

[Pure] Chemistry O Level Exam Paper
Preliminary Examination Set [V]
Secondary Four Express



CANDIDATE NAME:

CLASS:

INDEX NUMBER:

(Updated 2024)

6092/01

Chemistry

1 hour

Paper 1 Multiple Choice

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

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

Write your name, class and index number on the Answer Sheet in the spaces provided.

There are **forty** questions on this paper. Answer **all** questions. For each question, there are four possible answers **A, B, C** or **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

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

- 1 Magnesium sulfate is prepared by reacting excess magnesium carbonate with dilute sulfuric acid.



Which two pieces of apparatus are needed to obtain magnesium sulfate crystals by this reaction?

- 1 thermometer
- 2 evaporating dish
- 3 filter funnel
- 4 gas syringe

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

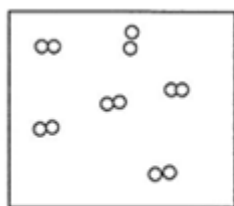
- 2 An unknown substance melts at $-210\text{ }^{\circ}\text{C}$ and boils at $-196\text{ }^{\circ}\text{C}$.

Which of the following correctly describes the arrangement and movement of the particles of this substance at $-204\text{ }^{\circ}\text{C}$?

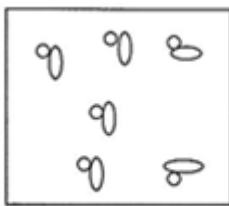
	arrangement	movement
A	closely packed in a disorderly manner	sliding past one another
B	closely packed in a disorderly manner	vibrating about fixed positions
C	closely packed in an orderly manner	sliding past one another
D	closely packed in an orderly manner	vibrating about fixed positions

3 The following diagrams can be used to illustrate

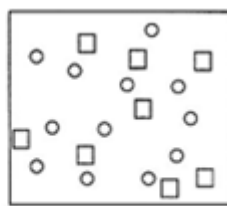
- 1 a mixture of elements and compounds
- 2 a mixture of elements
- 3 molecules of an element
- 4 molecules of a compound



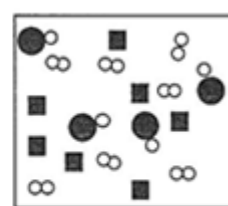
W



X



Y



Z

What is the correct order of the diagrams?

	1	2	3	4
A	X	W	Y	Z
B	X	Z	W	Y
C	Z	Y	W	X
D	Z	Y	X	W

4 A new substance was discovered, and a series of experiments were conducted on it.

Which observation suggests that the substance **cannot** be an element?

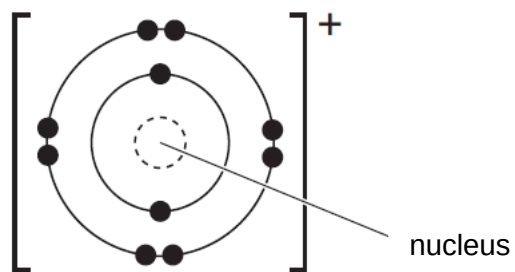
- A** It has a fixed boiling point.
- B** It dissolves in water to form a yellow-green solution.
- C** When heated strongly, a brown solid and a yellow gas are produced.
- D** When heated in air, it can form oxides with two different chemical formulae.

- 5 An atom of element T has x protons and y nucleons.

How many neutrons and electrons are present in a positive ion of another isotope of element T?

	neutrons	electrons
A	y	$x - 1$
B	$y - x$	$x + 1$
C	$y - x + 2$	$x - 1$
D	$y - x + 2$	x

- 6 The diagram of an ion of element Q is shown. In which period and group is element Q found in the Periodic Table?



	Group number	Period number
A	1	2
B	1	3
C	18	2
D	18	3

7 The physical properties of four substances are given below.

solid	melting point/°C	boiling point/°C	electrical conductivity	
			in solid	in liquid
1	1130	1950	✗	✓
2	-7.2	58	✗	✗
3	300	340	✗	✗
4	660	2470	✓	✓

Which of the following correctly matches the four substances?

	1	2	3	4
A	aluminium	bromine	astatine	sodium oxide
B	sodium oxide	bromine	astatine	aluminium
C	aluminium	astatine	silicon dioxide	sodium oxide
D	sodium oxide	astatine	silicon dioxide	aluminium

8 Chromium is a metal. The structure of chromium is described as a lattice of positive ions in a 'sea of electrons'.

Which statements about chromium are correct?

- 1 Chromium conducts heat because the positive ions are free to move.
- 2 Chromium conducts electricity because the electrons are free to move.
- 3 Chromium ions are held together because of their attraction for each other.
- 4 Chromium has a high melting point due to strong electrostatic forces of attraction.

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

- 9 Which of the following explains why graphite and copper can conduct electricity in the solid state?
- A Both graphite and copper contain mobile electrons.
 - B Both graphite and copper contain mobile ions.
 - C Graphite contains mobile electrons while copper contains mobile ions.
 - D Graphite and copper contain both mobile electrons and mobile ions.
- 10 The chemical formula of antimony oxide is Sb_2O_3 and that of potassium phosphate is K_3PO_4 .

Which chemical formula is likely to be antimony phosphate?

- A SbPO_4
 - B Sb_2PO_4
 - C $\text{Sb}_2(\text{PO}_4)_3$
 - D Sb_3PO_4
- 11 Some properties of four elements, P, Q, R and S, are shown in the table.
- Two of these elements are in Group 1 of the Periodic Table and two are in Group 17.

element	reaction with water	physical state at room temperature
P	reacts vigorously	solid
Q	does not react with water	solid
R	reacts explosively	solid
S	dissolves giving a coloured solution	liquid

Which statement is correct?

- A P is above R in Group 1.
- B Q is above R in Group 1.
- C S is below Q in Group 17.
- D R is below S in Group 17.

- 12** Transition elements can have variable oxidation states.
Which pair of compounds show a transition element in two different oxidation states?

- A** Co_2O_3 and LiCoO_2
B Cu_2O and CuSO_4
C K_2CrO_4 and CrO_3
D NiO and $\text{Ni}(\text{NO}_3)_2$

- 13** The table shows the pH ranges of an indicator, bromothymol blue.

colour of indicator	yellow		green		blue	
pH	4	5	6	7	8	9

The table shows the pH of four solutions.

solution	W	X	Y	Z
pH	3	5	7	9

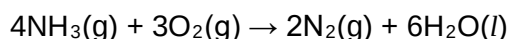
Bromothymol blue was added to a solution in a beaker.

Which description will **not** result in a change in colour of the indicator?

- A** Indicator was added to solution Z. Solution W was added to the mixture until in excess.
B Indicator was added to solution W. Solution X was added to the mixture until in excess.
C Indicator was added to solution X. Solution Y was added to the mixture until in excess.
D Indicator was added to solution Y. Solution Z was added to the mixture until in excess.
- 14** Which equation suggests that a metal oxide, RO, behaves as an amphoteric oxide?

- A** $\text{RO}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{R}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
B $\text{RO}(\text{s}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{RO}_2^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
C $\text{RO}(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{R}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq})$
D $\text{RO}(\text{s}) + \text{NH}_4^+(\text{aq}) \rightarrow \text{R}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{NH}_3(\text{g})$

- 15** Which mixture of solids would react with dilute nitric acid to form two different gases?
- A** copper and magnesium carbonate
 - B** copper(II) carbonate and magnesium oxide
 - C** copper(II) carbonate and magnesium
 - D** copper(II) oxide and magnesium carbonate
- 16** In an experiment to determine the concentration of hydrochloric acid, a student titrated 25.0 cm³ of hydrochloric acid with 0.1 mol/dm³ aqueous sodium hydroxide, using methyl orange as an indicator.
Which step would cause her calculated concentration of hydrochloric acid to be higher than its expected value?
- A** The burette was rinsed with distilled water followed by aqueous sodium hydroxide.
 - B** The conical flask was rinsed with distilled water followed by hydrochloric acid.
 - C** The titration reading was taken when methyl orange turns orange.
 - D** Reading the burette at an angle.
- 17** The mineral dolomite is a double carbonate of magnesium and calcium, with the formula CaMg(CO₃)₂. When 2.00 g of an impure sample of dolomite was completely dissolved in excess hydrochloric acid, 0.45 g of carbon dioxide was given off.
What is the percentage purity of the sample?
- A** 23.6%
 - B** 47.1%
 - C** 77.7%
 - D** 94.2%
- 18** 200 cm³ of ammonia burns in 120 cm³ of oxygen according to the following equation:



What volume of nitrogen will be obtained?

