

Name	Class	Index Number
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UNITY SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2020

SECONDARY FOUR EXPRESS



CHEMISTRY 6092/ 02

18 SEPTEMBER 2020

PAPER 2

PAPER 2 : 1 HOUR 45 MIN

READ THESE INSTRUCTIONS FIRST

Write your name and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

Section A

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

Section B

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

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 26.
The total mark for this paper is 80 marks.

This paper consists of **26** printed pages, including this cover page.

Section A (50 marks)

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

- 1 The table shows the temperature of the thermal decomposition of some metal carbonates.

metal	minimum temperature of decomposition of carbonate/ °C
calcium	840
lead	
lithium	1300
magnesium	402
silver	210

- (a) Construct a chemical equation for the decomposition of magnesium carbonate.

.....[1]

- (b) With reference to the table above, describe how the temperature needed for the decomposition of carbonate relate to the reactivity of the metal.

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

- (c) Predict the minimum temperature needed for the decomposition of lead(II) carbonate.

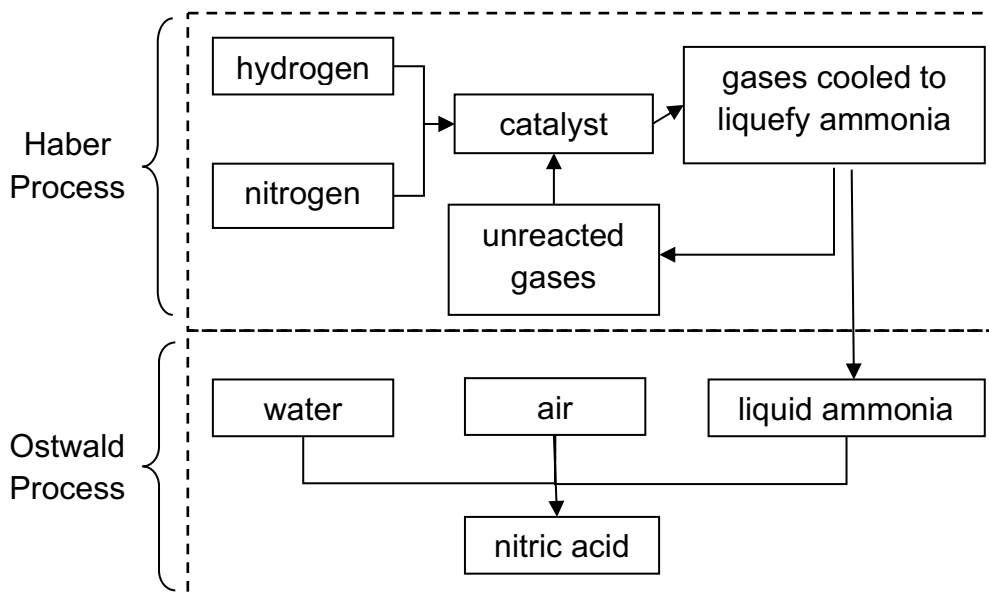
Explain your reasoning.

Temperature:

Reason:

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

- 2 The diagram below shows two important industrial processes producing compounds for many other industries to manufacture plastics compounds, agricultural materials, explosives etc.



- (a) State the conditions required for the Haber Process.

.....

[1]

- (b) Explain why air is not used as a raw material in the Haber Process.

.....

[1]

- (c) When the products of the Haber and Ostwald Processes are reacted together, a new compound is formed.

Name the compound and state one use of this compound.

.....

