East Spring Secondary School

Towards Excellence and Success

Name: ..... ( )

Class: .....

Preliminary Examination 2023
Secondary 4 Express

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

Tuesday **1 hour**
12 September 2023 **0800 – 0900**

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class, index number on the Answer Sheet in the spaces provided.

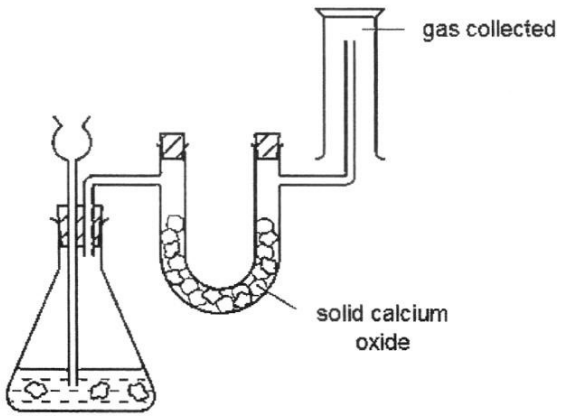
There are forty questions on this paper. Answer **all** questions. For each question there are four possible answers, **A**, **B**, **C** and **D**.
Choose the one you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

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 17.
The use of an approved scientific calculation is expected, where appropriate.

This question booklet consists of **17** printed pages including the cover page.

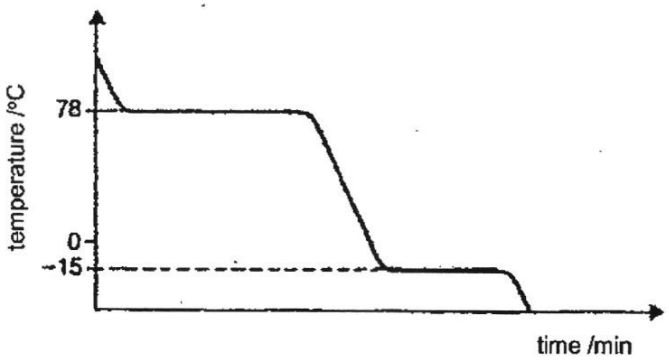
1 The diagram below shows the setup for a chemical reaction which produces a gas. The gas is then dried and collected.



What could the gas be?

A sulfur dioxide
B carbon dioxide
C oxygen
D hydrogen

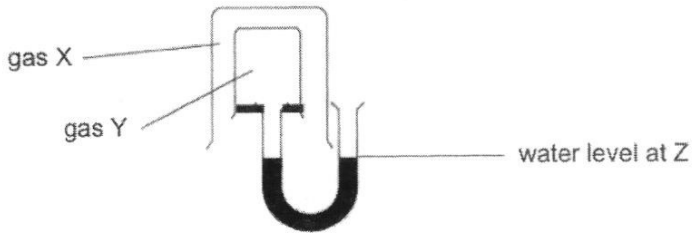
2 The cooling curve below shows how the temperature of a gaseous substance changes with time as it is cooled.



What is the state of the substance at 25°C?

A gas-liquid mixture
B liquid
C liquid-solid mixture
D solid

3 The set–up below shows how the relative rate of diffusion of gas X and Y can be determined.



The water level at Z does not move. Which of the following could be gas X and gas Y?

	X	Y
A	carbon monoxide	carbon dioxide
B	ethene	nitrogen
C	carbon dioxide	sulfur dioxide
D	sulfur dioxide	ammonia

4 When aqueous sodium hydroxide is warmed with substance R, a white precipitate that is soluble in excess sodium hydroxide was formed.

Then, when a piece of aluminium foil is added to the mixture, a colourless and pungent gas is evolved. The gas turns moist red litmus paper blue.

Which of the following could substance R be?

A ammonium chloride

B ammonium nitrate

C calcium chloride

D zinc nitrate

5 Which statement about methods of purification and analysis is correct?

A A liquid that boils over a range of temperatures may still be 100% pure.

B An insoluble substance may be purified using simple distillation.

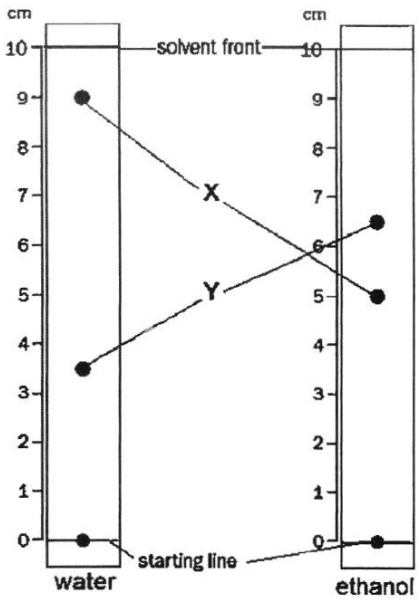
C Chromatography may only be used to separate coloured substances.

D Liquid air can undergo fractional distillation, giving oxygen as one of the products.

6 A sample was analysed by paper chromatography.

The first experiment was conducted using water as a solvent, and the second experiment was done using ethanol as a solvent.

The results of the two experiments are shown in the diagram below.



What conclusion can be drawn based on these results?

A Substance Y is more soluble in water than in ethanol.

B Substance X is more soluble in ethanol than substance Y.

C The R_f value of substance X is greater when water is a solvent instead of ethanol.

D The R_f value of substance Y smaller when ethanol is a solvent instead of water.

7 The table below shows information about the elements argon, Ar, and calcium, Ca.

element	Ar	Ca
proton number	18	20
nucleon number	40	40

Which of the following statements about the elements is correct?

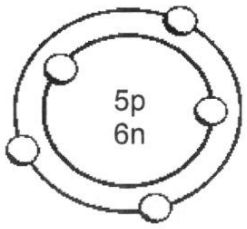
A A Ca^{2+} ion has the same number of electrons as an atom of Ar.

B A Ca^{2+} ion has the same number of protons as an atom of Ar.

C An atom of Ar has two more electrons than an atom of Ca.

D An atom of Ca has the same number of neutrons as an atom of Ar.

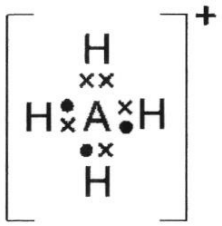
8 The diagram represents an isotope of an atom of element X.



Which one of the following correctly describes the particles of the other isotope of the element?

	number of protons	number of neutrons	number of electrons
A	5	6	5
B	5	5	5
C	6	5	5
D	11	12	11

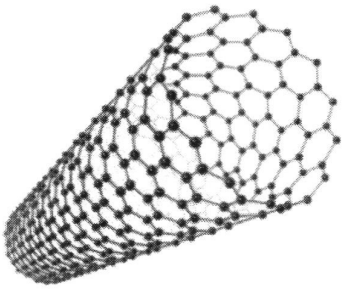
9 The ion AH_4^+ can be represented by the 'dot and cross' diagram shown.



Which Group of the Periodic Table does element A belong to?

A I **B** III **C** IV **D** V

10 Nanotube is an allotrope of carbon. These carbon nanotubes are molecular-scale tubes of carbon arranged similarly to the layers in graphite.



Which row about the physical properties of carbon nanotubes is correct?

	melting point	electrical conductivity
A	high	good
B	high	poor
C	low	good
D	low	poor

11 Iron is a metal. The structure of iron is described as a lattice of positive ions in a 'sea of electrons'.

Which statements about iron are correct?

1 Iron conducts electricity because the electrons are free to move.

2 Iron conducts heat in solid state because the positive ions are free to move.

3 Iron ions are held together because of their attraction for each other.

4 Iron has a high melting point due to the strong covalent bonds.

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

12 Hydrogen peroxide decomposes to form water and oxygen as shown in the equation below.

$$2H_2O_2\ (l) \rightarrow 2H_2O\ (l) + O_2\ (g)$$

When 24.8 g of impure hydrogen peroxide decomposes, 3.7 dm^3 of oxygen gas was collected.

What is the percentage purity of hydrogen peroxide?

A 28.2% **B** 42.3% **C** 56.4% **D** 84.6%

13 In a volumetric experiment, 25.0 cm^3 of 0.100 mol/dm^3 sodium hydroxide reacts exactly with 20.0 cm^3 of sulfuric acid.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

What is the concentration of sulfuric acid used?