- A** 80 cm³
- B** 100 cm³
- C** 240 cm³
- D** 320 cm³

19 What is the concentration of iron(III) ions in 0.01 mol/dm^3 of aqueous iron(III) sulfate?

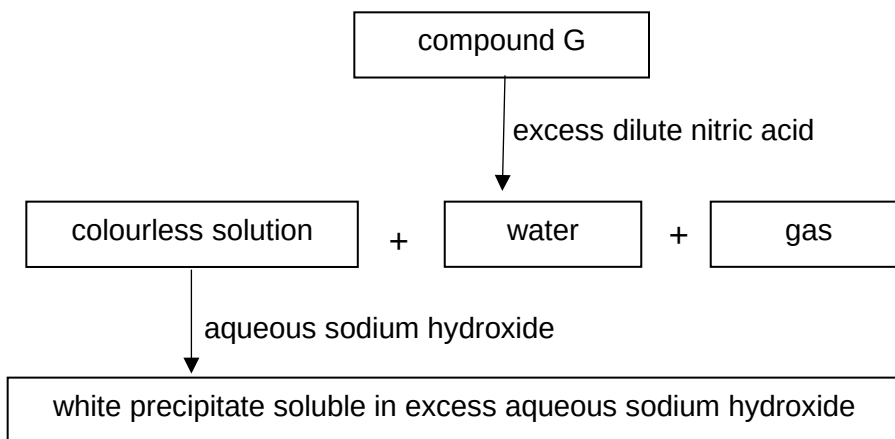
- A** 0.01 g/dm^3 **B** 0.02 g/dm^3
C 1.12 g/dm^3 **D** 1.68 g/dm^3

20 10.0 cm^3 of 0.10 mol/dm^3 lead(II) nitrate, $\text{Pb}(\text{NO}_3)_2$, is added to 30.0 cm^3 of 0.05 mol/dm^3 sodium chloride, NaCl , in a beaker.

After the reaction, a white precipitate of lead(II) chloride is present.
What else is present?

- A** aqueous lead(II) nitrate only
B aqueous lead(II) nitrate and aqueous sodium nitrate
C aqueous sodium nitrate only
D aqueous sodium chloride and aqueous sodium nitrate

21 The scheme below shows some reactions of compound G.



What is compound G likely to be?

- A** ammonium carbonate
B calcium carbonate
C zinc
D zinc carbonate

22 The presence of nitrates in the soil can be shown by warming the soil with aqueous sodium hydroxide and aluminium foil. Which observation shows that nitrates are present?

- A** Effervescence is observed.
- B** A gas that extinguishes a lighted splint with a 'pop' sound is produced.
- C** A gas that turns moist red litmus paper blue is produced.
- D** A white precipitate is seen.

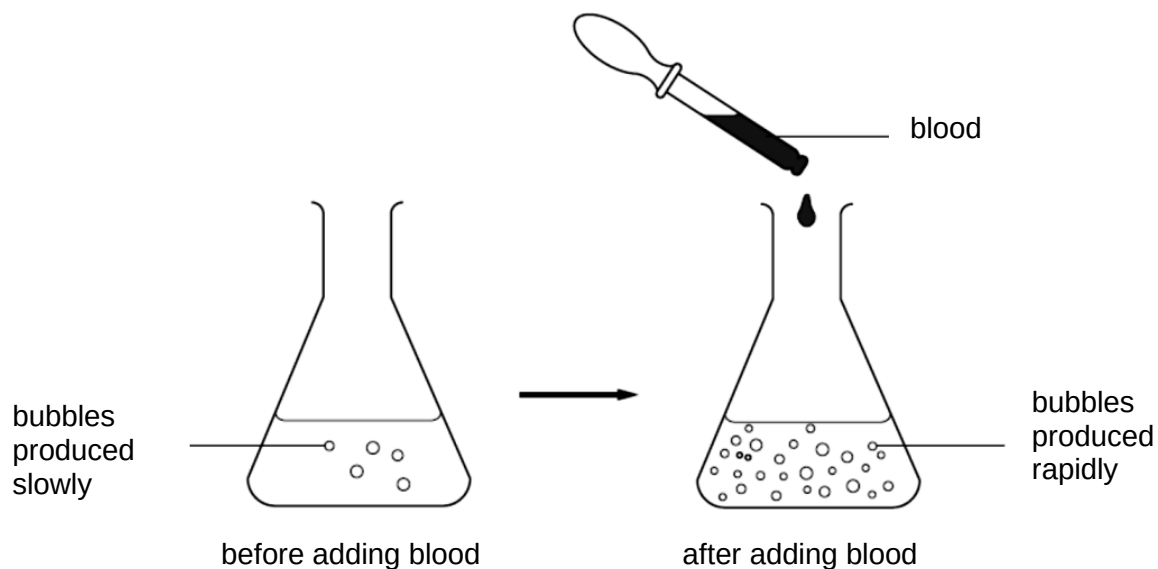
23 Element X displaces element Y from aqueous nitrate of Y. Hot element X does not react with cold water but react with steam to give hydrogen gas. Element Z reacts violently with water. What could element X, Y and Z be?

	X	Y	Z
A	copper	iron	lithium
B	copper	lead	sodium
C	zinc	iron	sodium
D	magnesium	silver	lithium

24 Which statement is correct about metal extraction?

- A** Metals above hydrogen are usually extracted by electrolysis.
- B** Iron can only be extracted by electrolysis.
- C** Calcium can be extracted by heating calcium oxide with carbon.
- D** Copper can only be extracted by passing hydrogen over heated copper(II) oxide.

- 25** A solution of hydrogen peroxide releases oxygen slowly at room temperature. The diagram shows the effect of adding blood to the solution.



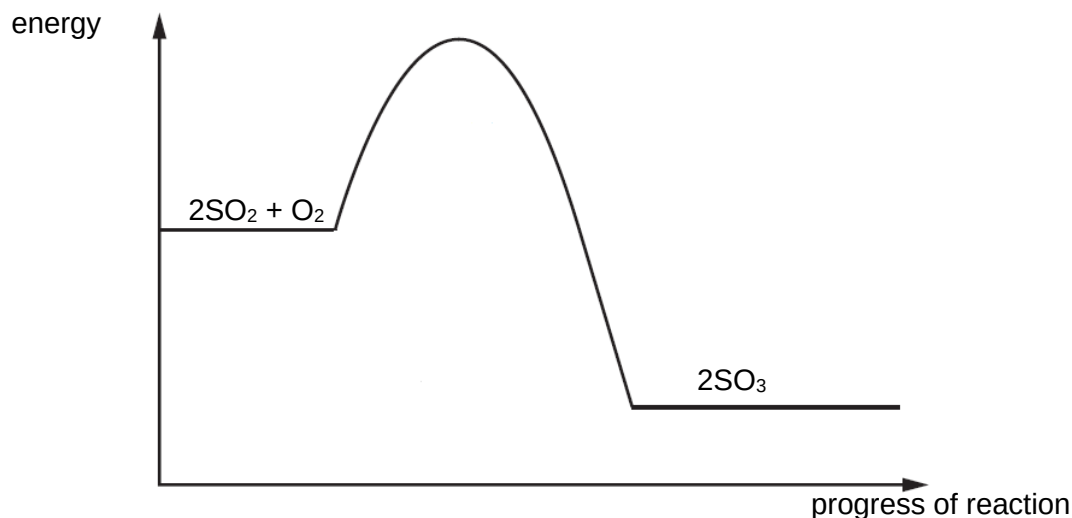
What could be the reason for the observed change?

- A** Blood contains an enzyme.
 - B** Blood contains water.
 - C** Hydrogen peroxide becomes more concentrated.
 - D** Hydrogen peroxide is neutralised by blood.
- 26** Which of the following reaction(s) is/are redox?

