Class	Centre/Index Number	Name

南洋女子中學校
Nanyang Girls' High School

Preliminary Examination 2024
Secondary 4

CHEMISTRY **6092/01**
Paper 1 Multiple Choice

1 hour
Friday 23 August **1200 – 1300**
Additional materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue, correction fluid or tape.

Write your name, register number and class in the spaces at the top of this page and on the Answer Sheet in the spaces provided.

There are **forty** questions on 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.

Read the instructions on the Answer Sheet very carefully.

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 20.

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

This document consists of **17** printed pages and **3** blank pages.

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1 A balloon full of helium gas was found to be smaller in size as the temperature changes from 30 °C to 10 °C.

Which statement best explains why this is so?

A The gas condenses into a liquid and so takes up less space.

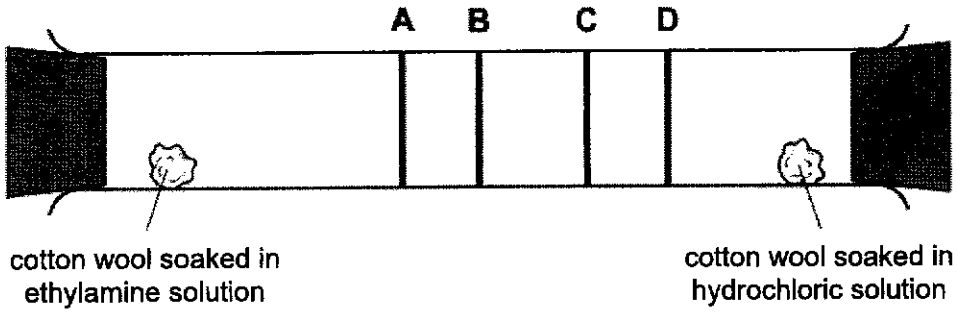
B The gas particles become smaller at lower temperatures.

C The gas particles diffuse through the balloon and escape.

D The gas particles move more slowly hence reducing the pressure.

2 Ethylamine gas, $C_2H_5NH_2$, and hydrogen chloride gas, HCl, react together to form a white solid, ethylamine hydrochloride.

At which position in the tube would a white ring of ethylamine hydrochloride be formed?



3 Substances can be elements, compounds or mixtures.

Which row is correct?

	element	compound	mixture
A	calcium	brass	zinc
B	methane	carbon	crude oil
C	nitrogen	carbon dioxide	water vapour
D	oxygen	glucose	air

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4 Four mixtures, each containing two substances are shown in the table.

The substances need to be separated and collected.

Which row correctly matches the mixture to the separation method?

	mixture	separation method
A	copper(II) sulfate and water	chromatography
B	methanol and ethanol	evaporation
C	oxygen and nitrogen	fractional distillation
D	sand and silver chloride	filtration

5 Two isotopes of chlorine are ^{35}Cl and ^{37}Cl.

Using these isotopes, how many different relative molecular masses are possible for the compound with the molecular formula $C_2H_3Cl_3$?

A 2 **B** 3 **C** 4 **D** 5

6 A piece of magnesium reacts with dilute hydrochloric acid.

Which statement is correct?

A A covalent compound is formed during the reaction.

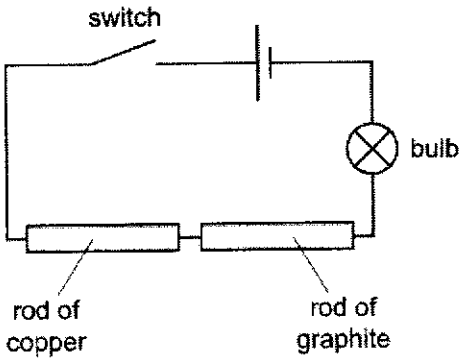
B Each chlorine atom loses one electron in the process.

C Each magnesium atom gains one electron in the process.

D Molecules of an element is formed during the reaction.

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7 The circuit diagram shows an experiment using a rod of copper and a rod of graphite.

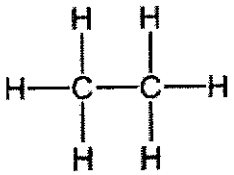


When the switch is closed, the bulb lights because an electric current flows through the copper and the graphite.

Which particle(s) move through these rods?

	copper(II) ions	electrons	carbon ions
A	✓	✗	✓
B	✗	✓	✗
C	✓	✓	✗
D	✗	✓	✓

8 The diagram shows the covalent bonds in an organic compound.



The total number of electrons in one molecule of this compound is .....X..... .

The total number of electrons in the bonds in one molecule of this compound is .....Y..... .

Which numbers correctly complete gaps X and Y?

	X	Y
A	18	14
B	18	12
C	14	14
D	14	12

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9 Two samples of a colourless solution are tested separated with aqueous sodium hydroxide, NaOH(aq), and aqueous ammonia, NH_3(aq), and the results are recorded.

- A white precipitate is formed with two drops of NaOH(aq). This precipitate dissolves in an excess of NaOH(aq).
- A white precipitate is formed with two drops of NH_3(aq). This precipitate dissolves in an excess of NH_3(aq).

What can be deduced from these results?

A The anion present is Cl^-.
B The anion present is not Cl^-.
C The cation ion present is Al^{3+}.
D The cation ion present is Zn^{2+}.

10 A solution of potassium chloride is added to a contaminated sample of water.
A white precipitate forms.
Which ion present in the water causes the precipitate to form?

A carbonate **B** magnesium **C** silver **D** sulfate

11 Compound R has a percentage composition by mass of 63.6 % nitrogen and 36.4 % oxygen.
What is the empirical formula of R?