[2]

(d) Haber Process : nitrogen to ammonia

Ostwald Process : ammonia to nitric acid

Write down the oxidation states of nitrogen for all three substances. [1]

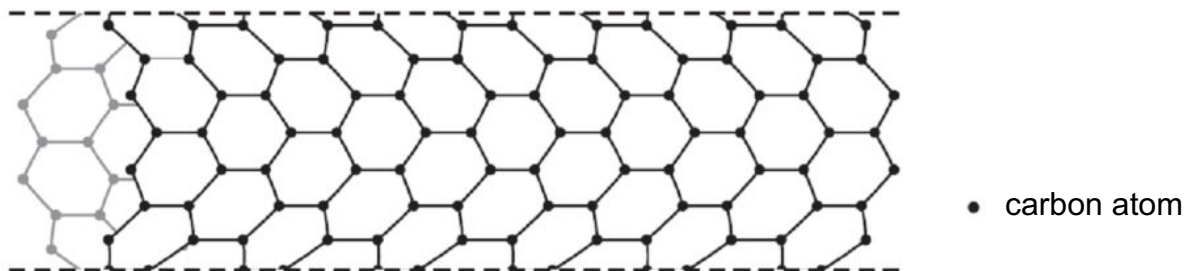
substance	oxidation state
nitrogen	
ammonia	
nitric acid	

(e) Deduce whether oxidation or reduction has taken place in each process.

(i) Haber
Process :[1]

(ii) Ostwald
Process:[1]

3 In recent years scientists have made tube-shaped structures of carbon called nanotubes.



(a) Predict, with explanation, if carbon nanotubes are able to conduct electricity.

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

- (b) Carbon nanotubes are fifty times stronger than steel, which is a mixture of iron and carbon. Explain, in terms of structure and bonding, why carbon nanotubes are strong.

.....

[2]

- (c) The iron in the steel has metallic bonding. Define metallic bonding.

.....
[1]

- 4 Elements **X**, **Y** and **Z** are found in Period 4 of the Periodic Table. The table below shows some information about the oxides of these elements.

	oxides of		
	X	Y	Z
solubility in water	insoluble	Slightly soluble	soluble
reaction with aqueous sodium hydroxide	oxide of X dissolves to form a colourless solution	oxide of Y dissolves to form a colourless solution	oxide of Z remains
reaction with dilute hydrochloric acid	oxide of X dissolves to form a colourless solution	oxide of Y remains	oxide of Z dissolves to form a colourless solution

- (a) Based on the information in the table, arrange elements **X**, **Y** and **Z** according to increasing proton number.

.....[1]

(b) Give **two** reasons why element **X** cannot be lead.

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.....

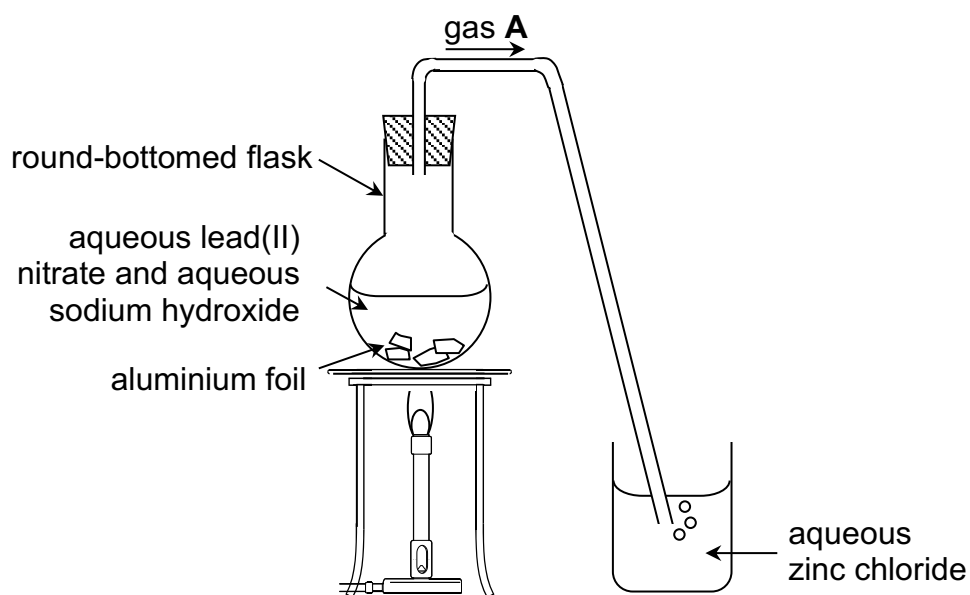
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.....