- 1 $\text{H}_2\text{SO}_4 + 6 \text{NH}_3 \rightarrow (\text{NH}_4)_2\text{SO}_4$
- 2 $2 \text{H}_2\text{SO}_4 + \text{Ni} \rightarrow \text{NiSO}_4 + 2 \text{H}_2\text{O} + \text{SO}_2$
- 3 $\text{K}_2\text{Cr}_2\text{O}_7 + 2 \text{KOH} \rightarrow 2 \text{K}_2\text{CrO}_4 + \text{H}_2\text{O}$

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

27 The energy profile diagram for the reversible reaction $2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3$ is shown.



Which statements about this reaction are both correct?

	statement 1	statement 2
A	The reverse reaction is endothermic.	The activation energy is different for the forward and reverse reactions.
B	The reverse reaction is endothermic.	The activation energy is the same for the forward and reverse reactions.
C	The reverse reaction is exothermic.	The activation energy is different for the forward and reverse reactions.
D	The reverse reaction is exothermic.	The activation energy is the same for the forward and reverse reactions.

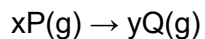
28 The table shows the energy released by the complete combustion of some compounds.

compound	M_r	enthalpy change (kJ/mol)
benzene	78	-3270
heptane	100	-4800
octane	114	-5510
propane	44	-2200

Which compound releases the least energy when **1 g** is completely burned?

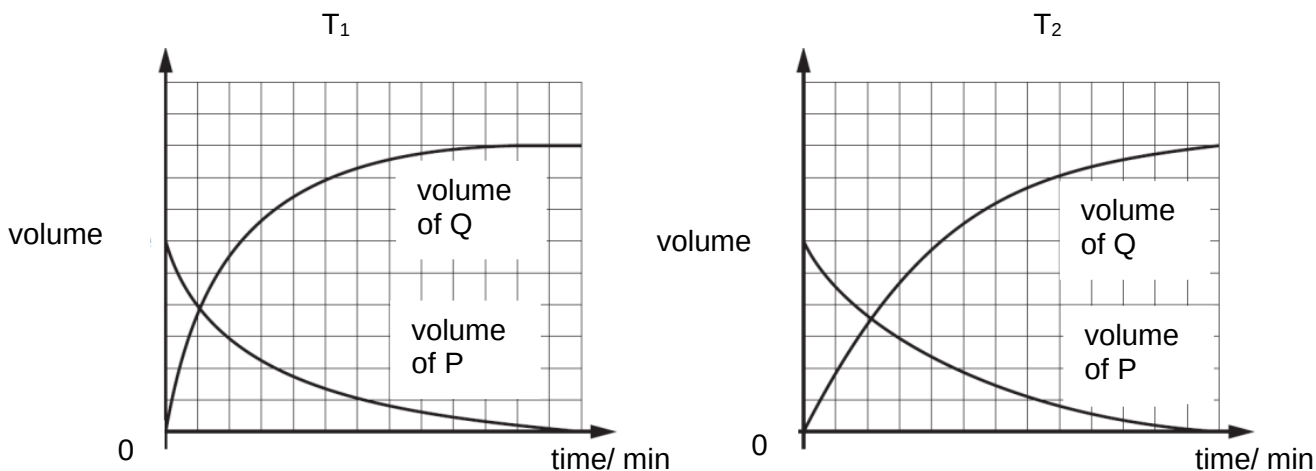
- | | |
|------------------|------------------|
| A benzene | B heptane |
| C octane | D propane |

29 Gas P decomposes to form gas Q.



Two experiments are carried out to investigate the effect of temperature, T_1 and T_2 , on the rate of reaction. All other conditions are kept the same.

The results are plotted on graphs, drawn to the same scale.



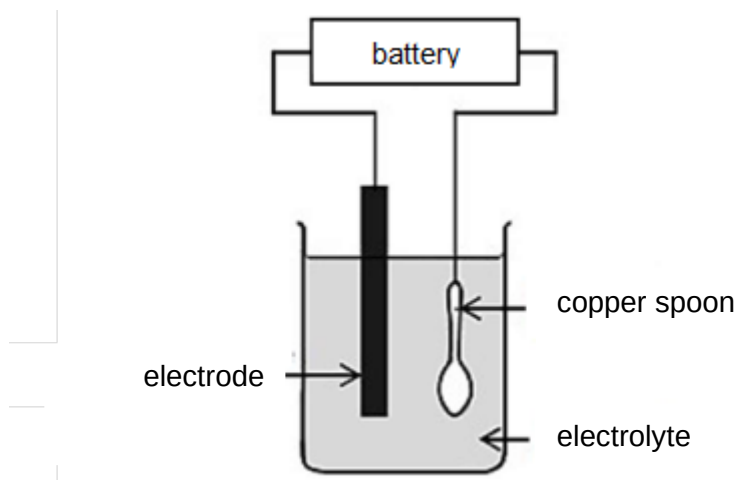
Which row is correct?

	x	y	temperature
A	2	3	T_1 is higher than T_2
B	2	3	T_2 is higher than T_1
C	3	2	T_1 is higher than T_2
D	3	2	T_2 is higher than T_1

30 The presence of iron catalyst in the Haber Process _____.

- A** decreases the activation energy of the reaction
- B** increases the activation energy of the reaction
- C** increase the energy level of the reactants
- D** lowers the enthalpy change of the reaction

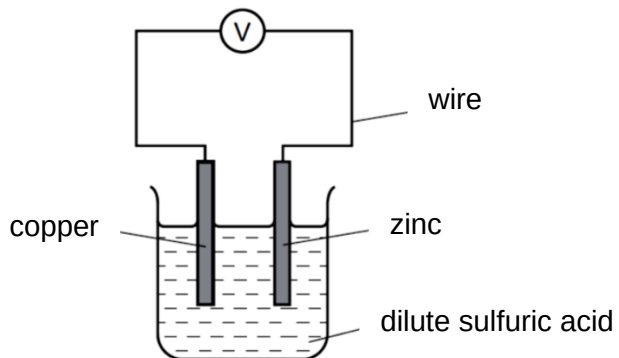
- 31 Which statement about the manufacture of ammonia through the Haber process is correct?
- A The reaction is reversible.
 - B The reaction is endothermic.
 - C Hydrogen is obtained from fractional distillation of air.
 - D Low pressure will result in an increase in yield of ammonia.
- 32 In the electrolysis of molten lead(II) bromide, 3 moles of lead(II) ions were discharged at the cathode. Which of the following would be discharged by the same amount of electricity?
- A 3 moles of iron(III) ions in the electrolysis of aqueous iron(II) chloride
 - B 3 moles of hydrogen ions in the electrolysis of aqueous zinc sulfate
 - C 6 moles of copper(II) ions in the electrolysis of aqueous copper(II) nitrate
 - D 6 moles of silver ions in the electrolysis of aqueous silver nitrate
- 33 The diagram shows the setup for the electroplating of a copper spoon with silver.



Which statement is **not** correct?

- A The electrode would be made of pure silver metal.
- B The electrolyte would be a soluble silver salt.
- C The spoon would be connected to the positive terminal of the battery.
- D The mass of the electrode decreases with time.

34 The diagram shows a simple cell.



Which statement about the simple cell is correct?

- A Electrons flow from copper along the wire to zinc.
- B Copper electrode decreases in size.
- C The pH value of the electrolyte increases.
- D Reddish-brown solid formed on the zinc electrode.

35 The general formula of the alkanes is C_nH_{2n+2} . Which physical property decreases as n increases?

- A boiling point
- B flammability
- C melting point
- D viscosity

36 The list shows reactions in which ethanol is either a reactant or a product.

1. combustion of ethanol
2. conversion of ethene to ethanol
3. fermentation of glucose
4. oxidation of ethanol to ethanoic acid

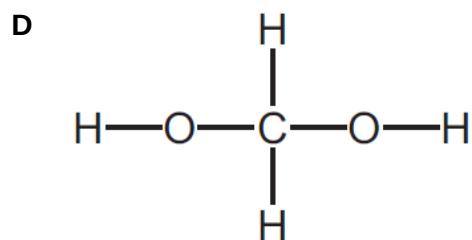
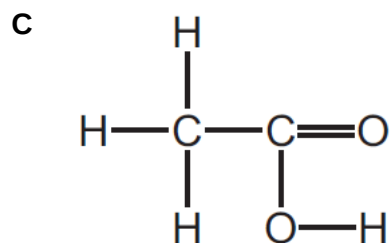
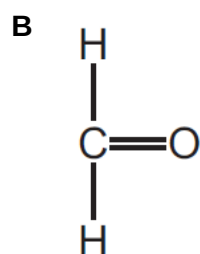
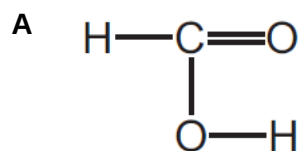
In which reactions is water also either a reactant or a product?

