RIVER VALLEY HIGH SCHOOL
SEC 4 END-OF-YEAR EXAMINATION

CHEMISTRY
PAPER 1
9 OCTOBER 2023
1 HOUR

NAME				
CLASS	4		**INDEX NO.**	

READ THESE INSTRUCTIONS FIRST

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number in the spaces provided.

There are **forty** questions in 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 provided.

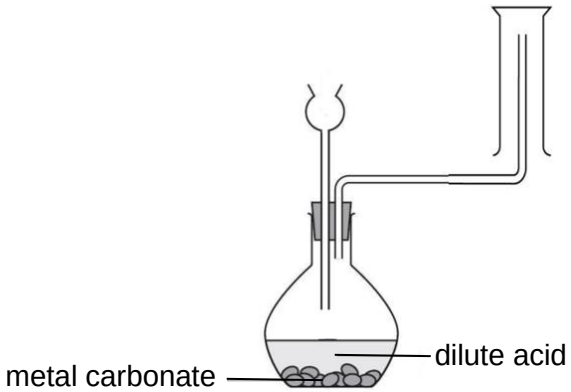
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page **16**.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **16** printed pages.

1 A scientist wants to collect a dry sample of an unknown gas, which turns moist blue litmus paper red. Which row shows the most suitable drying agent and collection method?

	drying agent	collection method
A	calcium oxide	gas syringe
B	concentrated sulfuric acid	upward delivery
C	fused calcium chloride	gas syringe
D	fused calcium chloride	upward delivery

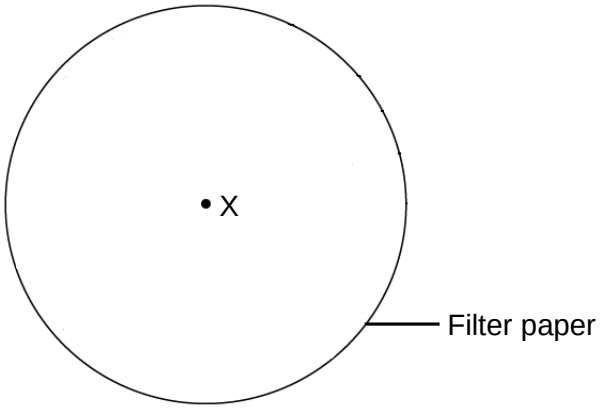
2 The diagram below shows an experimental set-up to collect the gas produced from the reaction between a metal carbonate and a dilute acid.



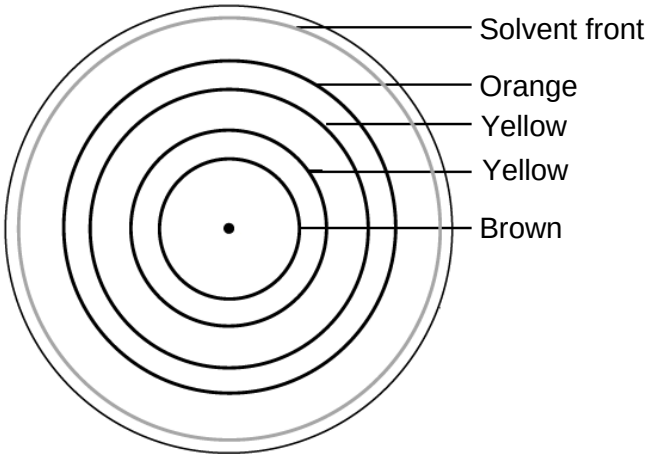
Which row shows the reactant to be added first in the flask and the number of errors in the set-up?

	reactant to be added first to the flask	number of errors
A	dilute acid	1
B	metal carbonate	1
C	dilute acid	2
D	metal carbonate	2

3 A solution of food dyes in a soft drink was extracted for analysis by paper chromatography. Two drops of the solution were placed at the centre of the circular filter paper, labelled X, as shown in the diagram below.



The filter paper was left to dry. Then, 10 drops of ethanol were slowly added to the centre of the filter paper and the chromatogram was left to develop. After some time, coloured circles were seen, as shown in the diagram below.



From the results above, which of the following statements about the soft drink is true?

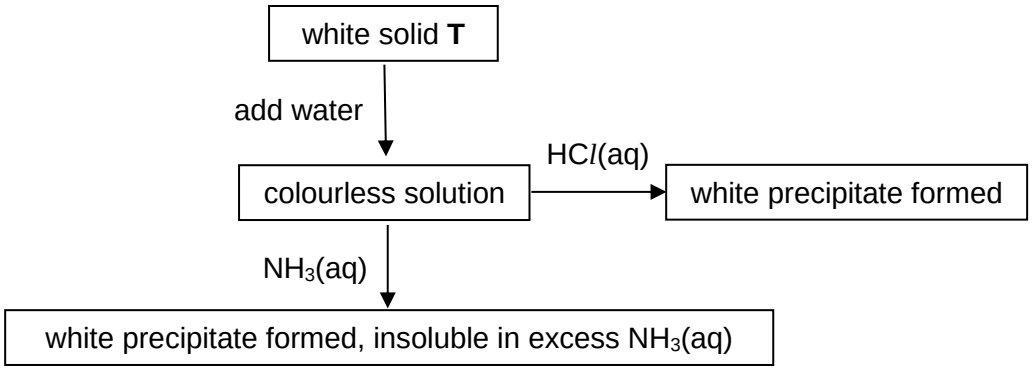
A It contains only three different food dyes.

B It contains some food dyes that are not soluble in ethanol.

C It contains food dyes that are soluble in ethanol.

D It is yellow in colour.

4 Tests are carried out on a sample of solid **T** as shown in the diagram below.



What is the identify of solid **T**?

A zinc nitrate

B aluminium sulfate

C lead(II) nitrate

D sodium sulfate

5 Which mixture of gases would change the colour of moist red litmus paper?

Mixture 1: Ammonia and carbon monoxide

Mixture 2: Oxygen and chlorine

Mixture 3: Sulfur dioxide and nitrogen monoxide

A 1 and 2 only

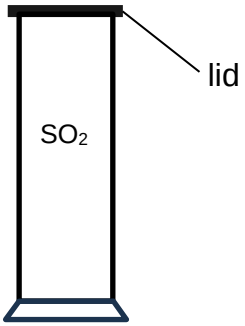
B 2 and 3 only

C 1 and 3 only

D 1, 2 and 3

6 The following shows 4 gas jars filled with different gases. The lid of each gas jar is then taken off and each gas jar is left open to the air for a few hours. Which gas jar will have most of the original gas in it at the end of the few hours?

A



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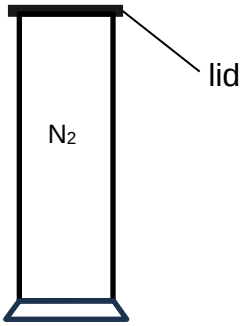
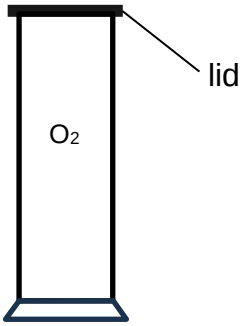
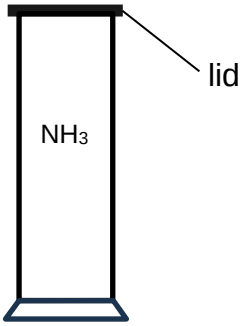


C

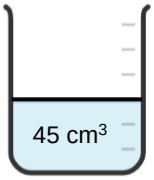


D

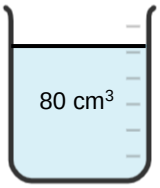


7 4 different beakers (**A**, **B**, **C** and **D**) were filled with 100 cm^3 of 4 different liquids and left on top of a table for a fixed length of time. Which of the beakers is filled with liquid with the lowest boiling point?

