ZHONGHUA SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2024

SECONDARY 4 EXPRESS

Candidate's Name	Class	Register Number

CHEMISTRY

6092 /02

Paper 2

11 September 2024
1 hour 45 minutes

Additional Materials: NIL

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number in the spaces at the top of this page and on all separate answer paper used.

Write in dark blue or black pen.

You may use a pencil for any diagrams, graphs or rough working.

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

Section A

Answer **all** questions.

Write your answers in the spaces provided on the question paper.

Section B

Answer **one** question.

Write your answers in the spaces provided on the question paper.

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

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

All essential working must be shown clearly.

A copy of the Periodic Table is printed on page 24.

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

Section A

Answer **all** the questions.

1 The table below consists of four different experimental procedures.

(a) Put a tick (✓) if a redox reaction had occurred.

	experimental procedure	Put a tick (✓) if a redox reaction has occurred.
(i)	a copper strip added to zinc nitrate solution	
(ii)	aqueous chlorine added to potassium iodide solution	
(iii)	hydrogen gas passed over heated copper(II) oxide	
(iv)	dilute sulfuric acid added to lithium hydroxide	

[2]

(b) A student repeated **(a)(ii)** by replacing aqueous chlorine with aqueous bromine.

Describe a difference in the rates of the two reactions and explain your answer.

.....

.....

..... [2]

(c) Write the chemical equation for the reaction in **(a)(iii).**

..... [1]

[Total: 5]

2 (a) Glasses are mainly made of silicates. Soda-lime glass is made by heating a mixture of calcium carbonate, sodium carbonate and sand in a furnace to a high temperature.
The simplified structures of silicate and soda-lime glass are shown in Fig. 2.1 and Fig. 2.2.

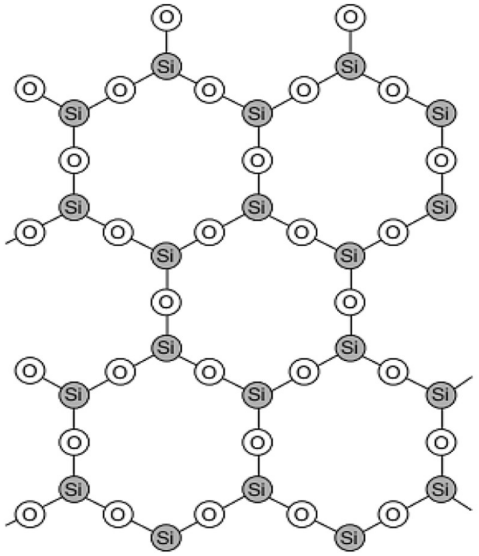
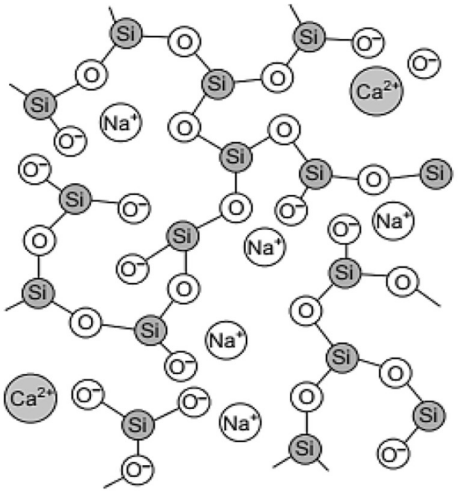
silicates	soda-lime glass
	

Fig. 2.1 **Fig. 2.2**

(i) Describe in terms of bonding two differences in silicate and soda-lime glass.

.....

.....

..... [2]

(ii) Predict and explain the electrical conductivity of soda-lime glass.

.....

.....

..... [2]

(b) Potassium hydroxide is used as an electrolyte in alkaline batteries and in electroplating. Table 2.1 shows the melting and boiling points of potassium hydroxide and chlorine.

