Name: Register Number: Class:

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80

NAN CHIAU HIGH SCHOOL
PRELIMINARY EXAMINATION 2024
SECONDARY FOUR

Parent's Signature:

CHEMISTRY **6092/2**

Paper 2 **20 August 2024, Tuesday**

1h 45 min

Candidates answer on the Question Paper.

INSTRUCTIONS TO CANDIDATES

Write your name, register number and class in the spaces provided on the question paper.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A: Structured Questions [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.

The number of marks is given in brackets [ ] at the end of each question or part question.
The total marks for this paper is 80.

A copy of the Periodic Table is printed on page 21.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **21** printed pages including the cover page.

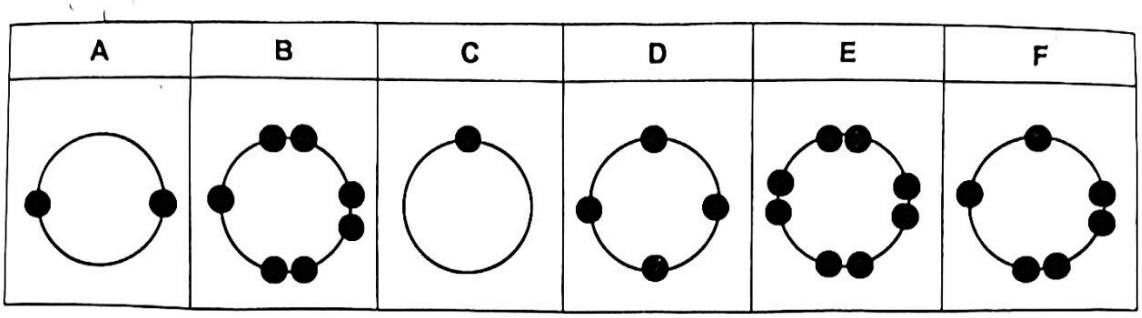
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Section A

Answer **all** questions.

1 These diagrams show the electron arrangement in the outer shells of six elements, **A** to **F**.

All elements are from Period 3 of the Periodic Table.



Use the letters **A** to **F** to answer the following questions.

You may use each letter once, more than once or not at all.

(a) **(i)** The element that exists in a monoatomic state at room temperature

.....[1]

(ii) The element that has giant molecular structure.

.....[1]

(iii) Two elements that form a covalent compound with the formula of XY_2.

.....[1]

(iv) The element that reacts with oxygen to form a gas that is responsible for acid rain.

.....[1]

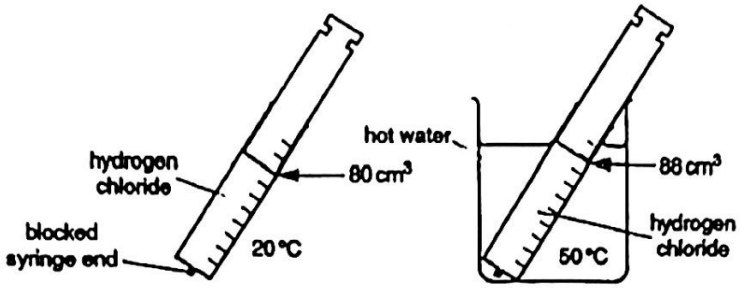
(v) The element that is the strongest reducing agent amongst these six elements..

.....[1]

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(b) A gas syringe was filled with 80 cm^3 of hydrogen chloride gas at 20 °C. The syringe was then placed in hot water at 50 °C.

The volume of the gas in the syringe was observed to increase to 88 cm^3 even though the atmospheric pressure did not change.



Using the kinetic particle theory, explain why the volume increases.

.....

.....

.....

..... [2]

[Total: 7]

2 Barium is a Group 2 metal. Barium is never found in nature as a free element due to its high chemical reactivity.

(a) The process of splitting a nucleus is known as nuclear fission. In nuclear fission, a neutron ^1_0n is fired at a nucleus, which absorbs it and breaks into smaller particles.

In the nuclear fission of uranium–235, barium–141 is obtained as one of the products, together with an **unknown atom A** and 3 free neutrons.

The reaction that occurs can be represented by the following equation:

$$^{235}_{92}U + {}^1_0n \rightarrow {}^{141}_{56}Ba + A + 3\,{}^1_0n$$

(i) State the number of protons, neutrons and electrons in an atom of barium–141.

protons: ..... neutrons: ..... electrons: .....