A N_2O **B** NO **C** NO_2 **D** N_2O_4

12 A chemist makes calcium nitrate by reacting 7.00 g of impure calcium oxide and an excess of dilute nitric acid according to the equation below.

$$CaO + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O$$

It was found that 13.3 g of pure, anhydrous calcium nitrate crystals was produced.
What is the percentage purity of calcium oxide used?
[relative atomic masses, A_r: Ca, 40; N, 14; H, 1; O, 16]

A 50.0 **B** 65.0 **C** 75.0 **D** 80.0

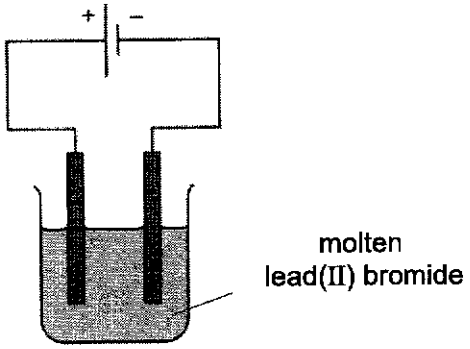
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13 60 cm^3 of propane, C_3H_8, was reacted with 100 cm^3 of oxygen. The resulting mixture was allowed to cool to 25.0 °C.

What is the volume of gases in the resulting mixture?

A 0 cm^3 **B** 60 cm^3 **C** 100 cm^3 **D** 140 cm^3

14 Lead(II) bromide is electrolysed using inert electrodes.



Which statement is correct?

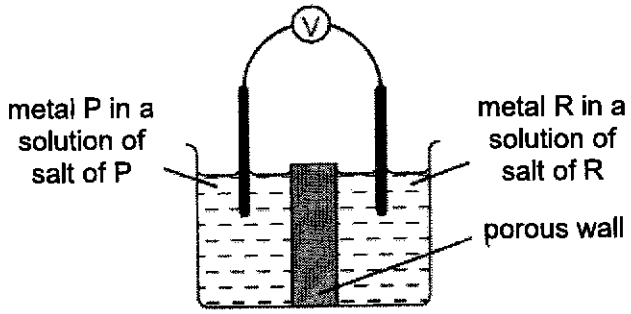
A A reddish-brown gas is seen.

B Electrons pass through the electrolyte from one electrode to the other.

C Ions pass through the circuit from one electrode to the other.

D The lead(II) ions are oxidised.

15 Which pair of metals, P and R, will produce the highest voltage when used as electrodes in a simple cell?



	metal P	metal R
A	copper	silver
B	magnesium	silver
C	magnesium	zinc
D	zinc	copper

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16 Concentrated aqueous potassium chloride is electrolysed using inert electrodes.

Which row shows what happens in this electrolysis and why it happens?

	change occurring	explanation
A	oxygen gas is produced at the anode	OH^-(aq) ions loses electrons more easily than Cl^-(aq) ions
B	during electrolysis, the pH of the electrolyte increases	H^+(aq) ions are discharged in the aqueous solution
C	solid potassium is produced at the cathode	K^+(aq) ions are discharged in the aqueous solution
D	the products stay the same if the aqueous potassium chloride is replaced by dilute aqueous potassium chloride	K^+ and Cl^- are present in both concentrated and dilute aqueous potassium chloride

17 An aqueous mixture of copper(II) nitrate and silver nitrate is electrolysed with pure copper electrodes.

Which half-equation correctly describes the change occurring at the anode?

A $Cu(s) \rightarrow Cu^{2+}(aq) + 2\,e^-$

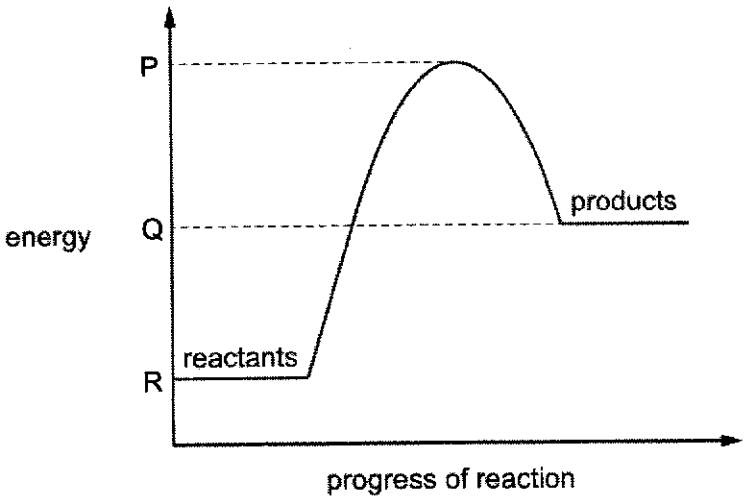
B $Cu^{2+}(aq) + 2\,e^- \rightarrow Cu(s)$

C $Ag(s) \rightarrow Ag^+(aq) + e^-$

D $Ag^+(aq) + e^- \rightarrow Ag(s)$

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18 The energy profile diagram for a reaction is shown below.



Which statement about this reaction is correct?

A It is endothermic and the activation energy is P to Q.
B It is endothermic and the activation energy is P to R.
C It is exothermic and the activation energy is P to Q.
D It is exothermic and the activation energy is P to R.

19 Which statements about the energy changes during a chemical reaction are correct?

1 The activation energy, *Ea*, is the maximum energy the colliding particles must have in order to react.
2 During an endothermic reaction, thermal energy is taken in from the surroundings leading to a decrease in temperature of the surroundings.
3 The making of chemical bonds is an exothermic process.

A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 1, 2 and 3

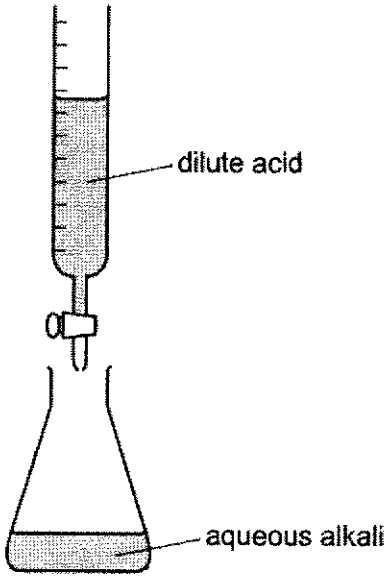
20 Two gases react inside a sealed vessel.
Which change in conditions would increase the rate of reaction?

