COMMONWEALTH SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2021

CHEMISTRY
PAPER 1

Name: _____ ( ) Class: _____

SECONDARY FOUR EXPRESS	**Fri 17 Sep 2021**
6092/01	**1h**
	1100 – 1200 h

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on the question paper and the OTAS sheet.
Write in soft pencil.
An approved scientific calculator may be used.

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

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 15.

This paper consists of **<15>** printed pages including the cover page.

[Turn over

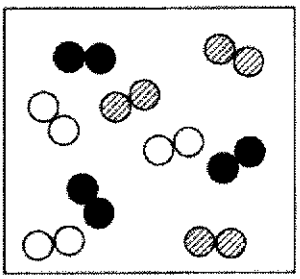
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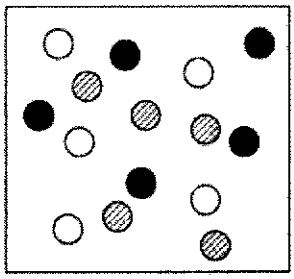
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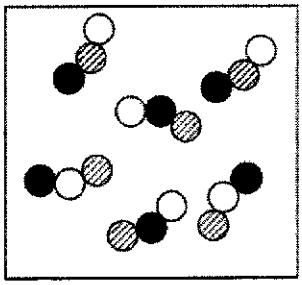
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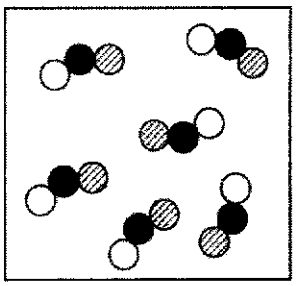
1 A gaseous mixture is made up of nitrogen, oxygen and chlorine.

Which diagram could show a pure sample of this mixture?

A 

B 

C 

D 

2 A new substance was discovered and a series of experiments were conducted on it. Which observation suggests that the substance is an element?

A The molten substance does not form any product during electrolysis.
B The solid substance dissolves in water to give an alkaline solution.
C The solid substance forms two oxides when heated in air.
D The substance is a good conductor of electricity only in aqueous solution.

3 An organic solvent (hexane) and aqueous sodium chloride were accidentally mixed together.

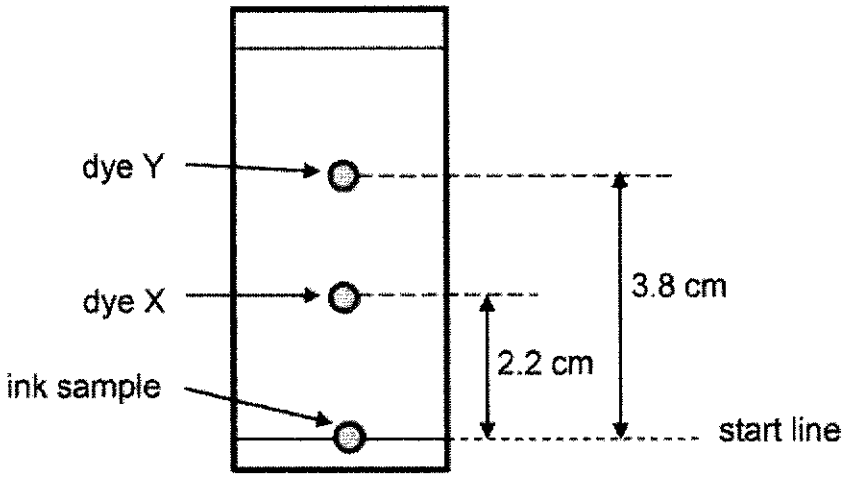
Which methods of separation are needed to obtain pure samples of hexane and solid sodium chloride?

A filtration followed by crystallization
B fractional distillation followed by evaporation to dryness
C simple distillation followed by crystallization
D using a separating funnel followed by evaporation to dryness

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4 The results of a paper chromatography experiment were shown below.



Given the R_f values of dye X is 0.40, determine the R_f value of dye Y.

A 0.50
B 0.69
C 0.70
D 5.50

5 A saturated solution of iron(II) chloride is allowed to cool during the process of crystallisation.

Which of the following statements are true?

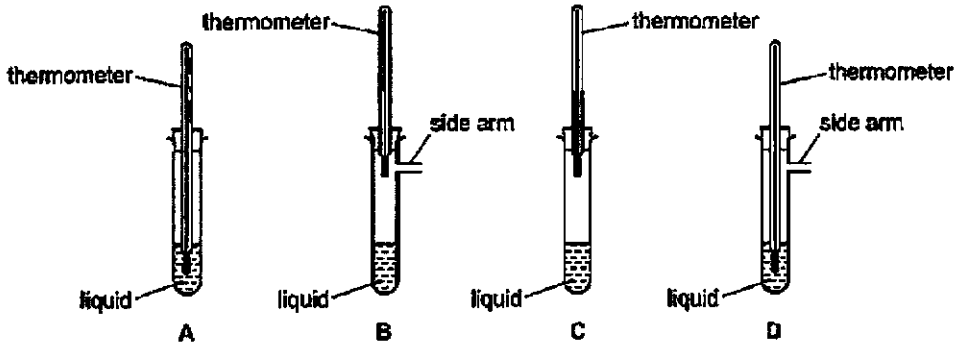
I. The mass of dissolved iron(II) chloride in the solution changes.
II. The concentration of the iron(II) chloride solution remains the same.
III. The solubility of iron(II) chloride decreases as it cools.
IV. The number of moles of dissolved iron(II) chloride in the solution remains the same.

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

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6 The tubes shown below contain a dilute solution of a solid dissolved in a liquid. Which apparatus is most suitable for finding the boiling point of the liquid?

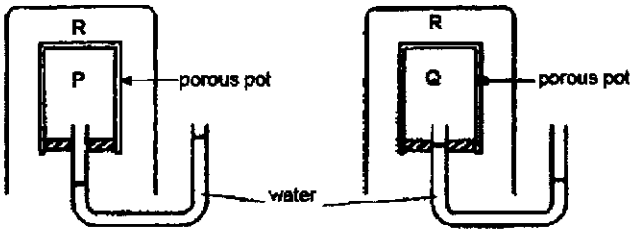


7 Which of the substances below are gases at room temperature?

substance	melting point /°C	boiling point /°C
I	44	76
II	- 30	69
III	- 101	- 35
IV	12	53
V	- 11	12
VI	98	890

A I and III
B IV and VI
C III and V
D II and V

8 The apparatus shows the diffusion of 3 gases. Two beakers containing gas **R** were placed over two porous pots containing gases **P** and **Q** as shown.

