Class	Index Number	Name

BUKIT MERAH SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2024
SECONDARY 4 EXPRESS

CHEMISTRY **6092/02**

Paper 2 **15 August 2024**

1 hour 45 minutes

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

READ THESE INSTRUCTIONS FIRST

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

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

Section B
Answer **one** question.
Write your answers in the spaces provided

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 26.

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

Section A

Answer **all** questions.

1 A list of compounds is shown.

aluminium oxide
calcium bromide
calcium oxide
ethane
ethene
hydrogen chloride
methane
nitrogen dioxide
potassium iodide
potassium manganate(VII)
sodium chloride

Answer the following questions using only the compounds in the list.

Each compound may be used once, more than once or not at all.

Which compound

(a) when in acidified solution, is used to test for sulfur dioxide,

……[1]

(b) is the main constituent of natural gas,

……[1]

(c) when dissolved in water, gives a yellow precipitate on addition of acidified aqueous silver nitrate,

……[1]

(d) is used in industries to neutralise acidic gases,

……[1]

(e) is a reactant used in the manufacture of ethanol,

……[1]

(f) reacts with both nitric acid and potassium hydroxide to give salt and water?

……[1]

[Total: 6]

2 A sample of ink contains a mixture of red, blue and yellow dyes. The chromatograms are run using a mixture of ethanol and water as solvent. Fig. 2.1 shows the graphical results of the coloured dyes of different R_f values in solvents with different proportions of ethanol.

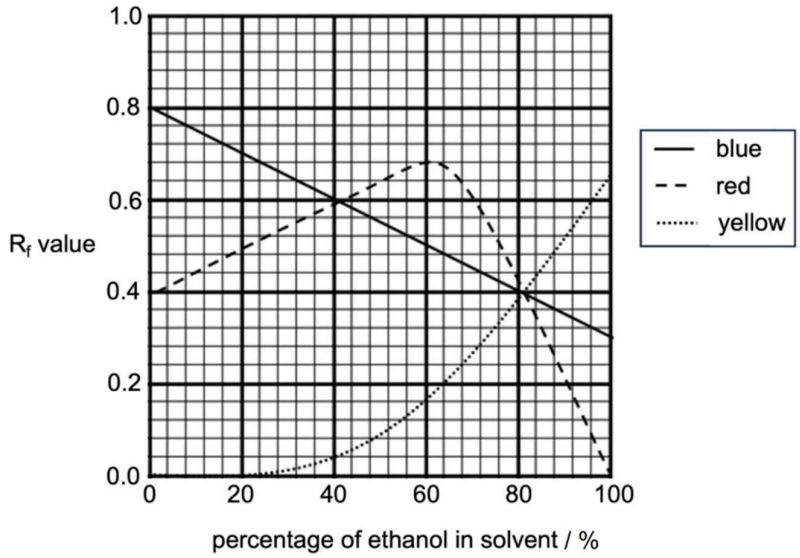


Fig. 2.1

(a) From Fig 2.1, deduce the R_f values of the blue dye on the chromatogram when the solvent is a mixture of 60cm^3 of ethanol and 40cm^3 of water.

……[1]

(b) The chromatography process is repeated with a filter paper when the solvent is a mixture of 20 cm^3 of ethanol and 80 cm^3 of water. A sample of ink was added to the middle of the filter paper.

On Fig. 2.2, sketch the chromatogram results for the three coloured inks. Label your results clearly.

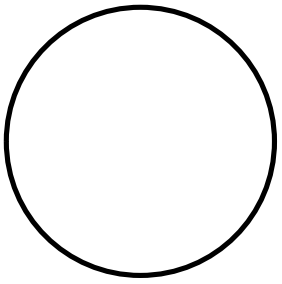


Fig. 2.2

[2]

(c) The student carried out chromatography on the ink using a different mixture of ethanol and water as solvent. There is only one spot forming on the chromatogram.

Using evidence from the graph, explain why he cannot conclude that the ink is a pure substance.

……

……[1]

[Total: 4]

3 Silicon is a semiconductor.

(a) Table 3.1 shows data obtained using the mass spectrum of silicon.