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

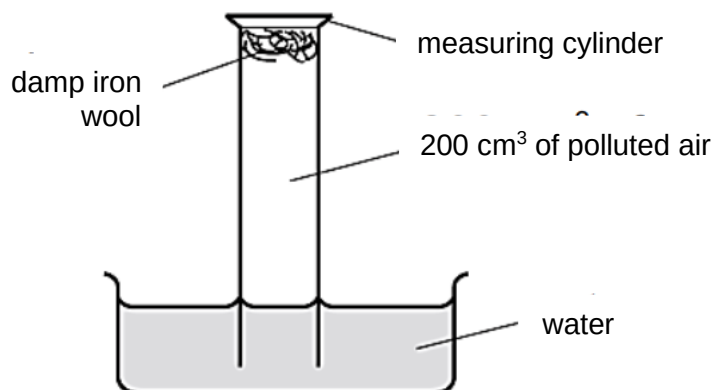
37 Which molecule is **not** produced by an addition reaction of ethene?

- A CH_3CH_3
- B $\text{CH}_2\text{BrCH}_2\text{Br}$
- C $\text{CH}_3\text{CH}_2\text{OH}$
- D $\text{CH}_3\text{CH}_2\text{CH}_3$

38 Which structure shows a carboxylic acid with the lowest relative molecular mass?



- 39 An experiment to find the percentage of oxygen in 200 cm³ of polluted air is shown.



The apparatus is left for one week. After this time, the volume of gas in the measuring cylinder is 164 cm³.

What is the percentage of oxygen, to the nearest whole number, in the polluted air?

- A 18%
 - B 21%
 - C 41%
 - D 82%
- 40 In the catalytic converter in the exhaust system of a car, harmful gases are converted into carbon dioxide, nitrogen and water.

- 1 Carbon monoxide reacts with hydrocarbons.
- 2 Carbon monoxide reacts with nitrogen monoxide.
- 3 Platinum and rhodium catalyse the redox reactions

Which processes take place in the catalytic converter?

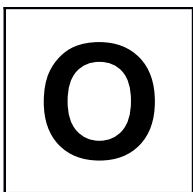
- A 1 and 2 only
- B 1 and 3 only
- C 2 and 3 only
- D 1, 2 and 3

The Periodic Table of Elements

Group																							
1	2																18						
		1 Hhydrogen1																					
		2 Hehelium4																					
3 Li lithium 7	4 Be beryllium 9																						
11 Na sodium 23	12 Mg magnesium 24																						
19 K potassium 39	20 Ca calcium 40	3	4	5	6	7	8	9	10	11	12							13	14	15	16	17	
37 Rb rubidium 85	38 Sr strontium 88	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
55 Cs caesium 133	56 Ba barium 137	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
87 Fr francium	88 Ra radium	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
		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							113 Nh nihonium	114 Fl flerovium	115 Mc moscovium	116 Lv livermorium	117 Ts tennessine	118 Og oganesson
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 dm³ at room temperature and pressure (r.t.p.).

The Avogadro constant, $L = 6.02 \times 10^{23} \text{ mol}^{-1}$.



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Preliminary Examination Set [V]
Secondary Four Express



CANDIDATE NAME:

CLASS:

INDEX NUMBER:

(Updated 2024)

6092/02

Chemistry

1 hour 45 minutes

Paper 2 Theory

READ THESE INSTRUCTIONS FIRST

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

Section A

Answer **all** questions.

Section B

Answer **all** questions. Question 11 has a choice of parts to answer.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

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.

Section A	
Section B	
Total	

Answer **all** questions.

Answer **all** questions.

- 1** Fig. 1.1 shows part of the Periodic Table.

[illegible]

Fig. 1.1

Select elements from Fig. 1.1 to answer the following questions. You may use each element once, more than once or not at all.

Write down the symbol for an element which:

- (a)** forms a stable ion by losing three electrons,

..... [1]

- (b)** exists as diatomic molecules,

..... [1]

- (c)** forms an ion which gives a red-brown precipitate on addition of aqueous ammonia,

..... [1]

- (d)** has chemical properties similar to those of magnesium,

..... [1]

- (e)** has a giant covalent structure,

..... [1]

- (f)** reacts with sodium to form an ionic compound with Mr less than 70.

..... [1]

[Total: 6]

- 2 A laboratory technician mixes red, blue and yellow dyes to make black dye for a paper chromatography experiment. A common solvent used to separate the dyes in black ink is a mixture of ethanol and water. The coloured dyes have different R_f values in solvents with different composition of ethanol as shown in Fig. 2.1.

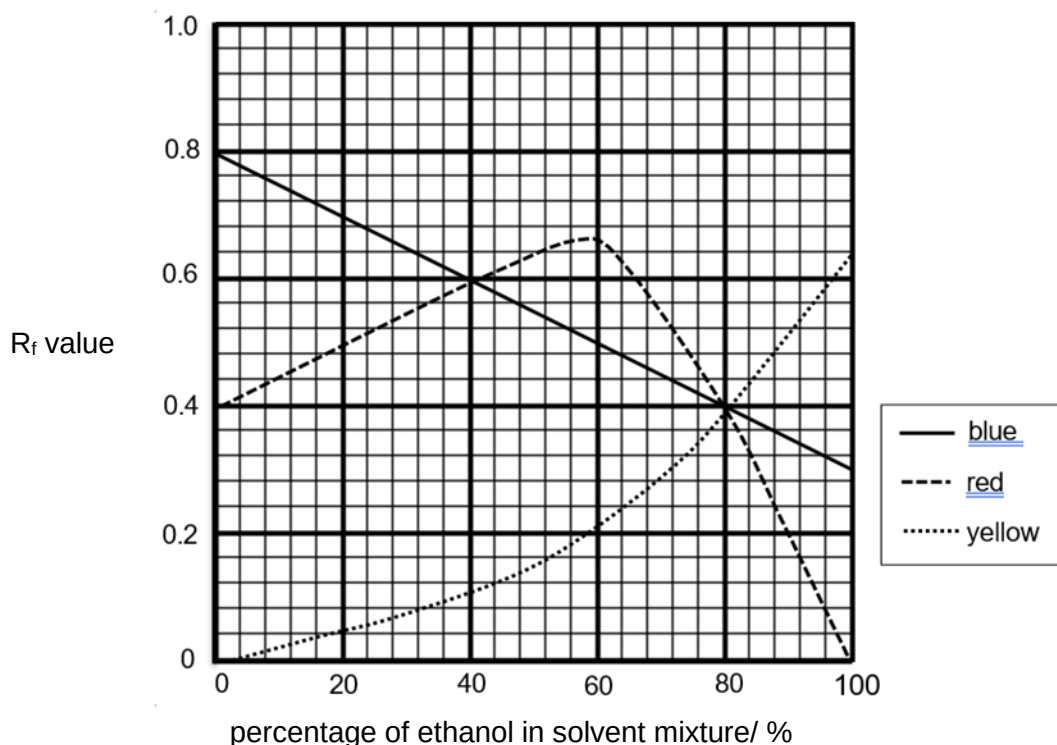


Fig. 2.1

- (a) Predict the colours of the separated spots observed when the solvent used consists of 40% ethanol in the mixture.

..... [1]

- (b) State the R_f value of the yellow dye on the chromatogram when the solvent is a mixture of 64 cm³ of ethanol and 136 cm³ of water.

..... [1]

- (c) Explain why a pure solvent of water or ethanol is not suitable for the separation of the black ink using paper chromatography.

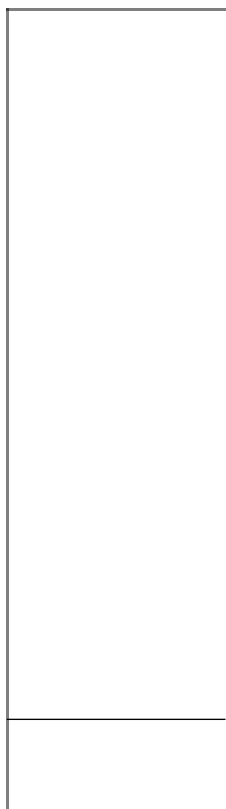
.....
.....
..... [2]

- (d)** A student carried out chromatography on the black ink using a mixture of ethanol and water as solvent. Only one spot was observed on the resulting chromatogram.

