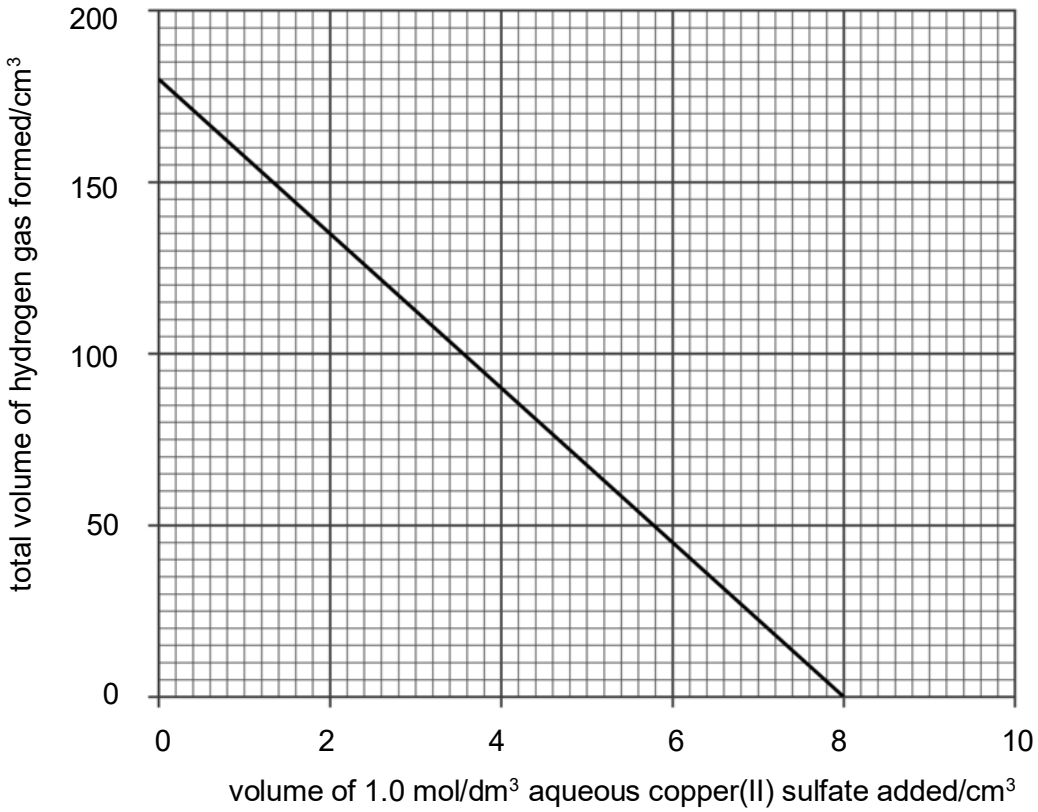


Fig. 5.1

(a) With reference to the graph, state the volume of hydrogen gas that would have been formed if the following solutions were added:

(i) 4 cm^3 of 1.0 mol/dm^3 copper(II) sulfate ……..

(ii) 10 cm^3 of 1.0 mol/dm^3 copper(II) sulfate ……..

(iii) 2 cm^3 of 3.0 mol/dm^3 copper(II) sulfate ……..

[3]

(b) State and explain the relationship between the volume of hydrogen formed and the volume of copper(II) sulfate added.

……..

……..

……..

……. [2]

(c) Suggest two other ways to speed up the reaction between zinc and dilute sulfuric acid which would not affect the final volume of hydrogen.

……..

……. [2]

(d) By referring to the graph, calculate the mass of zinc at the start of each experiment.

