NAME:		( )	CLASS:	

YISHUN TOWN SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2023

SEC 4 EXPRESS

CHEMISTRY

(6092/2)

DATE : 22 Aug 2023 DAY : Tuesday

DURATION : 1 hr 45 min MARKS : 80 marks

READ THESE INSTRUCTIONS FIRST

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

Section A

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

Section B

Answer **three** questions. Question **B8** and **B9** are compulsory. Choose one question from **B10**.
Write your answers in the spaces provided.

INFORMATION FOR CANDIDATES

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

You may use an approved calculator.

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

Section A	
Section B	
TOTAL	

This question paper consists of 19 printed pages, including the cover page

SECTION A

Answer all the questions in the spaces provided.

A1 The equations A, B, C, D and E show some reactions involving compounds of **M**.

A $MCO_3\ (s) \rightarrow MO\ (s) + CO_2\ (g)$

B $2MO\ (s) + C\ (s) \rightarrow 2M\ (s) + CO_2\ (g)$

C $MO\ (s) + H_2SO_4\ (aq) \rightarrow MSO_4\ (aq) + H_2O\ (l)$

D $MSO_4\ (aq) + 2NaOH\ (aq) \rightarrow M(OH)_2\ (s) + Na_2SO_4\ (aq)$

E $M(OH)_2\ (s) + 2HCl\ (aq) \rightarrow MCl_2\ (aq) + 2H_2O\ (l)$

(a) Use **only** the letters **A, B, C, D** and **E** to answer the questions. **[3]**

(i) Which equation(s) shows a neutralisation reaction? _____

(ii) Which equation(s) shows a precipitation reaction? _____

(iii) Which equation(s) shows an endothermic reaction? _____

(b) **M** is either magnesium or copper. Explain with reason what **M** is likely to be. **[1]**

_____

_____

A2 The properties of three solids, **P, Q** and **R** are given in table below. Use this information to identify the solids as element, mixture or compound. **[2]**

Solid	Percentage composition by mass	Strong heating in oxygen	Element, mixture or compound
P	constant	decomposes	
Q	varies	burns	
R	constant	oxidises to form one product	

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A3(a) When Group I metals tarnish in air, different types of oxides are formed. Some of these oxides are given in the table below.

Element	Oxides formed	Formula of oxides
Lithium	Lithium oxide	Li_2O
Sodium	Sodium peroxide	Na_2O_2
Potassium	Potassium superoxide	KO_2

(i) Draw the dot and cross diagram for lithium oxide showing all electrons. [2]

(ii) Calculate the oxidation state of the oxygen in each of the oxides. [2]

Formula of oxides	Oxidation state of oxygen
Li_2O	
Na_2O_2	
KO_2	

(b) Sodium oxide reacts with silicon dioxide to form sodium silicate.

(i) Write a balance chemical equation for this reaction. [1]

(ii) Both sodium oxide and silicon dioxide have high melting points. With reference to structure and bonding, explain their high melting points. [4]

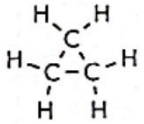
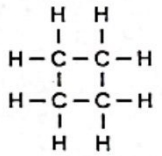
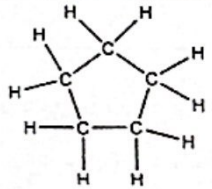
(c) Zinc oxide undergoes the following two reactions.

Reaction 1: $ZnO\ (s) + 2HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2O\ (l)$

Reaction 2: $ZnO\ (s) + H_2O\ (l) + 2NaOH\ (aq) \rightarrow Na_2Zn(OH)_4\ (aq)$

With reference to the two reactions, explain the chemical property of zinc oxide. [2]

A4 The table shows some information about a homologous series of organic compounds called cycloalkanes.

Name	Full structural formula	Boiling point /°C
cyclopropane		−33
cyclobutane		12
cyclopentane		40

(a) Explain how the formulae in the table show that the organic compounds belong to the same homologous series. [2]

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(b) Put ticks (√) in the boxes to show whether the following statements about the cycloalkane homologous series are true or false. [2]

	True	False
They have the same percentage by mass of carbon		
They decolourise aqueous bromine in the absence of sunlight.		

(c) State and explain the relationship between the number of carbon atoms and boiling points of cycloalkanes. [2]

(d) Draw the full structural formula of an isomer of cyclobutane. [1]

A5 The table below shows the time taken for the same mass of magnesium to react with the same volume of sulfuric acid of various concentrations at room temperature and pressure.

	dilute sulfuric acid				concentrated sulfuric acid		
Concentration / mol/dm^3	0.5	1.0	2.0	4.0	8.0	12.0	18.0
Time / s	450	45	22	5	106	750	Very little reaction

(a) Explain in terms of collision theory, the change in rate of reaction as the concentration of the dilute sulfuric acid increases from 0.5 mol/dm^3 to 4.0 mol/dm^3. [3]

(b) Explain why there was very little reaction when the concentration of the sulfuric acid was 18.0 mol/dm^3. [2]

(c) Figure 7 below shows the volume of gas produced when 0.24 g of powdered magnesium was reacted with 100 cm^3 of 0.5 mol/dm^3 sulfuric acid.

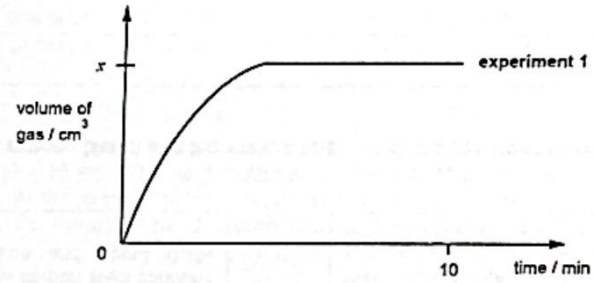


Figure 7

(i) Calculate the volume of gas produced in experiment 1. [3]

(ii) On Figure 7, sketch the curves that would be obtained when the following conditions of the reaction are changed. [2]

Experiment 2: Same mass of magnesium ribbon used instead of powdered magnesium. Label this graph A.

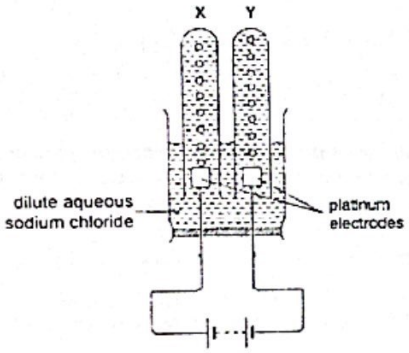
Experiment 3: Concentration of sulfuric acid used is changed from 0.5 mol/dm^3 to 0.75 mol/dm^3. Label this graph B.

