Class	Centre/Index Number	Name

南洋女子中學校
Nanyang Girls' High School

Preliminary Examination 2024
Secondary 4

CHEMISTRY

6092/02

Paper 2

1 hour 45 minutes

Friday 23 August **0845 – 1030**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, register number and class in the spaces at the top of this page.
Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid / tape.

Section A (70 marks)
Answer **all** questions.
Write your answers in the spaces provided.

Section B (10 marks)
Answer **one** question.
Write your answers in the spaces provided.

Examiner's Use	
Paper 1	
Paper 2	
Total	

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 24.

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

This document consists of **22** printed pages and **2** blank pages.

Section A

Answer **all** questions.

1 Choose from the following oxides to answer the questions.

Al_2O_3	CO	CO_2	CaO
H_2O	Na_2O	SO_2	PbO

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

(a) State the oxide which

(i) is produced as a result of incomplete combustion of carbon-containing fuels.

..... [1]

(ii) reacts with both acid and alkali.

..... [1]

(iii) has a simple molecular structure.

..... [1]

(iv) has an ion with an oxidation state of +2.

..... [1]

(v) conducts electricity when dissolve in water.

..... [1]

(vi) is made during the fermentation of glucose solution to make ethanol.

..... [1]

(b) Explain how ethanol can be separated from glucose solution in **(a)(vi)**.

.....

.....

.....

..... [2]

[Total: 8]

2 This question is about compounds that contain phosphorus.

(a) The formula for a phosphide ion can be written as $^{15}_{31}P^{3-}$.
Complete Table 2.1 to show the number of particles in this phosphide ion.

Table 2.1

particle	number of particles
electron	
neutron	
proton	

[1]

(b) State why the formula for the phosphide ion is P^{3-} rather than P^{2-} or P^{4-}.

.....

..... [1]

(c) Calcium phosphate, $Ca_3(PO_4)_2$ is a mineral that aids bone development.

(i) Explain, in terms of structure and bonding, if you expect calcium phosphate to have a high melting point.

.....

.....

.....

..... [2]

(ii) Calcuate the percentage by mass of phosphorus in calcium phosphate.

percentage by mass = ... % [1]

[Total: 5]

3 Molybdenum is a transition element which is used to make steel that is extremely hard. It exhibits variable oxidation states and can be manufacture by heating together molybdenum(IV) oxide, MoO_2, and aluminium.

(a) Construct the equation for this reaction.

.....

[1]

(b) **(i)** Complete the table to show the oxidation states of molybdenum and aluminium.

element	oxidation state in reactants	oxidation state in products
molybdenum		
aluminium		

[2]

(ii) In terms of oxidation states, explain why this is a redox reaction.

.....

.....

.....

.....

[2]

(c) Suggest which metal, molybdenum or aluminium, is less reactive.
Explain your answer.

.....

.....

[1]

(d) Molybdenum has a melting point of 2620 °C.

(i) With the help of a labelled diagram, describe the type of bonding that is present in molybdenum.

.....

.....

[2]

(ii) Suggest why molybdenum has a much higher melting point than aluminium.

.....

[1]

[Total: 9]

4 Chlorine, which is an element found in Group 17, is a strong oxidising agent.

(a) When chlorine gas is passed into aqueous iron(II) bromide, the colour of the solution changes from yellow to orange.

When the orange solution is heated, it gives off a brown vapour, leaving behind a yellow-brown solution **S.**

The brown vapour forms a reddish-brown liquid, element **T** on cooling.

The reddish brown colour disappears when propene is added to **T**.

(i) Name the yellow-brown solution **S**.

.....

[1]

(ii) With the help of an ionic equation between the reaction of chlorine and aqueous iron(II) bromide, suggest the identity of **T**.

.....

.....

.....

.....

