O

JURONGVILLE SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2024
Secondary 4 Express

STUDENT NAME			
CLASS		INDEX NUMBER	

CHEMISTRY

6092/02

Paper 2

02 August 2024

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 in the spaces 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, highlighters, 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.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 20.

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

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

Setter: Ms Ethel Chng

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

Section A
Answer **all** questions.

1 **(a)** Choose from the substances listed to answer the questions.

aluminium oxide

calcium oxide

carbon dioxide

iron(II) oxide

nitrogen monoxide

potassium oxide

sulfur dioxide

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

Identify the substance which

(i) dissolves in water to raise the pH of soils,

…… [1]

(ii) is a neutral oxide,

…… [1]

(iii) reacts with both acids and alkalis,

…… [1]

(iv) turns acidified potassium manganate(VII) from purple to colourless,

…… [1]

(v) warms with excess hydrochloric acid to form a green solution.

…… [1]

(b) The following are statements about alkali metals in the Periodic Table.

Put a tick (✓) in **one** box in each row to show which statements are **true** and which are **false**.

	true	**false**
They all float on water.		
They lose electrons more easily down the group.		
They rapidly tarnish in air.		
They react with water to form two alkaline products.		

[2]

[Total: 7]

2 Magnesium, with the symbol Mg and an atomic number of 12, has a relative atomic mass of approximately 24.3.

(a) Define *relative atomic mass* of an element.

……

…… [1]

(b) The relative atomic mass of 24.3 is a weighted average of the masses of its three naturally occurring isotopes, Mg-24, Mg-25, and Mg-26.

Given that the relative abundance of Mg-25 is 10%, calculate the relative abundances of Mg-24 and Mg-26.

relative abundance of Mg-24 …… [1]

relative abundance of Mg-26 …… [1]

(c) Given that the rate of diffusion of a gas is inversely proportional to the square root of its molar mass, comment on the relative rates of diffusion for the three Mg isotopes in the gaseous state.

……

…… [1]

(d) Analysis of a sample of a magnesium compound shows that it contains 18.9 g of magnesium, 5.8 g of boron and 25.3 g of oxygen.

Deduce the empirical formula for this magnesium compound.
Show your working.

empirical formula …….. [2]

(e) Admontite is a hydrated magnesium borate mineral with formula, $MgB_6O_{10} \cdot 7H_2O$.

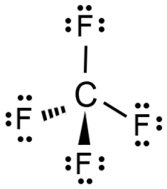
It has an alternative formula, $MgB_6O_x(OH)_6 \cdot yH_2O$.

State the values of x and y in the alternative formula.

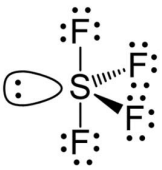
x = …….. and y = …….. [1]

[Total: 7]

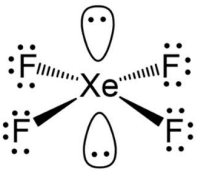
3 Fig 3.1 shows the structures of three tetrafluorides.



carbon tetrafluoride, CF_4



sulfur tetrafluoride, SF_4



xenon tetrafluoride, XeF_4

Fig 3.1

Each of these tetrafluorides exemplifies the diversity of chemical behaviour that can arise from different central atoms bonded to fluorine.

(a) Suggest how two of these structures do **not** follow normal bonding rules.

……

……

……

…… [2]

(b) Hydrolysis of sulfur tetrafluoride gives an intermediate product, thionyl fluoride, SOF_2. There is a double bond between atoms of sulfur and oxygen and a single bond between atoms of sulfur and fluorine.

Draw a 'dot-and-cross' diagram to show the bonding in a molecule of SOF_2.

Show outer electrons only.

[2]

(c) Explain, in terms of structure and bonding, why these fluoride compounds have low melting points.

……

……

……

…… [2]

[Total: 6]

4 The decomposition of most metal nitrates typically occurs upon heating, resulting in the formation of metal oxides, nitrogen dioxide and oxygen.

(a) The thermal decomposition of calcium nitrate is considered a redox reaction.

Use oxidation states to explain what is reduced and what is oxidised during the thermal decomposition of calcium nitrate.