Table 3.1

isotope	relative abundance	number of protons	number of neutrons
^{28}Si	92.17		
^{29}Si	4.71		
^{30}Si	3.12		

(i) Complete Table 3.1 to show the number of protons and neutrons present in each isotope of silicon. [1]

(ii) Calculate the relative atomic mass of silicon to two decimal places.

relative atomic mass of silicon = …… [1]

(b) Silicon dioxide, SiO_2, is the main constituent of sand and has a giant lattice structure similar to that of diamond. Fig. 3.1 shows part of the structure of silicon dioxide.

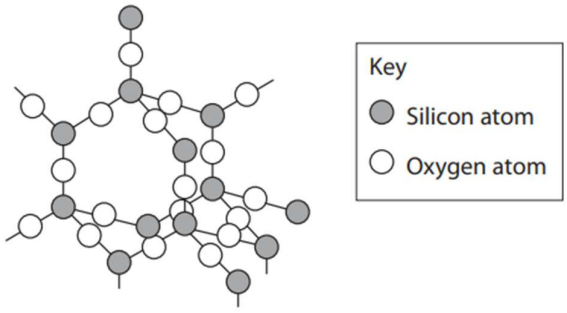


Fig. 3.1

Crystalline silicon dioxide is used on the surface of semiconductor devices to provide a heat-resistant, electrically insulating layer.

Explain how the structure and bonding of silicon dioxide make it useful for this application.

.....

.....

.....

.....

.....

.....

.....

.....[3]

[Total: 5]

4 Lead forms two chlorides, $PbCl_2$ and $PbCl_4$.

When chlorine is passed into a saturated solution of $PbCl_2$ in aqueous NH_4Cl, a yellow salt **Y**, is formed which has the following composition by mass:

Cl, 46.7%; H, 1.76%; N, 6.14%; Pb 45.4%

Y is ionic with a relative formula mass of 456.

(a) Determine the empirical formula of **Y**.

[2]

(b) One formula unit of **Y** contains one type of anion and one type of cation in the ratio of 1:2.

Given that **Y** is commonly known as ammonium hexachloroplumbate(IV), suggest the formula of each of the ions present in **Y**.

anion: ……

cation: ……..[2]

(c) What is the oxidation state of Pb in **Y**?

……[1]

[Total: 5]

5 Phosphoric acid (H_3PO_4) is a corrosive acid that can form three different classes of salts, namely primary phosphates, dibasic phosphates and tribasic phosphates.

It dissociates in a three-step process:

Step 1: $H_3PO_4(aq) \rightleftharpoons H_2PO_4^-(aq) + H^+(aq)$

Step 2: $H_2PO_4^-(aq) \rightleftharpoons HPO_4^{2-}(aq) + H^+(aq)$

Step 3: $HPO_4^{2-}(aq) \rightleftharpoons PO_4^{3-}(aq) + H^+(aq)$

Fig. 5.1 shows the pH graph of 0.1 mol/dm^3 of dilute phosphoric acid titrated with 0.1 mol/dm^3 of sodium hydroxide solution (NaOH). The horizontal axis is not labelled and stage C represents the stage when the dilute phosphoric acid is fully neutralised.

