



Paya Lebar Methodist Girls' School (Secondary)
Preliminary Examination 2026
Secondary 4 Express

CANDIDATE NAME	()	CLASS	
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CENTRE NUMBER	S				
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CHEMISTRY (G3)

6092/02

Paper 2

19 August 2026

1 hour 45 minutes

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

READ THESE INSTRUCTIONS FIRST

Write your name and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft 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. Indicate the question number in the grid 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 2.

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

For Examiner's Use	
Section A	/ 70
Section B	/ 10
Qn _____	
Total	/ 80

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
Key proton (atomic) number atomic symbol name relative atomic mass							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											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
		3	4	5	6	7	8	9	10	11	12						
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 dm³ at room temperature and pressure (r.t.p.). The Avogadro constant, $L = 6.02 \times 10^{23} \text{ mol}^{-1}$.

Section A [70 marks]

Answer **all** questions.

1. Use the list of substances to answer the questions.

barium carbonate

barium nitrate

calcium sulfate

calcium oxide

magnesium nitrate

magnesium oxide

potassium chloride

potassium hydroxide

hydrochloric acid

carbonic acid

sulfuric acid

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

(a) Which substance reacts with nitric acid to produce pure potassium nitrate?

..... [1]

(b) Which **two** substances can be used to prepare pure barium sulfate?

..... and [1]

(c) Which **two** substances can be used to prepare pure magnesium chloride?

..... and excess [1]

(d) Which substance causes rain to have a pH of 4.5?

..... [1]

(e) Which substance can be added to soil to neutralise the harmful effect of acid rain?

..... [1]

[total: 5]

2. Tin is a metal that forms both ionic and covalent compounds.

(a) Tin(IV) oxide, SnO_2 , is ionically bonded and exists as an amphoteric oxide.

SnO_2 reacts with aqueous sodium hydroxide, NaOH , to form a sodium salt and water only. The sodium salt contains a negative ion with the formula SnO_3^{2-} .

(i) State the meaning of the term amphoteric.

.....

..... [1]

(ii) Write the balanced chemical equation, with state symbols, for the reaction between SnO_2 and NaOH .

..... [2]

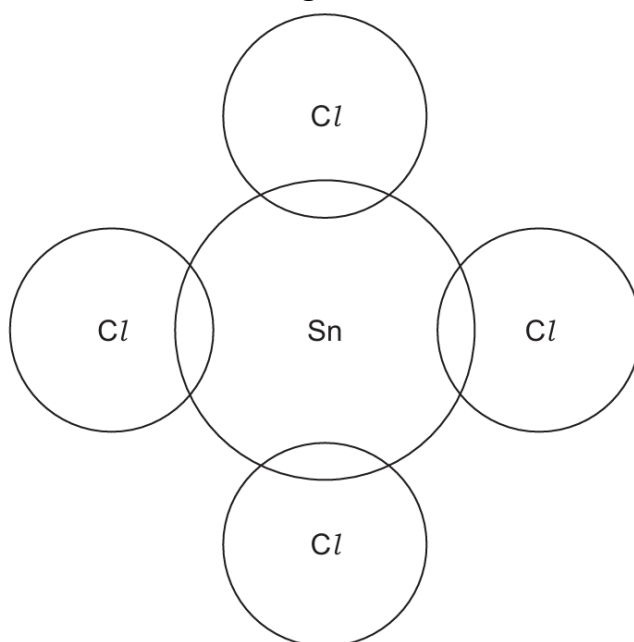
(iii) The relative formula mass, M_r , of SnO_2 is 151. Calculate the percentage by mass of tin in SnO_2 .

percentage by mass of tin in SnO_2 = ... % [1]

- (b) Tin(IV) chloride, SnCl_4 , is covalently bonded. A tin atom has four outer shell electrons.

Complete the dot-and-cross diagram in **Fig. 2.1** for a molecule of SnCl_4 . Show the outer shell electrons only.