……

……

……

……

…… [2]

(b) A characteristic feature of this thermal decomposition is the release of nitrogen dioxide gas.

Observation of brown fumes during heating would indicate that the metal nitrate is undergoing decomposition.

Describe a test to identify the **other** gas produced.

……

…… [1]

(c) In an experiment, a fixed amount of three metal nitrates, calcium nitrate, lead(II) nitrate and zinc nitrate, are heated separately.

(i) Assuming that the same amount of heat is applied, which metal nitrate will take the shortest time for nitrogen dioxide to appear? Explain your answer.

……

……

……

……

…… [2]

(ii) Which solid residue is yellow when hot and turns white on cooling?

…… [1]

[Total: 6]

5 Potassium nitrate is a useful water-soluble fertiliser.

(a) Name the method to prepare potassium nitrate.

…… [1]

(b) Write an equation, with state symbols, for the reaction to prepare potassium nitrate.

…… [2]

(c) Describe how pure dry crystals of potassium nitrate are obtained from its aqueous solution.

……

……

……

……

……

……

…… [2]

(d) In an experiment, a spatula of potassium nitrate was added to 50 cm^3 of water in a beaker.

The mixture was stirred to make a solution and the temperature of contents in the beaker changed from 20.4 °C to 18.7 °C.

(i) Determine if this change is endothermic or exothermic.

…… [1]

(ii) The enthalpy change of solution can be calculated using the given formula.

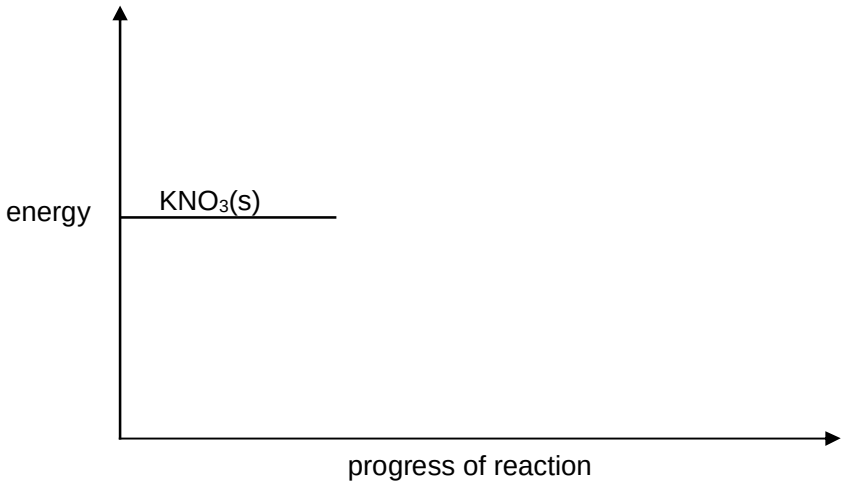
$$\Delta H = c \times m \times \Delta T$$

- The specific heat capacity of water, c, is 4.2 kJ per kg per °C.
- The mass of 50 cm^3 of water, m, is 0.050 kg.

Calculate the enthalpy change in kJ for this experiment.

enthalpy change …… kJ [1]

(iii) Complete the energy level diagram to show the product and energy change of solution when potassium nitrate dissolves in water.



[1]

[Total: 8]

6 Table 6.1 shows information about two electrolysis experiments.

Table 6.1

experiment	electrolyte	electrode	ionic equation for reaction at electrode
1	dilute $CuSO_4(aq)$	at negative graphite electrode	
		at positive graphite electrode	
2	dilute $CuSO_4(aq)$	at negative copper electrode	
		at positive copper electrode	

(a) Complete Table 6.1. [3]

(b) In terms of bonding, explain the electrical conductivity of graphite.

……

……

……

…… [2]

(c) Describe any changes in the colour and pH of the electrolyte in experiments 1 and 2.

……

……

…… [1]

(d) The initial mass of one of the copper electrodes was 50 g.

After an hour, the mass of the copper electrode was 53 g.

What was the total number of moles of electrons which flowed through the circuit?

moles of electrons …….. [2]

[Total: 8]

7 Transition metals and their compounds are good catalysts for many reactions, both in the laboratory and industry.

(a) State one **other** property of transition metals.