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.....[2]

- 5 A few pieces of aluminium foil were warmed in a mixture of aqueous lead(II) nitrate and aqueous sodium hydroxide as shown.



(a) Name gas **A**.

.....[1]

(b) Gas **A** dissolves in water to form a solution.

Suggest a pH value for the solution formed.

.....[1]

(c) A grey deposit is formed on the pieces of aluminium foil.

Explain how this grey solid is formed.

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

(d) Gas **A** is bubbled into aqueous zinc chloride until there is no further change.

State the observations.

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

- 6 (a) The changes in the type of fuels used between 1990 and 2002 is shown below in figure 1.

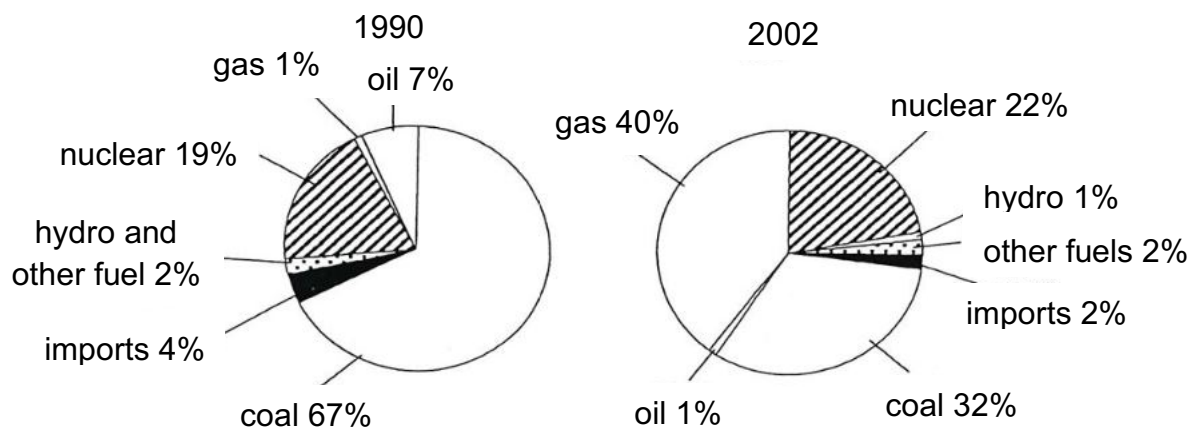


figure 1

Using the information from figure 1, state **two** main changes in the types of fuels used between 1990 and 2002.

Suggest an explanation for these changes.

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.....[3]

- (b) The relationship between the air: fuel ratio and the production of pollutants by vehicle engines is shown below in figure 2.

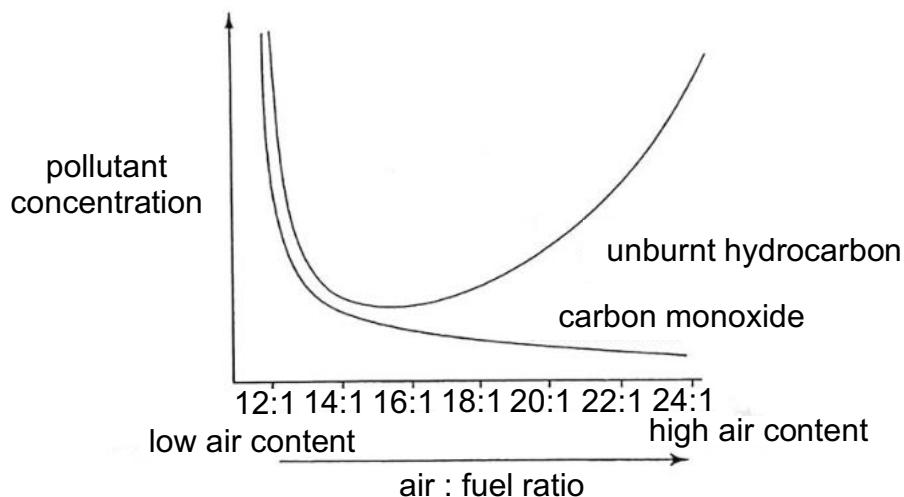


figure 2

Using the information from figure 2, describe and explain the shape of graph for carbon monoxide.