[1]

(ii) Determine the proton number and identity of the unknown atom **A**.

proton number: ..... identity of unknown atom **A**: .....

[1]

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(b) Compounds of barium have many uses in a wide variety of industries.

An example of barium compound commonly used in the development of photographic films is barium bromide.

Draw a dot-and-cross diagram for barium bromide, showing only the outer electrons.

[2]

(c) Barium occurs naturally as barium sulfate, which is commonly used in X-ray. A patient undergoing X-ray consumes barium sulfate to allow imaging of his gastrointestinal tract.

Barium sulfate is safe for humans as it is readily removed from the body.

(i) Using your understanding of salt preparation, describe how a dry sample of barium sulfate can be prepared in the school laboratory.

.....

.....

.....

.....

.....[2]

(ii) State the physical property of barium sulfate which allows it to be readily removed from the human body.

.....[1]

[Total: 7]

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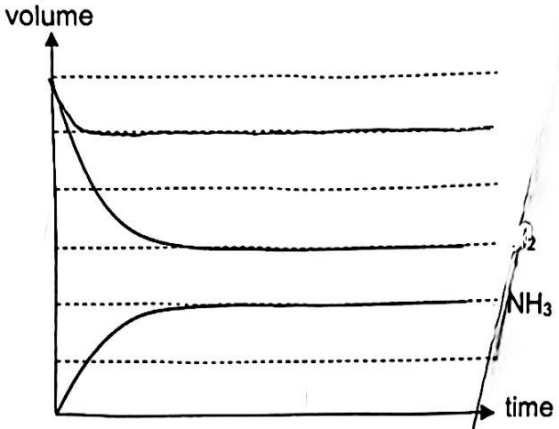
3 The Haber Process produces ammonia gas, which is used to make fertilizers.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92 \text{ kJ/mol}$$

The process converts atmospheric nitrogen to ammonia by a reaction with hydrogen using an iron metal catalyst under high temperatures and pressures

Same volumes of hydrogen and nitrogen gas are placed in a closed container and allowed to react at a certain temperature.

The following graph shows how the volumes of hydrogen and ammonia change as the reaction progressed.



(a) On the graph above, sketch and label the line to show how the volume of nitrogen gas changes as the reaction progresses. [1]

(b) Some bond energy values are given in the table below.

Using the enthalpy change for the reaction to form ammonia, calculate the bond energy of the N–H bond.

bond	bond energy/ kJ/mol	bond	bond energy/ kJ/mol
N – N	160	N ≡ N	944
N = N	410	H – H	436

bond energy = ...kJ/mol [2]

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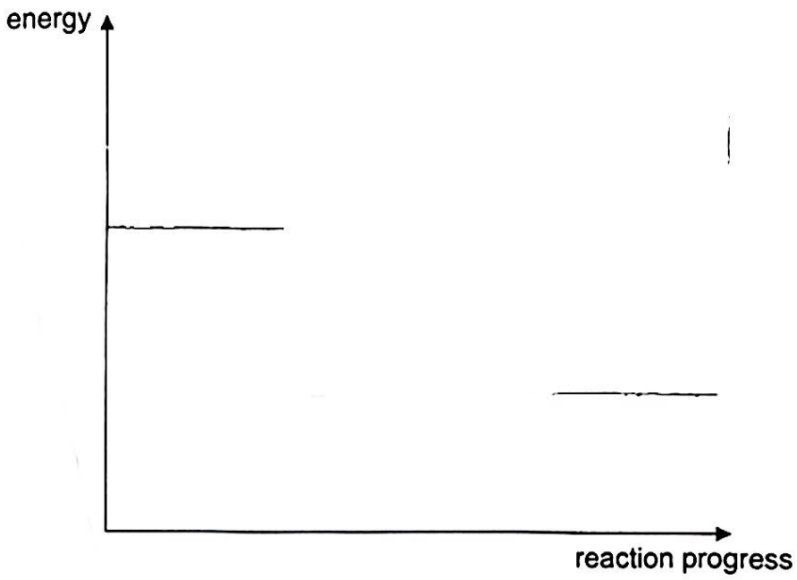
(c) On the axes given below, sketch the energy profile diagram for the formation of ammonia in the **absence of iron metal catalyst**.

On the same diagram, sketch the energy profile diagram for the formation of ammonia in the **presence of** iron metal catalyst.

