Name: _____( ) Class:_____

CHIJ KATONG CONVENT
PRELIMINARY EXAMINATIONS 2017
Secondary Four Express

CHEMISTRY (WITH SPA) 5073/01

Duration: 1 hour

Classes: 406

Candidates answer on the Optical Answer Sheet.

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid/ tape.
Write your name, class and index number in the spaces provided at the top of this page and on the Optical Answer Sheet.

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 on the question paper.
A copy of the Data Sheet is printed on page 13.
A copy of the Periodic Table is printed on page 14.

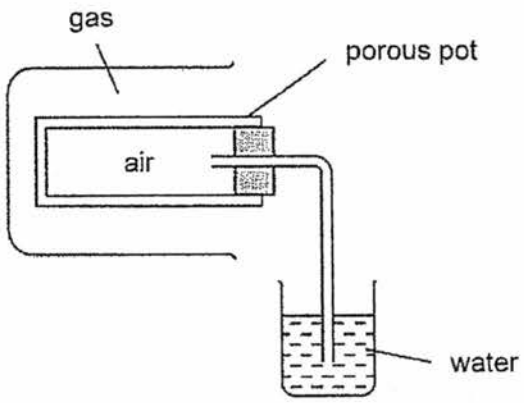
At the end of the examination, hand in:
1. Optical Answer Sheet; and
2. Question paper **separately**.

1 The sun-lit side of planet Venus has a temperature of 355 °C. The night side of the same planet has a temperature of -130 °C.

Which substance exists on one side of planet Venus as a liquid and the other side as a gas?

	melting point/ °C	boiling point/ °C
A	-210	-196
B	-183	-87
C	44	280
D	328	1744

2 The apparatus shown in the diagram was used to compare the rate of diffusion between a gas and air.

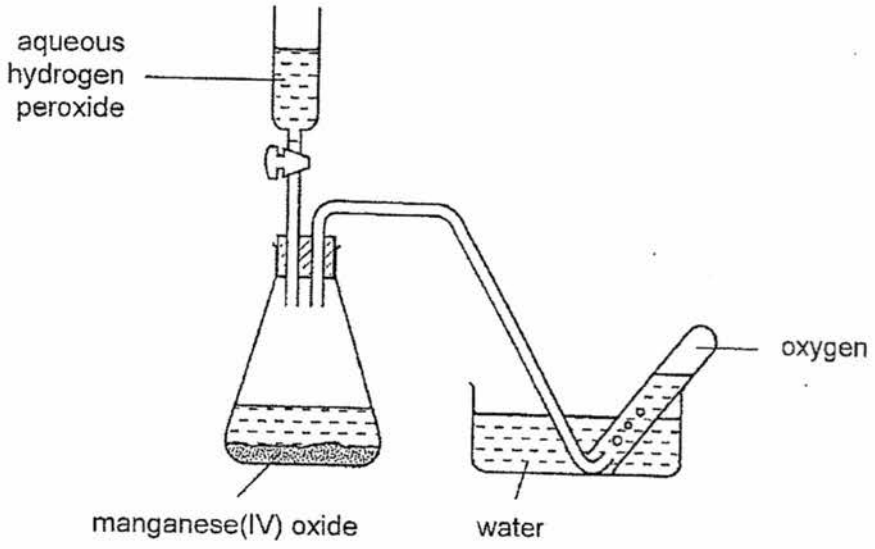


A beaker containing the gas was placed over the porous pot.

Which gas would cause bubbles to be observed in the beaker of water?

A carbon dioxide
B hydrogen
C oxygen
D sulfur dioxide

3 Aqueous hydrogen peroxide decomposes readily to form oxygen in the presence of manganese(IV) oxide as a catalyst. This reaction was used to produce and collect oxygen as shown in the diagram.



Which substance could have contaminated the first few test tubes of collected gas?

A chlorine
B hydrogen peroxide
C manganese(IV) oxide
D nitrogen

4 An organic solvent (hexane) and aqueous sodium chloride were accidentally mixed together.

Which methods of separation are needed to obtain pure samples of hexane and solid sodium chloride?

A filtration followed by crystallisation
B fractional distillation followed by evaporation to dryness
C simple distillation followed by crystallisation
D using a separating funnel followed by evaporation to dryness

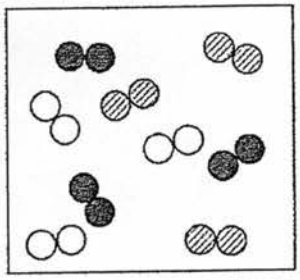
5 Which is the best method of obtaining pure water from ink?

A chromatography
B distillation
C filtration
D freezing

6 A gaseous mixture is made up of nitrogen, oxygen and chlorine.

Which diagram could show a pure sample of this mixture?

A



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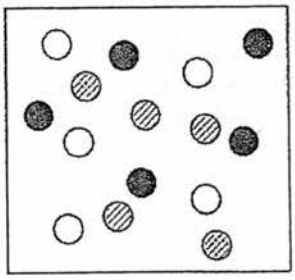

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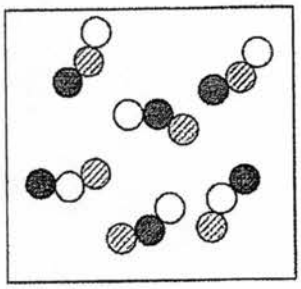

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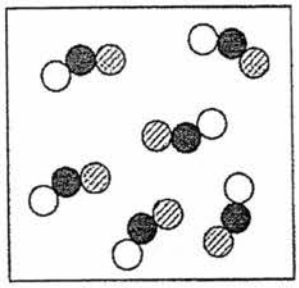


7 An ion, L^{2-}, has 18 neutrons and 18 electrons.

What does its nucleus contain?

A 16 protons and 16 neutrons
B 16 protons and 18 neutrons
C 18 protons and 16 neutrons
D 20 protons and 18 neutrons

8 The table shows the isotopic composition of iron.

isotope	percentage abundance/ %
^{54}Fe	5.8
^{56}Fe	91.6
^{57}Fe	2.2
^{58}Fe	0.4

What is the relative atomic mass of iron?

A 55.9
B 56.0
C 56.1
D 56.2

9 Talc is a mineral and has the formula $Mg_3Si_4O_{10}(OH)_2$.

What is the charge of the Si_4O_{10} ion?

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

10 The table shows the number of protons, neutrons and electrons in particles S, T, U and V.

particle	proton	neutron	electron
S	17	20	17
T	17	18	18
U	20	20	18
V	20	21	20

Which pair of particles would combine to form an ionic compound?

A S and T
B S and U
C T and U
D T and V

11 Element X has n protons and forms ions with a charge of -2. Element Y has (n+1) protons.

Which compound is formed when element X reacts with element Y?

A a covalent compound XY_2
B a covalent compound X_2Y
C an ionic compound XY_2
D an ionic compound X_2Y

12 Metals have positive ions in a 'sea of electrons'.

Which metal atom contributes the least number of electrons to this 'sea of electrons'?

A aluminium
B magnesium
C sodium
D zinc

13 Given they all have the same mass of 1 g, which substance has the smallest number of atoms?

A argon
B hydrogen
C iodine
D lead

14 Aerials in portable radios are made of a mixture of the oxides of calcium and iron known as 'ferrite'. It contains 18.5% calcium and 51.9% iron by mass.

Which is the empirical formula of 'ferrite'?