Fig. 2.1



[2]

- (c) The melting points of SnO_2 and SnCl_4 , are shown in **Table 2.1**.

Table 2.1

	melting point / °C
SnO_2	1630
SnCl_4	– 34

Explain, in terms of structure and bonding, why SnCl_4 has a much lower melting point than SnO_2 .

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.....

.....

[3]

[total: 9]

3. Four elements, **W**, **X**, **Y** and **Z**, from Period 3 of the Periodic Table were investigated. **Table 3.1** shows some of the properties of these four elements.

Table 3.1

Element	W	X	Y	Z
Atomic radius (pm)	186	160	110	99
First ionisation energy (kJ/mol)	496	738	1012	1252
Electrical conductivity	Good	Good	Poor	Poor

- (a) First ionisation energy is the energy required to remove the outermost electron from a neutral atom in its gaseous state.

Describe and explain the relationship between atomic radius and first ionisation energy.

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..... [3]

- (b) Element **Z** produced a brown gas when heated with potassium bromide. Suggest an identity for element **Z** and provide an explanation for the observation.

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..... [2]

(c) Identify the structure and bonding that exist in element **W** and **X**. Explain your answer.

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..... [2]

(d) Predict which element is most likely to form a giant covalent oxide. Explain your answer with reference to **Table 3.1**.

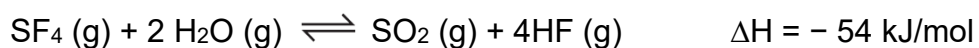
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..... [1]

[total: 8]

4. Gaseous sulfur tetrafluoride, SF₄, reacts with steam in a reversible reaction.



(a) Sketch the reaction pathway diagram in **Fig. 4.1** for the **reverse** reaction.

Include in your diagram:

- The position and the formulae of the reactants and products.
- An arrow, labelled E_a, to show the activation energy.
- An arrow, labelled ΔH_r, to show the enthalpy change of the reverse reaction.

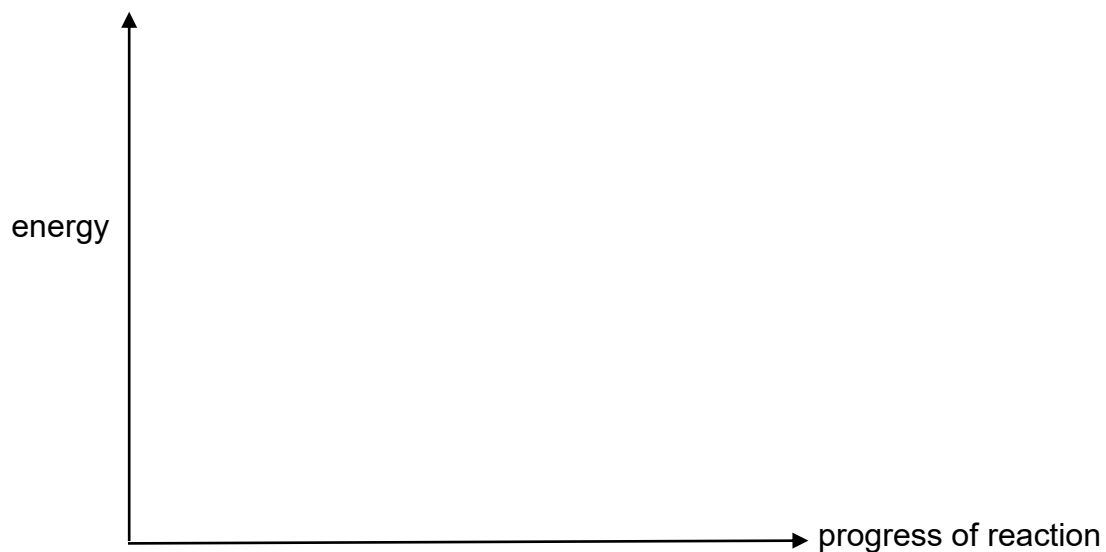


Fig. 4.1

[3]

(b) The equation for the reaction can be represented as shown in Fig. 4.2.