Table 2.1

	melting point/ °C	boiling point/ °C
chlorine	-101	-35
potassium hydroxide	360	1327

(i) Explain, in terms of structure and bonding, why potassium hydroxide has a much higher melting point than chlorine gas.

.....

.....

.....

..... [3]

(ii) Draw a "dot-and cross" diagram to show the bonding in a hydroxide ion.
Show outer shell electrons only.

[2]

[Total: 9]

3 Lavender flowers contain a variety of pigments including **X**, **Y** and **Z**. These pigments were separated using paper chromatography with a mixture of ethanol and water as a solvent.
Fig. 3.1 shows how the R_f value of the pigments varies with different compositions of ethanol.

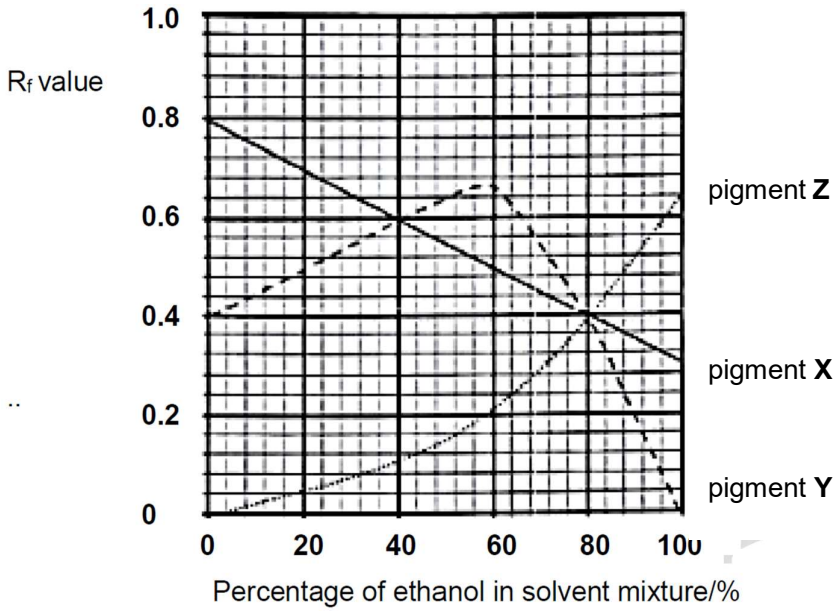


Fig. 3.1

(a) Explain the principle behind paper chromatography.

.....

..... [1]

(b) **(i)** Using Fig. 3.1, state and explain the number of spots obtained from the chromatography using lavender flowers, when the solvent consisted of 40% ethanol.

.....

.....

..... [2]

(ii) Using Fig. 3.1, explain why a pure solvent of water or ethanol is not suitable in separating the pigments effectively.

.....

.....

.....

..... [2]

[Total: 5]

4 Electrolysis is commonly used to give an object an attractive appearance or to prevent corrosion of a metal.
The apparatus shown in Fig. 4.1 was prepared to electroplate an iron object using 200 cm^3 of aqueous copper(II) sulfate as the electrolyte.

