Class | Register Number

Candidate Name _____

PEIRCE SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2020
SECONDARY 4 EXPRESS

CHEMISTRY **6092/01**
Paper 1 (Theory) **28 August 2020**
1 hour

Additional Materials
OTAS Sheet

INSTRUCTIONS TO CANDIDATES

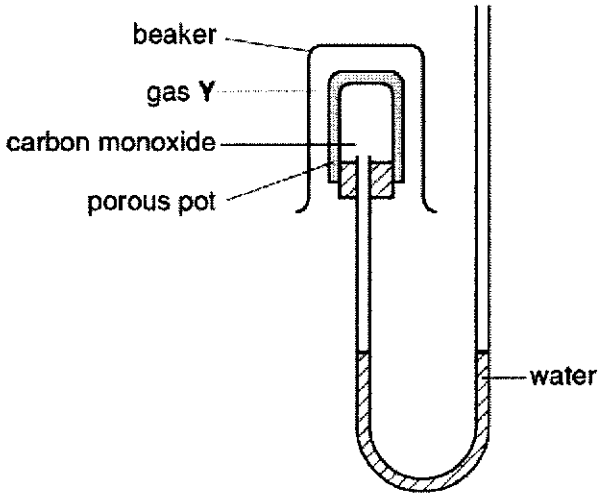
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Index number on the Answer Sheet in the spaces provided.

There are forty questions in this paper. Answer all questions. For each question, there are four possible answers, A, B, C and D. Choose the one you consider correct and record your choice in soft pencil on the separate answer sheet.

INFORMATION FOR CANDIDATES
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.
A copy of the Periodic Table is printed on page **20**.

This paper consists of **20** printed pages and **0** blank page.

1 A beaker of an unknown gas **Y** was inverted over a porous pot containing carbon monoxide as shown. The apparatus was left for a while but the water level did not change.



The gas **Y** could have been _____.

A ammonia
B carbon dioxide
C chlorine
D nitrogen

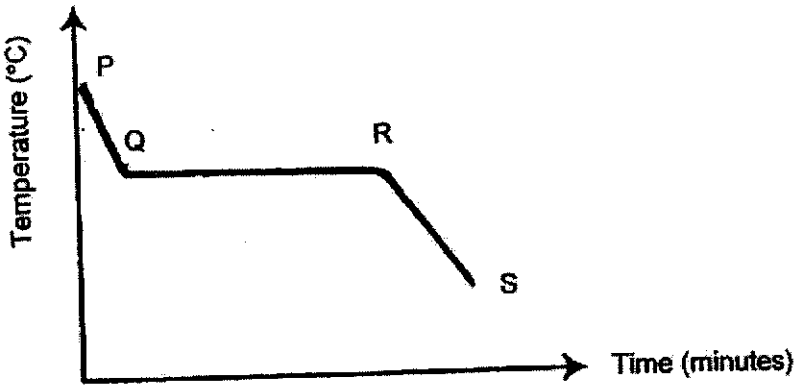
2 The boiling points of some gases are given in the following table.

Gases	Boiling point /°C
Nitrogen	-196
Xenon	-108
Oxygen	-183

A mixture of liquid oxygen, nitrogen and xenon at -200°C was heated up by 15 °C. Which of the substances will still be in the liquid state at this higher temperature?

A nitrogen only
B xenon only
C a mixture of nitrogen and oxygen
D a mixture of oxygen and xenon

3 A sample of solid **X** was heated until it was completely melted. The graph shows how its temperature varies with time as molten **X** is cooled.



Which of the following statements are **true** about the particles in **X**?

I Their total energy at stage **QR** is lower than at stage **RS**.

II They are closer to each other at stage **RS** than at stage **PQ**.

III They are more orderly arranged at stage **RS** than at stage **PQ**.

IV The forces of attraction are stronger at stage **PQ** than at stage **RS**.

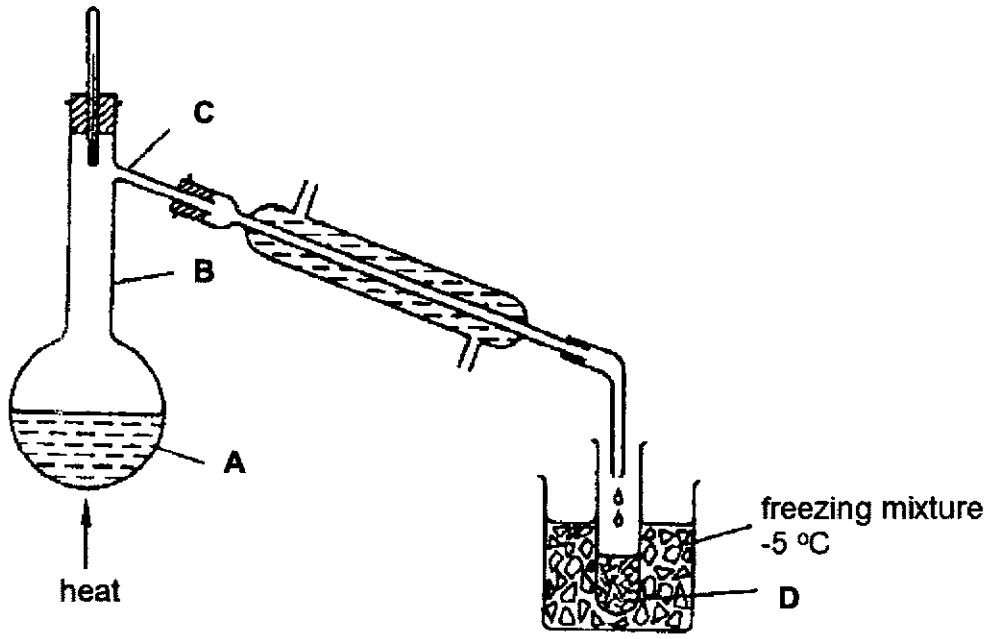
A **I** and **II** are correct.

B **I** and **III** are correct.

C **II** and **III** are correct.

D **II** and **IV** are correct.

4 Substance **X** melts at 10 °C and boils at 50 °C. It can be purified by distillation as shown in the diagram.



At which point will the particles of **X** be most regularly arranged?

5 Which test could be used to show that a sample of water is pure?

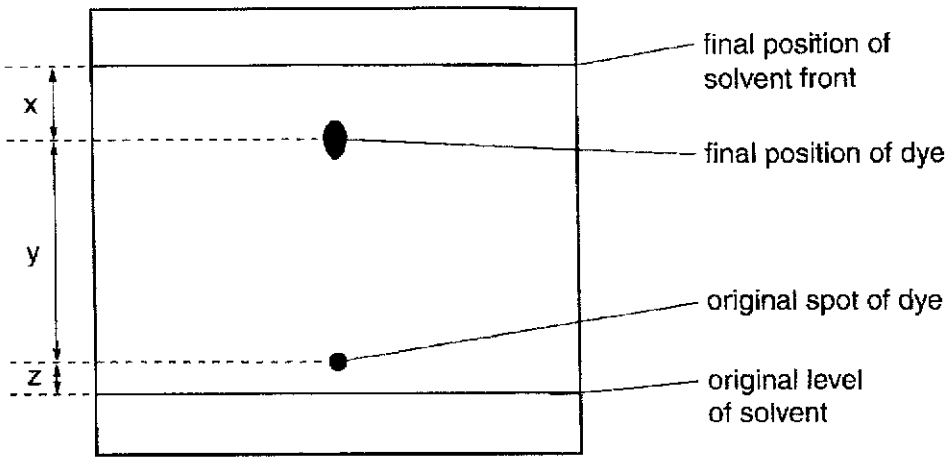
A It boils at exactly 100 °C at atmospheric pressure.

B It is colourless, odourless and drinkable.

C It turns anhydrous copper(II) sulfate blue.

D It turns cobalt(II) chloride paper pink.

6 The diagram shows the chromatogram obtained by analysis of a single dye.
Three measurements are shown.



How is the R_f value of the dye calculated?

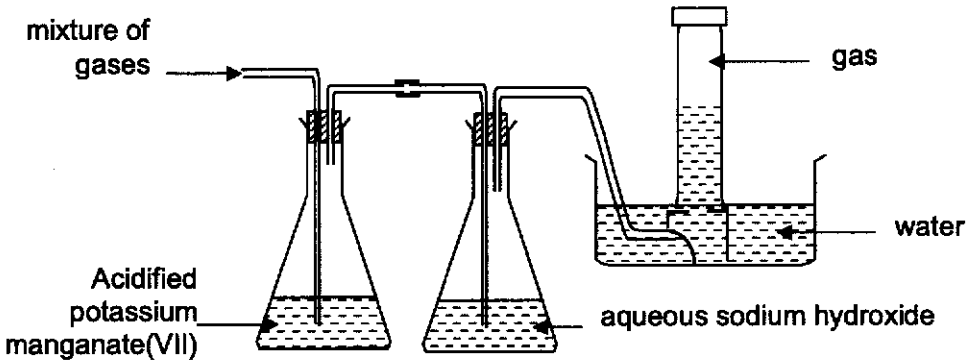
A $\frac{x}{x+y}$

B $\frac{y}{x+y}$

C $\frac{x}{x+y+z}$

D $\frac{y}{x+y+z}$

7 A gaseous mixture of ammonia, oxygen, carbon dioxide and chlorine was passed through the apparatus shown in the diagram below. Only one gas was collected in the gas jar.