A $CaFe_2O$
B $CaFe_2O_4$
C Ca_2FeO_2
D Ca_4Fe_2O

15 In a combustion reaction, 4 cm^3 of methane burned completely in 10 cm^3 of oxygen according to the equation:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

What is the final volume of gas left behind at room temperature and pressure?

A 4 cm^3
B 6 cm^3
C 12 cm^3
D 14 cm^3

16 Which statement about an alkaline solution is correct?

A It contains equal number of hydrogen and hydroxide ions.
B It contains more hydrogen ions than hydroxide ions.
C It contains more hydroxide ions than hydrogen ions.
D It contains only hydroxide ions.

17 In an experiment, five students each titrated 25.0 cm^3 of aqueous sodium hydroxide with dilute hydrochloric acid, using the same indicator.

The volume of hydrochloric acid used by each student is shown in the table.

student	I	II	III	IV	V
volume of dilute hydrochloric acid/ cm^3	19.4	19.5	19.4	19.5	21.0

Which statement explains the anomalous result obtained by student V?

A The burette was washed out with hydrochloric acid.
B The conical flask was washed out with aqueous sodium hydroxide.
C The pipette was washed out with aqueous sodium hydroxide.
D Too much indicator was added to the conical flask.

18 Nitrogenous fertiliser such as ammonium nitrate is used to increase crop yield.

Which substance can be added to increase the pH of acidic soil containing ammonium nitrate without causing a loss of nitrogen?

A calcium carbonate
B calcium hydroxide
C magnesium hydroxide
D potassium hydroxide

19 Which is not a redox reaction?

A $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
B $Cu^{2+} + Zn \rightarrow Cu + Zn^{2+}$
C $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$
D $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

20 Peroxodisulfuric acid, $H_2S_2O_8$, reacts with potassium iodide, KI, according to the equation:

$$H_2S_2O_8(aq) + 2KI(aq) \rightarrow K_2SO_4(aq) + H_2SO_4(aq) + I_2(aq)$$

What does the reaction show about the nature of peroxodisulfuric acid?

A It is acidic.
B It is basic.
C It is an oxidising agent.
D It is a reducing agent.

21 Water is formed when hydrogen is passed over the oxides of P and Q, but not when hydrogen is passed over the oxide of R. Furthermore, Q reduces the oxide of P.

Which is the order of reactivity for metals P, Q and R in increasing order?

A P, Q, R
B Q, P, R
C R, P, Q
D R, Q, P

22 Iron pipes corrode rapidly when exposed to seawater.

Which metal, when attached to the iron pipes, would not offer protection against corrosion?

A aluminium
B magnesium
C platinum
D zinc

23 Different types of steel differ in how much carbon they contain.

What are the properties of a high carbon steel?

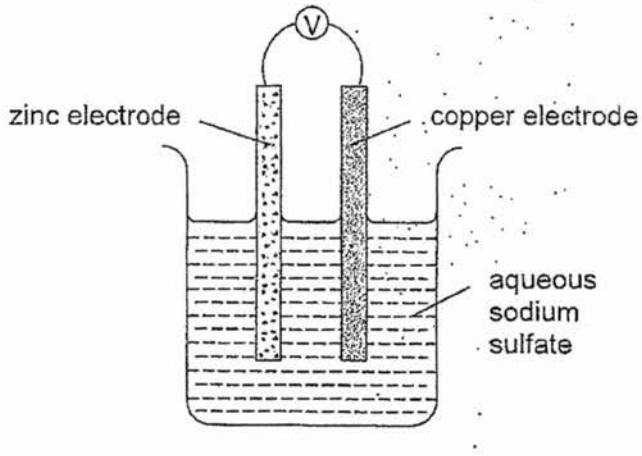
A soft and brittle
B soft and easily shaped
C strong and brittle
D strong and easily shaped

24 In an electrolysis experiment, the same amount of charge deposited 54.0 g of silver and 8.5 g of vanadium.

What is the charge on the vanadium ion?

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

25 The diagram shows a simple cell.



What happens when current flows through the circuit?

A Copper dissolves to form copper(II) ions.
B Electrons flow from the copper electrode to the zinc electrode.
C Hydrogen gas is liberated at the zinc electrode.
D Zinc dissolves to form zinc ions.

26 Which property cannot be predicted from the position of an element in the Periodic Table?

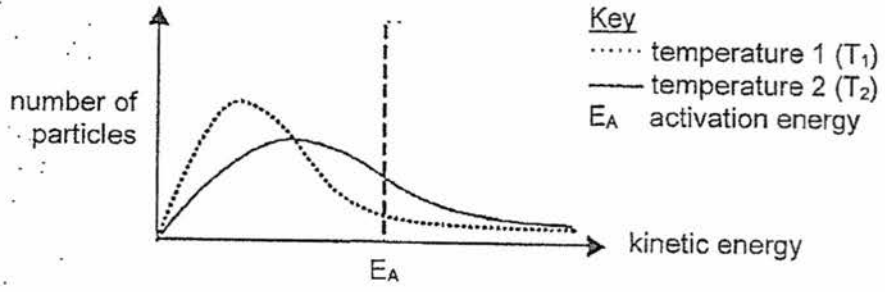
A the acidic or basic nature of its oxide
B the formula of its oxide
C the metallic or non-metallic character
D the number of isotopes it has

27 Excess bromine is shaken with a mixture of sodium chloride and sodium iodide solutions.

Which substances will the final mixture contain?

A bromine, iodine, sodium bromide
B bromine, iodine, sodium bromide, sodium chloride
C bromine, iodine, sodium bromide, sodium iodide
D Iodine, sodium bromide, sodium chloride

28 The diagram represents the distribution of kinetic energy of reactant particles at two different temperatures.



Given that the areas under the two curves are equal, which statement about the reaction is correct?

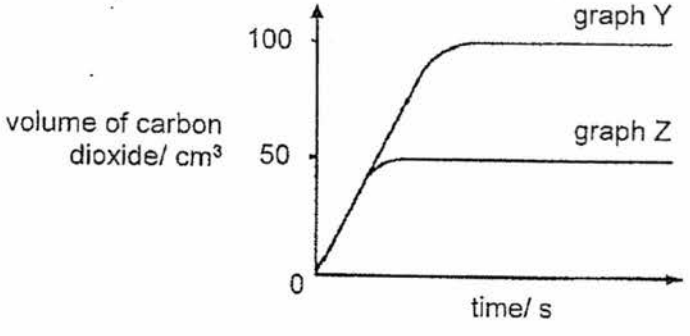
A At T_1, the activation energy is lower than at T_2.
B At T_1, the enthalpy change of the reaction is higher than at T_2.
C At T_2, a greater number of particles have sufficient energy to react.
D At T_2, the reaction takes a longer time to complete.

29 Two substances, X and Y, react to produce substance Z. The enthalpy change for the reaction is -120 kJ/mol, while the activation energy is +200 kJ/mol.

What is the activation energy for the decomposition of substance Z to substances X and Y?

A +80 kJ/mol
B +120 kJ/mol
C +200 kJ/mol
D +320 kJ/mol

30 Some sodium carbonate pellets were added to an excess of sulfuric acid at room temperature. The volume of carbon dioxide produced was measured over a period of time. Graph Y shows the results obtained.



Which change could have produced graph Z?

A Acid of half the original concentration was used.
B A lower temperature was used instead.
C Half the mass of sodium carbonate pellets was used.
D Powdered sodium carbonate of the same mass was used.

31 Which change would increase the speed of reaction between 1 mole of two gases?

A a decrease in surface area of the catalyst
B a decrease in temperature
C a decrease in the size of the reaction flask
D a decrease in the pressure of the gases

32 In the Haber process, nitrogen and hydrogen react to form ammonia.

Which is the main source of hydrogen?