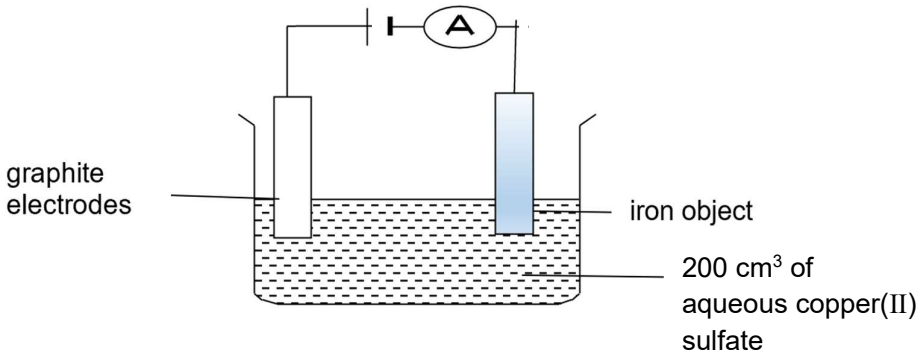
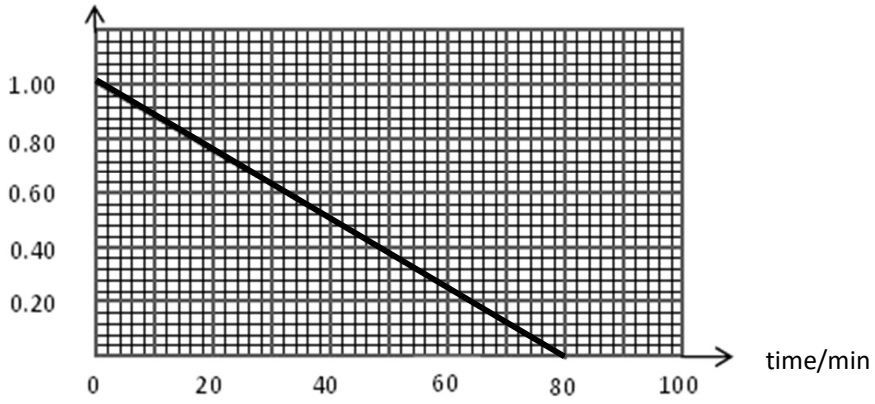


Fig. 4.1

Electrolysis was carried out and the graph below shows the concentration of aqueous copper(II) sulfate against time.

concentration of $CuSO_4(aq)$/ mol dm^{-3}



(a) Explain the shape of the graph by using ionic half-equation to support your answer.

.....

.....

..... [2]

(b) After the electrolysis has been running for some time, describe a test that the student can perform to ensure that all the copper(II) ions has been discharged.

.....

[1]

(c) Using data from the graph, calculate the increase in mass of the iron object after the electrolysis was conducted for 80 minutes.

increase in mass of the iron object ..... [2]

(d) Fig. 4.2 was modified from Fig.4.1.
Electrolysis was conducted using the same quantity of electricity as in Fig. 4.1.

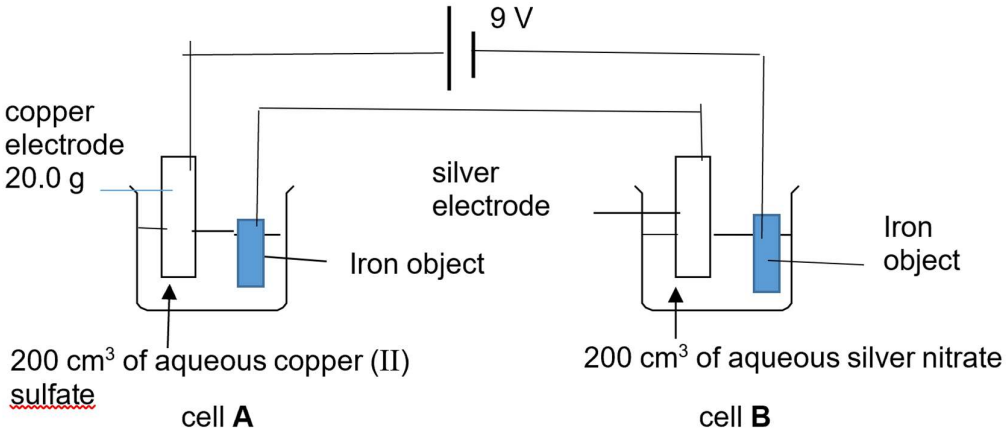
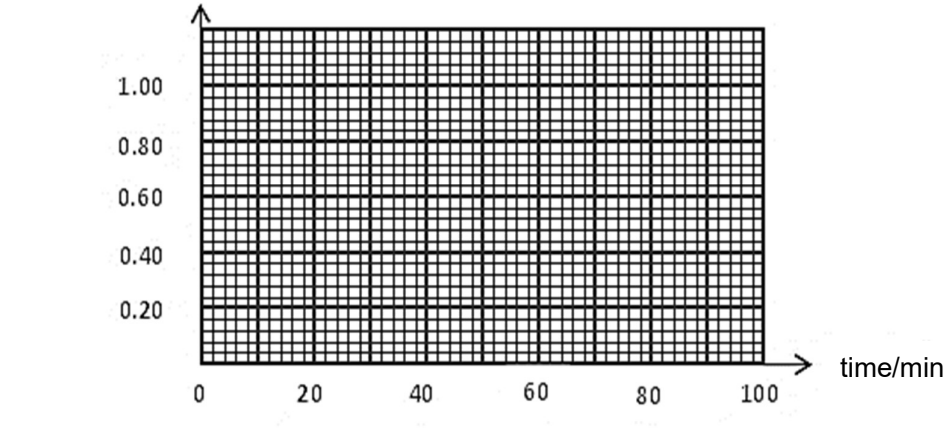