Fig. 4.2

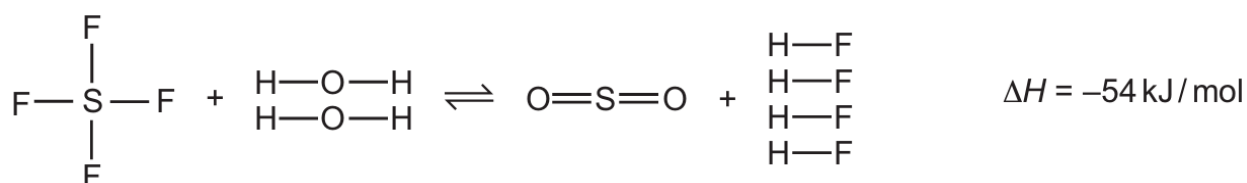


Table 4.1 shows some bond energies

Table 4.1

bond	S-F	O-H	H-F
bond energy in kJ/mol	330	460	570

- (i) Use the bond energies in Table 4.1 and the value of ΔH of the reaction to calculate the S=O bond energy in kJ/mol.

[3]

- (ii) A student suggests that the rate of reaction will increase as pressure increases.

Do you agree with her? Explain your answer with reference to the physical state of the reactants and collision theory.

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.....

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..... [2]

[total: 8]

[Turn Over

5. A student investigated the electrolysis of green copper(II) chromate solution, CuCrO_4 . Chromium is a transition metal and will form coloured compounds and ions.

Fig. 5.1 shows the apparatus.

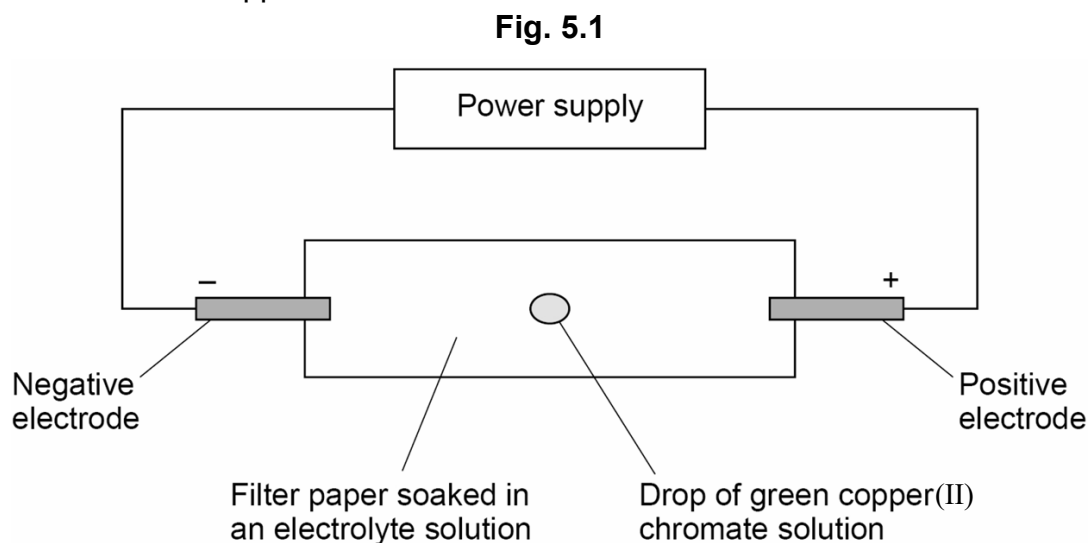
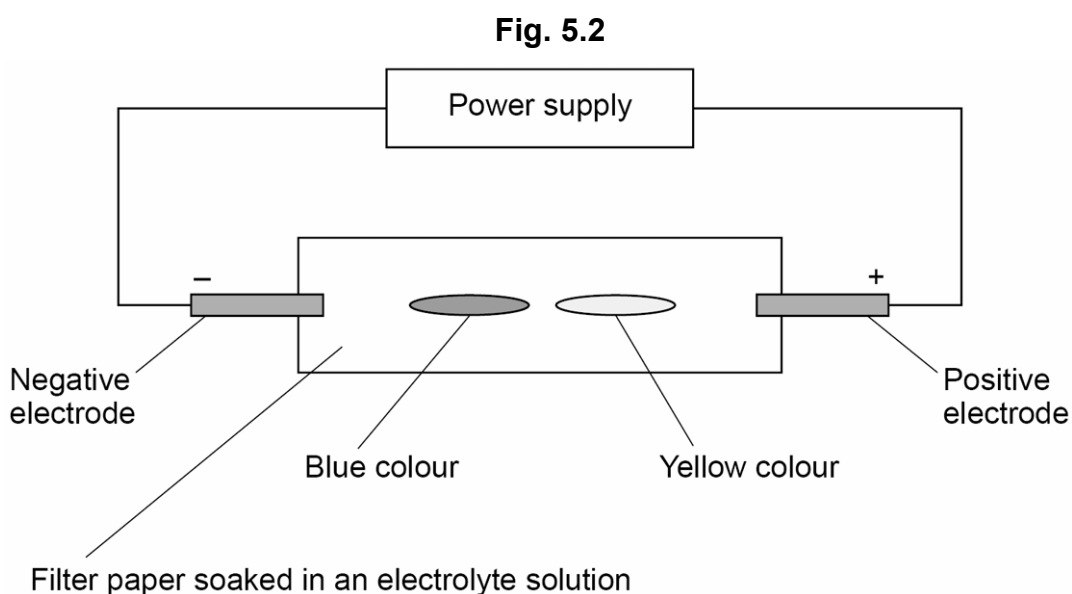