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.....[3]

- (c) Estimate the optimum air : fuel ratio to minimise pollution by carbon monoxide and unburnt hydrocarbons.

.....[1]

- 7 Considerable scientific research is taking place to develop hydrogen as a fuel for the future. Scientists are especially interested in developing hydrogen as motor fuel because it burns more cleanly and more efficiently than petrol.

(a) Suggest what is meant by the statement “hydrogen burns more cleanly than petrol.”

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

(b) Scientists use a term called the ‘energy density’ to compare fuels. Energy density is the energy produced from the combustion of one gram of a fuel. It can be calculated from the enthalpy (energy) change of the combustion of a fuel.

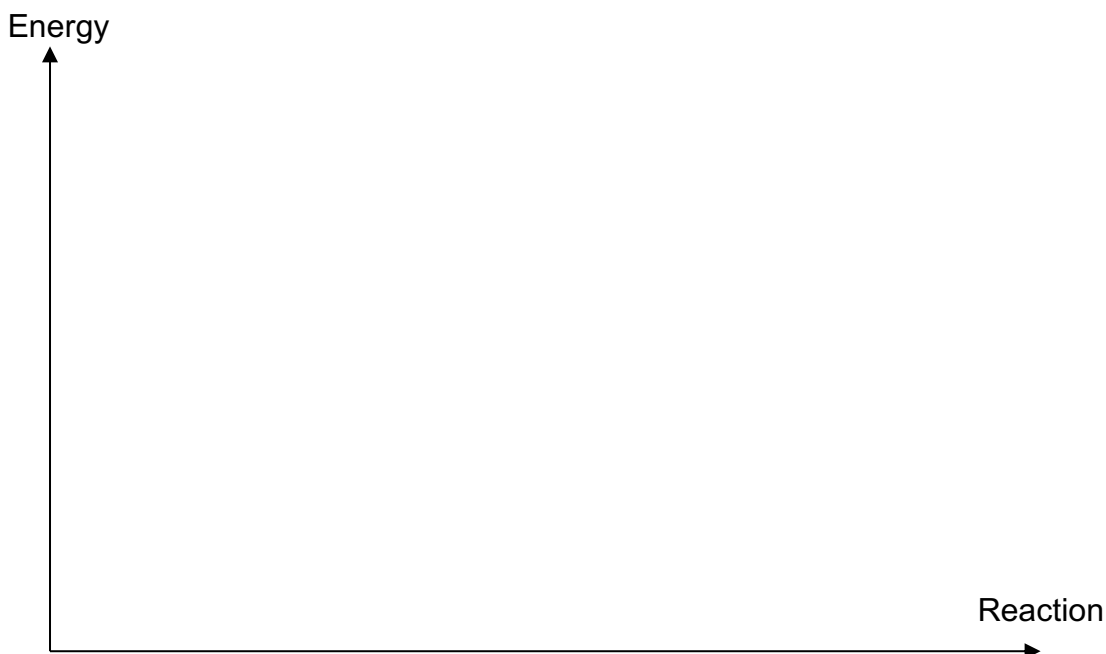
It is found that 5473 kJ of energy is released when one mole of petrol consisting of hydrocarbon, C_8H_{18} , burnt in air. However, 287 kJ of energy is released when one mole of hydrogen burnt in air.

(i) Calculate the energy density of hydrogen and of petrol. Hence, determine which fuel has a greater energy density.

[3]

- (ii) Petrol (C_8H_{18}) combusts completely to produce carbon dioxide and water. Complete the energy profile diagram below for the combustion of petrol.

Show the names of the reactants and products, and label the activation energy for the reaction. [2]



- (iii) Suggest a reason why petrol is the preferred fuel for motor vehicles despite the advantage of using hydrogen.

