ORCHID PARK SECONDARY SCHOOL
Section A (Total 50 marks)

Answer **all** the questions in this section in the spaces provided.

A1 Iron is extracted from iron ore in the Blast Furnace.

The equations **A, B, C, D and E** show some reactions that happen in the Blast Furnace.

A $C + O_2 \rightarrow CO_2$

B $CO_2 + C \rightarrow 2\,CO$

C $Fe_2O_3 + 3\,CO \rightarrow 2\,Fe + 3\,CO_2$

D $CaCO_3 \rightarrow CaO + CO_2$

E $SiO_2 + CaO \rightarrow CaSiO_3$

(a) Use the letters **A, B, C, D and E** to answer the following questions.

(i) Which equation shows combustion? [1]

……

(ii) Which equation shows thermal decomposition? [1]

……

(iii) Which equation shows the formation of a toxic gas? [1]

……..

(iv) Which equation shows a reaction between an acidic compound and a base? [1]

……

(v) Two equations show different elements in compounds being reduced. Give the letters for these **two** equations. [1]

…… and ……..

(b) Iron from the Blast Furnace is further processed to make steel.
Some types of steel contains more carbon than others.
How are the properties of high carbon steel different from those low carbon steel? [1]

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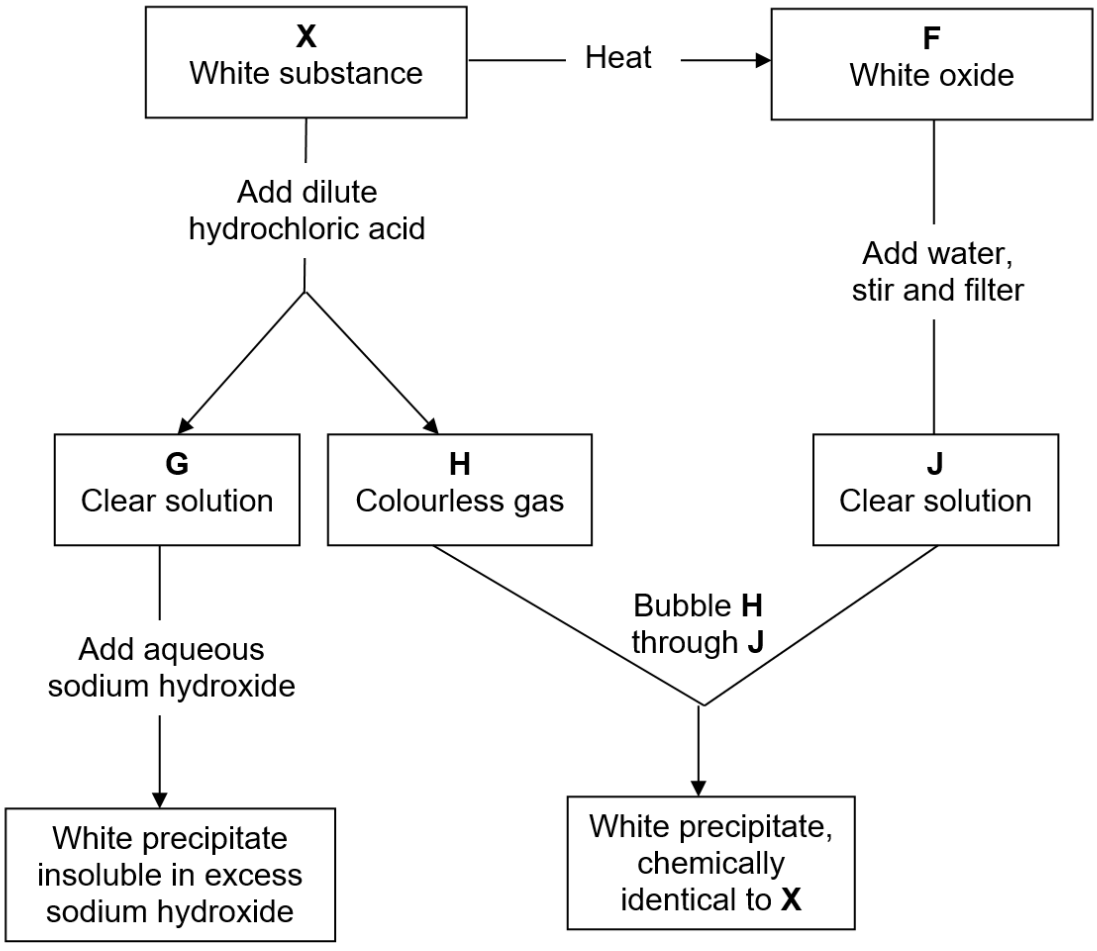
(c) **X** is one of the substance used in a Blast Furnace to manufacture iron.