A air
B crude oil
C ethanoic acid
D ethanol

33 Biodiesel, made from vegetable oil, can be used as a fuel for vehicles. Even though carbon dioxide is released when biodiesel is combusted, scientists still claim that biodiesel is a carbon neutral fuel.

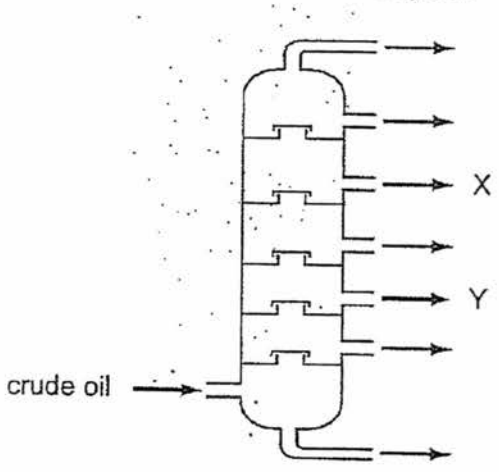
Which is the basis for this claim?

A Biodiesel is not a carbon compound.
B Biodiesel produces less carbon dioxide when it burns.
C Plants release carbon dioxide during respiration.
D Plants take up carbon dioxide during photosynthesis.

34 Which gas will not be removed from the exhaust gas of a petrol powered car by its catalytic converter?

A carbon dioxide
B carbon monoxide
C nitrogen dioxide
D unburnt hydrocarbons

35 Crude oil can be separated into different fractions using fractional distillation. The positions at which fractions X and Y are collected are shown in the diagram.



Which statement about the fractional distillation of crude oil is correct?

A The temperature increases up the column.
B X condenses at a lower temperature than Y.
C X has a higher boiling point than Y.
D X has longer chain molecules than Y.

36 A molecule of $C_{17}H_{36}$ undergoes catalytic cracking. The products of the reaction are one butane molecule, one propene molecule and some ethene molecules.

How many ethene molecules are produced during the reaction?

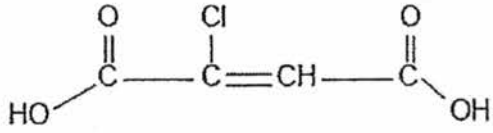
A 3
B 5
C 6
D 8

37 Adrenic acid is a naturally occurring polyunsaturated fatty acid with a molecular formula of $C_{22}H_{36}O_2$. It is one of the most abundant fatty acids in the early human brain.

What is the number of carbon-carbon double covalent bonds present in one molecule of the acid?

A 4
B 5
C 6
D 8

38 The diagram shows the structural formula of chloromaleic acid.



Which statement about chloromaleic acid is correct?

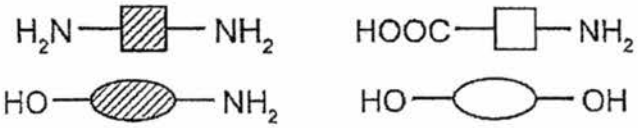
A It can undergo a substitution reaction with halogens.
B It decolourises bromine solution in the absence of sunlight.
C It will react with magnesium to produce a gas that relights a glowing splint.
D It will turn red litmus paper blue.

39 Alcohol X, was fully oxidised to organic compound Y. Reaction of Y with calcium carbonate produced a salt with the chemical formula $(C_2H_5CO_2)_2Ca$.

Which alcohol is used?

A C_2H_5OH
B $C_2H_5CH_2OH$
C $C_2H_5CH_2CH_2OH$
D $C_2H_5CH(OH)CH_2C_2H_5$

40 The diagrams show four monomers.



How many of these monomers could react with the molecule below to form a polymer?

A 1
B 2
C 3
D 4

Colours of Some Common Metal Hydroxides

aluminium hydroxide	white
calcium hydroxide	white
copper(II) hydroxide	light blue
iron(II) hydroxide	green
iron(III) hydroxide	red-brown
lead(II) hydroxide	white
zinc hydroxide	white

The Periodic Table of the Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H Hydrogen 1										4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulphur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	Po Polonium 84	At Astatine 85	Rn Radon 86
Fr Francium 87	226 Ra Radium 88	227 Ac actinium 89 †															

*58-71 Lanthanoid series

†90-103 Actinoid series

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	Pa Protactinium 91	238 U Uranium 92	Np Neptunium 93	Pu Plutonium 94	Am Americium 95	Cm Curium 96	Bk Berkelium 97	Cf Californium 98	Es Einsteinium 99	Fm Fermium 100	Md Mendelevium 101	No Nobelium 102	Lr Lawrencium 103

Key: a X b — a = relative atomic mass; X = atomic symbol; b = proton (atomic) number

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

Name: _____( ) Class:_____

CHIJ KATONG CONVENT
PRELIMINARY EXAMINATIONS 2017
Secondary Four Express

CHEMISTRY (WITH SPA)

5073
Duration: 1 hour 45 minutes

Class: 406

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name, registration number and class on all the work you hand in.
You may use a soft pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid/ tape.
The use of an approved scientific calculator is expected, where appropriate.

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

Section B
Answer **all** three questions, the last question is in the format of either/or.
Answer **all** questions in the spaces provided.

At the end of the examination fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Data Sheet is printed on page 21.
A copy of the Periodic Table is printed on page 22.

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

FOR EXAMINER'S USE	
Paper 1	/ 40
Section A	/ 50
Section B	/ 30
TOTAL	/ 120

This question paper consists of **22** printed pages.

Section A [50 marks]

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

1 The head of a match stick contains potassium chlorate and antimony sulfide.

(a) Antimony sulfide are added to matches to help them burn more vigorously. Part of its chain structure is shown in Fig. 1.1.

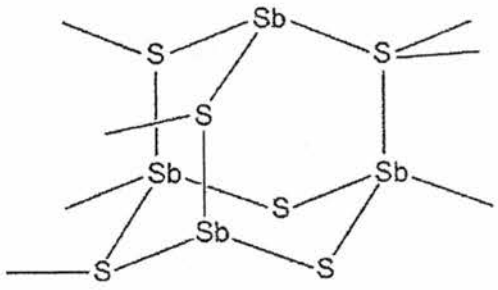


Fig. 1.1

With reference to its structure and bonding, explain why antimony sulfide has a high melting point.

.....

.....

.....

.....[2]

(b) When a match is struck on the side of the box, the friction produces enough heat to light the match. The equation for the reaction is:

$$5KClO_3 + 6P \rightarrow 5KCl + 3P_2O_5$$

(i) Explain, in terms of oxidation state, why potassium chlorate is the oxidising agent in the reaction.

.....

.....[1]

1 (b) (ii) One of the products, phosphorus(V) oxide, P_2O_5, absorbs moisture from the air to form metaphosphoric acid, HPO_3. On addition of more water, phosphoric acid, H_3PO_4, is formed.

Predict and explain the electrical conductivity of the acids formed.

.....

.....

.....

.....[2]

(iii) Show by calculation, which of these acids, HPO_3 or H_3PO_4, contains the greater percentage of phosphorus by mass.

[2]

[Total: 7]

2 Tartaric acid is an organic acid extracted from grape juice. Its structure is shown in Fig. 2.1.

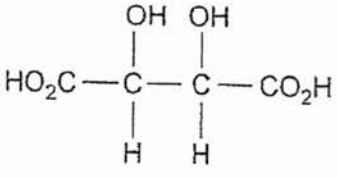


Fig. 2.1

(a) Tartaric acid is an example of a weak acid.