What is the property of the gas collected in the gas jar?

A It bleaches damp red litmus.

B It relights a glowing splint.

C It turns moist red litmus blue.

D It turns acidified potassium manganate(VII) colourless.

8 When a saturated solution of copper(II) sulfate is allowed to cool from 80 °C to room temperature, crystals separate out from the solution. Which of the following statements about this crystallization process is correct?

I The mass of the dissolved solute in the solution changes.

II The mass of the solvent in the solution remains the same.

III The concentration of the solution remains the same.

IV The solubility of copper(II) sulfate decreases as the temperature falls.

A I only

B I and IV

C I, II and IV

D I, III and IV

9 If the formula of radium chloride is $RaCl_2$ and the formula for sodium phosphide is Na_3P, then the formula for radium phosphide is _____.

A RaP

B RaP_2

C Ra_3P_2

D Ra_2P_3

10 The atomic numbers and mass numbers of elements **P** and **Q** are given below:

Element	*Atomic Number*	*Mass number*
P	20	40
Q	9	19

What is the relative molecular mass of the compound formed between **P** and **Q**?

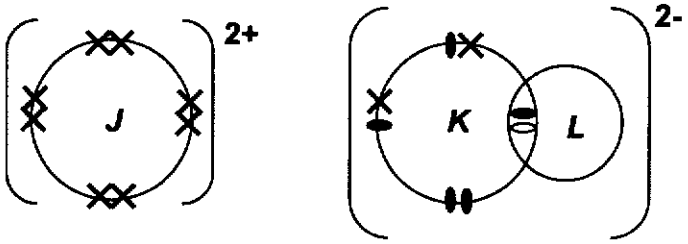
A 29

B 38

C 59

D 78

11 ***J***, ***K*** and ***L*** are three different elements in the Periodic Table. The electronic diagram (showing only the valence electrons) of the compound formed between ***J***, ***K*** and ***L*** is shown below:



Which of the following statements are correct?

I Element ***K*** could be nitrogen.
II Element ***J*** belongs to Group II of the Periodic Table.
III Element ***K*** and element ***L*** are bonded together by covalent bond.
IV Element ***L*** is a metal.

A I, II and III
B I, II and IV
C I, III and IV
D II, III and IV

12 On warming a salt with excess aqueous sodium hydroxide, a gas that turned damp red litmus paper blue was given off. On adding aluminum foil to the boiled solution, a further evolution of the same gas occurred.

What was the salt?

A ammonium chloride
B ammonium sulfate
C ammonium nitrate
D sodium sulfate

13 An indicator has just been produced in the laboratory. The table shows the colours of the indicator at different pH values.

pH	colour
0 – 3	Red
3.5 – 5	Green
6 – 14	purple

This new indicator would be suitable for distinguishing

A aqueous potassium nitrate and aqueous potassium hydroxide.
B aqueous hydrogen chloride and carbon dioxide.
C aqueous ammonia and aqueous potassium hydroxide.
D water and aqueous potassium chloride.

14 In an accident at a factory, some hydrochloric acid was spilt on the floor. Which substance, when added in excess would neutralise the acid **without** leaving an alkaline solution?

A Limestone powder
B Sodium carbonate
C Aqueous sodium hydroxide
D Aqueous magnesium chloride

15 Which of the following reagents cannot be used to differentiate sodium hydroxide solution from sodium chloride solution?

A Aqueous calcium nitrate solution
B Aqueous copper(II) nitrate solution
C Aqueous lithium nitrate solution
D Aqueous zinc nitrate solution

16 68 g of hydrogen peroxide decomposes in the presence of manganese(IV) oxide to give 1.2 dm^3 of oxygen gas as follows.

$$2\ H_2O_2 \rightarrow O_2 + 2\ H_2O$$

What is the percentage purity of the hydrogen peroxide?

A 2.5%

B 5.0%

C 10.0%

D 15.0%

17 A solution contains 12.60 g/dm^3 of the acid H_3ZO_3. 25.0 cm^3 of this solution reacted with an equal volume of 0.100 mol/ dm^3 NaOH. The equation for the reaction was

$$NaOH + H_3ZO_3 \rightarrow NaH_2ZO_3 + H_2O$$

What is element **Z**?

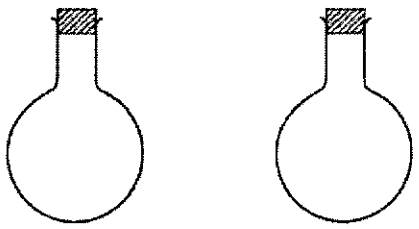
A Nitrogen

B Arsenic

C Silicon

D Sulfur

18 The diagram shows 2 flasks of gases. The number of atoms of gas in flask **Y** is approximately



X: 5 g neon **Y**: 5 g argon

A equal to the number of atoms of gas in flask **X**.

B twice the number of atoms of gas in flask **X**.

C half the number of atoms of gas in flask **X**.

D one quarter the number of atoms of gas in flask **X**.

19 Which statement about conduction of electricity is correct?

A Electricity is conducted in a metal wire by ions.

B Electricity is conducted in an acidic solution by ions.

C Electricity is conducted in a molten electrolyte by electrons.

D Electricity is conducted in an aqueous solution by electrons.

20 Which one of these gases in the air is mainly responsible for the greenhouse effect?

A carbon dioxide

B CFC

C ozone

D sulfur dioxide

21 In the Haber process for the manufacture of ammonia, what are the usual operating conditions?

	Pressure	**Temperature**	**Catalyst**
A	1 atm	200 °C	iron
B	1 atm	100 °C	nickel
C	200 atm	450 °C	iron
D	200 atm	450 °C	nickel

22 The table below shows information for five elements.

Element	**P**	**Q**	**R**	**S**	**T**
Relative atomic mass	16	24	27	39	88

Which two elements have similar chemical properties?

A **P** and **R**

B **Q** and **S**

C **P** and **S**

D **Q** and **T**

23 A coil of clean copper wire is suspended in a beaker of aqueous silver nitrate. Crystals of silver are deposited on the copper wire.

Which statement is **not** correct?

A The copper is oxidised.
B The solution turns blue.
C The total mass of the crystals of silver increases gradually.
D The total number of positive ions in the solution is unchanged.

24 Which equation does not represent a redox reaction?

A $Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$
B $Cl_2(g) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(s)$
C $Cl_2(g) + S^{2-}(aq) \rightarrow S(s) + 2Cl^-(aq)$
D $Cu^{2+}(aq) + Mg(s) \rightarrow Cu(s) + Mg^{2+}(aq)$

25 Crysotile, $Mg_3Si_2O_5(OH)_4$, is an asbestos mineral. What is the oxidation state of silicon in the mineral?

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

26 Which one of the following properties is true for **all** metals?

A All metals show variable valencies.
B All metals form coloured compounds.
C All metals are good electrical conductors.
D All metals react with dilute acids to produce hydrogen.

27 When a metal **G** was placed in aqueous copper(II) nitrate, a reddish brown solid was obtained. The temperature rose and some **G** remained unchanged. Which one of the following conclusions **cannot** be deduced from this information?

A The reaction is exothermic.
B The resulting solution is colourless.
C Metal **G** has been oxidized.
D Metal **G** is more reactive than copper

28 The following report appeared in a newspaper.

"Drums of bromine broke open after a vehicle crash on the motorway. Traffic was diverted as purple gaseous bromine drifted over the road, causing irritation to drivers' eyes. Firemen sprayed water over the scene of the accident, dissolving the bromine and washing it away."

What is **wrong** with the report?

A Bromine does not dissolve in water.
B Bromine does not vapourise readily.
C Bromine is less dense than air.
D Bromine is not purple.

