Name	Class				Index Number		

BROADRICK SECONDARY SCHOOL
SECONDARY 4 EXPRESS
PRELIMINARY EXAMINATION 2022

CHEMISTRY 6092/01

Paper 1 Multiple Choice Sept 2022

Additional Materials: Multiple Choice Answer Sheet 1 hour

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paperclips, highlighters, glue or correction fluid.
Write your name, class and register number on top of this page and on any separate answer paper used.

There are **forty** questions on 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.

Read the instructions on the Answer Sheet very carefully.

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

This document consists of **15** printed pages including this cover page.

Setter : MR. LIANG ZW

1 In a titration, 25.0 cm^3 of aqueous sodium hydroxide is transferred into a conical flask. A few drops of indicator are added. Dilute hydrochloric acid is then added to the flask until the end-point is reached.

Which pieces of apparatus are used to measure volume in this experiment?

	to measure dilute hydrochloric acid	to measure aqueous sodium hydroxide
A	burette	beaker
B	burette	pipette
C	pipette	pipette
D	pipette	beaker

2 Which gas is **not** obtained industrially by fractional distillation?

A ammonia

B argon

C nitrogen

D oxygen

3 An impure sample of compound X has a melting point of 120 °C.

X is purified and its melting point is measured again.

Which row is correct?

	method of purifying X	melting point of pure X / °C
A	crystallisation	115
B	distillation	115
C	crystallisation	125
D	distillation	125

4 When dilute hydrochloric acid is added to a white powder, a gas is produced.

The solution remaining is tested separately with small volumes of both aqueous ammonia and aqueous sodium hydroxide.

A white precipitate is produced in both tests.

What is the white powder?

A aluminium oxide

B calcium oxide

C copper(II) carbonate

D zinc carbonate

5 Which statement explains why isotopes of the same element have the same chemical properties?

A They have the same electronic structure.

B They have the same relative mass.

C They have the same nucleon number.

D They have the same proton number.

6 An aqueous solution of a sulfate is made from a solid hydroxide, of a metal *M*, by the reaction:

$$M(OH)_2(s) + H_2SO_4(aq) \rightarrow MSO_4(aq) + 2H_2O(l)$$

For which hydroxide would the method **not** work?

A barium hydroxide

B copper(II) hydroxide

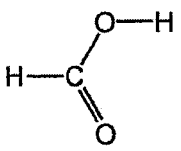
C iron(II) hydroxide

D magnesium hydroxide

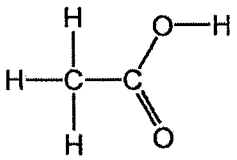
7 A covalent compound P has the empirical formula CH_2O.

Which structure represents P?

A



B



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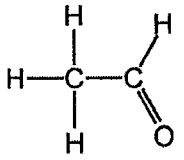
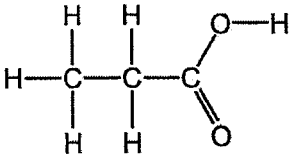


D



8 Which row explains why copper is a good conductor of electricity at room temperature?

	copper ions move freely	electrons move freely
A	no	no
B	no	yes
C	yes	no
D	yes	yes

9 What is the structure of sand?

A an ionic lattice

B a macromolecule

C a polymer

D a simple molecule

10 Pentane, C_5H_{12}, has a higher boiling point than propane, C_3H_8.

Which statement explains the difference in boiling point?

A Carbon-carbon single bonds are stronger than carbon-hydrogen bonds.

B Pentane has more covalent bonds to break.

C Pentane does not burn as easily as propane.

D The forces of attraction between pentane molecules are stronger than those between propane molecules.

11 Sodium nitride contains the nitride ion, N^{3-}.

Sodium nitride is unstable and decomposes into its elements.

What is the equation for the decomposition of sodium nitride?

A $2NaN_3 \rightarrow 2Na + 3N$

B $2Na_3N \rightarrow 6Na + N_2$

C $2NaN_3 \rightarrow Na_2 + 3N_2$

D $2Na_3N \rightarrow 6Na + 2N$

12 What is the mass of one mole of carbon-13?

A 0.013 g

B 0.026 g

C 1 g

D 13 g

13 The Haber process is a reversible reaction.

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

The reaction has a 30% yield of ammonia.

Which volume of ammonia gas, NH_3, measured at room temperature and pressure, is obtained by reacting 0.75 moles of hydrogen with excess nitrogen?

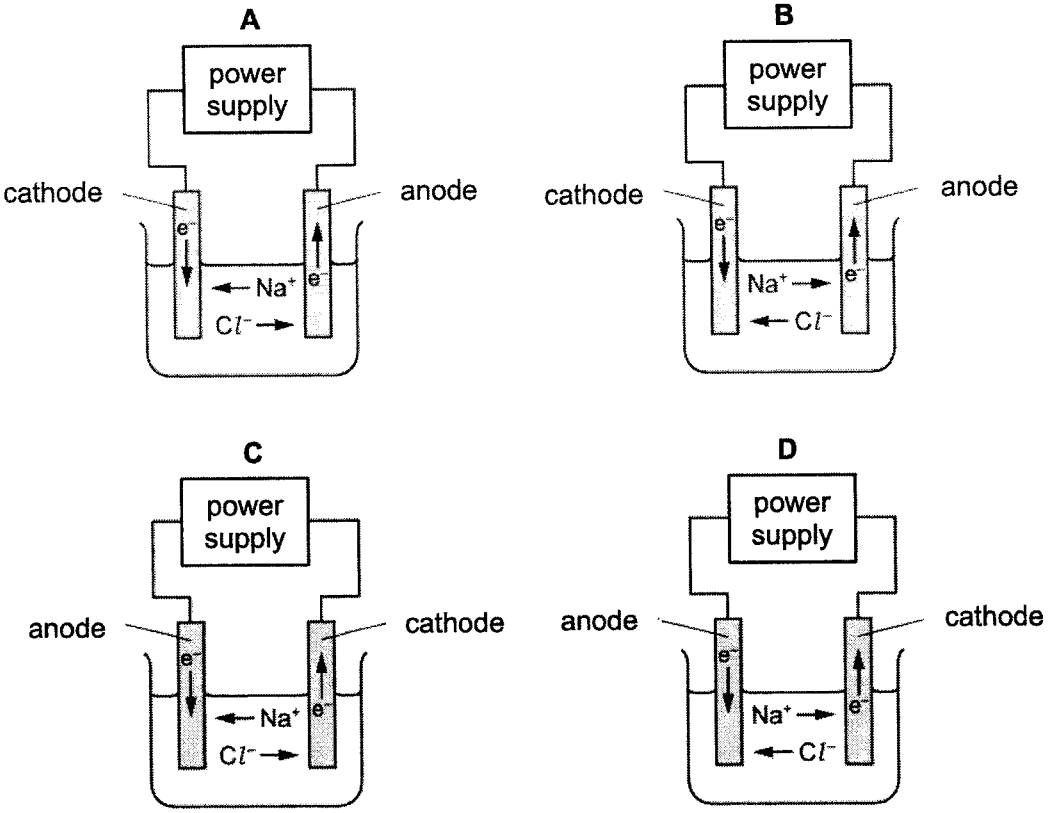
A 3600 cm^3

B 5400 cm^3

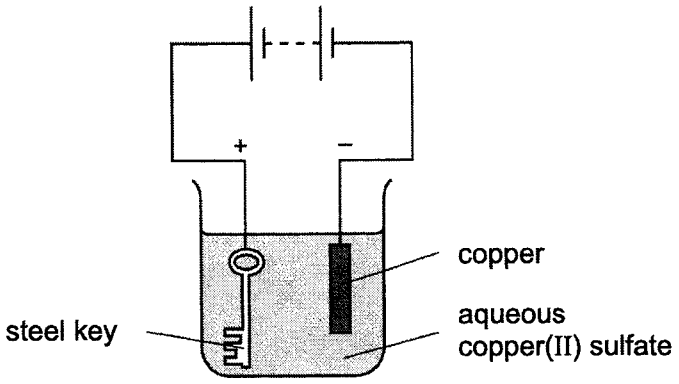
C 12000 cm^3

D 18000 cm^3

14 Which diagram shows the direction of movement of ions and electrons during the electrolysis of molten sodium chloride?