1 increasing the pressure inside the vessel
2 increasing the temperature inside the vessel
3 increasing the volume of the vessel

A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 1, 2 and 3

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21 The diagram shows a titration experiment.



Which row about the reaction in the conical flask is correct?

	reaction	value of ΔH
A	endothermic	positive
B	endothermic	negative
C	exothermic	positive
D	exothermic	negative

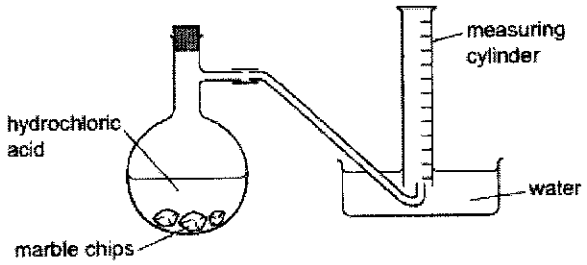
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22 A student plans to investigate how the rate of reaction changes when dilute hydrochloric acid and marble chips, $CaCO_3$, react.

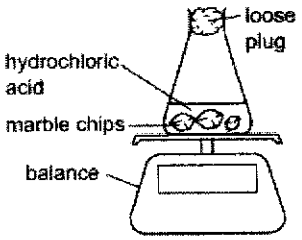
$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

Three methods are described below.

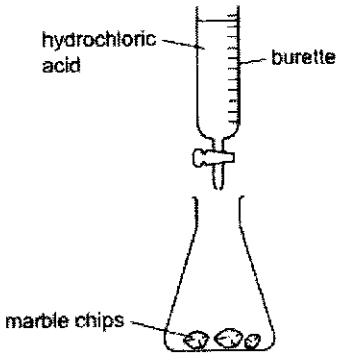
1



2



3



With the use of a stopwatch, which methods could be used to measure how the rate of reaction changes?

A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 1, 2 and 3

23 The following statements about dilute sulfuric acid are all correct.

1 A white precipitate is formed when aqueous barium chloride is added.
2 The solution turns anhydrous copper(II) sulfate from white to blue.
3 Addition of Universal Indicator shows that the solution has a pH value of less than 7.0.
4 The solution reacts with copper(II) oxide, forming a blue solution.

Which two statements confirm the acidic nature of the solution?

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

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24 Which element will burn in oxygen to form an acidic oxide?

A aluminium
B barium
C carbon
D magnesium

25 The diagram shows colours of indicators, methyl orange and methyl red at different pH values.

pH	2	3	4	5	6
colour of methyl orange	red		yellow		
colour of methyl red	red				yellow

The table shows the pH of four solutions.

solution	W	X	Y	Z
pH	2	3	5	6

In which solutions will both indicators be yellow?

A W and X **B** X and Y **C** Y and Z **D** Z only

26 Which method is not suitable to prepare copper(II) nitrate?

A React copper with nitric acid.
B React copper(II) carbonate with nitric acid.
C React copper(II) hydroxide with nitric acid.
D React copper(II) oxide with nitric acid.

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27 Which method of preparation of iron(II) sulfate is an example of a redox reaction?

A $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

B $FeO + H_2SO_4 \rightarrow FeSO_4 + H_2O$

C $Fe(OH)_2 + H_2SO_4 \rightarrow FeSO_4 + 2H_2O$

D $FeCO_3 + H_2SO_4 \rightarrow FeSO_4 + CO_2 + H_2O$

28 Which change in the properties of the halogens is not correct?

	chlorine → bromine → iodine
A	darker in colour
B	decrease in melting point
C	decrease in oxidising power
D	increase in density

29 The elements are arranged in groups and periods in the Periodic Table.
Which row is correct?

	group determined by	period determined by	elements in the Periodic Table are arranged by
A	the number of valence electrons	the number of occupied shells	increasing mass number
B	the number of occupied shells	the number of valence electrons	increasing proton number
C	the number of valence electrons	the number of occupied shells	increasing proton number
D	the number of occupied shells	the number of valence electrons	increasing mass number

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30 When a strip of magnesium is placed in aqueous silver nitrate, a displacement reaction takes place.

What is the ionic equation for this reaction?

A $Ag^{2+}(aq) + Mg(s) \rightarrow Ag(s) + Mg^{2+}(aq)$

B $2Ag^{+}(aq) + Mg(s) \rightarrow 2Ag(s) + Mg^{2+}(aq)$

C $2Ag^{+}(aq) + Mg(s) \rightarrow 2Ag(s) + Mg^{2+}(aq) + e^{-}$

D $2AgNO_3(aq) + Mg(s) \rightarrow 2Ag(s) + Mg(NO_3)_2(aq)$

31 Zinc is used to galvanise iron, which prevents the iron from rusting.

Which statements are correct?

1 When iron rusts, atoms of iron loses electrons to form ions.

2 Zinc will oxidise before the iron does, even if the layer of zinc is scratched.

3 The layer of zinc forms a barrier between the iron and the oxygen and water in the atmosphere.

A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 1, 2 and 3

32 Which statement about global warming is correct?

A Methane produced by decomposition of animals has no effect on the rate of global warming.

B The products of burning of fossil fuels have no effect on the rate of global warming.

C The products of decomposition of vegetative matter have no effect on the rate of global warming.

D The products of photosynthesis have no effect on the rate of global warming.

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33 Different strategies to reduce the effects of environmental issues have been suggested.

Which row is correct?

	strategy to reduce the effects of climate change	strategy to reduce the effects of acid rain
A	reduction in livestock farming	planting trees
B	reduction in livestock farming	using low-sulfur fuel
C	reduction in the use of renewable energy	planting trees
D	reduction in the use of renewable energy	using low-sulfur fuel

34 Hydrogen is used as a reactant both in the Haber process and in its addition to alkenes.

Which row is correct?

	catalyst in Haber process	product of addition of hydrogen to an alkene
A	iron	alkane
B	iron	alcohol
C	nickel	alkane
D	nickel	alcohol

35 Ethanol is produced by the fermentation of glucose from sugar cane. In some countries, ethanol is used as a fuel.

Which statements are correct?