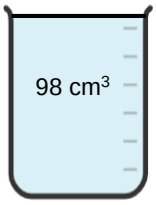
A



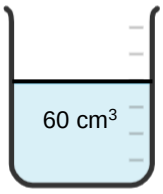
B



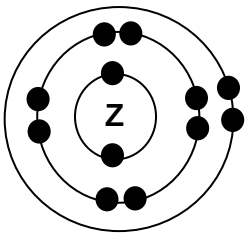
C



D



8 The diagram below shows the arrangement of electrons inside an atom **Z**.



State the identity of element **Z**.

A O **B** Ne **C** Mg **D** Ca

9 Four atoms and the ions they form are described in the table below.

atom	ion	number of electrons in ion	relative mass
P	$\mathbf{P}^{2+}$	23	57
Q	$\mathbf{Q}^{3+}$	23	58
R	$\mathbf{R}^{2+}$	24	56
S	$\mathbf{S}^{2+}$	26	58

Which two atoms are isotopes?

A **P** and **S** **B** **P** and **R**

C **Q** and **S** **D** **Q** and **R**

10 Which two substances conduct electricity using mobile ions?

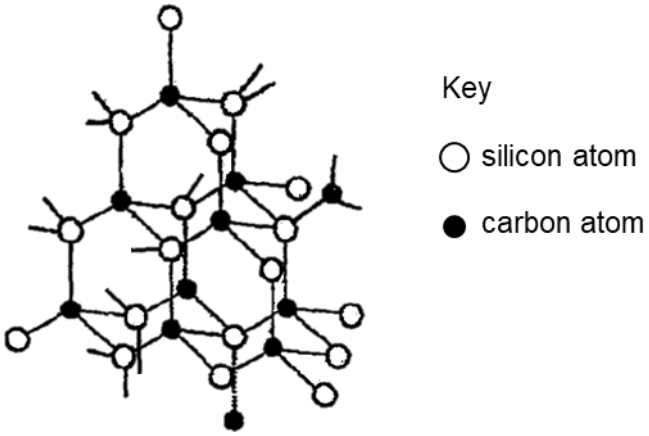
A manganese(IV) oxide and silicon

B calcium and hydrochloric acid

C graphite and sodium chloride

D ammonia solution and copper(II) nitrate

11 The diagram shows the structure of silicon carbide.



Which information about silicon carbide is correct?

	empirical formula	when strongly heated in oxygen
A	Si_2C	burns, giving a solid residue and a colourless gas
B	Si_2C	burns, giving a colourless gas only
C	SiC	burns, giving a solid residue and a colourless gas
D	SiC	burns, giving a colourless gas only

12 Which is the same for equal volumes of 1.00 mol dm^{-3} solutions of hydrochloric acid and ethanoic acid?

A pH of solution

B concentration in g dm^{-3}

C electrical conductivity of solution

D number of moles of sodium hydroxide required for complete neutralisation

13 The percentage by mass of iron in haemoglobin is 0.328%. The relative molecular mass of a haemoglobin molecule is 68000.

How many iron atoms are there in one haemoglobin molecule?

A 3 **B** 4

C 5 **D** 6

14 If there are *n* molecules in 10.0 g of hydrogen gas, how many molecules are there in 110 g of carbon dioxide gas?

A 0.25 *n* **B** 0.5 *n*

C *2 n* **D** 4 *n*

15 Phosphorus reacts with bromine to produce phosphorus tribromide.

$$2P + 3Br_2 \rightarrow 2PBr_3$$

What mass of phosphrous tribromide is produced when 6.55 g of phosphorus is added to 400 cm^3 of 0.700 mol dm^{-3} bromine solution?

[M_r: P, 31.0; Br, 79.9]

A 50.5 g **B** 57.2 g

C 75.8 g **D** 114 g

16 The following reactions are carried out.

reaction	result
aqueous sodium hydroxide is added to ammonium carbonate	gas **E** is given off
compound **F** is added to water containing Universal indicator	Universal indicator turns from green to red

What is gas **E** and compound **F**?

	gas **E**	compound **F**
A	ammonia	nitrogen monoxide
B	ammonia	nitrogen dioxide
C	carbon dioxide	nitrogen monoxide
D	carbon dioxide	nitrogen dioxide

17 Given a supply of dilute hydrochloric acid, aqueous sodium carbonate and aqueous lead(II) nitrate, how many different pure salts could be prepared?

A 0 **B** 1

C 2 **D** 3

18 The reaction representing the Haber Process is represented by the following equation:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Which of the following changes in reaction conditions in the Haber Process will decrease the activation energy of the reaction?

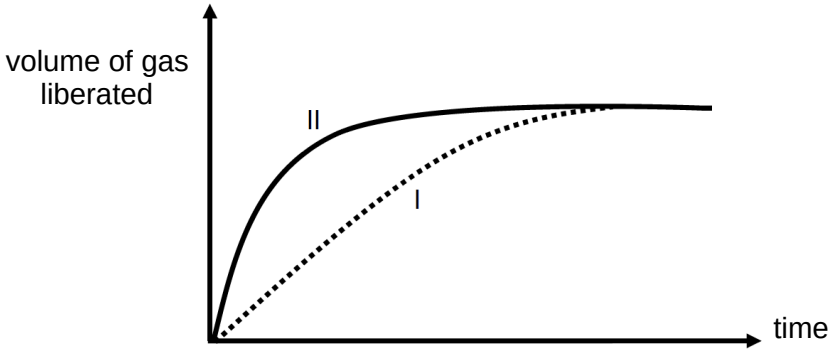
A using iron catalyst

B increasing the temperature

C increasing the amount of nitrogen present

D increasing the amount of ammonia present

19 An investigation was carried out to study the reaction between calcium carbonate and 50 cm^3 of excess acid.



Which change is **not** likely to result in the difference between experiments **I** and **II**?

	experiment I	experiment II
A	calcium carbonate granules was used	calcium carbonate powder was used
B	0.100 mol dm^{-3} HC*l* was used	0.200 mol dm^{-3} HC*l* was used
C	0.100 mol dm^{-3} H_2SO_4 was used	0.200 mol dm^{-3} HNO_3 was used
D	reaction was carried out at 30 °C	reaction was carried out at 50 °C

20 In which reaction is the underlined substance acting as the reducing agent?

A $\underline{Cl_2} + 2FeCl_2 \rightarrow 2FeCl_3$

B $H_2 + \underline{CuO} \rightarrow Cu + H_2O$

C $2\underline{HCl} + MgO \rightarrow MgCl_2 + H_2O$

D $ZnO + 2\underline{CO} \rightarrow Zn + 2CO_2$

21 A student wants to electroplate a silver spoon with gold. Below are four statements for the electroplating process.

1 The spoon is the anode.

2 The gold is the anode.

3 The electrolyte used is aqueous silver nitrate solution.

4 The concentration of the electrolyte decreases during electroplating.

Which statements are correct?