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(d) A student wanted to prepare a pure and dry sample of magnesium sulfate crystals. Briefly describe the changes she must make to the magnesium and sulfuric acid used in **experiment 1** in order to obtain pure magnesium sulfate crystals. Your answer should make reference to the quantities of the reactants used. [2]

(e) Another student replaced the magnesium with the same amount of calcium. Give a reason why the volume of gas obtained for the reaction of calcium with sulfuric acid would be significantly lesser than with magnesium. [1]

A6 The following electrolysis was set up using dilute sodium chloride solution as the electrolyte and platinum electrodes.



(a) Write ionic equations with state symbols for the reactions taking place at the cathode and anode. [2]

Cathode: _____

Anode: _____

(b) State the ratio of the volume of gas **X** to gas **Y** and explain why the volume of gas obtained is in this ratio. [2]

(c) After the electrolysis has been running for some time, one of the products of the electrolysis changes. State the change in product and explain why it forms. [2]

A7 The flow chart below shows the extraction of iron and titanium from their ores haematite and rutile respectively.

Haematite is reacted with coke at 1000°C in a furnace to produce molten cast iron. Cast iron contains iron and about 4% carbon.

↓

Oxygen is blown into the molten cast iron to produce low carbon steel. Low carbon steel contains mainly iron and about 0.1% carbon.

Rutile which is titanium dioxide is reacted with chlorine at 1500°C to produce titanium (IV) chloride

↓

The titanium (IV) chloride is reacted with magnesium at 1200°C in a sealed reactor. The sealed reactor contains an atmosphere of argon.

↓

The reactor is allowed to cool and then opened. The titanium is then separated from its other product, magnesium chloride.

(a) Explain how oxygen blown into the molten cast iron produces low carbon steel. [1]

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(b) Explain why the production of titanium requires an atmosphere of argon. [1]

(c) Using the information given, suggest two reasons why titanium costs much more than iron. [2]

(d) Write an ionic equation for the reaction between magnesium and titanium (IV) chloride. [1]

(e) Suggest the position of titanium in the metal reactivity series. Explain your answer. [2]

SECTION B

Answer all three questions in the spaces provided.

B8 Ozone and Its Reactions

Structure and Properties of Ozone

Ozone is a triatomic molecule with a boiling point of −112 °C. The first allotrope was discovered in 1840. All 3 atoms in ozone have a stable octet arrangement. The molecule also has a dative bond. A dative bond is a covalent bond in which both electrons come from the same atom.

O = O – O

Ozone is a powerful oxidising agent and is unstable at high concentrations. Ozone easily decomposes to oxygen as the formation of oxygen is energetically more stable.

Ozone in the Atmosphere

The atmosphere is divided into several regions. The region closest to the Earth is called the troposphere (0 – 15 km). The next region above the troposphere is known as the stratosphere (15 – 50 km). At the lower stratosphere, an ozone layer exists, which helps to protect us from UV radiation. On the other hand, ozone found at the tropospheric level is considered as a pollutant.

UV radiation contains different types of rays. The table below gives information about these rays.

UV Radiation	Wavelength / nm
UV – A	315 - 400
UV – B	280 - 315
UV – C	100 - 280

Chapman Cycle - Mechanism for Ozone Creation and Destruction

The Chapman Cycle illustrates the formation of the ozone layer. An oxygen molecule is photolysed by ultraviolet light into two oxygen atoms. At the lower stratosphere, each oxygen atom then quickly combines with an oxygen molecule to form an ozone molecule.

Step 1: $O_2 \xrightarrow{UV} 2O$

Step 2: $O + O_2 \rightarrow O_3$

The ozone formed can then absorb radiation (a form of energy) having a wavelength between 240 and 310 nm. This thus leads to the dissociation of the ozone to form oxygen molecule.

Step 3: $O_3 \xrightarrow{UV} O + O_2$

Step 4: If an oxygen atom and an ozone molecule meet, they can recombine to form 2 oxygen molecules.

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Ozone is constantly being created and destroyed by the Chapman Cycle. These reactions are natural processes, which have been taking place for millions of years. Photosynthesis helps the ozone layer to regenerate itself.

Mechanism I - Catalytic Process of Ozone Destruction

In the early 1960s, it was realised that there were other mechanisms for the destruction of ozone, apart from the mechanism in the Chapman Cycle. One of these mechanisms is given below.

Step 1: $Y + O_3 \rightarrow YO + O_2$

Step 2: $2YO \rightarrow 2Y + O_2$

where Y are highly unstable radicals which contain an odd number of electrons.

While the ozone is capable of its own recovery, much effort has been made to reduce the damage done to the depletion of the layer.

(a) Draw a dot and cross diagram to show the arrangement of outer shell electrons in a molecule of ozone. Use different symbols for the electrons of each oxygen atom. [2]

(b) With reference to the data, explain the extent of how the ozone in the lower stratosphere protects us from the different types of UV rays. [2]

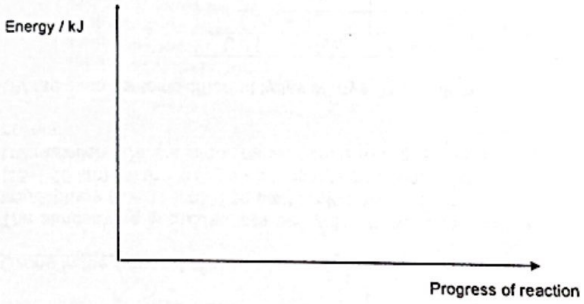
(c) (i) Write the chemical equation for Step 4 of the Chapman Cycle. [1]

(ii) With reference to the steps in the Chapman Cycle, explain why photosynthesis helps to regenerate the ozone layer. [2]

(d) (i) Write the overall equation for Mechanism I. [1]

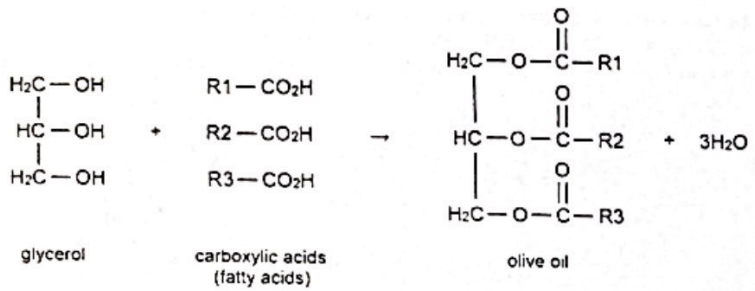
(ii) State one pollutant which is a possible source of radicals for Mechanism I. Explain why Mechanism I is called a catalytic process. [2]

(e) Sketch and label the energy level diagram for the decomposition of ozone to oxygen. [2]



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B9 Olive oil is formed from glycerol and three long chain carboxylic acids (fatty acids), as shown in the equation below.