This diagram below describes some of the reactions of **X.**



(i) Deduce the names **and** formulae of substances **X, F, G, H** and **J**.

X: ……

F: ……

G: ……

H: ……

J: …… [5]

(ii) Write a chemical equation for any **one** of reactions. [1]

……..

(iii) What is **X** used for in the Blast Furnace? [1]

……..

[Total: 13]

A2 The table shows the names and symbols of some isotopes of common elements.

Isotope name	Isotope symbol
Argon-40	$^{40}_{18}\mathrm{Ar}$
Chlorine-35	$^{35}_{17}Cl$
Carbon-12	$^{12}_{6}\mathrm{C}$
Strontium-90	$^{90}_{38}\mathrm{Sr}$
Neon-20	$^{20}_{10}\mathrm{Ne}$
Oxygen-16	$^{16}_{8}\mathrm{O}$
Chlorine-37	$^{37}_{17}Cl$
Calcium-40	$^{40}_{20}\mathrm{Ca}$

Use the isotopes in the table to answer the following questions.

(a) Give the names of **two** isotopes that contain the same number of <u>protons</u> in each of their atoms. [1]

…… and ……..

(b) Give the names of **two** isotopes that contain the same number of <u>neutrons</u> in each of their atoms. [1]

…… and ……..

(c) Give the names of **two** isotopes that contain eight electrons in the outer shell of each of their atoms. [1]

…… and ……..

(d) Which **two** isotopes form stable compounds that contain ions with a charge of 2+? [1]

…… and ……..

[Total: 4]

A3 The table below shows the R_f values of pure substances, **A, B, C, D** and **E**, where chromatography was carried out in separate experiments using two different solvents, **X** and **Y**.

	Substance				
Solvent	**A**	**B**	**C**	**D**	**E**
X	0.50	0.78	0.15	0.50	0.32
Y	0.98	0.00	0.50	0.65	0.32

(a) State which of the substances is insoluble in solvent **Y**.
Explain your answer. [2]

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……..……

(b) Using chromatography, a mixture was found to contain substances **A**, **D** and **E**. Suggest which solvent was used to obtain the results.
Explain your answer. [2]

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……..……

(c) A chromatography of five substances was carried out on the same chromatogram with both solvents **X** and **Y**.