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

22 In an electrolysis experiment, the same amount of charge deposited 32.0 g of copper and 17.0 g of vanadium. The charge on the copper ion was 2+.

What was the charge on the vanadium ion?

A 1+ **B** 2+

C 3+ **D** 4+

23 $\Delta H_{lattice}$ can be defined as the energy given out when gaseous ions combine to form one mole of solid giant ionic lattice. The stronger the attractive force between the ions in the crystal, the greater the amount of energy evolved.

Which of the following compounds would you expect to have the most negative $\Delta H_{lattice}$?

A NaF **B** NaC*l* **C** NaBr **D** NaI

24 In an experiment, 50 cm^3 of 0.25 mol dm^{-3} $AgNO_3$ was added to 50 cm^3 of 0.25 mol dm^{-3} KC*l*. 1575 J of energy was evolved. What is the amount of energy evolved when 100 cm^3 of 0.25 mol dm^{-3} $AgNO_3$ is added to 200 cm^3 of 0.25 mol dm^{-3} KC*l* instead?

A 787.5 J **B** 1575 J **C** 3150 J **D** 6300 J

25 In which of the following is there a positive enthalpy change?

A melting

B burning methane in air

C adding of a strip of magnesium into hydrochloric acid

D respiration

26 Which statement describes changes in the elements from left to right across a period of the Periodic Table?

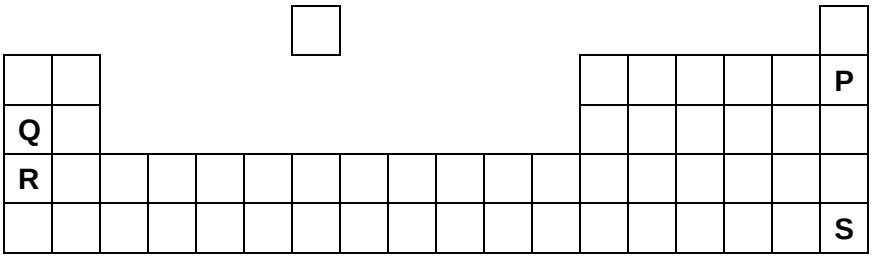
A The melting point decreases.

B The metallic character decreases.

C The number of neutrons decreases.

D The number of electron shells increases.

27 The positions of the elements **P**, **Q**, **R** and **S** are shown in the outline of part of the Periodic Table.



Which of the following shows the elements in order of increasing melting point?

A **P**, **Q**, **R**, **S**

B **P**, **S**, **Q**, **R**

C **P**, **S**, **R**, **Q**

D **S**, **P**, **R**, **Q**

28 Experiments were carried out on three halogens **X**, **Y**, and **Z**.

The ionic equations of the experiments are shown.

$$\mathbf{X}^-(aq) + \mathbf{Y}_2(aq) \rightarrow \text{no reaction}$$

$$\mathbf{Z}^-(aq) + \mathbf{X}_2(aq) \rightarrow \text{no reaction}$$

$$2\mathbf{Y}^-(aq) + \mathbf{Z}_2(aq) \rightarrow \mathbf{Y}_2(aq) + \mathbf{Z}^-(aq)$$

What is the order of reactivity of the halogens?

	most reactive ⟶ least reactive		
A	**Z**	**X**	**Y**
B	**Y**	**X**	**Z**
C	**X**	**Y**	**Z**
D	**Z**	**Y**	**X**

29 The table below shows the reaction of four metals, **W**, **X**, **Y**, and **Z**.

metal	reaction with dilute sulfuric acid	reaction with aqueous sulfate of **W**
W	no effervescence observed	no reaction
X	effervescence observed	grey solid deposited effervescence observed
Y	no effervescence observed	no reaction
Z	effervescence observed	grey solid deposited

What is the order of reactivity of the metals?

	least reactive →			most reactive
A	**W**	**Y**	**X**	**Z**
B	**W**	**Y**	**Z**	**X**
C	**Y**	**W**	**X**	**Z**
D	**Y**	**W**	**Z**	**X**

30 Which of the following iron sheets will be **least** likely to rust?

A Coated with zinc but has some scratches exposing the iron below.

B Coated with a layer of grease but has one side exposed.

C Coated with a layer of copper but has one side exposed.

D Coated with paint but has some scratches exposing the iron below.

31 Many countries have measures to reduce the amount of sulfur in unleaded petrol and diesel fuels. Which of the following could be a reason for such measures?

A To cut down the amount of fuel used in motor vehicles.

B To protect the ozone layer.

C To reduce the acidity of rain.

D To prevent the formation of photochemical smog.

32 Which statement about the fractional distillation of petroleum is correct?

A Pure compounds are collected in each fraction.

B The lowest part of the column has the lowest temperature.

C The molecules at the bottom of the column are the least flammable.

D The molecules reaching the top of the column produce the most soot when burnt.

33 Which of the following contain possible products formed when butane undergoes substitution reaction with excess chlorine gas?

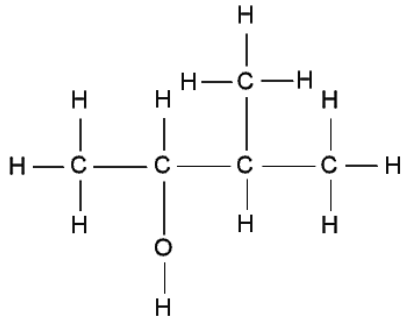
A HC*l* and C_4Cl_{10}

B HC*l* and CCl_4

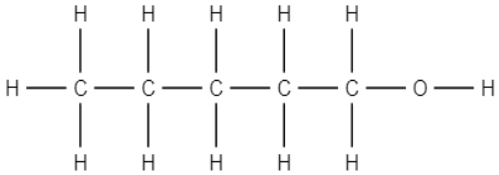
C H_2 and $C_4H_8Cl_2$

D CCl_4 and C_3H_8Cl

34 Which option is **not** an isomer of the compound shown below?



A



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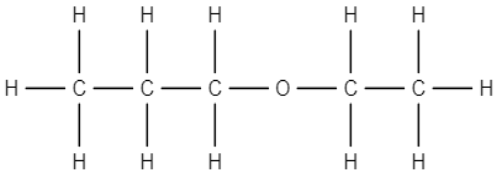

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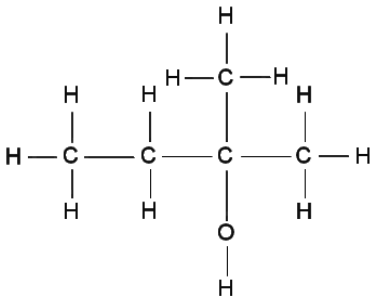
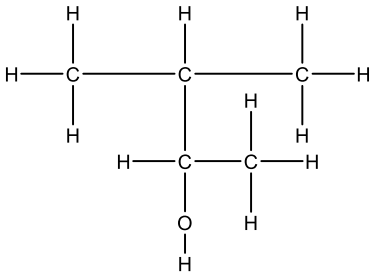


D



35 10 cm^3 of a hydrocarbon compound was completely burnt in excess oxygen. The total volume of the gaseous products formed was 80 cm^3. Which equation represents this combustion reaction?