1 Sugar cane is a non-renewable (finite) resource.

2 When sugar cane is growing, it removes carbon dioxide from the atmosphere.

A 1 only

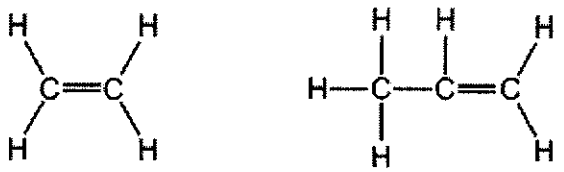
B 2 only

C both 1 and 2

D neither 1 nor 2

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36 The diagram shows the structures of ethene and propene.



ethene propene

Which statement is true about both 1 mole of ethene and 1 mole of propene?

A They contain equal numbers of atoms.

B They give equal volumes of carbon dioxide when burnt completely in oxygen.

C They give equal masses of ethane and propane when reacted with hydrogen.

D They react with equal masses of bromine.

37 Which equation shows the reaction of ethane with chlorine in the presence of ultraviolet light?

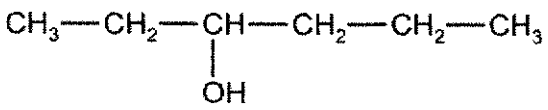
A $C_2H_6 + Cl_2 \rightarrow C_2H_6Cl_2$

B $C_2H_6 + Cl_2 \rightarrow C_2H_4Cl_2 + H_2$

C $C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$

D $C_2H_6 + Cl_2 \rightarrow 2CH_3Cl$

38 Hexan-3-ol is an alcohol.



hexan-3-ol

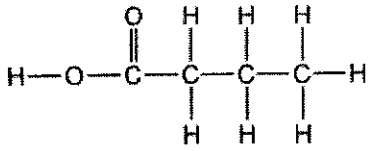
How many molecules of oxygen are needed for the complete combustion of one molecule of hexan-3-ol?

A 9 **B** 10 **C** 18 **D** 19

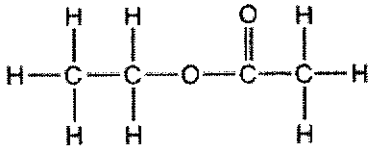
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39 What is the displayed formula of methyl propanoate?

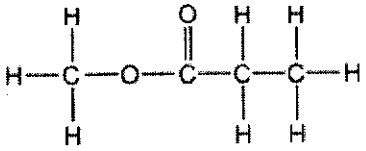
A



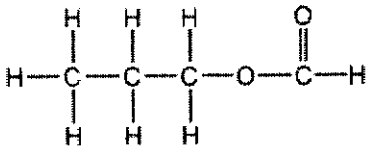
B



C



D



40 Polymer X is an addition polymer. The monomer used to make X is but-2-ene.

Polymer Y is a condensation polymer. The monomers used to make Y are $HOCH_2CH_2OH$ and $HOOCCH_2COOH$.

Which statement about X and Y is correct?

A The repeat unit of X is $-[CH(CH_3)CH(CH_3)]-$ and Y is a polyamide.

B The repeat unit of X is $-[CH(CH_3)CH(CH_3)]-$ and Y is a polyester.

C The repeat unit of X is $-[CH_2CH(C_2H_5)]-$ and Y is a polyamide.

D The repeat unit of X is $-[CH_2CH(C_2H_5)]-$ and Y is a polyester.

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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											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 –

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

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

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

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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
0845 – 1030

Friday 23 August
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.

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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]

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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]

[Turn over

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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]

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

_____ [1]

[Total: 9]

[Turn over

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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]

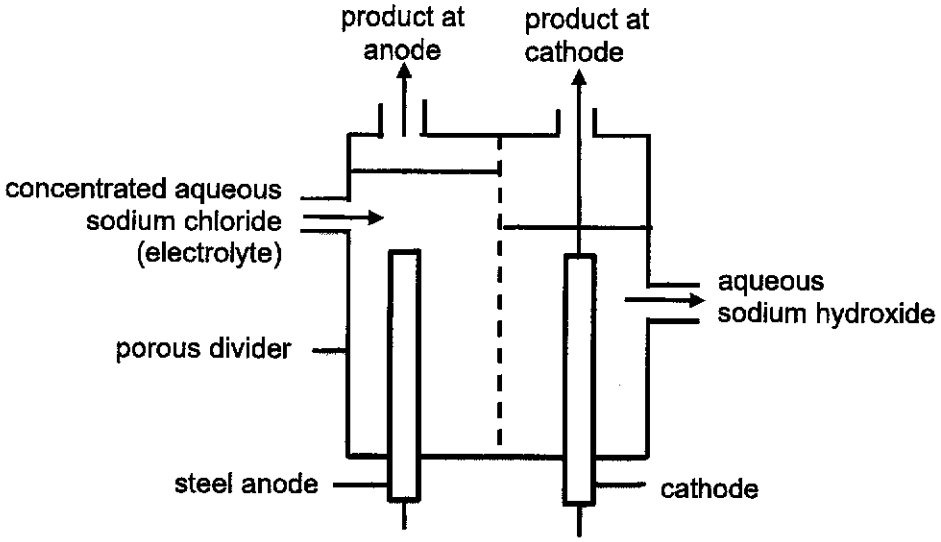
(iii) Draw the structure of the compound formed when **T** reacts with propene.

[1]

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(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

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(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.