15 The apparatus shown is set up to plate a steel key with copper.



The key does **not** get coated with copper.

Which change needs to be made to plate the key?

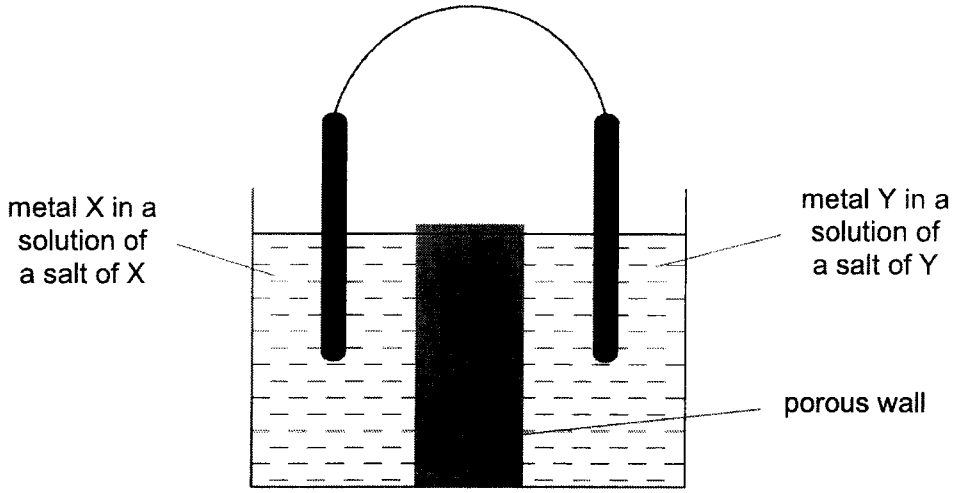
A increase the concentration of the aqueous copper(II) sulfate

B increase the voltage

C replace the solution with dilute sulfuric acid

D reverse the electrical connections

16 Which pair of metals X and Y will produce the highest voltage when used as electrodes in a simple cell?



	metal X	metal Y
A	copper	silver
B	magnesium	silver
C	magnesium	zinc
D	zinc	copper

17 Which row describes the changes that occur in an endothermic reaction?

	energy change	temperature
A	energy given out to the surroundings	decreases
B	energy given out to the surroundings	increases
C	energy taken in from the surroundings	decreases
D	energy taken in from the surroundings	increases

18 Which statement about fuels is correct?

A Heat energy is only produced by burning fuels.

B Hydrogen is used as a fuel although it is difficult to store.

C Methane is a good fuel because it produces only water when burned.

D Uranium is burned in air to produce energy.

19 Which statement about endothermic and exothermic reactions is correct?

A In an endothermic reaction, less energy is absorbed in bond breaking than is released in bond forming.

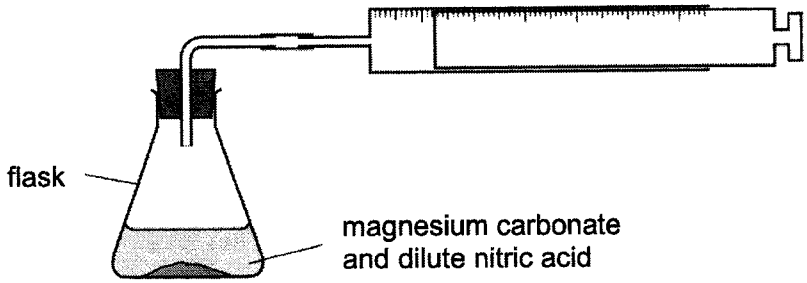
B In an endothermic reaction, the activation energy is always higher than in an exothermic reaction.

C In an exothermic reaction, more energy is absorbed in bond breaking than is released in bond forming.

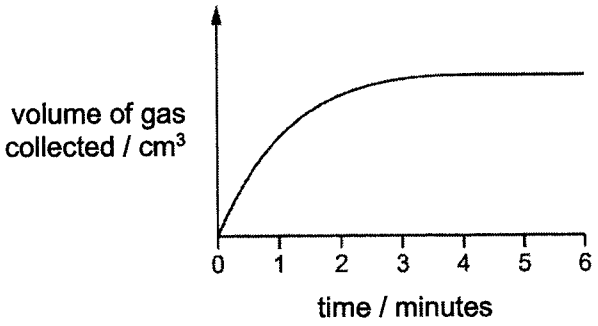
D In an exothermic reaction, the reactants are higher energy level than the products on an energy level diagram.

20 The apparatus shows a method of following the rate of the reaction between magnesium carbonate, $MgCO_3$, and dilute nitric acid, HNO_3.

$$MgCO_3(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$



The graph shows the volume of gas collected against time.



Three statements are made about the experiment.

1 The mass of the flask and its contents decreases as time increases.

2 The rate of the reaction decreases as time increases.

3 The reaction has finished after four minutes.

Which statements are correct?

A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

21 How does increasing the concentration affect the reacting particles in a chemical reaction?

	increases the collision rate	increases the proportion of particles with the activation energy
A	✓	×
B	✓	✓
C	×	×
D	×	✓

22 Zinc oxide is an amphoteric oxide.

Which of the following substances will react with zinc oxide?

A acids and bases

B acids only

C bases only

D neither acids nor bases

23 When aqueous iron(III) chloride is added to aqueous potassium iodide, a chemical reaction occurs and iodine is formed.

Which statement is correct?

A Iodide ions are oxidised, they gain electrons in this reaction.

B Iodide ions are oxidised, they lose electrons in this reaction.

C Iron(III) chloride is oxidised in this reaction.

D Neither iodide ions nor iron(III) chloride is oxidised in this reaction.

24 In which reaction is the underlined substance behaving as an oxidising agent?

A $\underline{BaCl_2} + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$

B $3CuO + \underline{2NH_3} \rightarrow 3Cu + N_2 + 3H_2O$

C $2FeCl_2 + \underline{Cl_2} \rightarrow 2FeCl_3$

D $O_2 + \underline{2SO_2} \rightarrow 2SO_3$

25 The oxide of an element X increases the rate of decomposition of hydrogen peroxide. At the end of the reaction the oxide of X is unchanged.

Which details are those of X?

	proton number	mass number
A	18	40
B	20	40
C	25	55
D	82	207

26 The proton number of indium, In, is 49.

What is the most likely formula for the oxide of indium?