Fig. 5.2 shows the results after the power supply was turned on for 15 min.



(a) Explain the results shown in **Fig. 5.2**.

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..... [2]

- (b) Eventually, the student observed that silver deposits are formed at the negative electrode instead of the expected reddish-brown deposits.

Suggest a reason for this observation. Explain your answer.

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..... [2]

- (c) A gas that relights a glowing splint is formed at the positive electrode.

Suggest a reason for this observation. Explain your answer with the help of a balanced half equation.

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..... [2]

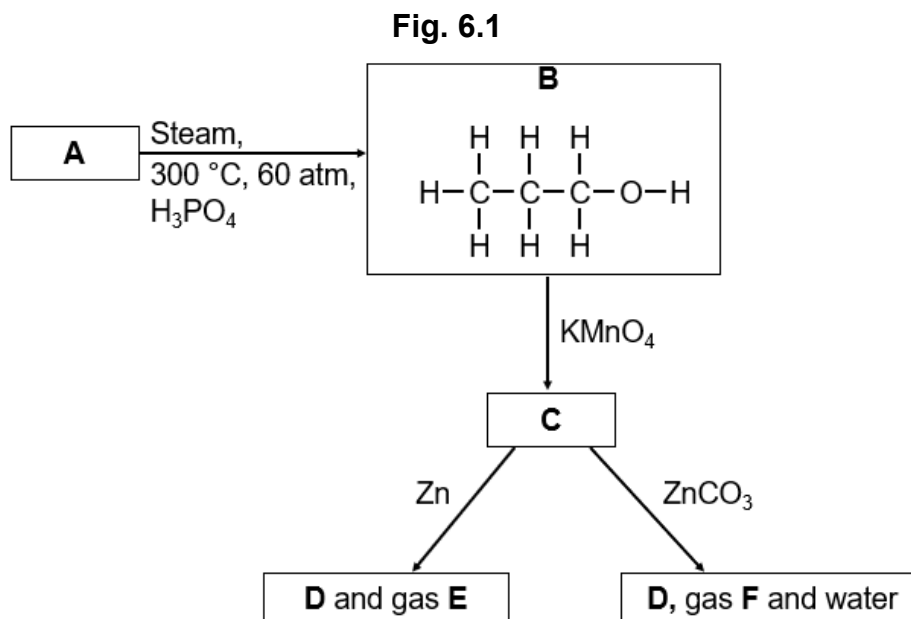
- (d) The power supply was turned off once deposits started appearing at the negative electrode, and the set up was left standing for another 15 min.