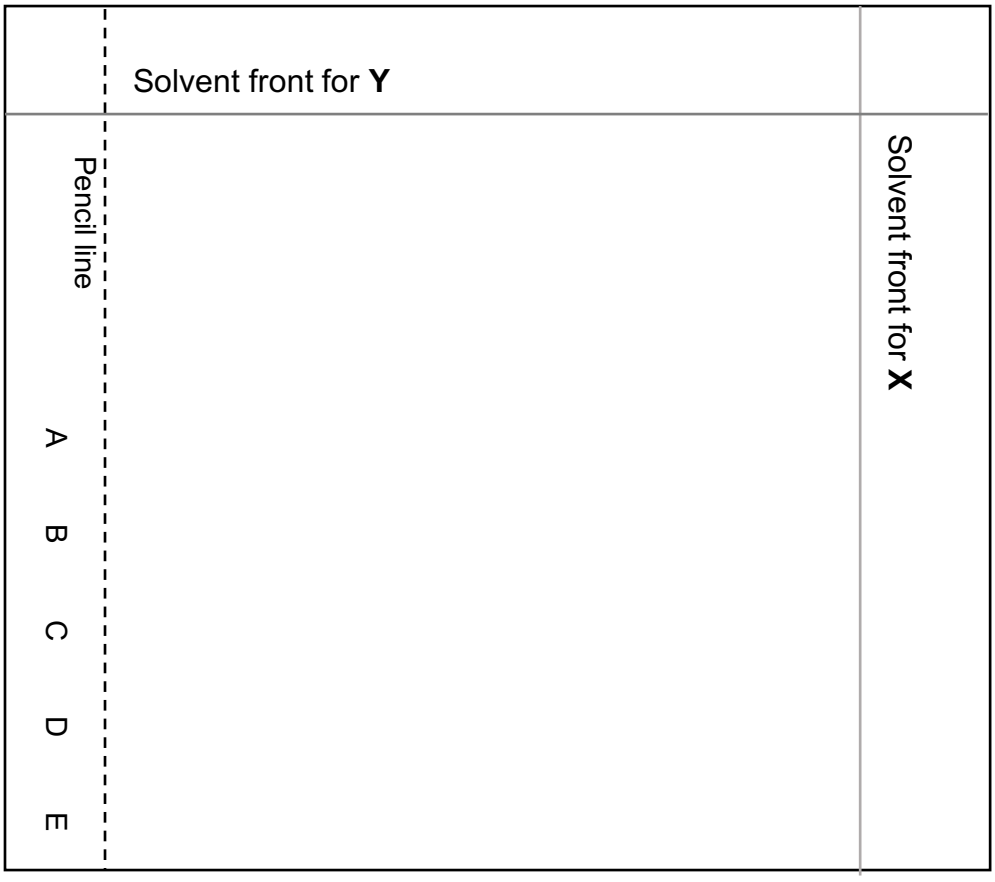
The chromatogram was first run using solvent **X**. It was then turned 90◦ on its side where a second chromatogram using solvent **Y** was run.

On the chromatogram on the next page,

(i) Mark with a "**B**" where you would find the final spot formed by substance **B**. [1]

(ii) Mark "**E**" where you would find the final spot formed by substance **E**. [1]

Chromatogram of substances A, B, C, D and E using solvent X and Y



(d) The use of a locating agent was required in the chromatography experiments. Explain why a locating agent is used. [1]

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……..……

[Total: 7]

A4 Phosphorus tribromide, PBr_3, is a covalently bonded compound.

It is used as a catalyst for making chemical compounds for medicines.
It has to be handled and stored carefully and because it is very toxic and it reacts very vigorously with water.

(a) Draw a "dot and cross" diagram to show the bonding in phosphorus tribromide. ***Show outer electrons only***. [2]

(b) When phosphorus tribromide reacts with water, it forms phosphorous acid, H_3PO_3, and hydrogen bromide, HBr.

Write a **balanced** equation for this reaction. [1]

……

(c) One way of making phosphorus tribromide is to react with bromine.

$$2\ P\ +\ 3\ Br_2\ \rightarrow\ 2\ PBr_3$$

(i) Bromine has an oxidation state of -1 in phosphorus tribromide. How does the oxidation state of phosphorus change during the reaction? [1]

……

……

(ii) Calculate the mass of bromine that reacts to make 54.2g of phosphorus tribromide. [2]

(d) Chlorine also reacts with phosphorus.

$$2\ P\ +\ 3\ Cl_2 \leftrightharpoons 2\ PCl_3$$

(i) When the same number of moles of phosphorus is reacted with both bromine and chlorine, the **rates** for the two reactions are different.

How would you expect the **rates** to differ?
Explain your reasoning. [1]

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(ii) In practice, when phosphorus reacts with chlorine, the yield of phosphorus trichloride is never 100%.
Suggest a reason why. [1]

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[Total: 8]

A5 **(a)** Antacid tablets neutralise acids.

A student investigated the time taken for an antacid tablet to react completely with excess hydrochloric acid (the reaction time) under different conditions.

The table below shows the results of the investigation.

Experiment number	Volume of acid / cm^3	Concentration of acid in mol / dm^3	Temperature of acid / °C	Reaction time / seconds
1	50	1.0	25	132
2	50	2.0	25	65
3	100	2.0	25	65
4	50	2.0	35	33

(i) Which **two** experiments show that the volume of acid used does **not** affect the rate of reaction? [1]

……and ……

(ii) Describe and explain the effect of increasing the temperature on the rate of reaction in terms of collision between reacting particles. [2]

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...……...……

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……..