Fig. 4.2

(i) Sketch a line on the graph below to show the concentration of aqueous copper(II) sulfate against time in cell **A**.
The initial concentration of aqueous copper(II) sulfate in cell **A** was 1.00 mol/dm^3.



[1]

(ii) Complete Table 4.3 to describe the reactions in cell **B**.

Table 4.3

solution	name of products of electrolysis		ionic equation for reaction at each electrode
silver nitrate solution	at anode		
	at cathode		

[2]

(iii) Calculate the increase in mass of the iron object in cell **B**.

increase in mass of iron object ..... [2]

[Total: 10]

5 Ammonia can be used to manufacture fertilisers and hydrazine.
The reaction between nitrogen and hydrogen to form ammonia is a reversible process. The chemical reaction is shown below.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \quad \Delta H = -92.4 \text{ kJ / mol}$$

Table 5.1 shows how the percentage yield of ammonia at equilibrium varies with both temperature and pressure.

Table 5.1

pressure/ atm	% yield at 200 °C	% yield at 300 °C	% yield at 400 °C	% yield at 500 °C
30	68	32	11	4
100	81	51	25	10
200	86	63	36	18
300	88	69	40	24

Ammonia can be used to manufacture hydrazine, N_2H_4 in a reaction called the Raschig process. The process involves a two-step process in the presence of sodium hypochlorite, NaOC*l* to convert ammonia to hydrazine.
In step 1, ammonia acts as a 'hydrogen donor' as it 'donates' one of its hydrogen atoms to sodium hypochlorite to form sodium hydroxide.

$$NH_3 + NaOCl \rightarrow NH_2Cl + NaOH$$

In step 2, NH_2Cl formed in step 1 is reacted with more ammonia to produce hydrazine.

$$NH_3 + NH_2Cl + NaOH \rightarrow N_2H_4 + NaCl + H_2O$$

(a) Using Table 5.1, describe and explain, how the percentage yield of ammonia at equilibrium changes with temperature.

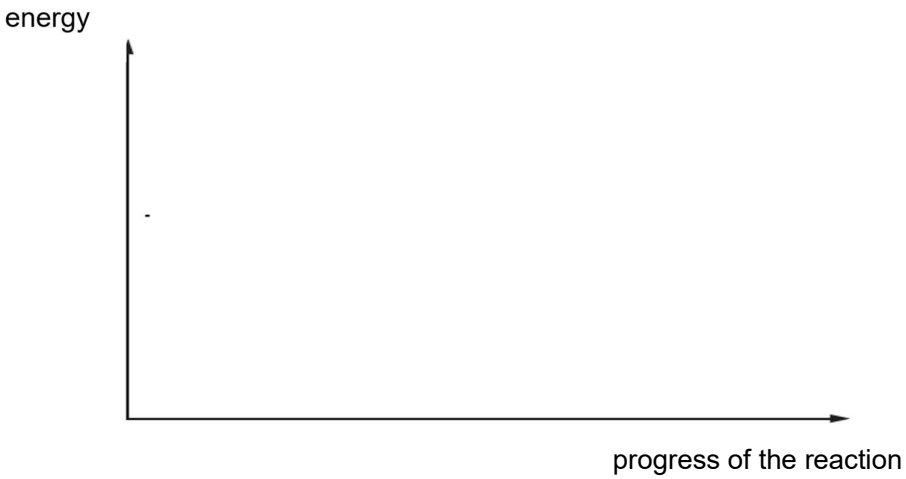
.....