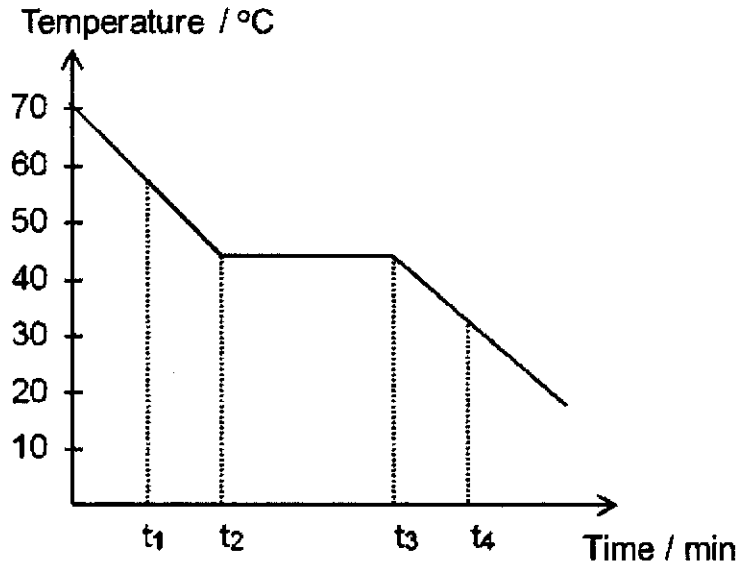


What are the relative molecular masses of gases **P**, **Q** and **R** in ascending order?

	Lowest ⟶ Highest		
A	**Q**	**P**	**R**
B	**Q**	**R**	**P**
C	**P**	**R**	**Q**
D	**P**	**Q**	**R**

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9 Stearic acid is a solid at room temperature. The cooling curve of stearic acid is as shown.



What can be inferred from the graph?

A At time interval t_1 to t_2, heat is absorbed from the surroundings.
B At time interval t_2 to t_3, all stearic acid exists as solid.
C At time interval t_2 to t_3, crystals of stearic acid start to form.
D At time interval t_3 to t_4, all the stearic acid molecules are irregularly arranged.

10 The table shows information about particles **R** and **S**.

Particle	Number of		
	protons	neutrons	electrons
R	11	12	10
S	19	20	18

Which of the following statement is correct for both **R** and **S**?

A Both are atoms in the same Group.
B Both are isotopes of the same element.
C Both are positive ions in the same Group.
D Both are positive ions in different Groups

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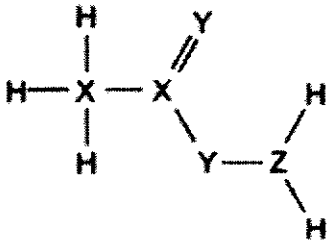
11 Boron consists of two isotopes. The table below shows the relative abundances of these two isotopes.

Isotopes	Relative abundance
$^{10}_{5}B$	19.7%
$^{11}_{5}B$	80.3%

What is the relative atomic mass of boron?

A 10.4
B 10.5
C 10.8
D 10.9

12 The diagram shows the structure of a covalent compound containing the element hydrogen and the unknown elements **X**, **Y** and **Z**.



Which of the following shows the correct number of valence electrons of the three elements, **X**, **Y** and **Z**?

	X	Y	Z
A	4	5	6
B	4	6	5
C	4	5	1
D	5	1	4

13 Which statement explains why calcium oxide, CaO, has a higher melting point than potassium bromide, KBr?

A Calcium is less reactive than potassium.
B The melting point of potassium is lower than calcium.
C The attraction between Ca^{2+} and O^{2-} is stronger than that between K^{+} and Br^{-}.
D Calcium oxide is a covalent compound and potassium bromide is an ionic compound.

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14 Melanin is a plastic containing 28.6% carbon, 4.8% hydrogen and 66.6% nitrogen by mass. If its relative molecular mass is 126, what is its molecular formula?

A CH_2N_2
B $C_2H_4N_4$
C $C_3H_6N_6$
D $C_4H_8N_8$

15 It was found that 20.0 cm^3 of 0.500 mol/dm^3 dilute hydrochloric acid completely react with 0.70 g of a sample sodium carbonate contaminated with sodium chloride.

What is the percentage purity of the sodium carbonate in the sample?

A 44.5%
B 45.4%
C 75.7%
D 80.9%

16 Given 1 g of each of the following substances, which substance has the smallest number of atoms?

A argon
B hydrogen
C iodine
D lead

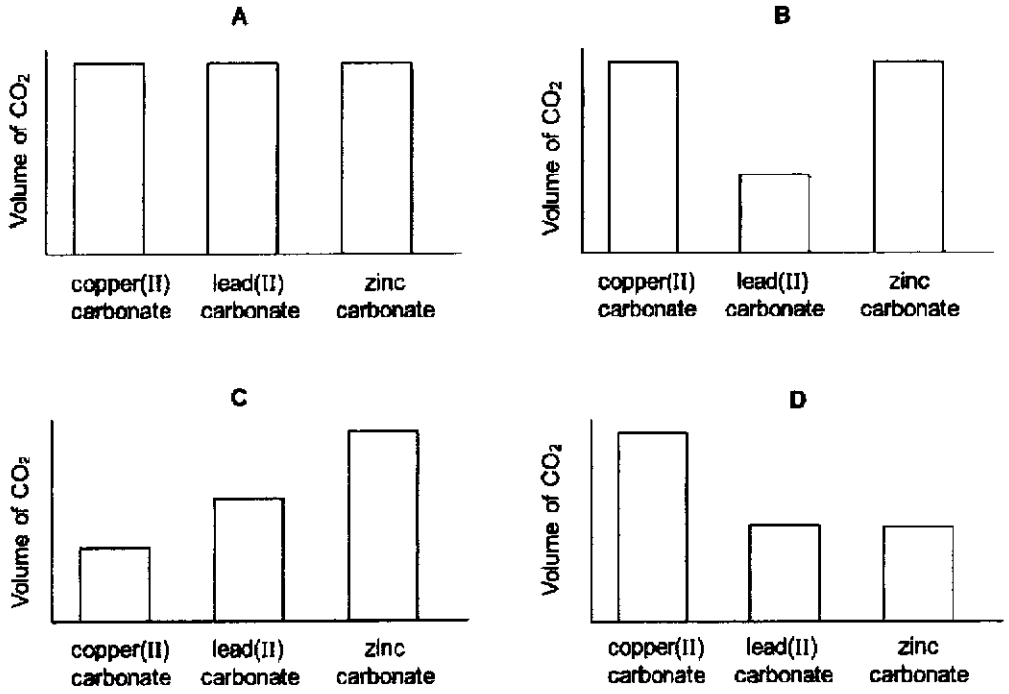
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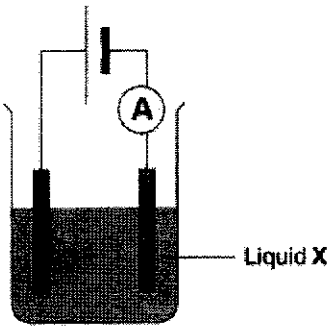
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17 Equal volumes of 1.5 mol/dm^3 dilute sulfuric acid were added to equal mass of copper(II) carbonate, lead(II) carbonate and zinc carbonate (all lumps) separately in three test tubes.