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.....[1]

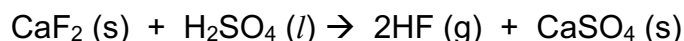
- (iv) "Biogas" is growing rapidly as an alternative energy supply, particularly in some countries. It is produced when carbohydrates in plants and animal waste were digested by bacteria.

Biogas, which consists mainly of methane, is used as a fuel because of its exothermic reaction with oxygen.

Explain why this reaction is exothermic in terms of bond breaking and bond making.

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.....[2]

- 8 Hydrogen fluoride attacks glass and is used to draw on glass. It is prepared by adding concentrated sulfuric acid to calcium fluoride. The reaction takes place at room temperature.



- (a) When 15.6 g of a sample of calcium fluoride was reacted with 12.5 cm³ of 20.0 mol/dm³ sulfuric acid at room temperature and pressure, 7.68 dm³ of hydrogen fluoride was formed.

- (i) What is the limiting reactant in this reaction?

[2]

(ii) Calculate the theoretical volume of hydrogen fluoride that was formed.

[2]

(b) Calculate the percentage purity of calcium fluoride.

[2]

- 9 Chromatography is the general name applied to a series of separation methods that employ a system with two phases of matter; a mobile phase and a stationary phase. Analytes in a mixture to be separated interact with the stationary phase with different affinities. While moving through the system, carried along by the mobile phase (solvent), analytes with a low affinity for the stationary phase will tend to move along rapidly, while those with a high affinity will tend to lag behind. Thin Layer Chromatography (TLC) is a fast and inexpensive form of chromatography that has many uses in the organic laboratory. The retention factor (R_f) is simply the fractional distance the solute spot moves along the plate relative to the solvent front. The stationary phase in TLC is typically an adsorbant made of silica gel.

Analgesics are substances that relieve pain. The most common of these is aspirin. Other common analgesics include acetaminophen. Additionally, to counteract the acidic properties of aspirin, an inorganic buffering agent is added to some preparations. In some cases, caffeine is added to counteract the sedative effects of the analgesic.

TLC will be used to analyse a commercial analgesic tablet. The above-mentioned compounds will also be run on the same TLC for comparison. The retention factor value for each standard and each analyte spot produced by the commercial analgesic tablet will be determined. This will then allow the compounds used in the analgesic tablet to be identified.

Literature values of the compounds are listed as followed.

compound	melting point/ °C	retention factor
Acetaminophen	168.0	0.333
Aspirin	136.0	0.639
Caffeine	236.1	0.125

The retention factor values are obtained after each of the components, **X**, **Y** and **Z**, are isolated and were analysed using TLC.

compound	melting point/ °C	retention factor
X	132.1 – 132.2	0.676
Y	166.2 – 168.2	0.378
Z	234.3 – 235.5	0.189

Source: <https://infohost.nmt.edu/~jaltig/TLC.pdf>

- (a) Use the literature information provided to name the components, **X**, **Y** and **Z**. [1]

name of X	name of Y	name of Z

- (b)** Based on the literature R_f values, which of the compounds has the highest affinity to the stationary phase, silica gel?

Explain your reasoning.

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..... [2]

- (c)** What can you conclude about the literature melting points and the experimental melting points?

Explain your reasoning.

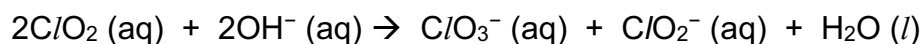
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..... [2]

Section B (30 marks)

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

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

- 10** Aqueous chlorine dioxide, a yellow solution, reacts with an alkali according to the following equation:



yellow

colourless

colourless

A student carried out different experiments to investigate the rate of reaction using different concentrations of aqueous chlorine dioxide and alkali. In each experiment, she measured how quickly the colour of chlorine dioxide disappeared.