What is the percentage of ethanol in the solvent mixture used? Explain why only one spot is observed.

.....
.....
..... [2]

- (e)** Draw and label on the chromatography paper below the chromatogram obtained when a mixture containing 90% ethanol is used.



[1]
[Total: 7]

- 3 Until recently, arsenic poisoning, either deliberate or accidental, has been a frequent cause of death. The symptoms of arsenic poisoning are identical to those of a common illness, cholera. A reliable test was needed to prove the presence of arsenic in a body.

In 1840, Marsh devised a reliable test for arsenic as shown in Fig 3.1.

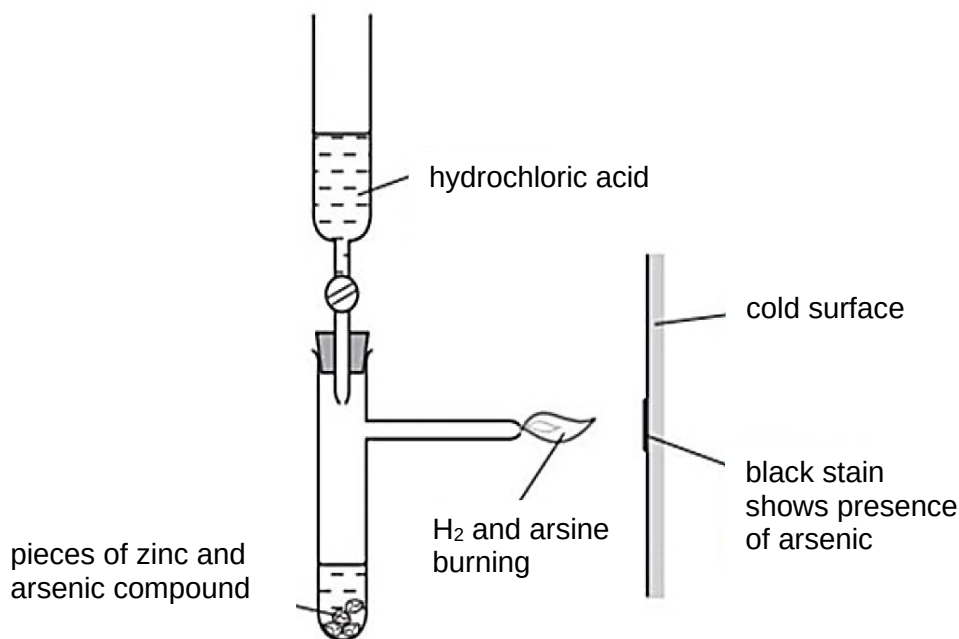


Fig 3.1

Hydrogen is formed in this reaction.

- (a) Any arsenic compound reacts with this hydrogen will form arsine which is arsenic hydride, a covalent compound.

The mixture of hydrogen and arsine is burnt at the jet and arsenic forms as a black stain on the glass.

- (i) Write an equation for the reaction which forms hydrogen.

..... [1]

- (ii) Arsenic (As) is located in Group 15.
Suggest the formula of arsine.

..... [1]

- (iii) Draw a 'dot and cross' diagram to show the bonding in the compound arsine.
Show the outer shell electrons only.

[2]

- (b) Table 3.1 shows the composition of another hydride of arsenic.

Table 3.1

arsenic	hydrogen
97.4%	2.6%

- (i) Determine the empirical formula of this hydride from the data above.

empirical formula: [2]

- (ii) The mass of one mole of this hydride is 154 g.
What is its molecular formula?

molecular formula: [1]

- (iii) Draw the full structural formula of this hydride from (b)(ii).

[1]

[Total: 8]

4 This question is about halogens and their compounds.

- (a) Explain in terms of electron transfer why halogens behave chemically as non-metals.

.....
..... [1]

- (b) Complete Table 4.1 to show the results of experiments where aqueous halogens are added to the solutions of aqueous halides.

Use the following legend:

✓ a reaction occurs

✗ no reaction occurs

Table 4.1

	At ₂ (aq)	Br ₂ (aq)	Cl ₂ (aq)
At ⁻ (aq)			
Br ⁻ (aq)			
Cl ⁻ (aq)			

[2]

- (c) Two students commented on the use of potassium iodide.

Student 1: "Potassium iodide can be very useful because when it is oxidised, a colour change is produced."

Student 2: "Aqueous potassium iodide can be used to test for the presence of an oxidising agent."

- (i) Describe the colour change when potassium iodide is oxidised.

..... [1]

- (ii) Explain why the reaction between aqueous potassium iodide and oxidising agents is a redox reaction.

.....
.....
..... [2]

- (d) Concentrated aqueous hydrochloric acid releases fumes of hydrogen chloride gas.

A long glass tube is set up as shown in Fig. 4.1.

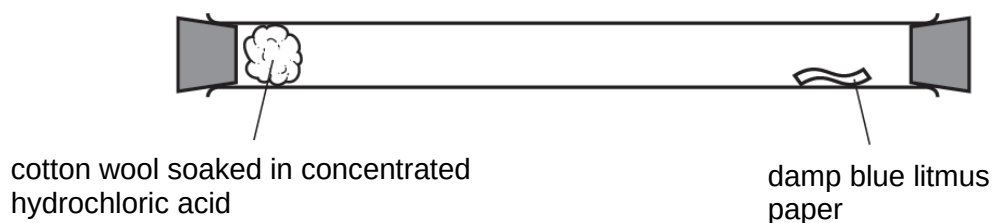


Fig. 4.1

Use the kinetic particle model to explain why the blue litmus paper turns red after a short while.

.....

 [3]

[Total: 9]

- 5 Ozone does not come directly from factories and vehicles. Ozone is formed when heat and sunlight cause chemical reactions between oxides of nitrogen (NOX) and Volatile Organic Compounds (VOC). This reaction can occur both near the ground and high in the atmosphere.

- (a) (i) Predict the effect of each factor on the ozone level by completing Table 5.1.

Table 5.1

Factor	Ozone levels (Increase or Decrease)
Smaller population density	
More electrical cars	
Sunny skies	

[1]

- (ii) Ozone levels in a city are usually at their peak in mid-afternoon. Suggest two reasons for this.

.....

 [2]

(b) In Singapore, a small fraction of our electricity is generated by burning petroleum. Most power stations have switched to the use of natural gas.

(i) Name one air pollutant produced by burning petroleum in a power station.

..... [1]

(ii) How can power stations reduce the amount of this pollutant from **(b)(i)** that is released into the atmosphere?

.....
..... [1]

[Total: 5]

- 6** A group of students were investigating the effects of 'acid rain'. They decided to look at the effect of acid on metals used as building materials. Lead and copper are used as materials for roofing and iron and aluminum can be used for window frames.

They learnt that the order of the reactivity of the metals as:

aluminium > iron > lead > copper

The students went on to test on the metals by adding dilute sulfuric acid to pieces of each metal to simulate the effects of 'acid rain' on the metals. It is found that only the iron seemed to give a reaction.

(a) Explain why the students deduce that aluminium did not react with the acid, even when aluminum is known to be more reactive than iron.

.....
..... [1]

(b) As the reaction is carried out with sulfuric acid, there were no reactions for both lead and copper. It did not prove that lead was more reactive than copper.

(i) Explain why the copper show no reactions with sulfuric acid.

.....
..... [1]

(ii) Describe an experiment the students can carry out to show that lead is more reactive than copper.

.....
.....
.....
..... [3]

- (c) Iron, when exposed to environmental factors can undergo rusting. Hence, sacrificial protection can be used to prevent rusting. State an example of sacrificial protection and explain how it prevents rusting.

.....

 [2]

[Total: 8]

- 7 Lead(II) carbonate reacts with dilute nitric acid as shown by the equation below:



Two experiments are carried out using lumps or powder of lead(II) carbonate of the same mass, with other conditions kept the same.

The results are shown in Fig. 7.1.