…… [1]

(b) Table 7.1 shows some examples of catalysts used in the industry.

Table 7.1

industrial process	manufacture	catalyst
Contact process	sulfuric acid	vanadium(V) oxide
Haber process	ammonia	iron
Ostwald process	nitric acid	platinum

All three industrial processes involve a reversible reaction.

(i) What is meant by a *reversible reaction*?

…… [1]

(ii) State **two** other conditions used in the Haber process.

…… [1]

(c) Suggest why many catalysts are used in powdered form.

……

…… [1]

(d) Describe and explain, in terms of collisions between reacting particles, the effect of increasing the temperature on the rate of reaction.

……

……

……

……

…… [2]

(e) Refer to Table 7.1 to suggest **two** reasons why industries do not necessarily increase the temperature.

……

…… [2]

[Total: 8]

8 Refining petroleum (crude oil)

Petroleum is a mixture of hydrocarbons and refining it is a complex process that involves transforming the mixture into various useful products through a series of complex processes. The initial step, fractional distillation, separates petroleum into different fractions such as petrol (gasoline), naphtha, kerosene (paraffin) and diesel.

Further refining processes, such as catalytic cracking and reforming, break down larger hydrocarbon molecules into smaller, more useful ones or rearrange their structures to enhance quality and performance. For example, naphtha undergoes cracking to form petrol and other fractions containing smaller alkanes and alkenes. Naphtha also undergoes reforming to restructure the straight-chain alkanes into branched-chain alkanes, cycloalkanes, and aromatic hydrocarbons. Hydrogen is produced as a by-product of the reactions.

These many processes yield several petroleum fractions, each tailored to meet specific market demands, from fuels essential for transportation and heating to feedstocks for the petrochemical industry, which are used in the production of plastics, synthetic fibers, and other materials.

Use of plastic materials (polymers)

Plastic materials are composed of long chains of repeating units called monomers. These materials are synthesized through polymerisation, where monomers chemically bond to form extensive networks. The diversity of plastics arises from the wide variety of monomers and polymerisation methods, resulting in an array of polymers with distinct properties tailored for specific applications. Table 8.1 gives some information about five important polymers.

Table 8.1

polymer	density in kg / m^3	maximum useable temperature / °C	solubility in organic solvents
low density poly(ethene)	920	85	soluble above 80 °C
high density poly(ethene)	960	120	soluble above 80 °C
poly(phenylethene)	1050	65	soluble
poly(chloroethene)	1390	60	soluble
poly(propene)	900	150	insoluble

The maximum usable temperature refers to the highest temperature at which a plastic material can continuously operate without experiencing significant degradation of its mechanical properties, physical structure or performance. Different plastics have varying maximum usable temperatures, influenced by their molecular structure and composition.

Plastics' lightweight, durability and cost-effectiveness have revolutionised numerous industries, including construction, healthcare, electronics and consumer goods. However, the widespread use of plastics also poses environmental challenges, emphasizing the need for sustainable practices to better manage plastic waste.

(a) Describe and explain how the process of fractional distillation separates petroleum into fractions.

……

……

……

……

……

…….. [2]

(b) Table 8.2 shows the uses of fractions obtained from petroleum.

Table 8.2

fraction	use
petrol	fuel for cars
naphtha	petrochemical feedstock
kerosene	
diesel	

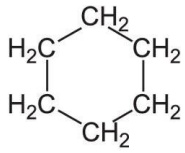
(i) Complete Table 8.2. [1]

(ii) Name one **other** fraction obtained from petroluem.

…….. [1]

(c) Table 8.3 shows information about two processes.

Table 8.3

process	equation	structure of a product
A	$C_6H_{14} \rightarrow C_6H_{12} + H_2$	
B	$C_6H_{14} \rightarrow C_3H_6 + C_2H_4 + CH_4$	

(i) Complete Table 8.3 by drawing the **full** structure of **one** of the products. [1]

(ii) Identify which process is cracking and which is reforming by circling the correct answers.

process A cracking / reforming

process B cracking / reforming

[1]

(d) Which polymer, given in Table 8.1, would be most suited for making a pipe to carry lubricating oil at 100 °C?

Give **two** reasons for your answer.

……

……

……

…… [2]

(e) Poly(propene) is made from the monomer propene.