(b) The table below shows the colour changes of several natural indicators.

Indicator	Colour at pH													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Beetroot	R							P							
Cherries	R			O				P	G						
Curry powder	C							Y	O	R					
Grape juice	R				O			G							
Tomato	C							Y	Br						
Turnip skin	O			P		B		G							

Key

B – Blue	C – Colourless	O – Orange	R – Red
Br – Brown	G – Green	P – Purple	Y – Yellow

(i) Suggest which indicator is ***most ideal*** for titration between a strong acid and a strong alkali. Give reasons for your answers. [2]

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……

(ii) A mixture of grape and tomato juice is added to a sample of sulfuric acid. State the colour of the resulting mixture. [1]

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[Total: 6]

A6 The table below shows the energy taken in and given off for five different reactions.

	Total Energy/ kJ	
Reaction	**Taken in**	**Given off**
V	450	270
W	110	230
X	680	830
Y	390	170
Z	520	900

(a) State which of the above reactions were endothermic. Explain your answer. [2]

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……..

(b) Reaction **Z** involved two solutions, **A** and **B**.

(i) State the activation energy needed for reaction **Z**. [1]

……

(ii) Describe **one** physical change that occurred when reaction **Z** took place. Explain your answer. [1]

……..

……..

……..

(iii) Sketch a labelled energy profile diagram to represent the reaction between solutions **A** and **B**. [2]

(c) A catalyst is added to reaction **W**.

State if the activation energy of reaction **W** increased or decreased or remained the same after the addition of a catalyst. Hence, explain how a catalyst works. [2]

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[Total: 8]

A7 Carbon monoxide can be removed from exhaust gases by using a catalytic converter. A platinum catalyst is used to speed up the reaction between carbon monoxide and nitrogen monoxide.

The diagram below shows some of the gases that enter and leave a catalytic converter.

(a) Write a balanced equation, with state symbols, for this conversion. [1]

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(b) Is the equation in **(a)** a redox reaction? Explain why. [2]

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……

……

(c) What harmful effect does carbon monoxide cause? [1]

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……

[Total: 4]

END OF SECTION A

Section B (Total 30 marks)

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.**

B8 The Solvay process

The Solvay process, also known as the ammonia-soda process, was developed in 1861 by the Belgian industrial chemist, Ernest Solvay. It is a major industrial process for the production of sodium carbonate (soda ash).

The ingredients used in the Solvay process are easily available and inexpensive. They include:

1. Salt Brine, or sodium chloride solution. It provides sodium ions in the making of the sodium carbonate. Brine can be easily sourced from both inland and the ocean.
2. Limestone, or calcium carbonate. It provides carbonate ions in the production of the sodium carbonate. Limestone is readily available from mining.
3. Ammonia is made industrially by the Haber's process. Ammonia is expensive, but it is recycled in the process.

The Solvay process is a continuous process using limestone to produce carbon dioxide which reacts with ammonia dissolved in brine to produce sodium carbonate.

The four main stages of the Solvay process are:

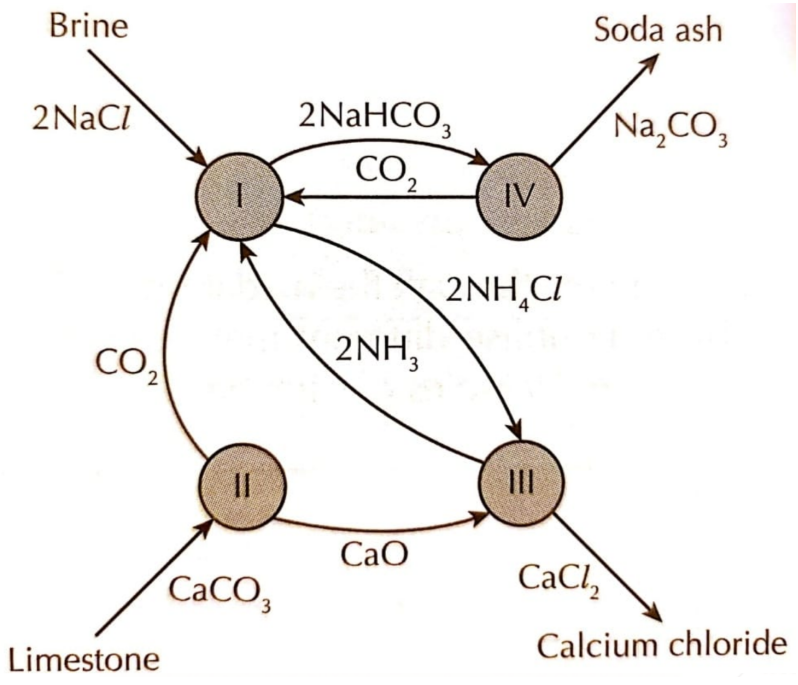
I. Brine Purification

II. Sodium Hydrogen Carbonate Formation

III. Ammonia Recovery

IV. Sodium Carbonate Formation

The schematic diagram below shows the summarized steps and material involved in the Solvay process.



(a) Study the information and diagram above carefully.

(i) Write an overall chemical equation for the Solvay process. [2]

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(ii) Name the by-product of the Solvay process reaction. [1]

……

(iii) Calcination is a process where a substance is heated, causing it to lose its water of crystallisation and the decomposition of the salt. In stage IV of the Solvay process, sodium hydrogen carbonate is heated at high temperature to produce sodium carbonate.

Write a balanced chemical equation for the thermal decomposition of $NaHCO_3$. [2]

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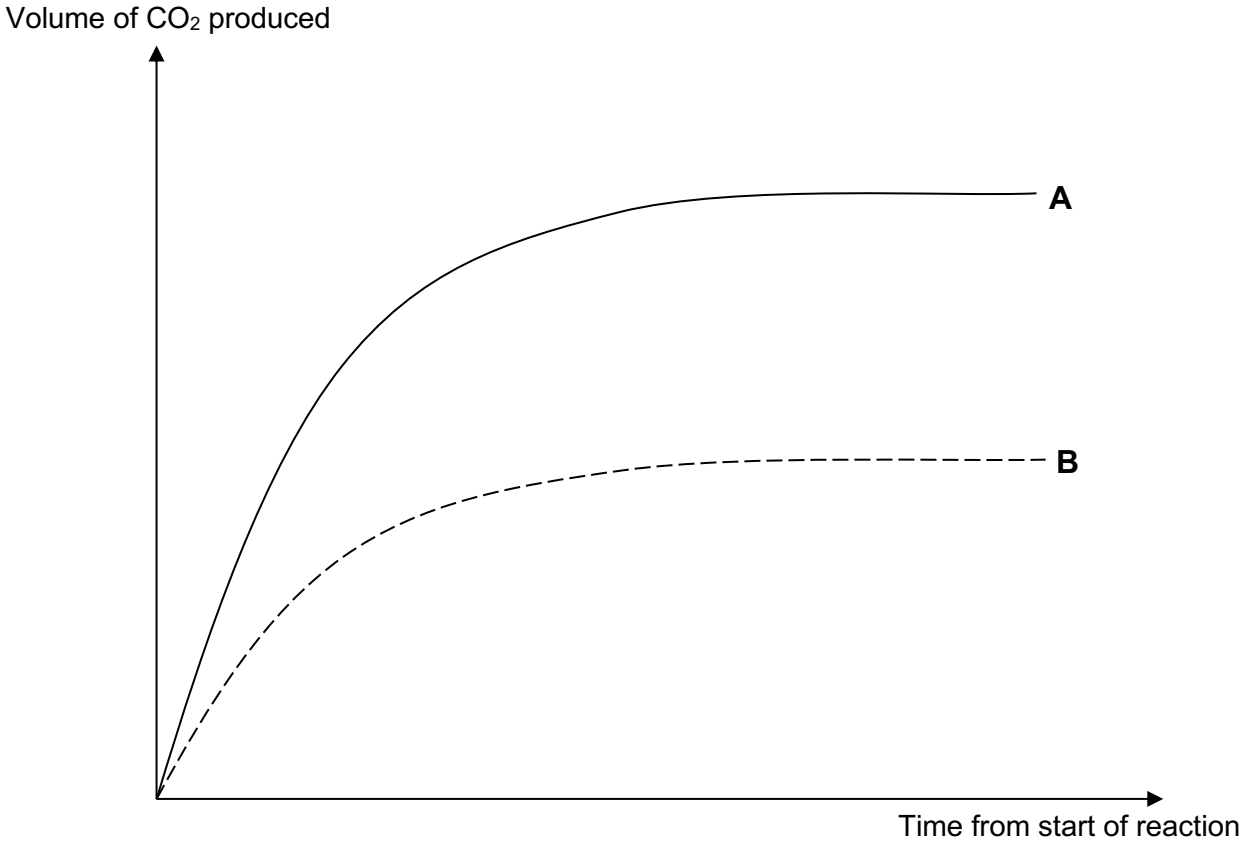
(b) Name the **two** substances that are recycled in the Solvay process. [1]