Which graph shows the relative volumes of carbon dioxide evolved from each test tube?



18 In the circuit below, the ammeter showed that no current was flowing as no reading was registered.



When hydrogen chloride or ammonia was bubbled through liquid **X**, the ammeter showed a reading.

What is liquid **X** likely to be?

A aqueous hydrogen chloride
B aqueous ammonia
C distilled water
D tetrachloromethane

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19 A series of four aqueous potassium hydroxide with different concentrations was prepared, and tested with the indicator brilliant cresol blue. The results are shown below.

pH	colour with brilliant cresol blue
9	blue
10	blue
11	green
12	yellow
13	yellow

Two unknown solutions were then tested with the indicator brilliant cresol blue.

unknown solution	colour with brilliant cresol blue
X	blue
Y	yellow

Based on the results of the above experiments, which of the following is the most likely conclusion about the pH of **X** and **Y**?

A The pH of **X** is 10, and the pH of **Y** is 12.
B The pH of **X** is 10, and the pH of **Y** is 12 or more.
C The pH of **X** is 10 or less, and the pH of **Y** is 12 or more.
D The pH of **X** is 10, and the pH of **Y** is between 12 and 13, inclusive.

20 Which calcium compound does **not** increase the pH of acidic soils?

A calcium carbonate
B calcium hydroxide
C calcium oxide
D calcium sulfate

21 Which statement about an alkaline solution is correct?

A It contains equal number of hydrogen and hydroxide ions.
B It contains more hydrogen ions than hydroxide ions.
C It contains more hydroxide ions than hydrogen ions.
D It contains only hydroxide ions.

22 Which of the following methods would **not** produce ammonia gas?

A Boiling concentrated aqueous ammonia.
B Heating aqueous ammonium nitrate with copper(II) hydroxide.
C Heating aqueous ammonium sulfate with aqueous potassium hydroxide.
D Heating aqueous calcium nitrate with aluminium foil and aqueous sodium hydroxide.

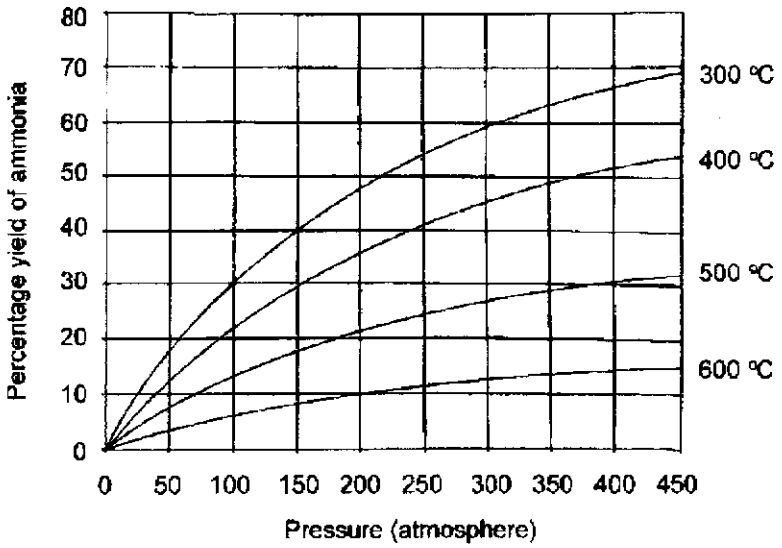
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23 In the Haber process for the manufacture of ammonia, which of the following statements are correct?

I. The catalyst used is a transition metal.
II. Unreacted nitrogen and hydrogen are circulated back into the system.
III. Both reactants are obtained from the fractional distillation of liquefied air.
IV. The reaction is reversible.

A I, II and III
B I, II and IV
C II, III and IV
D All of the above

24 The graph below shows how the percentage yield of ammonia varies with temperature and pressure.



Based on the graph, which of the following statements is **not** correct?

A The yield of ammonia increases with increasing pressure.
B The yield of ammonia decreases with increasing temperature.
C The effect of pressure on the yield of ammonia is greater at higher temperatures.
D Maximum yield is achieved at 300°C and 450 atmosphere.

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25 Which of the following methods will **not** slow down the rusting process of an iron nail?

A submerge the iron nail in oil
B electroplate the iron nail with silver metal
C submerge the iron nail in a container completely filled with boiled water
D weld a piece of copper metal to the iron nail

26 Approximately 40% of all iron and steel is produced by recycling.
Which of the following statements is the possible reason for recycling iron?

A Recycling improves the living conditions of marine life.
B Recycling reduces the amount of pollution at the site of the ore extraction.
C Scrap steel contains a higher percentage of iron than iron ore.
D Recycling reduces the need to collect the scrap iron and steel.

27 Which are the main gases that escape from the top of the blast furnace during the manufacture of iron?

A carbon dioxide, carbon monoxide, hydrogen
B carbon dioxide, carbon monoxide, nitrogen
C carbon dioxide, oxygen, sulfur dioxide
D nitrogen, oxygen, steam

28 Which of the following combinations below correctly states how the increase in the percentage of carbon in steel affects its properties?

	strength	malleability	melting point	brittleness
A	↑	↑	↓	↓
B	↑	↓	↑	↓
C	↑	↓	↓	↑
D	↓	↑	↑	↑

29 Which property is **not** typical of transition metals?

A They formed coloured compounds.
B They have high melting points.
C They have low densities.
D They show variable oxidation states.

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30 In which reaction is the underlined substance acting as a reducing agent?

A chlorine + iron(II) chloride → iron(III) chloride
B hydrogen + copper(II) oxide → copper + water
C hydrochloric acid + magnesium oxide → magnesium chloride + water
D iron(III) oxide + carbon monoxide → iron + carbon dioxide

31 Which of the following reaction is endothermic?

A Combustion of petroleum gases
B Decomposition of copper(II) carbonate
C Displacement of reaction of silver ions by copper
D Neutralisation of dilute nitric acid by aqueous ammonia

32 Hydrogen reacts with chlorine according to the equation below.

$$H_2 + Cl_2 \rightarrow 2HCl \qquad \Delta H = -184 \text{ kJ/mol}$$

The H-H bond energy is 436 kJ/mol and the Cl-Cl bond energy is 242 kJ/mol. What is the H-Cl bond energy?

A 862 kJ/mol
B 678 kJ/mol
C 431 kJ/mol
D 247 kJ/mol

33 Which statement explains why coal dust forms an explosive mixture with air?

A Coal dust catalyse the explosion.
B Crushing coal breaks chemical bonds.
C Coal dust have a large surface area.
D Crushing coal releases hydrogen from compounds in coal.