Indicate clearly which graph is for the reactions with and without the iron catalyst.

Label on your diagrams:

- the formulae of the reactants and products
- the enthalpy change of the reaction
- the activation energy, E_a, of the reactions



[3]

[Total: 6]

4 Caesium is a Group 1 element whereas bromine is a Group 17 element.

The boiling points of caesium and bromine are shown in the table below.

element	boiling point /°C
caesium	670
bromine	59

(a) Explain the difference in the boiling points of caesium and bromine in terms of structure and bonding.

.....

.....

.....

.....

.....[3]

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(b) Caesium reacts with bromine to form caesium bromide.

$$2Cs(s) + Br_2(l) \rightarrow 2CsBr(s)$$

State if bromine is the oxidising agent or the reducing agent. Explain your answer.

.....

.....

.....

.....[2]

(c) When fluorine gas is bubbled through an aqueous solution of caesium bromide, a reaction takes place and the colour of the solution was observed to change.

(i) Name the type of reaction that occurred.

.....[1]

(ii) State the colour change observed.

.....[1]

(iii) The same number of moles of caesium bromide was reacted separately with fluorine and chlorine.

How would you expect the rates to differ? Explain your reasoning.

.....

.....[1]

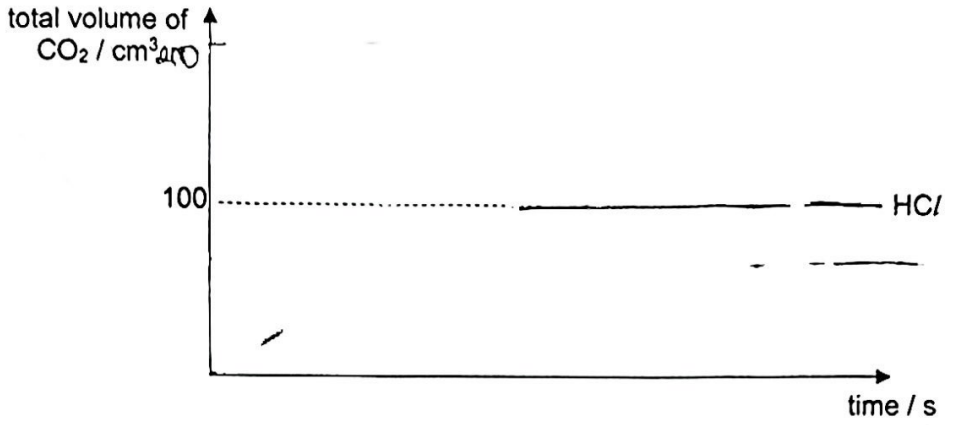
[Total: 8]

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5 Excess potassium carbonate was added to dilute hydrochloric acid according to the following equation.

$$K_2CO_3(s) + 2HCl(aq) \rightarrow 2KCl(aq) + CO_2(g) + H_2O(l)$$

A graph showing the total volume of carbon dioxide given out at regular time intervals for this reaction is shown below.



(a) Two similar experiments were carried out using the same volumes and concentrations of dilute sulfuric acid and dilute ethanoic acid respectively.

On the same graph above, draw and label the graphs of dilute sulfuric acid and dilute ethanoic acid reacting with excess sodium carbonate.

Indicate the total volume of carbon dioxide gas produced for each of the acids. [2]

(b) Explain the differences in the **rate of reaction** in the graphs drawn in **(a)** in terms of collision theory.

.....

.....

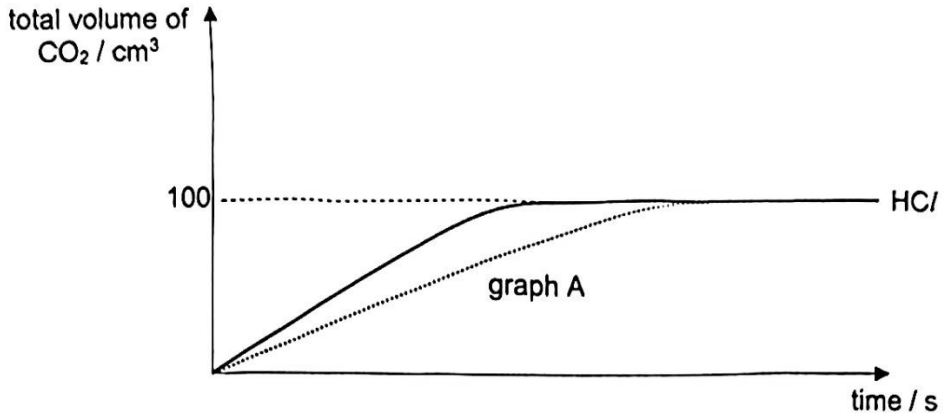
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.....[3]

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(c) A change was made to the condition of the experiment and the reaction was carried out a third time. Graph A was then obtained as shown below.