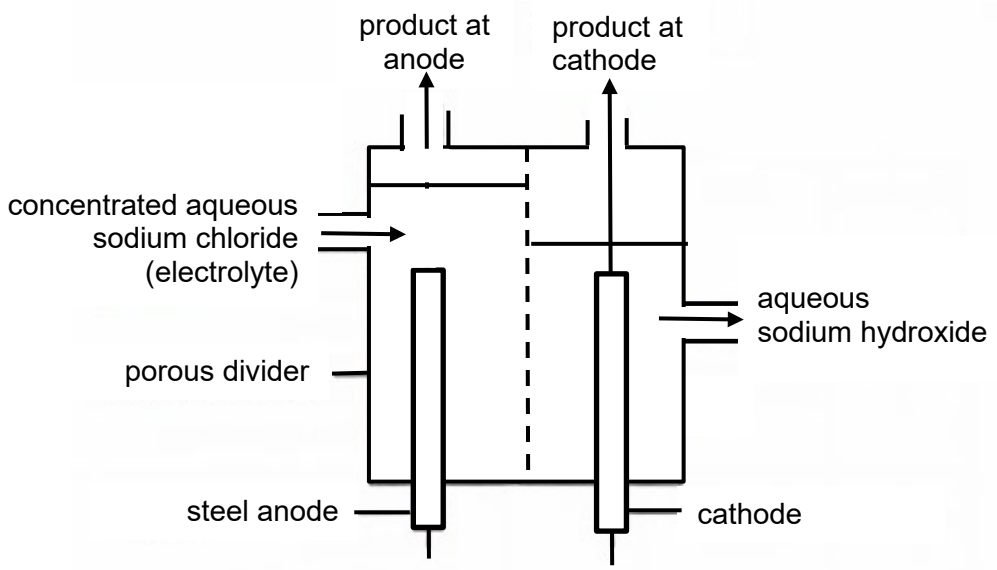
[2]

(iii) Draw the structure of the compound formed when **T** reacts with propene.

[1]

(b) Chlorine and sodium hydroxide can be manufactured by the electroysis of concentrated aqueous sodium chloride.

A simplified diagram of the method of manufacturing chlorine and sodium hydroxide is shown in the diagram below.



(i) Write an equation for the reaction occuring at the electrodes.

Cathode: .....

Anode: ..... [2]

(ii) Suggest a chemical test to confirm the presence of the product at the anode.

..... [1]

(iii) Explain why aqeuous sodium hydroxide flows out from the electrolytic cell from the right.

.....

..... [1]

(iv) Suggest why the porous divider is placed between the two electrodes.

.....

..... [1]

[Turn over

(v) The anode is made of steel. Explain why steel is not a suitable material for the anode and suggest a better material that can be used in its place.

.....

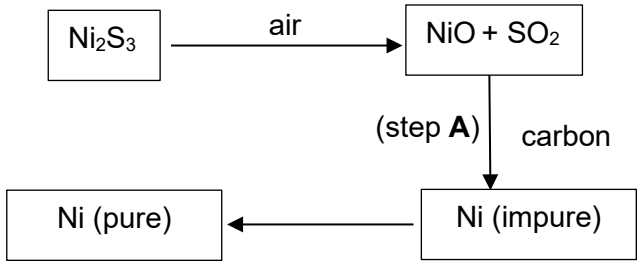
.....

.....

..... [2]

[Total: 11]

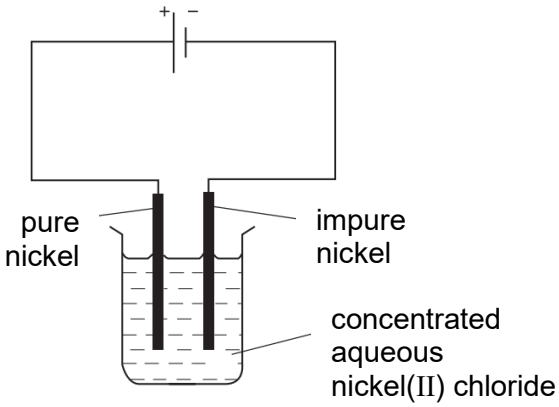
5 The chemistry of nickel metal shows a direct resemblance to that of copper. For instance, it usually exists in its compounds in variable oxidation states and forms Ni^{2+} ions in aqueous solutions. Pure nickel may be obtained from its sulfide ore by the means of the scheme below.



(a) Write an equation for the formation of impure nickel in step **A** and explain **fully** the environmental effect(s) of the product(s) of the reaction.