34 Which change would increase the speed of reaction between two gases?

A a decrease in surface area of the catalyst
B a decrease in temperature
C a decrease in the size of the reaction flask
D a decrease in the pressure of the gases

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35 An electric current was passed through molten calcium chloride, producing 2.00 g of calcium metal at the cathode.

What mass of chlorine was produced at the anode?

A 2.78 g
B 3.55 g
C 4.00 g
D 8.50 g

36 Which statements best explains why bitumen has a higher boiling point than paraffin?

1. Bitumen is more reactive than paraffin.
2. Bitumen is a pure substance whereas paraffin is a mixture.
3. Forces of attraction between the molecules of paraffin are weaker than that between the molecules of bitumen.
4. There are bigger molecules in bitumen compared to the molecules in paraffin

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

37 The general formula for alkene is C_nH_{2n}.

Which physical property does **not** increase as n increases?

A boiling point
B density
C percentage of carbon by mass
D viscosity

38 Which statement about fractional distillation of petroleum is correct?

A The higher up the column, the greater the temperature.
B The higher up the column, the greater the density.
C The molecules collected at the bottom of the column are the most flammable.
D The molecules reaching the top of the column have the smallest relative molecular mass.

39 Which of the substances will react with ethene to form more than one product?

A bromine
B hydrogen
C oxygen
D steam

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40 A chemical analysis on a famous brand of fruit juice shows the presence of a substance with the structural formula $CH_3CO_2C_9H_{18}CH_3$.

What is the most likely use of this substance in the fruit juice?

A antioxidant
B flavouring
C preservative
D coagulant

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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.).

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PRELIMINARY EXAMINATION 2021

CHEMISTRY
PAPER 2

Name: _____( ) Class: _____

Secondary Four Express | **Mon 13 Sep 2021**

6092/02 | **1 h 45 min**
1100 – 1245 h

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on the question paper and any separate answer sheets used.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough work.
Do not use staples, paper clips, highlighters, glue or correction fluid.
An approved scientific calculator may be used.

Section A
Answer **all** questions in the spaces provided on the Question Paper.

Section B
Answer all **three** questions. The last question is in the form of either/or and only one of the alternatives should be attempted.
Circle the question B11E or B11O that you have attempted.
Write your answers in the spaces provided on the Question Paper.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is printed on page 19.

For Examiner's Use	
Section A	**/ 50**
B9	**/ 10**
B10	**/ 10**
B11 E / O	**/ 10**
Total	**/ 80**

Parent's / Guardian's Signature | |

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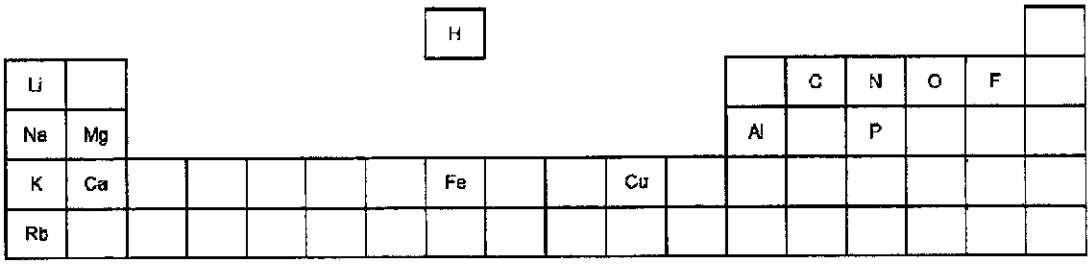
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Section A (50 marks)

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

For examiner's use

A1 The diagram shows part of the Periodic Table. Only some of the elements are shown.



Answer each of the following questions using only those elements shown in the diagram. Each element may be used once, more than once or not at all.

Give one element which

(a) has an atom with only seven electrons.

..... [1]

(b) forms an ion of type X^{2-} which has only two completely filled shells of electrons.

..... [1]

(c) a metallic element that burns in oxygen to form a white solid residue which is soluble in excess aqueous ammonia.

..... [1]

(d) has a chloride of type XCl_4.

..... [1]

(e) is the most powerful oxidising agent.

..... [1]

[Total: 5]

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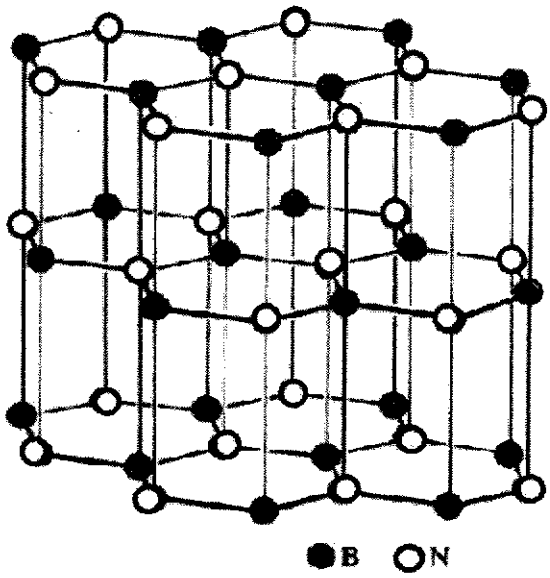
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A2 Boron nitride powder is a widely used compound in makeup as it is shimmery, slides smoothly onto skin and also chemically unreactive which lowers the chances of causing skin irritation.

For examiner's use

The diagram below shows the structure of boron nitride, with each hexagonal ring consisting of three boron atoms and three nitrogen atoms.



(a) Suggest why boron nitride powder is able to slide smoothly onto skin.

.....

..... [1]

(b) Both boron nitride and graphite have giant molecular structure.
Explain, in terms of bonding, why graphite conducts electricity but boron nitride does not conduct electricity.

.....

.....

.....

.....

..... [4]

[Total: 5]

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A3 Aqueous solutions of **sodium carbonate, calcium hydroxide, copper(II) chloride** and **silver nitrate** are stored in four bottles labelled **A, B, C** and **D**, but not necessarily in that order.

For examiner's use

A class of pupils was instructed to carry out the following procedures on these solutions. The record of one pupil is shown below.

Procedure	Observations	Equation
Mix **A** with **B**	A white precipitate is observed. Precipitate dissolves with the addition of dilute hydrochloric acid.	
Mix **A** with **C**	A green solid is observed. Precipitate dissolve with addition of dilute hydrochloric acid.	
Mix **C** with **D**	A white precipitate is formed in a blue solution. Precipitate does not dissolve with the addition of dilute hydrochloric acid.	

(a) Use the information above to identify solutions **A, B, C** and **D**. [4]

A is .....

B is .....

C is .....

D is .....

(b) Complete the above table by writing the appropriate balance equation for each reaction producing the precipitate in the experiment report shown above. [3]

[Total: 7]

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A4 Zinc is an essential trace element which is necessary for the healthy growth of animals and plants. Zinc deficiency in humans can be treated by using zinc salts as dietary supplements.