Given that the same volume and concentration of dilute hydrochloric acid was used, suggest a change in the third experiment that resulted in graph A.

.....

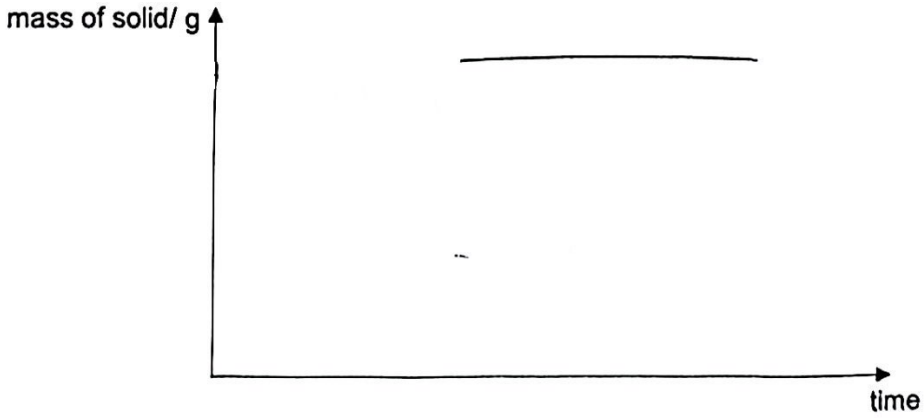
.....[1]

(d) Another method to obtain carbon dioxide gas is to heat metal carbonates strongly for 5 minutes.

The same mass of potassium carbonate and zinc carbonate were heated until no more changes in mass was observed.

On the axes given below, sketch the graphs of the mass of the solid against time for potassium carbonate and zinc carbonate.

Label your graphs clearly.

