	Class	Register Number
Name		

6092/02
CHEMISTRY

23/4P/6092/2

PAPER 2

Tuesday **29 August 2023** **1 hour 45 minutes**

VICTORIA SCHOOL

PRELIMINARY EXAMINATION
SECONDARY FOUR

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.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

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

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

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

A copy of the Periodic Table is printed on page 22.

Section A	**/ 50**
Section B	**/ 30**
Total	**/ 80**

Deductions	
Presentation	
Significant Figures	
Units	

This question paper consists of 22 printed pages, including the cover page.

Section A

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

A1 Select substances from the list to answer the following questions.

You may use each substance once, more than once or not at all.

CuO

K

CO_2

$Ca(OH)_2$

SO_3

Ni

Cl_2

SO_2

(a) Which substance is a product of respiration?

....[1]

(b) Which substance gives a lilac flame when added to water?

....[1]

(c) Which substance is a catalyst in the hydrogenation of alkenes?

....[1]

(d) Which substance can produce effervescence when reacted with ammonium chloride?

....[1]

(e) Which two substances when added together will form only one compound?

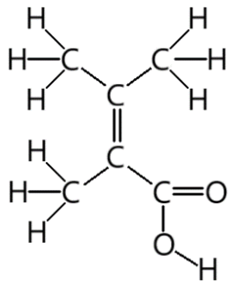
....[1]

(f) Which substance is emitted by volcanoes and lead to global warming and acid rain?

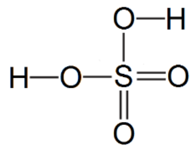
....[1]

[Total: 6]

A2 Fig. 2.1 shows the structures of compound **S** and compound **T**.



compound **S**



compound **T**

Fig. 2.1

(a) Compound **S** is a weak acid while compound **T** is a strong acid.

(i) Explain why compounds **S** and **T** are classified as acids.

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

(ii) A student states that compounds **S** and **T** can be identified by making measurements using magnesium strips.

Describe how the student can show this.

……………………………………………………………………………………...……........

……………………………………………………………………………………...……........

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

(iii) Describe what will be observed when compound **S** is added into a test-tube of aqueous iodine.

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

(b) 25.0 cm^3 of 1.2 mol/dm^3 compound **S** was titrated with aqueous sodium hydroxide.

The pH of the mixture was monitored with a pH probe connected to a datalogger.

Fig. 2.2 shows the pH curve of the titration.

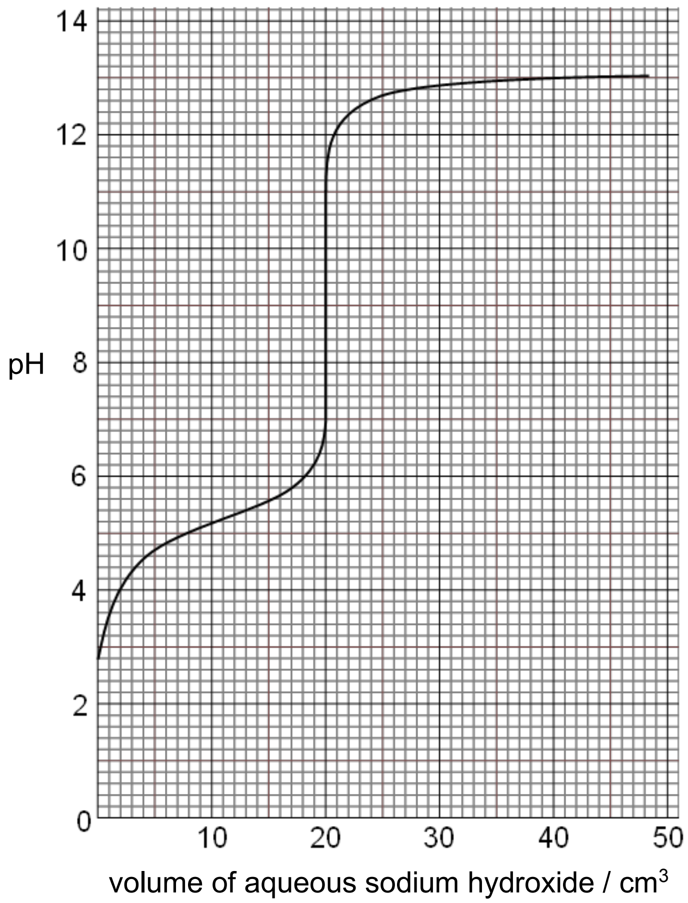


Fig. 2.2

(i) Write the ionic equation when compound **S** reacts with dilute sodium hydroxide.