The groups R1, R2 and R3 represent hydrocarbon chains each containing 17 carbon atoms. A given oil molecule can be formed from any combination of the following fatty acids.

name of fatty acid	formula	M_r	melting point / °C
stearic acid	$CH_3(CH_2)_{16}CO_2H$	284	69.0
oleic acid	$CH_3(CH_2)_7CH{=}CH(CH_2)_7CO_2H$	282	13.0
linoleic acid	$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7CO_2H$	280	− 5.0
linolenic acid	$CH_3CH_2(CH{=}CHCH_2)_3(CH_2)_6CO_2H$	278	− 11.0

(a) State the effect of the number of C=C bonds on the melting point of the fatty acids. [1]

(b) The average number of C=C bonds in each oil molecule can be compared experimentally by determining the mass of iodine that reacts with 100 g of the oil.

In an experiment, 100 g of olive oil was found to react with 86.2 g of iodine.

(i) Calculate the number of C=C bonds in each olive oil molecule.
(Mr of an olive oil molecule is 884) [3]

(ii) From your answer in (b)(i), suggest a possible combination of the fatty acids that is present in a molecule of olive oil. [1]

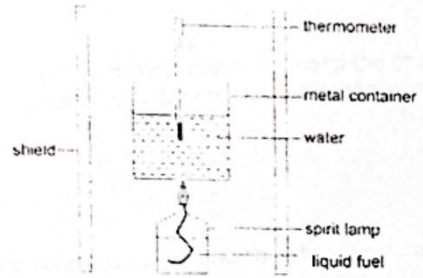
(c) Glycerol can be oxidised to a carboxylic acid called glyceric acid. During the oxidation process, only one of the hydroxyl groups in glycerol is oxidised to the carboxyl group. Draw the full structural formula of glyceric acid. [1]

(d) Describe a chemical test to distinguish between stearic acid and linoleic acid. [2]

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EITHER

B10 The experiment shown in the diagram below was set up to determine the enthalpy change of combustion when different liquid fuels are burnt. The heat produced by the burning of the fuel warms a known mass of water. The rise in temperature of the water can be used to derive the amount of heat produced during the combustion of the fuel.



A student found two records in a data sheet which gave the following information.

Burning 0.92 g of ethanol causes the temperature of the water to increase by 10°C and the amount of energy given out is 16.8 kJ.	The temperature of 1 cm^3 of water rises by 1°C for every 4.2 J of energy given out during the burning of the fuel.

(a) Calculate the amount of energy given out when 1 mole of ethanol is burnt. [1]

(b) Calculate the amount of energy given out when the temperature of 10 cm^3 of water rises by 8°C. [1]

(c) The table shows the bond energies for some bonds.

Bond	Bond energy (kJ/mol)	Bond	Bond energy (kJ/mol)
C = O	804	C – H	413
O = O	498	C – C	348
O – H	464	C – O	360

(i) Ethanol burns in excess oxygen to produce carbon dioxide and water. Write the chemical equation for the complete combustion of ethanol. [1]

(ii) Use the information in the table to calculate the enthalpy change, ΔH, of the combustion of ethanol. [3]

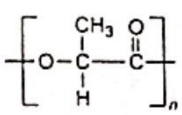
(iii) The values obtained in **(a)** and **(b)(ii)** are different. Suggest two reasons which could have led to a difference in the enthalpy of combustion. [2]

(d) Describe how the energy of the reactants and products, activation energy and enthalpy of the reaction will change if at all, when gaseous ethanol is used instead of liquid ethanol. [2]

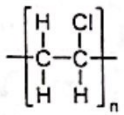
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OR
B10

(a) Polylactic acid (PLA) is a polymer that is derived from renewable sources such as corn starch, tapioca roots and sugarcane. PLA is biodegradable. Polyvinyl chloride (PVC) is a synthetic polymer that is derived from crude oil. The structures of the polymer of PLA and PVC are shown below.



PLA



PVC

(i) Draw the structural formula of the monomer of PLA and PVC. [2]

monomer of PLA

monomer of PVC

(ii) Describe one similarity and one difference in the polymerisation process to form PLA and PVC. [2]

(iii) Suggest two advantages of using polymers such as PLA rather than PVC. [2]

(iv) During a manufacturing process of PLA, 13500 g of the monomer was used. Calculate the mass of the PLA polymer chain formed assuming 100% conversion. [2]

(b) Ethanoic reacts with butanol to form an ester. Draw the full structural formula of the ester produced and state the conditions for the esterification process. [2]

Conditions for esterification: _____

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YISHUN TOWN SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2023

SEC 4 EXPRESS

CHEMISTRY

(6092/1)

DATE : 30 Aug 2023 DAY : Wednesday

DURATION: 1 hr MARKS: 40 marks

ADDITIONAL MATERIALS

Multiple Choice Answer Sheet (OMS)

READ THESE INSTRUCTIONS FIRST

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

There are forty questions. 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. Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

INFORMATION FOR CANDIDATES

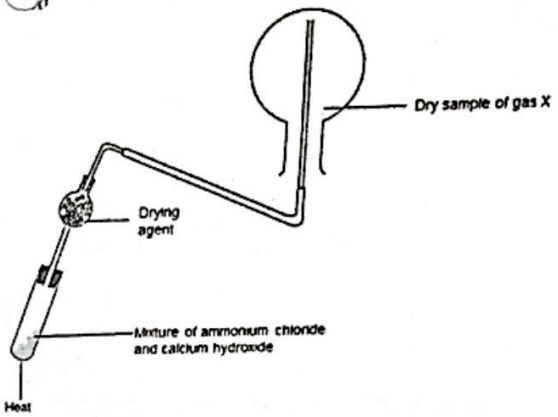
Any rough working should be done in this booklet.

You may use an approved calculator.

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

This question paper consists of 16 printed pages

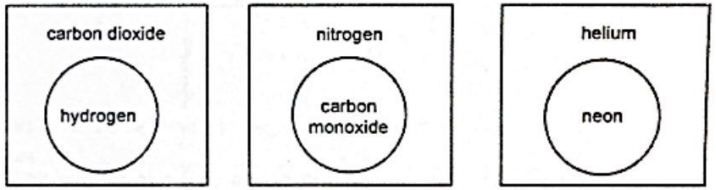
1 A student wanted to collect a dry sample of gas X using the reactants and apparatus below.



What is gas X and a suitable drying agent that can be used?