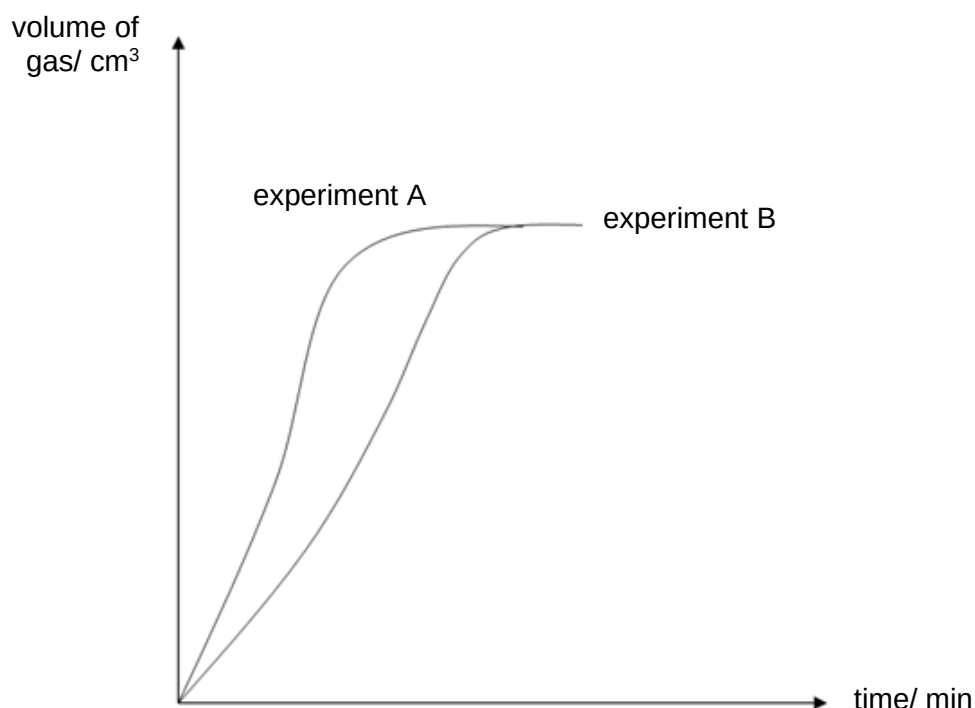


Fig. 7.1

- (a) With reference to the graph, which experiment, **A** or **B**, was carried out using lumps of lead(II) carbonate?

Explain your answer in terms of collisions between particles.

.....

 [2]

- (b) Experiment **A** is repeated using the same mass of calcium carbonate in place of lead(II) carbonate. All other conditions are kept constant.

Will the total volume of gas produced be more, less, or the same, as compared to Experiment **A**?

Explain your answer.

.....
.....
..... [2]

- (c) Experiment **A** is repeated using excess sulfuric acid in place of nitric acid. All other conditions are kept constant.

(i) Sketch in Fig. 7.1 the result you would expect to obtain. [1]

(ii) Explain the shape of your graph.

.....
.....
.....
.....
..... [2]

[Total: 7]

- 8 This question is about the electrolysis of aqueous copper(II) nitrate.
Some students investigated the electrolysis of copper(II) nitrate solution using inert electrodes.
Fig. 8.1 shows the apparatus.

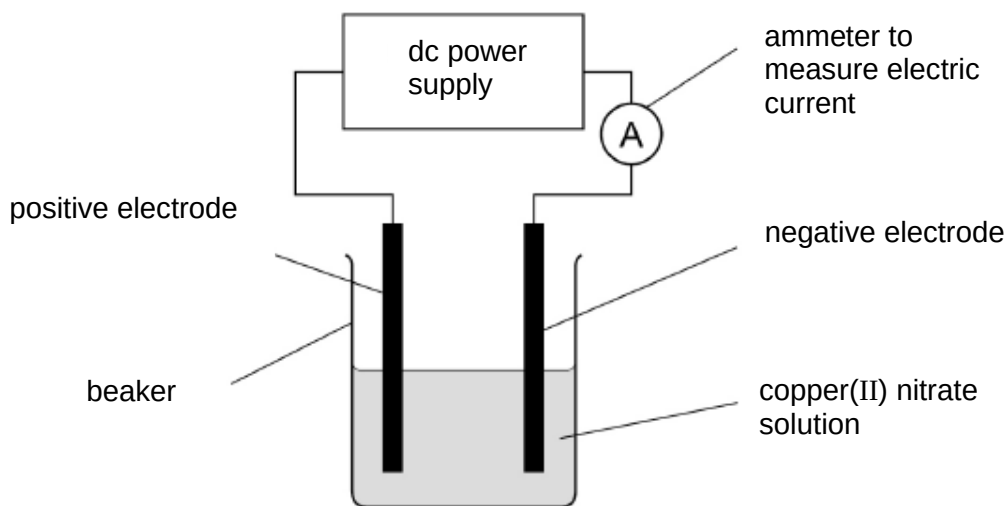


Fig. 8.1

The students investigated how the mass of copper produced at the negative electrode varies with time and current.

This is the method used.

1. Weigh the negative electrode.
2. Set up the apparatus shown.
3. Adjust the power supply until the ammeter shows a current of 0.3A.
4. Switch off the power supply after 5 minutes.
5. Rinse the negative electrode with water and allow to dry.
6. Reweigh the negative electrode.
7. Repeat steps 1 to 6 for different times.

Repeat steps 1 to 7 at different currents.

- (a) Write the ionic equation for the reaction at the negative electrode.

..... [1]

- (b) Some of the copper produced did not stick to the negative electrode but fell to the bottom of the beaker.
Suggest how the students could find the total mass of the copper produced.

.....
.....
.....
..... [3]

- (c) The student plotted their results on a graph.
Figure 8.2 shows the graph.

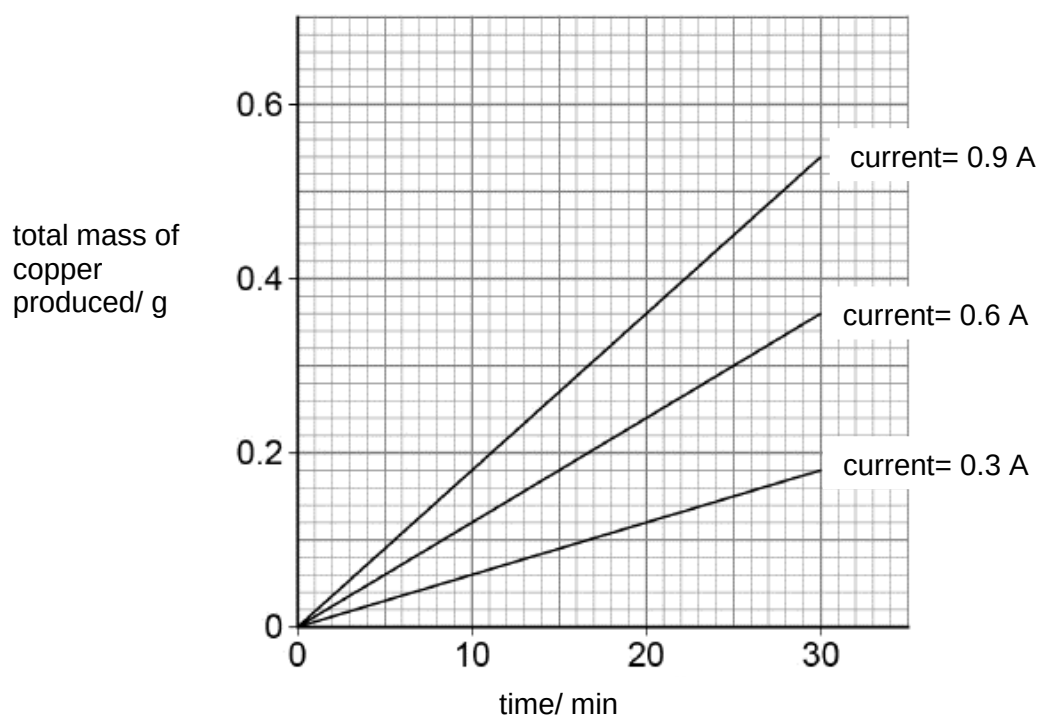


Fig. 8.2

A student concludes that the total mass of copper produced is directly proportional to the time taken and the current.

Do you agree? Justify your answer using the information given.

.....

 [2]

- (d) Describe and explain what happens to the copper(II) nitrate solution during electrolysis.