[2]

[Total: 9]

6 The diagram shows the apparatus that a student used for an electrochemical cell experiment.

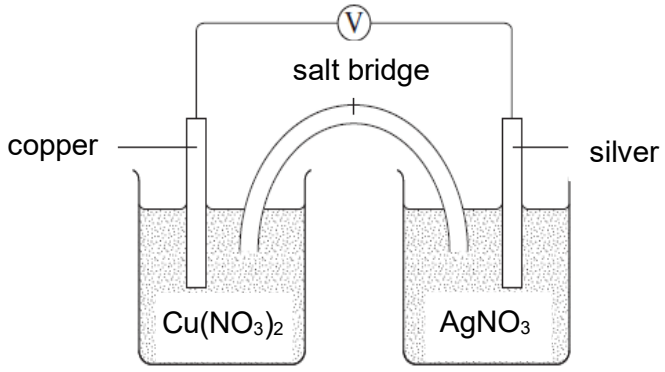


Fig. 6.1

The initial mass of each electrode was 5.0 g. After some time, the electrodes were removed from the solutions, dried and reweighed. The mass of the copper electrode had changed by 0.5 g.

(a) Explain what has caused the change in mass of the copper electrode.

……..

……..

…….. [2]

(b) Calculate the mass of the silver electrode after the experiment.

[3]

(c) Other than the changes to the electrodes, describe a change that would be **seen** in the electrochemical cell.

……..

…….. [1]

[Total: 6]

7 Butane gas is a useful hydrocarbon because it combusts to release energy. The equation for the combustion of butane is shown below:

$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$

(a) Explain in terms of bond forming and bond breaking, why energy is released in the combustion of butane.

……..

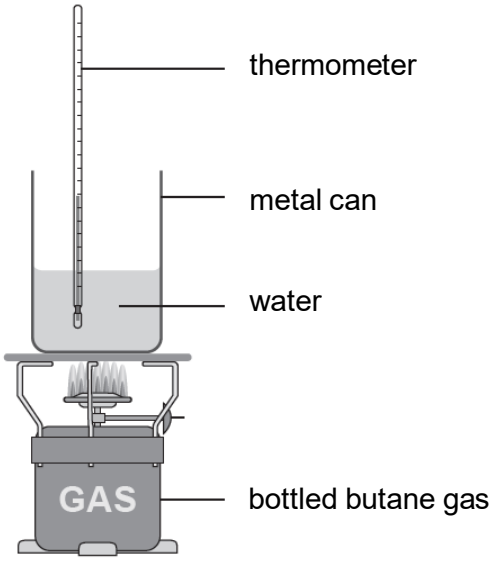
……..

……..

……... [2]

(b) Bottled butane gas is used to heat some water, as shown in the diagram below.

A student measures the temperature rise in the water and calculates that when 3.65 g of butane is combusted, 160 kJ of heat is released.



(i) Calculate the enthalpy change of combustion of butane, Δ*H* in kJ/ mol.

enthalpy change of combustion = …….. kJ/ mol [2]

(ii) The theoretical enthalpy change for the combustion reaction of butane gas is Δ*H* = –2878 kJ/mol.

Suggest two reasons why the result calculated in **(b)(i)** is different from the theoretical value.

……...

……...

……...

……..... [2]

[Total: 6]

8 Elements can be extracted from their compounds using displacement reactions and electrolysis.

(a) Bacteria can dissolve copper from mining waste to make a solution of aqueous copper(II) sulfate.

Copper, a reddish-brown solid can be extracted from the solution by adding iron to aqueous copper(II) sulfate. The metal can also be obtained through electrolysis of the solution.

(i) Write a chemical equation for the reaction when iron is added to aqueous copper(II) sulfate.

…….. [1]

(ii) Draw a clearly labelled diagram to show copper can be extracted from aqueous copper(II) sulfate by electrolysis. Indicate on your diagram where copper would be obtained.

[2]

(b) Bromine can be extracted from seawater.

Bromide compounds in the seawater react with chlorine gas in a displacement reaction. The extraction of bromine from seawater by electrolysis, however, is challenging.

(i) Construct an ionic equation, with state symbols, for the displacement reaction between chlorine gas and bromide ions. Describe what is observed in the reaction.

……

……

…… [2]

(ii) Suggest why the extraction of bromine from seawater by electrolysis is challenging.