_____

_____

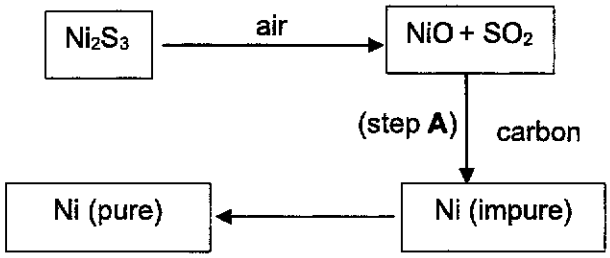
_____

_____ [2]

[Total: 11]

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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.



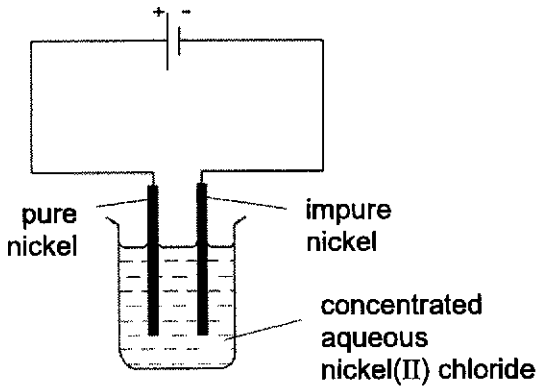
(a) Write an equation for the formation of impure nickel in step **A** and explain **fully** the environmental effect(s) of the product(s) of the reaction.

[3]

[Turn over

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



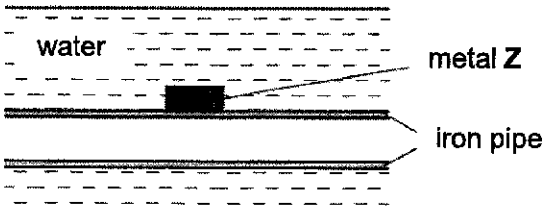
Student A: I think it will not work as the electrolyte is incorrect.
Student B: The electrolyte used is correct but the positions of the pure and impure nickel need to be exchanged.

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

[5]

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(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]

[Turn over

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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, $\Delta H = -92$ kJ.

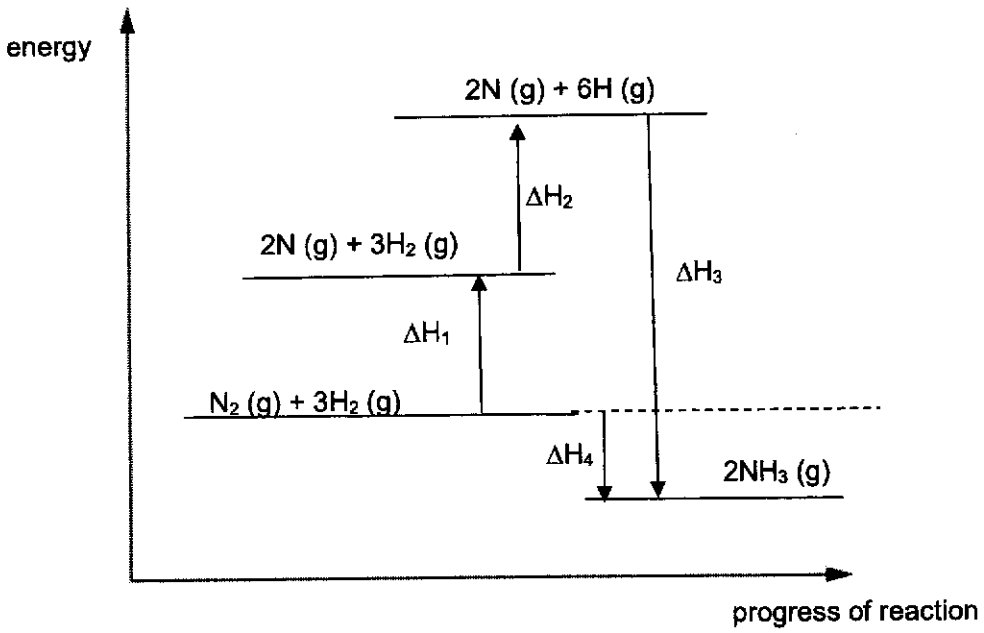
(a) Explain how one is able to tell from the information above if the reaction is exothermic or endothermic.

_____ [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:



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(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]

[Turn over

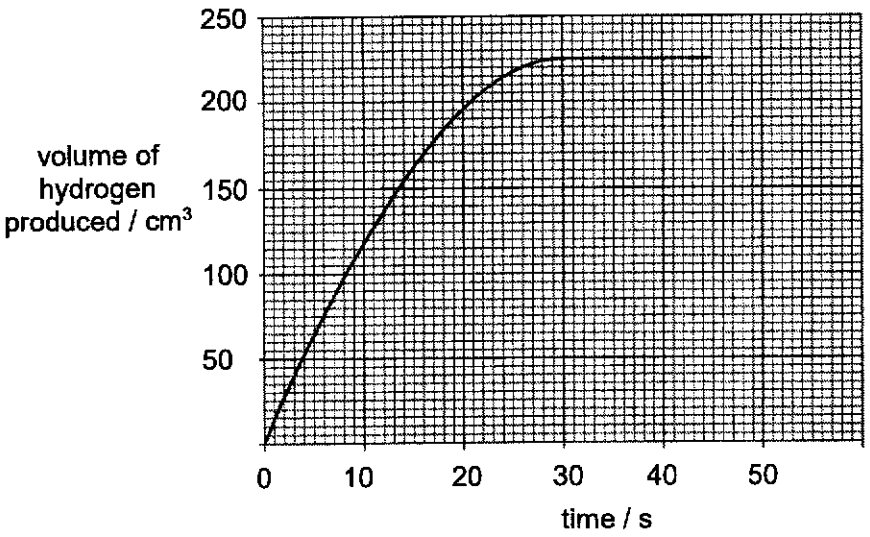
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7 A student carried out three experiments using lithium and water.

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]

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(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

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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]

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(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.