Explain what is meant by a *weak acid*.

.....

.....[1]

2 **(b)** Describe a simple test to show that tartaric acid is a weak acid.

.....

.....

.....

.....[2]

(c) A solution of tartaric acid was titrated with 0.100 mol/dm^3 potassium hydroxide. Potassium tartrate and water are the products obtained.

$$C_2H_2(OH)_2(CO_2H)_2 + 2KOH \rightarrow C_2H_2(OH)_2(CO_2K)_2 + 2H_2O$$

(i) 6.00 cm^3 of aqueous potassium hydroxide was required to neutralise 20.0 cm^3 of tartaric acid.

Calculate the concentration, in mol/dm^3, of the tartaric acid solution.

[2]

(ii) Describe how a dry solid sample of the salt produced could be obtained from the products of the reaction.

.....

.....

.....

.....[2]

[Total: 7]

3 Titanium (melting point of 1688 °C) can be extracted from its ore, rutile. Fig. 3.1 shows how titanium metal is extracted from rutile.

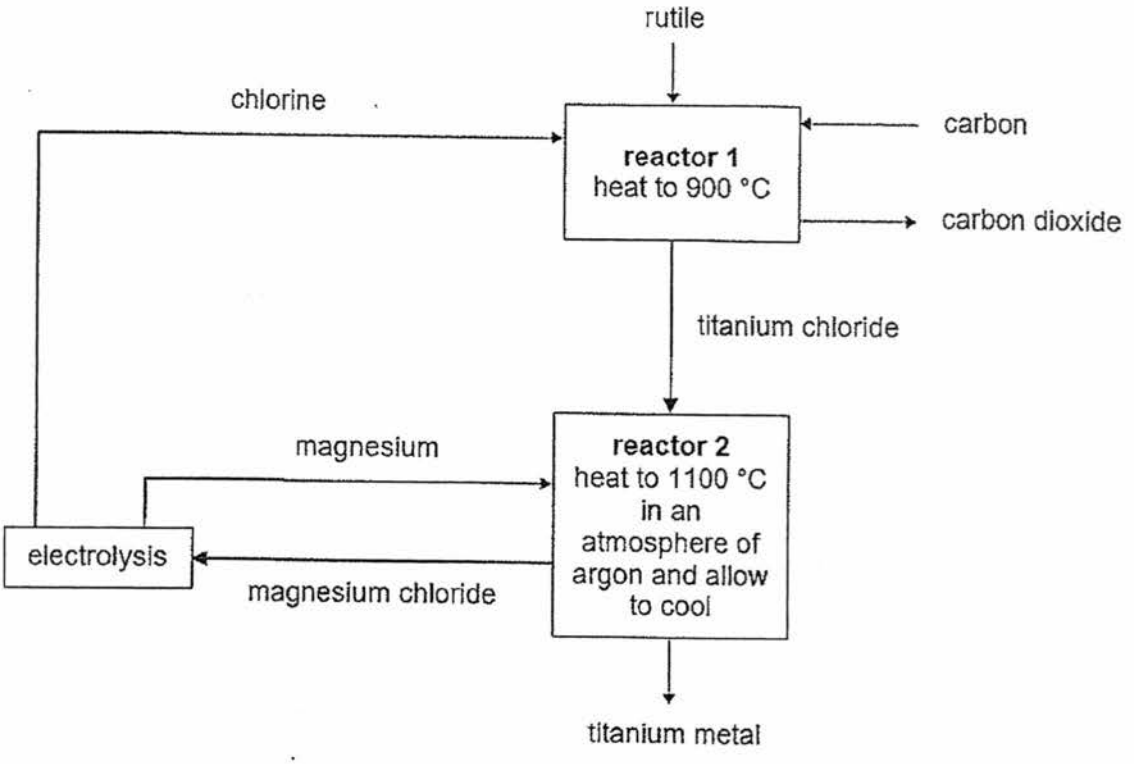


Fig. 3.1

(a) Using the information provided, arrange carbon, magnesium and titanium in increasing order of reactivity.

.....

.....[1]

(b) Describe an example of recycling in the extraction of titanium.

.....

.....[1]

(c) Explain why an atmosphere of argon must be used in reactor 2.

.....

.....

.....

.....[2]

3 **(d)** Fig. 3.2 shows how the mass of titanium metal produced changes with different mass of pure and impure rutile.

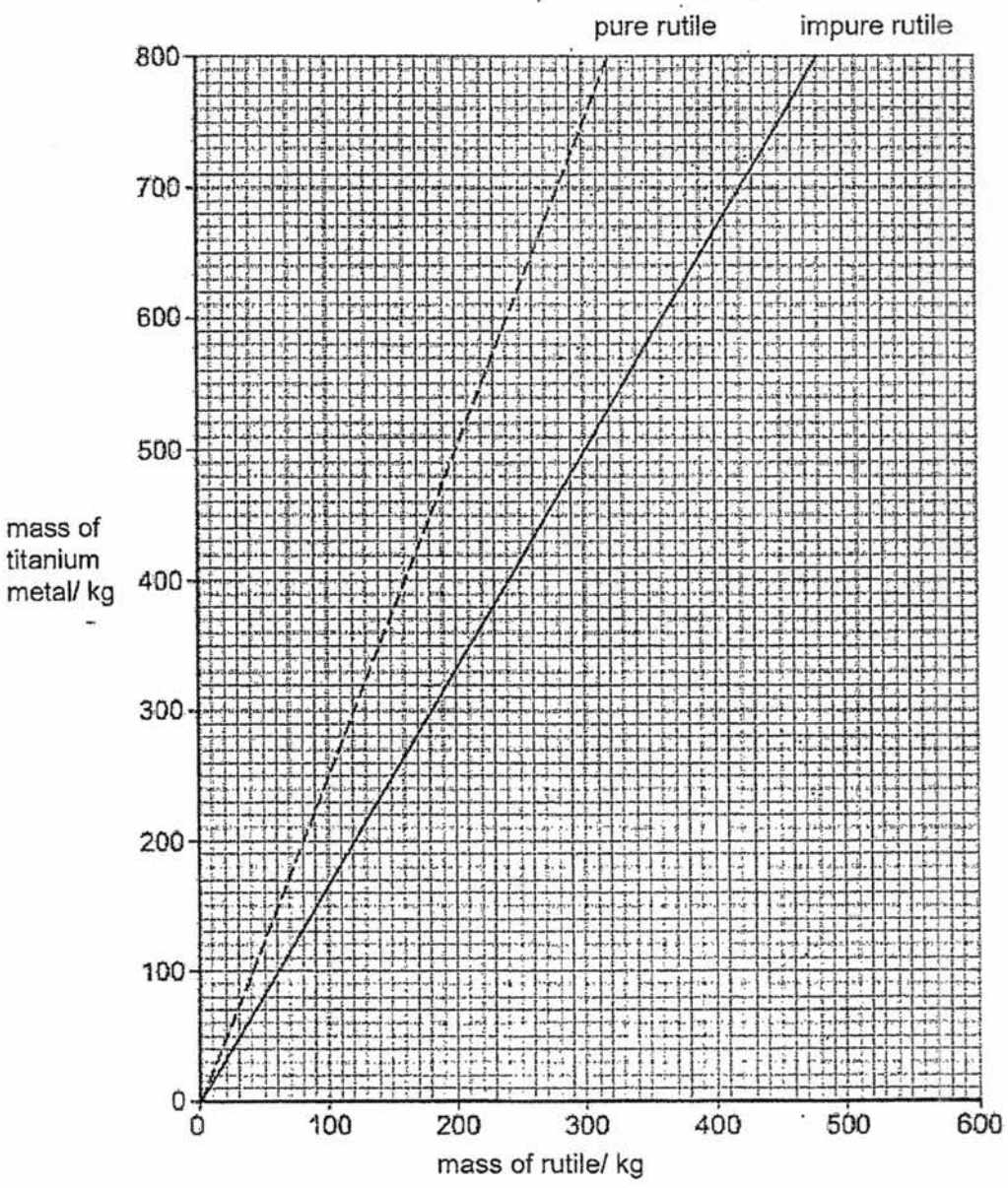


Fig. 3.2

(i) State the mass of titanium that can be obtained from 200 kg of pure rutile.