A In_2O

B In_2O_3

C InO

D InO_2

27 Which statement(s) is/are true about all the noble gases?

1 The number of protons in their atoms equals the number of neutrons.

2 The number of protons in their atoms does not equal the number of electrons.

3 They all have eight electrons in their outer shell.

4 They do not react to form ionic compounds.

A 1, 2 and 3

B 1 and 3 only

C 3 only

D 4 only

28 Many metal carbonates decompose when they are heated.

Which row describes what happens when potassium carbonate, calcium carbonate and copper(II) carbonate are heated using a Bunsen burner?

	decomposes easily	decomposes with difficulty	does not decompose at Bunsen temperatures
A	calcium carbonate	copper(II) carbonate	potassium carbonate
B	copper(II) carbonate	calcium carbonate	potassium carbonate
C	copper(II) carbonate	potassium carbonate	calcium carbonate
D	potassium carbonate	calcium carbonate	copper(II) carbonate

29 Three correct statements about aluminium are listed.

1 Aluminium is the most common metal in the Earth's crust.
2 It is costly to extract aluminium from its ore, bauxite.
3 The world's supply of bauxite is limited.

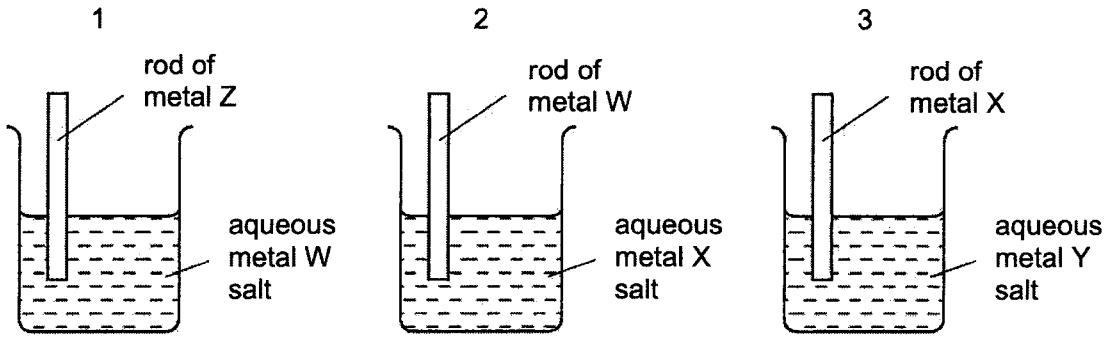
Which statement(s) explain why aluminium should be recycled?

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

30 Which process, used to prevent iron from rusting, involves sacrificial protection?

A alloying
B electroplating
C galvanising
D painting

31 Three different beakers are set up as shown.



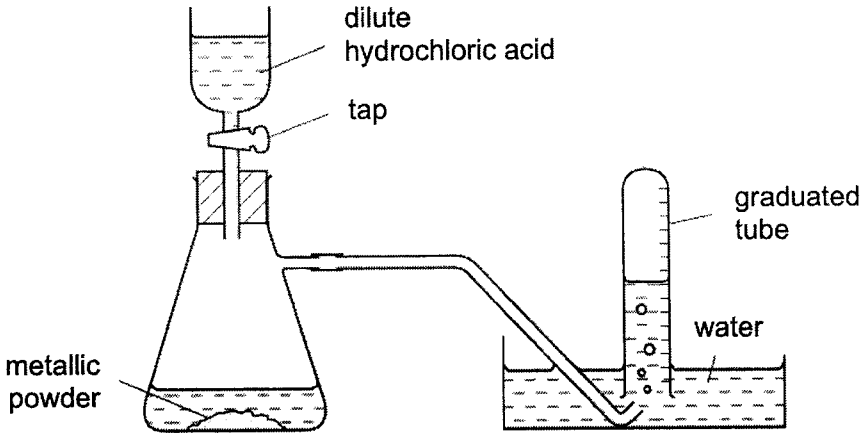
In beaker 1, metal W is displaced from solution.
In beaker 2, metal X is displaced from solution.
In beaker 3, metal Y is displaced from solution.

What is the order of decreasing reactivity of the four metals?

	most reactive →			least reactive
A	W	X	Y	Z
B	Y	X	W	Z
C	Z	W	X	Y
D	Z	X	W	Y

32 The diagram shows the experimental setup for measuring the volume of hydrogen given off when an excess of dilute hydrochloric acid is added to powdered metal.

The volume of gas is measured at room temperature and pressure.



The experiment is carried out three times, using the same mass of powder each time but with different powders:

- pure magnesium
- pure zinc
- a mixture of magnesium and zinc

Which powder gives the greatest volume of hydrogen and which the least volume in 5 minutes?

	greatest volume of H_2	least volume of H_2
A	magnesium	zinc
B	magnesium	the mixture
C	zinc	magnesium
D	zinc	the mixture

33 Ammonia is produced using the Haber process.

Which row shows the source of the raw materials and the optimum reaction conditions?

	source of nitrogen	source of hydrogen	temperature / °C	pressure / atm
A	air	hydrocarbons	200	450
B	hydrocarbons	air	450	200
C	air	hydrocarbons	450	200
D	air	hydrocarbons	450	450

34 The processes photosynthesis, respiration and fermentation all change the amount of carbon dioxide in the atmosphere.

Which process(es) increase(s) the amount of carbon dioxide in the atmosphere?

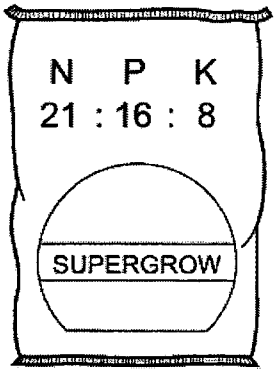
A photosynthesis and fermentation

B photosynthesis only

C respiration and fermentation

D respiration only

35 Which combination of chemical compounds can be used to produce the fertiliser shown?



A $(NH_4)_3PO_4$, KCl

B NH_4NO_3, $Ca_3(PO_4)_2$

C NH_4NO_3, $CO(NH_2)_2$

D NH_4NO_3, K_2SO_4, $(NH_4)_2SO_4$

36 The two statements are about the fractional distillation of crude oil. The statements may or may **not** be correct. They may or may **not** be linked.

statement 1 Fractional distillation is used to separate crude oil into useful fractions.

statement 2 The fractions with lower boiling points are found at the top of the fractionating column.

What is correct about these two statements?

A Both statements are correct and statement 2 explains statement 1.

B Both statements are correct but statement 2 does not explain statement 1.

C Statement 1 is correct but statement 2 is incorrect.

D Statement 1 is incorrect but statement 2 is correct.

37 Which statements about alcohols are correct?

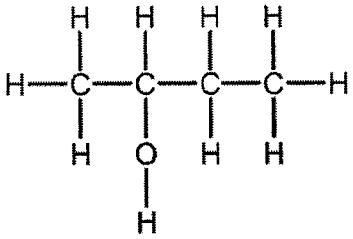
1 All alcohols contain the hydroxide ion, OH^-.

2 Ethanol can be formed from ethene using a reaction catalysed by yeast.

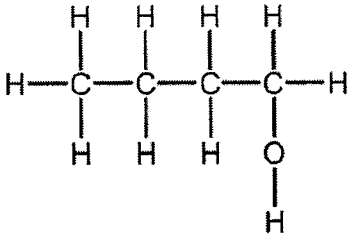
3 Methanol can be oxidised to methanoic acid.