For examiner's use

(a) Crystals of zinc sulfate may be prepared by reacting dilute sulfuric acid with a suitable compound of zinc.

(i) State the formula of a suitable zinc compound and the preparation method.

Formula of a suitable zinc compound: .....

Preparation method: ..... [1]

(ii) Describe the steps involved in the preparation of zinc sulfate.

.....

.....

.....

.....

..... [3]

(b) One salt which is used as a dietary supplement is hydrated zinc sulfate, $ZnSO_4.xH_2O$. A simple experiment was carried out to determine the value of x in the formula of $ZnSO_4.xH_2O$ by heating carefully to drive out the water.

$$ZnSO_4.xH_2O\ (s) \rightarrow ZnSO_4\ (s) + xH_2O\ (g)$$

Steps:

1. Weigh empty boiling tube
2. Fill empty boiling tube with hydrated salt and weigh
3. Heat boiling tube carefully for a short time
4. Cool the boiling tube with its contents for a short while
5. Weigh the cooled boiling tube with its contents
6. Repeat steps 3 to 5 several times until the mass reading is constant

The final results are shown below.

Mass of empty boiling tube / g	Mass of boiling tube and hydrated salt / g	Mass of boiling tube and anhydrous salt / g
74.3	78.1	76.3

(i) Why was the boiling tube heated, cooled and reweighed several times?

..... [1]

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(ii) Calculate the number of moles of the anhydrous salt produced. [1]

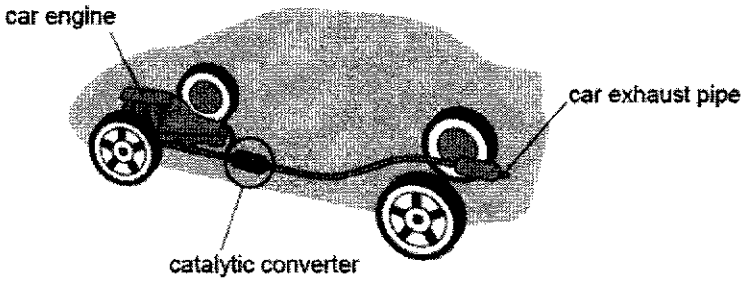
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(iii) Calculate the number of moles of water removed by heating. [1]

(iv) Use your results in **(ii)** and **(iii)** to calculate the value of x in $ZnSO_4.xH_2O$. [1]

[Total: 8]

A5 Since 1975, the cars have been installed with catalytic converters to convert harmful pollutants into less harmful emissions before leaving the car exhaust pipe. Most of the cars are powered by burning petrol which is a mixture of hydrocarbons in the car engine. As a result, the pollutants are mainly carbon monoxide, oxides of nitrogen and unburnt hydrocarbons.



(a) Which pollutant is **least** likely to be produced when the petrol is just ignited in a cold car engine? Explain your answer.

.....

.....

..... [2]

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(b) Recent innovation in the automobile industry includes the use of gold to ***improve the efficiency*** of oxidation process in catalytic converters.

(i) Why does the use of gold improve the efficiency of the catalytic converter?

..... [1]

(ii) The catalytic converter contains a very small amount of gold.
Do you expect the amount of gold to change after the catalytic converter is used for a few years? Explain your answer.

.....

..... [1]

(c) One of the harmful emissions is carbon monoxide. Explain how carbon monoxide affects the human health.

.....

..... [2]

[Total: 6]

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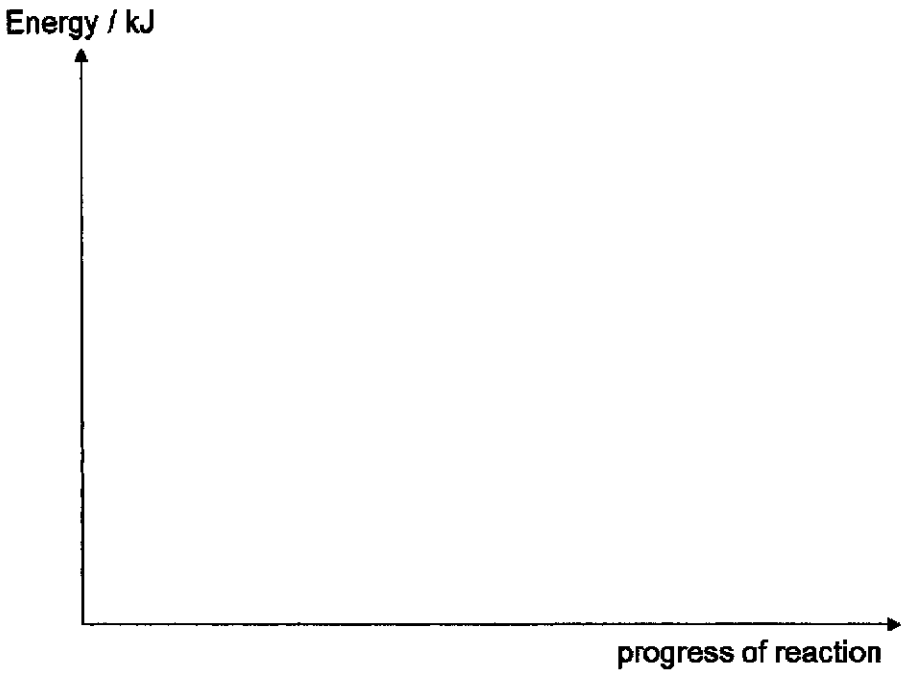
A6 The overall equation in a hydrogen fuel cell can be represented by the following equation.

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$$2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(l) \qquad \Delta H = -572\ kJ/mol$$

(a) Draw an energy profile diagram for the overall reaction in a hydrogen fuel cell.

Your diagram should
- Include the reactants and products of the reaction,
- Show the energy change, ΔH, of the reaction,
- Show the activation energy, E_a, of the reaction.



[3]

(b) Explain, in terms of bond breaking and bond forming, why this reaction is exothermic.

.....

.....

.....

..... [2]

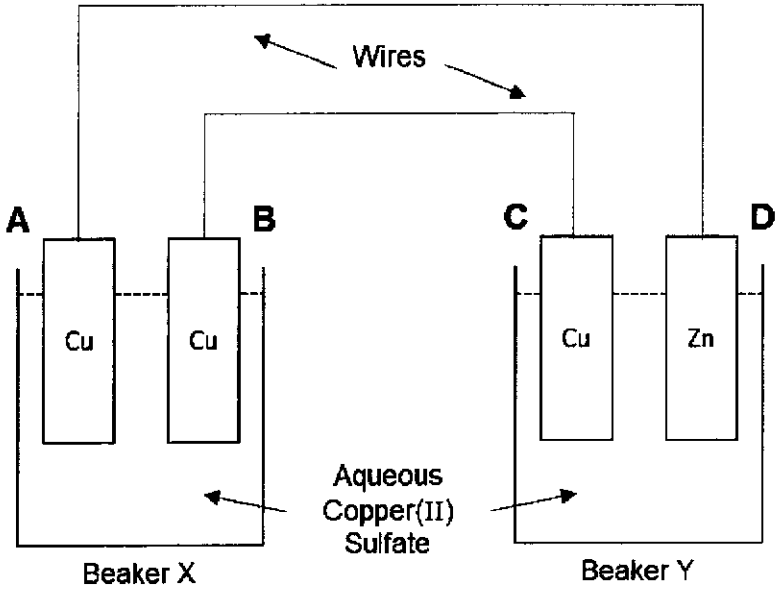
[Total: 5]

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A7 John sets up the following circuit using different metals as electrodes in an investigation.