[1]

(ii) State the pH of the salt formed.

……………………………………………………………………………………………[1]

(iii) 25.0 cm^3 of 1.2 mol/dm^3 compound **T** is titrated with the same aqueous sodium hydroxide.

Sketch the pH curve on Fig. 2.2. [2]

(c) 50 cm^3 of 1.2 mol/dm^3 compound **S** and compound **T** were placed in separate beakers. 1.0 g of calcium carbonate was added into each beaker.

(i) A student predicted the reaction with compound **T** will complete earlier.

Explain why the student is wrong.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(ii) Calculate the volume of gas produced when calcium carbonate reacts with compound **S**.

[3]

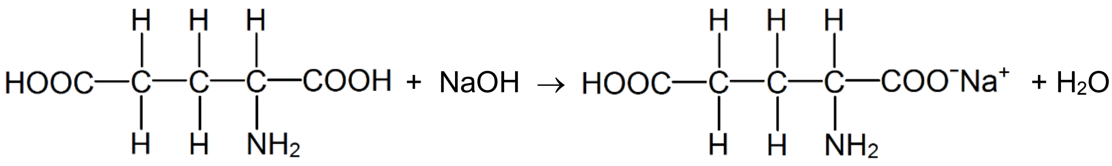
(d) Compound **S** and methanol was warmed with some concentrated compound **T**.

Draw the **displayed formula** of the compound formed.

[2]

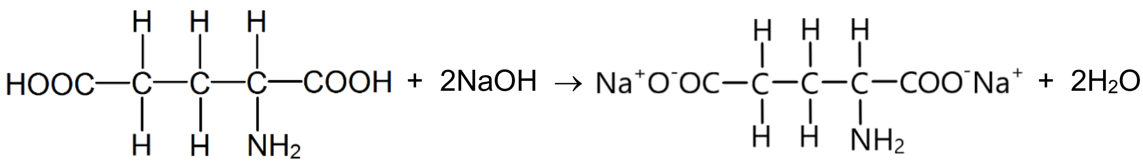
[Total: 14]

A3 **(a)** Monosodium glutamate, commonly known as MSG, can be prepared by reacting aqueous glutamic acid with aqueous sodium hydroxide.



monosodium glutamate

In a titration, 25.0 cm^3 aqueous glutamic acid reacts with 22.40 cm^3 of 1.0 mol/dm^3 sodium hydroxide.



disodium glutamate

(i) Explain why titration must be used to prepare monosodium glutamate from aqueous glutamic acid.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

(ii) State the volume of 1.0 mol/dm^3 sodium hydroxide to be added into 250 dm^3 of the same aqueous glutamic acid to produce a pure solution of monosodium glutamate. Explain your answer.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(b) Copper(II) glutamate is prepared by reacting aqueous glutamic acid with excess copper(II) carbonate.

(i) Name another chemical which reacts with aqueous glutamic acid to form copper(II) glutamate.

……………………………………………………………………………………………………[1]

(ii) State the advantage of using excess copper(II) carbonate instead of aqueous glutamic acid in the preparation of copper(II) glutamate.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

[Total: 5]

A4 Ethanol is manufactured by the reaction between ethene and steam.

$$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$$

Table 4.1 shows the bond energies of some chemical bonds.

Table 4.1

bond	bond energy in kJ/mol	bond	bond energy in kJ/mol
O = O	498	O – H	463
O – O	144	C – H	414
C – C	346	C = O	804
C = C	610	C – O	358