4 The alcohols X and Y shown are isomers.

X



Y



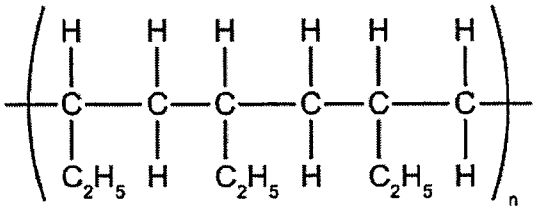
A 1, 2 and 3

B 3 only

C 2 and 4 only

D 3 and 4 only

38 The section of a polymer chain is shown.



Which molecule would produce this polymer and by which type of polymerisation?

	molecule	type of polymerisation
A	$CH_3–CH=CH–CH_3$	condensation
B	$CH_3–CH_2–CH=CH_2$	addition
C	$CH_3–CH_2–CH_2–CH=CH_2$	condensation
D	$CH_3–CH=CH–CH_3$	addition

39 The formula of an ester is $CH_3CH_2CH_2COOCH_2CH_2CH_3$.

Which acid and alcohol react together to make the ester?

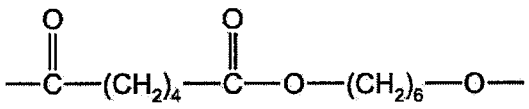
	acid	alcohol
A	butanoic acid	butanol
B	butanoic acid	propanol
C	propanoic acid	butanol
D	propanoic acid	propanol

40 P is a polymer that:

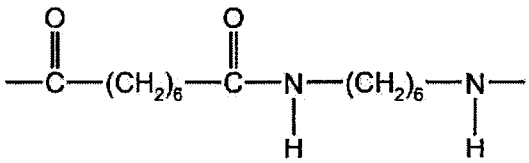
- has six carbon atoms in each of the monomers from which it is formed,
- is not a polyester,
- is formed using condensation polymerisation.

What is the partial structure of P?

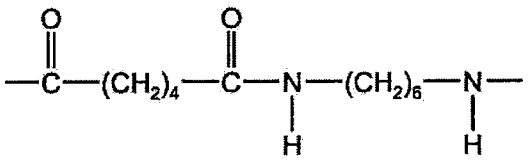
A



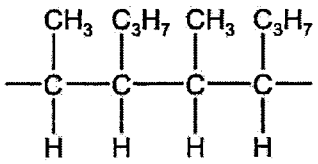
B



C



D



The Periodic Table of Elements

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.).

Name	Class				Index Number		

BROADRICK SECONDARY SCHOOL
SECONDARY 4 EXPRESS
PRELIMINARY EXAMINATION 2022

CHEMISTRY **6092/02**

Paper 2

Aug 2022

Candidates answer on the Question Paper.
No Additional Materials are required.

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on top of this page.
Write in dark blue or black pen.
You may use a **soft pencil** for any diagrams or graphs.

Section A (50 Marks)
Answer **all** questions in the spaces provided.

Section B (30 Marks)
Answer all **three** questions. The last question is in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page **20**.

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

FOR EXAMINER'S USE	
P1	/ 40
P2 Section A	/ 50
P2 Section B	/ 30
P3	/40

This document consists of **20** printed pages including this cover page.

Setter : MR. LIANG ZW

Section A [50 marks]

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

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

For Examiner's Use

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

A $CaCO_3 \rightarrow CaO + CO_2$

B $SiO_2 + CaO \rightarrow CaSiO_3$

C $C + O_2 \rightarrow CO_2$

D $CO_2 + C \rightarrow 2CO$

E $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Use the letters, A, B, C, D and E to answer the following questions.

(a) Which equation shows thermal decomposition?

..... [1]

(b) Which equation shows combustion?

..... [1]

(c) Which equation shows a reaction between an acidic compound and a base?

..... [1]

(d) Which equation shows the formation of a toxic gas?

..... [1]

(e) Two equations show different elements in compounds being reduced.

Give the letters for these **two** equations.

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

(f) Iron from the Blast Furnace is further processed to make steel. Some types of steel contain more carbon than others.

How are the properties of high carbon steel different from those of low carbon steel?

.....

..... [2]

[Total: 7]

A2 Fluorine forms numerous compounds of varied properties.

For Examiner's Use

The chemical formulae and melting points of two of the compounds formed are shown below.

compound	chemical formula	melting point / °C
aluminium fluoride	AlF_3	1291
phosphorus trifluoride	PF_3	-151

(a) Draw a 'dot and cross' diagram to show the bonding formed in aluminium fluoride and phosphorus trifluoride.

Show only the outer shell electrons.

aluminium fluoride

phosphorus trifluoride

[4]

(b) Explain in term of bonding and structure, why aluminium fluoride has a high melting point while phosphorus trifluoride has a low melting point.

.....

.....

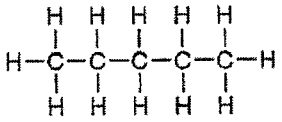
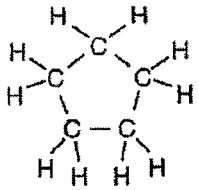
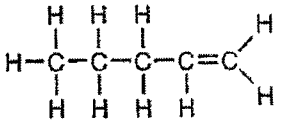
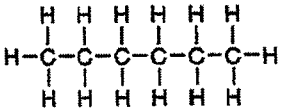
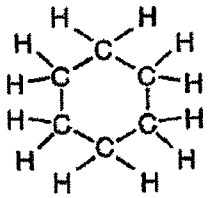
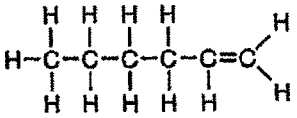
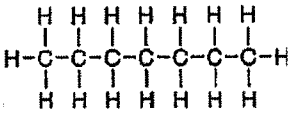
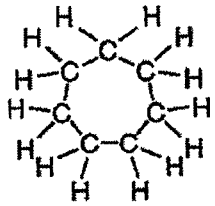
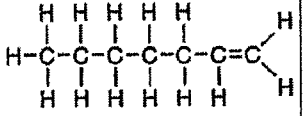
.....

..... [3]

[Total: 7]

A3 The table shows the names and structures of some hydrocarbons.

For Examiner's Use

number of carbon atoms	**alkanes**	**cycloalkane**	**alkene**
5	pentane 	cyclopentane 	pentene 
6	hexane 	cyclohexane 	hexene 
7	heptane 	cycloheptane 	heptene 

(a) Cycloalkanes are an example of a homologous series.

(i) Explain how the formulae of cycloalkanes in the table show this.

..... [1]

(ii) Suggest **two** differences in physical properties between cyclopentane and cycloheptane.

.....

..... [2]

(iii) The molecular formula of hexadecane is $C_{16}H_{34}$.

Give the molecular formula for cyclohexadecane

..... [1]

(b) **(i)** Are cycloalkanes isomers of alkanes? Explain your reasoning.

For Examiner's Use

.....

..... [1]

(ii) Draw the structure of a branched chain isomer of hexane which is a straight chain alkane with the formula C_6H_{14}.

[1]

(c) The percentage of carbon and hydrogen in some molecules are shown in the table.

name of molecule	percentage of carbon by mass	percentage of hydrogen by mass
hexane	84	16
hexene	86	14
cycloheptane	86	14

Explain why the percentages of carbon and hydrogen are the same for hexene and cycloheptane, but different for hexane.

.....

.....