A $2C_3H_6(g) + 9O_2(g) \rightarrow 6CO_2(g) + 6H_2O(g)$

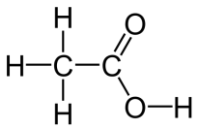
B $C_4H_8(g) + 6O_2(g) \rightarrow 4CO_2(g) + 4H_2O(g)$

C $C_4H_{10}(g) + 4O_2(g) \rightarrow 3CO(g) + 5H_2O(g) + C(s)$

D $C_8H_{16}(l) + 12O_2(g) \rightarrow 8CO_2(g) + 8H_2O(g)$

36 Compound **X** is oxidised to form an organic compound **Y** with an empirical formula of C_2H_4O. Given that compound **Y** has a M_r of 88.0, which of the following is the reactant compound **X**?

A



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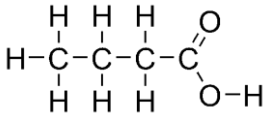

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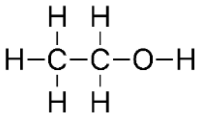
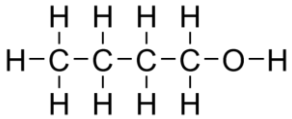


D



37 The molecular formula of vinyl chloride is $C_2H_4Cl_2$.

Which of the following reactions can produce this compound?

Reaction 1: Addition of chlorine to ethene

Reaction 2: Addition of hydrogen chloride to ethene

Reaction 3: Substitution reaction of ethane with chlorine

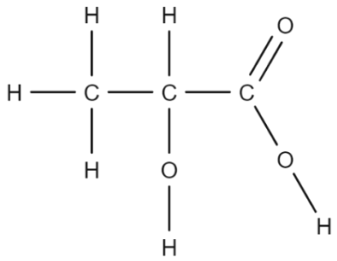
A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

38 Lactic acid can be found in sour milk. The structural formula of lactic acid is shown below.



Which statement about lactic acid is **false**?

A It is soluble in water.

B It decolourises liquid bromine rapidly.

C It undergoes complete combustion to produce carbon dioxide and steam only.

D Two molecules of lactic acid may react with each other in the presence of concentrated sulfuric acid and heat.

39 The ester $C_2H_5COOC_3H_7$ has a fragrance that smells like pineapple and pear. Which of the acids is used to synthesise this ester?

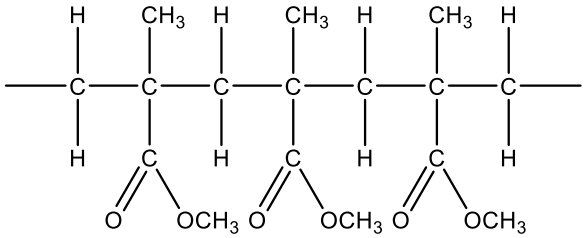
A methanoic acid

B ethanoic acid

C propanoic acid

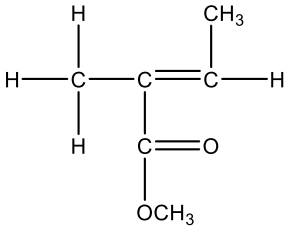
D butanoic acid

40 The diagram below represents part of a plastic polymer molecule.

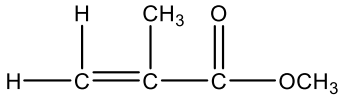


Which of the following shows the structure of the monomer used to make this polymer?

A



B



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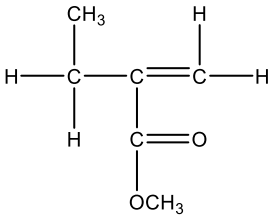
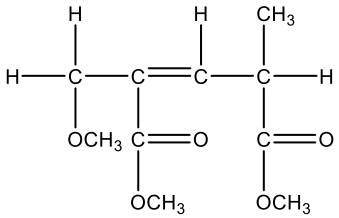


D



The Periodic Table of Elements

I	II						III	IV	V	VI	VII	0
						1 H hydrogen 1.0						2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0						5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3						13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57 – 71 lanthonoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	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 –

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

lanthonoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodynium 144.2	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einstenium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

Avogadro's constant is 6.02×10^{23} mol^{-1}

Molar gas volume at standard temperature and pressure (s.t.p.) is 22.7 dm^3 mol^{-1}

Molar gas volume at room temperature and pressure (r.t.p.) is 24 dm^3 mol^{-1}

RIVER VALLEY HIGH SCHOOL
SEC 4 END-OF-YEAR EXAMINATION

CHEMISTRY
PAPER 2
9 OCTOBER 2023
1 HOUR 45 MINUTES

NAME _____

CLASS 4 _____ **INDEX NO.** _____ _____

READ THESE INSTRUCTIONS FIRST

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Read these notes carefully.
Write your name, class and index number in the spaces at the top of this page.
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 **all** questions.
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 **20**.

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

FOR EXAMINERS' USE ONLY	
PAPER 1 (30%)	**/ 40**
PAPER 2 (50%)	**/ 80**
PAPER 3 (20%)	**/ 40**
A1	/ 5
A2	/ 12
A3	/ 8
A4	/ 6
A5	/ 8
A6	/ 11
B7	/ 12
B8	/ 8
B9	/ 10
Statements	
Significant Figures	
Units	
TOTAL	**/ 100%**

This document consists of **18** printed pages and **2** blank pages.

Section A

Answer **all** questions.

A1 Use the list of substances to answer the questions.

lead(II) hydroxide

lead(II) nitrate

magnesium chloride

magnesium oxide

sodium sulfate

sulfuric acid

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

(a) Which substance should be reacted with hydrochloric acid to produce pure lead(II) chloride?

……..……..…… [1]

(b) Which substance must be prepared by titration?

……..……..…… [1]

(c) Which **two** substances should be reacted to produce pure magnesium sulfate?

…… and excess ……..……..…… [2]

(d) Which magnesium compound and lead(II) compound can be separated by adding water followed by filtration?

……..……..…… [1]

[Total: 5]

A2 **(a)** Potassium metal reacts with water to form solution **A** and gas **B**. When solution **A** reacts with dilute hydrochloric acid, solution **C** is formed.

(i) Write a chemical equation for the reaction of potassium metal with water to form solution **A** and gas **B**.

……..…… [1]

(ii) Write a chemical equation for the reaction of solution **A** with hydrochloric acid to form solution **C**.

……..…… [1]

(iii) Explain why the melting points of potassium and gas **B** are different.

……..……

……..…..……..

……..…..……..

……..…..……..

……..…..…….. [3]

(iv) Describe and explain the change in the size of the potassium atom as it reacts to produce potassium ions in solution **A**.

……..……

……..…..……..

……..…..…….. [2]

(v) Draw a dot-and-cross diagram to show the bonding of the salt in solution **C**.

[1]

(b) Unlike potassium and other Group I elements, iron is less reactive and cannot react with water.

(i) Give **two** other properties of iron that do not fit with the properties of the elements in Group I.

……..……

……..…..…….. [2]

(ii) Give **two** similarities between iron and the elements in Group I.

……..……

……..…..…….. [2]

[Total: 12]

A3 **(a)** Nitrous acid, HNO_2, is a weak monoprotic acid.

(i) Write a chemical equation to show the dissociation of nitrous acid in water.

……..…...…….. [1]

(ii) Nitrous acid can be produced by the following chemical reaction.

$$N_2O_3 + H_2O \rightarrow 2HNO_2$$

Deduce whether N_2O_3 reacts with aqueous sodium hydroxide. Explain your answer.