..... [2]

(b) Using the equation for the manufacture of ammonia, complete the energy profile diagram to show the forward reaction for the manufacture of ammonia gas.

Your diagram should label and show

- the reactants and products of the reaction,
- the enthalpy change, ΔH, of the reaction and
- the activation energies, *E*a and Ea' for the uncatalysed and catalysed reactions.



[3]

(c) Write the overall balanced chemical equation for the conversion of ammonia to hydrazine. The overall equation can be derived from the equations in step 1 and 2.

..... [2]

(d) Calculate the percentage purity of ammonia used if 75 g of hydrazine is produced from 100 g of ammonia.

percentage purity of ammonia ..... [2]

(e) In swimming pools, nitrogen compounds such as urea and ammonia may be found. These nitrogen compounds react with hypochlorous acid, HOCl to produce trichloroamine, NCl_3 and another product. Trichloroamine causes swimming pool to have a strong smell.

(i) Write a balanced equation for the reaction between ammonia and hypochlorous acid to produce trichloramine, NCl_3.

.....[1]

(ii) Explain in terms of oxidation state, whether the reaction in **(e)(i)** is a redox reaction.

.....

.....[1]

[Total: 11]

6 *Ideonella sakaiensis* is a type of bacteria found in cow stomachs that can break down polyethylene terephthalate (PET), a type of plastic commonly used to produce bottles. The structure of PET is shown in Fig. 6.1.

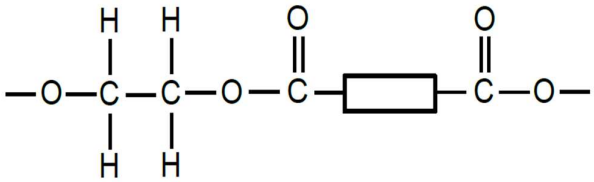


Fig. 6.1

(a) PETase produced by the bacteria breaks down PET to produce ethylene glycol and terephthalic acid.

(i) Draw the full structural formulae of the monomers that react to form PET.

monomer 1	monomer 2

[2]

(ii) State the role of PETase in the breakdown of PET.

.....

[1]

(b) Plastic products can be upcycled to form vanillin, which is a synthetic vanilla flavour.
Vanillin contains the aldehyde functional group.
Table 9.1 shows information about homologous series of aldehydes.

Table 6.1

name	number of carbon atoms	formula	solubility
methanal	1	HCHO	soluble
ethanal	2	CH_3CHO	soluble
propanal	3	C_2H_5CHO	partially soluble
	4		insoluble

(i) Complete Table 6.1 to show the name and formula of the aldehyde that contains 4 carbon atoms.

..... [2]

(ii) Deduce the general formula for aldehydes.

..... [1]

(iii) Using information on the structures of aldehydes, suggest and explain a factor that affects the solubility of organic compounds.

.....

..... [2]

(c) Waxworms were recently discovered to be able to eat and digest poly(ethene) plastic. The saliva from waxworms can metabolise poly(ethene) into ethylene glycol.
Poly(propene) is another plastic used in packaging which has low density and high heat resistant.

(i) Draw the structural formula of two repeat units of poly(propene).