A 0.0625 mol/dm^3 **B** 0.0800 mol/dm^3

C 0.125 mol/dm^3 **D** 0.250 mol/dm^3

14 Which compound contains the lowest percentage of sulfur by mass?

A SO_2 **B** H_2SO_4 **C** Na_2S **D** MgS

15 Which product is formed at the anode when molten zinc chloride is electrolysed?

A chloride ions

B chlorine molecules

C zinc ions

D zinc atoms

16 A student wants to electroplate an iron spoon with silver only.
Which of the following set ups should she use to carry out the task successfully?

	anode	cathode	electrolyte
A	iron spoon	silver	copper(II) sulfate solution
B	silver	iron spoon	copper(II) sulfate solution
C	iron spoon	silver	silver nitrate solution
D	silver	iron spoon	silver nitrate solution

17 Hydrogen reacts with chlorine according to the equation below.

$$H_2 + Cl_2 \rightarrow 2\,HCl \qquad \Delta H = -184\ kJ$$

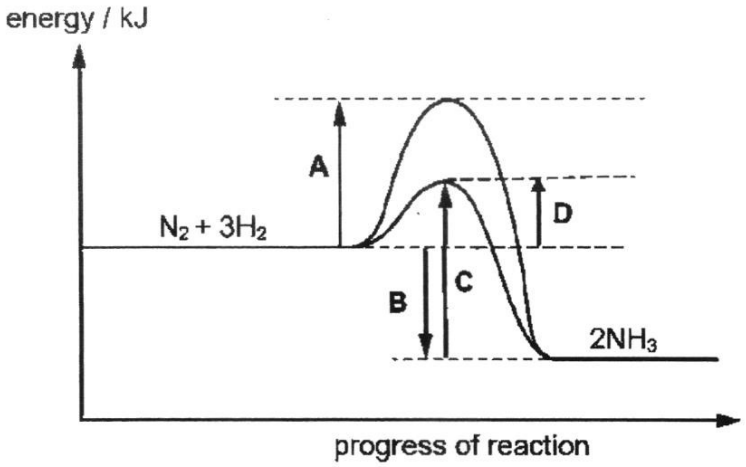
	H–H	Cl–Cl
bond energy in kJ/mol	436	242

What is the H–Cl bond energy in kJ/mol?

A 339 **B** 431 **C** 678 **D** 862

18 The energy profile diagram for both the catalysed and uncatalysed reactions in the production of ammonia is shown below.

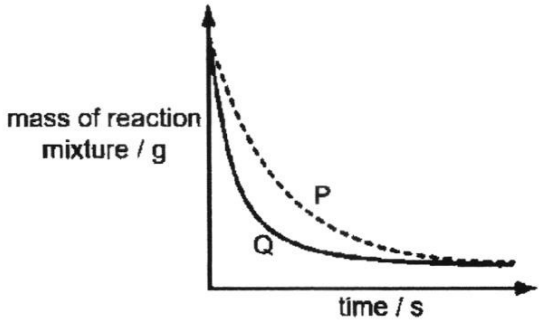
What is the activation energy for the formation of ammonia in the presence of a catalyst?



19 A student investigates the rate of reaction between marble chips and excess hydrochloric acid.

The loss in mass of the reaction flask is measured.

The graph shows the results of two experiments, P and Q.



Which change explains the difference between graph P and Q?

A A catalyst was added in P.

B A higher temperature was used in P.

C Bigger marble chips were used in Q.

D Hydrochloric acid was more concentrated in Q.

20 The table below shows the colour changes when a few drops of aqueous potassium iodide and acidified aqueous potassium manganate(VII) were added separately into four different solutions.

solution	potassium iodide	potassium manganate (VII)
1	colourless to brown	purple to colourless
2	colourless to brown	no change
3	no change	purple to colourless
4	no change	no change

Which solutions contain an oxidising agent?

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

21 Which of the following reactions suggest that substance M is an alkali?

A Aqueous M reacts with dilute hydrochloric acid to produce a precipitate.

B Aqueous M reacts with zinc oxide to form zinc nitrate solution.

C Aqueous M reacts with ammonium chloride to form ammonia gas when warmed.

D Aqueous M reacts with zinc carbonate to produce a gas.

22 The following table shows information on an acid-base indicator.

colour at pH 1	pH range at which colour change occurs	colour at pH 12
yellow	3.0 – 4.6	blue

Which statement about the indicator is correct?

A It is blue in colour in a solution of nitric acid.

B It cannot distinguish between a strong acid and a strong alkali.

C It is suitable for an acid-base titration where the end point is pH 9.

D It cannot be used to differentiate between water and sodium hydroxide solution.

23 A student has five reagents.

- dilute hydrochloric acid
- dilute sulfuric acid
- dilute nitric acid
- solid calcium carbonate
- solid copper(II) carbonate

How many salts can be prepared using these reagents?

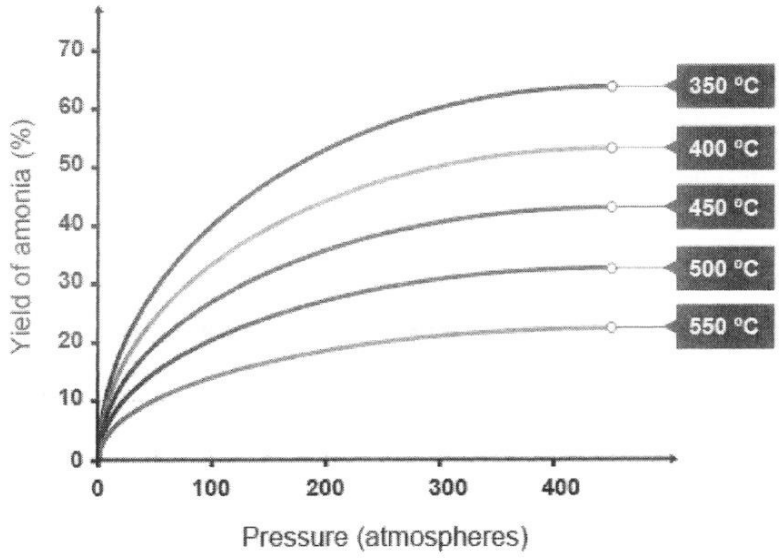
A 3 **B** 4 **C** 5 **D** 6

24 What is the correct sequence of steps that should be carried to obtain a pure sample of barium sulfate from barium nitrate?

1 add dilute sulfuric acid
2 filter
3 crystallise
4 wash

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

25 The graph below shows the yield of ammonia from Haber process at different temperatures.



Which of the following statements can be inferred from the graph?

A A higher percentage yield of ammonia can be obtained at higher pressure.

B Some of the ammonia formed will decompose to form hydrogen and nitrogen.

C The speed of reaction is dependent on the presence of iron catalyst.

D At the right temperature and pressure, all of the hydrogen and nitrogen can be converted into ammonia.

26 Across a period, the character of the elements changes from metallic to non-metallic.

What is the reason for this trend?

A There is an increase in the nucleon number.

B There is an increase in the number of neutrons.

C There is an increase in the number of electron shells.

D There is an increase in the number of valence electrons.

27 A new element was discovered and has similar properties to the alkali metals.

Which of the following is likely to be a property of this new element?

A It has a low melting point.

B It does not react with water.

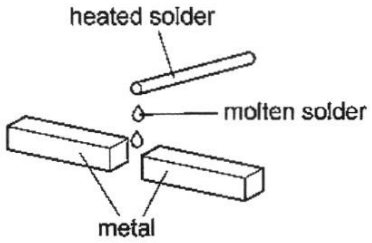
C It forms coloured compounds.

D It reacts with non-metals to form covalent compounds.

28 Which of the following substances is most likely a transition metal?

	density / g/cm^3	melting point / °C	number of chlorides
A	1.55	842	1
B	3.12	−7	1
C	4.93	113	2
D	8.96	1083	2

29 Solder is an alloy of lead and tin. It is used for joining pieces of metal together.



Which statement about solder is correct?

A It can be represented by a chemical formula.

B It contains a mixture of lead and tin atoms.

C It contains lead and tin atoms chemically bonded.

D It has a higher melting point than lead.

30 Four unknown metals, Q, R, S and T, are reacted with water, steam, and dilute hydrochloric acid. The results are shown in the table.

	reaction with water	reaction with steam	reaction with dilute hydrochloric acid
Q	slow reaction	fast reaction	fast reaction
R	no reaction	no reaction	no reaction
S	no reaction	very slow reaction	slow reaction
T	fast reaction	explodes	explodes

Which statements are correct?

1 R is the least reactive metal.

2 T could be potassium.

3 S is more reactive than Q.

A 1 only

B 2 only

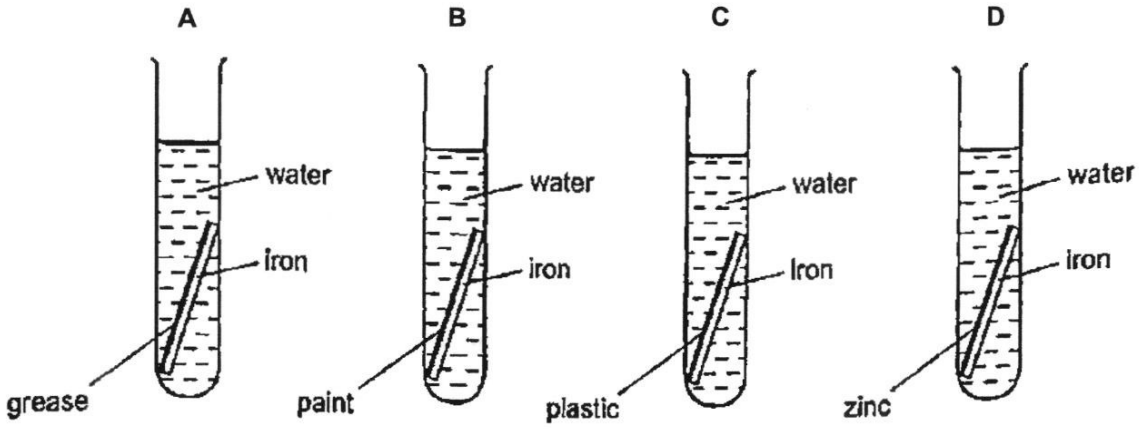
C 1 and 2 only

D 1, 2 and 3

31 Four test tubes were set up as shown.

Each piece of iron was protected on one side by a different coating.