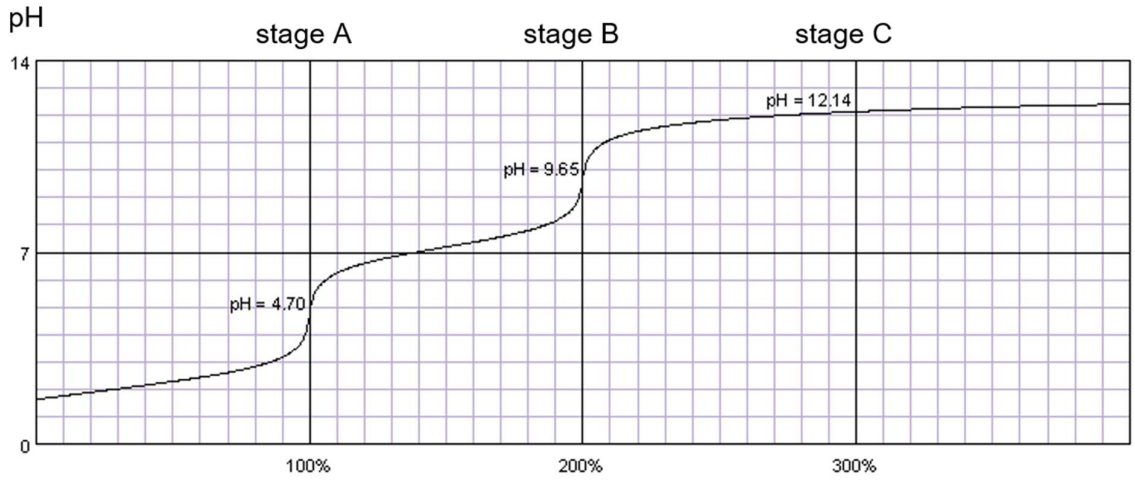


Fig. 5.1

(a) The horizontal axis is the percentage of the volume ratio of two reactants used.

Complete the following to show how the percentage should be calculated to obtain the horizontal axis of the pH graph in Fig. 5.1.

$$\frac{\text{volume of } \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots}{\text{volume of } \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots} \times 100\%$$

[1]

(b) Write the formula of the salt formed at stage **A** of the titration.

……[1]

(c) Table 5.1 shows three indicators and the pH where colour change takes place.

Table 5.1

indicator	pH where colour change takes place
methyl orange	3.1 – 4.4
bromothymol blue	6.0 – 7.6
phenolphthalein	8.3 – 10.0

State which indicator can indicate the completion of stage **B**. Explain your answer.

……

……

……

……[2]

[Total: 4]

6 The first ionisation energy is defined as the energy required to remove the most loosely held electron in an atom to form an ion.

Table 6.1 shows the first ionisation energy for the elements in Group 1.

Table 6.1

element	ionisation energy (MJ/mol)
lithium	0.526
sodium	0.502
potassium	0.425
rubidium	0.409
caesium	0.382

(a) Based on your understanding about the reactivity of Group 1 metals, state and explain the relationship between ionisation energy and reactivity of Group 1 metals with reference to its atomic structure.

……

……

……

……[2]

(b) Predict the ionisation energy for fluorine.

Explain your answer.

……

……

……

……[2]

[Total: 4]

7 The addition reaction between ethene and bromine is described by the equation below.

$$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$$

Table 7.1 shows some bond energies.

Table 7.1

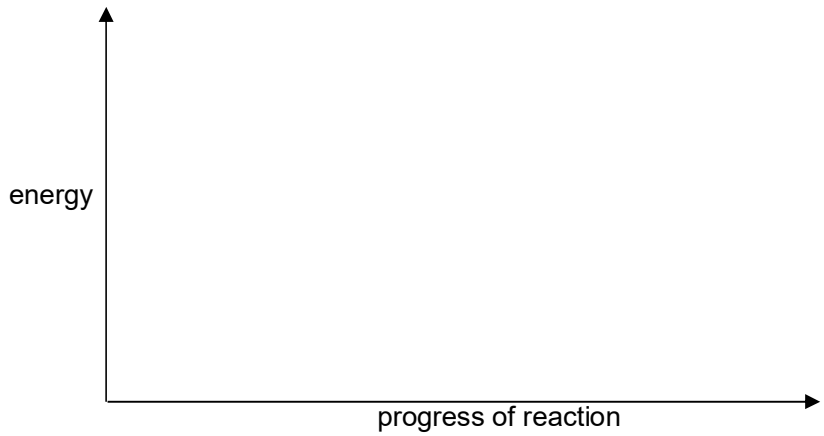
bond	bond energy (kJ/mol)	bond	bond energy (kJ/mol)
C-C	349	C-H	410
C=C	602	Br-Br	193
H-H	436	C-Br	276
H-Br	366		

(a) Calculate the enthalpy change, ΔH, for this reaction.