..... [2]

(d) Bromine water can be used in a test to distinguish between cycloalkanes and alkenes.

Describe the results that would be obtained if this test is carried out on separate samples of cyclooctane and octene.

.....

.....

..... [2]

[Total: 10]

A4 Aqueous thiosulfate, $S_2O_3^{2-}(aq)$, reacts with aqueous iodine according to the equation.

For Examiner's Use

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

In a titration, 40.0 cm^3 of 0.1 mol/dm^3 aqueous thiosulfate was added to 30 cm^3 of 0.1 mol/dm^3 aqueous iodine.

(a) Determine the limiting reagent. Show your working.

[3]

(b) If only 0.001 mol of I^- was produced, calculate the percentage yield.

percentage yield .....% [2]

(c) Explain why aqueous thiosulfate acts as a reducing agent in this reaction in terms of changes in oxidation states.

.....

.....

..... [2]

(d) Name another suitable reagent that can be used to confirm that aqueous thiosulfate is a reducing agent. Include the observation in your answer, if any.

.....

.....

..... [2]

[Total: 9]

A5 Iron(II) sulfate crystals decompose when heated to give three gases U, V and W and an orange-brown solid T.

For Examiner's Use

- Gas U was tested with filter paper soaked with acidified potassium manganate(VII). The filter paper changed colour from purple to colourless.
- Analysis of gas V showed it contained 40.0% sulfur and 60.0% oxygen by mass.
- When gas W was condensed it formed a colourless liquid that turned anhydrous copper(II) sulfate from white to blue.
- Solid T was dissolved in dilute nitric acid. Aqueous ammonia was added drop by drop and a red-brown precipitate was obtained.

(a) **(i)** What is the formula for gas U?

..... [1]

(ii) Determine the empirical formula of gas V.

empirical formula of gas V ..... [2]

(iii) Name gas W.

..... [1]

(iv) Give the name or the formula of the metal ion present in solid T.

..... [1]

(b) Iron(II) sulfate dissolves in water to give a green solution X. Aqueous sodium hydroxide was added drop by drop to solution X.

A green precipitate, Y, was formed.

(i) Name precipitate Y.

..... [1]

(ii) Construct the ionic equation, with state symbols, to show the formation of the precipitate Y.

..... [1]

(c) Use the following information to suggest the steps needed to prepare by precipitation pure barium sulfate, using aqueous iron(II) sulfate and powdered barium carbonate in a laboratory.

For Examiner's Use

- barium sulfate is insoluble in water
- barium carbonate is insoluble in water
- barium nitrate is soluble in water

.....

.....

.....

.....

..... [3]

[Total: 10]

A6 Group I and Group VII elements show different trends in their properties.

For Examiner's Use

Group I
Li
Na
K
Rb

Group VII
F
Cl
Br
I

(a) Explain why the reactivity of metals in Group I increases on going down the group.

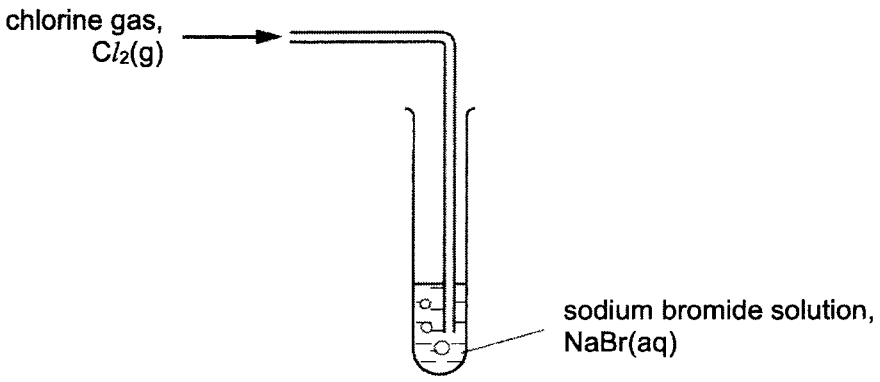
.....

.....

.....

..... [2]

(b) When chlorine gas is bubbled into sodium bromide solution, a reaction occurs.



This reaction is commonly known as a 'displacement reaction'.

(i) Write an ionic equation for the displacement reaction.

..... [2]

(ii) Explain your observations in **(i)**.

.....

..... [1]

For Examiner's Use

(c) The radii of atoms and ions can be measured.

The table below shows some information about the atomic and ionic radii of Group I and Group VII elements.

element	number of shells of electrons in atom	atomic radius / *pm*	number of shells of electrons in ion	ionic radius / *pm*
Group I				
lithium (Li)	2	152	1	68
sodium (Na)	3	185	2	98
Group VII				
fluorine (F)	2	71	2	133
chlorine (C*l*)	3	99	3	181

[1 pm = 10^{-12} m]

(i) Suggest a reason for the difference in radius of a fluorine atom when it forms a fluorine ion.

.....

..... [1]

(ii) Lithium and fluorine are found in the same period.

Suggest why the atomic radius decreases across a period.

.....

..... [1]

[Total: 7]

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.

B7 Read the information about the industrial electrolysis of brine.

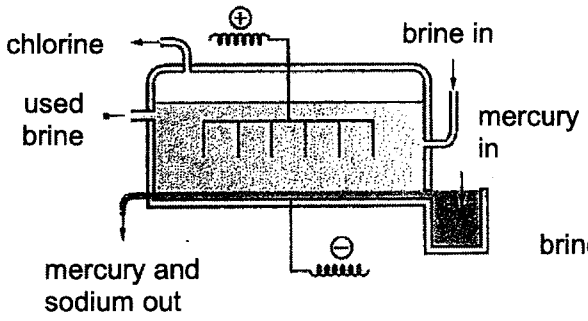
For Examiner's Use

Industrial Electrolysis of Brine

Brine is a concentrated solution of sodium chloride, containing about 25% by mass of sodium chloride. Electrolysis of brine produces chlorine, hydrogen and sodium hydroxide.

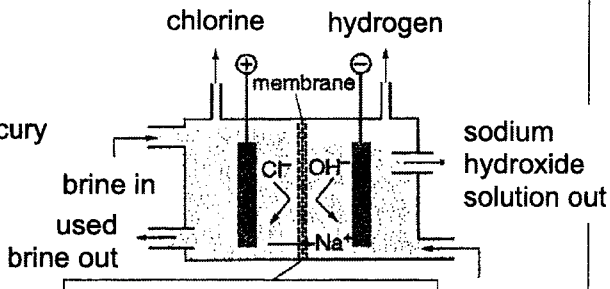
Industrial electrolysis of brine used to be carried out in mercury cells but is now mostly carried out in membrane cells. The diagrams below show how these cells work.

mercury cell



The sodium and mercury mixture flows into another tank (not shown) where sodium reacts with water to make sodium hydroxide and hydrogen.

membrane cell



positive sodium ions move through the membrane but negative ions and water molecules cannot

The membrane cell allows sodium hydroxide and chlorine to be produced in the same cell. Without the membrane, the sodium hydroxide would not be pure because it would contain chloride ions.

One other problem that the membrane cell solves is that it keeps the chlorine gas and hydroxide ions separate. Chlorine and hydroxide ions react together which would reduce the amount of chlorine gas made and create more impurities in the sodium hydroxide.