_____

_____

_____

_____

_____

_____

_____

_____ [4]

[Total: 9]

[Turn over

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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]

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(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]

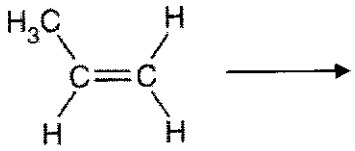
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10 Food packaging used in industries produces a lot of waste which includes both glass and plastic.

(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.

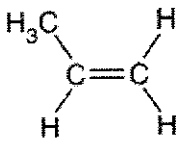


[1]

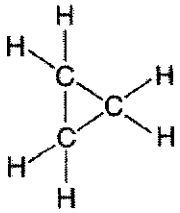
(ii) With the aid of an equation, calculate the percentage yield of carbon dioxide if 4800 dm^3 of carbon dioxide is released when 4.2 kg of propene is burnt.

[2]

(b) Propene and cyclopropane are isomers.



propene



cyclopropane

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

_____

_____ [1]

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(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											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 –

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

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

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

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2024 SIP Chemistry Prelim Key

Paper 1

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

Explanation

No	Ans	Explanation
1	D	When T decreases, particles have less KE and move more slowly from one another.
2	A	Ethylamine has lower M_r of 45 as compared to hydrogen chloride with M_r of 36.5 and diffuses at a slower rate. Hence the white solid will be formed at A.
3	D	Oxygen is an element, glucose $C_6H_{12}O_6$ is a compound (fixed composition) and air (which has variable composition of components from which it's made up) is a mixture.
4	C	copper(II) sulfate and water can be separated by simple distillation(to obtain water) or crystallization (to obtain copper(II) sulfate); methanol and ethanol are separated by fractional distillation due to their different bp; methanol and ethanol can be separated by fractional distillation due to their different bp; sand and silver chloride cannot be separated by filtration as both are insoluble in water.
5	C	The molecules that can be obtained are $C_2H_3{}^{35}Cl_3$, $C_2H_3{}^{37}Cl_3$, $C_2H_3{}^{35}Cl_2{}^{37}Cl$, $C_2H_3{}^{35}Cl{}^{37}Cl_2$
6	D	Magnesium reacts with dilute hydrochloric acid to form magnesium chloride (ionic compound) and hydrogen (molecules of element). Magnesium atom transfer 2 electrons, one to each chlorine atom.
7	B	Particles that enable electrical conductivity are free, mobile ions and delocalised electrons. Copper is able to conduct electricity due it its 'sea' of delocalised electrons while graphite can conduct electricity as there is one valence electron per carbon atom that is not involved in bonding.
8	A	The total number of electrons in the compound includes those which are not in the valence shells. Each bond in the diagram represents a pair of electrons.
9	D	Zinc ions produces a white precipitate in both aq sodium hydroxide and ammonia which dissolves in excess.
10	C	Only silver ions will form a white precipitate with chloride ions.
11	A	Percentage composition of N in N_2O = (14x2)/(14x2+16) x 100% = 63.6% Percentage composition of O in N_2O = (16)/(14x2+16) x 100% = 36.4%

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<table>
<tr><td>12</td><td>B</td><td>No. of moles of calcium nitrate = 13.3/(40+2x14+6x16) = 0.08110
By comparing mole ratio, no. of moles of calcium oxide = 0.08110
mass of calcium oxide present = 0.081 x (40+16) = 4.54 g
Percentage purity = 4.54/7 x 100% = 65.0%</td></tr>
<tr><td>13</td><td>C</td><td><table>
<tr><td></td><td>C_3H_8 +</td><td>$5O_2 \rightarrow$</td><td>$3CO_2$ +</td><td>$4H_2O$</td></tr>
<tr><td>Initial</td><td>60</td><td>100</td><td></td><td></td></tr>
<tr><td>Used</td><td>20</td><td>100</td><td></td><td></td></tr>
<tr><td>Left / produced</td><td>40</td><td>0</td><td>60</td><td>80 (but it will cool to a liquid)</td></tr>
</table>Total volume of gas = 40 + 60 = 100 cm^3</td></tr>
<tr><td>14</td><td>A</td><td>Products of electrolysis: lead (grey) and bromine (reddish – brown)
Reaction at cathode: Pb^{2+} reduced by gaining 2 e^- to form Pb.
Reaction at anode: Br^- oxidised by losing 2 e^- to form Br_2.</td></tr>
<tr><td>15</td><td>B</td><td>Magnesium and silver are the furthest from each other in the electrochemical series and hence, produces the highest voltage.</td></tr>
<tr><td>16</td><td>B</td><td>For concentrated potassium chloride,
Hydrogen ions gets reduced to form hydrogen gas at the cathode (potassium will not be discharged) while chloride ions (due to its high concentration) gets oxidised to form chlorine gas.
The potassium and hydroxide ions will form potassium hydroxide which has a pH of more than 7, resulting in an increase in the pH of the electrolyte.</td></tr>
<tr><td>17</td><td>A</td><td>At the copper anode, copper, which loses electrons more readily than the anions present, will undergo oxidation to form copper(II) ions.</td></tr>
<tr><td>18</td><td>B</td><td>As the energy level of the products is higher than that of the reactants, this is an endothermic reaction. The activation energy, which is the minimum energy particles must possess before a reaction can proceed, can be found by subtracting R from P.</td></tr>
<tr><td>19</td><td>C</td><td>Statement 1: The activation energy, Ea, is the minimum energy the colliding particles must have in order to react.
The other 2 statements are true as thermal energy is taken in during an endothermic reaction and this leads to a decrease in T of the surrounding.
Bonding making is an exothermic process as energy is given out.</td></tr>
<tr><td>20</td><td>A</td><td>Increasing the pressure and temperature in the vessel increases the rate of reaction involving gases.</td></tr>
<tr><td>21</td><td>D</td><td>Neutralisation is exothermic in nature and the enthalpy change is negative.</td></tr>
<tr><td>22</td><td>A</td><td>Method 1 measures the volume of carbon dioxide gas collected through the displacement of water, method 2 measures the mass loss due to loss of carbon dioxide. There's no measurement in a physical quantity in method 3 that allows the rate of reaction to be measured.</td></tr>
<tr><td>23</td><td>D</td><td>Statements 3 and 4 confirm the acidic nature of dilute sulfuric acid as acids have pH less than 7 and react with copper(II) oxide.</td></tr>
<tr><td>24</td><td>C</td><td>Non-metal oxides are usually acidic in nature. Carbon reacts with oxygen to form carbon dioxide which is acidic.</td></tr>
<tr><td>25</td><td>D</td><td>The indicators turn yellow in solutions with pH more than 5. Only Z has pH more than 5.</td></tr>
<tr><td>26</td><td>A</td><td>Copper(II) nitrate is a soluble salt which can be prepared by reacting excess base / carbonate with acid.</td></tr>
</table>