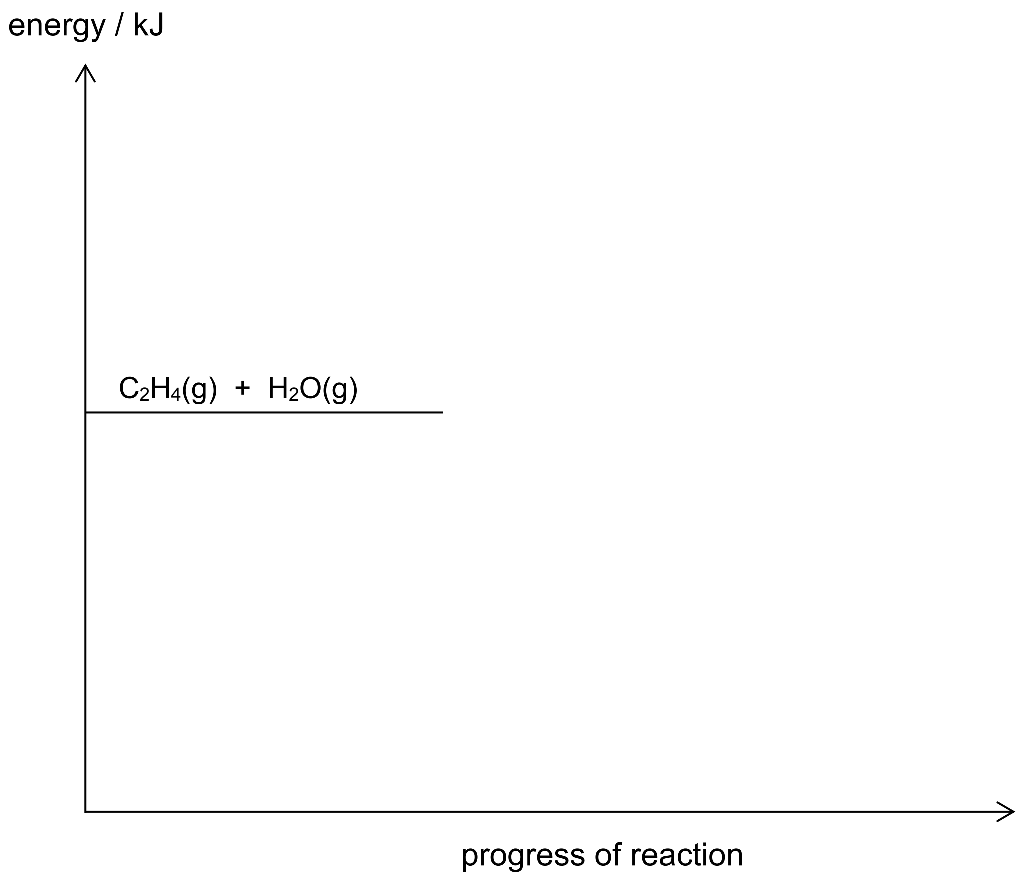
(a) Using the bond energies provided, calculate the total energy change for this reaction.

[3]

(b) Complete the energy profile diagram for the reaction between ethene and steam.

Your diagram should show:

- the products of the reaction
- the energy profile and activation energy, $E_a(1)$, for the reaction
- the energy profile and activation energy, $E_a(2)$, for the reaction when nickel is added
- the enthalpy change of reaction, ΔH



[4]

[Total: 7]

A5 *Ideonella sakaiensis* is a type of bacteria found in cow stomachs that can break down polyethylene terephthalate (PET), a type of plastic commonly used to produce bottles.

The structure of PET is shown in Fig. 5.1.

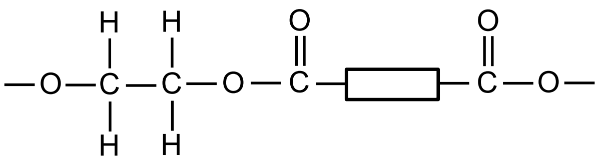


Fig. 5.1

(a) PETase produced by the bacteria breaks down PET to produce ethylene glycol and terephthalic acid.

(i) Draw the full structural formulae of the monomers that react to form PET.

[2]

(ii) State the role of PETase in the breakdown of PET.

....[1]

Plastic products can be upcycled to form vanillin, which is a synthetic vanilla flavour.

Vanillin contains the aldehyde functional group.

(b) Table 5.1 shows information about homologous series of aldehydes.

Table 5.1

name	number of carbon atoms	formula	solubility
methanal	1	HCHO	soluble
ethanal	2	CH_3CHO	soluble
propanal	3	C_2H_5CHO	partially soluble
	4		insoluble

(i) Complete Table 5.1 to show the name and formula of the aldehyde that contains 4 carbons. [2]

485

(ii) Deduce the general formula for aldehydes.