.....[1]

3 (d) (ii) Calculate the percentage purity of rutile in the impure ore for the same mass of titanium obtained.

[1]

(e) Describe how the titanium produced in reactor 2 can be separated from magnesium chloride.

.....

.....

.....

.....[2]

[Total: 8]

4 Heat packs are commonly used by walkers and climbers as hand or body warmers. One of the ingredients found in heat packs is powdered iron.

All the ingredients are contained in a plastic bag. When the bag is opened, air enters the pack and it slowly heats up and remains at a temperature of about 40 °C for several hours. The equation represents the chemical reaction taking place in the heat pack.

$$4Fe + 3O_2 + 5H_2O \rightarrow 2Fe_2O_3.5H_2O$$

(a) Identify the substance that is oxidised during the reaction. Explain your answer in terms of electrons transfer.

.....

.....[2]

(b) Sketch a labelled energy profile diagram for the reaction taking place in the heat pack, indicating clearly the reactants, products, activation energy (E_a), and enthalpy change (ΔH).

[2]

4 (c) In certain brands of the heat pack, a carbon catalyst is added to it.

Explain, in terms of the collision theory, why is the carbon catalyst added to the heat pack.

.....

.....

.....

.....[3]

[Total: 7]

5 Some metal carbonates, when heated, decompose to produce carbon dioxide. Fig. 5.1 shows the results from an investigation on the rate of decomposition of four metal carbonates. In each experiment, 1.00 g of metal carbonate was heated to the same temperature using flame of the same intensity. The volume of carbon dioxide produced was measured at every minute interval.

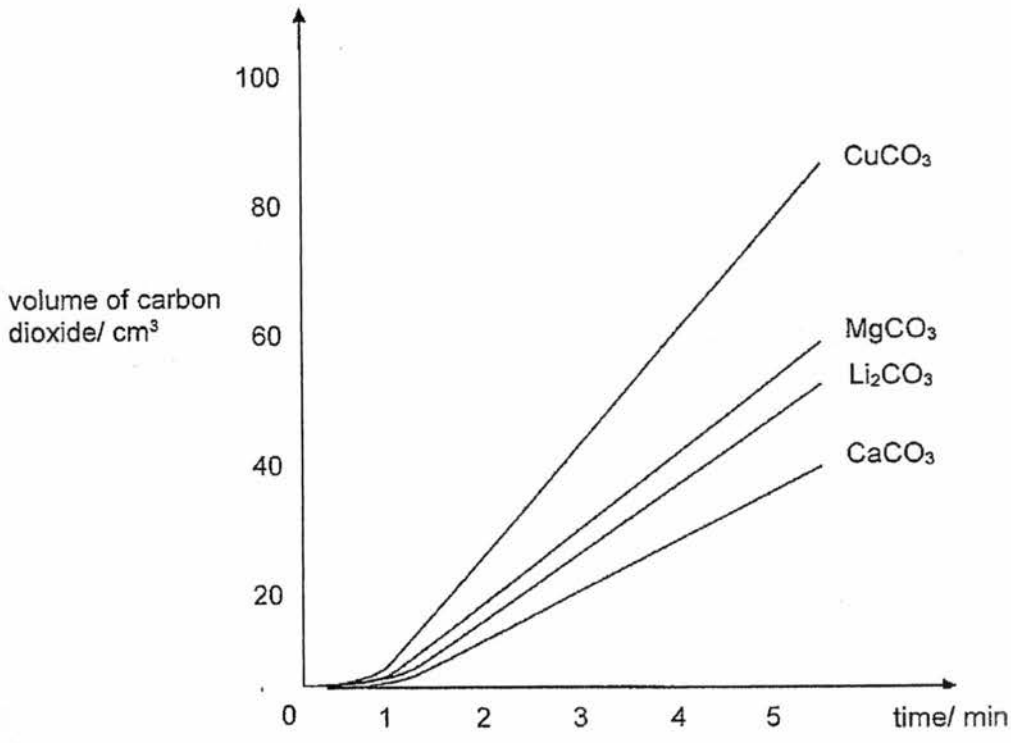


Fig. 5.1

(a) Explain why very little carbon dioxide was collected at the start of each experiment.

.....

.....[1]

5 **(b)** Using Fig. 5.1, explain why the decomposition of metal carbonates was not complete at the end of the investigation.

.....

.....[1]

(c) Using only information from Fig. 5.1, state and explain which metal carbonate decomposed at the fastest rate.

.....

.....

.....

.....[2]

(d) Describe and explain how the volume of carbon dioxide will change with time if sodium carbonate was used for the experiment.

.....

.....

.....

.....[2]

[Total: 6]

6 The amount of carbon monoxide present in air can be detected and measured by the reaction with a white crystalline solid called iodine pentoxide, I_2O_5. The chemical equation for the reaction is given as:

$$5CO(g) + I_2O_5(s) \rightarrow I_2(s) + 5CO_2(g)$$

(a) Describe a change that can be observed for the reaction.

.....[1]

(b) State a source of carbon monoxide and explain how it is produced.

.....

.....

.....

.....[2]

6 (c) Explain why it is important to have a reliable chemical test for carbon monoxide.

.....

.....

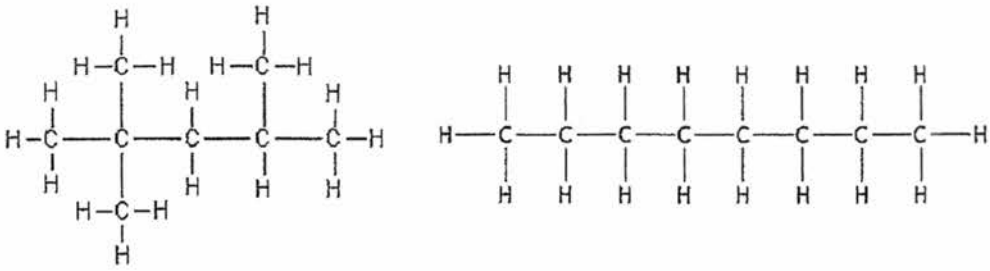
.....

.....[2]

[Total: 5]

7 (a) 2,2,4-trimethylpentane, also known as isooctane, is an isomer of octane C_8H_{18}.

The structures of isooctane and octane are shown in Fig. 7.1.



isooctane octane

Fig. 7.1

The enthalpy changes of combustion and boiling points for isooctane and octane are given in the Table 7.1.

Table 7.1

hydrocarbon	enthalpy change of combustion/ kJ mol^{-1}	boiling point/ °C
isooctane	- 5460	99.3
octane	- 5460	126.1

(i) Write a balanced equation for the complete combustion of isooctane.