The blue and yellow spots were observed to spread out from the electrodes, but the blue spot spread out more and further away from the electrode.

Suggest a reason for the observation.

.....
.....
..... [2]
[total: 8]

6. Fig. 6.1 shows information about some chemical reactions.



(a) Write down the chemical formulae of the substances.

A:

C:

D:

E:

F:

[4]

(b) Suggest a test to distinguish between gas E and gas F.

.....

..... [1]

(c) Predict the observation when aqueous sodium hydroxide is added to the aqueous solution containing D.

.....

..... [1]

(d) Zinc carbonate also reacts with sulfuric acid and hydrochloric acid.

Table 6.1 shows the temperature rise when 2.0 g of zinc carbonate is added to 25.0 cm³ of 0.1 mol/dm³ of the three solutions separately.

Table 6.1

	C	Sulfuric acid	Hydrochloric acid
Temperature rise / °C	1.8	6.8	4.3

Explain the difference in temperature rise.

[3]

- (e)** A student said the reaction of zinc carbonate with sulfuric acid and hydrochloric acid will produce the same volume of carbon dioxide gas.

With the help of balanced chemical equations and chemical calculation, suggest why the student is wrong.

..... [3]

[3]

[Total:12]

7. The industrial production of ammonia via the Haber process involves balancing reaction rate, equilibrium yield and economic considerations.

The overall reaction is:

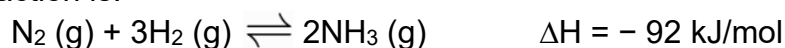
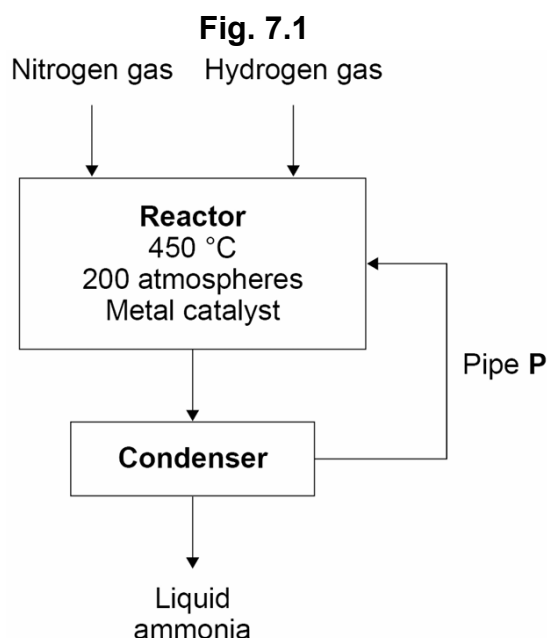


Fig. 7.1 represents the Haber process.



The production of ammonia via the Haber process plays an important role in increasing agricultural productivity as ammonia is a key ingredient in fertilisers. However, while the Haber process greatly benefits food production, it also has environmental implications as it contributes to greenhouse gas emissions. Hence, efforts are ongoing to improve the efficiency of the Haber process and reduce its environmental footprint.

A chemical engineering company evaluated different operating conditions to improve the efficiency of a new ammonia plant.

Table 7.1 shows the yield of NH_3 at equilibrium when the process is operated at 200 atm pressure and different temperatures.