	Gas X	Drying agent
A	hydrogen chloride	calcium oxide
B	ammonia	concentrated sulfuric acid
C	hydrogen chloride	concentrated sulfuric acid
D	ammonia	calcium oxide

2 Three balloons are placed inside plastic containers containing different gases at room temperature and pressure as shown below.



Which correctly describes the balloon in each set up after a while?

	I	II	III
A	becomes bigger	remains the same	deflates
B	becomes bigger	becomes bigger	becomes bigger
C	deflates	remains the same	becomes bigger
D	deflates	becomes bigger	becomes bigger

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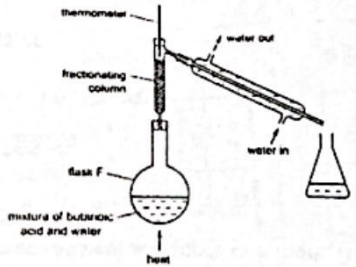
3 The atmosphere of Venus contains mainly oxygen, argon and nitrogen. The melting and boiling points of these gases are shown in the table below.

gas	melting point / °C	boiling point / °C
oxygen	-219	-183
argon	-189	-186
nitrogen	-210	-196

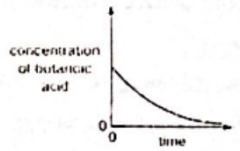
What temperature should the sample of air be decreased to in order to obtain only liquid oxygen?

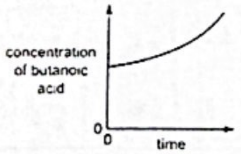
A -180°C
B -185°C
C -187°C
D -198°C

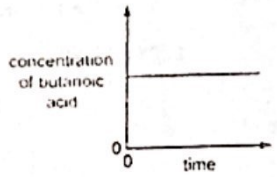
4 The apparatus shown is used to distil butanoic acid (boiling point 164°C) from a mixture of butanoic acid and water.

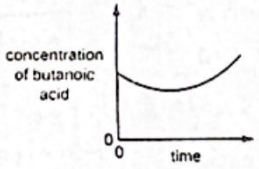


Which graph best shows the change in the concentration of the butanoic acid in flask F during the distillation process?

A


B


C


D


5 Which solution when added to both the reagents below will produce a gas?

- Sodium carbonate
- Aqueous sodium hydroxide with aluminium foil

A dilute nitric acid
B aqueous ammonium nitrate
C dilute sulfuric acid
D aqueous potassium sulfate

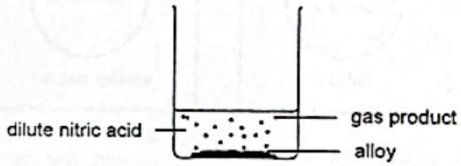
6 Ions of two isotopes of nickel are shown below. They are labelled as X and Y.

$^{58}_{28}Ni^{2+}$ X $\quad$ $^{60}_{28}Ni^{2+}$ Y

Which statement is correct about these ions?

A Both ions have the same number of electrons but different number of neutrons.
B In both ions, there are more electrons than protons.
C Ion X has the same mass as ion Y.
D Each ion has more protons than neutrons in its nucleus.

7 An alloy of iron and carbon was added to a beaker of dilute nitric acid as shown in the diagram below.

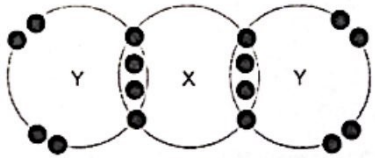


Which row correctly shows the type of particles present in the substances as shown in the diagram?

	iron	carbon	dilute nitric acid	gas product
A	ions and electrons	atoms	ions and molecules	molecules
B	ions	molecules	ions	molecules
C	ions	molecules	ions and molecules	atoms
D	ions and electrons	atoms	ions	atoms

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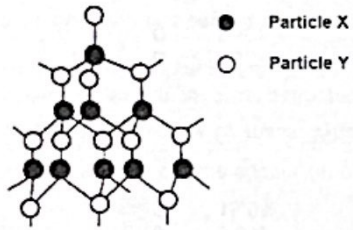
8 The outer electronic structure of a molecule is shown below.



What could elements X and Y be?

	X	Y
A	magnesium	oxygen
B	carbon	oxygen
C	lead	oxygen
D	silicon	chlorine

9 A substance has the following structure.

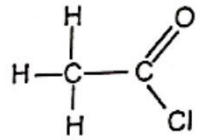


Which of the following statements about this structure are correct?

I Particle X may be a silicon atom.
II This is a simple molecular compound with strong covalent bonds between atoms.
III This substance is soluble in organic solvents.
IV This substance is stable to heat.

A I and II only
B I and IV only
C II and III only
D II and IV only

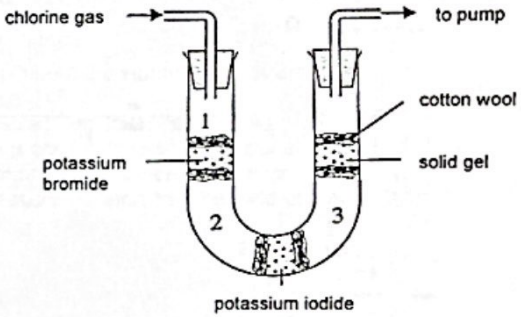
10 The diagram shows the structure of ethanoyl chloride.



What is the total number of valence electrons **not** used for bonding?

A 5
B 10
C 14
D 26

11 Gaseous chlorine was passed through the following apparatus. The apparatus was continuously heated.



What observations would be made at regions **1, 2 and 3**?

	Region 1	Region 2	Region 3
A	reddish brown gas	black solid	violet gas
B	reddish brown gas	violet gas	black solid
C	yellow gas	reddish brown gas	violet gas
D	yellow gas	reddish brown gas	black solid

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12 P is a Group I element. What would happen when a small piece of P is put into a bowl that contains water and a few drops of litmus solution?

I Heat is released.
II An electrolyte is formed.
III The solution turns blue.
IV A gas is given off.

A I and III only
B III and IV only
C I, III and IV only
D I, II, III and IV

13 In an experiment, 1 cm^3 of a gaseous hydrocarbon, Z, requires 4 cm^3 of oxygen for complete combustion to give 3 cm^3 of carbon dioxide. All gas volumes are measured at r.t.p.

Which formula represents Z?

A C_2H_2
B C_2H_4
C C_3H_4
D C_3H_8

14 68 g of impure hydrogen peroxide decomposes in the presence of manganese (IV) oxide to give 1.2 dm^3 of oxygen gas as follows.

$$2H_2O_2 \rightarrow O_2 + 2H_2O$$

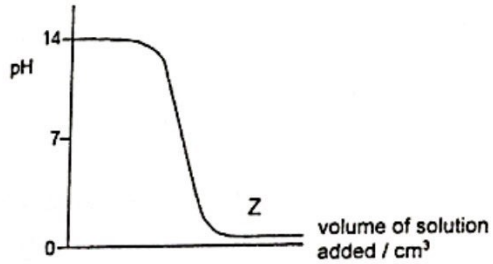
What is the percentage purity of the hydrogen peroxide?