.....

 [3]

- (e) Calculate the number of atoms of copper produced when copper(II) nitrate solution is electrolysed for 20 minutes at a current of 0.6A.

number of Cu atoms: [2]

[Total: 10]

9 Gas Chromatography

Gas chromatography is a commonly used separation technique in many environmental and forensic laboratories for quality control as well as identification and quantitation of compounds in a miscible mixture. Gas chromatography allows for the separation and detection of compounds even in very small quantities. A broad variety of samples can be analysed as long as the compounds are sufficiently stable to heat and reasonably volatile.

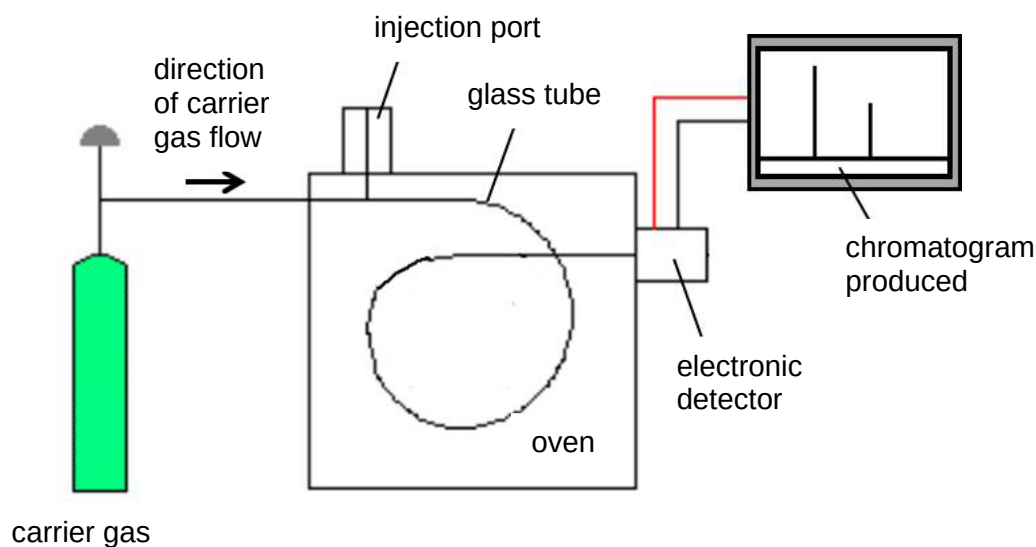


Fig 9.1

Fig. 9.1 shows a schematic diagram of the gas chromatography machine. The gas chromatography machine consists of a thin glass tube placed inside an oven, where the temperature can be adjusted. A carrier gas, such as helium, is allowed to flow through the glass tube.

Next, a small sample of a mixture is injected into the glass tube and heated at a fixed temperature. The substance (in the mixture) with lower boiling point evaporates more easily and moves through the glass tube due to the flow of the carrier gas. The mixture separates into its constituent substances as it passes through the glass tube.

The time taken by each substance to reach the end of the glass tube is known as the retention time. Different substances have different retention times as they move through the glass tube at different rates.

A signal is recorded by the electronic detector when each substance reaches the end of the glass tube.

- (a)** Helium is often used as a carrier gas in gas chromatography because it will not react with the mixture of substances analysed.

Explain why helium will not react with other substances.

.....
.....
.....

[2]

- (b) Gas chromatography is often compared to fractional distillation due to their similarities.

State two similarities between gas chromatography and fractional distillation.

similarity 1

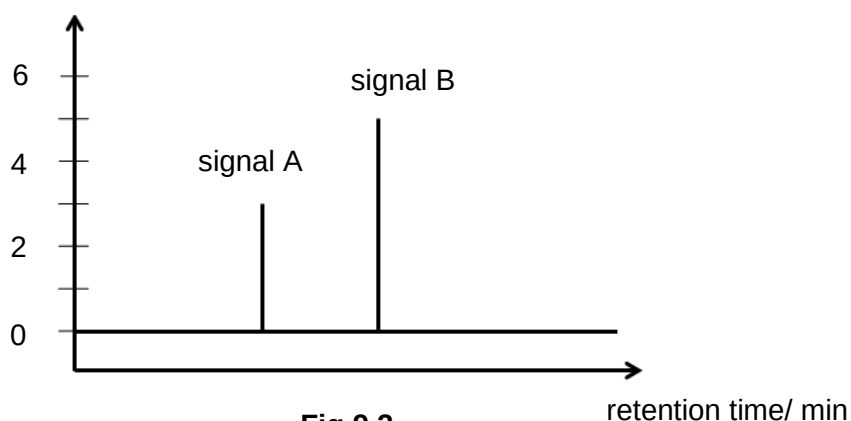
similarity 2 [2]

- (c) A mixture of mesitylene and toluene is separated using gas chromatography. The boiling point of each compound is provided in the table below.

compound	boiling point / °C
mesitylene	165
toluene	111

Fig 9.2 shows the chromatogram obtained.

height of detector signal



- (i) Identify the compound that produced each signal.

signal	compound
A	
B	

[1]

- (ii) The ratio of the heights of the signals gives the ratio of the amounts of the compounds present in the mixture.

Use the chromatogram above to find the percentage of each compound present.

Show your working in the space below.

[2]

- (d) The flow rate of the carrier gas can affect the retention times of the substances separated by gas chromatography.

Three identical mixtures of benzene and hexane are separated using gas chromatography with different flow rates of the carrier gas. The type of carrier gas used, and the temperature of the oven are kept constant for the three separations.

Fig. 9.3 shows the chromatograms obtained for the different flow rate of carrier gas.