.....[1]

(ii) Suggest why the enthalpy change of combustion for isooctane and octane are the same.

.....

.....

.....

.....[2]

7 (a) (iii) Suggest why the boiling points for isooctane and octane are different.

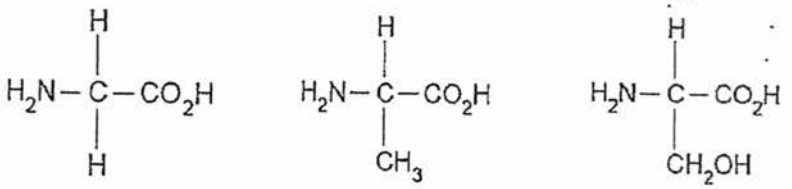
.....

.....

.....

.....[2]

(b) Spider silk is composed of polyamide chains mainly made from amino acids. Fig. 7.2 shows the structural formula of the three main amino acids, glycine, alanine and serine, found in spider silk.



glycine alanine serine

Fig. 7.2

(i) Assuming spider silk is made from repetitive sequences of –glycine–alanine–serine–, draw the structural formula of the repeat unit of the polyamide chain.

[2]

(ii) The M_r of each polyamide chain is about 600 000.

Assuming the polyamide chain is made from equal amounts of the above three amino acids, calculate the average number of amino acids monomers in each polyamide chain.

[3]

[Total: 10]

Name:_____( ) Class: _____

Section B [30 marks]

Answer **three** questions.

Question **10** is in the form of an **Either/Or** question. Only one part should be answered.

Write your answers in the spaces provided.

8 Dilute aqueous sodium chloride forms hydrogen and oxygen during electrolysis. Fig. 8.1 shows an electrolytic cell used for the process.

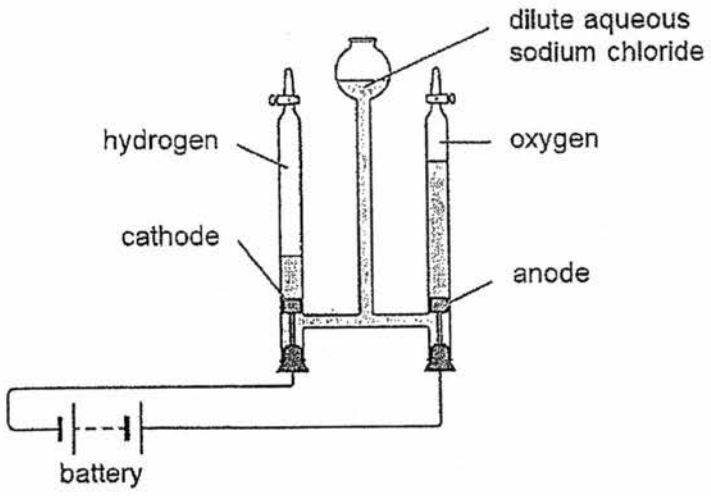


Fig. 8.1

(a) Write ionic equations for the reactions at the cathode and anode.

cathode: .....

anode: .....[2]

(b) The gases are collected and their volumes are measured. In theory, the ratio of hydrogen and oxygen should be 2:1.

Oxygen is more soluble than hydrogen in water. This changes the ratio of gases that are collected.

(i) Using the transfer of electrons, explain why the theoretical ratio of hydrogen to oxygen is 2:1.

.....

.....[1]

8 **(b)** **(ii)** Explain how and why the solubility of oxygen affects the ratio of hydrogen to oxygen that is collected.

.....

.....

.....

.....[2]

(iii) The deviation from the expected ratio is more obvious at the start of electrolysis, but becomes less noticeable after the electrolysis has been running for some time.

Suggest a reason why this happens.

.....

.....

.....

.....[2]

(c) Describe and explain the changes to the concentration of sodium chloride during the electrolysis.

.....

.....[1]

(d) The same apparatus can be used to electrolyse concentrated aqueous sodium chloride.

State one difference between the products obtained from the electrolysis of concentrated and dilute aqueous sodium chloride.

.....

.....[1]

(e) Suggest why inert electrodes are used for the electrolysis.

.....

.....[1]

[Total: 10]

9 The first ionisation energy of elements is the energy required to remove one mole of electrons from one mole of gaseous atoms to form one mole of gaseous ions with a charge of +1.

This can be represented by the equation:

$$Na(g) \rightarrow Na^+(g) + e^- \qquad \Delta H = +494 \text{ kJ/mol}$$

The second ionisation energy of elements is the energy required to remove one mole of electrons from one mole of gaseous ions with a charge of +1 to form one mole of gaseous ions with a charge of +2.

This can be represented by the equation:

$$Na^+(g) \rightarrow Na^{2+}(g) + e^- \qquad \Delta H = +4562 \text{ kJ/mol}$$

Hence, the energy required to remove 2 moles of electrons from 1 mole of gaseous sodium atoms is 494 + 4562 = 5056 kJ/mol.

Table 9.1 shows the first and second ionisation energy for Group I elements, while Table 9.2 shows the first and second ionisation energy for Group II elements.

Table 9.1

element	first ionisation energy/ kJ mol^{-1}	second ionisation energy/ kJ mol^{-1}
lithium	520	7298
sodium	496	4562
potassium	419	3052
rubidium	403	2633
caesium	376	2234

Table 9.2

element	first ionisation energy/ kJ mol^{-1}	second ionisation energy/ kJ mol^{-1}
beryllium	900	1757
magnesium	737	1451
calcium	590	1145
strontium	550	1064
barium	503	965

9 (a) Describe and explain the trend in ionisation energy down Group I and II.

.....

.....

.....

.....

.....

.....[3]

(b) (i) Write the electronic configurations for sodium and magnesium atoms.

Na: .....

Mg: .....[1]

(ii) Using your answer in **(b)(i)**, suggest why the difference between the first and second ionisation energy is significantly higher for sodium than magnesium.

.....

.....

.....

.....[2]

(c) Write a balanced equation, including state symbols, for the third ionisation energy of sodium.

.....[1]

(d) Calculate the energy required for 12 g of magnesium atoms to form Mg^{2+} ions.

[3]

[Total: 10]

10 Either

Ammonia can be manufactured using the Haber process. The percentage yield of ammonia using different temperatures and pressures are shown in the Table 10.1.

Table 10.1

pressure/ atm	ammonia yield/ %				
	100 °C	200 °C	300 °C	400 °C	500 °C
10	88.2	50.7	14.7	3.9	1.2
25	91.7	63.6	27.4	8.7	2.9
50	94.5	74.0	39.5	15.3	5.6
100	96.7	81.7	52.5	25.2	10.6
200	98.4	89.0	66.7	38.8	18.3
400	99.4	94.6	79.7	55.4	31.9
1000	99.9	98.3	92.6	79.8	57.5

(a) Describe how the percentage yield of ammonia is affected by

(i) increasing temperature,

.....

.....[1]

(ii) decreasing pressure.

.....

.....[1]

(b) **(i)** With reference to the information provided, state the optimum conditions for the Haber process.

.....[1]

(ii) Explain why the conditions stated in **(b)(i)** are not used commercially.

.....

.....

.....

.....[2]

10 (c) The ammonia manufactured in Haber Process can be used to prepare nitric acid in another reaction called the Ostwald Process. This process converts ammonia into nitric acid in a three-step reaction.