[3]

(b) Two students looked at the set up below and commented if the set up can be used to purify impure nickel.

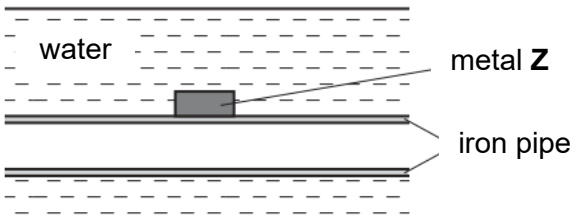


Student A: I think it will not work as the electrolyte is incorrect.
Student B: The electrolyte used is correct but the positions of the pure and impure nickel need to be exchanged.

Which student do you agree with? Use your understanding on electrochemistry to explain your choice.

[5]

(c) The diagram below shows how an underwater iron pipe can be protected from rusting.



Predict if nickel can be used as metal **Z** to prevent the pipe from rusting.
Explain your answer.

.....

.....

.....

..... [2]

[Total: 10]

6 The following reaction takes place in the Haber process used to manufacture ammonia gas:

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

The enthalpy change for the formation of ammonia, ΔH = -92 kJ.

(a) Explain how one is able to tell from the information above if the reaction is exothermic or endothermic.

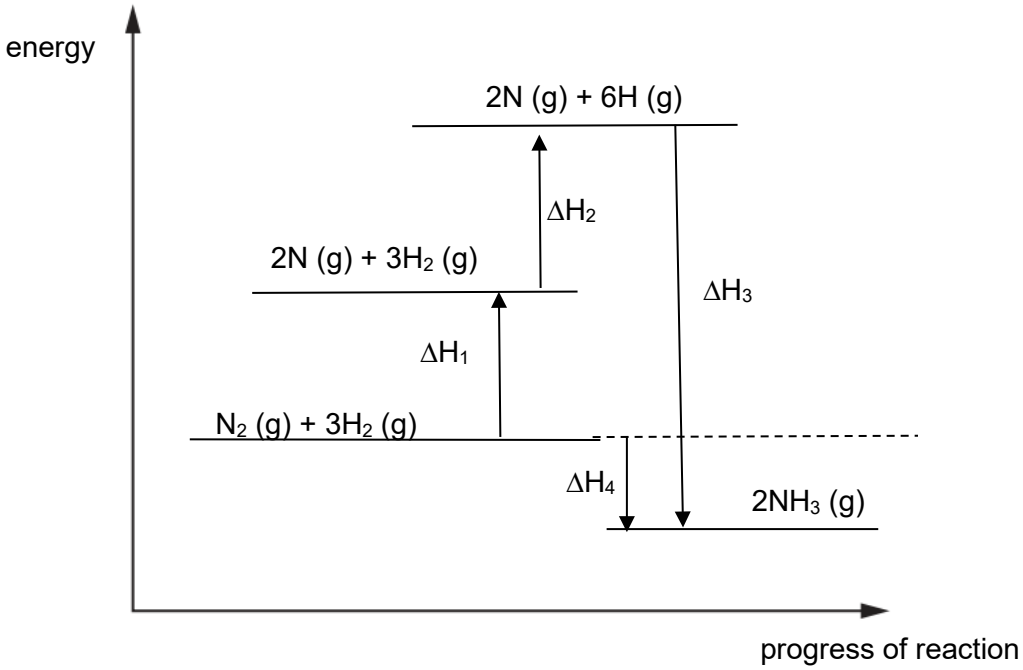
.....

[1]

(b) The table below shows some bond energies measured in kJ/mol.

Bond	Bond energy / kJ/mol	Bond	Bond energy / kJ/mol
H−H	436	N=N	409
N−N	163	N≡N	941

The energy profile diagram for the formation of ammonia gas from nitrogen and hydrogen can be drawn as shown below:



(i) Use the information above to calculate the values of ΔH_1, ΔH_2, ΔH_4 and ΔH_3. Hence, determine the bond energy of the N−H bond in kJ/mol.

[5]

(ii) Use the energy profile diagram to estimate the activation energy needed for this reaction.