……

…… [1]

(c) The displacement reactions of both copper and bromine involve both oxidation and reduction.

(i) For the reaction between aqueous copper(II) sulfate and iron, explain in terms of electrons, which element is oxidised and which is reduced.

……

……

……

…… [2]

(ii) For the reaction between chlorine gas and bromide ions, explain in terms of oxidation states, which substance is the oxidising agent.

……

……

……

…… [2]

[Total: 10]

9 Pure calcium carbide, CaC_2, is a colourless, crystalline solid with a melting point of 2160 °C. It was discovered by chance in 1892 by Canadian inventor, Thomas Willson, and has now become an important precursor for the manufacture of various compounds used in fertilizer production, metallurgy, pharmaceuticals and plastics.

Willson had attempted to produce aluminium by heating aluminium oxide with carbon but was unsuccessful. It occurred to him that calcium might be able to convert aluminium oxide to aluminium. To make calcium, Wilson heated a mixture of lime (calcium oxide), and coal tar (mainly carbon). However, instead of calcium, a substance that smelt like garlic was obtained together with a neutral gas. This new substance reacted vigorously when in contact with water, forming a flammable gas and an alkaline solution.

After consultation with American chemist Francis Venable, he learnt that the new substance was calcium carbide and the flammable gas produced by its reaction with water was acetylene, C_2H_2.

Willson and others proceeded to large scale manufacture of acetylene for carbide lamps and other forms of lighting as well as oxyacetylene welding apparatus.

modified from https://www.chemistryworld.com/podcasts/calcium-carbide/9355.article

(a) Carbide ions have a triple bond between two carbon atoms.

Draw a dot and cross diagram, showing outermost electrons only, for a carbide ion.

[2]

(b) By referring to reactivity of elements, explain why Willson was not successful in producing aluminium by heating aluminium oxide with carbon.

……

…….. [1]

(c) **(i)** Write an equation for the reaction between calcium carbide and water.

……..[1]

(ii) Compare this reaction with the reaction of calcium with water.

State one similarity and one difference between the two reactions.

Similarity: ……..……..……..……..……..……...

……..…… [1]

Difference: ……..……..……..……..……..……..…

……..……..……..……..……..……..……..... [1]

(d) Suggest the name of the neutral gas obtained when lime (calcium oxide) is reacted with coal tar(carbon).

……..……..……..……..……..……..…… [1]

(e) Acetylene, C_2H_2, also known as ethyne, is the first member of the alkyne homologous series.

(i) State the molecular formula of the third member of the alkyne homologous series.

……..……..……..……..……..……..……..... [1]

(ii) Explain why acetylene is an unsaturated compound.

……..……..……..……..……..……..……..

……..……..……..……..……..……..…….. [1]

(f) Aluminium can be obtained by electrolysis of molten aluminium oxide using graphite electrodes.

Industrially, pure aluminium oxide is not used as electrolyte but a mixture of molten aluminium oxide dissolved in molten cryolite, (a sodium aluminium compound) is used instead. If pure aluminium oxide is used, a temperature of 2000 °C would be needed for electrolysis. However, a much lower temperature of 1000 °C is needed if the mixture is used.

(i) Explain the advantage of using a mixture of aluminium oxide dissolved in cryolite as electrolyte over pure aluminium oxide during electrolysis.

……

…… [1]

(ii) Construct an ionic half-equation for the reaction at the anode.

…… [1]

(iii) In the electrolysis of the molten mixture, the graphite anodes need to be replaced regularly.

Suggest why this is so.

……

…… [1]

[Total: 12]

10 A series of experiments were carried out to investigate the effect of different catalysts on the rate of a reaction.

Table 10.1 shows the time taken for the reaction to complete when different metal compounds were used as catalysts.

The metal compounds contained Group 2 metals or transition metals.