The table shows the results obtained with differing concentrations of aqueous chlorine dioxide and alkali used in each experiment.

experiment	concentration of ClO_2 / mol/dm ³	concentration of OH^- / mol/dm ³	rate of disappearance of ClO_2 / mol/dm ³
1	0.020	0.030	0.00276
2	0.040	0.030	0.01104
3	0.020	0.060	0.00552
4	0.040	0.060	0.02208
5	0.040	0.090	0.03312
6	0.120	0.030	0.09936

The reaction of aqueous chlorine dioxide with alkali is interesting because it is an example of disproportionation reaction. Disproportionation happens when the oxidation state of the same element both increases and decreases in the reaction.

- (a) Describe the trend in the rate of reaction with respect to the concentration of the reagents used.

Explain and justify your answer using the results in the table, stating clearly the experiment number you are using for **each** reagent.

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.....[3]

- (b) Using Collision Theory, explain the trend stated in (a).

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.....[2]

- (c) Two students have different opinions about the data.

student 1 :	I think that the rate of reaction depends on the concentration of aqueous chlorine dioxide to a greater extent.
student 2 :	I think that the rate of reaction depends on the concentration of alkali to a greater extent.

Who do you agree with? Explain your answer using the results from the table. State which experiment number you are using, and show clearly how you arrived at your answer.

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

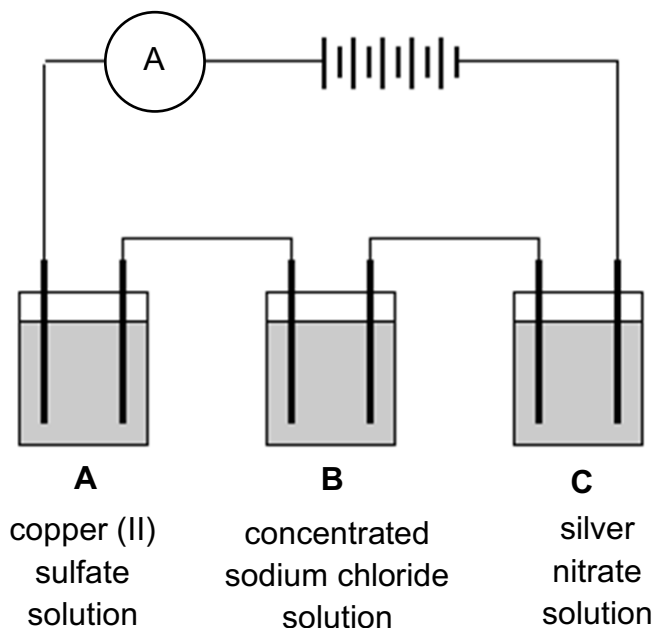
- (d) Predict the rate of disappearance of ClO_2 , if the experiment was conducted using 0.040 mol/dm^3 of ClO_2 and 0.120 mol/dm^3 of OH^- .

.....[1]

- (e) Use the idea about oxidation state to explain why the reaction of chlorine dioxide with an alkali is a disproportionation reaction.

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

- 11 The diagram shows the electrolysis of three different solutions using inert electrodes.



- (a) (i) Write equations for the reactions that happens at each electrode in Cell **B** during electrolysis. Include state symbols.

Cathode:

Anode:.....[2]

- (ii) Describe **two** observations that takes place at Cell **B**.

Explain your observations.

.....

[4]

(b) It was recorded that at room temperature and pressure, 6.0 dm^3 of oxygen was liberated from Cell **A**.

(i) Calculate the increase in mass of the cathodes in Cell **A**.

[2]

(ii) What is another observation in Cell **A**? Explain your observation.