……

(c) The diagram below shows the graphs of reaction between dilute hydrochloric acid and the soda ash solution.



(i) In Experiment **A**, 15 cm^3 of 1 mol/dm^3 Na_2CO_3 reacted with exactly 30 cm^3 of 1 mol/dm^3 HC*l*.
State the volume and concentration of HC*l* used to react with another identical sample of soda ash solution in experiment **B**. [1]

……

(ii) On the same graph, sketch the graph (labelled it as experiment **C**) of the reaction between 10 cm^3 of 1.5 mol/dm^3 Na_2CO_3 and 35 cm^3 of 1.25 mol/dm^3 HC*l*. [1]

(iii) Explain the shape of your graph in **(d)(ii).** [2]

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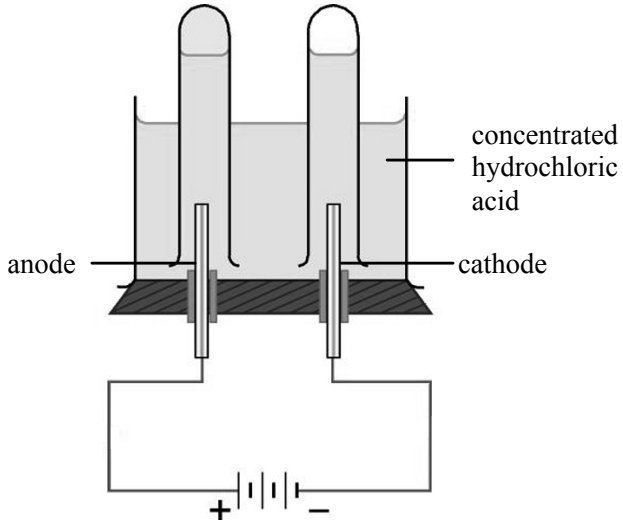
[Total: 10]

B9 **(a)** Concentrated hydrochloric acid is electrolysed using the following apparatus.



(i) Why are metal electrodes not used? [1]

……..

(ii) Write the ionic half equations, with state symbols, for the reactions that occurs at the anode and cathode.
State and explain whether oxidation or reduction has taken place at the anode and cathode. [4]

Anode: ……

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……..……

………..

Cathode: ……

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……..……

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(iii) Describe a simple test that would identify the gas given off at the anode. [1]

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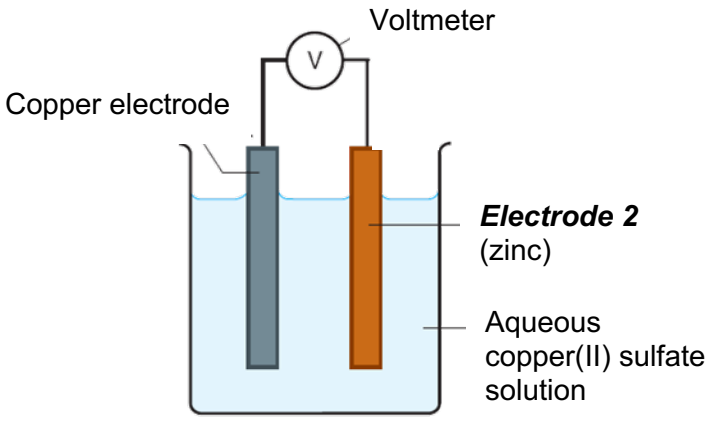
(b) The set-up below can be used to generate electricity in a cell.