……..……

……..…...…….. [1]

(b) A student was given two samples of nitrous acid solutions. One of them was contaminated by a silver salt. To determine which sample was contaminated, electrolysis was carried out on both samples.

It is known that the anion of nitrous acid is not discharged during electrolysis.

(i) The student recorded the observations of the electrolysis of one sample of nitrous acid in Table 3.1.

Table 3.1

observation	half-equation	electrode
gas relights a glowing splint.		cathode / anode
gas extinguishes a lighted splint with a 'pop' sound.		cathode / anode

Complete Table 3.1 by writing the half-equations and circling the type of electrode where the reaction is taking place. [3]

(ii) Hence, write the overall equation for the electrolysis in **(b)(i)**.

……..……. [1]

(iii) Suggest briefly if the sample of nitrous acid electrolysed in **(b)(i)** is contaminated by a silver salt.

……..…….

……..…...…….. [1]

(iv) The electrolysis method is **not** always suitable to determine if a sample of nitrous acid is contaminated. With reference to the redox series, explain why.

……

…… [1]

[Total: 8]

A4 At ambient temperatures, the free oxygen and nitrogen in the air do not react. However, in an internal combustion engine the temperature is high enough for a reaction to take place. The formation of nitrogen monoxide starts at about 1200 °C.

Fig 4.1 shows how the rate of formation of nitrogen monoxide changes with temperature.

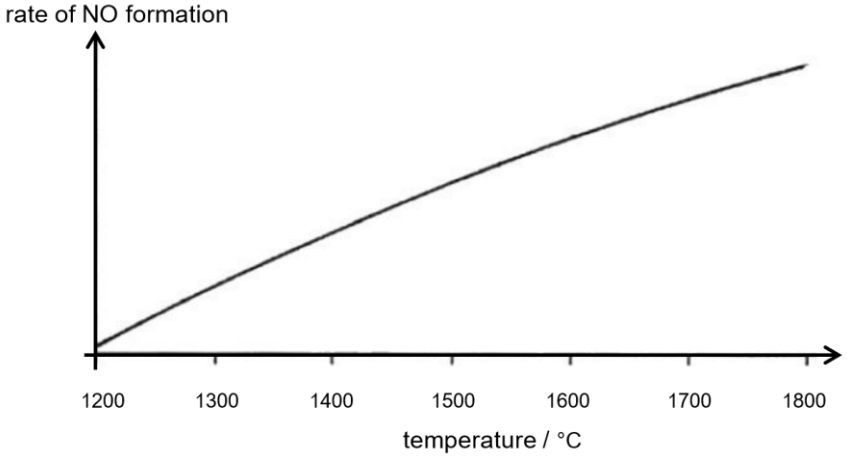


Fig. 4.1

(a) Write an equation to show how nitrogen monoxide is formed in an internal combustion engine.

…… [1]

(b) Explain the shape of the graph above using ideas about colliding particles.

……

……

……

……

……

……

…… [3]

(c) To remove nitrogen monoxide and other pollutant gases, a catalytic converter is attached to the exhaust pipe underneath a car. It is a metal box with a ceramic honeycomb inside. The honeycomb is coated with a mix of metals such as platinum, palladium, and rhodium.

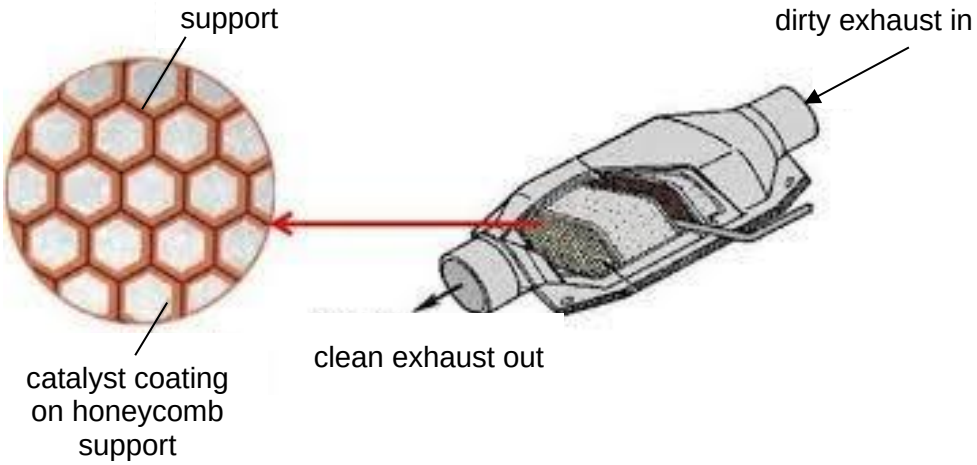


Fig. 4.2

Suggest why the catalytic converter is shaped in a honeycomb structure.

……

…… [1]

(d) Three-way catalytic converters are used in motor vehicles nowadays. Besides removing carbon monoxide and oxides of nitrogen, a three-way catalytic converter also converts unburnt hydrocarbons in exhaust gases into harmless gases.

Write a balanced chemical equation to show the removal of one such unburnt hydrocarbon, C_4H_{10}.

…… [1]

[Total: 6]

A5 **(a)** Define what *oxidation* and *reduction* are in terms of oxidation state.

……

…… [1]

(b) Metal compounds are often heated to high temperatures to convert them into metal oxides for further processing. Below are two examples of such conversions:

Reaction 1: $2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$

Reaction 2: $CuSO_4.5H_2O(s) \rightarrow CuO(s) + H_2SO_4(aq) + 4H_2O(g)$

Explain, in terms of oxidation states, if these reactions are redox reactions.

……

……

……

……

……

…… [3]

(c) A student studied the action of heat on 4 different substances, **A**, **B**, **C** and **D**. She knew that two of them were metals, and the other two were metal carbonates.

She weighed out 4.00 g of each solid and heated them in separate crucibles. Table 5.1 shows the masses of the four solids before and after strong heating.

Table 5.1

	mass / g	
solid	before	after
A	4.00	2.58
B	4.00	5.38
C	4.00	4.00
D	4.00	5.00

Based on the data given in Table 5.1, suggest and explain which two solids are:

(i) metals

……

……

…… [2]

(ii) metal carbonates

……

……

……

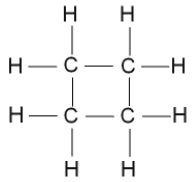
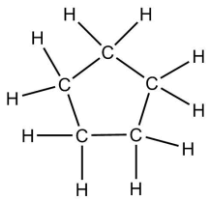
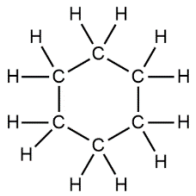
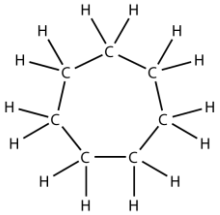
…… [2]

[Total: 8]

A6 **(a)** Cyclopentane belongs to the cycloalkanes homologous series.

Table 6.1 shows some information of cyclopentane and three other members of cycloalkanes.

Table 6.1

full structural formula	name of compound	molecular formula	boiling point/ °C
	cyclobutane	C_4H_8	12.5
	cyclopentane	C_5H_{10}	?
	cyclohexane	C_6H_{12}	80.8
	cycloheptane	C_7H_{14}	118.1

(i) Using the information in Table 6.1, state **two** evidence that suggest that the four compounds belong to the same homologous series.