[1]

(ii) Explain how waxworms can help in the environmental problems posed by plastics.

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..... [1]

[Total: 10]

7 A student added powdered manganese(IV) oxide into two separate solutions, dilute hydrochloric acid and aqueous hydrogen peroxide.
The chemical equations for both reactions are given below.

reaction **A**: $MnO_2(s) + 4HCl(aq) \longrightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)$

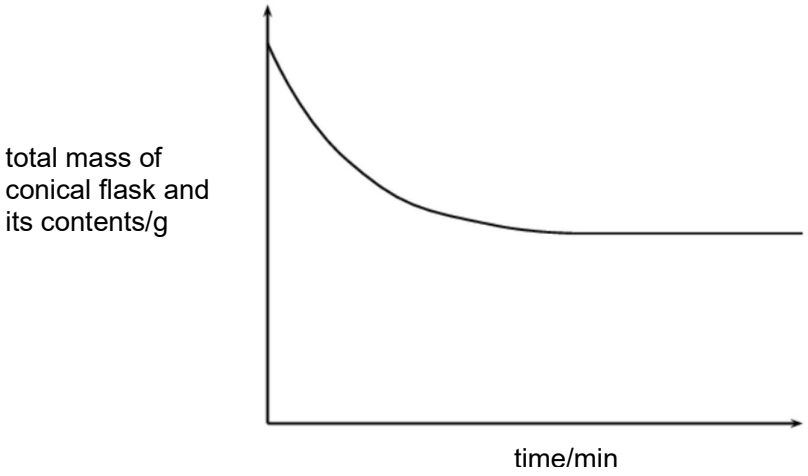
reaction **B**: $2H_2O_2(aq) \xrightarrow{MnO_2(s)} 2H_2O(l) + O_2(g)$

(a) The student followed the rate of reaction **B** by measuring the total mass of the conical flask and its contents over time. The results are shown in Table 7.1.

Table 7.1

time/min	0	5	10	15	20	25
mass/g	550.00	549.84	549.76	549.71	549.69	549.69

(i) He plotted his results and obtained the graph below.



He repeated the experiment at a lower temperature.
On the axes above, sketch the graph of his repeated experiment. [1]

(ii) The student used the same method to follow the rate of reaction **A**.
Suggest a reason to explain why this method is not accurate in investigating the rate of reaction **A**.

.....

..... [1]

(iii) Suggest and explain one change you could make to experiment **A** to improve the accuracy of measuring the rate of reaction.

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.....

..... [2]

(b) The student modified his experiments such that he was able to accurately determine the rate of both reactions.
He then repeated the experiment for each reaction using a larger mass of powdered manganese(IV) oxide and made the following conclusions from his results.

Conclusion 1: The rate of reaction for **A** was significantly higher than the previous experiment.

Conclusion 2: The total volume of oxygen gas collected in **B** remained unchanged.

Explain why both his conclusions are correct.

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..... [2]

(c) Explain in terms of collision theory between particles why the rate of reaction for **B** was significantly higher when the catalyst, MnO_2 is used.

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..... [2]

[Total:8]

8 Vehicular exhaust emissions significantly contribute to pollution in Singapore. To address this issue, the Land Transport Authority introduced the Vehicle Emission Scheme (VES) to reduce harmful emissions. The VES incentives car and taxi buyers to purchase cleaner vehicles by offering rebates or imposing surcharges based on the vehicle's emission levels.

The VES evaluates a vehicle's emissions of the following pollutants:

- carbon dioxide (CO_2)
- carbon monoxide (CO)
- hydrocarbons (C_xH_y)
- nitrogen oxides (NO_x), including nitrogen monoxide (NO) and nitrogen dioxide (NO_2)
- particulate matter (PM)

Emission levels for these pollutants are compared to standards listed in Table 8.1 to determine their banding.