Step 1: $4NH_3\ (g) + 5O_2\ (g) \rightleftharpoons 4NO\ (g) + 6H_2O\ (g)$

Step 2: $2NO\ (g) + O_2\ (g) \rightleftharpoons 2NO_2\ (g)$

Step 3: $3NO_2\ (g) + H_2O\ (l) \rightarrow 2HNO_3\ (aq) + NO\ (g)$

(i) Explain why the products of the Ostwald Process are not wasted.

.....

.....[1]

(ii) It is possible to monitor the progress of the Ostwald Process by measuring pH changes during the process.

State and explain the changes in pH before the start of step 1 and at the end of step 2.

.....

.....

.....

.....[2]

(iii) Calculate the maximum mass of nitric acid which can be made from 840 dm^3 of ammonia at room temperature and pressure.

[2]

[Total: 10]

10 OR

Perfumes usually contain three classes of compounds called top notes, middle notes and end notes.

(a) Top notes consist of small, light molecules that evaporate quickly. An example of a top note is styrallyl acetate as shown in Fig. 10.1.

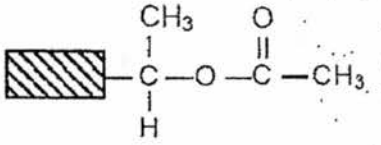


Fig. 10.1

(i) With reference to its structure, explain why the compound is likely to have a pleasant smell.

.....

.....[1]

(ii) Draw the structural formulae of the two compounds that are needed to form styrallyl acetate.

[2]

10 (b) Middle notes vapourise less readily than the top notes. A typical middle note is 2-phenylethanol. The structure of 2-phenylethanol is as shown in Fig. 10.2.

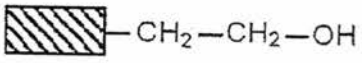


Fig. 10.2

Describe a chemical test to distinguish between styrallyl acetate and 2-phenylethanol.

.....

.....

.....

.....

.....

.....[3]

(c) End notes of a perfume are responsible for the long lasting odour which stays with the user. The structural formula of a typical end note is as shown in Fig. 10.3.

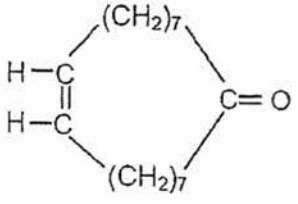


Fig. 10.3

(i) Explain why the end note is an unsaturated compound.

.....

.....[1]

(ii) Draw the structural formula of the product formed when the end note undergoes hydrogenation.

[1]

10 (c) (iii) Iodine value is a measure of how unsaturated a compound is. It is the mass, in grams, of iodine that reacts with 100 g of the compound.

Calculate the iodine value for the end note.

[2]

[Total: 10]

Colours of Some Common Metal Hydroxides

aluminium hydroxide	white
calcium hydroxide	white
copper(II) hydroxide	light blue
iron(II) hydroxide	green
iron(III) hydroxide	red-brown
lead(II) hydroxide	white
zinc hydroxide	white

The Periodic Table of the Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
											1 H Hydrogen 1						4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulphur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	Po Polonium 84	At Astatine 85	Rn Radon 86
Fr Francium 87	226 Ra Radium 88	227 Ac actinium 89 †															

*58-71 Lanthanoid series

†90-103 Actinoid series

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	Pa Protactinium 91	238 U Uranium 92	Np Neptunium 93	Pu Plutonium 94	Am Americium 95	Cm Curium 96	Bk Berkelium 97	Cf Californium 98	Es Einsteinium 99	Fm Fermium 100	Md Mendelevium 101	No Nobelium 102	Lr Lawrencium 103

Key: a / X / b

a = relative atomic mass

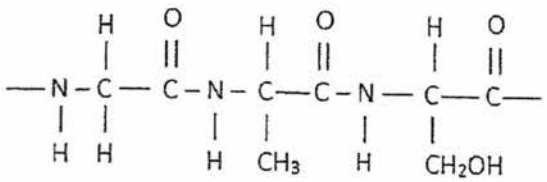
X = atomic symbol

b = proton (atomic) number

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

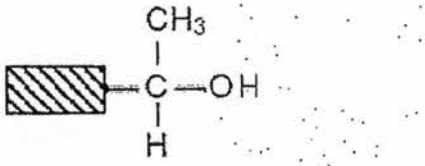
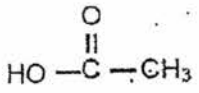
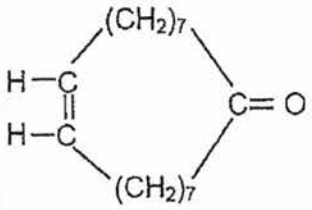
Section A (50 marks)		
Qn no	**Answer**	Marks/ Remarks
1(a)	Giant molecular structure with strong covalent bonds between antimony and sulfur atoms; A lot of energy needed to overcome the strong forces of attraction;	[1] [1]
1(b)(i)	Oxidation state of phosphorus increased from 0 in phosphorus to +5 in phosphorus(V) oxide;	[1]
1(b)(ii)	Electrical conductors/ can conduct electricity; They have mobile ions in the aqueous state/ when dissolved in water to serve as charge carriers; A: poor/low electrical conductivity A: if only mention mobile H^+ ions R: mobile electrons	[1] [1]
1(b)(iii)	% P in HPO_3 = 31/80 x 100% = 38.75% OR 38.8% (3 sf); % P in H_3PO_4 = 31/98 x 100% = 31.63% OR 31.6% (3 sf); Note: no working no mark R: fractions	[1] [1]
2(a)	An acid which dissociates/ionises partially in water to produce H^+ ions;	[1]
2(b)	Add a few drops of universal indicator to a sample of the acid; Green universal indicator/colourless solution will turn orange/yellow; A: use a pH meter to measure pH of tartaric acid, methyl orange (1m) R: red	[1] [1]
2(c)(i)	No. of mole of KOH = 0.100 x (6/1000) = 0.0006 mol; No. of mole of tartaric acid = 0.0006/2 = 0.0003 mol Conc. of tartaric acid = 0.0003 x (1000/20) = 0.015 mol/dm^3;	[1] [1]

2(c)(ii)	Heat the salt solution obtained to saturation; Cool and allow crystallisation to take place; Filter to obtain the crystals; Wash with distilled water, dry between pieces of filter paper;	[1] for 2 points in logical sequence
3(a)	Titanium, carbon, magnesium;	[1]
3(b)	The magnesium chloride produced in reactor 2 is collected and electrolysed to produce magnesium metal which is then used to react with titanium chloride again; OR Chlorine produced by electrolysis is used to react with rutile to produce titanium chloride in reactor 1;	[1]
3(c)	Argon is used to provide an unreactive/ inert atmosphere; To prevent the oxidation of/ reaction of oxygen with magnesium/ titanium/ titanium chloride; A: ensure that titanium chloride only reacts with magnesium in reactor 2	[1] [1]
3(d)(i)	500 kg;	[1]
3(d)(i)	% purity = 200/300 x 100%; = 66.7% (3 sf)	[1]
3(e)	Wash the mixture with water to dissolve the soluble magnesium chloride; Filter the mixture to obtain titanium as the residue and aqueous magnesium chloride as the filtrate; R: filtration	[1] [1]
4(a)	Iron/Fe; Each Fe atom loses 3 electrons to form Fe^{3+} ions/Fe_2O_3; A: loses electrons to form Fe^{3+}	[1] [1]
4(b)	R: $-\Delta H$	[1] for exo energy profile diagram [1] for all correct labels unlabelled /incorrect axes -1m
4(c)	Catalyst allows the pack to heat up faster; More colliding particles possess energy equal to or greater than activation energy; Frequency of effective collisions increases, speed of reaction increases; R: more effective collisions, number of effective collisions increases	[1] [1] [1]