……

……

…… [2]

(ii) Using the information in Table 6.1, predict the boiling point of cyclopentane.

…… [1]

(iii) Both pent-1-ene and cyclopentane are hydrocarbons with the same molecular formula C_5H_{10}.

Does pent-1-ene belong to the same homologous series as the four compounds shown in Table 6.1? Explain.

……

…… [1]

(iv) Describe a chemical test to differentiate pent-1-ene from cyclopentane.

……

……

…… [2]

(b) (i) Pent-1-ene can be obtained from cracking a larger alkane from crude oil. Suggest a chemical equation to show how pent-1-ene can be obtained from cracking of $C_{20}H_{42}$.

…… [1]

(ii) There are two general methods of cracking, namely catalytic cracking and thermal cracking. Suggest a reason why it is more economically advantageous to use catalytic cracking.

……

…… [1]

(c) (i) Apart from cracking, alkenes can also be obtained from alcohols.

Name the type of reaction that can synthesise pent-1-ene from pentan-1-ol.

…… [1]

(ii) Draw two other isomers of pentan-1-ol, such that one of these isomers has a different functional group from pentan-1-ol.

[2]

[Total: 11]

Section B

Answer **all** questions.

B7 In temperate countries, ice can form on roads during winter, causing cars to skid on the slippery surface of solid ice.

The surface of ice has a very thin layer of water. De-icers are substances that can be added to this layer of water where it dissolves and stops the water from freezing. De-icers also help to melt the solid ice under the layer of water. By adding de-icers onto roads during winter, accidents due to cars skidding on the slippery surface of ice can be minimised.

Table 7.1 shows a few de-icers. ΔH_{sol} represents the enthalpy change that happens when the de-icer dissolves. 'Lowest effective temperature' represents the temperature at which water freezes in the presence of the de-icer.

Table 7.1

de-icer	lowest effective temperature / ^{o}C	ΔH_{sol} / kJ mol^{-1}
sodium chloride, NaC*l*	−7	+3.9
magnesium chloride, MgCl_2	−18	−155
urea, CH_4N_2O	−4	+15.0

(a) One of the functions of de-icers is to melt the ice on roads.

(i) State whether the addition of de-icer increases or decreases the melting point of ice.

……..……..…… [1]

(ii) Explain how your answer in **(a)(i)** causes the de-icer to work.

……..……..……

……..……..…… [1]

(b) Using the information given in Table 7.1, suggest why magnesium chloride is a better de-icer than sodium chloride and urea.

……..……..……..

……..……..……..

……..……..……..

……..……..……..

……..……..…….. [2]

(c) Draw the energy level diagram of sodium chloride dissolving in water.

[2]

(d) One of the de-icers, sodium chloride, is a salt that can be made from the neutralisation between aqueous sodium hydroxide and hydrochloric acid as shown below:

$$NaOH(aq) + HCl\ (aq) \rightarrow NaCl(aq) + H_2O(l) \quad \Delta H = -56.7\ kJ\ mol^{-1}$$

(i) Calculate the amount of energy evolved when 1 kg of sodium chloride is made from the reaction between aqueous sodium hydroxide and hydrochloric acid.

[2]

(ii) Write down the ionic equation for the neutralisation between aqueous sodium hydroxide and hydrochloric acid.

……..…… [1]

(e) The de-icer urea can be synthesised commercially from ammonia and carbon dioxide as shown.

$$2NH_3 + CO_2 \rightarrow CH_4N_2O + H_2O$$

(i) Given that urea contains one C=O bond and two C-N bonds, draw the full structural formula of urea.

[1]

(ii) Using the bond energy values provided in Table 7.2, calculate the enthalpy change of the reaction in **(e)**.

Table 7.2

bond	energy/ kJ mol^{-1}	bond	energy/ kJ mol^{-1}	bond	energy/ kJ mol^{-1}
H–H	436	C–C	350	O–H	460
N–H	390	C–H	410	C–O	360
N–N	160	C–N	305	C=O	740
N=N	410	C=N	615		
N≡N	994	C≡N	890		

[2]

[Total: 12]

B8 One of the constituents of Lycra, a fabric used in swimwear, is polyurethane with the following structure:

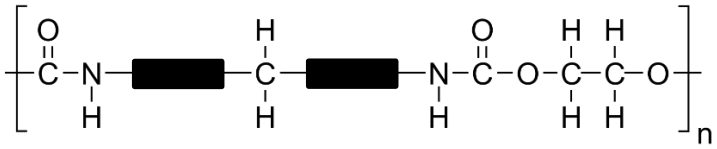


Fig. 8.1

(a) **(i)** Polyurethane can be synthesised from monomers **A** and **B**. Monomer **A** is shown in Fig. 8.2.

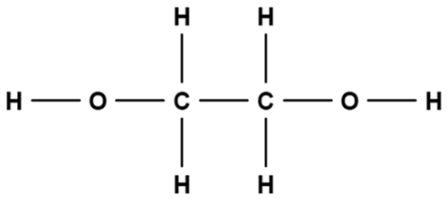


Fig. 8.2

Given that water molecules are eliminated in the synthesis of polyurethane, draw the structure of the other monomer, **B**.

[1]

(ii) Name the type of linkage between monomers **A** and **B**.

……..……..…… [1]

(b) Alkyne is a family of organic compounds with similar chemical properties as the alkenes. Ethyne, a member of the alkyne homologous series, is shown in Fig. 8.3.

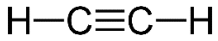


Fig. 8.3

Ethyne can be used as a starting reagent to synthesise monomer **A**.

(i) Name the type of reaction that can convert ethyne to monomer **A**.

……..……..…… [1]

(ii) Suggest the reagents and conditions used for the reaction in **(b)**(**i**).

……..……..…… [1]

(iii) Write chemical equation(s) to show how ethyne can be converted to monomer **A**.

……

…… [1]

(iv) Monomer **A** is not the only product formed during the synthesis when ethyne is used as the starting reagent. Draw one other possible isomer of monomer **A** that could be formed during this reaction.

[1]

(c) Describe how monomers **A** and **B** can be differentiated using chemical reactions.

……

……

……

…… [2]

[Total: 8]

B9 Sodium azide, NaN_3, is best known as the chemical found in car airbags.

Table 9.1 shows two methods to produce sodium azide.

Table 9.1

reaction	equation	atom economy
1	$2Na + 3N_2 \rightarrow 2NaN_3$	100%
2	$2NaNH_2 + N_2O \rightarrow NaN_3 + NaOH + NH_3$	*x*%

(a) Discuss the differences between the way that bonds are formed in Na, NaN_3 and NH_3.

……

……

……

……

……

……

……

…… [3]

(b) In **reaction 1**, 0.400 g of sodium is added to the reactor. What volume of nitrogen gas, measured at room temperature and pressure, is needed to completely react with 0.400 g of sodium?

[2]

(c) In recent years, concerns about environmental sustainability have motivated chemists to develop new reactions that minimise the amount of waste produced in the process of manufacturing sodium azide.

Thus, they have developed a measure known as “atom economy” to evaluate the environmental-friendliness of a reaction.

$$\text{atom economy} = \frac{M_r \text{ of desired product}}{\text{total } M_r \text{ of all products}} \times 100\%$$

(i) Calculate the atom economy of **reaction 2**.