Draw the structure of poly(propene).

[1]

(f) State the structure and bonding in plastics.

……

…… [1]

(g) **(i)** Describe **one** method of recycling plastics.

……

…… [1]

(ii) Discuss **one** challenge of recycling plastics.

……

…… [1]

[Total: 12]

9 The NASA space shuttle uses fuel cells to generate electricity.

Fig. 9.1 shows a hydrogen fuel cell.

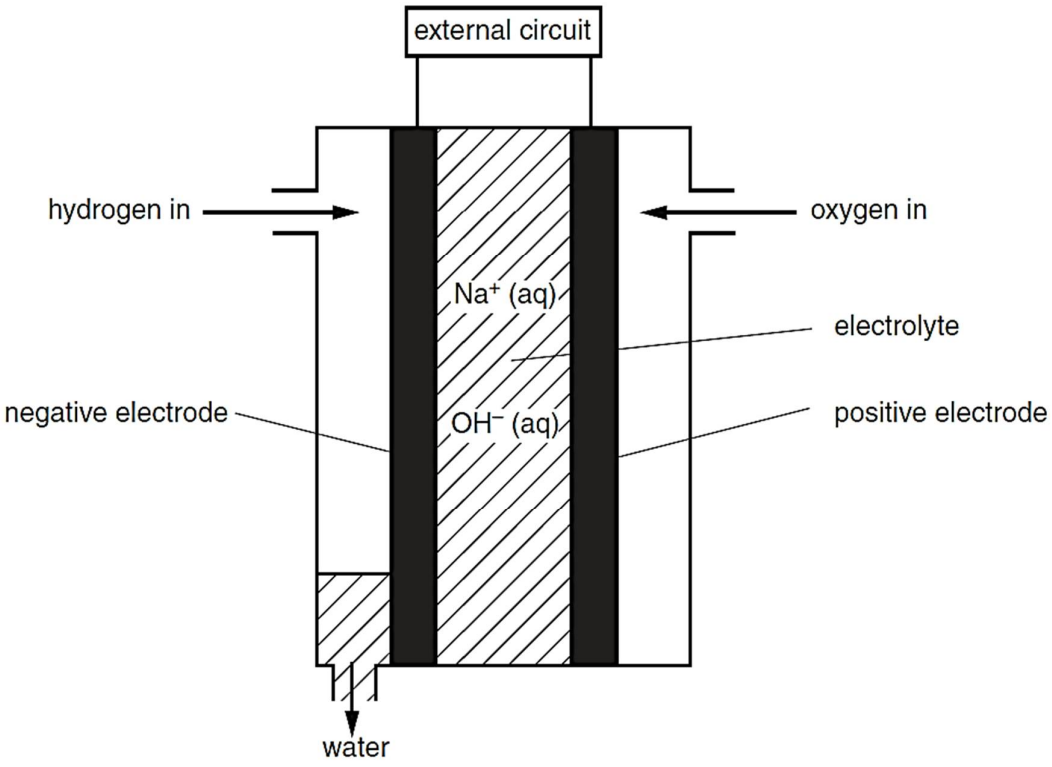


Fig. 9.1

At the positive electrode, oxygen reacts with water.

$$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$$

At the negative electrode, hydrogen reacts with hydroxide ions.

$$H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$$

(a) Write the overall chemical equation of the reaction taking place in a hydrogen fuel cell.

…… [1]

(b) A fuel cell uses 250 dm^3 of hydrogen.
Calculate the minimum volume of oxygen needed in this fuel cell.

volume of oxygen …… dm^3 [1]

(c) What type of reaction, reduction or oxidation, takes place at the positive electrode?
Explain your answer.

……

…… [1]

(d) Name the electrolyte used in Fig. 9.1 and explain its electrical conductivity.

……

…… [1]

(e) Give **two** disadvantages of using hydrogen as a fuel to generate electricity.

……

…… [2]

(f) Hydrogen and biofuels are renewable energy sources, offering viable alternatives to fossil fuels. Hydrogen, produced through electrolysis powered from renewable sources, is a potential clean fuel of the future, as it does not have any direct greenhouse gas emissions. Not only does it have less environmental impact, but it also has higher energy density and efficiency.