29 A strip of brass is added to excess dilute hydrochloric acid. Which observations are correct?

	Colour of residue	**Colour of filtrate**
A	Black	Blue solution
B	Blue	Colourless solution
C	Grey	Blue solution
D	Reddish brown	Colourless solution

30 The table below refers to four metals and some of their compounds.

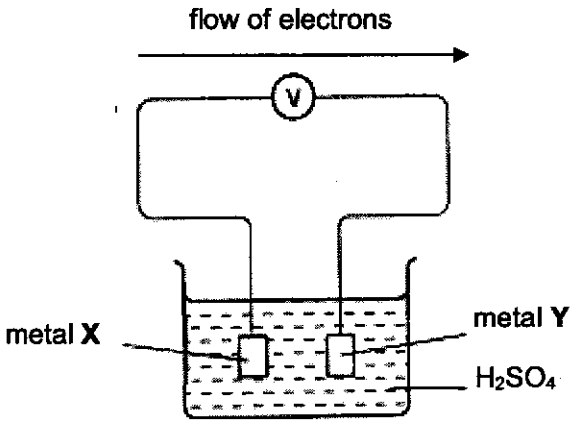
Metal	Action of dilute sulfuric acid on metal	Effect of hydrogen on heated oxide	Action of metal on a solution of the sulfate of J
G	hydrogen evolved	reduced	no reaction
H	no reaction	reduced	no reaction
I	hydrogen evolved	no reaction	J formed
J	hydrogen evolved	no reaction	no reaction

Which one of the following is the order of thermal stability of their carbonates toward heating?

More stable towards heating → less stable towards heating

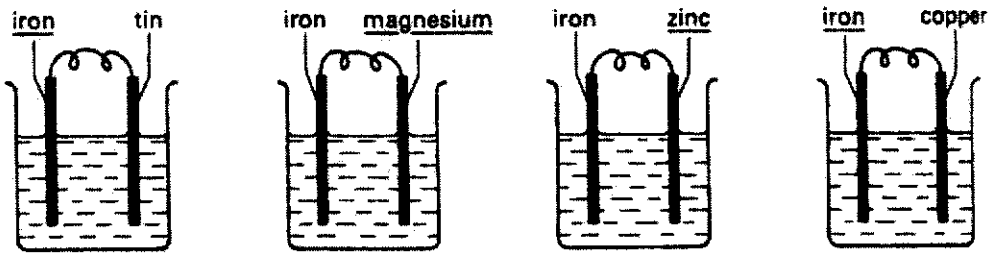
A	**H**	**G**	**J**	**I**
B	**H**	**J**	**G**	**I**
C	**I**	**J**	**G**	**H**
D	**I**	**H**	**G**	**J**

31 The diagram below shows a simple cell. Which one of the following pairs of metals would electrons flow in the direction as shown in the diagram?



	X	Y
A	Copper	Lead
B	Iron	Zinc
C	Zinc	Aluminium
D	Zinc	Iron

32 Four simple cells were set up using aqueous sodium chloride as the electrolyte as shown in the diagrams below.



In each cell, only the underlined electrode dissolved. To establish the order of reactivity of the metals, it is necessary to set up two or more cells. Which of the following pairs of cells are needed in addition to the four cells above?

	First cell electrodes	**Second cell electrodes**
A	iron/iron	iron/zinc
B	tin/copper	magnesium/zinc
C	tin/magnesium	zinc/copper
D	tin/zinc	magnesium/copper

33 In an experiment, 6 moles of lead(II) ions (Pb^{2+}) were discharged in the electrolysis of molten lead(II) bromide. What is the amount of metal ions discharged if the same amount of electricity is used in the following experiments?

A 4 moles of aluminium ions (Al^{3+}) in the electrolysis of molten aluminium oxide

B 6 moles of sodium ions (Na^{+}) in the electrolysis of molten sodium chloride

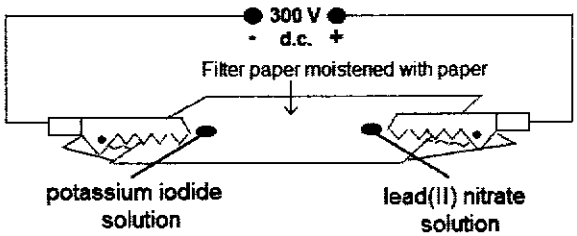
C 12 moles of calcium ions (Ca^{2+}) in the electrolysis of molten calcium chloride

D 12 moles of copper(II) ions (Cu^{2+}) in the electrolysis of aqueous copper(II) sulfate

34 Concentrated aqueous iron (II) iodide is electrolysed using platinum electrode. Which of the following correctly describes the reactions at each electrode?

	Ions attracted to cathode	**Observation at anode**
A	I^- and OH^-	Colourless gas evolved
B	I^- and OH^-	Grey deposits formed
C	Fe^{2+} and H^+	Brown solution formed
D	Fe^{2+} and H^+	Colourless gas evolved

35 A drop of potassium iodide solution and a drop of lead(II) nitrate solution had been added to a piece of filter paper moistened with water. The filter paper was then connected to an electric circuit as shown below.



Which of the following would occur in the experiment illustrated above?

A A precipitate of lead(II) iodide is formed around the middle of the filter paper.

B Hydrogen gas is being liberated at the anode and oxygen gas is being liberated at the cathode.

C Lead is being deposited around the cathode and a brown iodine stain is being formed around the anode.

D Yellow precipitate is formed on the filter paper closer to the lead(II) nitrate solution end.

36 The equations for three reactions are given below:

Reaction **1** $H_2 \rightarrow 2H$

Reaction **2** $2H + O \rightarrow H_2O$

Reaction **3** $HCl \rightarrow H + Cl$

Which of these reactions are endothermic?

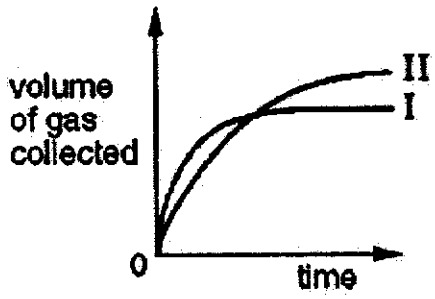
A Reaction **1** only.

B Reactions **1** and **2** only.

C Reactions **1** and **3** only.

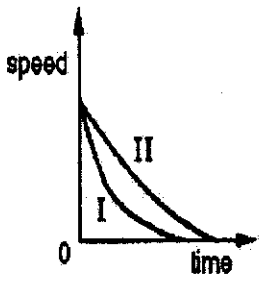
D Reactions **2** and **3** only.

37 In two separate experiments, a substance was decomposed and the gas evolved was collected. The graph below shows the total volume of gas collected against time for each experiment.

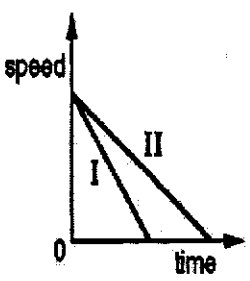


Which one of the following graphs shows how the speed of reaction varied with time in each experiment?

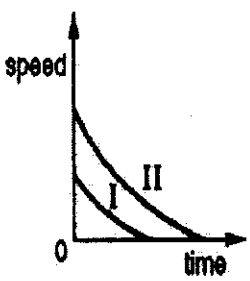
A



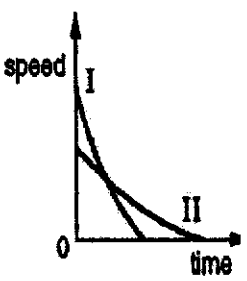
B



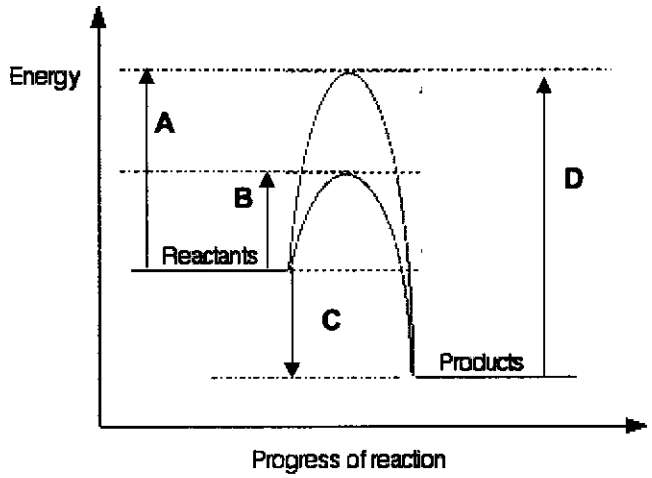
C



D



38. The diagram below shows an energy profile diagram for a chemical reaction. Which energy change is the activation energy for the catalysed reaction?



39 Ammonium chloride dissolving in water is an example of an endothermic reaction. Which of the following statements is/are true when ammonium chloride is dissolved in water?

