RIVER VALLEY HIGH SCHOOL
SEC 3 END-OF-YEAR EXAMINATION

CHEMISTRY

PAPER 2

9 OCTOBER 2023

1 HOUR 15 MINUTES

NAME	

CLASS	3		**INDEX NO.**			

READ THESE INSTRUCTIONS FIRST

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

Read these notes carefully.
Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.
*Circle the question you attempted in the table on the right.

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 **16**.

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

FOR EXAMINERS' USE ONLY	
Section A	
A1	/ 4
A2	/ 7
A3	/ 11
A4	/ 11
A5	/ 12
Section B	
B6 (Either / Or)*	/ 10
TOTAL	
Statements	
Significant Figures	
Units	
PAPER 2 (60.4%)	**/ 55**
PAPER 1 (39.6%)	**/ 30**
	/ 100%

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

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 45.

A1 Table 1.1 shows some information about particles **A** to **F**.

Table 1.1

Particle	Number of protons	Number of neutrons	Number of electrons
A	13	14	13
B	17	20	18
C	19	20	18
D	29	35	27
E	30	34	30
F	47	61	46

Use the letters **A**, **B**, **C**, **D**, **E** and **F** to answer the following questions.

(a) Which **two** particles are atoms?

.... [1]

(b) Which **two** particles have the same mass number?

.... [1]

(c) Which **two** particles combine to form a white precipitate?

.... [1]

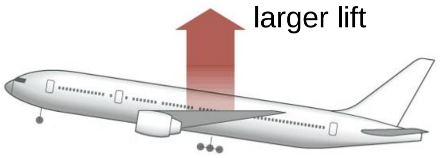
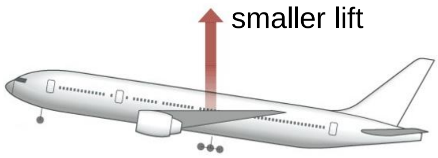
(d) Which particle combine with hydroxide ion, OH^-, to form a blue precipitate?

.... [1]

[Total: 4]

A2 Recently, it was reported in the New York Times that in the hottest days of the summer, some airplanes were forced to be grounded by extreme heat as the high temperatures reduced the performance of the airplanes' engines. When temperature increases, air density decreases. This means that the number of particles per unit volume decreases, which then reduces lift and makes it harder for airplanes to take off.

Table 2.1

LOWER TEMPERATURES	**HIGHER TEMPERATURES**
	
Box A	Box B

(a) Using 'o' to represent air particles, draw diagrams to show the arrangement of air particles at lower temperature and higher temperature in Box A and Box B respectively in Table 2.1. [2]

(b) Use ideas of kinetic particle theory to explain how lower temperatures allow an airplane to take off more easily.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(c) The combustion process in airplanes' engines produce pollutants such as nitrogen monoxide, NO, gas and nitrogen dioxide, NO_2.

(i) Complete Fig. 2.2 to show how a pure and dry sample of nitrogen monoxide gas can be collected from the mixture of pollutants.

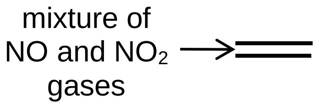


Fig. 2.2

[2]

(ii) Suggest a test to find out if the gas collected is still contaminated with nitrogen dioxide.

………………………………………………………………………………………

……………………………………………………………………………………… [1]

[Total: 7]

A3 **(a)** Nitrogen reacts with hydrogen to form ammonia in the presence of finely divided iron according to the equation shown.

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

Fig 3.1 shows the volume of ammonia formed when 300 cm^3 of hydrogen and 200 cm^3 of nitrogen were added to the reacting mixture.

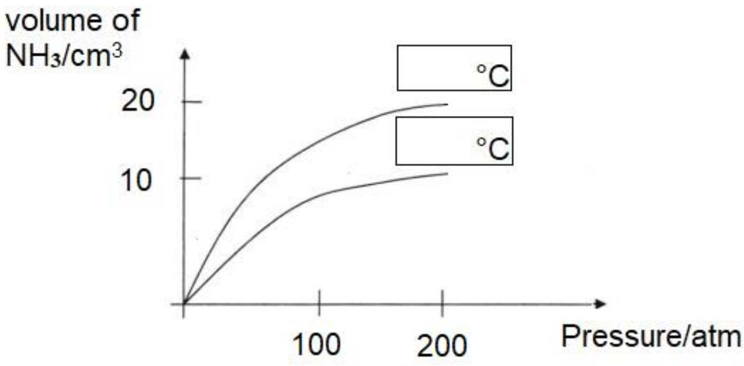


Fig. 3.1

(i) Draw a dot-and-cross diagram to show the bonding in nitrogen. Show only the valence electrons.

[1]

(ii) The reaction was first carried out at 200 °C, and repeated at 400 °C.

In the boxes provided in Fig 3.1, state the temperature (200 °C or 400 °C) that best corresponds to the shape of each curve. [1]

(iii) Calculate the percentage yield of ammonia when the reaction was carried out at 200 atm and 200 °C.

[3]

(iv) Suggest how the reacting conditions can be changed to increase the percentage yield of the reaction.