The table below shows some information of the two types of cell.

	mercury	membrane
overall energy consumption (kWh per tonne of chlorine) 1 tonne = 1,000,000 g	3360	2650
purity of sodium hydroxide produced	high purity	high purity
concentration of sodium hydroxide produced	50% concentration	30% concentration
other points	mercury is toxic and must be removed from used brine	low maintenance costs

For Examiner's Use

(a) (i) In the membrane cell, it is important that negative ions do not pass through the membrane.

Explain why.

.....

.....

.....

..... [3]

(ii) It is an advantage that negative ions do not pass through the membrane. Describe other advantages of using membrane cell instead of mercury cell.

.....

.....

..... [2]

(iii) Give a disadvantage of using membrane cell over mercury cell.

.....

..... [1]

(b) Calculate the energy consumption of the membrane cell per mole of chlorine gas produced.

Give your answer to 3 significant figures.

[2]

(c) **(i)** Write the overall equation for the reaction in the membrane cell.

For Examiner's Use

.....

[1]

(ii) Calculate the maximum mass of sodium hydroxide that can be produced from 1 tonne of concentrated brine.

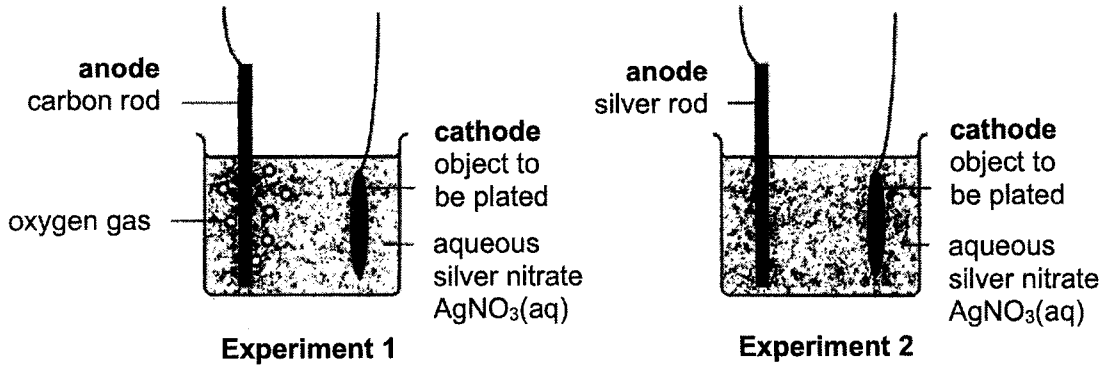
Give your answer to 3 significant figures.

[3]

[Total: 12]

B8 A student sets up two different experiments for electroplating an object with silver.

For Examiner's Use



(a) Write equations, with state symbols, to show the reactions that happen at the anode and cathode during each experiment.

experiment 1

anode: .....

cathode: .....

experiment 2

anode: .....

cathode: ..... [3]

(b) At the beginning of each experiment the student removes a sample of the electrolyte, aqueous silver nitrate, and puts it in a test-tube.

The student then adds a few drops of aqueous sodium chloride to the sample.

(i) Describe and explain what the student sees.

Include an ionic equation in your answer.

.....

..... [2]

(ii) After some time, the student observes that no more silver is being deposited on the object in experiment 1 but more silver is still being deposited on the object in experiment 2.

Suggest a reason for this observation and describe how he could use aqueous sodium chloride to find out if his reasoning is correct.

.....

..... [2]

(c) If an iron object is placed in a beaker of aqueous silver nitrate, a silver coating forms on the iron.

If a gold object is placed in aqueous silver nitrate, no reaction happens.

Explain why.

.....

..... [1]

[Total: 8]

For Examiner's Use

EITHER

For Examiner's Use

B9 Poly(propene) and nylon are both used to make strong, waterproof ropes.

Poly(propene) is an addition polymer. Nylon is a condensation polymer.

(a) Describe the differences between addition polymers and condensation polymers.

.....

.....

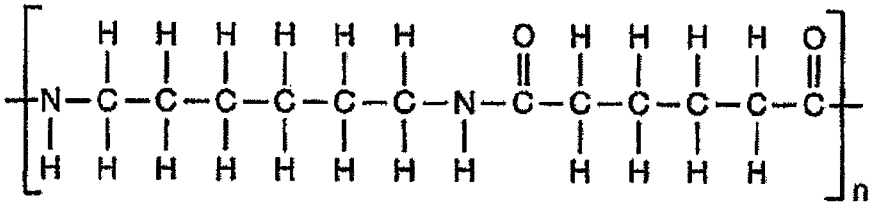
.....

.....

..... [3]

(b) There are several different types of nylon. One type of nylon is nylon-6,6.

This is the repeating unit of nylon-6,6.



(i) Draw the structures of the two monomers that react to form nylon-6,6.

monomer 1

monomer 2

[2]

For Examiner's Use

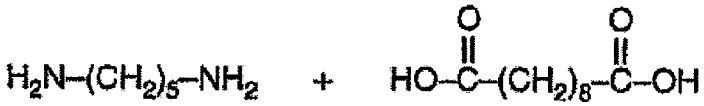
(ii) During the manufacturing process, the chain length of the nylon is controlled so that the nylon polymer molecules have an average relative molecular mass in the range of 14 000 to 22 000.

What is the range of the average number of repeating units in the nylon-6,6 molecules?

Show your working.

[2]

(c) Nylon-5,10 is made by reacting these two monomers together.



(i) Draw the repeating unit of nylon-5,10.

[1]

(ii) Give one similarity and one difference between the structures of the repeating units of nylon-6,6 and nylon-5,10.

similarity .....

.....

difference .....

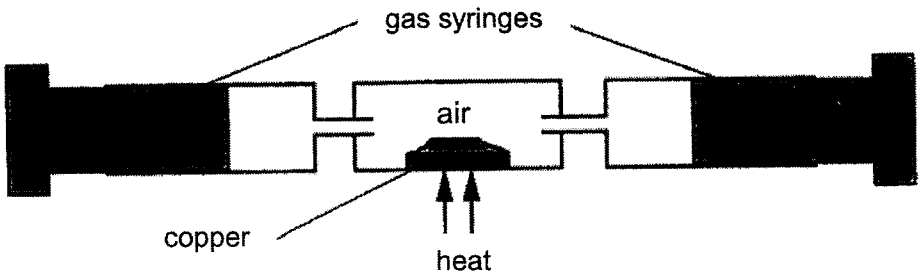
..... [2]

[Total: 10]

OR

For Examiner's Use

B10 An experiment (Experiment 1) was set up to heat copper in air.



At the start of Experiment 1, the apparatus contained a total of 200 cm^3 of air.

During heating, the copper reacted with oxygen in the air to form black copper(II) oxide.

The copper was heated until the volume of gas, measured at room temperature and pressure, remained constant.

(a) **(i)** Explain why it was important to continue heating until the volume remained constant.

.....

..... [1]

(ii) The table shows some data about the mass change during the experiment.

mass of copper at the start of the experiment	mass of solid left at the end of the experiment
1.00 g	1.07 g

Use the data in the table to show that the solid left at the end of the experiment contains unreacted copper.

Show your working.

.....

..... [3]

For Examiner's Use

(b) **(i)** Name the gas that is left in the gas syringes at the end of the experiment.

.....

[1]

(ii) Estimate the total volume of gas left in the gas syringes at the end of the experiment.

Explain your reasoning.