In which test tube is the iron least likely to rust?



32 In the manufacture of iron by the blast furnace, which are the main gases that escape from the top of the blast furnace?

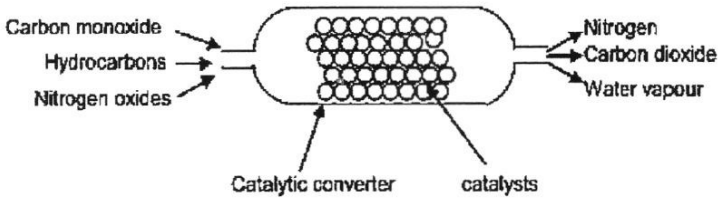
A nitrogen, oxygen, steam

B nitrogen, carbon dioxide, carbon monoxide

C carbon monoxide, carbon dioxide, hydrogen

D oxygen, carbon dioxide, sulfur dioxide

33 The diagram below shows a section of a catalytic converter in the car's exhaust system.



Which processes take place in the converter?

1 Nitrogen oxides decompose to form oxygen and nitrogen.

2 Hydrocarbons oxidise to form carbon dioxide and water vapour

3 Carbon monoxide reacts with hydrocarbons to form carbon dioxide and water vapour.

A 1 and 2

B 1 and 3

C 2 and 3

D 1, 2 and 3

34 Petroleum can be separated into fractions by fractional distillation.

Which statement about this process is **not** correct?

A The lubricating oil fraction is a source of polishes and waxes.

B In a fractionating column, bitumen is obtained below lubricating oil.

C The fraction obtained at the top of the fractionating column has the highest boiling point.

D The relative molecular masses of the compounds obtained near the bottom of the fractionating column are higher than those of the compounds obtained near the top of the column.

35 One mole of polyunsaturated oil is converted completely to margarine. When the reaction is completed, the mass of the margarine is 6.0 g more than the mass of the vegetable oil.

How many carbon-carbon double bonds does the polyunsaturated vegetable oil contain?

A 1 **B** 2 **C** 3 **D** 6

36 What is the structure of the product of the reaction between butene, $CH_2{=}CH{-}CH_2{-}CH_3$, and bromine, Br_2?

A $CH_2Br{-}CH_2{-}CH_2{-}CH_2Br$

B $CH_2Br{-}CH_2{-}CHBr{-}CH_3$

C $CH_3{-}CHBr{-}CH_2Br{-}CH_3$

D $CH_2Br{-}CHBr{-}CH_2{-}CH_3$

37 X is an organic compound that fizzes when added to solid calcium carbonate.

What could be correct about X?

A It could be formed by reducing an alcohol.

B It could form an ester with a carboxylic acid.

C It could have the empirical formula C_2H_4O.

D It could have the molecular formula C_2H_4O.

38 In which of the following reactions below is hydrogen either a reactant or a product?

1 addition of magnesium to propanoic acid
2 conversion of butene to butane
3 conversion of vegetable oil to margarine
4 fermentation of glucose

A 1 and 2

B 2 and 3

C 1, 2 and 3

D 1, 3 and 4

39 If one mole of each alcohol is burnt in excess oxygen, which alcohol will produce CO_2 and H_2O in a mole ratio of 3:4?

A CH_3OH **B** C_2H_5OH

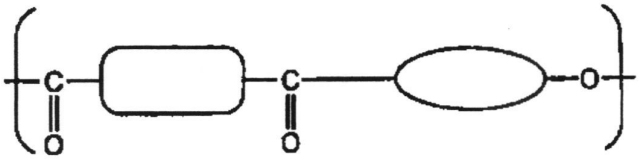
C C_3H_7OH **D** C_4H_9OH

40 Terylene is a polyester made by condensation polymerisation of the two monomers shown.

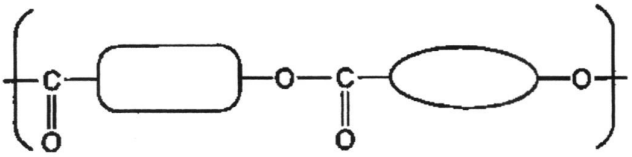
and

What is the repeat unit of the polymer?

A



B



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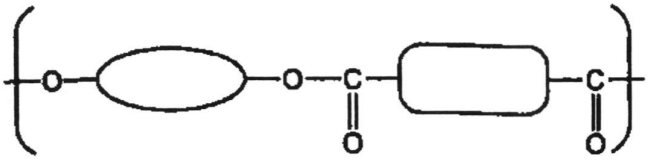
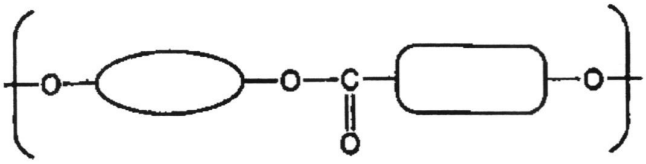


D



End of Paper 1

East Spring Secondary School

Towards Excellence and Success

Name: ..... ( )

Class: .....

Preliminary Examination 2023
Secondary 4 Express

CHEMISTRY **6092/02**
Paper 2

Monday **1 hour 45 minutes**
28 August 2023 **0800 – 0945**

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions. The last question in the form either/or.
Answer all questions in the spaces provided.

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 27.

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

Section	Marks
Section A	50
Section B	30
Total	80

This Question Paper consists of **27** printed pages including the cover page.

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

1 (a) The equations **A** – **E** illustrate some chemical reactions.

A $Mg\ (s) + 2HCl\ (aq) \rightarrow H_2\ (g) + MgCl_2\ (aq)$

B $2H_2\ (g) + O_2\ (g) \rightarrow H_2O\ (l)$

C $CuCO_3\ (s) \rightarrow CuO\ (s) + CO_2\ (g)$

D $Fe_2O_3\ (s) + 3CO\ (g) \rightarrow 3CO_2\ (g) + 2Fe\ (l)$

E $FeCl_2\ (aq) + 2NaOH\ (aq) \rightarrow Fe(OH)_2\ (s) + 2NaCl\ (aq)$

(i) Which chemical reaction (**A**, **B**, **C**, **D** or **E**) represents combustion?

.....[1]

(ii) Which of the reaction(s) is/are **not** a redox reaction?

.....[1]

(iii) Name the type of reaction in **E**.

.....[1]

(iv) State one use for reaction **B**.

.....[1]

(v) Identify the basic oxide in reaction **D**.

.....[1]

(b) Which of the statements about graphite are **true** and which are **false**?

	true	**false**
It is a polymer.		
It is insoluble in water.		
It can be oxidised by oxygen to form a non-metal oxide.		
It is a good electrical conductor in solid state.		

[2]

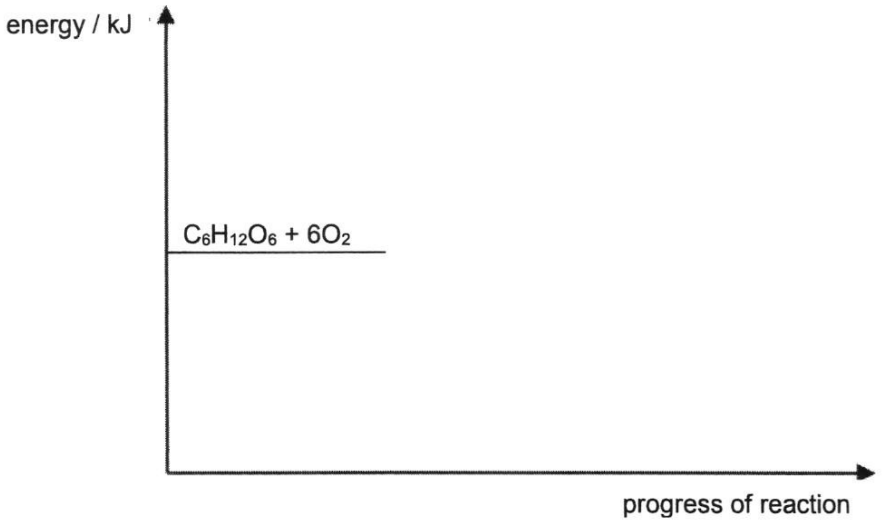
[Total: 7]

2 Glucose reacts with excess oxygen to produce carbon dioxide and water in a process known as aerobic respiration.

The overall enthalpy change and chemical equation for the reaction of 1 mole of glucose with oxygen is shown below.

$$C_6H_{12}O_6\ (s) + 6O_2\ (g) \rightarrow 6CO_2\ (g) + 6H_2O\ (g) \qquad \Delta H = -2800\ kJ$$

(a) Draw an energy profile diagram for the reaction of 1 mole of glucose with excess oxygen. Indicate the labels for enthalpy change, activation energy, and formulae of the products on the diagram clearly.