5(a)	Energy was still being absorbed to overcome the activation energy/ most reactant particles have insufficient activation energy to undergo decomposition; A: little or not enough energy for decomposition	[1]
5(b)	Volume of carbon dioxide has not reached a constant/ is still increasing at the end of 5 minutes; A: CO_2 was still being produced	[1]
5(c)	Copper(II) carbonate/ $CuCO_3$; Highest volume of carbon dioxide produced per unit time; A: copper carbonate A: most carbon dioxide produced throughout the experiment	[1] [1]
5(d)	No carbon dioxide will be collected as time pass; Sodium carbonate is stable to heat/ does not decompose upon heating; R: less/little carbon dioxide, no change in volume of carbon dioxide, volume of carbon dioxide collected will be a horizontal/straight line R: very hard/hard to decompose sodium carbonate, sodium is heat stable	[1] [1]
6(a)	White solid turns purplish-black/black/purple; A: solid turns purplish-black/black/purple R: a black solid is formed	[1]
6(b)	Incomplete combustion of fossil fuels; When there is insufficient oxygen; A: alkanes, alkenes, carbon containing substances/fuels, carbon R: air for oxygen	[1] [1]
6(c)	Carbon monoxide is a colourless and odourless gas; Can cause death at high levels within minutes/ breathing difficulties/ binds to haemoglobin to form carboxyhaemoglobin;	[1] [1]
7(a)(i)	$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$;	[1]
7(a)(ii)	The number of C-H and C-C bonds broken, as well as the number of C=O and O-H bonds formed are the same for both hydrocarbons; Same amount of energy taken in/absorbed and given out/released; R: same number of bonds/same bonds are broken and formed	[1] [1]
7(a)(iii)	Less intermolecular forces of attraction between isooctane molecules; Less energy needed to overcome the intermolecular forces; R: weaker intermolecular forces of attraction	[1] [1]
7(b)(i)	 [1]: 2 proper amide linkages [1]: consists of 1 glycine, 1 alanine, 1 serine	if polymer -1m
7(b)(ii)	Mr of repeat unit = 215; Number of repeat units = 600 000/215; Number of amino acids = 2790.7 x 3 = 8372.1 = 8372; R: 8373	[1] [1] [1] allow ECF

Section B (30 marks)		
Qn no	Answer	Marks/ Remarks
8(a)	cathode: $2H^+(aq) + 2e^- \rightarrow H_2(g)$; anode: $4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$; A: if all state symbols missing R: wrong state symbol(s), partial state symbols	[1] [1]
8(b)(i)	For every mole of water electrolysed, 4 mole of electrons are transferred from hydroxide ions to hydrogen ions to form 2 mole of hydrogen gas and 1 mole of oxygen gas;	[1]
8(b)(ii)	The hydrogen to oxygen ratio increases/ oxygen to hydrogen ratio decreases; Less oxygen collected/ more oxygen dissolves in solution compared to hydrogen;	[1] [1]
8(b)(iii)	Solution becomes saturated with oxygen; Oxygen no longer dissolves in solution and is collected as gas; A: oxygen cannot dissolve into the solution anymore	[1] [1]
8(c)	Concentration of sodium chloride increases as water is being used up; A: water is being removed from solution, OH^- and H^+ ions are removed/used up/discharged from the solution	[1]
8(d)	Chlorine gas produced at the anode for concentrated sodium chloride compared to oxygen gas and water for dilute sodium chloride; A: chloride gas produced at anode instead of oxygen gas, aqueous NaOH produced in the electrolysis of concentrated NaCl but not for dilute NaCl	[1]
8(e)	To prevent the electrodes from reacting with the electrolytes or the products formed/ prevent the electrodes from dissolving into the solution; A: prevent reaction with solution/ions of solution, so they do not take part in reactions A: if students assume electrolysis of conc. NaCl then accept prevention of reaction with chlorine only (R: chloride)	[1]
9(a)	Ionisation energy decreases down Group I and II; Down the group, electron to be removed/valence electron is found further away from the nucleus; Less energy is needed to overcome electrostatic forces of attraction between nucleus and electron to be removed/ electrostatic forces of attraction between nucleus and electron is weakened; A: forces of attraction R: bonds for forces of attraction, break for overcome, less electrostatic forces of attraction, electrostatic forces of attraction decreases, nucleon for nucleus, neutron for nucleus	[1] [1] [1]
9(b)(i)	Sodium: 2,8,1; Magnesium: 2,8,2;	[1]
9(b)(ii)	The two electrons to be removed for sodium are third and second electron shells; Those of magnesium are from the third electron shell; OR Removing the second electron will disrupt the stable electronic configuration of sodium ion Removing the second electron will give magnesium ion the stable electronic configuration;	[1] [1] [1] [1]

	OR More energy needed to remove second electron from sodium once stable/full/octet configuration is attained; Less energy needed to remove second electron of magnesium as it will achieve the stable/full/octet configuration;	[1] [1]
9(c)	$Na^{2+}(g) \rightarrow Na^{3+}(g) + e^-$; R: missing/wrong state symbol(s)	[1]
9(d)	Number of moles in 12 g of Mg = 12/24 = 0.5 mol Energy required to remove 2 electrons from 1 mol of Mg = 737 + 1451 = 2188 kJ; Energy required to form 12 g of Mg^{2+} ions = 2188 x 0.5 = 1094 kJ; R: wrong unit	[1] [1] [1]
10Either		
(a)(i)	Percentage yield of ammonia drops as temperature increases;	[1]
(a)(ii)	Percentage yield of ammonia decreases as pressure decreases;	[1]
(b)(i)	100 °C, 1000 atm;	[1]
(b)(ii)	Extremely high pressure of 1000 atm is operationally dangerous/ may cause explosion of the reaction vessel/ incurs high maintenance cost; Speed of reaction is too slow at 100 °C; A: costly to maintain pressure at 1000 atm and 100 °C (1m)	[1] [1]
(c)(i)	Nitrogen monoxide produced in step 3 can be used for step 2; R: water produced in step 1 can be used for step 3 R: products from each step can be used for the next step R: products can be reused for other steps	[1]
(c)(ii)	pH is above 7 before the start of step 1 while pH is below 7 at the end of step 2; Ammonia gas present at the start is alkaline while nitrogen dioxide produced at the end is acidic;	[1] [1]
(c)(iii)	No. of moles of ammonia = 840/24 = 35 mol; No. of moles of nitric acid = 35 x (2/3) = 23.33 mol Mass of nitric acid = 23.33 x (1+14+16x3) = 1470 g;	[1] [1]

10Or		
(ai)	It has the ester functional group; A: ester linkage	[1]
(aii)	Alcohol  Carboxylic acid 	[1] [1]
(b)	Add acidified potassium manganate(VII) to both solutions; If purple solution turns colourless, the sample is middle note/2-phenylethanol; If purple solution remains purple, the sample is top note/styrallyl acetate; OR Add acidified potassium dichromate(VI) solution to each sample; if the solution turned from orange to green, the sample is middle note or if the solution remained orange, the sample is top note.	[1] [1] [1]
(ci)	It has a carbon-carbon double bond;	[1]
(cii)		[1]
(ciii)	1 mol of end note reacts with 1 mol of iodine. No. of mole of end note = 100/250 = 0.4 mol; No of mole of iodine = 0.4 mol Mass of iodine =0.4 x 2 x 127 =101.6 g; R: missing unit	[1] [1]