Table 10.1

experiment	metal compound	temperature at start/ °C	time taken for reaction to complete/ s
1	$CoCl_2$	25	28
2	$FeCl_2$	26	21
3	$MgCl_2$	26	45
4	$Co(NO_3)_2$	25	28
5	$Fe(NO_3)_2$	26	21
6	$Mg(NO_3)_2$	25	45
7	$Fe(NO_3)_3$	25	17

(a) Explain why it is important to take note of the temperature at the start of each reaction.

……..

…… [1]

(b) Explain, in terms of particles, how a catalyst speeds up the rate of a reaction.

……..

……..

……..

…… [2]

(c) Group 2 metal compounds are less effective than transition metal compounds as catalysts.

Explain how the information in the table supports the statement.

……

…… [1]

(d) Two different iron ions were used in the experiments. Which iron ion appears to be the more effective catalyst? Explain your reasoning.

……

…… [1]

(e) State the effect of the type of anion in the catalyst compound on the rate of reaction. Justify your answer using results from the table.

……

……

……

…… [2]

(f) Suggest the chemical formula of another metal compound catalyst that would cause the reaction to be completed in 17s at 25 °C.

…… [1]

[Total: 8]

Candidate Name:	Class:	Index No:

Section B

Answer **one** question from this section.

11 Chlorine gas reacts with methane in the presence of ultraviolet (UV) light through a series of steps as shown below to produce chloromethane.

Chloromethane is a flammable gas with a melting point of -98°C and boiling point of -24°C.

1 Initiation — The formation of two reactive chlorine atoms from a chlorine molecule.

$$Cl_2 \rightarrow 2Cl$$

2 Propagation — The two-step chain reaction where a reactive chlorine atom reacts with methane to form a reactive methyl group which then reacts with a chlorine molecule to form chloromethane, CH_3Cl.

$$CH_4 + Cl \rightarrow CH_3 + HCl$$

$$CH_3 + Cl_2 \rightarrow CH_3Cl + Cl$$

3 Termination — Two reactive particles combine to form stable molecules.

$$2Cl \rightarrow Cl_2$$

$$CH_3 + Cl \rightarrow CH_3Cl$$

(a) Name the type of reaction that takes place in the presence of ultraviolet light between chlorine and methane.

…… [1]

(b) Explain why a chlorine atom Cl, is highly reactive.

……

…… [1]

(c) Suggest another possible equation for the termination stage of the reaction.

…… [1]

(d) **(i)** By considering the collision of particles, explain why the reaction of chlorine with methane typically produces a mixture of organic products instead of pure chloromethane.

……

……

……

…… [2]

(ii) Suggest which reactant, methane or chlorine, should be used in excess in order to produce more chloromethane instead of other organic products.

…….. [1]

(e) Chloromethane boils at a low temperature yet does not thermally decompose into its constituent elements. Explain why this is so in terms of structure and bonding.

……..

……..

……..

…….. [2]

(f) Describe the changes in arrangement and motion of chloromethane molecules when the temperature is increased from -100 ^{o}C to -30 ^{o}C.

……..

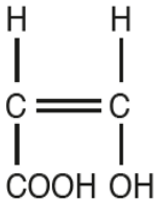
……..

……..

…….. [2]

[Total: 10]

12 The structure of compound **X** is shown.



(a) Describe a suitable test to show the presence of the hydroxyl group in the compound.

……..

……..

…… [2]

(b) **(i)** Draw the structure of the addition polymer formed from compound **X**. Show two repeating units in your structure.

[2]

(ii) Describe a chemical test to determine if all of a sample of **X** has been converted to the addition polymer.

……..

……..

……..

…….. [2]

(c) **(i)** Draw the repeat unit of the condensation polymer formed from compound **X**.

[1]

(ii) Suggest how the condensation polymer formed can be broken down to obtain its monomers.

……...

…… [1]

(d) Draw a displayed formula for a saturated isomer of compound **X**.

[1]

(e) **Y**, another member of the same homologous series as **X** has 2 more carbon atoms.

Other than melting and boiling points, state another difference in physical properties between these two members.

……..

…… [1]

[Total: 10]

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key: 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	3	4	5	6	7	8	9	10	11	12	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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