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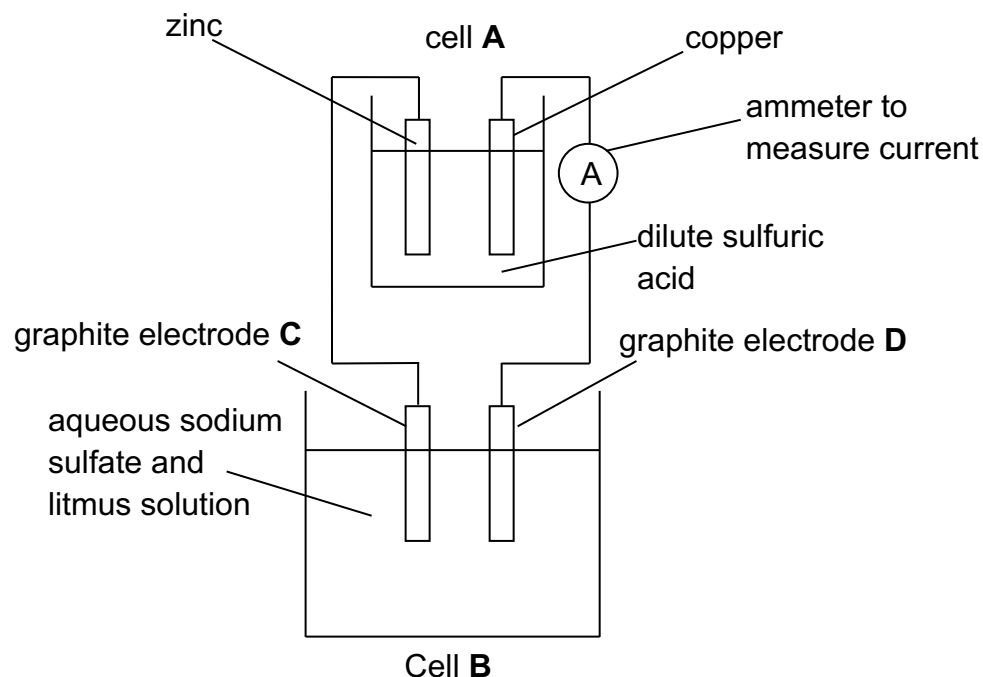
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.....

.....[2]

EITHER

- 12** The diagram below shows an electrolytic setup. It consists of cell **A** where the 2 electrodes are zinc and copper and Cell **B** where the 2 electrodes are made of graphite.



(a) For Cell **A**,

(i) Indicate on the diagram the direction of electron flow with an arrow.[1]

(ii) Write an ionic equation with state symbols for the reaction that takes place at the positive electrode.

.....[1]

(iii) If the dilute sulfuric acid is replaced by ethanol, will there be a reading on the ammeter? Explain your answer.

.....

[2]

- (iv) Without changing the copper electrode, what change in ammeter reading would be obtained if the zinc electrode is replaced by magnesium?

Explain your answer.

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

- (b) For cell **B**,

- (i) State clearly the products formed at each electrode.

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

- (ii) Write the ionic equation for the reaction that takes place at electrode **D**.

.....[1]

- (iii) The litmus solution around electrode **C** turns blue after some time.

Explain this observation.

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

- (iv) When graphite is replaced by aluminium at electrode D, the ammeter shows a reading for a short while before zero is obtained.

Why is there no reading?

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

OR

- 12 The table below shows a study of a precipitation reaction between dilute sulfuric acid and aqueous barium hydroxide.

The reaction tubes contain different volumes of barium hydroxide and dilute sulfuric acid as stated in the table. To each tube, two drops of methyl orange indicator are added. Precipitate occurs in all reaction tubes and after 20 minutes, the height of the precipitate in each tube is measured and recorded.

reaction tube	1	2	3	4	5	6
volume of 0.50 mol/dm^3 of barium hydroxide (cm^3)	5.0	5.0	5.0	5.0	5.0	5.0
volume of 1.00 mol/dm^3 of sulfuric acid (cm^3)	1.0	1.5	2.0	2.5	3.0	3.5
height of precipitate (cm)	2.5	3.0	3.5	4.0	4.0	

- (a) What is the name of the precipitate produced in the reaction?

.....[1]

- (b) What is the colour of the solution that is observed in

- (i) reaction tube 1?

.....[1]

- (ii) reaction tube 5?

.....[1]

- (c) (i) Predict the height of the precipitate in reaction tube 6.