A 2.5%
B 5.0%
C 10.0%
D 15.0%

15 A chloride of iron contains 55.9% of chlorine by mass. What is the empirical formula of this chloride?

A Fe_2Cl_6
B $FeCl$
C $FeCl_2$
D $FeCl_3$

16 The graph shows how the pH changes in a reaction between an acid and an alkali.

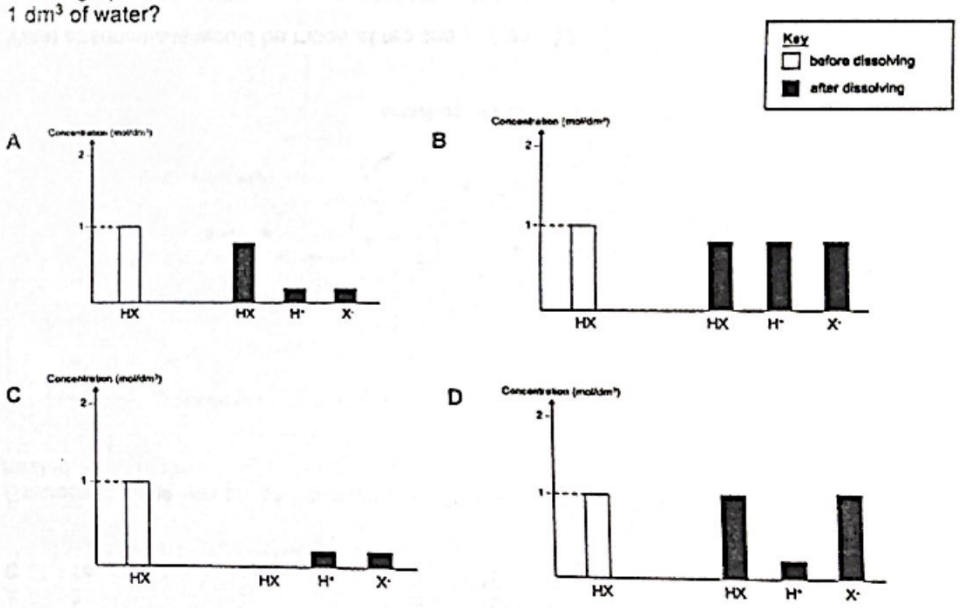


What conclusions can be deduced from the graph?

1 An acid is added to a fixed volume of an alkali.
2 Only salt and water are present at part Z of the graph.
3 Neutralisation occurs at about pH 7.
4 A weak acid was added to a strong alkali.

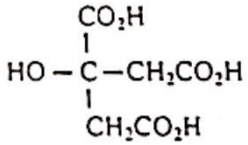
A 1 and 2 only
B 1 and 3 only
C 2 and 4 only
D 1, 2 and 3

17 Which graph shows the solution formed when one mole of a **weak acid**, HX is dissolved in 1 dm^3 of water?



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18 The structure below is citric acid.



How many moles of sodium hydroxide are needed to neutralise one mole of citric acid?

A 1 B 2
C 3 D 4

19 Which of these sequences of reaction produces the best yield of calcium sulfate?

A Adding dilute nitric acid to calcium carbonate followed by dilute sulfuric acid.
B Mixing solid calcium nitrate and solid potassium sulfate.
C Addind calcium carbonate to dilute sulfuric acid.
D Adding calcium oxide solid to dilute sulfuric acid.

20 Which statement about metals and their compounds is not correct?

A Unreactive metals are likely to be found as elements in soil or rocks.
B Metals low in the reactivity series are generally extracted from their oxides by heating with carbon.
C Heating magnesium with iron (III) oxide produces iron and magnesium oxide.
D A higher temperature is needed to reduce copper (II) oxide to copper than zinc oxide to zinc by hydrogen.

21 A metal consists of a lattice of positive ions in a 'sea of electrons'.

What happens to the electrons and positive ions in a metal wire when an electric current is passed through it?

	electrons	positive ions
A	replaced by new electrons	replaced by new ions
B	replaced by new electrons	unchanged
C	unchanged	replaced by new ions
D	unchanged	unchanged

22 Steel is an alloy of iron with a very small percentage of carbon. Which statement is **incorrect**?

A An increase in the percentage of carbon makes the steel more brittle.
B A decrease in the percentage of carbon makes the steel less malleable.
C Carbon disrupts the orderly arrangement of iron.
D Iron atoms are of different size from carbon atoms.

23 Bismuth (III) oxychloride dissolves in concentrated hydrochloric acid to give a colourless solution of bismuth (III) chloride. This reaction is reversible.

$$BiOCl\,(s) + 2HCl\,(aq) \rightleftharpoons BiCl_3\,(aq) + H_2O\,(l) \qquad \Delta H = -132\ kJ/mol$$

The activation energy for the forward reaction is 45 kJ/mol.

What is the activation energy for the reverse reaction?

A - 45 kJ/mol B +87 kJ/mol
C - 87 kJ/mol D +177 kJ/mol

24 Which statements about the Haber Process are true?

1 Nitrogen is reduced to form ammonia.
2 Hydrogen is obtained from the fractional distillation of air.
3 A high temperature will increase the yield of ammonia
4 A high pressure will increase the yield of ammonia

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

25 Which changes include both oxidation and reduction?

A $C \rightarrow CO \rightarrow CO_2$
B $N_2 \rightarrow NH_3 \rightarrow NO$
C $PbO_2 \rightarrow PbO \rightarrow Pb$
D $Fe \rightarrow FeCl_2 \rightarrow FeCl_3$

26 Hydrogen peroxide, H_2O_2, reacts with silver oxide according to the following equation.

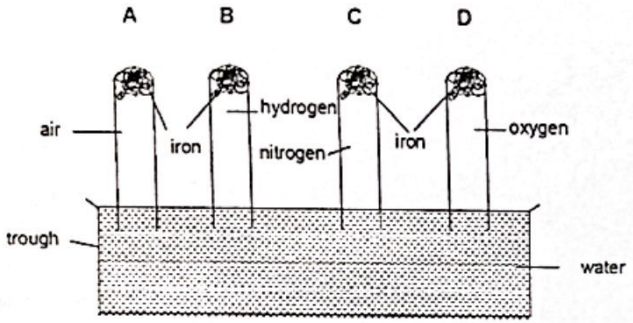
$$Ag_2O\,(s) + H_2O_2\,(l) \rightarrow 2Ag\,(s) + H_2O\,(l) + O_2\,(g)$$

In this reaction, what is hydrogen peroxide behaving as?