[3]

(b) In a reaction, 144 cm^3 of carbon dioxide was produced.

Calculate the enthalpy change for this reaction.

[2]

(c) In another experiment, an aqueous solution of glucose was heated with alkaline copper(II) sulfate solution. A red precipitate of an oxide of copper was formed.

1.44 g of this oxide was found to contain 1.28 g of copper.

Determine the empirical formula of this oxide of copper. Show your working clearly.

[2]

(d) Respiration and photosynthesis are important processes in the carbon cycle.

Describe how respiration and photosynthesis regulate the amount of carbon dioxide in the atmosphere.

.....

.....

.....

.....

.....[2]

[Total: 9]

3 **(a)** Propyl ethanoate, $CH_3COOC_3H_7$, is a colourless liquid with a pear-like smell. It is used as artificial flavoring in food.

(i) Propyl ethanoate can be obtained from the reaction between an alcohol and an acid.

Name the alcohol.

.....[1]

(ii) Ethene is the starting reagent in the production of the carboxylic acid used in the manufacturing of propyl ethanoate.

Describe how this carboxylic acid can be made from ethene.

Include in your answer the reacting condition(s) and reactants involved.

.....

.....

.....

.....

.....[3]

(b) In a different reaction, propene undergoes addition polymerisation under high temperature and pressure.

(i) Draw the full structural formula for a repeating unit in the polymer.

[1]

(ii) A sample of the polymer formed by propene contains molecules with an average relative molecular mass of 21 840.

How many carbon atoms are there in an average molecule of the polymer?

.....[1]

(iii) Describe **three** differences between addition polymersation and condensation polymerisation.

addition polymerisation	condensation polymerisation

[3]

[Total: 9]

4 Fluorine, chlorine, bromine and iodine are collectively known as halogens. The name "halogen" means "salt-producing", as halogens react with metals to produce a wide range of salts.

When halogen vapours are passed over iron wool, the iron wool burns to form iron halides as shown in Fig. 4.1.

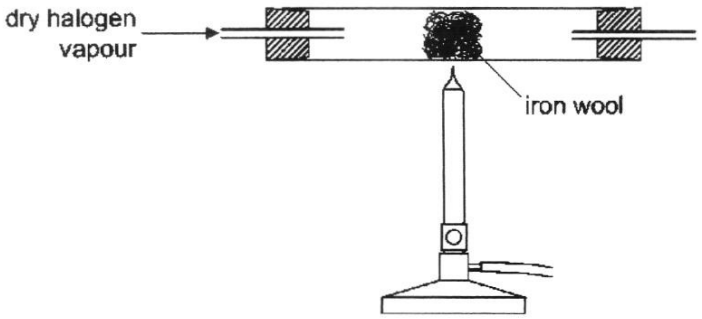


Fig. 4.1

Table 4.1 below gives some information on the halogens and iron halides.

Table 4.1

halogen	halide(s) formed	formula
fluorine	iron(III) fluoride	FeF_3
chlorine	iron(III) chloride	$FeCl_3$
bromine	mixture of iron(II) bromide and iron(III) bromide	$FeBr_2$ $FeBr_3$
iodine	iron(II) iodide	FeI_2

(a) Mendeleev put all of the halogens in Group VII.

(i) Do the formulae of the halides given in Table 4.1 show clearly that all of the halogens belong in the same group?

Explain your answer.

.....

.....[2]

(ii) Deduce the trend in oxidising power of halogens they go down the Group.

Explain your answer based on the information given in Table 4.1.

.....

.....

.....[2]

(b) Iron(III) chloride is a precursor for the industrial production of sodium ferrate, Na_2FeO_4. Sodium ferrate is used as a non-toxic wastewater treatment chemical as iron compounds are generally non-toxic.

Step 1: $FeCl_3 + 3NaOH \rightarrow Fe(OH)_3 + 3NaCl$

Step 2: $2Fe(OH)_3 + 3NaOCl + 4NaOH \rightarrow 2Na_2FeO_4 + 5H_2O + 3NaCl$

(i) Suggest the formula of the ferrate anion.

.....[1]

(ii) Explain if iron is oxidised or reduced in **Step 2**, in terms of oxidation state.

.....

.....

.....[2]

[Total: 7]

5 Fig. 5.1 shows the melting points of elements in Period 3 of the Periodic Table.

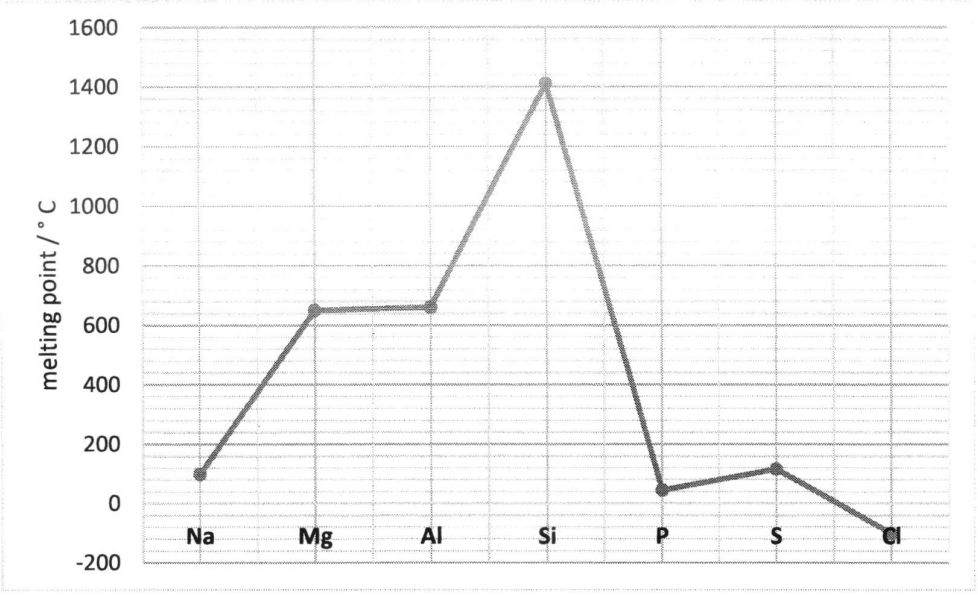


Fig. 5.1

(a) Describe the general trend in the melting points of the elements in Period 3.

.....

.....

.....[2]

(b) Explain, in terms of bonding and structure, why magnesium and phosphorus have different melting points.

.....

.....

.....

.....

.....

.....

.....[3]

(c) The formulas and boiling points of some of the oxides of the Period 3 elements are given in Table 5.1.

Table 5.1

name	formula	boiling point / °C
dichlorine monoxide	Cl_2O	2.0
phosphorous(V) oxide	P_4O_{10}	360.0

(i) Draw a 'dot-and-cross' diagram for dichlorine monoxide.
Show only the valence electrons.

[2]

(ii) Suggest a reason for the difference in boiling points of the two compounds.

.....

.....

.....[2]

[Total: 9]

6 **(a)** Fig. 6.1 shows the electrolysis of three different aqueous solutions using inert electrodes.

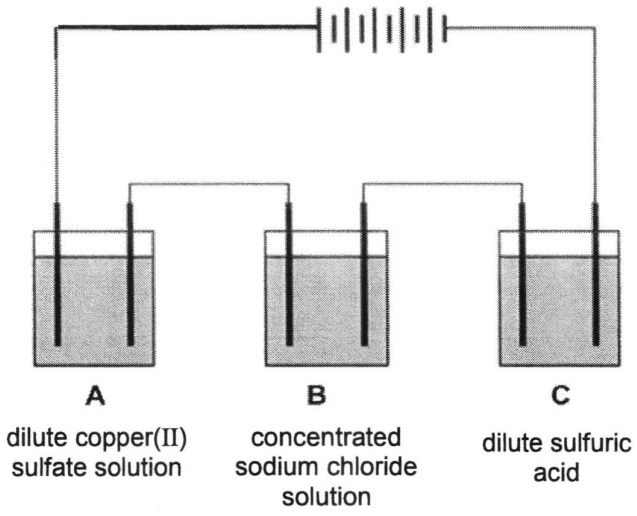


Fig. 6.1

Study Fig. 6.1 carefully and complete Table 6.1 below by filling in the missing information.