………...[1]

(iii) Using information on the structures of aldehydes and your knowledge of Organic Chemistry, suggest two factors that affect the solubility of organic compounds.

factor 1: …………………………………………………………………………………

…………………………………………………………………………………...

factor 2: …………………………………………………………………………………

……………………………………………………………………………….[2]

Waxworms were recently discovered to be able to eat and digest poly(ethene) plastic. The saliva from waxworms can metabolise poly(ethene) into ethylene glycol.

(c) **(i)** Suggest the chemical reaction involved in the metabolism of poly(ethene) into ethylene glycol.

………...[1]

(ii) Explain how waxworms can help in the environmental problems posed by plastics.

………………..……………………………………………………………………………...

………...[1]

[Total: 10]

A6 Two pigments, **A** and **B**, both purple in colour, were subjected to radial chromatography. A small amount of the pigment was placed at the centre of a piece of filter paper and allowed to dry.

Drops of pure ethanol were slowly added to the centre of the filter paper. The appearances of the filter papers after chromatography is completed are shown in Fig. 6.1.

Fig. 6.1

(a) Describe and explain the difference in the chromatograms for pigments **A** and **B**.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

Column chromatography uses a column containing powdered starch instead of filter paper for chromatographic separation.

(b) Pigment **B** was added to the top of the column and allowed to soak as shown in Fig. 6.2.

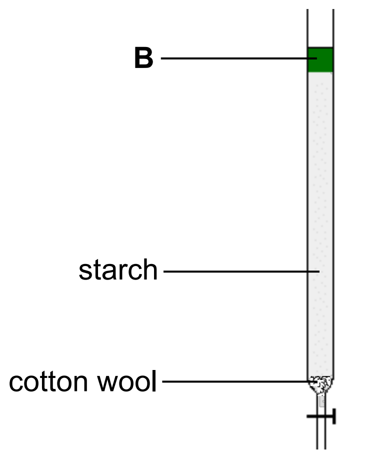


Fig. 6.2

(i) Suggest what should be added next to the top of the column for chromatographic separation to take place.

……………………………………………………………………………………………[1]

(ii) Give one advantage of using paper chromatography compared to column chromatography.

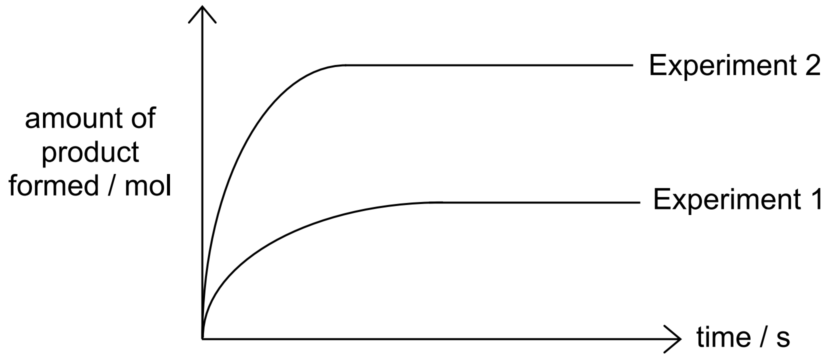
……………………………………………………………………………………………[1]

Pigment **A** is manganese violet, which can be synthesised from the reaction between manganese dioxide, ammonium dihydrogenphosphate and phosphoric acid.

(c) Two experiments were conducted to synthesise manganese violet.

Experiment 1 used 20 cm^3 of 2 mol/dm^3 phosphoric acid.

Experiment 2 used 10 cm^3 of 8 mol/dm^3 phosphoric acid.



(i) State the chemical that is likely to be the limiting reactant in both experiments.

Explain your answer.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(ii) Use ideas about collisions between particles to explain how concentration changes the time taken for Experiments 1 and 2 to complete.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

[Total: 8]

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B7 Manganese ores

Manganese is the twelfth most abundant metal in the earth crust. Some information on the rocks containing the various manganese ores mined at different mines are given in Table 7.1. Because the ores are not distributed evenly within the rocks, rocks obtained from different regions of the same mine will contain different amounts of ore.