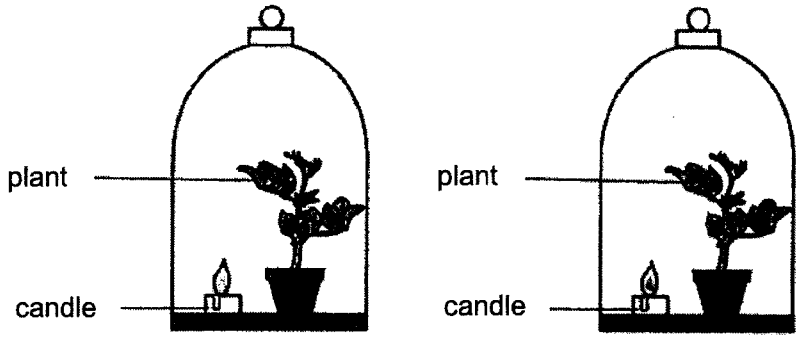
.....

.....

[2]

(c) A burning candle and a plant were placed in two jars of air.

Both jars were left in sunlight.



Jar A **Jar B**

A 200 cm^3 sample of air from Jar A was tested immediately after the candle burned out using the same procedure as in Experiment 1.

A 200 cm^3 sample of air from Jar B was tested a few days after the candle burned out using the same procedure as in Experiment 1.

Describe and explain how the results of the tests would differ for each jar.

.....

.....

.....

.....

.....

.....

[3]

[Total: 10]

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											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.).

BROADRICK SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2022
SEC 4 EXPRESS CHEMISTRY (6092)
MARKING SCHEME

Paper 1: MULTIPLE-CHOICE QUESTIONS (40 MARKS)

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

Section A [50 marks]

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

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

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

A $CaCO_3 \rightarrow CaO + CO_2$

B $SiO_2 + CaO \rightarrow CaSiO_3$

C $C + O_2 \rightarrow CO_2$

D $CO_2 + C \rightarrow 2CO$

E $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Use the letters, A, B, C, D and E to answer the following questions.

(a) Which equation shows thermal decomposition?

A [1]

(b) Which equation shows combustion?

C [1]

(c) Which equation shows a reaction between an acidic compound and a base?

B [1]

(d) Which equation shows the formation of a toxic gas?

D [1]

(e) Two equations show different elements in compounds being reduced.

Give the letters for these two equations.

D and E [1]

(f) Iron from the Blast Furnace is further processed to make steel. Some types of steel contain more carbon than others.

How are the properties of high carbon steel different from those of low carbon steel?

Harder and stronger [1]
Less malleable / more brittle [1] [2]

[Total: 7]

A2 Fluorine forms numerous compounds of varied properties.

For Examiner's Use

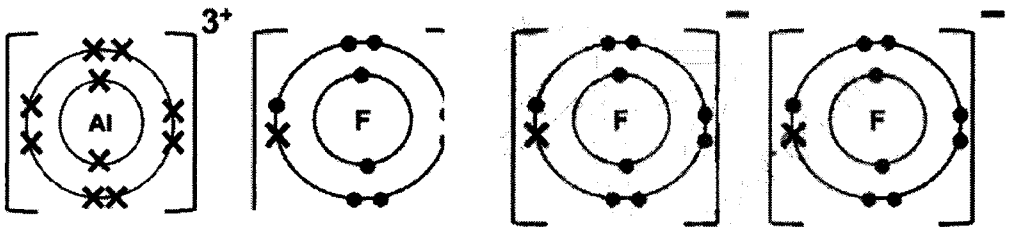
The chemical formulae and melting points of two of the compounds formed are shown below.

compound	chemical formula	melting point / °C
aluminium fluoride	AlF_3	1291
phosphorus trifluoride	PF_3	-151

(a) Draw a 'dot and cross' diagram to show the bonding formed in aluminium fluoride and phosphorus trifluoride.

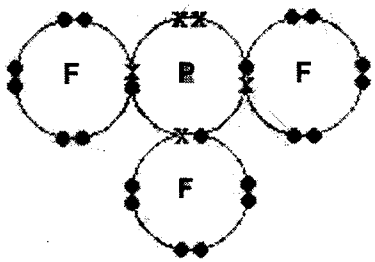
Show only the outer shell electrons.

aluminium fluoride



[1] correct 'dot and cross' diagram of Al^{3+} ion and F^- ion
[1] ratio of Al^{3+}: F^- is 1 : 3

phosphorus trifluoride



[1] correct no. of shared electrons (3 pairs)
[1] correct 'dot and cross' diagram of PF_3 [4]

(b) Explain in term of bonding and structure, why aluminium fluoride has a high melting point while phosphorus trifluoride has a low melting point.

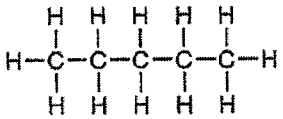
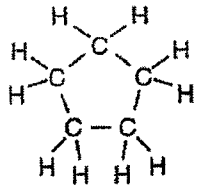
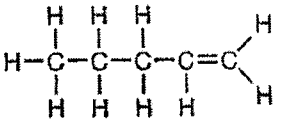
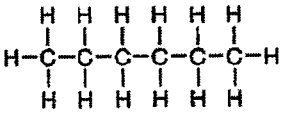
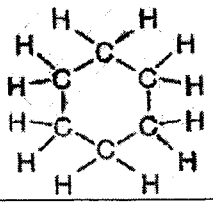
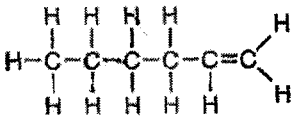
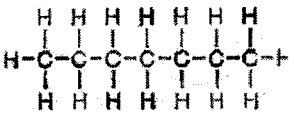
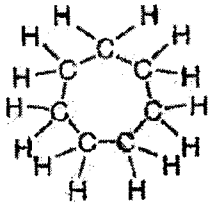
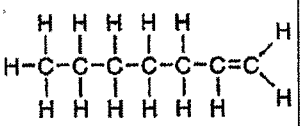
- **Aluminium fluoride has a giant ionic lattice structure [1]**
- **Phosphorus trifluoride has a simple molecular structure [1]**
- **More heat energy is required to overcome the strong electrostatic forces of attraction between the ions in aluminium fluoride as compared to the weak intermolecular forces of attraction between phosphorus trifluoride molecules [1]** [3]

[Turn over

[Total: 7]

For Examiner's Use

A3 The table shows the names and structures of some hydrocarbons.

number of carbon atoms	**alkanes**	**cycloalkane**	**alkene**
5	pentane 	cyclopentane 	pentene 
6	hexane 	cyclohexane 	hexene 
7	heptane 	cycloheptane 	heptene 

(a) Cycloalkanes are an example of a homologous series.

(i) Explain how the formulae of cycloalkanes in the table show this.

It has a general formula of C_nH_{2n} [1]

(ii) Suggest **two** differences in physical properties between cyclopentane and cycloheptane.

viscosity / melting and boiling point / flammability / density [any for 2 m]

[2]

(iii) The molecular formula of hexadecane is $C_{16}H_{34}$.

Give the molecular formula for cyclohexadecane

$C_{16}H_{32}$ [1]

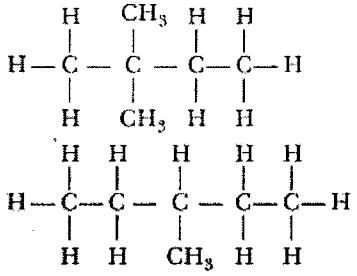
[Turn over

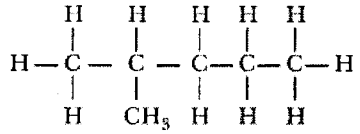
(b) **(i)** Are cycloalkanes isomers of alkanes? Explain your reasoning.