Vehicles with cleaner emissions are placed in higher bands, A1 and A2, while more polluting vehicles fall into lower bands, C1 and C2. A vehicle's overall band, and thus its VES rebate or surcharge, is determined by the pollutant with the lowest band score among all the pollutants.

Under the VES:

- Registering a car or taxi in bands A1 or A2 qualifies for an emission rebate, reducing the vehicle's registration fee.
- Registering a car or taxi in bands C1 or C2 incurs an emission surcharge.
- The rebate and surcharge do not apply for registering a car or taxi in band B.

Table 8.1

band	CO_2 (g/km)	C_xH_y (g/km)	CO (g/km)	NO_x (g/km)	PM (mg/km)	rebate/surcharge (-/+) for cars	rebate/surcharge (-/+) for taxis
A1	≤90	≤0.020	≤0.15	≤0.007	=0.0	-25,000	-37,500
A2	≤125	≤0.036	≤0.19	≤0.013	≤0.3	-15,000	-22,500
B	≤160	≤0.052	≤0.27	≤0.024	≤0.5	0	0
C1	≤185	≤0.075	≤0.35	≤0.030	≤2.0	+15,000	+22,500
C2	>185	>0.075	>0.35	>0.030	>2.0	+25,000	+37,500

(a) Table 8.2 shows the emission information of a car on sale.

Table 8.2

CO_2 (g/km)	C_xH_y (g/km)	CO (g/km)	NO_x (g/km)	PM (mg/km)
83	0.062	0.21	0.037	0.4

(i) Using the emission information in Table 8.2 and with reference to the banding information in Table 8.1 of a car on sale, determine the worst performing pollutant and its band.

..... [1]

(ii) What is the amount of rebate or surcharge that is acquired?

..... [1]

(b) Despite not being an environmental pollutant, the amount of carbon dioxide emission is listed in the Vehicle Emission Schemes among other major air pollutants.

Explain with an example, why high levels of carbon dioxide can have a detrimental effect on the environment.

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..... [2]

(c) The efficiency of car engines is tested in a test facility. The mass of various gaseous pollutants is measured from the exhaust pipe of a car at different speeds. The results are shown in Fig. 8.1.

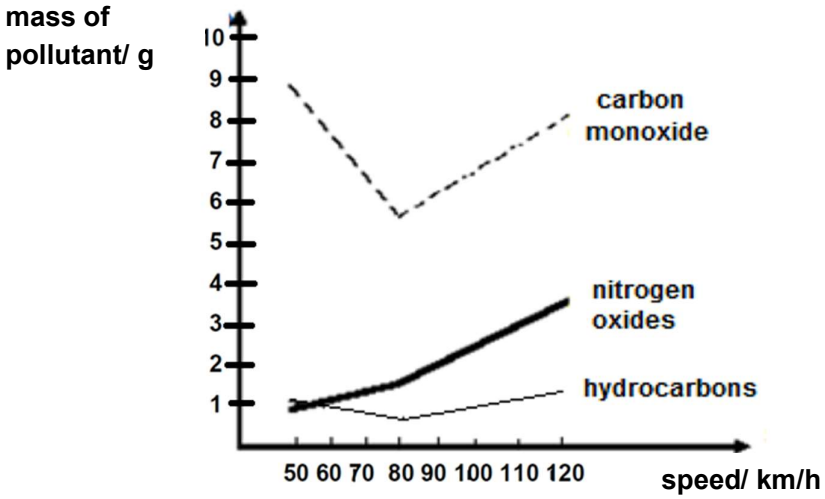

Fig. 8.1

(i) Suggest and explain which pollutant has the highest increase when the speed increases from 50 km/h to 120 km/h.

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..... [2]

(ii) Describe and explain the trend of carbon monoxide emissions in Fig. 8.1 as the speed of the motor car increases from 50 km/h to 120 km/h.