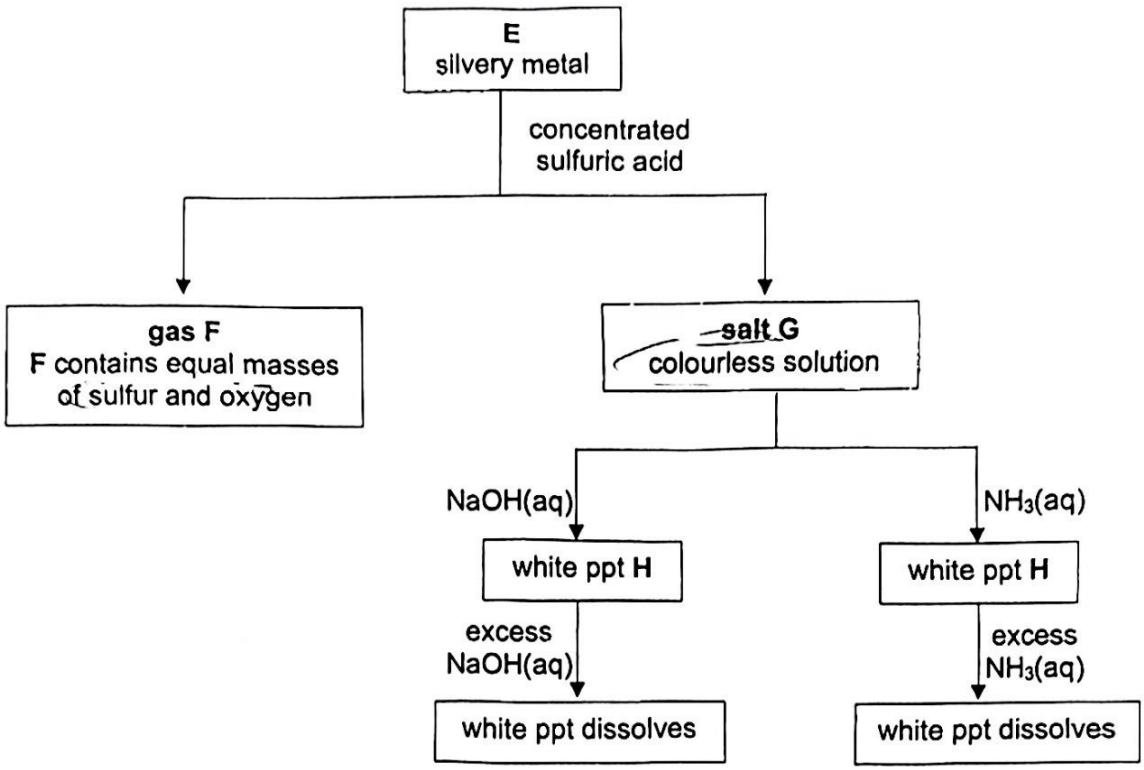


[1]

[Total: 7]

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6 A reaction scheme is shown below.



(a) Name the following substances.

(i) precipitate **H**: .....

(ii) metal **E**: .....

(iii) salt **G**: ..... [3]

(b) Write the ionic equation, with state symbols, for the formation of white precipitate **H** when aqueous ammonia was added to solution **G**.

.....[2]

(c) Determine the empirical formula of gas **F**.

[2]

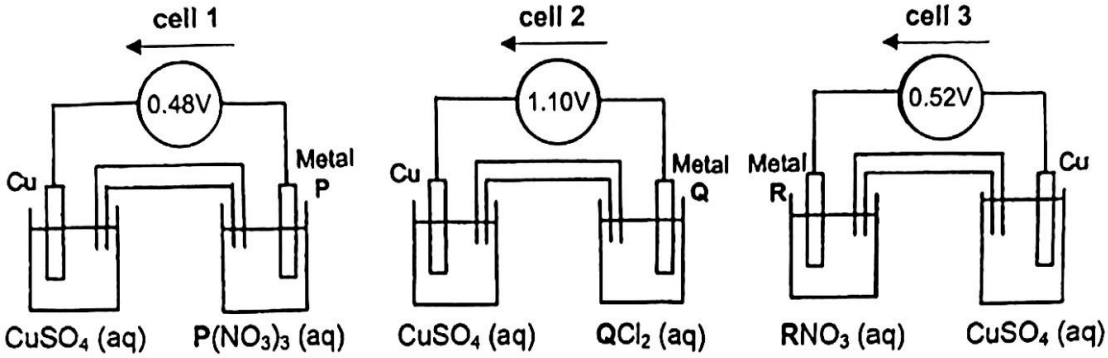
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(d) Describe a simple test to identify gas F and state the expected observation.

.....[1]

[Total: 8]

7 Three electrochemical cells are set-up with a voltmeter each connected as shown below. The direction of the electron flow in each cell is indicated by the arrow above each diagram.



(a) Arrange the four metals, Cu, **P**, **Q** and **R** in ascending reactivity.

.....[1]

(b) Suggest the voltage of the electrochemical cell if the beaker containing metal **P** and aqueous $P(NO_3)_3$ is connected to the beaker containing metal **R** and aqueous RNO_3.

.....[1]

(c) Suggest a method to extract metal **R** from its ore.

.....[1]

(d) Describe what changes will be observed in the beakers of cell 1 after some time.

.....

.....

.....[2]

(e) Metal **Q** is used to make galvanized iron. Explain how this can prevent iron from rusting.

.....

.....

.....[2]

[Total: 7]

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8 **Emissions from combustion engines**

Dust and smoke particles are found in the emissions from combustion engines that use petrol as a source of fuel. The use of catalytic converters and the appropriate air : fuel ratio in vehicles can significantly lower the number of pollutants emitted from combustion engines. Figure 1 below shows the relationship between the air : fuel ratio in a combustion engine and the relative levels of emission of different air pollutants.