Table 7.1

mine	percentage of manganese ore in rock	manganese ore	manganese compound in ore
Alpha	5 – 9 %	pyrolusite	MnO_2
Beta	2 – 12 %	manganite	$MnO(OH)$
Gamma	8 – 13 %	hausmannite	Mn_3O_4
Delta	1 – 4 %	rhodochrosite	$MnCO_3$

Extraction of manganese

Manganese is extracted by smelting of the ores in a blast furnace. The higher oxides such as manganese(III) oxide (Mn_2O_3) and manganese(IV) oxide (MnO_2) are reduced to manganese(II) oxide by carbon monoxide. Manganese(II) oxide can be reduced to the metal only at elevated temperature by carbon.

The presence of silica in the ores complicates the extraction of manganese as it chemically combines with manganese(II) oxide and prevents it from being reduced. This is overcome by roasting limestone with the manganese ores. However, this produces more slag, which tends to dissolve manganese and lower the yield of metal in the melt. In addition, silica can be reduced to silicon and enter the molten metal. Depending on the conditions of the smelting processes, the metal obtained may contain between 65% to 80% manganese with varying amounts of iron, silicon and carbon.

Purification of manganese

If pure manganese is required, the manganese ores are first roasted to obtain manganese(II) oxide and then reacted in dilute sulfuric acid to form raw manganese(II) sulfate solution. Aqueous ammonia is then added to precipitate out iron(III) and aluminium ions. The addition of aqueous hydrogen sulfide will precipitate out cobalt, copper, lead and zinc. The purified solution is electrolysed using stainless steel and graphite electrodes as shown in Fig. 7.1. The electrolyte must be replaced periodically or effervescence at the cathode will intensify.

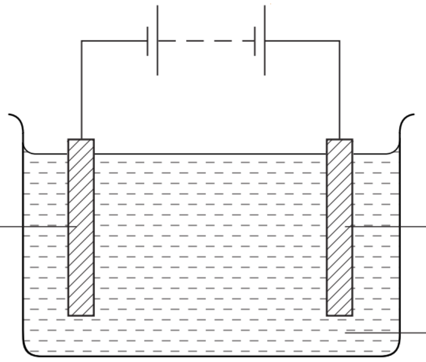


Fig. 7.1

When the manganese deposited on the stainless steel sheet is a few millimetres thick, the sheet is extracted and the manganese deposits are removed by hammering. The flakes are heated to 500 °C to remove hydrogen gas, resulting in a manganese of greater than 99.9% purity.

(a) Show that one tonne of rock mined from Gamma mine always produce a higher mass of manganese than one tonne of rock mined from Alpha mine.

[3]

(b) Write a balanced equation for action of carbon monoxide on the manganese compound in hausmannite in the blast furnace.

[1]

(c) State the reasons why the yield and purity of manganese obtained from the smelting of ores in a blast furnace are low.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[3]

(d) Explain why roasting limestone with manganese ores will overcome the problem caused by silica.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

(e) Suggest why aqueous ammonia is chosen over aqueous sodium hydroxide to precipitate out iron(III) and aluminium ions in the raw manganese(II) sulfate solution.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

(f) **(i)** State why effervescence at the cathode will intensify if the electrolyte is not replaced periodically.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(ii) Explain why hydrogen gas is found in the manganese flakes obtained from the electrolysis process.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(g) Manganese and sodium are metals.

State a use for manganese where sodium is not suitable.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

[Total: 12]

B8 The Leclanché cell is a dry cell widely used as a source of electricity for torches and clocks.

Fig. 8.1 shows the components of a Leclanché cell.

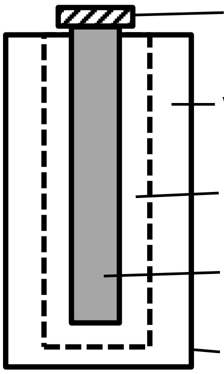


Fig. 8.1

The electric cell works by redox reaction. The following reaction occurs at the zinc case.

$$Zn \rightarrow Zn^{2+} + 2e^-$$

The following reaction occurs at the carbon rod.

$$2MnO_2 + 2H^+ + 2e^- \rightarrow Mn_2O_3 + H_2O$$

The hydrogen ions are provided by the dissociation of the ammonium ions.

$$NH_4^+ \rightleftharpoons NH_3 + H^+$$

The Leclanché cell can deliver a voltage of about 1.4 volts.

(a) Describe how electricity is generated when the Leclanché cell is being used.

....

....

....