A An acid B An oxidizing agent
C A reducing agent D A dehydrating agent

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27 An experiment was set up as shown in the diagram below. Which tube will have the highest water level after one month?



28 Diesel and petrol are commonly used as fuels for cars. The combustion of these fuels produces air pollutants. The table below shows the mass of air pollutants found in exhaust fumes when 1 kg of each fuel is combusted under identical conditions.

air pollutant produced	mass of air pollutant after diesel is combusted / g	mass of air pollutant after petrol is combusted / g
carbon monoxide	15	300
unburnt hydrocarbons	20	25
oxides of nitrogen	95	40

What can be inferred from the data given in the table?

A Burning of petrol contributes more towards acid rain.
B Petrol requires less oxygen for complete combustion.
C Combustion of petrol is more exothermic than that of diesel.
D A diesel engine has a higher temperature than a petrol engine.

29 10 g each of zinc and copper powder were burnt in excess oxygen. Which row correctly states the volume of oxygen reacted and the rate of the reaction?

	volume of oxygen reacted	rate of reaction
A	same for both	faster with zinc
B	smaller with zinc	faster with zinc
C	smaller with zinc	faster with copper
D	smaller with copper	faster with zinc

30 Which statement about a catalyst is **not** true?

A A catalyst changes the enthalpy of the reaction, ΔH.
B A catalyst changes the rate of reaction.
C A catalyst has no effect on the kinetic energy of the reacting particles.
D A catalyst provides an alternative reaction pathway that has a lower activation energy.

31 Dilute sulfuric acid reacts with copper (II) oxide to form copper (II) sulfate and water. What would **not** alter the rate of this reaction?

A the concentration of sulfuric acid
B the pressure at which the reaction takes place
C the size of the particles of copper (II) oxide
D the temperature of the reacting mixture

32 When water is liquid, it ionises slightly.

$$H_2O\ (l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

The forward reaction is endothermic.

When the temperature of water is increased, which changes take place?

1 The water becomes acidic.
2 The water becomes alkaline.
3 More water molecules form ions.

A 1 and 3 B 1 only
C 2 and 3 D 3 only

33 A solid layer of element R is formed at the cathode when an aqueous solution of ions of R is electrolysed. Which statement about element R is correct?

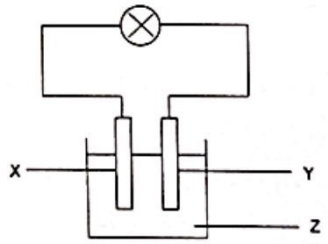
A Ions of R lose electrons at the cathode.
B Element R must be below hydrogen in the reactivity series.
C Element R forms positive ions at the cathode.
D The oxidation state of element R increases.

34 In an electrolysis experiment, the same amount of charge deposited 54.0 g of silver and 29.75 g of tin. What was the charge on the tin ion?

A 1+ B 2+
C 3+ D 4+

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35 A simple cell was set up to light up a bulb as shown in the diagram below.



What should X, Y and Z be for the bulb to light up the brightest?

	X	Y	Z
A	magnesium	iron	ethanoic acid
B	magnesium	iron	sulfuric acid
C	magnesium	zinc	ethanoic acid
D	magnesium	zinc	sulfuric acid

36 How many of the statements below correctly describe the petroleum gas fraction obtained after crude oil undergoes fractional distillation?

- Its molecules are hydrocarbons.
- Its molecules have a variable number of carbons.
- The fraction has a fixed boiling point.
- The fraction is collected below petrol.

A 1 B 2
C 3 D 4

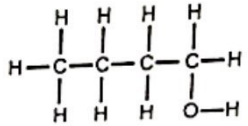
37 Compound X has the following properties.

- X can be made by a fermentation process.
- X when added to acidified potassium manganate (VII), forms Y.
- X can react with Y to form Z and water.

To which homologous series do X, Y and Z belong?

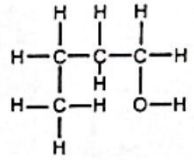
	X	Y	Z
A	alcohol	carboxylic acid	ester
B	alcohol	ester	carboxylic acid
C	carboxylic acid	alcohol	ester
D	carboxylic acid	ester	alcohol

38 Compound Q has the structure shown.

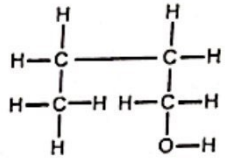


Which structure is an isomer of Q?

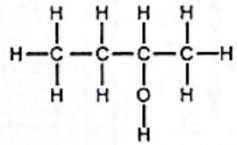
A



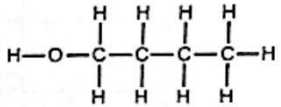
B



C



D



39 The hydrocarbon $C_{17}H_{36}$ can be cracked. Which compound is least likely to be produced in this reaction?

A C_3H_8 B C_4H_8
C C_8H_{18} D $C_{16}H_{34}$

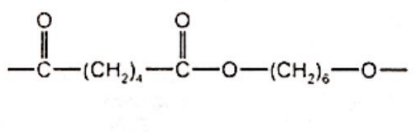
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40 P is a polymer that

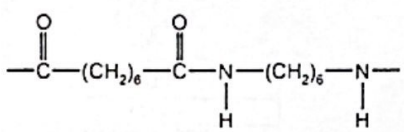
- has six carbon atoms in each of the monomers from which it was formed.
- is not a polyester.
- is formed by condensation polymerisation.

What is a possible structure of P?