……………………………………………………………………..………………… [1]

(b) Ammonia is widely used to produce fertiliser in agriculture. A common method to produce fertiliser is to react ammonia with sulfuric acid.

Construct a chemical equation for the reaction between ammonia and sulfuric acid.

………………………………………………………………..……….………………….. [1]

(c) Ammonia gas can also be produced by reacting an oxide of nitrogen with hydrogen.

$$N_xO_y + \text{excess } H_2 \rightarrow xNH_3 + yH_2O$$

0.100 mol of the oxide N_xO_y was mixed with excess hydrogen at room temperature and pressure.

Results showed that 4800 cm^3 of ammonia and 7.20 g of water was produced at room temperature and pressure.

(i) Determine the formula of the oxide of nitrogen.

[3]

(ii) Hence, state the empirical formula of the oxide of nitrogen.

………………………………………………………………..…………..……… [1]

[Total: 11]

A4 **(a)** Copper(II) sulfate was titrated against sodium iodide as shown in the equation below.

$$2CuSO_4 + 2NaI \rightarrow Cu_2SO_4 + I_2 + \text{Product } \mathbf{Z}$$

(i) At the end of the reaction, the solution appears brown. Explain why.

………………………………………………………………………………… [1]

(ii) Identify product **Z.**

………………………………………………………………………………… [1]

(iii) Complete Table 4.1 to show the oxidation states of copper and iodine in the reactants and products.

Table 4.1

element	oxidation state in reactant	oxidation state in product
copper		
iodine		

[2]

(iv) Which element is reduced in the reaction? Use ideas of electron transfer to explain your answer.

…………………………………………………………………………………

………………………………………………………………………………… [2]

(b) Manganese is a transition element with variable oxidation states. To investigate the variable oxidation states, a student added substance **X** to a sample of potassium manganate(VII), $KMnO_4$, solution.

reaction:	$MnO_4^-(aq)$	$\xrightarrow{\text{step 1}}$	$MnO_4^{2-}(aq)$	$\xrightarrow{\text{step 2}}$	$MnO_2\ (s)$
observation:	purple solution		green solution		black solid

(i) During the reaction, the solution turned from purple to green, and finally a black suspension was formed.

Is manganese oxidised or reduced in step 1 of the reaction? Explain your answer in terms of change in oxidation state.

…………………………………………………………………………………

…………………………………………………………………………………

………………………………………………………………………………… [2]

(ii) The half-equation for the reaction of manganate(VII) ion, MnO_4^{2-}, to form manganese dioxide, MnO_2 is shown.

Fill in the blanks to balance the equation.

$$MnO_4^{2-} + \text{……..…}H_2O + \text{……..…}e^- \rightarrow MnO_2 + 4OH^-$$ [1]

(iii) Suggest why a suspension was observed at the end of step 2.

……………………………………………………………………..………….……… [1]

(iv) State whether substance **X** is an oxidising or reducing agent.

……………………………………………………………………..………….……… [1]

[Total: 11]

A5 History of the Singapore Coins

The three series of the one-dollar Singapore coins have been developed over time.

The first and second series consist of alloys.

The third series is made up of bi-metallic materials comprising an inner circle of multi-ply nickel-plated steel and an outer ring of multi-ply brass-plated steel.

Table 5.1 shows the development of the one-dollar coin from the first to the third series.

Table 5.1

	first series	second series	third series
year of launch	1967	1987	2013
image of the $1 coin			
mass of coin /g	16.85	6.30	7.62
material	Copper-nickel	Aluminium-bronze	Nickel plated steel (inner circle) Brass plated steel (outer circle)

The third-series coins are minted on multi-ply plated steel, comprising a steel core plated with three layers of metals: brass over copper over nickel.

Due to various design considerations, different metals have been used to manufacture the coins over the years.

Table 5.2 shows the properties of the various metals used to manufacture the one-dollar Singapore coin.

Table 5.2

	melting point / °C	density / kg m^{-3}	composition	coefficient of linear expansion at 20°C / arbitrary units
aluminium	660	2700	pure aluminium	23.0
copper	1082	8900	pure copper	16.7
iron	1538	7250	pure iron	12.0
nickel	1453	8900	pure nickel	12.8
bronze	1040	8730	90% copper 10% tin	17.3
brass	950	8450	70% copper 30% zinc	16.7
steel	1510	7850	99% iron 1% carbon	11.1

(a) With reference to the data in Table 5.1 and 5.2, suggest why the second-series one-dollar Singapore coin is the lightest.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(b) Use ideas of structure to explain why a mixture of metals, rather than pure metals, are used to make the first and second series of one-dollar Singapore coins.

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……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(c) Using information from Table 5.2, compare the difference in melting point between a pure metal and when it is mixed with other elements.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(d) The coefficient of linear thermal expansion (CTE) is a material property that indicates the extent to which a material expands upon heating. CTE is related to a material's ability to overcome the attractive forces within the material. The higher the coefficient, the weaker the attractive forces within the material, hence the greater the material expands.