Table 6.1

solution	**name of product of electrolysis**	
A: dilute copper(II) sulfate solution	at the positive electrode	oxygen
	at the negative electrode	
B: concentrated sodium chloride solution	at the positive electrode	
	at the negative electrode	
C: dilute sulfuric acid	at the positive electrode	oxygen
	at the negative electrode	

[4]

(b) Describe and explain the colour change of dilute copper(II) sulfate solution in beaker **A** during the experiment.

.....

.....

.....[2]

(c) A student took samples of the electrolyte from beakers **A**, **B** and **C** before the start of the experiment to perform tests on them, labelling them solutions **A**, **B**, **C** respectively. However, she accidentally mixed up the labels.

Describe tests that the student can perform to differentiate solutions **A**, **B** and **C**.
State the expected observations.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[3]

[Total: 9]

Section B

Answer all **three** questions in this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

7 Chemistry of the Ozone Layer

Ozone (O_3) is a molecule made up of three oxygen atoms and is mostly found in the stratosphere (layer of atmosphere that is 15 km to 50 km above sea level). It protects us from the Sun's harmful ultraviolet (UV) radiation. Although it represents only a tiny fraction of the atmosphere, ozone is crucial for life on Earth.

In the atmosphere, ozone is formed naturally through the interaction of UV radiation with molecular oxygen (O_2), according to the equation below.

$$3O_2\,(g) \rightarrow 2O_3\,(g) \qquad \Delta H = +286\ kJ$$

Ozone Depleting Substances (ODS)

In the 1970s, scientists suspected that reactions involving man-made halogen-containing compounds could be contributing to lower levels of ozone in the stratosphere. These compounds are called Ozone Depleting Substances (ODS). They are gaseous compounds that contain halogen atoms like chlorine and bromine.

In the stratosphere, ODS are converted and broken down by ultraviolet radiation from the Sun, releasing chlorine and bromine atoms. ODS that release chlorine atoms include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and methyl chloroform. ODS that release bromine atoms are called halons.

The rate of conversion is different for each compound, and we measure this as the atmospheric lifetime in years. The larger the lifetime, the slower the release and the longer the compound will remain in the atmosphere. Values generally range from 1 to 100 years.

The ozone depletion potential (ODP) is a measure of the potential of a compound to destroy ozone. ODP is calculated with respect to CFC-11 (CFC-11 has an ODP of 1). Larger values indicate more potential to deplete ozone. Some common ODS are shown in Table 7.1.

Table 7.1

	Ozone depleting substance	Chemical Formula	Ozone Depletion Potential (ODP)	Atmospheric Lifetime (years)
Chlorine-containing	CFC-11	CCl_3F	1	52
	CFC-12	CCl_2F_2	0.82	102
	Methyl chloroform	CH_3CCl_3	0.16	5
	HCFC-141b	CH_3CCl_2F	0.12	9.2
Bromine-containing	Halon-1211	$CBrClF_2$	7.9	16
	Halon-1301	$CBrF_3$	15.9	65
	Halon-2402	$CBrF_2CBrF_2$	13	20

The Mechanism of Ozone Depletion

Once in the stratosphere, ultraviolet radiation from the Sun causes the ODS gases to release reactive chlorine and bromine atoms.

For example, CFCs are molecules made up of chlorine, fluorine and carbon. Because they are extremely stable molecules, CFCs do not react with other chemicals in the lower atmosphere, but exposure to ultraviolet radiation in the upper stratosphere breaks them apart, releasing chlorine atoms.

These chlorine atoms are called "radicals" as they contain an unpaired electron. The symbol for a free radical is a dot next to the atom. This dot shows that it has an unpaired electron, for example, C*l*•.

Free radicals occur when bonds are broken via homolytic fission. This means that when the covalent bond is broken, one electron goes to one atom, and one goes to the other. Fig. 7.2 shows the formation of chlorine radicals from a CFC molecule.

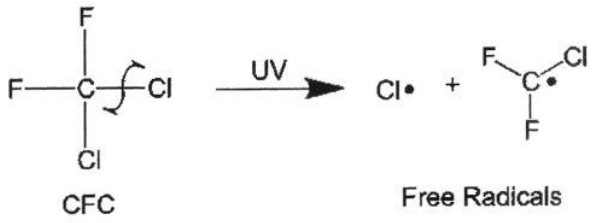


Fig. 7.2

The free chlorine (C*l*•) radical then reacts with ozone, forming one chlorine monoxide (C*l*O) molecule and an oxygen molecule (O_2). Next, when a chlorine monoxide molecule reacts with another ozone molecule, oxygen molecules are formed together with a chlorine radical. This radical will repeatedly continue to react with more ozone. Hence, one chlorine radical can destroy over 100,000 ozone molecules.

Fortunately, chlorine atoms do not remain in the stratosphere forever. Free chlorine atoms react with gases, such as methane (CH_4), and get bound up into hydrogen chloride (H*Cl*) molecules. These molecules eventually end up back in the troposphere (8-15 km above sea level) where they are washed away by rain.

(a) Explain why the enthalpy change of formation (ΔH) of ozone has a positive sign.

.....

.....[1]

(b) With reference to Table 7.1, compare the ozone depletion potential between the chlorine-containing ODS and bromine-containing ODS.

.....

.....[1]

(c) CFC-11 has the molecular formula CCl_3F. CFC-12 has the molecular formula CCl_2F_2. Suggest and draw the full structural formula of CFC-13 in the space below.

[1]

(d) The numbering of the halon ozone depleting substances is as such. In Halon-1211, $CBrClF_2$, the first number refers to the number of carbon atoms. The second number shows number of fluorine atoms. The third number shows number of chlorine atoms. The fourth number shows the number of bromine atoms.

Write the molecular formula for Halon-1103.

.....[1]

(e) Under the section "The Mechanism of Ozone Depletion", a chlorine radical is described as a chlorine atom that contains an unpaired electron.

Explain, with reference to its electronic structure, why the chlorine radical is considered very reactive.

.....

.....[1]

(f) As outlined in the passage, CFCs cause the breakdown of ozone in several steps.

The first step happens when energy from ultraviolet light breaks a bond in a CFC to produce a chlorine radical.

$$CCl_2F_2 \rightarrow CClF_2 + Cl^{\bullet}$$

Table 7.2 shows the bond energies for some of the bonds in CFCs.

Table 7.2

bond	bond energy (kJ/mol)
C–Cl	340
C–F	485

Use the data in Table 7.2 to explain why the ozone layer contains many more chlorine atoms than fluorine atoms.

.....

.....

.....

.....[2]

(g) (i) With reference to the paragraph after Fig. 7.2, write two balanced chemical equations representing the steps for ozone depletion, starting from the chlorine radical reacting with ozone.

1. .....

2. .....

[2]

(ii) Suggest how the chlorine radical acts as a catalyst for the breakdown of ozone.

.....

.....[1]

(h) The Montreal Protocol is an international environmental agreement signed in 1987 to protect the ozone layer. It aims to phase out the production and consumption of ozone-depleting substances.

Because of measures taken under the Montreal Protocol, emissions of ODS are falling and the ozone layer is expected to be fully healed near the middle of the 21st century. To date, 197 countries have signed the Montreal Protocol. Fig. 7.3 shows the charts for world ODS consumption in comparison to the ozone hole area between 1979 – 2015.

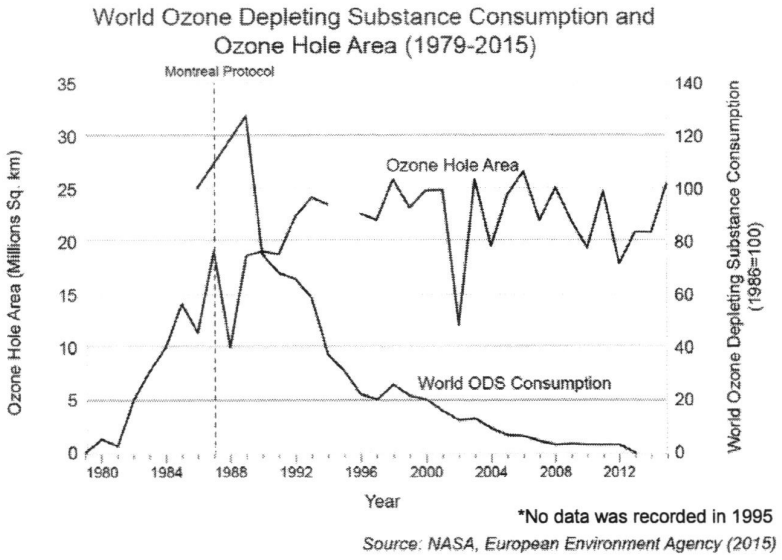


Fig. 7.3

(i) State how the Montreal Protocol affected the world ODS consumption after 1987.

.....

.....[1]

(ii) Considering the data from the passage and Table 7.1 on page 14, suggest why the ozone hole area still remains relatively large despite implementing the Montreal Protocol.

.....

.....[1]

[Total: 12]

8 The standard electrode potential, E^o, is the measure of the tendency of losing or gaining electrons, when a strip of metal is brought in contact with a solution containing its own ions. The reactivity of the metals can be deduced from E^o values.