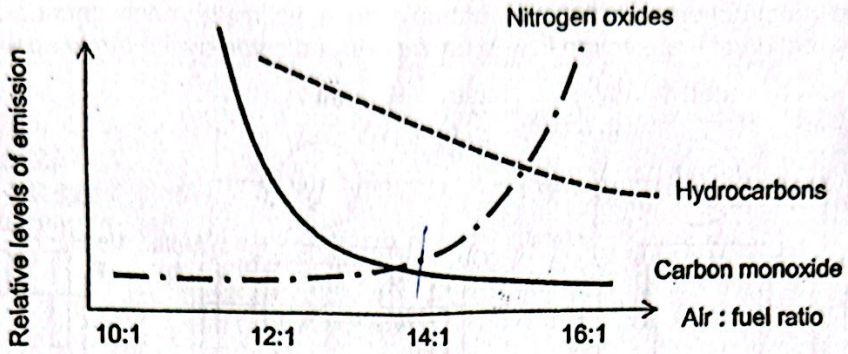


Fig. 1

Carbon Monoxide Detection

Carbon monoxide is a colourless, odourless toxic gas. Inhalation of a large amount of carbon monoxide can lead to poisoning where the transportation of oxygen in the blood is prevented. To detect the level of carbon monoxide in the environment, carbon monoxide detectors can be used. A simplified diagram of a carbon monoxide electrochemical sensor is shown in Figure 2 below.

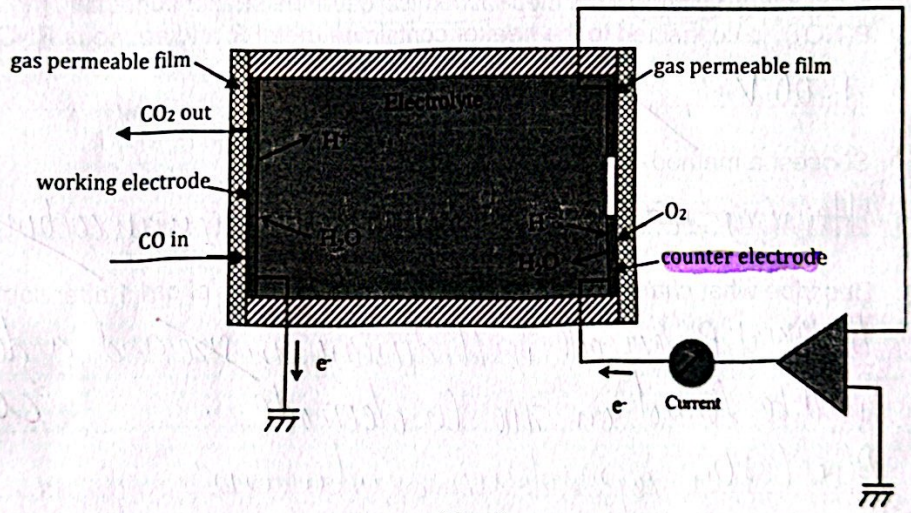


Fig. 2

When carbon monoxide comes into contact with the working electrode in the sensor, a reaction occurs where H^+ ions and CO_2 are given out. The H^+ ions produced then flows through the electrolyte to the counter electrode and reacts with oxygen gas to form water.

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O \text{ ---------(1)}$$

reduction

The overall reaction that occurs in the electrochemical sensor is shown below.

$$2CO + O_2 \rightarrow 2CO_2 \text{ ----------(2)}$$

$2H_2O + CO \rightarrow 2H^+ + CO_2 + 2e^-$

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These electrode reactions induce an electric current flow. By measuring the current between the working electrode and the counter electrode, the equivalent measured gas readings can be measured.

Pollution Standards Index (PSI)

Haze typically occurs when pollutants like carbon monoxide, particulate matter and other microscopic particles linger in air, reducing visibility. The common cause of haze includes agricultural burning, emissions from industries and combustion engines.

In Singapore, the National Environment Agency (NEA) uses the Pollutant Standards Index (PSI) as an indicator of air quality. It is based on five pollutants: particulate matter (PM10), sulfur dioxide, carbon monoxide, ozone and nitrogen dioxide.

To calculate the overall PSI, the PSI value for **each** of the five pollutants is first determined, using the following table.

Table 8.1

i	PSI value, P_i	Concentration, C_i				
		PM10 ($\mu g\ m^{-3}$)	SO_2 ($\mu g\ m^{-3}$)	CO ($mg\ m^{-3}$)	Ozone ($\mu g\ m^{-3}$)	NO_2 ($\mu g\ m^{-3}$)
1	50	50	80	5.0	118	–
2	100	150	365	10.0	157	–
3	200	350	800	17.0	235	1130
4	300	420	1600	34.0	785	2260
5	400	500	2100	46.0	980	3000

[μg = microgram where 1 $\mu g = 10^{-6}$ g; 1 mg = 10^{-3} g]

The overall PSI is then based on the maximum value out of the five calculated PSI pollutant values.