[1]

(ii) Suggest why the atom economies of the two reactions are different.

……

……

……

…… [2]

(iii) In reality, **reaction 1** is not carried out despite a high atom economy. This is because the rate of reaction is very low. Suggest a reason why.

……

……

…… [2]

[Total: 10]

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The Periodic Table of Elements

I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0		Key proton (atomic) number atomic symbol name relative atomic mass									5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3											13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57 – 71 lanthonoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	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 –

lanthonoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodynium 144.2	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einstenium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

Avogadro's constant is 6.02×10^{23} mol^{-1}

Molar gas volume at standard temperature and pressure (s.t.p.) is 22.7 dm^3 mol^{-1}

Molar gas volume at room temperature and pressure (r.t.p.) is 24 dm^3 mol^{-1}

RIVER VALLEY HIGH SCHOOL

2023 SEC 4 END-OF-YEAR EXAMINATION

CHEMISTRY

Paper 1

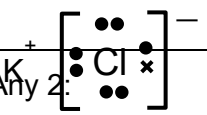
1	2	3	4	5	6	7	8	9	10
C	D	C	C	A	A	A	C	D	D
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	D	B	B	A	B	D	A	C	D
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
B	C	A	C	A	B	C	A	D	A
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
C	C	A	D	B	D	B	B	C	B

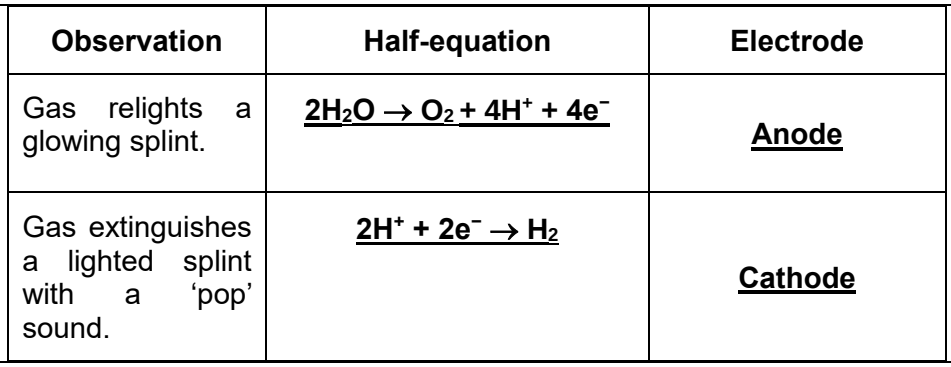
Paper 2

Section A

A1	**(a)**	**<u>Lead(II) nitrate</u>**
	(b)	**<u>Sodium sulfate</u>**
	(c)	**<u>Sulfuric acid</u>** and **<u>excess magnesium oxide</u>**
	(d)	**<u>Magnesium chloride and lead(II) hydroxide</u>** OR **<u>magnesium oxide and lead(II) nitrate</u>**

A2	**(a)**	**(i)**	$2K + 2H_2O \rightarrow 2KOH + H_2$
		(ii)	$KOH + HCl \rightarrow KCl + H_2O$
		(iii)	**<u>More energy</u>** is required to overcome the stronger **<u>electrostatic attraction between K^+ ions and ('sea' of) delocalised / mobile valence electrons</u>** than the weaker **<u>intermolecular forces (of attraction)</u>** **<u>between H_2 molecules</u>** .
		(iv)	Size of potassium atom **<u>decreases</u>**. K atom **<u>loses</u>** its valence **<u>electron</u>** to form K^+ ion in KOH, and has **<u>one less electron shell</u>**.

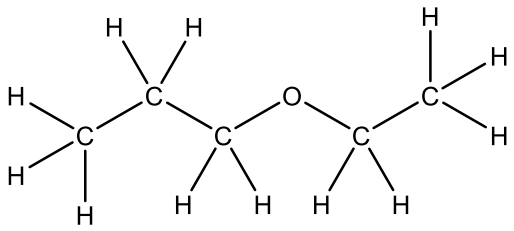
		(v)	
	(b)	**(i)**	Any 2: Iron has higher melting / boiling point. Iron has higher density / is hard. Iron forms coloured compounds. Iron exhibition variable oxidation states in their compounds. Iron can act as a catalyst in some reactions.
		(ii)	Any 2: Both can conduct electricity. Both are malleable / ductile. Both are grey in colour. Both have giant metallic lattice structure. Both react by losing valence electron(s).

A3	**(a)**	**(i)**	$HNO_2 \rightleftharpoons H^+ + NO_2^-$
		(ii)	**Acidic** N_2O_3 will react with alkaline aqueous sodium hydroxide. Or N_2O_3 will **neutralise** aqueous sodium hydroxide/ N_2O_3 and aqueous NaOH will take part in **neutralisation** reaction.
	(b)	**(i)**	
		(ii)	**$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$**
		(iii)	Sample is not contaminated because **Ag^+ would have been preferentially reduced** / **Ag would have been produced**
		(iv)	It is not suitable when the cation and anion of the contaminant are **not preferentially discharged / preferentially reduced and oxidised / at a higher position than H^+ / water in the redox series / contaminant is at a low concentration**.

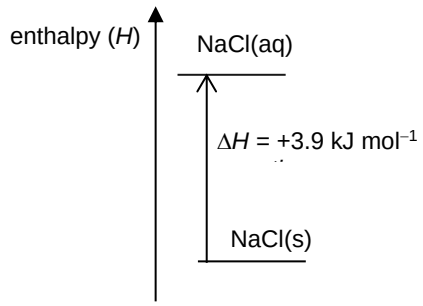
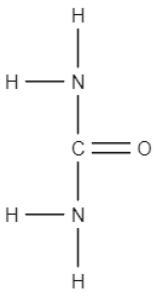
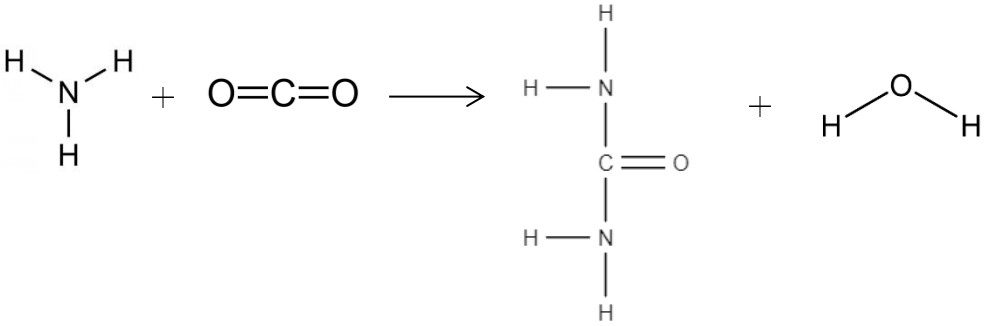
Observation	Half-equation	Electrode
Gas relights a glowing splint.	**$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$**	**Anode**
Gas extinguishes a lighted splint with a 'pop' sound.	**$2H^+ + 2e^- \rightarrow H_2$**	**Cathode**