A reference electrode, the standard hydrogen electrode (SHE), set to 0.00 V, is paired with any metal electrode to determine the metal's standard electrode potential.

The standard electrode potential (E^o) of some metal electrodes are listed in Table 8.1.

The smaller the E^o value, the more reactive the metal, the higher the tendency the metal can be oxidised to form the metal cation.

Table 8.1

electrode reaction	E^o / V
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
$2H^+ + 2e^- \rightleftharpoons H_2$	0.00
$Co^{2+} + 2e^- \rightleftharpoons Co$	−0.28
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	−0.76
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	−2.38
$Ba^{2+} + 2e^- \rightleftharpoons Ba$	−2.90

(a) Two separate experiments were carried out using different pieces of zinc metal.

In experiment 1: zinc metal was added to a colourless solution of barium nitrate.
In experiment 2: zinc metal was added to a pink solution of cobalt(II) nitrate.

Describe what will be observed in each experiment.
Include a balanced equation, where appropriate.

observation in experiment 1: .....

.....

.....

observation in experiment 2: .....

.....

.....[3]

(b) Table 8.2 describes the reactions of two unknown metals X and Y.

Table 8.2

metal X	No visible reaction observed between metal X and dilute acid. Metal X displaces copper from its salt solution.
metal Y	Metal Y reacts with both cold water and steam. Magnesium displaces metal Y from its salt solution.

Use the information in Table 8.1 and Table 8.2 to predict the E° values of metal X and metal Y.

metal X: .....

metal Y: ..... [2]

(c) A student decides to investigate the thermal stability of the carbonates of the four metals, Co, Zn, Mg and Ba.

He heats each metal carbonate in a test tube and bubbles the gas produced through limewater.

(i) State what measurements he should collect.

.....

.....[1]

(ii) Describe how he can use his measurements to place the metal carbonates in order of thermal stability.

.....

.....[1]

(d) Recycling metals uses less energy and produces less waste than extracting them from their ores.

Give one **other** reason why recycling metals such as zinc is important.

.....

.....[1]

[Total: 8]

EITHER

9 The rate of reaction was investigated for the reaction between excess sodium thiosulfate and different acids.

Experiment **A**: 5.00 cm^3 of 1.00 mol/dm^3 of hydrochloric acid

Experiment **B**: 5.00 cm^3 of 1.00 mol/dm^3 of ethanoic acid

Experiment **C**: 5.00 cm^3 of 1.00 mol/dm^3 of sulfuric acid

Fig. 9.1 shows the set-up to investigate the rate of the reaction between the acids and sodium thiosulfate solution.

As the reaction progresses, it becomes more difficult to see the cross 'X' through the solution. The time taken was recorded when the cross 'X' disappears from the top view in Fig. 9.1.

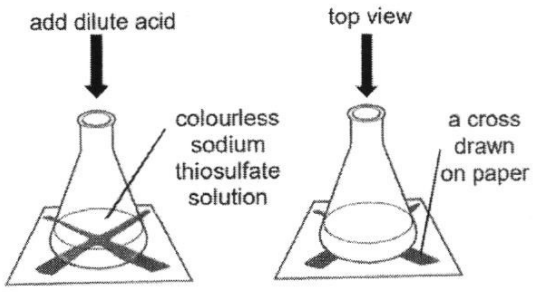


Fig. 9.1

(a) The equation for the reaction between sodium thiosulfate and hydrochloric acid is given below.

$$Na_2S_2O_3\ (aq) + 2HCl\ (aq) \rightarrow 2NaCl\ (aq) + S\ (s) + SO_2\ (g) + H_2O\ (l)$$

Explain why it becomes more difficult to see the cross as the reaction progress.

.....

.....[1]

(b) Fig. 9.2 shows the graph obtained for experiments **A** and **C**.

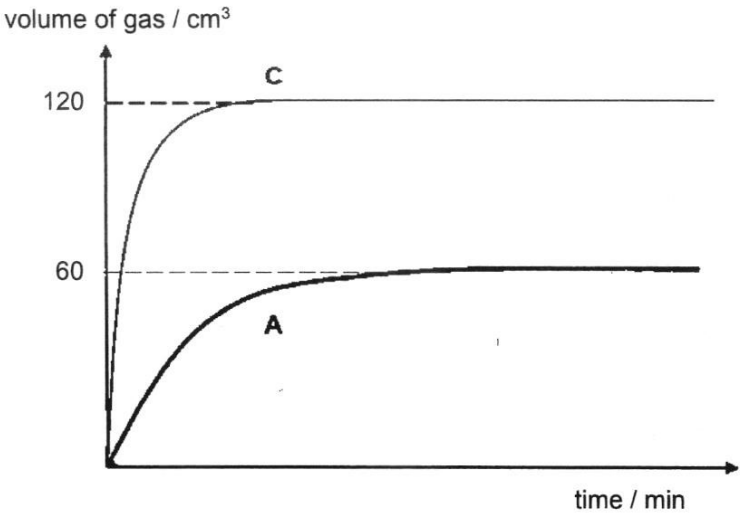


Fig. 9.2

(i) On Fig. 9.2, sketch the graph for the results obtained for experiment **B**.
Label the graph as '**B**'. [1]

(ii) Show by calculation that the volume of sulfur dioxide gas produced is 60 cm^3 for experiment **A**.

[1]

(iii) Describe and explain the shape of the graph for Experiment **A**.

.....

.....

.....

.....[2]

(iv) Explain why the graph is steeper for Experiment **C** than Experiment **A**, with reference to collisions between reacting particles.

.....

.....

.....

.....

.....

.....

.....[2]

(c) Some metal oxides can act as catalysts for the reaction.

(i) A student thinks that chromium(III) oxide acts as a catalyst for the reaction.

Describe what he should do and what results he would obtain if he is right.

.....

.....

.....

.....

.....[2]

(ii) Catalysts lower the activation energy for the reaction.

Explain how they do this.

.....

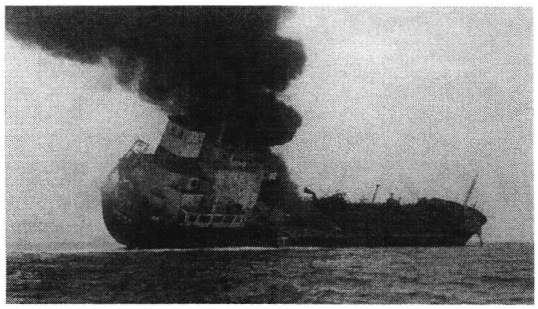
.....[1]

[Total: 10]

OR

9 **(a)** Oil tankers transport crude oil.

Occasionally they may be involved in an accident and catch fire as shown.



Explain why the burning hydrocarbons in the oil produce thick black smoke.

.....

.....[2]

(b) Some ships carry condensate oil, rather than crude oil.
Fig. 9.1 shows the composition of fractions in crude oil and condensate oil.

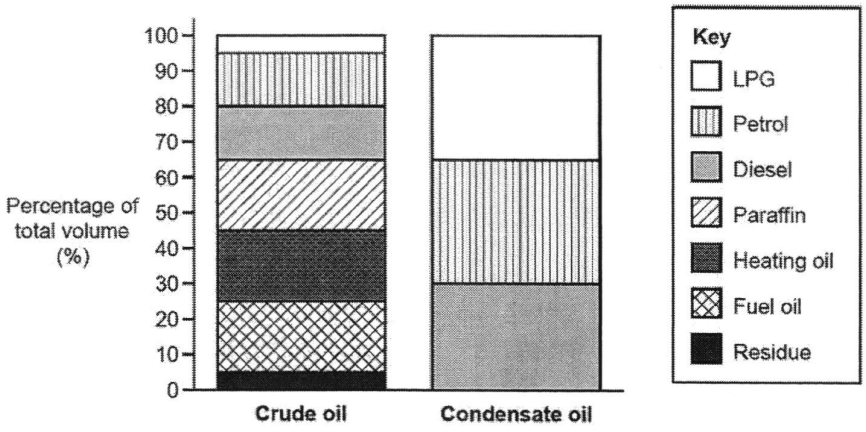


Fig. 9.1

Describe **one** similarity and **one** difference between crude oil and condensate oil.

.....

.....

.....[2]

(c) The bar chart in Fig. 9.2 shows the relative supply and demand for some fractions obtained from crude oil.