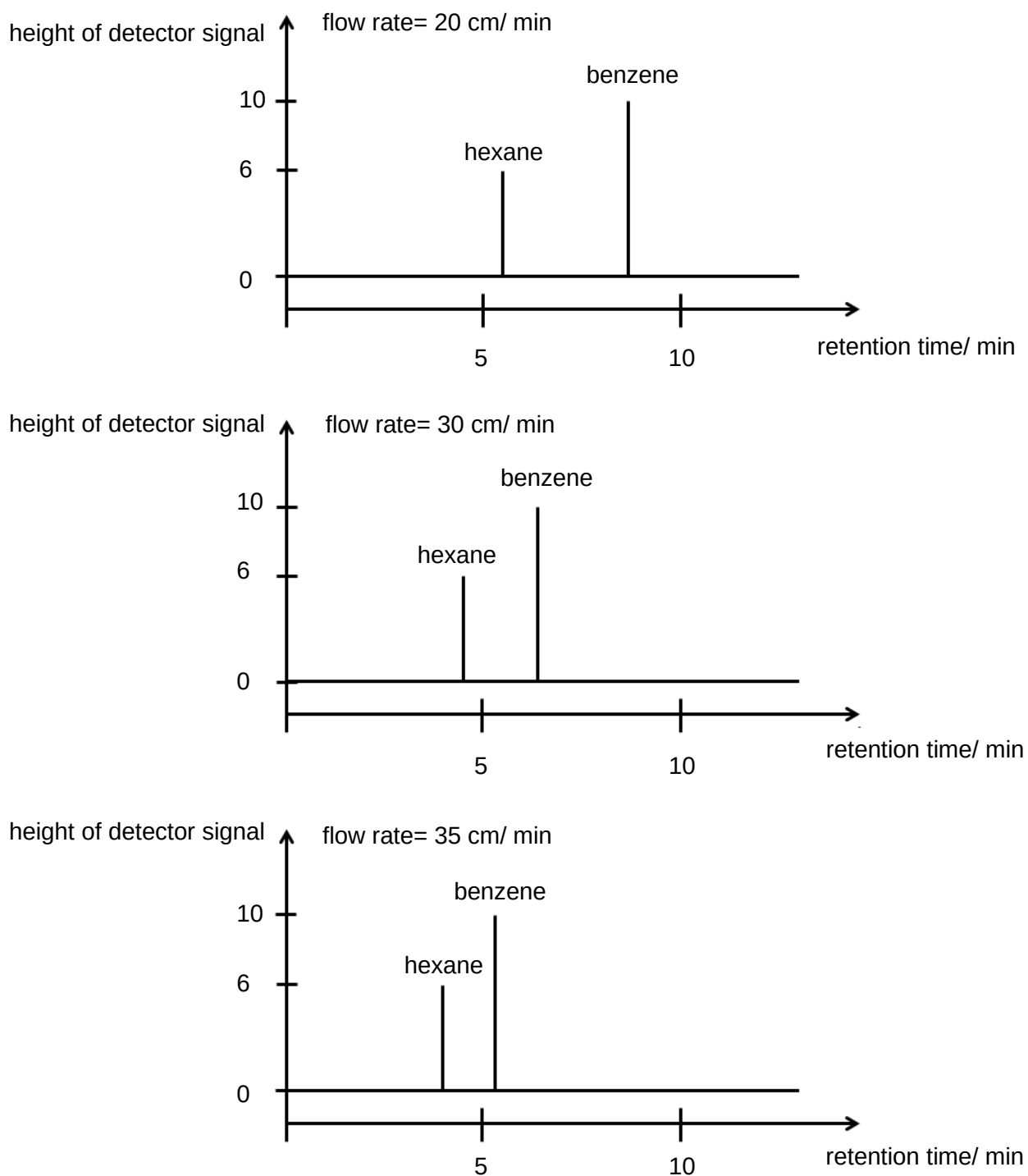


Fig. 9.3

- (i) Use the information provided in Fig 9.3, describe how the flow rate of the carrier gas affects the retention time of the compounds.

.....
.....
..... [2]

- (ii) Another identical mixture of benzene and hexane is separated with gas chromatography. The type of carrier gas and temperature used are kept constant, but the flow rate of the carrier gas is increased to higher than 35 cm/min.

Only one signal is obtained in the chromatogram shown in Fig. 9.4.

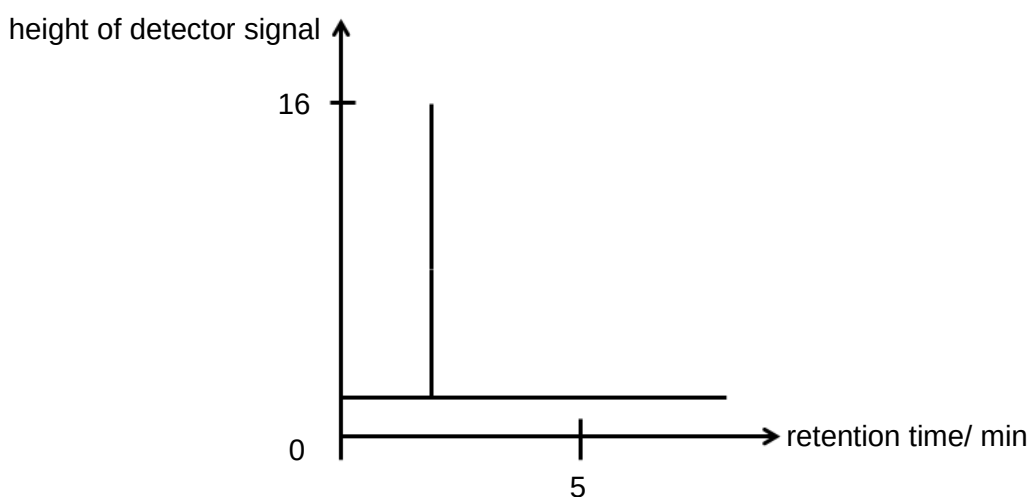


Fig. 9.4

Suggest why only one signal is obtained.

.....
..... [1]

[Total: 10]

Section B [10 marks]

Answer **one** question from this section.

- 10** Vinegar, also known as 'sour wine', is a type of carboxylic acid industrially made by the oxidation of an aqueous solution of ethanol in air and catalysed by bacteria which provide enzymes that speed up the oxidation process.

(a) Give the chemical name and draw the full structural formula of vinegar.

chemical name

full structural formula

[1]

(b) Apple cider vinegar is industrially made from oxidation of ethanol obtained from apple juice.

Briefly describe the process of how ethanol is obtained from apple juice. Include a balanced equation in your answer, stating the conditions required clearly.

.....
.....
.....
.....
.....
.....

[3]

- (c) The extent to which a particular type of gasoline will burn smoothly in an engine is indicated by the octane rating. Brands of petrol are typically available with octane ratings in the range of 83 to 98.

Table 10.1 lists the octane ratings of three organic compounds which can be used as fuels.

Table 10.1

compound	octane rating
<pre> H H H H H H — C — C — C — C — C — H H H H H H </pre>	62
<pre> H H — C — H H H H H H — C — C — C — C — H H H H H </pre>	92
<pre> H H — C — H H H H H H — C — C — C — C — H H H H H </pre>	116

- (i) Explain why the above compounds are classified as isomers.

.....

.....

.....

..... [2]

- (ii) Suggest a relationship between the structure of the compound and the octane rating.

.....
..... [1]

- (iii) Heptane, an alkane with 7 carbon atoms, is a particularly bad fuel and has been assigned an octane rating of zero. It can be cracked into smaller molecules under high temperatures and a catalyst.

A large volume of heptane was subjected to cracking and the main product was methane. The other only product gas **B**, which has a relative molecular mass of 28, was also isolated in the product mixture and was found to be unsaturated.

Write a balanced equation to show the cracking process. Describe a chemical test that can be used to distinguish between methane and gas **B**.

.....
.....
.....
.....
..... [3]

[Total: 10]

- 11** The structure of compound **A** is shown in Fig. 11.1.

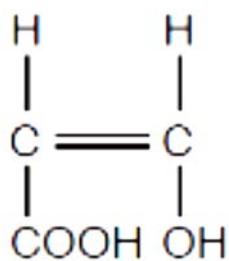


Fig. 11.1

Compound **A** can undergo two types of polymerisation.

- (a)** State the type of polymerisation and draw a section (showing two repeat units) of the polymer produced by each type of polymerisation.

first type of
polymerisation:

second type of
polymerisation:

- (b) The structure of compound **B**, a diester, is shown in Fig. 11.2.

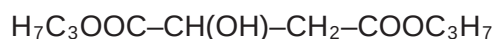


Fig. 11.2

B was made from malic acid and two molecules of an alcohol with three carbon atoms.

A student tried to describe the full structural formula of malic acid.

- Malic acid is a carboxylic acid because it contains the carboxyl group.
- Malic acid is also an alcohol as it contains the hydroxyl group.

Using the information above, draw out the full structural formula of malic acid.

[2]

- (c) Succinic acid is a colourless organic acid.
The structure of this acid is shown in Fig. 11.3.

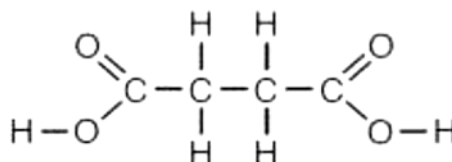
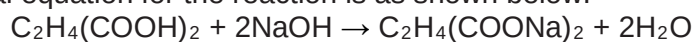


Fig. 11.3

In a titration carried out, succinic acid is neutralised by aqueous sodium hydroxide.

The chemical equation for the reaction is as shown below.



Calculate the minimum volume of 0.0200 mol/dm³ sodium hydroxide required to neutralize 25.0 cm³ of 0.0500 mol/dm³ succinic acid.

volume of sodium hydroxide:cm³ [2]

- (d) There are several types of nylon. One type of nylon is nylon-6,6. Fig. 11.4 shows the repeating unit of nylon-6,6.

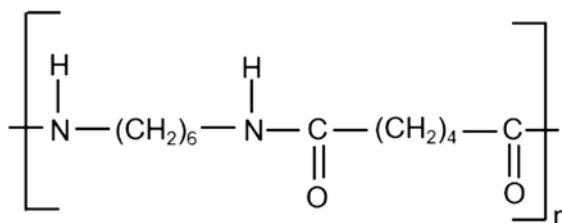


Fig. 11.4

- (i) During the manufacturing process, the chain length of the nylon is controlled so that the nylon polymer molecules have an average relative molecular mass in the range of 12000 to 20000.

What is the range of the average number of repeating units in the nylon-6,6 molecules? Show your working.

[Mr of the repeating unit: 226]

[2]

- (ii) Nylon-5,10 is made by reacting the two monomers shown in Fig. 11.5.



Fig. 11.5

Give one similarity and one difference between the structures of the repeating units of nylon-6,6 and nylon-5-10.

.....

 [2]

[Total: 10]