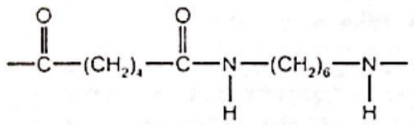
A



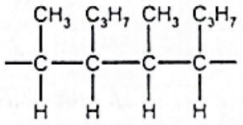
B



C



D



The Periodic Table of Elements

Group	I	II											III	IV	V	VI	VII	0
																		2 He helium 4
	3 Li lithium 7	4 Be beryllium 9					1 H hydrogen 1						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											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 –		

Key

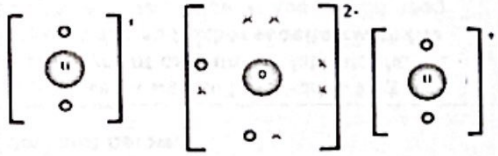
proton (atomic) number
atomic symbol
name
relative atomic mass

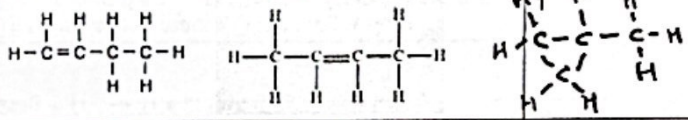
lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175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

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

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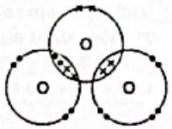
1. D	6. A	11. C	16. B	21. B	26. C	31. B	36. B
2. C	7. A	12. D	17. A	22. B	27. D	32. D	37. A
3. B	8. B	13. C	18. C	23. D	28. D	33. B	38. C
4. B	9. B	14. B	19. A	24. D	29. B	34. B	39. D
5. A	10. B	15. C	20. D	25. B	30. A	35. B	40. C

	ANSWER		REMARKS
A1(a)(i)	C & E	1 (both must be correct)	
(a)(ii)	D	1	
(a)(iii)	A	1	
(b)	M is copper. The **oxide of M can be reduced/displaced by carbon** indicating that M is less reactive than carbon. **Copper is less reactive than carbon** while magnesium is more reactive than carbon.	1 (explanation must be correct)	It is the oxide of M that is reduced not M.
A2	P – compound Q – mixture R – element	2m (all correct) 1m(1 or 2 wrong) 0m (all wrong)	
A3(a)(i)		1m (for correct Li^+ structure) 1m (for correct O^{2-} structure)	Check if full shell or outermost shell required. Check if structure is ionic or covalent
(a)(ii)	Formula of oxides / Oxidation state of oxygen Li_2O / -2 Na_2O_2 / -1 KO_2 / -0.5 or -1/2	2m (all correct) 1m(1 or 2 wrong) 0m (all wrong)	
(b)(i)	$Na_2O + SiO_2 \rightarrow Na_2SiO_3$	1	Make reference to Calcium silicate in iron extraction
(b)(ii)	Sodium oxide exists as a **giant ionic lattice structure** with **strong electrostatic forces of attraction between ions** which require **a lot of energy to overcome.** Hence it has a high melting point	1, 1	No need to specify the name of the ions.

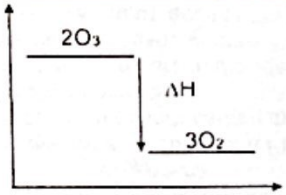
	Silicon dioxide exists as a **giant covalent structure** with **strong covalent bonds between atoms** which require **a lot of energy to overcome.** Hence it has a high melting point.	1, 1	Note the 3 giant covalent structures: graphite, diamond, silicon dioxide
(c)	ZnO is **an amphoteric oxide.** **In reaction 1, ZnO reacts with acid** indicating that it is behaving as a base. **In reaction 2, ZnO reacts with alkali** indicating that it is behaving as an acid.	1 1	Qn requires reference to equation so state clearly the substance you are referring to or state the equation number.
A4(a)	They all have the **same general formula of C_nH_{2n}** Each consecutive member, cyclopropane C_3H_6, cyclobutane C_4H_8 and cyclopentane C_5H_{10} all **differ by a CH_2 group.**	1 1	Empirical formula is not the same as general formula
(b)	True False	1 1	
(c)	The greater the number of carbon atoms in the cycloalkanes, the higher the boiling point. As the number of carbon atoms increases, the **molecule is larger.** There are **stronger intermolecular forces of attraction between molecules** hence **more energy** needed to overcome the forces.	1 1	State clearly the 2 variables.
(d)		1	When drawing org structures, count the number of bonds around each atom
A5(a)	As the concentration of sulfuric acid increases, the rate of reaction increases. At higher concentration, there **are more particles per unit volume so the particles collide more frequently. This leads to a higher frequency of effective collisions** and a faster rate of reaction.	1 1 1	Separate out the description and explanation.
(b)	At such a high concentration of sulfuric acid, the acid does not **ionise completely** so the **concentration of H^+ ions is low.**	1 1	
(c)(i)	$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$ No of moles of Mg = 0.24/24 = 0.01 mol No of moles of H_2SO_4 = 100/1000 X 0.5 = 0.05 mol Mg : H_2SO_4	 1 1	Present answers clearly with proper statements and units. Working for limiting reagent

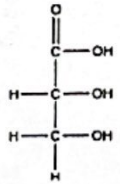
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	1 : 1 0.01 mol : 0.01 mol Hence, magnesium is limiting reactant No of moles of H_2 = 0.01 mol Volume of H_2 = 0.01 X 24 = 0.24 dm^3	 1	must be shown using mole ratio.
(c)(ii)	Graph A: slower rate & same yield as Expt 1 Graph B: faster rate & same yield as Expt 1	1 1 (no mark if graphs follow Expt 1 gradient)	Label each graph according to instructions. Graphs should be drawn neatly.
(d)	Student needs to **use excess magnesium.** Change the mass of magnesium used to **more than or equal to 1.2g** OR Mass of magnesium must be **more than 1.2g** and volume and concentration of **sulfuric acid remains unchanged.** OR **Mass of magnesium remains unchanged but reduce volume of sulfuric acid to 20 cm^3 and below.** OR **Mass of magnesium remains unchanged but decrease concentration of sulfuric acid to 0.1 mol/dm^3 and below.**	1 1 (mass must be stated) 1 1 1 1 1 1	Question requires reference to quantities ie masses, volumes, concentrations. Qn does not require a description of salt prep process
(e)	Calcium will react with sulfuric acid to form **an insoluble layer of calcium sulfate** around the calcium **preventing further reaction with the acid.**	1	'amount' refers to no of moles. So the no of moles of metal used is the same. This factor does not affect the volume of gas
A6(a)	Cathode: $2H^+ (aq) + 2e \rightarrow H_2 (g)$ Anode: $4OH^- (aq) \rightarrow 2H_2O (l) + O_2 (g) + 4e$	1 1	
(b)	The ratio of gas X (oxygen) to gas Y (hydrogen) is 1:2. For every 2 mole of electrons, 1 mole of hydrogen gas is formed at Y and 0.5 mol of oxygen gas is formed at X.	1 1	Write the ratio in full sentence. Use eqn mole ratios to explain
(c)	At the positive electrode, **chlorine gas** will form instead of **oxygen gas.** After electrolysis has been running for some time, the **electrolyte becomes concentrated sodium chloride solution. Cl^- ions will be discharged** instead of OH^- ions.	1 (must show change) 1	Always write Cl^- ions get discharged even before all the OH^- ions are discharged.