NEA provides health advisories for different groups of people based on the 24-hr PSI.

Table 8.2

24-hr PSI	Healthy Persons	Elderly, Pregnant women, Children	Persons with chronic lung disease, heart disease, stroke
< 100	Normal activities		
101–200	Minimise prolonged or strenuous outdoor physical exertion.	Minimise prolonged outdoor activity.	Avoid all outdoor activities. If outdoor activity is unavoidable, wear N95 mask.
201–300	Avoid prolonged or strenuous outdoor physical exertion. If outdoor activity is unavoidable, wear N95 mask.	Avoid all outdoor activities. If outdoor activity is unavoidable, wear N95 mask (for adults).	
>300	Minimise all outdoor exposure. If outdoor activity is unavoidable, wear N95 mask.		

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(a) (i) Use the information from the Figure 1 to explain the relationship between the air : fuel ratio in a combustion engine and the relative levels of emission of carbon monoxide and hydrocarbons.

.....

.....[1]

(ii) Suggest why the level of nitrogen oxides increases when the air : fuel ratio is greater than 14 : 1.

.....

.....

.....

.....[2]

(b) By looking at equations 1 and 2,

(i) explain whether the counter electrode acts as the anode or the cathode in the carbon monoxide electrochemical sensor.

.....

.....[1]

(ii) Write the ionic half equation for the reaction that occurs at the working electrode.

.....[1]

(c) (i) Given that the PSI value of sulfur dioxide, ozone, nitrogen dioxide, PM10 and carbon monoxide are 150, 112, 133 and 185 and 218 respectively for the same sample of air tested, determine the overall PSI. Explain your answer.

.....

.....[1]

(ii) Assuming that the current overall PSI level is your answer in **(c)(i)**, what advice would you give to a Physical Education (PE) teacher who will be conducting a PE lesson soon?

.....

.....[1]

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(d) Suggest why NEA advise people to avoid outdoor activities when the 24-hour PSI exceeds 301.

.....

.....

.....

.....

[3]

[Total: 10]

9 A series of electrolysis experiments using blue aqueous copper(II) chloride as electrolyte and platinum electrodes are carried out to determine the factors that affect the mass of copper deposited at the cathode.

experiment	duration of electrolysis /s	current pass through the electrolyte / A	concentration of copper(II) chloride solution / mol/dm^3	mass of copper deposited / g
1	100	9.7	1.0	0.643
2	100	9.7	0.5	0.643
3	200	9.7	0.5	1.29
4	100	19.4	1.0	1.29

(a) Using the data given in the table above, describe the relationship between the mass of copper deposited and the current used.

.....

.....

.....

.....[2]

(b) Find the mass of copper deposited when a current of 4.85 A is passed through 1.0 mol/dm^3 of aqueous copper(II) chloride for 50 s. Show your working clearly.

mass of ~~silver~~ deposited = ...[2]

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(c) Two samples of the electrolyte were collected during the experiment. Sample 1 was collected before electrolysis was carried out. Sample 2 was collected after electrolysis has been carried out for a few minutes.

Excess magnesium metal was added to both samples of electrolyte.

Describe and explain the observations seen in the two samples of electrolyte when excess magnesium was added.

.....

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.....

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.....

.....[4]

(d) Describe the differences between what happens when electricity passes through the platinum electrodes compared to what happens when electricity passes through the solution.

.....

.....

.....

.....[2]

[Total: 10]

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Section B

Answer **ONE** question from this section.

10 Naphtha is one of the fractions obtained from the fractional distillation of crude oil. It consists of hydrocarbon molecules with between 7 to 14 carbon atoms. Naphtha is a common feedstock used for cracking to obtain other hydrocarbons.

(a) Explain why cracking is an important process in the oil industry.

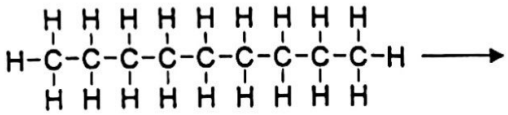
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.....[2]

(b) **(i)** Nonane, C_9H_{20} is a saturated hydrocarbon found in naphtha. Cracking of nonane forms propene, ethane and one other product.

Complete the balanced equation for the cracking of nonane, showing the full structural formulae of the products formed.