Biofuels, derived from inorganic materials such as plastic waste and metals, involve practices that exhaust natural resources and cause ecological damage. They increase greenhouse gas emissions since the carbon dioxide released during their combustion is not offset by the carbon dioxide absorbed during their production process. Biofuels, however, do not require oxygen to burn, as they generally have higher oxygen content in their molecular structure compared to fossil fuels.

Complete the table by identifying and correcting **two** errors in the description of hydrogen and biofuels.

error	corrections to error

[2]

[Total: 8]

Section B

Answer **one** question from this section.

10 Alcohols have a variety of uses. While ethanol is most recognised for its presence in alcoholic drinks, many alcohols are key solvents in the production of pharmaceuticals, perfumes, and cosmetics due to their ability to dissolve different substances.

The smallest alcohols, methanol, ethanol and propanol, are miscible in water. The larger the alcohol molecule, the lower the miscibility. However, the melting and boiling points of alcohols increase with increasing molecular size, due to stronger intermolecular forces of attraction.

(a) Use the information to give **one** piece of evidence that alcohols are a homologous series.

……

…… [1]

(b) State the general formula of alcohols.

…… [1]

(c) Draw the structure of **two** isomers of propanol.

[2]

(d) In an experiment, 5 g of ethanol was heated with 5 g of ethanoic acid in the presence of a few drops of concentrated sulfuric acid.

(i) Name the products of this reaction.

…… [1]

(ii) What is the mass of the organic product formed given that the yield is 60%?

mass of organic product …… [3]

(e) Ester and amide linkages can be hydrolysed by warming in any acidic or alkaline solution.

Fig. 10.1 shows the structure of compound X, which is an amide.

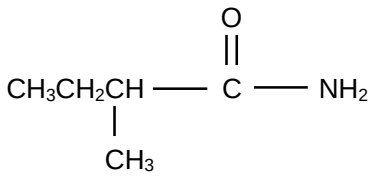


Fig. 10.1

Draw the structures of the products of hydrolysis of compound X.

[2]

[Total: 10]

11 Table 11.1 gives information about the first five members of the homologous series of carboxylic acids.

Table 11.1

name of acid	formula	relative molecular mass	melting point / °C	boiling point / °C
methanoic acid	HCO_2H	46	8.4	101
ethanoic acid	CH_3CO_2H	60	17	118
propanoic acid	$C_2H_5CO_2H$	74	−22	141
butanonic acid	$C_3H_7CO_2H$	88	−8	164
pentanoic acid				

(a) Predict the formula and the relative molecular mass for pentanoic acid.

……..…… [1]

(b) Is it easier to predict the melting or boiling point of pentanoic acid?
Explain your answer.

……

……

……..…… [2]

(c) Draw the displayed formula for propanoic acid.

[1]

(d) Describe how ethanoic acid is prepared in the laboratory.

Include any reagents and conditions required, as well as expected observations.

……

……

……

……..…… [2]

(e) A fatty acid is made up of a carboxyl group and a hydrocarbon chain.

Fatty acids can be classified as saturated, monounsaturated or polyunsaturated.

(i) Describe a chemical test that can be used to distinguish between a saturated fatty acid and an unsaturated fatty acid.

……...

……...

……...

……...

…… [2]

(ii) A fat molecule consists of fatty acids and glycerol.

Fig. 11.1 shows the structure of compound X, which is a fat molecule.

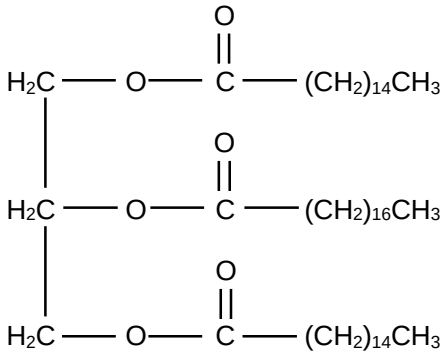


Fig. 11.1

Draw the structures of **two** fatty acids formed by hydrolysis of compound X.

[2]

[Total: 10]

End of Paper

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) numbers 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 209	85 At astatine 210	86 Rn radon 222
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 162	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinum –	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 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}.