[1]

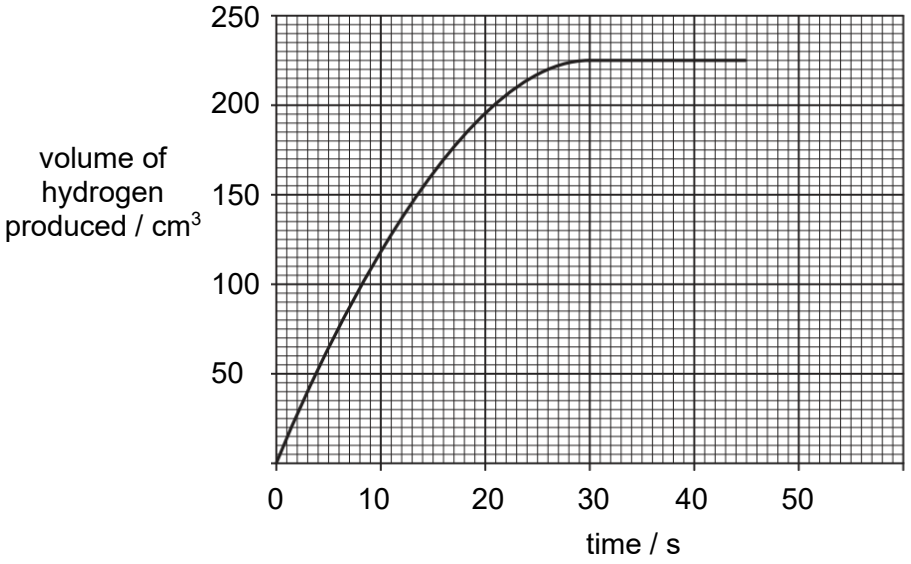
[Total: 7]

7 A student carried out three experiments using lithium and water.

In experiment 1, 0.13 g of lithium was added to 150 cm^3 of water.

$$2\ Li\ (s) + 2H_2O\ (l) \rightarrow 2LiOH\ (aq) + H_2\ (g)$$

The volume of hydrogen produced was measured at intervals and the following graph was obtained.



(a) State two observations which would be made after adding lithium to water.

.....

.....

.....

..... [2]

(b) Explain how the rate of reaction changes during the experiment and why the reaction eventually stops.

.....

.....

.....

..... [2]

(c) Using information on the graph, or by calculations, state the time taken for half the lithium to react.

.....[1]

(d) The student carried out two futher experiments.

Experiment 2 was the same as experiment 1 except that 0.0325 g of lithium was used.

Experiment 3 was the same as experiment 1 except that the temperature of water was raised by 10 °C.

(i) Deduce the volume of gas produced in:

Experiment 2: .....

Experiment 3: .....[2]

(ii) Deduce how rates of reaction for each of experiments 2 and 3 would be different from experiment 1. Use ideas about colliding particles to explain your deduction.

Experiment 2: .....

.....

.....

.....

.....[2]

Experiment 3: .....

.....

.....

.....

.....[2]

[Total: 11]

[Turn over

8 The following information provides a comparison between 2 flue gas desulfurisation (FGD) processes.

Flue gas desulfurisation is a set of reactions used to remove sulfur dioxide, SO_2, from exhaust flue gases of power plants and from other sulfur dioxide emitting processes. In 2003, about 110000TWh primary energy was consumed world-wide and on a global scale, sulfur emitting processes provided about 26% of the net electricity generated.

Atmospheric SO_2 is an air pollutant responsible for respiratory problems and acid rain. In the past few decades, FGD processes have undergone considerable developments in terms of improved removal efficiency and reliability, as well as reduced costs.

Wet scrubbers, the most commonly used FGD system, is relatively adaptable to existing plants and has low operating costs because of low prices of limestone, $CaCO_3$. Limestone in this process reacts with sulfur dioxide to produce calcium sulfite, $CaSO_3$ which is then oxidized to calcium sulfate, $CaSO_4$.

The Copper Oxide Technology, another FGD process, on the other hand, is able to reduce SO_2 and oxides of nitrogen,NO_x in a single unit and does not produce landfill waste.