(i) Draw an arrow on the diagram to show the direction of the flow of electrons in the wire. [1]

(ii) Write an ionic equation for the reaction between zinc and aqueous copper(II) sulfate. [1]

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(iii) The voltage of the cell was measured when the following metals were used as ***Electrode 2***.

Copper ***Iron*** ***Lead*** ***Zinc***

Complete the table by writing the metals in the correct order. [1]

Meter Reading / V	***Metal***
1.40	
0.79	
0.25	
0.00	

(iv) Explain why distilled water is not used as the electrolyte. [1]

……

……

[Total: 10]

EITHER

B10 Ammonia is produced commercially by the Haber process. In this process, nitrogen and hydrogen gases are reacted together, as shown in the equation.

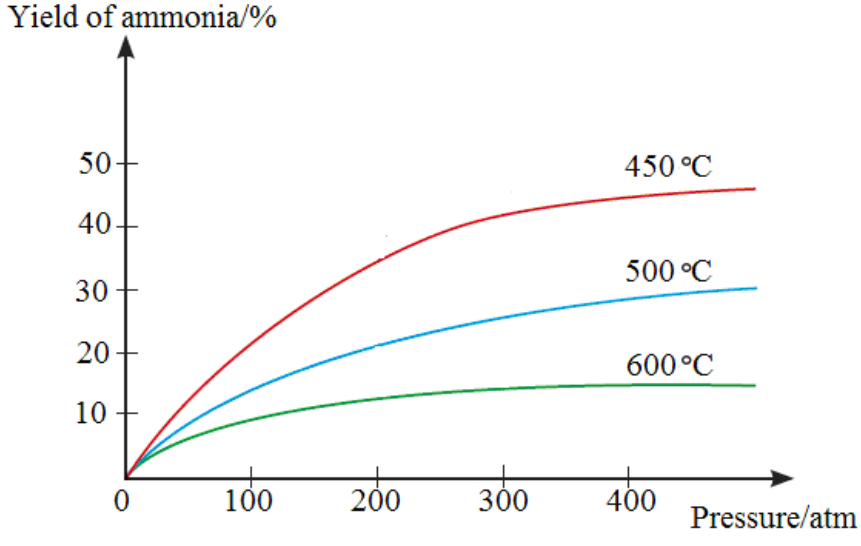
$$N_2\,(g) \;+\; 3\,H_2\,(g) \;\rightleftharpoons\; 2\,NH_3\,(g)$$

(a) State the sources of nitrogen and hydrogen used for Haber process. [1]

……

……

(b) The graph shows the percentage yield of ammonia at different pressures and temperatures.



(i) According to the graph, which conditions would give the best percentage yield of ammonia? [1]

……..

(ii) Industrially, a temperature of 450 ºC and pressure of 200 atm is used. Explain why these conditions were chosen, even though does not produce the maximum percentage of ammonia? [2]

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……

……

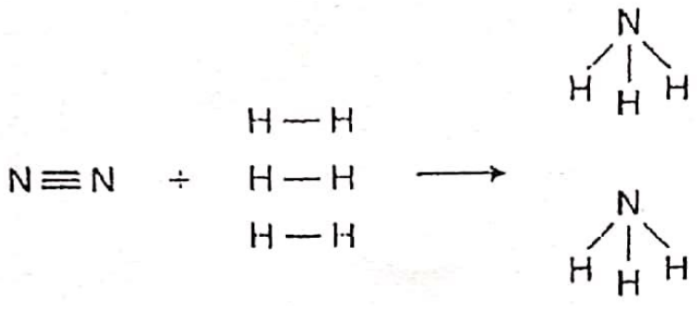
(iii) State how the rate of ammonia production can be increased, apart from changing the temperature and pressure conditions. [1]

……..

(c) Ammonia is used to make nitrogenous fertilisers, ammonium nitrate, NH_4NO_3.

Calculate the mass of nitrogen in 600 tonnes of ammonium nitrate. [2]

(d) The formation of ammonia from nitrogen and hydrogen can also be represented by the equation:



The amount of energy required to break one mole of bonds in the above reaction are shown in the table.