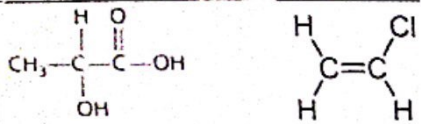
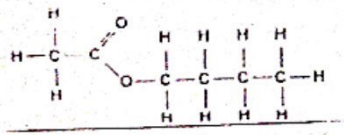
A7(a)	Oxygen **reacts with / oxidises carbon** in the molten cast iron **to form carbon dioxide/carbon monoxide** hence reducing the carbon content in the cast iron	1 (Product must be stated for mark)	
(b)	Titanium is very reactive. Argon is used to create an **inert / unreactive atmosphere** so that **oxygen will not react with the titanium or with magnesium**	1	Oxygen reacts with hot magnesium or titanium metal not titanium chloride. Answer shd be specific to question and not generalise eg oxygen will react with the reactants/products
(c)	Operating temperature for extraction of titanium is much higher (1500°C) than for extraction of iron (1000°C) so cost is higher. There are more stages in the manufacture of titanium than in iron extraction which increases energy usage leading to higher cost. Extracting titanium requires atmosphere of argon which is more expensive than reaction in oxygen for iron extraction. Any 2	1 1	Ans should state data, inference and link to qn. Show clear comparison in answer.
(d)	$2Mg + Ti^{4+} \rightarrow Ti + 2Mg^{2+}$	1	Balance both particle and charge
(e)	Titanium is less reactive than magnesium Magnesium **displaces titanium from titanium (IV) chloride** hence magnesium is more reactive.	1 1	
B8(a)		1m (correct double bond with 8 outermost electrons) 1m (dative bond with 8 valence electrons for the 2 oxygen atoms sharing the dative bond)	The question asks for 3 different symbols for each O atom. Use x, ● ○
(b)	The ozone **can protect us from UV-B** (wavelength 280-315 nm) **and UV-C** (100-280 nm)	1 (with explanation)	Quote data, make inference and link to qn.

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	as ozone is able to absorb rays with wavelength 240 – 310 nm. However, ozone **cannot protect us from UV-A** as the wavelength of UV-A (315-400 nm) falls outside of the absorption range of ozone.	1 (with explanation)	
(c)(i)	$O + O_3 \rightarrow 2O_2$	1	
(c)(ii)	Photosynthesis produces oxygen. In step 2, **one oxygen molecule reacts with one oxygen atom to form ozone.** Hence with a supply of oxygen by photosynthesis, ozone can be regenerated.	1 1	Step 1 is irrelevant to the qn. Focus should be on Step 2 which uses the O_2 produced by photosynthesis to regenerate ozone
(d)(i)	$2O_3 \rightarrow 3O_2$	1	Overall eqns should not have the same substance as both reactant and product
(d)(ii)	One source of radicals is from **chlorofluorocarbons** (CFCs) which provide the chlorine radical. In Step 1 of Mechanism I, the **radical reacts with ozone to form an** intermediate **compound which is then reacted in Step 2 to regenerate the radical** again. Hence the radical acts as a catalyst and can be used again to react with another ozone molecule	1 1	State clearly what the catalyst reacts with in step 1 before stating that it is regenerated in step 2
(e)		1m exo graph 1m labelled with reactants, prod, enthalpy (ecf from di) Allow name instead of formula	Info is given in 2nd para: Ozone easily decomposes to oxygen as the formation of oxygen is energetically more stable (meaning reaction is exo)
B9(a)	The greater the number of C = C bonds, the lower the melting point of the fatty acids.	1	State relationship between the 2 variables clearly.
(b)(i)	No of moles of olive oil = 100/884 = 0.11312 mol No of moles of I_2 = 86.2/254 = 0.33937 mol Olive oil : I_2 0.11312 mol : 0.33937 mol	1 1	Note that halogens are diatomic. Answers shd be to 5 sf (intermediate)

	1 : 3 In each olive oil molecule, there are 3 C=C bonds	1	The ratio of oil to halogen gives the no of C=C double bonds
(b)(ii)	Glycerol with two stearic acid and one linolenic acid Glycerol with one stearic acid, one oleic acid and one linoleic acid Glycerol with three oleic acid	1 (Any one)	
(c)		1	Qn requires full structural formula so show all bonds. Only hydroxyl groups at the ends of a molecule can be oxidised to carboxylic acids
(d)	Add aqueous bromine For linoleic acid, aqueous bromine will turn from reddish brown to colourless. For stearic acid, aqueous bromine will remain reddish brown	1 (test) 1 (result)	Do not use bromine water.
B10	EITHER		
(a)	Amount of energy given out = 16.8/0.92 X 46 = 840 kJ	1	Write clear statements
(b)	Amount of energy given out = 4.2 X 8 X 10 = 336 J	1	Write clear statements
(c)(i)	$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$	1	The qn states combustion not oxidation so prod are CO_2 and H_2O
(c)(ii)	Energy taken in to break bonds = 348 + 5(413) + 360 + 464+3(498) = 4731 kJ Energy given out to form bonds = 4(804) + 6(464) = 6000 kJ ΔH = 4731 – 6000 = -1269 kJ	1 1 1	Write proper statements with units
(c)(iii)	In the heat experiment, there is heat loss to surroundings. In the heat experiment, there could be incomplete combustion taking place	1 1	
(d)	Energy of reactants will be higher. Ea will be lower/smaller	½ ½	Qn says to describe not explain.

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	Enthalpy will be larger / more negative / more exothermic Energy of products remains unchanged.	½ ½	
B10	OR		
(a)(i)		1 1	Monomers do not have open-ended structures. Check that your bonds are correct.
(a)(ii)	**Similarity**: Both have monomers that join together to form covalent bonds **Difference**: During manufactre of PVC, only a single product is formed. While in manufacture of PLA, a water molecule is lost during the reaction	1 1	Qn asks for similarities and differences in the process of polymerisation.
(a)(iii)	**PLA is biodegradable** and can be broken by acid or alkali hydrolysis while **PVC is non-biodegradable**. PLA is made from **plants which is a renewable source** while PVC is made from **crude oil which is a non-renewable source**. The monomer used to form PLA is made from plants which absorb carbon dioxide during photosynthesis. So when PLA is burnt, there is no net increase in carbon dioxide to the environment. The monomer used to mae PVC comes from crude oil so when burnt, adds to the carbon dioxide in the atmosphere. Any 2	1 1	Info is given in the qn. Compare similar qualities. Renewable is not the same concept as biodegradable so do not mix them in one ans.
(a)(iv)	No of monomers used to make polymer = 13500/90 = 150 Molar mass of one repeating unit = 72g/mol Mass of polymer = 72 X 150 = 10800g	1 1	
(e)		1	

	Conditions: **Heat / Warm / Reflux** with **concentrated sulfuric acid** as catalyst	1 (must have both conditions)	

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