ΔH = ... kJ/mol [3]

(b) Hence or otherwise, draw an energy profile diagram for the addition reaction between ethene and bromine.

Your diagram should show and label
- reactants and products
- the activation energy for the reaction
- the enthalpy change of the reaction



[2]

[Total: 5]

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

$$PbCO_3\ (s) + 2HNO_3\ (aq) \rightarrow CO_2\ (g) + Pb(NO_3)_2\ (aq) + H_2O\ (l)$$

Two experiments are carried out at 30°C and 40°C using excess dilute nitric acid. All other experimental conditions were kept constant. Fig. 8.1 shows the results of both experiments.

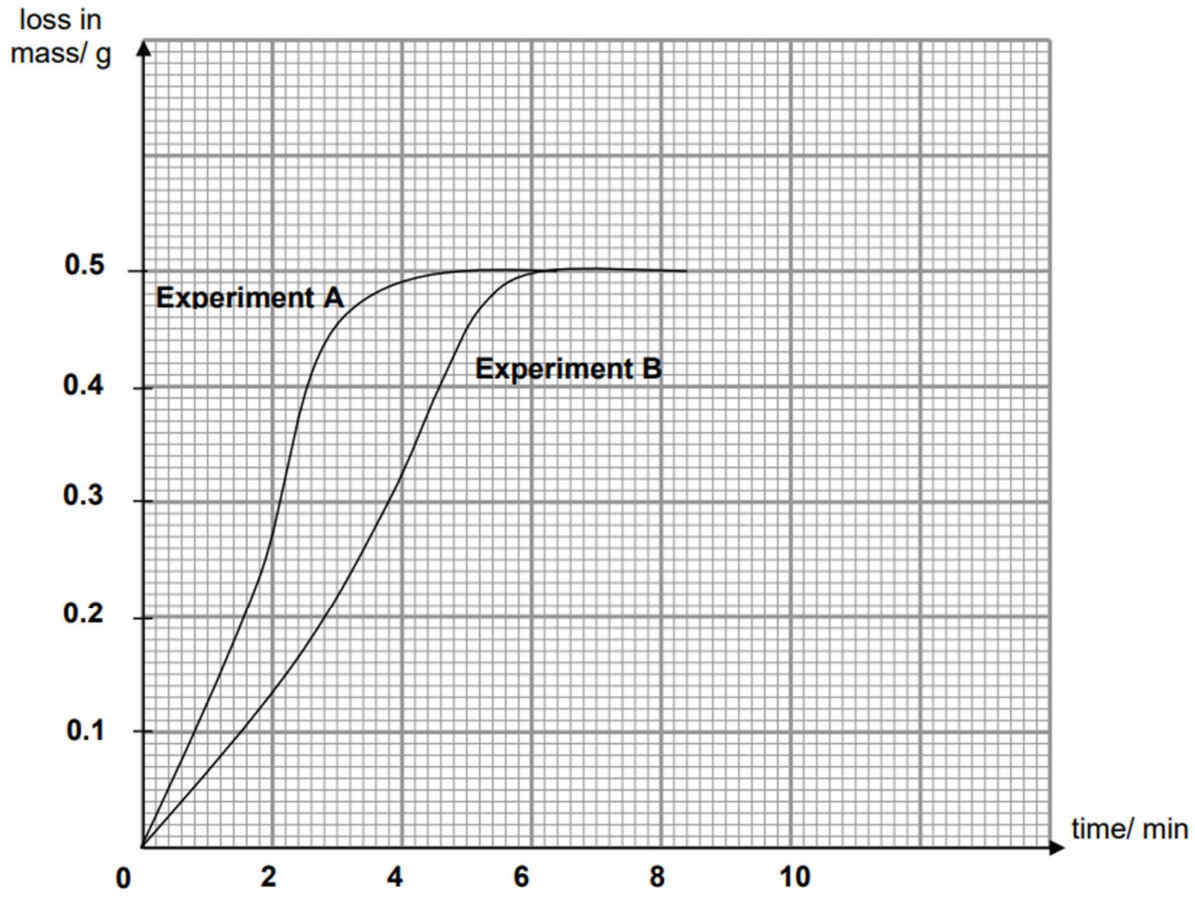


Fig. 8.1

(a) With reference to the shape of the graph, state which experiment was carried out at 40 °C.