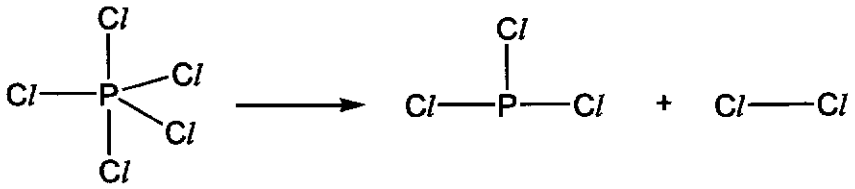
I The solution takes in heat from the surroundings.
II There is an increase in the temperature of the solution.
III The solution has a greater energy content than that of the solid and water at the beginning.

A I and II only
B I and III only
C II and III only
D I, II and III

40 Gaseous phosphorus pentachloride can be decomposed into gaseous phosphorus trichloride and chlorine by heating. The table below gives the bond energies.

bond	bond energy (kJ/mol)
P–C*l* (in both chlorides)	330
C*l*–C*l*	240

What is the enthalpy change in the decomposition of PCl_5 to PCl_3 and Cl_2?



A –90 kJ/mol

B +90 kJ/mol

C –420 kJ/mol

D +420 kJ/mol

The Periodic Table of Elements

Group I	Group II						Group III	Group IV	Group V	Group VI	Group VII	Group 0
						1 H hydrogen 1						2 He helium 4
3 Li lithium 7	4 Be beryllium 9						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 –		

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

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.).

Class	Register Number

Candidate Name _____

PEIRCE SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2020
SECONDARY 4 EXPRESS

CHEMISTRY **6092/02**
Paper 2 (Theory) **25 August 2020**
1 hour 45 minutes

INSTRUCTIONS TO CANDIDATES
Write your full name, register number and class in the spaces provided on the cover of this question paper and on the writing paper.

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

Section B
Answer **three** questions, the last question is in the form **either/or**.
Write your answers in the spaces provided on the Question Paper.

INFORMATION FOR CANDIDATES
The number of marks is given in the brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is provided on page **22**.

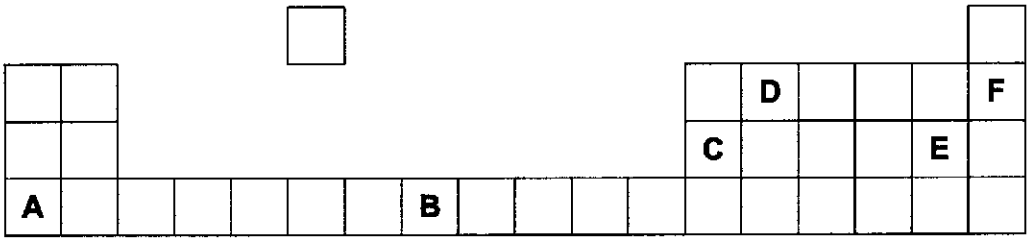
For Examiner's Use	
Section A	
B9	
B10	
B11	
TOTAL	

This question paper consists of **22** printed pages and **0** blank page.

Section A [50 marks]

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

A1 The position of six elements, represented by letters, **A**, **B**, **C**, **D**, **E** and **F** are shown in the Periodic Table below.



Select from the given letters, **A** to **F**, the element that best fits the following characteristics. The elements (**A** to **F**) can be used once, more than once or not at all.

(a) An element which combines with element **E** to form a very volatile compound. [1]

_____

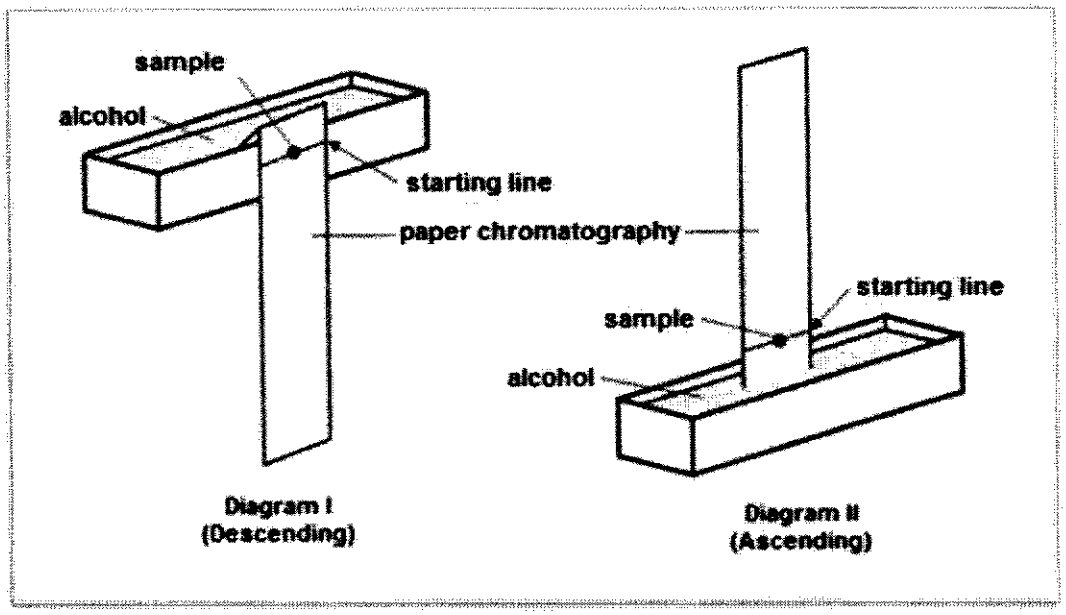
(b) An element which is the strongest reducing agent. [1]

_____

(c) An element which can be used as a catalyst in chemical reactions. [1]

_____

A2 Paper chromatography can be carried out in two different ways. In descending method, solvent flows down the paper as shown in **Diagram I**. In ascending method, solvent travels up the paper as shown in **Diagram II**.



An ink sample from the same source is analysed using the two different methods. The type of solvent and duration of the experiment is kept constant.

The results obtained are shown in **Diagram III**. A complete separation of the ink is shown in chromatogram ***X***. Only the solvent front is shown in chromatogram ***Y***.

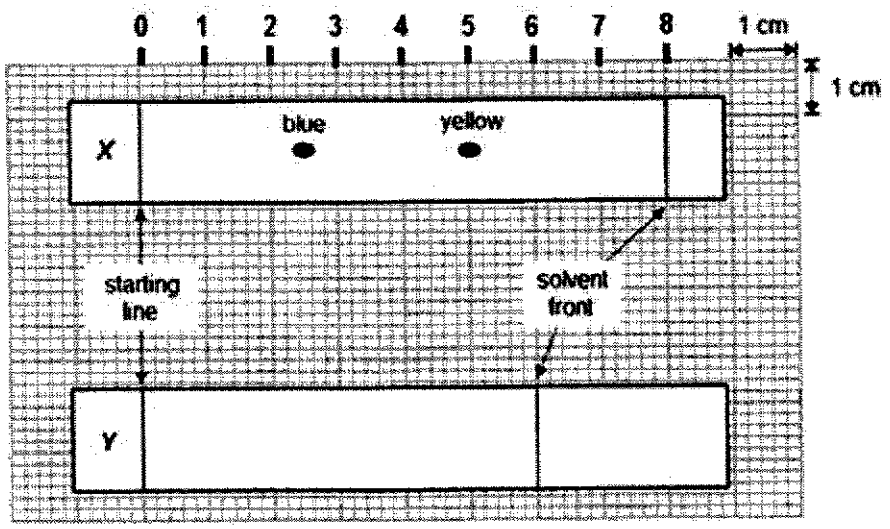


Diagram III

(a) Explain why the starting line is drawn using pencil. [1]

_____

(b) Which chromatogram, ***X*** or ***Y*** is obtained using the descending method? Explain your choice. [2]

_____

_____

_____

(c) **(i)** Calculate the R_f value of the blue and yellow dyes in chromatogram ***X***. [2]

(ii) Draw on **Diagram III** to show the position of the blue and yellow dyes in chromatogram ***Y***. [2]

(d) Which method is better to be used in separating the different dyes in the ink? Explain your answer. [1]

_____

_____

_____

A3 The table below shows three metals, **A**, **B** and **C** and their properties.

metal	melting point (°C)	observation when cut with a knife	observation when hot metal reacts with chlorine gas
A	850	difficult to cut	small flashes of light
B	98	easy to cut	bright flashes of light
C	1535	cannot be cut	no flashes of light

(a) Which metal, **A**, **B** or **C**, is an alkali metal? Give reasons for your answer. [2]

(b) A student investigated the products of the reaction of metals, **A**, **B** and **C** with water. He thinks that this method will prove that one of the metals is an alkali metal. Suggest a simple test on the products. [2]

A4 Germanium is an element in the Periodic Table with proton number of 32.