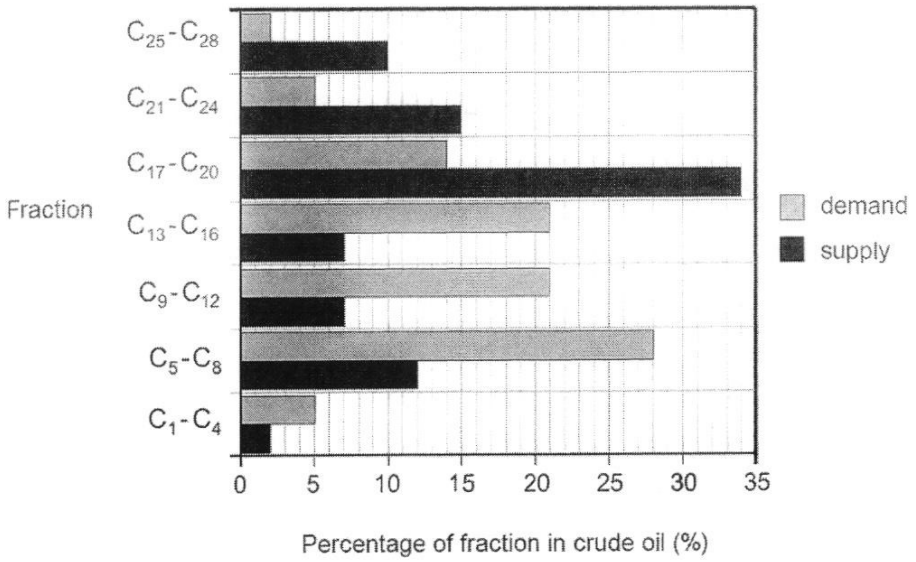


Fig. 9.2

Use the bar chart to describe how the **difference** between the relative supply and demand of the fractions changes as chain length of the molecules increases.

.....

.....

.....

.....[3]

(d) Oil companies have tried to solve the problem of the high demand for some fractions by cracking.

$C_{14}H_{30}$ can be cracked to form hexene (C_6H_{12}), butane and ethene in a cracking tower according to the equation below.

$$C_{14}H_{30} \rightarrow C_6H_{12} + C_4H_{10} + 2C_2H_4$$

100 kg of $C_{14}H_{30}$ entered a cracking tower.

After the reaction, 21.2 kg of ethene was produced. Show that the percentage yield of ethene is 75%.

[3]

[Total: 10]

East Spring Secondary School
4E Pure Chemistry Prelim 2023
Paper 1 (6092/01)

Answer Scheme

Paper 1 (40 marks)

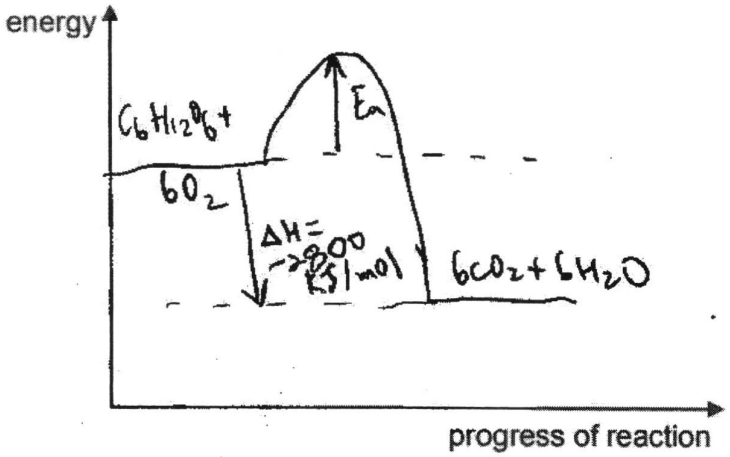
1	2	3	4	5	6	7	8	9	10
D	B	B	D	D	C	A	B	D	A
11	12	13	14	15	16	17	18	19	20
D	B	A	B	B	D	B	D	D	A
21	22	23	24	25	26	27	28	29	30
C	D	D	B	A	D	A	D	B	C
31	32	33	34	35	36	37	38	39	40
D	B	A	C	C	D	C	C	C	C

ESSS 4E Pure Chemistry Paper 2 (6092/2)
2023 PRELIM Answer Scheme

Section A (50 marks)

Qn	Answer	Marks
1	i. B ii. C, E iii. Precipitation / double displacement iv. fuels in cars / hydrogen fuel cell v. Fe_2O_3 / iron(III) oxide	1M each
1b	Which of the statements about graphite are **true** and which are **false**?	4c-2 2-3c-1 0-1c-0

	true	false
It is a polymer.		✓
It is insoluble in water.	✓	
It can be oxidised by oxygen to form a non-metal oxide.	✓	
It has good electrical conductivity when molten.	✓	

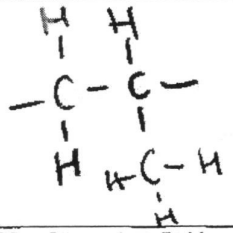
2a		1M: label reactants and products balanced eqn 1M: label Ea correctly 1M: label ΔH correctly (no need write -2800 kJ)
2b	No. of mol of CO_2 = 144/24000 = 0.006 mol Mole ratio comparison, $CO_2 : C_6H_{12}O_6$ = 6 : 1 = 0.006 : 0.001 mol Enthalpy change = (-2800) x 0.001 mol = **-2.8 kJ**	 M1 A1

<table>
<tr><td>2c</td><td>
<table>
<tr><td></td><td>Cu</td><td>O</td></tr>
<tr><td>mass</td><td>1.28g</td><td>0.16g</td></tr>
<tr><td>A_r</td><td>64</td><td>16</td></tr>
<tr><td>no. of mol</td><td>0.02</td><td>0.01</td></tr>
<tr><td>÷ by smallest number of mols</td><td>2</td><td>1</td></tr>
</table>
empirical formula = <u>Cu_2O</u>
</td><td>1 – calc mol for Cu and O

1 – final ans</td></tr>
<tr><td>2d</td><td>• <u>respiration release carbon dioxide</u> / increase levels of carbon dioxide / carbon in the atmosphere
• <u>photosynthesis takes in or absorbs carbon dioxide</u> / reduces levels of carbon dioxide / carbon in the atmosphere</td><td>1

1</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>3ai</td><td>Propanol</td><td>1</td></tr>
<tr><td>3aii</td><td>1. Ethene undergoes <u>addition/hydration</u> with <u>steam</u> at <u>300deg C and phosphoric(V) acid catalyst and 60 atm</u> to form <u>ethanol</u>.

2. Ethanol then undergoes <u>oxidation</u> with <u>acidified potassium manganate(VII) / potassium dichromate(VI) / natural oxidation in air</u> to form <u>ethanoic acid</u>.</td><td>1M: addition reaction
1M: conditions

1M: oxidation</td></tr>
<tr><td>3bi</td><td>  </td><td>1</td></tr>
<tr><td>3bii</td><td>M_r of propene C_3H_6 = 3(12) + 6(1) = 42

n = 21840 / 42 = 520

no. of carbon atoms = 520 x 3 = <u>1560</u></td><td>

1</td></tr>
<tr><td>3biii</td><td>Addition polymerization <u>does not involve loss of atoms/molecules</u>, but condensation polymerisation <u>involves loss of atoms/molecules such as water.</u>

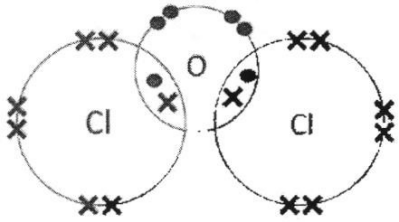
For addition polymerisation, there is <u>one type of functional groups in the monomers</u>, while condensation reaction there are <u>two types of functional groups in the monomers</u>;

For addition reaction, there is only <u>one product</u> which is the <u>polymer</u>, while condensation reaction there are <u>two products</u>, <u>polymer and small molecules</u>;</td><td>1

1

1</td></tr>
</table>

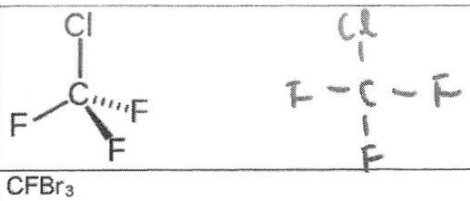
	In addition polymerisation, the monomers **contain unsaturated C=C only**, while the monomers **contain 2 different functional groups** in condensation polymerisation. The relative Mr of the polymer is a multiple of the monomer in addition polymerisation, but the relative Mr of the polymer is not a multiple of its monomers in condensation polymerisation. In addition polymerisation, the empirical formula of the polymer and monomer are the same, while in condensation polymerisation, the empirical formula of the polymer and monomers are different. Accept any other reasonable answer (eg: shorter time vs longer reaction time; forms high Mr polymer at once vs Mr of polymer increases as reaction proceeds)	Any 3
4ai	Yes. From the chemical formula, **all the halogens form 1- ion. / all have oxidation state are -1 / all gain 1 electron** to achieve stable noble gas electronic configuration in the ion. Reject: they have 7 valence electrons (does not show in formula)	1 1
4aii	Oxidising power **decreases** down the group. **fluorine and chlorine** is a stronger oxidising agent as it is able to oxidise iron **from 0 to +3 oxidation state** while bromine and **iodine** is only able to **oxidise iron from 0 to +2 oxidation state.** OR F, Cl and Br can oxidise Fe to Fe^{3+}, but (Br and) iodine can only oxidise iron to Fe^{2+}. *(Accept charge as an explanation)* Students can also talk about loss of electrons (make iron lose 3 electrons vs lose 2 electrons)	1 1
4bi	FeO_4^{2-}	1
4bii	**Oxidised**. **The oxidation state of iron increases from +3 in iron(III) ion/iron(III) hydroxide to +6 in FeO_4^{2-}.** Must state reactant and product, and calculate increase in oxidation state.	1 1