....

....[3]

(b) State, with reason, whether the carbon electrode is the anode or cathode.

....

....[1]

(c) The cell becomes wet and smelly when it runs out.

Explain this observation.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………[2]

(d) **(i)** The zinc case is replaced with iron case.

The new Leclanché cell delivers a voltage of 1.1 volts.

Explain the difference.

………………………………………………………………………………………………

………………………………………………………………………………………………[1]

(ii) State another disadvantage for using iron case over zinc case.

………………………………………………………………………………………………

………………………………………………………………………………………………[1]

[Total: 8]

EITHER

B9 The structures of two forms of carbon are shown in Fig. 9.1.

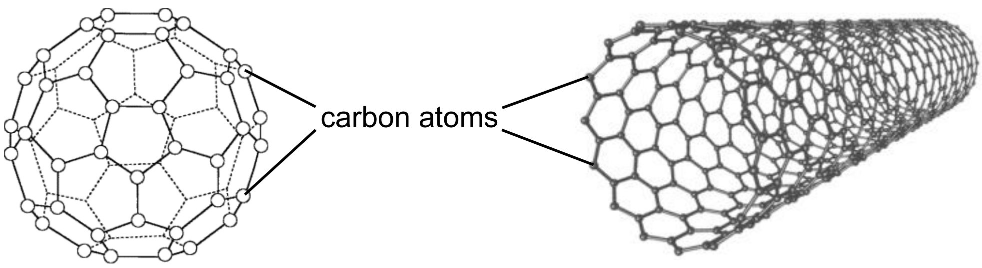


Fig. 9.1

(a) State one similarity and one difference in the bonding and structures of fullerene and carbon nanotube.

Hence, or otherwise, explain why fullerenes cannot conduct electricity while carbon nanotube can.

....

....

....

....

....

....

....

....

....[5]

(b) **(i)** Explain, in terms of structure and bonding, why fullerenes sublime at a relatively low temperature of 600 °C.

....

....

....[2]

(ii) Another fullerene has a relative molecular mass of 840.

Tick (✓) the most likely sublimation temperature for this fullerene.

less than 600 °C	exactly 600 °C	more than 600 °C

[1]

(c) Carbon nanotubes are degraded by aqueous sodium hypochlorite ($NaClO$).

$$C + 2NaClO \rightarrow 2NaCl + CO_2$$

In terms of oxidation states, explain if the reaction between carbon nanotubes and sodium hypochlorite is a redox reaction.

....

....

....

....[2]

[Total: 10]

495

OR

B9 A factory is suspected of releasing pollutants containing zinc, lead(II) and nitrate ions into the nearby river.

A scientist tested the two samples of water by adding aqueous sodium hydroxide and aqueous ammonia followed by adding aluminium foil and heating. He recorded his observations in Fig. 9.2.

test	on adding a few drops	on adding excess	on adding aluminium foil and heating
aqueous sodium hydroxide	white precipitate formed	white precipitate dissolved in excess, forming colourless solution	no observable reaction
aqueous ammonia	white precipitate formed	some white precipitate dissolved, forming colourless solution, but some remained insoluble	colourless pungent gas evolved, gas turn moist red litmus paper blue

Fig. 9.2

Based on this information, the scientist claimed that the factory had indeed been releasing zinc and lead(II) ions into the river. However, the factory owner argued that this data showed that the factory was only releasing aluminium ions.

(a) **(i)** Explain how the data shows that zinc is present in the water.

....

....[1]

(ii) A judge ruled that there was insufficient evidence to prove the case with regard to the presence of lead(II) and aluminium.

Explain why there is insufficient evidence and describe a test to prove that lead(II) ions are present in the water.

....

....

....

....[2]

(b) The scientist claims that nitrate ions are detected in the water as the test with aqueous ammonia produced ammonia gas.

Do you agree? Explain your answer.

……

……

……[2]

(c) The factory produces chlorine and chlorine containing compounds.

(i) Draw the 'dot-and-cross' diagrams for the two compounds formed when chlorine reacts with oxygen and with magnesium.

Show outer electrons only.

[4]

(ii) Describe what would be observed when chlorine is added to aqueous zinc iodide.

…………………………………………………………………………………………………

…………………………………………………………………………………………………[1]

[Total: 10]

End of Paper

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							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											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

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.).