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(a) Suggest which beaker is functioning as the simple cell in the set up above.

..... [1]

(b) Draw arrows on both wires to show the flow of electrons in the circuit above. [1]

(c) Complete the table below to predict the observations made.

Location	Observations
Electrode **A**	
Electrode **B**	
Electrolyte **X**	
Electrolyte **Y**	

[4]

(d) Write the balanced equation for the reaction occurring at electrode **B**.

..... [1]

(e) Predict one change to the observation made at electrode **A**, if any, when electrode **B** is replaced by a carbon electrode.

..... [1]

[Total: 8]

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A8 Information about carbon compounds containing halogens are shown in the table below.

Name of compound	Formula	Boiling point / °C
ethanoyl chloride	CH_3COCl	52
ehtanoyl bromide	CH_3COBr	75
ethanoyl iodide	CH_3COI	108

(a) Give the formula of ethanoyl fluoride.

.....

[1]

(b) Describe and explain the trend in the boiling point of the compounds as the halogen changes from chlorine to iodine.

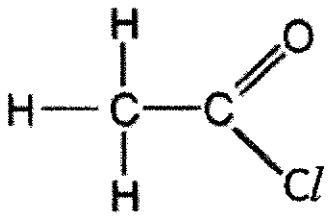
.....

.....

.....

[3]

(c) Ethanoyl chloride has the structure shown below.



Ethanoyl chloride behaves like ethanoic acid when it reacts with alcohols to form an ester.

(i) Draw the structure of the ester formed when ethanoyl chloride reacts with methanol.

[1]

(ii) Besides the ester being formed in **(ci)**, another product is formed. Give the formula of this product formed.

..... [1]

[Total: 6]

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Section B (30 marks)

Answer all three questions from this section.

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

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B9 Magnesium is the eighth most abundant element in the Earth's crust, but does not occur uncombined in nature. It is found in large deposits in minerals such as magnesite, $MgCO_3$ and dolomite, $CaMg(CO_3)_2$. The magnesium oxide obtained from roasting of the ores is reacted with silicon to produce magnesium.

The sea also contains large amounts of magnesium, mostly in the form of magnesium chloride, and this is the main source of the 850,000 tonnes of magnesium extracted each year. 1000 dm^3 of seawater yields about 1.3 kg of magnesium.

The following steps are performed to extract magnesium from seawater.

1. Reaction of magnesium chloride with aqueous sodium hydroxide to obtain magnesium hydroxide.
2. Reaction of magnesium hydroxide with dilute hydrochloric acid to obtain magnesium chloride.
3. Electrolysis of molten magnesium chloride to obtain magnesium.

(a) Write an ionic equation (with state symbols) for step 1.

..... [2]

(b) Explain why it is **not** possible to obtain magnesium chloride directly from seawater through evaporation to dryness.

.....

..... [2]

(c) Calculate the concentration of magnesium ions in seawater in mol/dm^3.

[1]

(d) For electrolysis of the molten compound, the melting point of magnesium chloride can be lowered by addition of small amounts of solids such as sodium chloride or potassium chloride. Explain why zinc chloride **cannot** be used.

.....

..... [1]

(e) Write the half equation for the reaction that occurs at the positive electrode during the electrolytic process in Step 3.

..... [1]

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(f) A student came across an article that says water should not be used to put out a fire in which magnesium is burning. Is there any truth in the statement? Justify your answer.

.....

..... [1]

(g) Without heating the ore, suggest how a sample of magnesium hydroxide can be obtained starting from dolomite.

.....

.....

.....

.....

..... [2]

[Total: 10]

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B10 Manganese(IV) oxide, MnO_2, can be used in the preparation of chlorine and oxygen using the following two reactions. In reaction **2**, manganese(IV) oxide acts as a catalyst.

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Reaction 1: MnO_2 (s) + 4HCl (aq) → Cl_2(g) + $2H_2O$ (*l*) + $MnCl_2$ (aq)

Reaction 2: $2H_2O_2$ (aq) → O_2 (g) + $2H_2O$ (*l*)

(a) Explain why reaction **1** is a redox reaction in terms of oxidation state.

.....

.....

..... [2]

(b) A student conducted a study on reaction **1** and obtained the following results.

Experiment No	Volume of HCl (cm^3)	Concentration of HCl (mol/dm^3)	Mass of MnO_2 used (g)	Volume of Cl_2 produced (dm^3)
1	100	1.0	1.74	0.48
2	100	1.0	0.87	0.24

With reference to the experiments, explain the difference in the volume of chlorine formed. You may use calculations to support your answer.

.....

.....

..... [2]

(c) A student conducted a study on reaction **2** and obtained the following results.

Experiment No	Volume of H_2O_2 (cm^3)	Concentration of H_2O_2 (mol/dm^3)	Mass of MnO_2 used (g)	Volume of O_2 produced (dm^3)
1	100	1.0	1.74	1.20
2	100	1.0	0.87	

Predict the volume of oxygen formed at room temperature and pressure for experiment 2.

..... [1]

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(d) Explain how manganese(IV) oxide is able to increase the speed of decomposition of hydrogen peroxide in reaction **2**.

.....

.....

..... [1]

(e) Chlorine is bubbled into aqueous iron(II) chloride to form aqueous iron(III) chloride.

Explain, with the aid of equations, how aqueous sodium hydroxide can be used to distinguish between aqueous iron(II) chloride and aqueous iron(III) chloride.

.....

.....

.....

.....

.....

..... [4]

[Total: 10]

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B11E A silk fibre is composed of many identical protein chains, which are mainly made from equal amounts of the following three amino acid monomers, glycine, alanine and serine.

(a) **(i)** Name the type of polymerisation that will take place when the monomers react.

..... [1]

(ii) Explain how the named polymerisation in **(ai)** takes place between the amino acids.

.....

.....

.....

..... [2]

(b) One possible structure of the silk protein is shown below.

Give the structural formula of the repeating unit of the silk protein, containing the three amino acids.

[2]

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(c) The relative molecular mass, M_r, of a silk protein molecule is about 600,000. Assuming it is made from equal amounts of the above three amino acids, calculate the number of amino acid monomers required to make the protein chain. [2]

(d) When the mixture of amino acids polymerises, the polymer is unlikely to contain only this regular, repeating pattern. Explain why.