(a) **(i)** Germanium reacts with oxygen to form germanium oxide that has a melting point of 116 °C. Predict the structure of germanium oxide. [1]

(ii) Predict whether germanium oxide is acidic, basic or amphoteric. [1]

(b) **(i)** Germanium reacts with chlorine to form germanium tetrachloride. Draw the 'dot and cross' diagram to show the bonding in germanium tetrachloride. (Showing only valence electrons.) [2]

(ii) Explain whether germanium tetrachloride is able to conduct electricity. [1]

(c) Silicon is another element in the same Group as germanium. Silicon forms the compound silicon dioxide which has a high melting point of 1710 °C. Explain, in terms of structure and bonding, why silicon dioxide has such a high melting point. [2]

A5 Iron, which is an important metal, is extracted from its ore in a blast furnace.

(a) In a blast furnace, coke is added at the top together with other raw materials. The coke is first heated in the presence of air to form carbon dioxide.

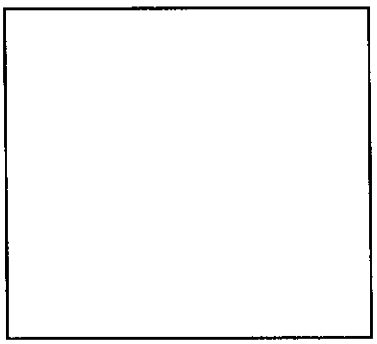
Draw diagrams to represent the arrangement of particles before and after the coke was heated. Use the legend given below. [2]

legend

● : atom of oxygen

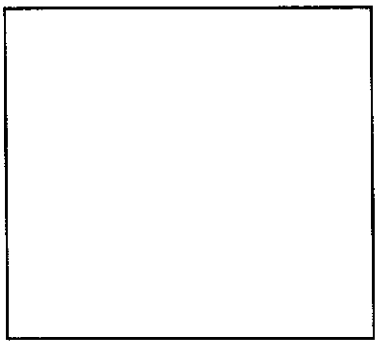
○ : atom of carbon

(i) before heating



particles of coke

(ii) after heating



particles of carbon dioxide

(b) Steel is an alloy made from iron and carbon.

(i) Give two reasons why steel is considered a mixture and not a compound. [2]

(ii) Explain why steel is stronger than pure iron. [2]

A6 Hydrazine undergoes combustion reaction to give nitrogen and steam. The equation of the reaction is as follows:

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g) \quad \Delta H = -662 \text{ kJ/mol}$$

Hydrazine is often used as a rocket fuel.

(a) Other than the heat produced from the reaction, state **one** advantage of using hydrazine as a rocket fuel, in terms of its impact on the environment. [1]

_____

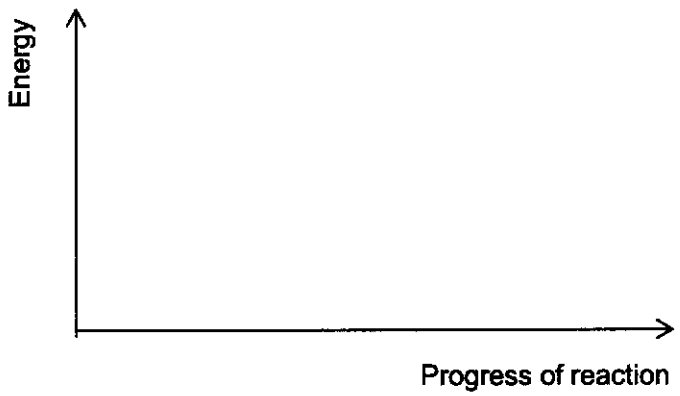
_____

(b) Explain why hydrazine is stored in the liquid state rather than as a gas. [1]

_____

_____

(c) Draw the energy profile diagram for the combustion of hydrazine on the axes provided. Indicate the activation energy and enthalpy change in your diagram. [3]



(d) Calculate the total heat energy released, in kJ, during the combustion of 10 g of hydrazine. [2]

A7 In a series of experiments, different types of acid were added to powdered sodium carbonate. The acids added were hydrochloric acid (HCl), sulfuric acid (H_2SO_4) and phosphoric acid (H_3PO_4).

(a) Phosphoric acid is a weak acid. Define 'weak acid'. [1]

_____

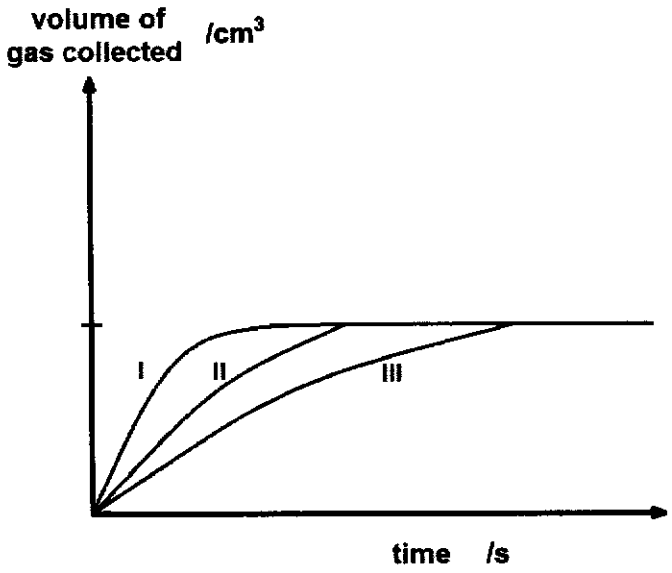
(b) Phosphoric acid is a tribasic acid. Write an ionic equation to show the ionisation of phosphoric acid. [1]

_____

(c) Different sodium salts can be formed by reacting sodium carbonate and phosphoric acid. Other than Na_3PO_4, suggest the formula of **two** other salts formed from phosphoric acid and sodium carbonate. [1]

_____

(d) The graph below shows the volume of gas collected over a fixed period of time when the three different acids were added to powdered sodium carbonate. In all experiments, the three different acids of the same concentration and volume were added in excess to the same mass of sodium carbonate.



In the table below, match the acids used to the curves labeled I, II and III obtained in the graph. [2]

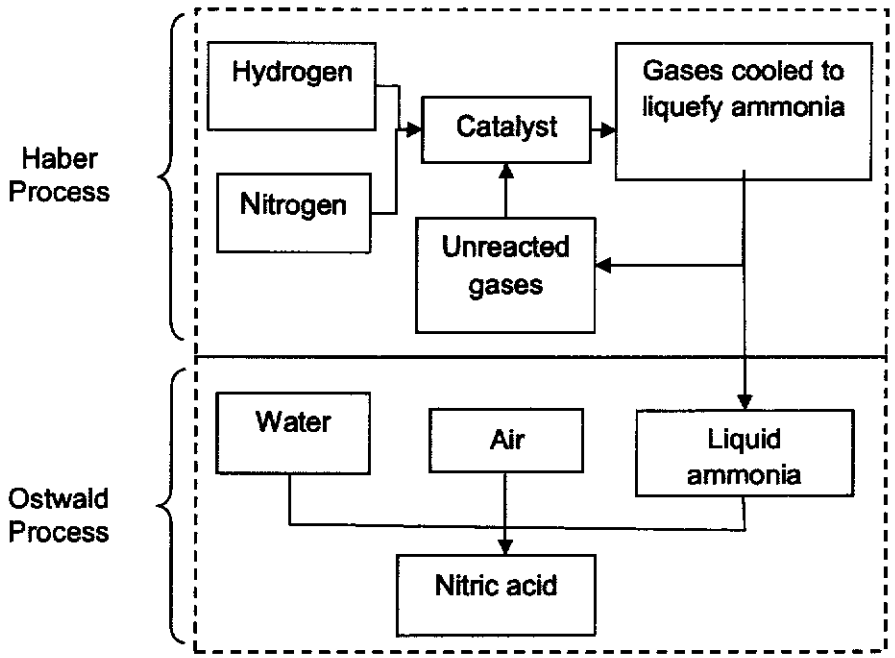
Acid used	Curve
HCl	
H_2SO_4	
H_3PO_4	

(e) On the graph shown on the previous page, sketch the curve obtained when

(i) the mass of sodium carbonate added to sulfuric acid is doubled but in lump form. Label this curve as **IV**. [1]

(ii) sodium carbonate added to sulfuric acid is replaced with calcium carbonate of the same mass. Label this curve as **V**. [1]

A8 The diagram below shows two important industrial processes, the Haber Process and Ostwald Process. Both processes produce raw materials to manufacture compounds such as plastics, agricultural materials and explosives.



(a) State the source of each of the raw materials for the Haber Process. [2]

(i) hydrogen _____

(ii) nitrogen _____

(b) When the mixture of gases is cooled, only ammonia changes to a liquid. Explain this observation. [1]

_____

_____

_____

(c) Explain what should be done to the unreacted hydrogen and nitrogen in the mixture of gases. [1]

_____

_____

(d) Explain why air is not used as a raw material in the Haber Process. [1]

_____

_____

(e) In the Ostwald Process, ammonia is converted to nitric acid.