(i) Use ideas of bonding to explain why metals have low coefficient of thermal expansion.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(ii) Carbon (diamond) has the lowest known CTE of all naturally occurring materials, but polymers such as poly(tetrafluoroethene) typically have high CTE.

Use ideas of structure and bonding to explain this difference in property.

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……………………………………………………………………………………

……………………………………………………………………………………

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……………………………………………………………………………………

…………………………………………………………………………………… [3]

(iii) Silicon carbide is an important ceramic material in the industry due to its very low CTE. It is formed when carbon and silicon react together. The structure of silicon carbide is shown in Fig. 5.3.

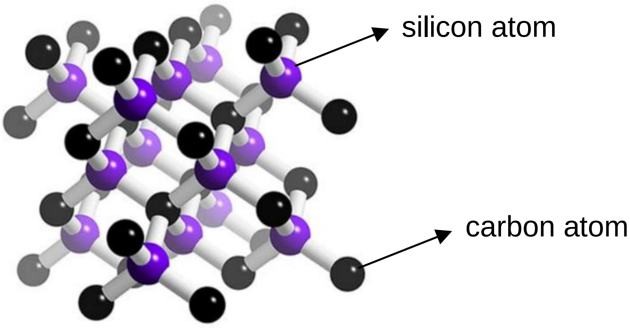

Fig. 5.3

Suggest **two** other properties of silicon carbide that makes it suitable for its use as ceramic materials.

……………………………………………………………………………………

…………………………………………………………………………………… [2]

[Total: 12]

Section B

Answer **one** questions in this section in the spaces provided.
The total mark for this section is 10.

EITHER

B6 Ocean acidification refers to the process in which the ocean becomes more acidic due to increased level of carbon dioxide gas dissolving into seawater to form carbonic acid, H_2CO_3. Carbonic acid is a weak diprotic acid that dissociates to form bicarbonate ion in the first step of its acid dissociation. A diprotic acid generally undergoes a two-step acid dissociation to form hydrogen ions as shown below.

Step1**:** $H_2A \rightarrow H^+ + HA^-$

Step 2: $HA^- \rightarrow H^+ + A^{2-}$

Ocean acidification poses a problem to calcifying sea organisms such as oysters and sea clams that build their hard shells, which is made of calcium carbonate, from the available calcium and carbonate ions in the seawater. Unlike calcium carbonate, calcium bicarbonate is highly soluble in water. Hence, they cannot be used by calcifying organisms to make shells.

(a) Define the term weak acid.

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(b) Construct a balanced chemical equation, with state symbols, for the first acid dissociation of carbonic acid, H_2CO_3.

………………………………………………………………………………………… [2]

(c) Many sea organisms such as oysters and sea clams have hard shells made of calcium carbonate. Suggest why ocean acidification can cause harm to these organisms.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(d) Table 6.1 shows the ions commonly found in seawater.

Table 6.1

Ca^{2+}	Mg^{2+}	Na^{+}	Cl^{-}	CO_3^{2-}

(i) By combining the ions in Table 6.1, state **two** ionic salts that can be prepared using the titration method. Explain your answer.

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…………………………………………………………………………………… [3]

(ii) Describe the key steps that can be taken to prepare pure and dry samples of the salts in **(d)(i)** after performing titration using a suitable indicator.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

[Total: 10]

OR

B6 Table 6.2 shows the colours displayed by the universal indicator papers when dipped into a variety of solutions with different pH values.

Table 6.2

solution	colour of universal indicator
P	blue
Q	green
R	red
S	yellow
T	purple

(a) State the solution that is likely a weak alkali.

.... [1]

(b) The solution in **(a)** is suspected to be methyl amine, CH_3NH_2. Methyl amine ionises in water in a similar manner to ammonia.

Construct a balanced chemical equation, with state symbols, to show the ionisation of gaseous methyl amine in water.

.... [2]

(c) A student claims that solution **Q** is neutral and hence does not contain H^+ or OH^- ions. Explain whether the claim is correct, wrong or partially correct.

....

....

....

.... [2]

(d) Solubility is the amount of solute (measured in g or mol) that can dissolve in a unit volume of solvent (measured in dm^3) at a given temperature. The unit of measurement for solubility is g dm^{-3} or mol dm^{-3}. As a general rule of thumb, any substance with solubility < 0.01 mol dm^{-3} is considered insoluble.

Table 6.3 shows the solubility of the Group 2 metal sulfates.

Table 6.3

Group 2 metal sulfates	solubility (mol dm^{-3})
magnesium sulfate	2.17
calcium sulfate	0.0226
strontium sulfate	0.000617
barium sulfate	x

(i) State the trend of the solubility of Group 2 metal sulfates down the group.

………………………………………………………………………………………… [1]

(ii) Deduce a possible value of x.

………………………………………………………………………………………… [1]

(iii) Describe the key steps that can be taken to prepare a pure and dry sample of magnesium sulfate salt.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [3]

[Total: 10]

The Periodic Table of Elements

Key

atomic number
atomic symbol
name
relative atomic mass

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

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

The volume of one mole of any gas is 22.7 dm^3 at standard temperature and pressure (s.t.p.).

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}