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27	A	Iron has been oxidised to form iron(II) while hydrogen in sulfuric acid has been reduced to form hydrogen gas.
28	B	The melting point of halogens increases as molecular size increases.
29	C	The group number in the Periodic Table is determined by the number of valence electrons while the period number is determined by the number of occupied shells. The elements are arranged according to increasing proton number.
30	B	The charge on the silver ion is 1+. Silver ions undergo reduction to form silver, Ag while magnesium undergo oxidation to form Mg^{2+}.
31	D	In rust prevention, zinc forms a barrier between iron and the oxygen and water in the atmosphere. When a layer of zinc is scratched, it gets oxidised before iron does. When iron rusts, atoms of iron loses electrons to form ions.
32	D	Oxygen which is formed during photosynthesis does not have an effect on global warming.
33	B	A reduction in livestock farming reduces the production of methane and reduces the effect of climate change. Using low-sulfur fuel reduces the amount of sulfur dioxide which contributes to acid rain.
34	A	Finely divided iron is used as catalyst in the Haber process. The addition of hydrogen to alkene produces alkane.
35	B	Sugar cane is a renewable resource. Sugar cane undergoes photosynthesis in which carbon dioxide is utilised.
36	D	Since there is only one carbon-carbon double bond in both molecules, they react with equal masses of bromine.
37	C	Ethane reacts with chlorine in a step-wise substitution reaction in which the hydrogen atom in ethane is progressively replaced by a chlorine atom.
38	A	Equation for combustion of hexan-3-ol: $C_6H_{13}OH + 9O_2 \rightarrow 6CO_2 + 7H_2O$
39	C	Methyl propanoate can be formed from methanol and propanoic acid. The C–O must be found in methanol while the C=O must be found in the acid.
40	B	The repeat unit of X is –[CH(CH_3)CH(CH_3)]– while Y must be a polyester as it is formed between a dicarboxylic acid and a diol.

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Paper 2

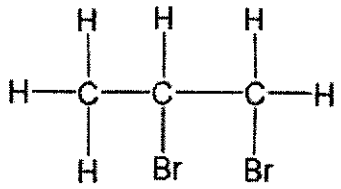
<table>
<tr><td>1</td><td>(a)(i)</td><td>CO</td><td>1</td></tr>
<tr><td></td><td>(ii)</td><td>Al_2O_3 / PbO</td><td>1</td></tr>
<tr><td></td><td>(iii)</td><td>CO / CO_2 / SO_2 / H_2O</td><td>1</td></tr>
<tr><td></td><td>(iv)</td><td>CaO / PbO</td><td>1</td></tr>
<tr><td></td><td>(v)</td><td>CO_2 / CaO / Na_2O / SO_2</td><td>1</td></tr>
<tr><td></td><td>(vi)</td><td>CO_2</td><td>1</td></tr>
<tr><td></td><td>(b)</td><td>• fractional distillation
• boiling points of both glucose and ethanol are different.</td><td>1
1</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>(a)</td><td><table><tr><th>particle</th><th>number of particles</th></tr><tr><td>electron</td><td>18</td></tr><tr><td>neutron</td><td>16</td></tr><tr><td>proton</td><td>15</td></tr></table></td><td>1</td></tr>
<tr><td></td><td>(b)</td><td>P <u>needs 3 electrons</u> to fulfill the noble gas configuration / octet structure.</td><td>1</td></tr>
<tr><td></td><td>(c)(i)</td><td>Yes. It is an ionic compound with
<u>giant crystal / ionic lattice structure</u> and <u>strong electrostatic forces of attraction between oppositely charged ions.</u>
<u>A lot of energy is required</u> to overcome the strong electrostatic forces of attraction hence, calcium phosphate is expected to have high melting point.</td><td>1

1</td></tr>
<tr><td></td><td>(ii)</td><td>Percentage by mass of phosphorus = 2x31/(3x40+2x31+8x16) x 100%
= 20.0%</td><td>1</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>(a)</td><td>$3MoO_2 + 4Al \rightarrow 2Al_2O_3 + 3Mo$</td><td>1</td></tr>
<tr><td></td><td>(b)(i)</td><td><table><tr><th>element</th><th>oxidation state in reactants</th><th>oxidation state in products</th></tr><tr><td>molybdenum</td><td>+4</td><td>0</td></tr><tr><td>aluminium</td><td>0</td><td>+3</td></tr></table></td><td>1

1</td></tr>
<tr><td></td><td>(ii)</td><td>Molybdenum(IV) oxide has been reduced as the oxidation state of molybdenum has decreased from +4 in MoO_2 to 0 in Mo.
Aluminium has been oxidised as the oxidation state has increased from 0 in Al to +3 in Al_2O_3.
Since oxidation and reduction occur simultaneously, this is a redox reaction.</td><td>1