(i) Write down the oxidation states of nitrogen in the following substances: [2]

ammonia : _____ nitric acid: _____

(ii) Using your answers in **(i)**, explain whether ammonia is oxidised or reduced in the Ostwald Process. [1]

_____

_____

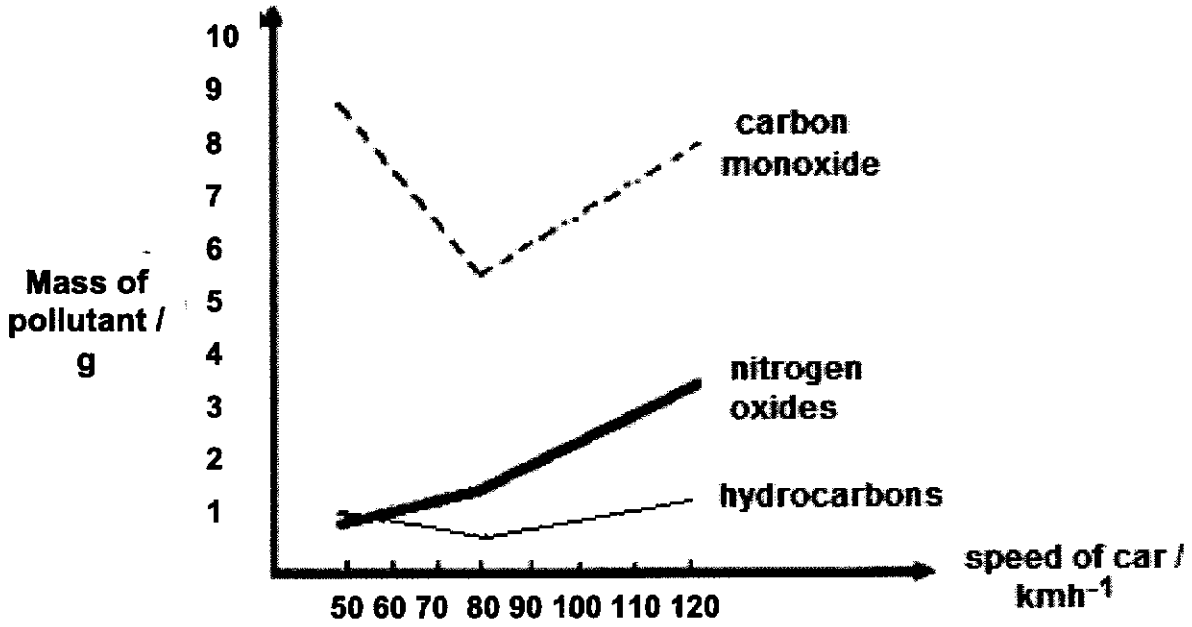
Section B

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

The total mark for this section is 30.

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

B9 **(a)** The graph below shows the mass of gaseous pollutants released from an exhaust pipe of a car travelling at different speeds.



(i) Which pollutant has the highest rate of increase with the increase in speed from 50 kmh^{-1} to 120 kmh^{-1}? Explain your answer. [2]

(ii) Account for the trend of carbon monoxide emissions in the graph as the speed of the motor car increases from 50 kmh^{-1} to 120 kmh^{-1}.

[3]

(b) CFCs are slowly being replaced with compounds containing hydrogen. Some of these replacement compounds are shown in the table below.

Formula of replacement compound	Commercial code of compound	Potential for destroying the ozone layer (on a scale of 0 - 10)
$CHClF_2$	22	0.05
CF_3CH_2F	134	0.00
CH_3CCl_2F	141	0.12
CH_3CHF_2	152	***X***

(i) State the full name of CFCs. [1]

(ii) Explain how CFCs destroys the ozone layer when released into the atmosphere. [3]

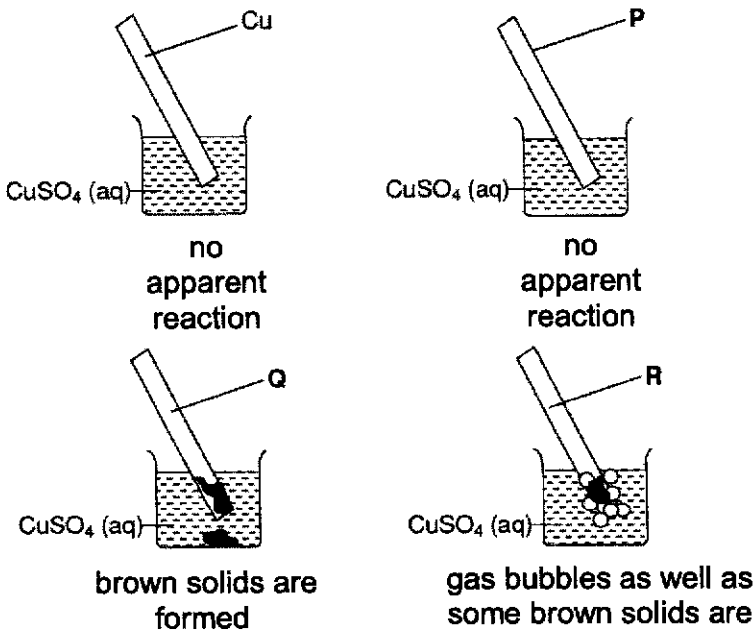
(iii) Suggest a value for ***X*** and explain your answer. [1]

B10 (a) The following experiments were conducted to determine the order of reactivity of four metals, copper, **P**, **Q** and **R**.

In the first experiment, the oxides of the four metals were heated. The results are shown in the Table below.

Metal Oxide	CuO	P_2O	QO	RO
Observation	No Reaction	Metal P is formed	No Reaction	No Reaction

In the second experiment, copper, **P**, **Q** and **R** are added separately to copper(II) sulfate solution. The observations are shown in Figure below.



(i) For the reaction between **Q** and copper(II) sulfate solution, give another observation that should be seen. Explain the observations. [2]

(ii) Explain the formation of bubbles in the reaction between **R** and copper(II) sulfate solution. Write the chemical equation for this reaction. [2]

(iii) Arrange the four metals in increasing order of reactivity. [1]

(b) Fungicide, which is used to prevent the growth of fungi, contains aqueous copper(II) sulfate.

(i) Galvanised iron is steel coated with a layer of zinc. Explain why fungicide should not be stored in cans made from galvanized iron. [2]

(ii) Write an ionic equation, with state symbols, for the reaction that happens in **(i)**. [2]

(c) Explain why zinc blocks are attached to the steel hulls of ships. [1]

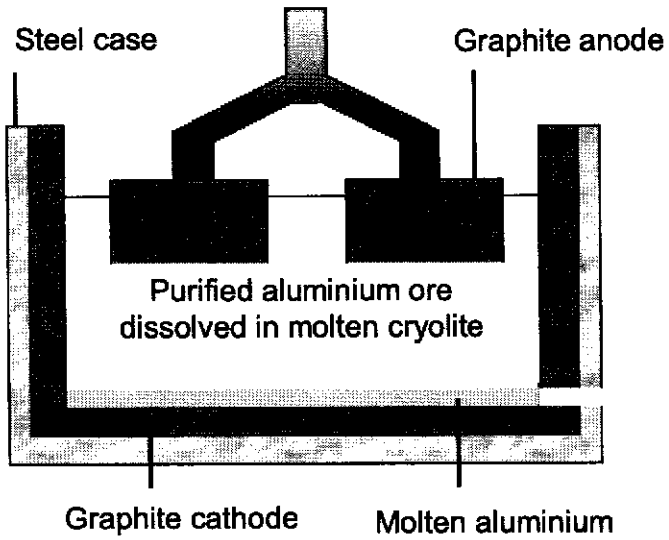
EITHER

B11

Extraction of Aluminium

Aluminium is an important metal to humans. It is used for a variety of purposes, from building aircraft bodies to preserving food. Unlike metals lower down the reactivity series, aluminium cannot be extracted by reduction with carbon. Rather, it is extracted by electrolysis.

The ore of aluminium is bauxite, Al_2O_3. To extract aluminium from bauxite, the bauxite would first need to be melted. However, aluminium oxide has a very high melting point of more than 2000 °C. To overcome this problem, the bauxite is dissolved in molten cryolite, which lowers the melting point of the mixture to about 1200 °C. Graphite is used as both the cathode and the anode as shown in the diagram below.



At the cathode, molten aluminium forms and is tapped off at the bottom of the reaction tank. At the anode, oxygen forms and reacts with the graphite. Because of this reaction, the anodes constantly have to be replaced.