5a	Melting point of **elements increase rapidly from sodium to silicon**, with the exception of magnesium and aluminium with almost the same point. The **melting point decreases from silicon to chlorine.** / The **melting point drops from silicon to phosphorus**, and the **value rises slightly from phosphorus to sulfur** and **drops from sulfur to chlorine.**	1 1
5b	Magnesium has **giant metallic structure**. It has **strong metallic bonds / strong electrostatic forces of attraction** between cations and delocalised electrons, hence **large amount of energy** needed to overcome. Phosphorus has **simple molecular structure**. **Weak intermolecular forces of attraction** between molecules, hence **little energy** needed to overcome.	1M – Mg bonding 1M – P bonding 1M - structure
5ci		1M: corr no. of bonding e⁻ shared between Cl and O 1M: corr ec
5cii	Phosphorous(V) oxide is a **bigger molecule** than dichlorine monoxide. Hence the **intermolecular forces of attraction between molecules are higher / more extensive / covers larger surface area** compared to dichlorine monoxide. Hence **more energy needed to overcome** the forces of attraction.	1 1
6a		1M for each row

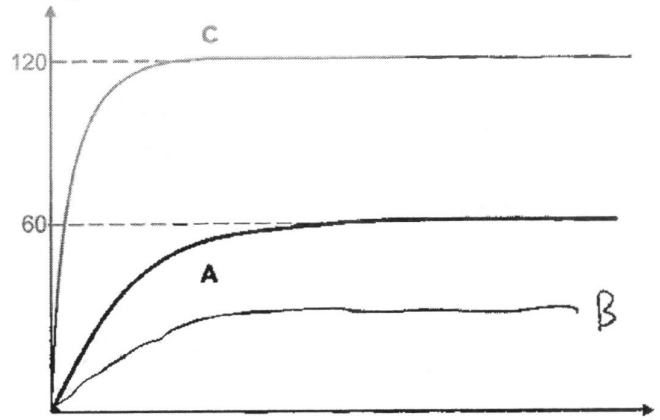
solution	name of products of electrolysis	
A: dilute copper(II) sulfate solution	at the positive electrode	oxygen
	at the negative electrode	Copper (solid)
B: concentrated sodium chloride solution	at the positive electrode	Chlorine (gas)
	at the negative electrode	Hydrogen (gas)
C: dilute sulfuric acid	at the positive electrode	Oxygen
	at the negative electrode	Hydrogen (gas)

6b	The solution will eventually **turn from blue to colourless / blue colour fades / blue to light blue** as all of the aq. **copper(II) ions are** reduced to copper / copper(II) **ions are preferentially discharged** to form copper.	1 1
6c	To identify solution A: Add **aqueous sodium hydroxide** into the solutions. **Light blue precipitate forms of copper(II) hydroxide forms, insoluble in excess** [1] is the solution from Cell A. / Add **acidified barium** nitrate into each solutions, and the solution that **produces a white precipitate** due to formation of ***barium sulfate*** [1] is solution from Cell A. / Solution A is **blue in colour** as it is copper(II) sulfate. To identify Solution B: Add **acidified silver nitrate** into the remaining solutions. The solution that forms **a white precipitate** of **silver chloride** [1] is solution **B.** The remaining solution is Solution C. To identify solution C: Add **Universal indicator**. It **turns from green to red / blue litmus** paper turns red.	1 1 1

Section B (30 marks)

Qn	Answer	Marks
7a	The energy change includes a plus sign, indicates energy change is positive as **more heat is absorbed** from the surroundings **to break bonds in reactants than heat released to form bonds in products.**	1
7b	The **bromine** containing ODS have **higher** ozone depletion potential than **chlorine** containing ODS	1
7c		1
7d	$CFBr_3$	1
7e	It needs to **gain 1 more electron** to pair the unpaired electron, thus achieving stable noble gas configuration.	1
7f	The amount of **energy absorbed** to **break** the **C-Cl bond, 340 kJ/mol**, is **lower** than the amount of energy **absorbed** to **break** the **C-F bond** (485 kJ/mol). Hence, more **C-Cl bonds are easily broken than C-F bonds**, hence there are more chlorine atoms in the ozone layer.	1M 1
7gi	$Cl\bullet + O_3 \rightarrow ClO + O_2$ $ClO + O_3 \rightarrow 2O_2 + Cl\bullet$ -1 if did not include radical unpaired electron.	1M – eqn 1M – balance
7gii	The radical is only **needed in small amount** / the radical **remains chemically unchanged** in the reaction. *Each **chlorine atom** **reacts** with an **ozone molecule** to **form** ClO and O_2. The **ClO molecule reacts with more ozone** to **produce another chlorine atom**, and this chlorine atom **goes on to react with more ozone molecules, breaking it down into oxygen**. The chain **reaction** is **repeated** from step 1.*	1
7hi	It effectively **decreased** the consumption of ODS	1
7hii	This is because **some ODS have a very long lifetime** of 65 or 102 years. They are still lingering in the atmosphere destroying ozone.	1

8a	Expt 1: **solution remains colourless** Expt 2: **Pink solution turns colourless** OR **grey solid is deposited** $Zn(s) + Co^{2+}(aq) \rightarrow Co(s) + Zn^{2+}(aq)$ OR $Zn + Co(NO_3)_2 \rightarrow Co + Zn(NO_3)_2$	1 1 1
8b	metal X: value between 0.00 V to +0.34 V metal Y: value between –2.38 V and 0.00 V -1 if no sign or units included. Don't penalise for decimal places	1 1
8ci	The **time taken** for a **white ppt** to form in limewater	1
8cii	The **longer the time taken** for white ppt to form, the more reactive the metal, **hence the higher the thermal stability of metal carbonate** (vice versa)	1
8d	**Zinc ore/metal ore** is a finite/limited resource, hence there is a need to **conserve/save** them to ensure there is **sufficient for future generation**;	1

EITHER 9a	Formation of sulfur will be **produced as a precipitate / solid**, thus making it difficult to see the cross.	1
9bi	volume of gas / cm^3  	1 (gentler gradient than A, lower vol.)
9bii	mol of HCl = 5.00 / 1000 × 1.00 = 0.00500 mol mol of SO_2 = 0.00250 mol volume of SO_2 = 0.00250 × 24 000 = 60 cm^3 (shown)	 1
9biii	Initially, there are many reactant particles, so **rate of reaction is fast** and **gradient is steep**. Over time, there are less reactant particles, the **rate of reaction slows down and gradient becomes gentler**. Eventually, all H+ ions are used up, hence **reaction stops** and **gradient of graph becomes zero.**	3c-2 1-2c-1
9biv	For the same amount of acid used, **sulfuric acid ionises in water to produce twice the concentration of H+** ions compared to hydrochloric acid, there are **more H+ particles per unit volume;** **results in increased frequency of collisions and effective collisions**, **increasing the speed of reaction and hence steeper gradient for experiment C**.	1 1
9ci	Repeat each of the experiments and **add a fixed mass of chromium(III) oxide** and **measure the time taken until the cross cannot be seen.** If the **time taken is less** than the time taken for each experiment without any chromium(III) oxide, **the speed / rate of reaction is faster**, hence chromium(III) oxide acts as a catalyst.	1 1

9cii	**Catalysts provide an alternative (reaction) pathway** with lower activation energy *hence, more particles have energy equal to / greater than the activation energy, leading to increased frequency of collisions and effective collisions.*	1

OR 9a	The **incomplete combustion** / insufficient oxygen of fuels produces **unburnt carbon** / carbon particulates / **soot**	1 1
9b	**any one similarity from:** (both are) mixtures (both contain) LPG (both contain) Petrol (both contain) Diesel diesel and petrol form roughly the same proportion(~15% each in crude oil/~30% each in condensate oil) of each mixture **any one difference from:** crude oil has more fractions / condensate has fewer fractions / crude oil has 7 fractions and condensate has (only) 3 fractions (only) crude oil has residue (only) crude oil has fuel oil (only) crude oil has heating oil (only) crude oil has paraffin crude oil has less LPG crude oil has less petrol crude oil has less diesel condensate has equal distribution of fractions	1 1
9c	up to C_{13}-C_{16} demand is greater than supply (1) from C_{17}-C_{20} upwards supply is greater than demand (1) third mark: quote data	1 1 1
9d	Moles of $C_{14}H_{30}$ = (100x1000) / 198 = 505.1 Moles of C_2H_4 = 505.1 x 2 = 1010.2 Mass of C_2H_4 = 1010.2 x 28 = 28 285.6 g % yield = 21.2/28.286 x 100 = 74.9% ≈ **75%**	M1 M1 A1