The table below shows some data on the treatment of flue gas containing 1 kilogram of sulfur.

	Input		**Output**			
			Emission to air, g/kgS			
	Electricity / kWh/kgS	**Natural resources / g/kgS**	**NO_x**	**SO_2**	**CO_2**	**Solid waste**
Wet scrubbers	6.0	2.1	44.7	21.2	1360	8.4
Copper Oxide Technology	1.6	308.4	10.9	10.9	684	0.9

Adapted from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.835.385&rep=rep1&type=pdf

(a) Explain fully why there is a need to remove sulfur dioxide from the environment.

.....

.....

.....

..... [2]

(b) Name a possible source of energy for the power plants.

..... [1]

(c) Suggest how oxides of nitrogen are formed.

.....

[1]

(d) Name **one** other substance, besides calcium sulfite and calcium sulfate, that will be formed by the limestone acting on the flue gases.

.....

[1]

(e) With reference to the data provided, describe **one advantage** and **one disadvantage** of each process.

.....

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.....

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.....

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[4]

[Total: 9]

Section B

Answer one question from this section.

9 The table shows some properties of five esters.

name	structure	relative molecular mass	melting point / °C	boiling point / °C
methyl ethanoate	CH_3COOCH_3	74	−98	57
ethyl ethanoate	$CH_3COOCH_2CH_3$	88	−84	77
propyl ethanoate	$CH_3COOCH_2CH_2CH_3$	102	−95	102
butyl ethanoate	$CH_3COOCH_2CH_2CH_2CH_3$	116	−78	126
pentyl ethanoate	$CH_3COOCH_2CH_2CH_2CH_2CH_3$	130	−71	148

(a) These esters are part of a homologous series.

Using the data given, state **two** characteristics of a homologous series.

1. .....

.....

2. .....

..... [2]

(b) The next member of the homologous series is hexyl ethanoate.

Explain why it is more difficult to predict the melting point than the boiling point of hexyl ethanoate.

.....

.....

.....

..... [2]

(c) At 25 °C, ethyl ethanoate is a liquid.

Explain how the data in the table shows this.

.....

.....

.....

..... [2]

(d) **(i)** Methyl ethanoate can be made from an organic acid and compound **Y**. Draw the structures of the two compounds from which methyl ethanoate is made.

organic acid	compound **Y**

[2]

(ii) Hence, calculate the maximum mass of methyl ethanoate that can be made from 1.20 g of organic acid and excess compound **Y**.

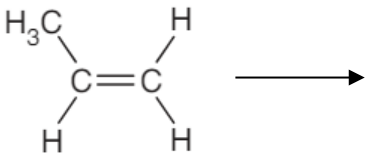
[2]

[Total: 10]

10 Food packaging used in industries produces a lot of waste which includes both glass and plastic.

(a) One of the plastics that is commonly used in food packaging is polypropene which is formed by addition polymerisation.

(i) Complete the equation by drawing the structure of polypropene.

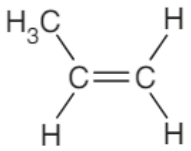


[1]

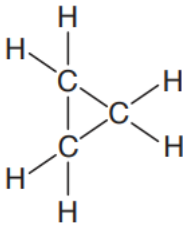
(ii) With the aid of an equation, calculate the percentage yield of carbon dioxide if 4800 dm^3 of carbon dioxide is released when 4.2 kg of propene is burnt.

[2]

(b) Propene and cyclopropane are isomers.



propene



cyclopropane

(i) Suggest how the structures of propene and cyclopropane show that they are isomers.

.....

.....

[1]

(ii) Describe a chemical test that can distinguish propene from cyclopropane.

.....

.....

.....

..... [2]

(c) The glass waste from food packaging can be melted at high temperatures and then made into new objects.

(i) Using the movement of particles, describe the changes in movement and arrangement of the particles when melting occurs.

.....

.....

.....

..... [2]

(ii) Glass waste contains SiO_2. In terms of structure and bonding, explain why this melting takes place at high temperatures.

.....

.....

.....

..... [2]

[Total: 10]

END OF PAPER

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The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).
The Avogadro constant, L = 6.02 x 10^{23} mol^{-1}