[2]

(ii) Describe a chemical test that can be carried out to distinguish propene from ethane and state the observation for each compound.

.....

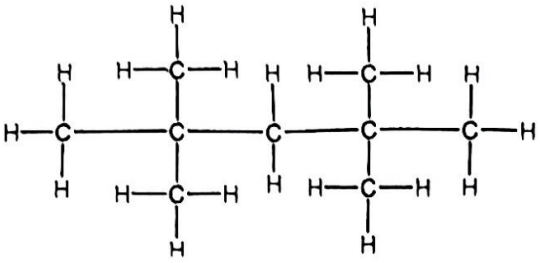
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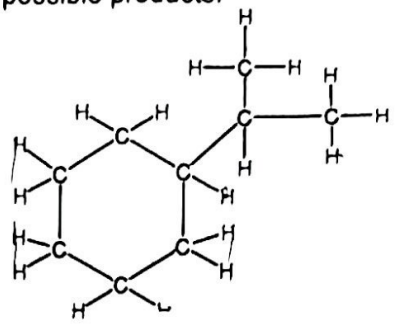
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(c) Catalytic reforming is a chemical process that converts straight chain hydrocarbons into branched chain alkanes and cyclic compounds.

The catalytic reformation of nonane gave the following possible products.



product 1



product 2

Are products 1 and 2 isomers of nonane?

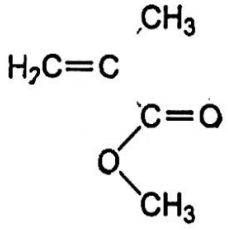
Explain your answer.

.....

.....[2]

(d) Polymethyl methacrylate (PMMA) is a versatile plastic that is commonly known as acrylic.

The structure of the monomer of PMMA is shown below.



(i) State the functional groups that are present in the monomer of PMMA.

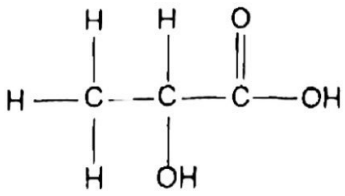
.....[1]

(ii) Draw the structure of PMMA, showing two repeat units.

[1]
[Total: 10]

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11 Organic acids are carbon–containing acids. An organic acid commonly found in the body is lactic acid. Lactic acid is formed in the muscles during intense exercise.



lactic acid

(a) Draw the full structural formula of the salt formed when lactic acid reacts with sodium oxide.

[1]

(b) Lactic acid can react with amines to form amides.

Draw the structure of the amide formed when lactic acid reacts with ethylamine, $CH_3CH_2NH_2$. Show the amide bond clearly.

[1]

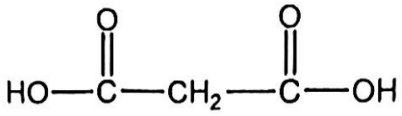
(c) Lactic acid can be made by hydration of a suitable compound, **X**, $C_3H_4O_2$, which contains a carbon–carbon double bond.

Propose the structure of this compound **X** that can be hydrated to form lactic acid.

[1]

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(d) **Y** is an isomer of lactic acid. Under suitable conditions, **Y** undergoes oxidation to form malonic acid.



malonic acid

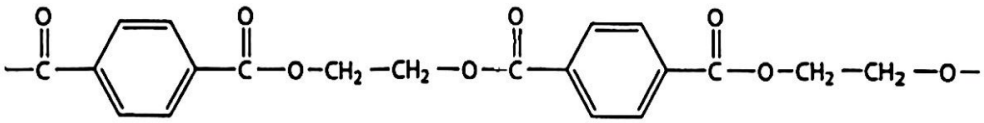
Write the structural formula of **Y** and suggest reagent and condition for **Y** to form malonic acid.

Structural formula of **Y**:

reagent and condition:.....[2]

(e) Polyethylene terephthalate (PET) is a polymer that is commonly used in bottles for carbonated drinks.

The partial structure of PET is shown below.



(i) Recycling of PET can be carried out using an acid catalyst to convert the polymer back into its monomers. Name the process of this chemical method of recycling.

.....[1]

(ii) Draw the structural formula of the two monomers that are formed when PET is recycled by chemical methods.

[2]

(f) Separate samples of malonic acid and PET were obtained. Describe a chemical test that can be carried out to distinguish malonic acid from PET and state the observation for each sample.

.....

.....

.....[2]

[Total:10]

End of Paper

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