Explain your answer in terms of collisions between particles.

.....

.....

.....

.....

.....

.....[3]

(b) Calculate the rate of reaction in g/min for the first 2 min of Experiment **B**.

rate of reaction = …… g/min [1]

(c) Explain why there was a loss in mass over time.

……[1]

(d) Calculate the mass of lead(II) carbonate used in each experiment.

mass of lead(II) carbonate = …….. g [2]

(e) If temperature was kept constant at 30°C for both experiments **A** and **B**, state another condition that could have resulted in the results shown in Fig. 8.1.

……[1]

(f) Experiment **B** is repeated using half the mass of lead(II) carbonate with all other conditions are kept constant.

On Fig. 8.1, draw a graph to show the results of this experiment. [1]

[Total: 9]

9 Fig. 9.1 shows two different set-ups that a student used to investigate the effects of passing different gases through substances in a glass tube.

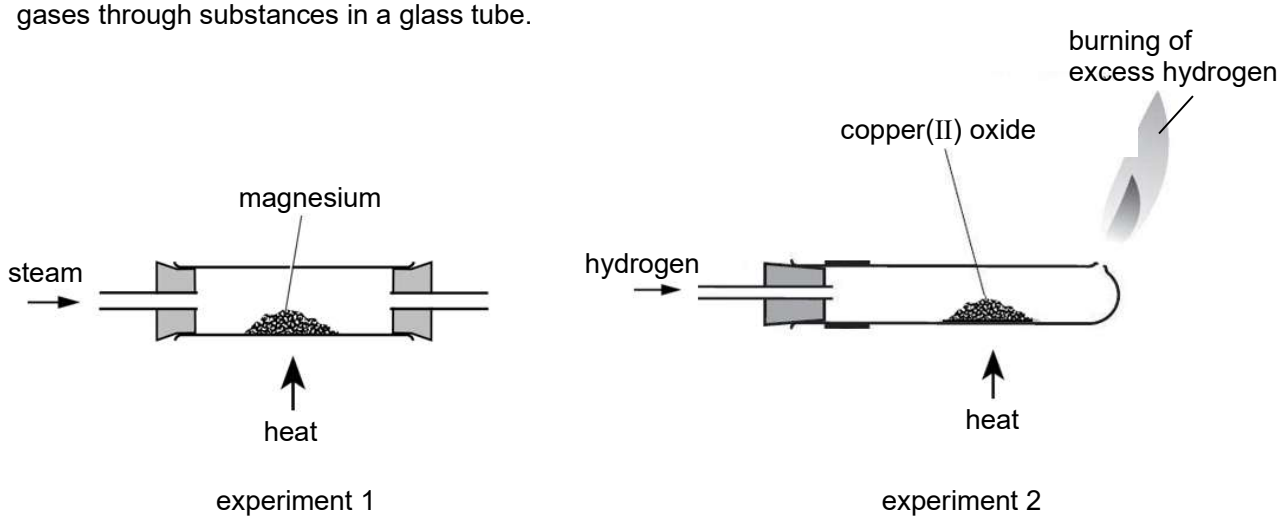


Fig. 9.1

(a) Describe what he would expect to observe in each experiment.

Support your answer with chemical equations for the reactions that occur.

experiment **1** .....

.....

.....

experiment **2** .....

.....

.....[4]

(b) Suggest why it is important to continue passing hydrogen through the glass tube until the set-up is completely cooled at the end of experiment **2**.

.....

.....[1]

(c) Experiments **1** and **2** were repeated.

(i) Experiment **1** was repeated using copper.
Experiment **2** was repeated using magnesium oxide.

Explain why no reaction occurs in both experiments.