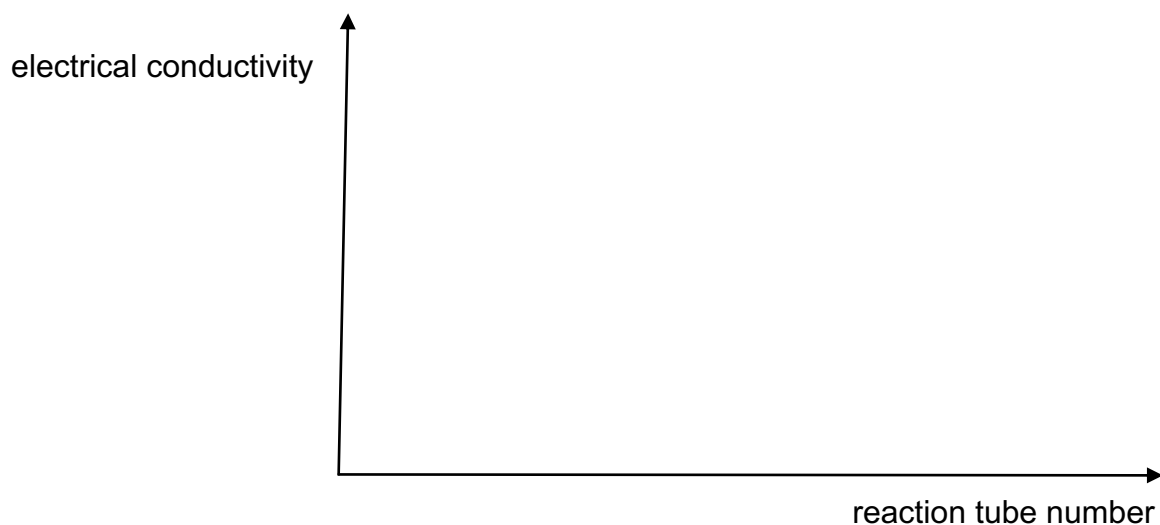
.....[1]

- (ii) Explain briefly for your answer to c(i).

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

- (d) The electrical conductivity of each reaction tube was measured.

Sketch a graph of electrical conductivity against the reaction tube number.



[2]

- (e) A student tried to prepare two salts, lead (II) sulfate and sodium nitrate, using the method described in the paragraph below.

Aqueous lead (II) nitrate was mixed with aqueous sodium sulfate and the precipitate of lead (II) sulfate was obtained by filtration. The residue was dried in an oven. The filtrate was heated until the solution is saturated. Crystals of sodium nitrate was formed when the saturated solution was cooled.

- (i) State one missing step in the preparation of lead (II) sulfate.

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

- (ii) Explain why the student could not obtain pure crystals of sodium nitrate using the method described above.

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

(iii) Name a suitable method to prepare pure crystals of sodium nitrate.

.....[1]

End of Paper

The Periodic Table of Elements

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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 -	117 Ts tennessine -	118 Og oganesson -	119 Nh nihonium -	120 Dl dubnium -	121 Uu unbinilium -	122 Uub unbibium -	123 Uut untrium -	124 Uuq unquadium -	125 Uup unpentium -	126 Uuh unhexium -	127 Uus unseptium -	128 Uuo unoctium -	129 Uuhc unhennium -	130 Uuhs unhassium -	131 Uuhv unhassium -	132 Uuht unhassium -	133 Uuhz unhassium -	134 Uuiz unhassium -	135 Uuiz unhassium -	136 Uuiz unhassium -	137 Uuiz unhassium -	138 Uuiz unhassium -	139 Uuiz unhassium -	140 Uuiz unhassium -	141 Uuiz unhassium -	142 Uuiz unhassium -	143 Uuiz unhassium -	144 Uuiz unhassium -	145 Uuiz unhassium -	146 Uuiz unhassium -	147 Uuiz unhassium -	148 Uuiz unhassium -	149 Uuiz unhassium -	150 Uuiz unhassium -	151 Uuiz unhassium -	152 Uuiz 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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
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 -

actinoids

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).