Table 7.1

Temperature / °C	Equilibrium yield of NH_3 / %
350	38.5
400	31.4
450	24.8
500	18.9
550	14.1

Table 7.2 shows the yield of NH_3 at equilibrium when the process is operated at 450°C at different pressures, and the estimated annual cost to operate the plant at the respective pressures.

Table 7.2

Pressure / atm	Equilibrium yield of NH_3 / %	Annual operation cost for the plant / million dollars
100	14.5	105
150	20.3	118
200	24.8	135
250	27.9	167
300	30.1	215

Table 7.3 shows the performance of different metal catalysts that can be used for this process.

Table 7.3

Catalyst	Activation Energy / kJ mol^{-1}	Initial Rate $\times 10^{-3} / \text{mol dm}^{-3} \text{ s}^{-1}$	Catalyst Lifetime / years
Iron	72	5.8	10
Ruthenium	56	8.6	6
Cobalt	81	4.9	8

(a) With reference to **Fig. 7.1**, why is the condenser linked to the reactor via pipe **P**?

..... [1]

(b) Describe the relationship between temperature and equilibrium yield of ammonia.

..... [1]

(c) Arrange the catalysts in order of increasing catalytic effectiveness. With reference to the collision theory, explain the trend in catalytic effectiveness.

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..... [3]

- (d) A student stated that an increase in pressure will have a greater effect on the equilibrium yield of ammonia than a decrease in temperature.

Do you agree with her? Explain your answer.

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..... [3]

- (e) In terms of oxidation states, explain if the formation of ammonia via the Haber process is a redox reaction.

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..... [3]

- (f) Give one negative environmental implication that can be caused by the Haber process.

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..... [1]

[total: 12]

8. The question is about the homologous series of alcohols.

- (a) A homologous series is a family of organic compounds whose members have the same functional group.

Give **one other** characteristic for all members of a homologous series.

..... [1]

- (b) Complete **Table 8.1** by giving one advantage and one disadvantage each for methods 1 and 2 that are used to manufacture ethanol.

Table 8.1		
	Method 1 Use glucose as the starting material	Method 2 Use ethene as the starting material
advantage	1.	1.
disadvantage	2.	2.

[3]

- (c) Butane-1,4-diol has the structural formula $\text{HO}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{OH}$.

- (i) Write a balanced chemical equation for the reaction between butane-1,4-diol and ethanoic acid. What is the essential condition for this reaction to work?

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

- (ii) Butane-1,4-diol can be represented as shown.



Butanedioic acid can be represented as shown.



Draw two repeat units of the polymer formed from the reaction of butane-1,4-diol with butanedioic acid. Show all the atoms and bonds present.

[2]
[total: 8]

Section B [10 marks]

Answer **one** question from this section.

9. In an experiment, the voltage produced when nickel electrode was paired with different metal electrodes in a chemical cell is measured.

Fig. 9.1 shows the apparatus.

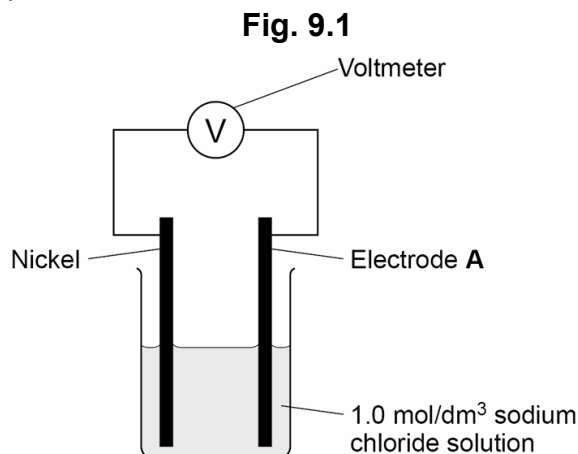


Table 9.1 shows the results.