……

……

……

……[2]

(ii) A student wants to repeat Experiment **2** with silver(I) oxide. He read in a textbook that silver(I) oxide decomposes readily at 280 °C and that copper(II) oxide does not decompose when heated to 280 °C.

Explain why the two oxides react differently.

……

……[1]

[Total: 8]

10 Carpet fibre can be made by the polymer polytrimethylene terephthalate (PTT).

Fig. 10.1 shows one repeating unit of PTT

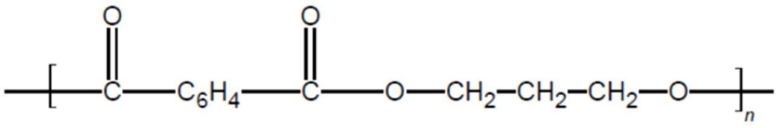


Fig. 10.1

Carpet fibre can also be made by the natural rubber polymer, poly(isoprene), which can be extracted from rubber trees.

Fig. 10.2 shows two repeating units of poly(isoprene).

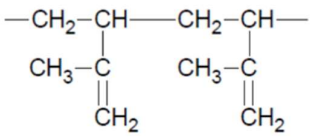


Fig. 10.2

(a) Draw the structures of the monomers used to form PTT and poly(isoprene).

monomers used to form PTT:

monomer used to form poly(isoprene):

[2]

(b) Calculate the number of moles of repeating units present in 1kg of PTT and 1kg of poly(isoprene) respectively.

number of moles of repeating units present = ……[2]

(c) Hence, using suitable calculations or otherwise, explain how and why burning 1.0 kg of poly(isoprene) contributes more to global warming than burning 1.0 kg of PTT.

……

……

……

……

……

……[2]

(d) To address the environmental impact of PTT and poly(isoprene), which resist decomposition and contribute to land pollution, one viable solution involves depolymerisation.

(i) Suggest how depolymerisation works.

……[1]

(ii) Suggest one alternative approach that can also help prevent land pollution.

……[1]

[Total: 8]

11 The **Clark Sensor**, shown in Fig 11.1 is an electrolysis cell which is used to measure the concentration of oxygen gas dissolved in samples of water from rivers, seas and blood.

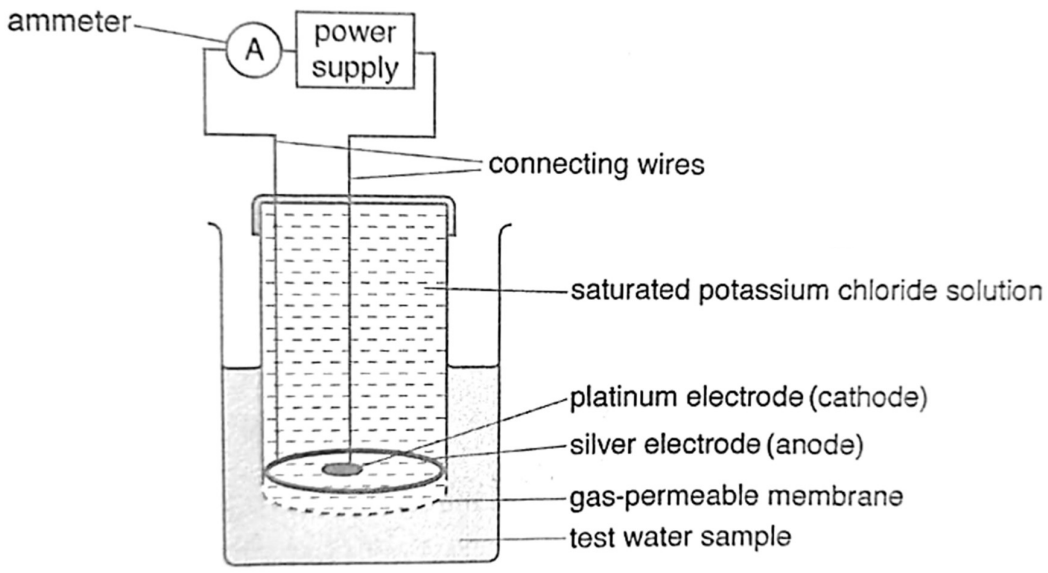


Fig. 11.1

Oxygen gas dissolved in water sample can diffuse across the gas-permeable membrane. This causes the oxygen to react at the platinum electrode. The following equation shows the overall reaction occurring when the measurements are taken.

$$4Cl^- + 4Ag + O_2 + 4H^+ \rightarrow 4AgCl + 2H_2O$$

During this reaction, the movement of electrons generates higher rate of flow of electrons. The rate of flow of electrons is proportional to the concentration of oxygen in the water sample.