Cost of Electrolysis

Electrolysis is a very expensive process because of the large amounts of energy which need to be provided for the process to take place. In the extraction of aluminium, the typical current which is used averages about 30 000 A. In addition, having to constantly replace the graphite anodes with new ones also adds to the cost of the electrolysis process. Hence, aluminium is an expensive and valuable metal.

Calculations involving electrolysis

To calculate the number of moles of the aluminium that is produced in a given time, one would need to use Faraday's law. In Faraday's law, it is stated that

$$\text{Current in amperes} = \frac{\text{Charge in coulombs}}{\text{Time in seconds}},$$

where 96500 coulombs deliver a charge that is equivalent to 1 mole of electrons. By finding the charge delivered in a given time, one could then find the number of moles of electrons produced and make use of the half-equation for the production of aluminium to find the mass of aluminium produced.

(a) (i) Write half-equations for the reactions occurring at the cathode and the anode. Include state symbols. [2]

_____

_____

_____

(ii) Hence, write the overall equation for the electrolysis of bauxite. [1]

_____

(b) Adding cryolite to the bauxite lowers the melting point of the mixture. Suggest the benefit of adding cryolite to lower the melting point. [1]

(c) By writing a chemical equation, explain why the anodes have to be constantly replaced. [2]

(d) By using the half-equations for the reactions taking place at the cathode and the anode, or otherwise, calculate

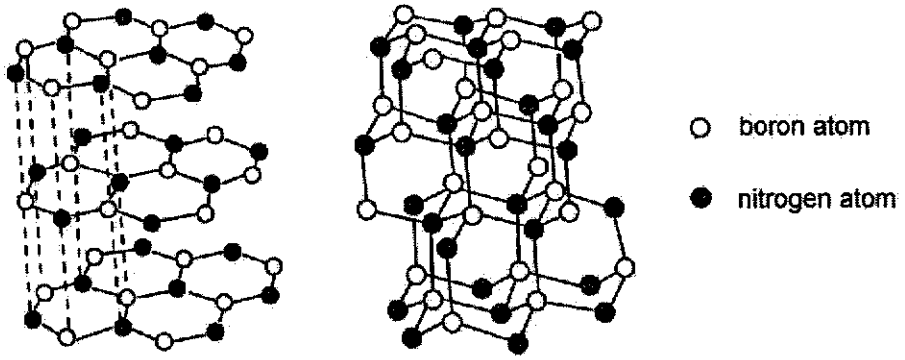
(i) the charge delivered by a typical setup designed to electrolyse aluminium from bauxite that is left running for 1 hour. [1]

(ii) the mass of aluminium which is produced by this electrolysis setup per hour. [2]

(iii) A company has to deliver 20 tonnes of purified aluminium to a customer using this electrolysis setup. Calculate the amount of time it would take for the company to produce the required mass of aluminium using this setup. [1]

OR

B11 Boron nitride is found to exist in two possible forms, hexagonal boron nitride and cubic boron nitride as shown below.



Hexagonal boron nitride Cubic boron nitride

(a) Carbon can also be found in two different forms (allotropes). Name the allotropes of carbon which has a similar structure as [1]

(i) hexagonal boron nitride _____

(ii) cubic boron nitride _____

(b) Based on the structures shown, explain the difference in **one** physical property of hexagonal and cubic boron nitride other than electrical conductivity. [3]

_____

_____

_____

_____

_____

_____

(c) The melting points of hexagonal boron nitride and two other compounds of nitrogen are given below.

Compound	Melting point / °C
Hexagonal boron nitride	2973
Aluminium nitride (AlN)	2200
Hydrazine (N_2H_4)	2

(i) Draw the 'dot and cross' diagram to represent the bonding in hydrazine. Shows all electrons. [2]

(ii) Draw the 'dot and cross' diagram to represent the bonding in aluminium nitride. Shows only valence electrons. [2]

(iii) Both hexagonal boron nitride and aluminium nitride have a very high melting points. Explain why in terms of the structures present in both substances. [2]

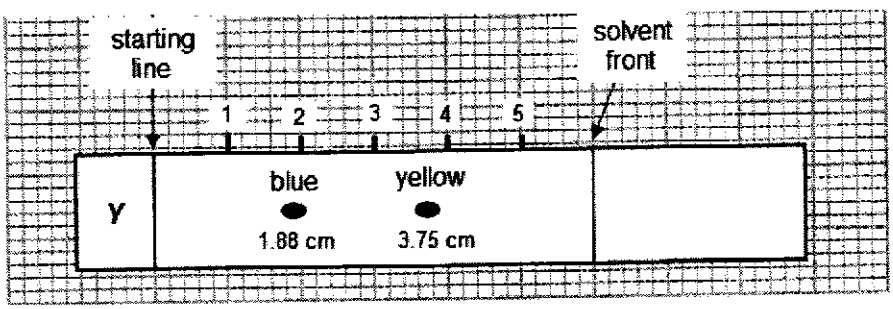
---------- END OF THE PAPER ----------

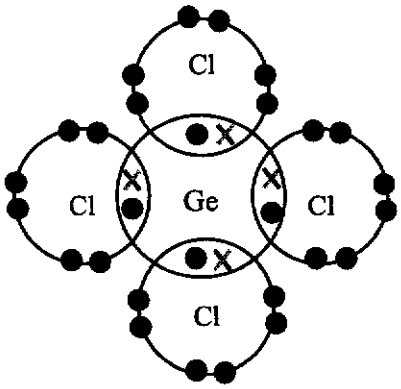
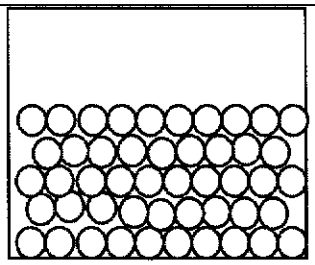
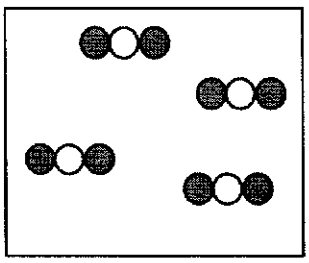
2020 6092 prelim suggested Mark scheme

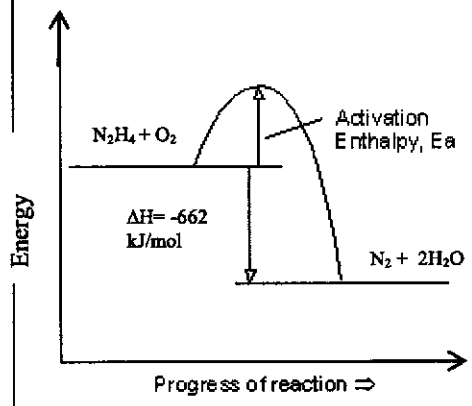
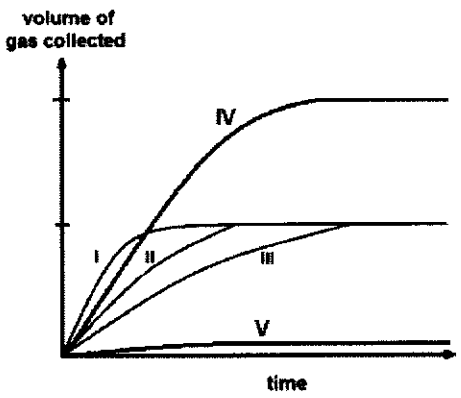
Paper 1 [40 marks]

1	2	3	4	5	6	7	8	9	10
D	D	C	D	A	B	B	B	C	D
11	12	13	14	15	16	17	18	19	20
A	C	B	A	C	B	B	C	B	A
21	22	23	24	25	26	27	28	29	30
C	D	D	A	D	C	B	D	D	C
31	32	33	34	35	36	37	38	39	40
D	B	A	C	D	C	D	B	B	D