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..... [3]

(d) To further reduce pollutants in car emissions, the Land Transport Authority requires all vehicles registered in Singapore to be fitted with a catalytic converter.
With reference to nitrogen oxides in Fig. 8.1, explain with the help of chemical equations, if necessary, how a catalytic converter helps to reduce the nitrogen oxides emission.

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..... [3]

[Total: 12]

Section B

Answer **one** question from this section.

9 Magnesium sulfate is used to flush toxins from the body. The colourless crystalline heptahydrate, $MgSO_4.7H_2O$ is known as Epsom salts and can be bought from pharmacies and supermarkets. It can be prepared in the laboratory.
4.33 g of magnesium carbonate was reacted with 250 cm^3 of 0.200 mol/dm^3 sulfuric acid.

(a) Identify the limiting reagent and calculate the mass of magnesium sulfate formed.

mass of magnesium sulfate ..... [3]

(b) Suggest why crystal of Epsom salt are not obtained if the evaporating dish is heated to dryness.

.....

..... [1]

(c) Calculate the percentage by mass of water of crystallisation in hydrated magnesium sulfate, $MgSO_4.7H_2O$.

[1]

(d) Describe briefly another method to prepare hydrated magnesium sulfate and name the substance used.

.....

.....

..... [2]

(e) The table below provides some information on sulfate salts of Group 2 elements.

name of salt	solubility (maximum mass in grams dissolved in 100 cm^3 of water at room temperature and pressure)
magnesium sulfate	35.1
calcium sulfate	0.21
barium sulfate	2.45×10^{-4}
radium sulfate	2.10×10^{-8}

From the information given in the table above, suggest how you would prepare a pure, dry sample of radium sulfate. Name the starting reagents in your answer.

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..... [3]

[Total:10]

10 The Leclanché cell is a dry cell widely used as a source of electricity for torches and clocks. Fig. 10.1 shows the components of a Leclanché cell.

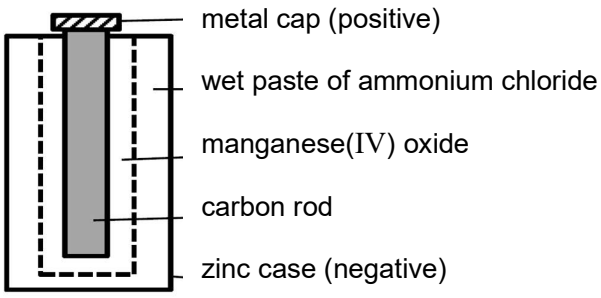

Fig. 10.1

The electric cell works by redox reaction. The following reaction occurs at the zinc case.

$$Zn \rightarrow Zn^{2+} + 2e^-$$

The following reaction occurs at the carbon rod.

$$2MnO_2 + 2H^+ + 2e^- \rightarrow Mn_2O_3 + H_2O$$

The hydrogen ions are provided by the dissociation of the ammonium ions.

$$NH_4^+ \rightleftharpoons NH_3 + H^+$$

The Leclanché cell can deliver a voltage of about 1.4 volts.

(a) Describe how electricity is generated when the Leclanché cell is being used.

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.....

..... [3]

(b) State, with reason, whether the carbon rod is the anode or cathode.

.....

..... [1]

(c) The cell becomes wet and gives out a pungent smell when it runs out.
Explain this observation.

..... [1]

(d) The zinc case is replaced with iron case.
The new Leclanché cell delivers a voltage of 1.1 volts.
Explain the difference.

.....

..... [1]

(e) Lithium-ion is used in batteries to power cell phones, computers, e-bikes, scooters, toys, and even cars.

(i) Why is lithium, a reactive metal, used in car batteries and cell phones?

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..... [1]

(ii) Give two differences in the chemical properties between zinc and lithium. Include a chemical equation for one of the reactions.

.....

.....

.....

..... [3]

[Total:10]

End of paper

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key proton (atomic) 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 –		114 Fl flerovium –		116 Lv livermorium –		

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 –