In hospital, the portable blood glucose monitoring device include a Clark Sensor to monitor the amount of dissolved oxygen in the patient's blood. Table 11.1 shows the ammeter reading taken from Clark Sensor for five different blood samples.

Table 11.1

blood sample	ammeter reading (nA)
A	10
B	12
C	30
D	2
E	14

The **Winkler Method** is another method for determining the oxygen concentration in water samples. It involves a series of chemical reactions that convert dissolved oxygen into a measurable form, allowing for precise quantification. This method is widely employed in environmental science, aquatic biology, and water quality monitoring to assess oxygen levels, which are crucial indicators of ecosystem health and water quality.

The following shows the steps involved:

1. Manganese(II) sulfate is added to an excess of alkali.

$$Mn^{2+}\ (aq) + 2OH^{-}\ (aq) \rightarrow Mn(OH)_2\ (s)$$

2. The resulting mixture is added to 100 cm^3 of the water sample containing dissolved oxygen.

$$2H_2O\ (l) + 4Mn(OH)_2\ (s) + O_2\ (g) \rightarrow 4\ Mn(OH)_3\ (s)$$

3. An excess of acidified potassium iodide is then added.

$$2Mn(OH)_3\ (s) + 2I^{-}\ (aq) + 6H^{+}\ (aq) \rightarrow 2Mn^{2+}\ (aq) + I_2\ (aq) + 6H_2O\ (l)$$

4. The mixture is then transferred to a conical flask and titrated with a standard solution of sodium thiosulfate using starch as an indicator.

$$I_2\ (aq) + 2S_2O_3^{2-}\ (aq) \rightarrow 2I^{-}\ (aq) + S_4O_6^{2-}\ (aq)$$

(a) Write the ionic half equations, with state symbols, occurring at the anode and cathode of the Clark Sensor when **no** measurement was taken.

anode: ……..……..

cathode: ……..……[2]

(b) Explain why the overall reaction at the Clark Sensor when measurements are taken is a redox reaction.

……

……

……

……

……

……[2]

(c) Suggest why the water sample in a Clark Sensor is stirred constantly during the measurement.

……

……[1]

(d) One of the electrodes in Clark Sensor needs to be cleaned regularly to remove a white solid which forms during the measurement.

Identify the electrode and white solid formed.

……[1]

(e) With reference to Table 11.1, suggest which blood sample is poisoned with carbon monoxide.

Explain your answer.

……

……

……

……

……

……[2]

(f) State how manganese is showing typical behaviour of a transition element in the Winkler Method.

……

……[1]

(g) In Winkler Method. a 100 cm^3 sample of water containing dissolved oxygen required 11.20 cm^3 of 0.01 mol/dm^3 of sodium thiosulfate solution to react.

Calculate the concentration of O_2 in this sample in mol/dm^3.

Concentration of O_2 = …… mol/dm^3 [3]

[Total: 12]

Section B

Answer **one** question from this section.

12 (a) Ethers are used as an antiseptic to prevent infection when an injection is administered into the body. Table 9.1 shows some information about a homologous series known as ethers.

Table 9.1

name	formula	boiling point/ ºC
methoxymethane	CH_3-O-CH_3	-24.8
methoxyethane	CH_3-O-C_2H_5	7.0
methoxypropane	CH_3-O-C_3H_7	39
W		70.3

(i) Deduce the name and formula of **W**, the fourth member of ether.

name	
formula	

[2]

(ii) Ethers and alcohols are isomers.