Paper 2

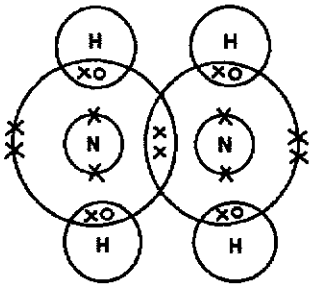
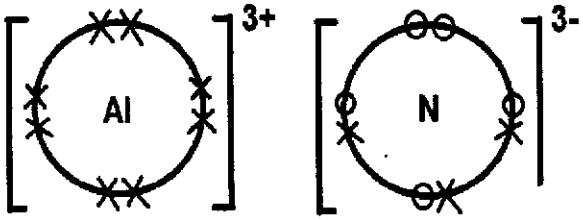
A1	a		D	1
	b		A	1
	c		B	1
				3
A2	a		Pencil is used because the graphite in it is insoluble in alcohol/solvent and thus will not travel (up/down) on the paper (together with the ink dyes) with the solvent. [1]	1
	b		Chromatogram X. The solvent front in chromatogram X travels a further distance than in chromatogram Y. This is due to the pull of gravity on the solvent/alcohol [1].	1
	c	i	R_f value of the blue dye = $\frac{1.88}{6}$ = 0.313 R_f value of the yellow dye = $\frac{3.75}{6}$ = 0.625	1 1
		ii		1 1
	d		Descending method with the same duration of time for the process The dyes in descending method travel further from the starting line .Thus, the dyes will not overlap / dyes are far apart to be distinguished / separation is more complete [1].	1 1
				8
A3	a		B, because it has a low melting point, is soft and reacts vigorously with chlorine (provides at least 2 reasons)	1 1

	b		When alkali metal reacts with water, an alkaline solution will be produced, which will turn Universal Indicator purple/ red litmus paper blue	1 1
				4
A4	a	i	Simple molecular (covalent) structure	1
		ii	Amphoteric	1
	b	i		2
		ii	It is unable to conduct electricity as it does not have free (mobile) electrons or ions.	1
	c		Silicon dioxide has a higher melting point as it has a giant molecular structure with strong covalent bonding between atoms throughout the solid. Thus a lot of energy needed to break the strong covalent bonds during melting	1 1
				7
A5	a	i		1
		ii		1
	b	i	- Steel can be separated into iron and carbon using physical methods/ The iron and copper in steel are not chemically combined - Steel has the same chemical properties as its elements - Iron and carbon can be in any ratio by mass in brass -Steel melts over a range of temperatures/ has no fixed melting oint(Any2)	2
		Ii	The different-sized carbon atoms disrupt the orderly arrangement of the iron atoms, making it harder for the layers of iron atoms to slide over each other when a force is applied.	1 1
				6
A6	a		It only produces nitrogen and steam, which are non-pollutants, during combustion	1

	b		The particles in a liquid are packed much more closely together than in a gas, hence a there is more mass of liquid than gas in a given volume.	1
	c		 [1]- activation energy (with direction) [1]- enthalpy change (with direction) [1]-correct energy level of reactants and products (specify chemicals)	3
	d		Mr of hydrazine= 2x14 + 4 = 32 No. of moles of hydrazine in 10 g = 10/32 = 0.3125 mol Total energy released = 0.3125 x 662 = 206.875 = 207 kJ(3 s.f.)	1 1
				7
A7	a		Weak acid is a substance which ionises / dissociates partially in water to produce H^+ ions. [1]	1
	b		$H_3PO_4(aq) \rightarrow 3H^+(aq) + PO_4^{3-}(aq)$	1
	c		NaH_2PO_4 and Na_2HPO_4 [1]	1
	d		**Acid used** / **Curve** HCl / II H_2SO_4 / I H_3PO_4 / III [2] marks for all correct	2
	e	i & ii		1 1
				7
A8	a	i	Electroysis of water / Cracking of petroleum/ crude oil	1
		ii	Fractional distillation of air	1
	b		Ammonia has a higher boiling point than nitrogen and hydrogen, so it will condense to a liquid first.	1
	c		The hydrogen and nitrogen should be recycled for further reaction to produce more ammonia	1

	d		Nitrogen or hydrogen would react with oxygen in air / Explosion of hydrogen and oxygen would occur	1
	e	i	-3; +5	1 1
		ii	Ammonia is oxidized, as the oxidation state of nitrogen increases from -3 (in NH_3) to +5 (in HNO_3)	1
				8
B9	a	i	Nitrogen oxides . When the speed of the car increases, the engine gets hotter / increase in temperature in car engine causes more nitrogen and oxygen in the air to react to form nitrogen oxides [2].	1 1
		ii	Trend: Emissions of carbon monoxide decreases during 50 to 80kmh^{-1} and increases during 80 to 120kmh^{-1}. Explanation for decrease during 50 to 80kmh^{-1}: As the car moves faster from 50 to 80kmh^{-1}, more oxygen is taken in into the car engine leading to more complete combustion of petrol taking place . This increases the amount of carbon dioxide. OR As the car moves faster from 50 to 80kmh^{-1}, more oxygen is taken in into the car engine leading to less incomplete combustion of petrol taking place . This decreases the amount of carbon monoxide. At minimum point: Carbon monoxide emission is minimum at 80kmh^{-1} since the car engine functioning most efficiently at this speed / most complete combustion of petrol taking place at this speed . Explanation for increase during 80 to 120kmh^{-1}: At higher speed from 80kmh^{-1} onwards, rate of combustion of petrol is greater than the rate of oxygen gas entering the engine.	1 1 1
	b	i	CFCs is chlorofluorocarbons .	1
		ii	In the presence of ultraviolet radiation[1], the CFCs will decompose to form reactive chlorine atoms [1] . These chlorine atoms will react with the ozone molecule to form chlorine oxide and oxygen [1] . Thus, depleting the ozone layer.	1 1 1
		iii	X is 0.00 since chlorine atoms are not present in CH_3CHF_2 to react with ozone.	1
				10
B10	a	i	The blue copper(II) sulfate solution becomes lighter in colour. [1] Reason: Copper is less reactive than **Q**, Cu^{2+} ions which are responsible for the blue colour get displaced as metallic copper [1]	1 1
		ii	R is a reactive metal and it reacts with the water used to prepare the copper(II) sulfate solution to form bubbles of hydrogen. [1] $R + 2H_2O \rightarrow R(OH)_2 + H_2$ [1]	1 1
		iii	**P**, copper, **Q**, **R**	1
	b	i	copper being less reactive than zinc [1] will cause zinc (from galvanised iron) to displace copper from the copper(II) sulfate solution [1]	1 1
		ii	$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$ *-1 for missing/wrong state symbols*	2
	c		Zinc, being more reactive than iron in steel, will corrode in place of iron.	1
				10

E B11	a	i	Cathode: Al^{3+} (*l*) + $3e^-$ → Al (s) [1] Anode: $2O^{2-}$ (*l*) → O_2 (g) + $4e^-$ [1] If state symbols are wrong in both equations but the rest of the equation is written correctly, penalise once only.	1 1
		ii	$4Al^{3+} + 6O^{2-} \rightarrow 4Al + 3O_2$ OR $2Al_2O_3 \rightarrow 4Al + 3O_2$ Correct chemical symbols and balanced equation	1 1
	b		When the melting point is lowered, less energy would need to be used to melt the aluminium oxide. This would result in cost savings. Do not award mark if student just writes that cost is reduced without explaining the reason behind the cost reduction.	1
	c		At high temperatures, the oxygen gas reacts with the graphite (carbon) anodes to form carbon dioxide gas. [1] Hence, as time passes, the mass of the anodes would reduce and they would have to be replaced $C + O_2 \rightarrow CO_2$	1 1
	d	i	Charge delivered by the setup = 30000 X 60 X 60 = 1.08 X 10^8 C [1]	1
		ii	No of moles of electrons produced = $\frac{1.08 \times 10^8}{96500}$ = 1120 mol (3sf) [1] Hence, no of moles of aluminium produced = $\frac{1120}{3}$ = 373 mol (3sf) Mass of aluminium produced = 373 X 27 = 10100 g (3sf) or 10.1kg (3sf) [1]	1
		iii	Time the company needs to produce the aluminium = $\frac{20 \times 10^3}{10.1}$ = 1990 hrs [1] (3sf) If 3sf not given in questions or if there is rounding error, penalise only once for part (ii) and (iii) combined.	1
				10
O B11	a	i	graphite	Both 1
		ii	diamond	
	b		Hexagonal boron nitride (HBN) is <u>soft</u> while cubic boron nitride (CBN) is very <u>hard</u> [1]. The layers of <u>atoms</u> in HBN is held by weak van der Waals' forces while the <u>atoms</u> in CBN are held by strong covalent bonds in tetrahedral arrangement [1]. When a force is applied, the layers of atoms in HBN can slide over another while atoms in CBN cannot slide/making the structure rigid [1].	1 1 1

	c	i	*Draw covalent bonding in hydrazine (as shown below) correctly, showing all electrons with legend.* [2]  **legend** X = electron of N O= electron of H **Note:** Deduct 1 mark for showing valence electrons only or missing legend	1 1
		ii	 **legend** on of Al of N **Note:** Deduct 1 mark for showing all electrons ONLY	2
		iii	Hexagonal boron nitride requires a very large amount of heat energy to break the strong covalent bonds between atoms in the giant molecular structure . While aluminium nitride requires a very large amount of heat energy to overcome the strong electrostatic forces of attraction between ions in the giant ionic lattice structure [2].	1 1
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