Bond	Amount of energy needed to break the bond (kJ)
N ≡ N	945
H – H	436
N – H	391

(i) Using the energy values in the table, calculate the energy

I. Needed to break all the bonds in the reactants.

II. Given out when bonds in the products are formed. [2]

(ii) Using your answers to parts I and II, explain whether the reaction is exothermic or endothermic. [1]

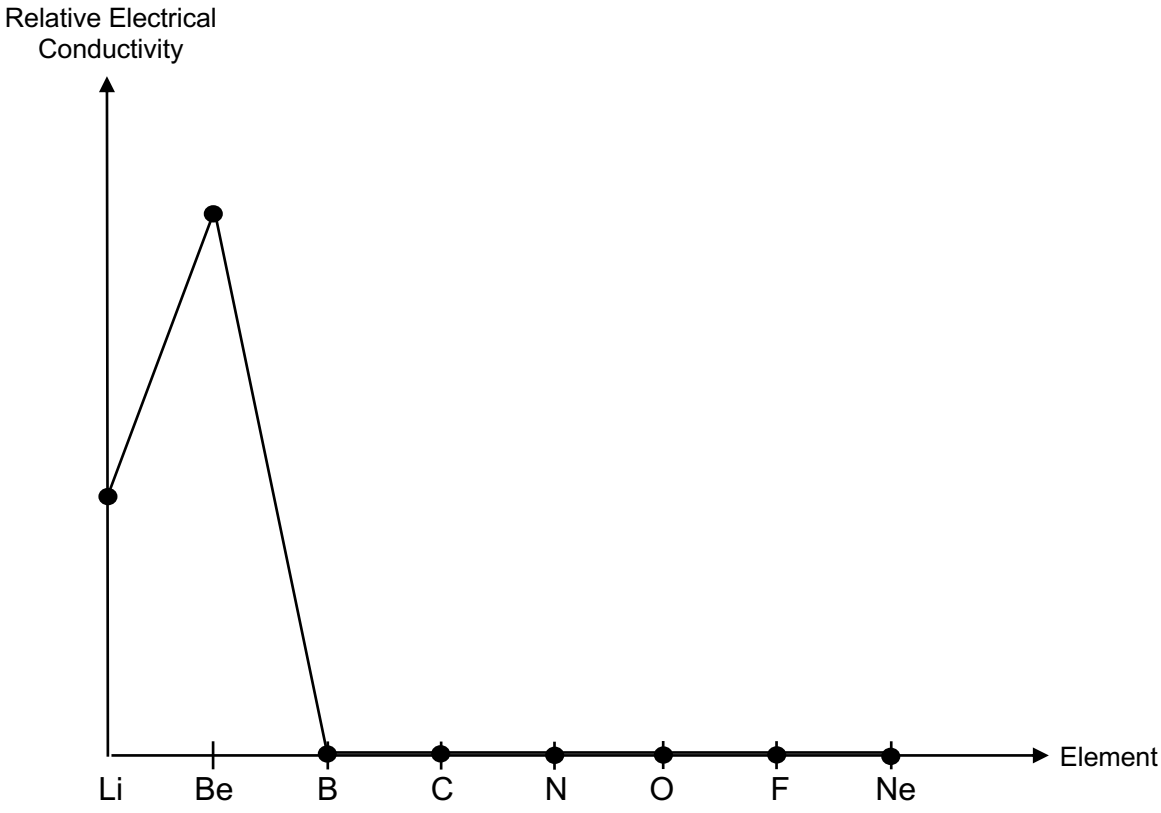
……..

…….

[Total: 10]

OR

B10 The graph below shows the elements in Period 2 and their relative electrical conductivity.



(a) Describe the trend shown by the graph. [1]

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(b) Based on the Periodic Table, give reasons for the overall trend described in **(a).** [2]

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(c) Carbon exist in the natural world in two forms.

(i) From the information given, state the form of carbon that is represented in the graph and give reason(s) for your answer. [2]

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(ii) With the aid of diagrams, describe the differences between the **structures and bonding** between the two forms of carbon. [4]

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(d) Pure crystalline boron is a shiny, black semiconductor. Under high temperatures, it conducts electricity and under low temperatures, it behaves like an insulator.
Name the type of substance that boron is. [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.)