Name and draw the full structural formula of the isomer of methoxyethane.

name	
full structural formula	

[2]

(iii) The isomer in **(ii)** reacts with ethanoic acid to form an ester.

Name and draw the full structural formula of this ester.

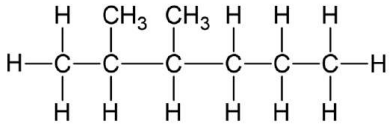
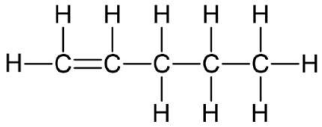
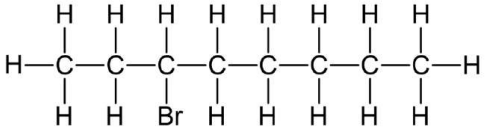
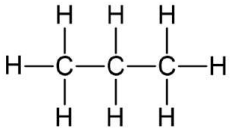
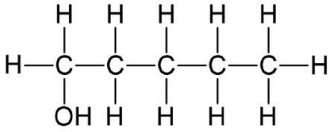
name	
full structural formula	

[2]

(b) Octane is a straight-chain alkane that comprises 8 carbon atoms. It is a component of petrol and is highly flammable.

Table 12.2 shows the structures of organic compounds **A** to **E**. These organic compounds are obtained either from a reaction involving octane or when one of the compounds in the table undergoes further chemical reaction.

Table 12.2

organic compound	structure of compound
A	
B	
C	
D	
E	

(i) Compounds **A**, **B**, **C** and **D** are formed when octane undergo one of the following processes:

- cracking
- isomerisation
- substitution reaction

Identify and explain which process results in the formation of **A**, **B**, **C** and **D**.

……

……

……

……[3]

(ii) Compound **E** is produced when one of the compounds **A**, **B**, **C** or **D** undergoes further reaction.

State which compound **A**, **B**, **C** or **D** and the reagent and/or conditions needed for it to form compound **E**.

……..

…….[1]

[Total: 10]

13 In the past, the World Cup soccer ball's innermost layer is a spherical bladder formed from butyl rubber. Butyl rubber is composed mostly of isobutylene. Fig. 13.1 shows the structure of isobutylene.

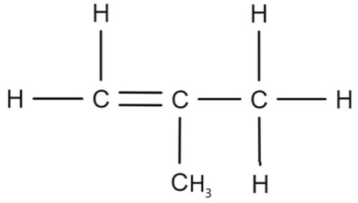


Fig. 13.1

(a) (i) Name the homologous series that isobutylene belongs to and state its general formula.

……[2]

(ii) Draw an isomer of isobutylene.

[1]

(b) Isobutylene undergo a few chemical reactions to become compound **X**.

Fig. 13.2 shows the structure of compound **X**.

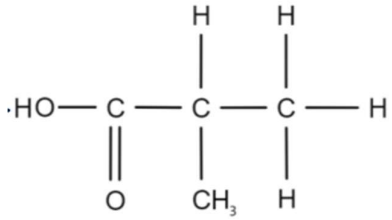


Fig. 13.2

(i) Describe a chemical test to differentiate isobutylene and compound **X**.

test: ……...

observation with isobutylene: ……

……

observation with compound **X**: ……

……[2]

(ii) Suggest how isobutylene can be made into compound **X**. Include in your answer, the names of any reagents used and the conditions required for the reaction to occur.

……

……

……

……[2]

(c) Isobutylene exists as a gas at room temperature and pressure. However, after isobutylene undergo polymerisation to form poly(isobutylene), its melting point increases drastically.

In terms of bonding and structure, explain why the melting point increases drastically after isobutylene undergoes polymerisation.

……

……

……

……

……

……[3]

[Total: 10]

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key: proton (atomic) number; atomic symbol; name; relative atomic mass									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	3	4	5	6	7	8	9	10	11	12	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 –	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 dm^3 at room temperature and pressure (r.t.p.).
The Avogadro constant, $L = 6.02 \times 10^{23}\ mol^{-1}$.