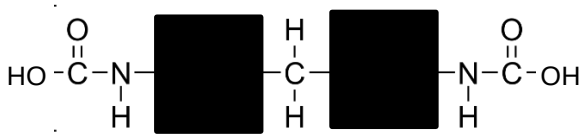
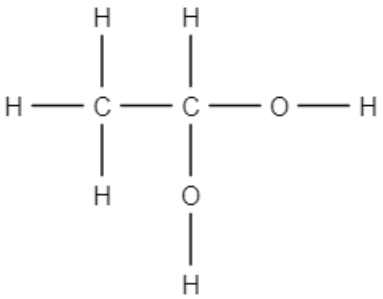
A4	**(a)**	**$N_2 + O_2 \rightarrow 2NO$**
	(b)	As temperature increases, the average **kinetic energy** of the reacting particles **increase**. The frequency of collisions increases. Also, a **larger fraction / more reacting particles** has **energy greater than or equal to the activation energy**. Therefore the **frequency of effective collisions increases**, resulting in a **higher rate** of NO formation as temperature increases.
	(c)	This is to **increase the surface area** of catalyst in contact with pollutant gases, which increases the rate of catalysis/reaction.
	(d)	**$C_4H_{10} + \frac{13}{2} O_2 \rightarrow 4CO_2 + 5H_2O$**

A5	**(a)**		**Oxidation** occurs when the **oxidation state** of an element in a substance **increases**. **Reduction** occurs when the **oxidation state** of an element in a substance **decreases**.
	(b)		Reaction 1 is a redox reaction. Fe^{2+} is oxidised as **oxidation state of Fe** increases from **+2 in Fe^{2+}/ $FeSO_4$ to +3 in Fe^{3+}/ Fe_2O_3**. SO_4^{2-} is reduced as **oxidation state of S** decreases from **+6 in SO_4^{2-}/ $FeSO_4$ to +4 in SO_2**. Reaction 2 is not a redox reaction as there is **no change in oxidation states** in any of the elements present.
	(c)	**(i)**	**B** and **D**. Their **mass increased** after heating because the metals react with oxygen to **form metal oxides or react/combine with oxygen**.
		(ii)	**A** and **C**. **A decreased in mass** because the metal carbonate **decomposed / reacted** on heating **to form metal oxide and carbonate / release carbon dioxide**. **Mass of C remained unchanged** as the metal carbonate **did not decompose** on heating **OR is thermally stable / stable to heating**.

A6	**(a)**	**(i)**	1. They have the **same general formula** of $\mathbf{C_nH_{2n}}$ 2. They have **similar cyclic structure** or has **ring**) 3. They have the **same prefix (cyclo) AND suffix** (**-ane**)
		(ii)	Accept any value from 43 to 50 °C
		(iii)	No, pent-1-ene has **alkene functional group** but the cycloalkanes do not have/ they have **different functional groups/ pent-1-ene is an alkene/** pent-1-ene has a **suffix of -ene**
		(iv)	Add **aqueous bromine**. If it is pent-1-ene, **orange** aqueous bromine will be **decolourised**. If it is cyclopentane, aqueous bromine will **remain orange.**
	(b)	**(i)**	$C_{20}H_{42} \rightarrow C_5H_{10} + C_{15}H_{32}$ [or any other relevant cracking equations]
		(ii)	Catalytic cracking uses lower temperature and pressure than thermal cracking, hence **less energy** is used Or even though catalytic cracking requires catalyst, **catalyst is regenerated** at the end of reaction and can be **reused** Or speed up the reaction to generate more products for sale in the same given amount of time.
	(c)	**(i)**	Elimination
		(ii)	**AT LEAST ONE ether.** e.g.  and any other isomer: - different position of alcohol functional group - branched alcohol - another ether

Section B

B7	**(a)**	**(i)**	NaC*l* **<u>decreases</u>** the melting point of ice.
		(ii)	When the melting point is lowered, the salt and ice mixture is now at a **<u>temperature above its melting point</u>**, thus the slippery ice melts into a liquid.
	(b)	Only the **<u>ΔH_{sol} of magnesium chloride is exothermic OR the dissolving of magnesium chloride releases energy</u>**, which can help the ice melt. [1] Magnesium chloride also has the **<u>lowest effective temperature</u>**.	
	(c)		
	(d)	**(i)**	$n_{NaCl} = \frac{1000}{23.0+35.5}$ = 17.09 mol Amount of energy = 17.09 x 56.7 = 969 kJ
		(ii)	$H^+ + OH^- \rightarrow H_2O$
	(e)	**(i)**	
		(ii)	**2**  $\Delta H_{bond\ breaking}$ = **2 x 3 x 390 + 2 x 740 = 2340 + 1480** = +3820 kJ mol^{-1} $\Delta H_{bond\ formation}$ = **–(2 x 305 + 740 + 4 x 390 + 2(460))** = –3830 kJ mol^{-1} $\Delta H_{reaction}$ = +3820 – 3830 = **–10.0 kJ mol^{-1}**

B8	**(a)**	**(i)**	**<u>Ester</u>** linkage
		(ii)	
	(b)	**(i)**	Addition
		(ii)	Steam, Phosphoric acid catalyst, heat at high pressure
		(iii)	$C_2H_2 + 2H_2O \rightarrow (OH)CH_2CH_2(OH)$ / $C_2H_4(OH)_2$ Or $C_2H_2 + H_2O \rightarrow (OH)CHCH_2$ / C_2H_3OH $(OH)CHCH_2 + H_2O \rightarrow (OH)CH_2CH_2(OH)$ / $C_2H_4(OH)_2$
		(iv)	
	(c)		Add **<u>sodium carbonate (or any specific carbonate)</u>** to a solution of the monomers. Monomer A will not react with sodium carbonate, no effervescence observed Monomer B will react with sodium carbonate and **<u>effervescence will be observed</u>** Or Add **<u>Mg (or any specific reactive metal)</u>** to a solution of the monomers. Monomer A will not react with Mg, no effervescence observed Monomer B will react with Mg and **<u>effervescence will be observed</u>** Or add **<u>acidified aqueous $KMnO_4$</u>** **<u>Purple acidified KMnO4 will decolorise in A, but remain purple in B</u>**.

B9	**(a)**		Na: Each Na atom **delocalises** its valence **electron**, resulting in **electrostatic attraction / metallic bond** between Na^+ ions and 'sea' of delocalised mobile valence electrons. NaN_3: Each **Na atom transfers / loses / gives** its valence **electrons to N atom**, resulting in **electrostatic attraction / ionic bond** between Na^+ and N_3^- ions. NH_3: **N atom** and **H atom share electrons**, resulting in **covalent bond** between N and H atoms.
	(b)		$n_{Na} = \frac{0.400}{23.0}$ = 0.01739 mol $2Na \equiv 3N_2$ n_{N_2} = 0.01739 x $\frac{3}{2}$ = 0.02609 mol volume of N_2 = 0.02609 x 24 = 0.626 dm^3
	(c)	**(i)**	Atom economy = $\frac{23.0+3(14.0)}{23.0+3(14.0)+23.0+16.0+1.0+14.0+3(1.0)}$ x 100% = $\frac{65.0}{122.0}$ = 53.3%
		(ii)	For reaction 1, atom economy is 100% because **all atoms have been convert into NaN_3 / NaN_3 is the only product**. For reaction 2, atom economy is lower because **not all atoms have been convert into NaN_3 / there are by-products**.
		(iii)	The **N≡N** bond / **triple** bond in N_2 is very strong. Hence, it requires **a lot of energy to break** / reaction has a **high activation energy** / N_2 is **inert / unreactive**.