Table 9.1

Electrode A	Symbol of metal	Voltage in volts
Copper	Cu	−0.59
Magnesium	Mg	2.12
Nickel	Ni	0.00
Silver	Ag	−1.05
Zinc	Zn	0.51

- (a) Arrange the five metals in **Table 9.1** in order of decreasing reactivity. Explain your answer.

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..... [3]

- (b) The standard electrode potential measures the tendency of the metal electrode to gain electrons under standard conditions. A negative value indicates that the metal electrode is above hydrogen in the reactivity series and is less likely to gain electrons as compared to the hydrogen electrode.

Table 9.2 shows the standard electrode potentials of magnesium, zinc and copper.

Table 9.2

$\text{Mg}^{2+} + 2\text{e}^{-} \rightarrow \text{Mg}$	- 2.38 V
$\text{Zn}^{2+} + 2\text{e}^{-} \rightarrow \text{Zn}$	- 0.76 V
$\text{Cu}^{2+} + 2\text{e}^{-} \rightarrow \text{Cu}$	+ 0.33 V

- (i) Calculate the voltage recorded when copper electrode is paired with magnesium electrode using the set up shown in **Fig. 9.1**.

[1]

- (ii) Two experiments are carried out using nickel metal and nickel(II) nitrate solution.

	Reagent	Observation
Experiment 1	Nickel is added to nitric acid.	Effervescence observed.
Experiment 2	Magnesium is added to aqueous nickel(II) nitrate.	Grey deposits observed, green solution turned colourless.

With reference to **Table 9.1** and balanced chemical equations, suggest reasons for the observations.

Experiment 1.....

.....

Experiment 2

.....

..... [4]

- (iii) Predict the standard electrode potential of nickel. Explain your answer.

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..... [2]

[total: 10]

10. Nitrogen reacts with oxygen under different conditions to form a range of oxides.

Table 10.1 shows some information about different types of oxides formed.

Table 10.1

name of oxide	chemical formula	physical state at r.t.p	boiling point / °C	oxidation state of nitrogen	effect of aqueous solution on Universal Indicator
nitric oxide	NO	gas	– 152.0	+2	green
nitrogen dioxide	NO ₂	gas	21.2	+4	red
nitrous oxide	N ₂ O	gas	– 88.5	+1	green
dinitrogen trioxide	N ₂ O ₃	liquid	3.5	+3	orange
dinitrogen tetroxide	N ₂ O ₄	solid	21.7	+4	orange
dinitrogen pentoxide	N ₂ O ₅	solid	33.0		red

(a) Fill in the oxidation state of nitrogen in dinitrogen pentoxide in **Table 10.1**.

[1]

(b) Deduce the relationship between the oxidation states of nitrogen and the nature of its oxide.

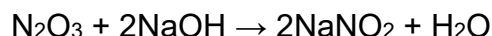
.....
 [1]

(c) Describe how a mixture of nitric oxide, nitrogen dioxide and nitrous oxide can be separated.

.....

 [3]

- (d) Solutions of nitrogen dioxide and dinitrogen trioxide react with aqueous sodium hydroxide according to the equations below.



- (i) For which compound nitrogen dioxide or dinitrogen trioxide would you expect the rate of reaction with sodium hydroxide to be slower?

Explain your answer, in terms of concentration of ions and collisions.

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

- (ii) In one reaction, 20.0 cm³ of 1.0 mol/dm³ aqueous sodium hydroxide completely reacted with a sample of nitrogen dioxide.

What volume of the same concentration of calcium hydroxide would be required to react with the same amount of nitrogen dioxide?

..... [1]

- (iii) Like nitrogen dioxide, carbon dioxide also reacts with aqueous calcium hydroxide. What difference would be observed in the two reactions?

..... [1]

- (e) State one negative impact that oxides of nitrogen would have on the environment.

.....
..... [1]
[total: 10]

END OF PAPER