1</td></tr>
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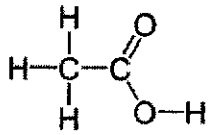
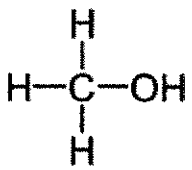
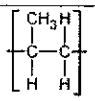
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	(c)	Molybdenum is less reactive as it has been displaced from its oxide / molybdenum(IV) oxide has been reduced by alumnium	1
	(d)(i)	Metallic bonding. Structure drawn to show cations in a 'sea' of delocalized electrons.	1 1
	(ii)	Stronger electrostatic forces of attraction due to higher number of electrons and protons present in Mo.	1
4	(a)(i)	iron(III) chloride	1
	(ii)	$Cl_2(g) + 2Br^- \rightarrow Br_2(aq) + 2Cl^-(aq)$ T is bromine.	1 1
	(iii)		1
	(b)(i)	$2H^+(aq) + 2e^- \rightarrow H_2(g)$ $2Cl^-(aq) \rightarrow Cl_2(aq) + 2e^-$	1 1
	(ii)	Moist blue litmus paper turns red then bleached	1
	(iii)	Both hydrogen and chloride ions are discharged from the solution, leaving behind sodium and hydroxide ions.	1
	(Iv)	To prevent mixing of the products from the 2 electrodes.	1
	(v)	Steel contains iron which will react with chlorine to form iron(II) chloride. Graphite / any inert electrode	1 1
5	(a)	$2NiO + C \rightarrow 2Ni + CO_2$ produces carbon dioxide gas which is a greenhouse gas that contributes to global warming. This leads to the melting of polar ice caps and flooding of low-lying areas / decrease in crop yield / unusual weather conditions / release of carbon dioxide dissolved in oceans which further adds to greenhouse effect	1 1 1
	(b)	Student B is correct as: Ni^{2+} ions are present in the electrolyte and will get preferentially discharged at the cathode to form Ni. The positions of the electrodes are incorrect as: • impure nickel should be connected to the positive terminal of the battery so that it can undergo • oxidation to form Ni^{2+} • pure nickel should be connected to the negative terminal of the battery so that Ni^{2+}can undergo • reduction to form Ni	 1 1 1 1 1
	(c)	Nickel is less reactive than iron and loses electrons less readily Hence, it cannot protect the pipe which is made of iron from rusting.	1 1
6	(a)	The enthalpy change / ΔH value is negative so it is an exothermic	1

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		reaction.	
	(b)(i)	ΔH_1 = +941 kJ (breaking of N≡N) ΔH_2 = 3(+436) = +1308 kJ (breaking of H−H) ΔH_4 = -92 kJ ΔH_3 = -(+941 +1308) + (- 92) = -2341 kJ Bond energy of N−H = 2341/6 ≈ 390 kJ/mol	1 1 1 1 1
	(ii)	E_a = 941 + 1308 ≈ 2250 kJ/mol	 1
7	(a)	• reacts quickly with water / lithium dissolves in water • lithium darts about in water • effervescence / bubbles produced 1 mark for 1 observation	2
	(b)	• the rate of reaction decreases as the amount of lithium present decreases • eventually stops as there is no more lithium present.	1 1
	(c)	9.5s	1
	(d)(i)	Experiment 2: 56.3 cm^3 Experiment 3: 225 cm^3	1 1
	(ii)	Experiment 2: Rate of reaction will be slower as amount of lithium is less resulting in fewer effective collisions per unit time. Experiment 3: Rate of reaction will be faster as particles possess more KE / more particles possess energy equal to or greater than E_a resulting in more effective collisions per unit time.	 1 1 1 1
8	(a)	SO_2 contributes to the formation of acid rain which lowers the pH of soil/water bodies and corrodes structures and buildings made of limestone and metal.	1 1
	(b)	Fossil fuels / petroleum	1
	(c)	Nitrogen from air reacts with oxygen at high temperatures to produce oxides of nitrogen.	1
	(d)	Carbon dioxide	1
	(e)	Wet scrubbers: Advantage: low operating cost Disadvantage: produces carbon dioxide which is a greenhouse gas Copper oxide technology: Advantage: reduces both oxides of sulfur and nitrogen / does not produce landfill waste / does not produce carbon dioxide	 1 1

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		Disadvantage: requires the use of a lot of natural resources (308.4g/kgS as compared to 2.1g/kgS for wetscrubbers) 1 mark for each advantage/ disadvantage	1 1
9	**(a)**	They have the • Same general formula of $C_nH_{2n+2}COO$ where n is ≥2 • Same functional group of COO • M_r between successive members differ by 14 / molecular formula between successive members differ by a $-CH_2$ Any 1 for 1 mark.	2
	(b)	The melting point increases then decreases (no clear trend) but the boiling point increases as the molecular size / M_r increases	1 1
	(c)	The melting point is below 25 °C and the boiling point is above 25 °C OR 25 °C is between its melting and boiling point.	1 1
	(d)(i)	 organic acid  compound **Y** 1 mark for each correct drawing	2
	(ii)	No. of moles of acid = 1.20 g / 60 = 0.02 mol No. of moles of methyl ethanoate = 0.02 mol Mass of methyl ethanoate = 0.02 x 74 = 1.48 g	1 1
10	**(a)(i)**		1
	(ii)	• $2C_3H_6 + 9O_2 \rightarrow 6CO_2 + 6H_2O$ • No. of moles of propene = (4.2x1000)/42 = 100 mol Volume of carbon dioxide produced = 3 x 100 x 24 = 7200 dm^3 Percentage yield = 4800/7200 x 100% = 66.7 % ECF allowed for incorrectly balanced equation.	 1 1
	(b)(i)	• Both have the molecular formula C_3H_6 but • the arrangement of atoms is different (candidate needs to explain	1

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		the difference fully in their own words)	
	(ii)	• reagent: Br_2 (aq) • reddish brown bromine decolourises when added to propene but remains unchanged when added to cyclopropane	1 1
	(c)(i)	• movement: from vibrate about fixed position to move throughout the liquid • arrangement: from very close, orderly arrangement to close but disorderly arrangement	1 1
	(ii)	• SiO_2 has a giant molecular structure and strong covalent bonds between atoms. • A lot of energy is needed to overcome the bonds hence it has a high melting point.	1 1

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