.....

..... [1]

(e) The silk fibre is at least five times as strong as steel, and twice as elastic as nylon. Suggest ***another*** *advantage* and *disadvantage* of using this silk fibre as compared to nylon.

.....

..... [2]

[Total: 10]

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B11O (a) Glucose, $C_6H_{12}O_6$, produced during photosynthesis in green plants, is a renewable source from which ethanol can be made. Ethanol is a liquid fuel used as a substitute for petrol.

The processes involved can be summarised as follows.

Process **1**: Photosynthesis in green plants
$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Process **2**: Fermentation of glucose to form ethanol

Process **3**: Complete combustion of ethanol
$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

(i) State all the essential conditions for the fermentation of aqueous glucose in Process **2**.

..... [1]

(ii) Write an equation for the reaction that takes place during this fermentation.

..... [1]

(iii) What is seen when the sugar solution and yeast are fermented?

.....

..... [1]

(iv) The ethanol made in Process **2** is known to be 'carbon-neutral'.

Why is ethanol considered as a carbon-neutral fuel? Use the processes above to explain your answer.

.....

.....

.....

..... [3]

(b) Wines, which contain ethanol, may have a sour taste of vinegar after being exposed to air for some time. The sour taste of vinegar contains ethanoic acid.

(i) Draw the **full** structural formula of the ethanol. [1]

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(ii) Explain how the ethanoic acid is formed from the ethanol.

For examiner's use

.....

..... [1]

(iii) 10.0 cm^3 of a certain brand of vinegar required 50.0 cm^3 of 0.2 mol/dm^3 aqueous sodium hydroxide for neutralisation of the ethanoic acid in it. Calculate the concentration of ethanoic acid present in the vinegar in mol/dm^3.

[2]

[Total: 10]

**** END OF PAPER ****

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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.).

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Paper 1

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

Paper 2

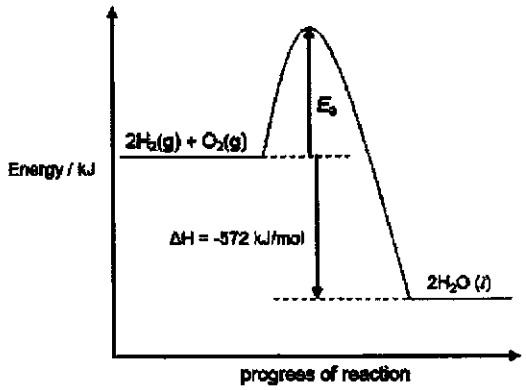
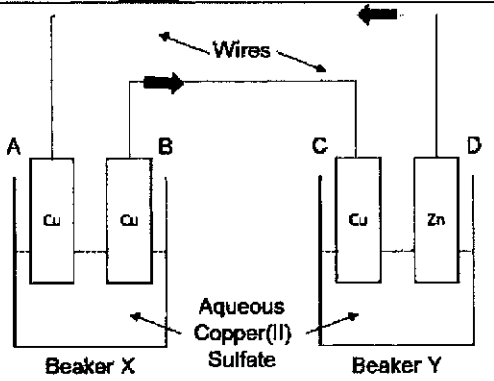
Section A

1	**(a)**		N / Nitrogen
	(b)		O / Oxygen
	(c)		Al / Aluminium
	(d)		C / Carbon
	(e)		F / Fluorine
2	**(a)**		The **layers** of atoms **are held together by weak intermolecular forces of attraction**, **a small amount of force/energy applied can cause the layers to slide over one another / easy for layers to slide over one another**.
	(b)		**All the 3 valence electrons in boron are covalently bonded** to the nitrogen atoms. **No mobile charge carriers** are available to conduct electricity in boron nitride. In graphite, **3 out of 4 valence electrons in a carbon atom are covalently bonded** to other carbon atoms. **The unbonded valence electron act as a mobile charged carrier** to conduct electricity in graphite.
3	**(a)**		**A** is sodium carbonate / Na_2CO_3 **B** is calcium hydroxide / $Ca(OH)_2$ **C** is copper(II) chloride / $CuCl_2$ **D** is silver nitrate / $AgNO_3$ **[1m for each correct name or formula]**
	(b)		$Na_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3 + 2NaOH$ $Na_2CO_3 + CuCl_2 \rightarrow 2NaCl + CuCO_3$ $CuCl_2 + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2AgCl$

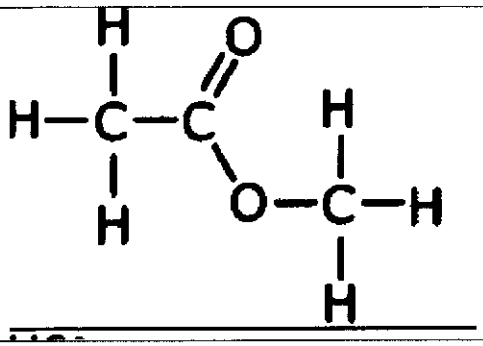
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4	**(a)**	**(i)**	$Zn(OH)_2$/ZnO/$ZnCO_3$ Reaction of insoluble solids with acids
		(ii)	Add **excess** ZnO/$ZnCO_3$ to dilute sulfuric acid **Stir** until no more solids can dissolve **Filter** to obtain the **filtrate, $ZnSO_4$** **Heat** the filtrate to **saturation** Allow saturated solution to **cool** and **crystallise** **Wash** and **dry** the crystals with **filter paper** **Every 2 points – 1m**
	(b)	**(i)**	This is to ensure **all the water of crystallisation has been removed [1m]** from the hydrated salt.
		(ii)	Mr of $ZnSO_4$ = 65 + 32 + 4(16) =161 Mole of $ZnSO_4$ = (76.3 – 74.3) / 161 = **0.0124 mol [1m]**
		(iii)	Mole of H_2O = (78.1 – 76.3) / 18 = **0.1 mol [1m]**
		(iv)	Mole ratio of $ZnSO_4$: H_2O 0.0124 : 0.1 1 : 8 Value of x is **8 [1m]**
5	**(a)**		Oxides of nitrogen / nitrogen dioxide **[1m]** Cold engine has a low temperature. **Insufficient energy is available for the reaction between nitrogen and oxygen in the Air.** / **Nitrogen and oxygen in the air are less likely to react [1m]** to form oxides of nitrogen as it require high temperature.
	(b)	**(i)**	Gold is a better **catalyst / to speed up the reaction [1m]**
		(ii)	No. Catalyst **remains chemically unchanged / not used up [1m]** after the reaction.
	(c)		Carbon monoxide **combines with haemoglobin in the blood [1m]** to form carboxyhaemoglobin which **inhibits the transport of oxygen [1m]** which will lead to death.

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6	(a)		 **[correct Ea & ΔH - 1m]** **[correct reactants & products – 1m]** **[correct shape of graph – 1m]**
	(b)		The **energy released** during **bond forming of O-H bonds in H_2O** is **greater** than the **energy absorbed** during the **bond breaking of H-H in H_2 and O=O bonds** in O_2.
7	(a)		Beaker Y **[1m]**
	(b)		 **[1m]**
	(c)		Electrode A: The electrode increases in size Electrode B: The electrode decreases in size Electrolyte X: Solution remain blue / no visible change Electrolyte Y: Intensity of the blue colour decreases / Colour fade **[1m for each correct observation]**
	(d)		$Cu \rightarrow Cu^{2+} + 2e^-$ **[1m]**
	(e)		Mass of copper solid deposited decreases **[1m]**
8	(a)		CH_3COF **[1m]**
	(b)		As the halogen changes from chlorine to iodine, **the boiling point of the compound increases**. **[1m]** The **molecular size and the intermolecular forces of attraction increases** **[1m]** from chlorine to iodine hence the **energy requires to overcome the stronger intermolecular forces of attraction increases**. **[1m]**

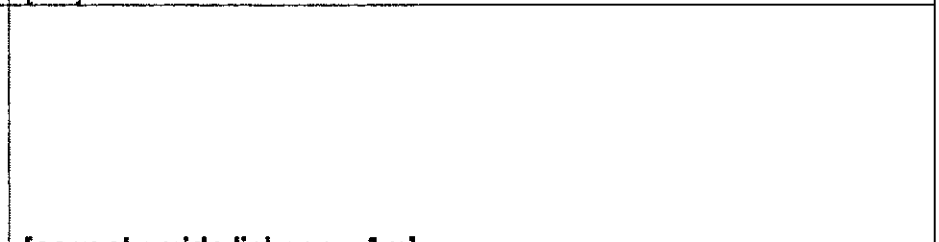
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	(c)	(i)	
		(ii)	HC*l*

Section B

9	**(a)**		$Mg^{2+} + 2OH^- \rightarrow Mg(OH)_2$
	(b)		Seawater contains **other dissolved solids** such as sodium chloride hence evaporation of seawater will **not produce pure magnesium chloride**. **[1m]**
	(c)		No. of moles of Mg^{2+} = 1300/24 ÷ 1000 = 0.0542 mol/dm^3 **[1m]**
	(d)		Zinc **is less reactive than** magnesium and zinc ions **will be preferentially discharged** **[1m]** forming zinc atoms, thus preventing magnesium from being produced.
	(e)		$2Cl^- \rightarrow Cl_2 + 2e^-$ **[1m]**
	(f)		Yes. At high temperatures, water becomes steam and burning **magnesium will react with steam to form hydrogen gas which is combustible** **[1m]** and flammable leading to explosion
	(g)		• Add excess dilute nitric/hydrochloric acid, stir. **[1m]** • Add aqueous sodium hydroxide to precipitate out magnesium hydroxide. **[1m]**
10	**(a)**		C*l* in HCl is oxidised as the **oxidation state of chlorine increases from -1 in HC*l* to 0 in Cl_2**, therefore oxidation occurs. **[1m]** Mn in MnO_2 is reduced as the **oxidation state of manganese decreases from +4 in MnO_2 to +2 in $MnCl_2$**, therefore reduction occurs. **[1m]** Since both oxidation and reduction occurs, this is a redox reaction
	(b)		No. of moles of MnO_2 in reaction 1 = 1.74/87 = **0.02 mol** No. of moles of MnO_2 in reaction 2 = 0.87/87 = **0.01 mol**

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			The number of **moles** of MnO_2 in experiment 1 is **twice** the number of moles in experiment 2 therefore the number of moles of Cl_2 in experiment 1 is twice the number of moles in reaction 2 and since volume ratio is equal to mole ratio, the volume would also be twice. **[no of moles - 1m]** **[volume ratio = mole ratio – 1m]**
	(c)		1.20 dm^3 **[1m]**
	(d)		Manganese(IV) oxide provides an **alternative pathway** with a **lower activation energy** required for the decomposition of hydrogen peroxide. **[1m]**
	(e)		$2NaOH + FeCl_2 \rightarrow 2NaCl + Fe(OH)_2$ **[1m]** $3NaOH + FeCl_3 \rightarrow 3NaCl + Fe(OH)_3$ **[1m]** When a few drops of aqueous sodium hydroxide is added to aqueous iron(II) chloride, a **green** precipitate of $Fe(OH)_2$ is formed, insoluble in excess aqueous sodium hydroxide. **[1m]** When a few drops of aqueous sodium hydroxide is added to aqueous iron(III) chloride, a **reddish-brown** precipitate of $Fe(OH)_3$ is formed, insoluble in excess aqueous sodium hydroxide. **[1m]**
11E	**(a)**	**(i)**	Condensation polymerisation **[1m]**
		(ii)	Each monomers contain **2 functional group, amine and carboxyl groups [1m]**. When 2 monomers react, **a molecule of water and an amide linkage is formed [1m]** between the monomers. OR The **C – O bonds in the carboxylic functional group and the N – H bonds in the amine functional group** [1m] between 2 monomers will **be broken to form a molecule of water and amide linkage**. [1m]
	(b)		 **[correct amide linkage – 1m]** **[correct sequence of atoms – 1m]**
	(c)		Relative molecular mass of 1 repeating unit = 3(14) + 8(12) + 4(16) + 13(1) = 215 **[1m]** Average number of monomers = (600000 / 215) x 3 = 8372 **[1m]**

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	(d)		This is because there is **a mixture of 3 different monomers** and they can **polymerise in any order [1m]** hence the polymer is unlikely to contain only this repeating pattern.
	(e)		Advantages • Biodegradable • Renewable Disadvantages • Expensive **[1m for each possible correct answer]**
11O	**(a)**	**(i)**	Presence of yeast 37 °C Absence of oxygen [1m for all correct conditions]
		(ii)	$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ **[1m]**
		(iii)	Bubbling / effervescence **[1m]**
		(iv)	In **process 1, carbon dioxide is absorbed to produce glucose [1m]** during photosynthesis in green plants. In **process 2 and 3, carbon dioxide is released to the atmosphere during fermentation of glucose and combustion of glucose as fuel. [1m]** There is **no net carbon dioxide emission** to the atmosphere. **[1m]**
	(b)	**(i)**	**[1m]**
		(ii)	Ethanol is **oxidised by oxygen in atmospheric a**ir in the **presence of bacteria [1m]**
		(iii)	$NaOH + CH_3COOH \rightarrow CH_3COONa + H_2O$ Moles of NaOH = 0.2 x 0.05 = 0.01 mol **[1m]** Moles of CH_3COOH = 0.01 mol Concentration of CH_3COOH = 0.01 / 0.01 = 1 mol/dm^3 **[1m]**

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