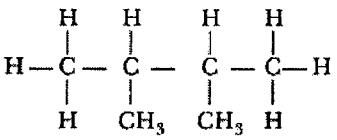
For Examiner's Use

No, cycloalkanes have a <u>different chemical formula</u> from alkanes <u>for the same number of carbons</u> [1]

(ii) Draw the structure of a branched chain isomer of hexane which is a straight chain alkane with the formula C_6H_{14}.







[any plausible isomer for 1 m] [1]

(c) The percentage of carbon and hydrogen in some molecules are shown in the table.

name of molecule	percentage of carbon by mass	percentage of hydrogen by mass
hexane	84	16
hexene	86	14
cycloheptane	86	14

Explain why the percentages of carbon and hydrogen are the same for hexene and cycloheptane, but different for hexane.

Hexene and cycloheptane have the <u>same carbon : hydrogen ratio of 1 : 2</u> thus the percentages of carbon and hydrogen by mass are the same [1]

Hexane has a carbon : hydrogen ratio of 3 : 7 thus the percentages of carbon and hydrogen by mass are different from hexene and cycloheptane [1] [2]

(d) Bromine water can be used in a test to distinguish between cycloalkanes and alkenes.

Describe the results that would be obtained if this test is carried out on separate samples of cyclooctane and octene.

The test-tube containing the sample of <u>cyclooctane turns/remains reddish-brown/red-brown/brown</u> [1]

The test-tube containing the sample of octene <u>decolourises</u> bromine water from <u>reddish-brown/red-brown/brown to colourless</u> [1] [2]

[Total: 10]

[Turn over

A4 Aqueous thiosulfate, $S_2O_3^{2-}(aq)$, reacts with aqueous iodine according to the equation.

For Examiner's Use

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

In a titration, 40.0 cm^3 of 0.1 mol/dm^3 aqueous thiosulfate was added to 30 cm^3 of 0.1 mol/dm^3 aqueous iodine.

(a) Determine the limiting reagent. Show your working.

No. of moles of $S_2O_3^{2-}$ = $\frac{40}{1000}$ x 0.1 = 0.004 mol [0.5]

No of moles of I_2 = $\frac{30}{1000}$ x 0.1 = 0.003 mol [0.5]

Mole ratio of $S_2O_3^{2-}$: I_2 → 2 : 1

0.004 mol of $S_2O_3^{2-}$ requires 0.002 mol of I_2 to react [1]

Thus, the limiting reactant is $S_2O_3^{2-}$ [1] [3]

(b) If only 0.001 mol of I^- was produced, calculate the percentage yield.

Mole ratio of $S_2O_3^{2-}$: I^- → 2 : 2 → 1 : 1

No. of moles of I^- = 0.004 mol [1]

% yield = $\frac{0.001}{0.004}$ x 100 % = <u>25%</u> [1]

percentage yield **<u>25%</u>** [2]

(c) Explain why aqueous thiosulfate acts as a reducing agent in this reaction in terms of changes in oxidation states.

The oxidation state of iodine <u>decreases</u> [1] from <u>0 in I_2</u> to <u>−1 in I^-</u> [1] [2]

(d) Name another suitable reagent that can be used to confirm that aqueous thiosulfate is a reducing agent. Include the observation in your answer, if any.

Acidified potassium manganate(VII) / Acidified potassium permanganate [1]

It will <u>decolourise from purple to colourless</u> [1] [2]

[Total: 9]

A5 Iron(II) sulfate crystals decompose when heated to give three gases U, V and W and an orange-brown solid T.

For Examiner's Use

- Gas U was tested with filter paper soaked with acidified potassium manganate(VII). The filter paper changed colour from purple to colourless.
- Analysis of gas V showed it contained 40.0% sulfur and 60.0% oxygen by mass.
- When gas W was condensed it formed a colourless liquid that turned anhydrous copper(II) sulfate from white to blue.
- Solid T was dissolved in dilute nitric acid. Aqueous ammonia was added drop by drop and a red-brown precipitate was obtained.

(a) (i) What is the formula for gas U?

SO_2 [1]

(ii) Determine the empirical formula of gas V.

	S	O
% mass	40	60
A_r	32	16
no. of moles	$\frac{40}{32} = 1.25$	$\frac{60}{16} = 3.75$
mole ratio	$\frac{1.25}{1.25} = \underline{1}$	$\frac{3.75}{1.25} = \underline{3}$

[1] correct working presented in a tabular form
[1] correct empirical formula

empirical formula of gas V **$\underline{SO_3}$** [2]

(iii) Name gas W.

water (vapour)/ steam [1]

(iv) Give the name or the formula of the metal ion present in solid T.

Iron(III) / Fe^{3+} [1]

(b) Iron(II) sulfate dissolves in water to give a green solution X. Aqueous sodium hydroxide was added drop by drop to solution X.

A green precipitate, Y, was formed.

(i) Name precipitate Y.

Iron(II) hydroxide [1]

(ii) Construct the ionic equation, with state symbols, to show the formation of the precipitate Y.

$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$

[1] correct formulae and balanced equation
[1] correct state symbols [2]

[Turn over

(c) Use the following information to suggest the steps needed to prepare by precipitation pure barium sulfate, using aqueous iron(II) sulfate and powdered barium carbonate in a laboratory.

For Examiner's Use

- barium sulfate is insoluble in water
- barium carbonate is insoluble in water
- barium nitrate is soluble in water

- **Add excess barium carbonate to dilute nitric acid, filter to obtain barium nitrate as the filtrate [1]**

- **Mix solutions of barium nitrate and iron(II) sulfate and filter the mixture to obtain barium sulfate as the residue [1]**

- **Wash the residue with distilled water and dry between two pieces of filter paper [1]**

[3]

[Total: 10]

A6 Group I and Group VII elements show different trends in their properties.

For Examiner's Use

Group I
Li
Na
K
Rb

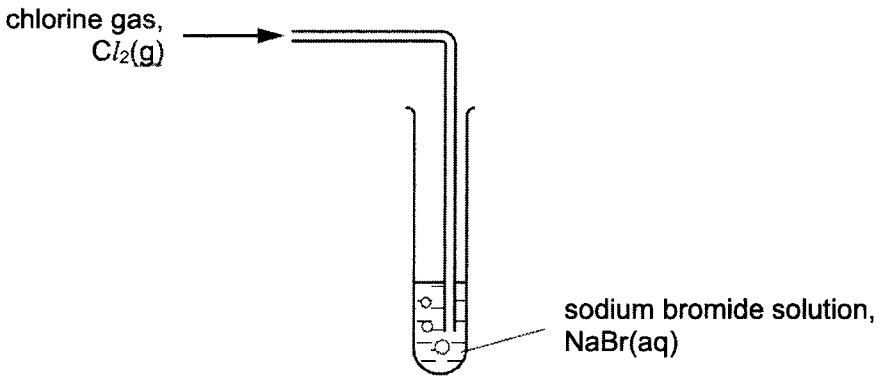
Group VII
F
Cl
Br
I

(a) Explain why the reactivity of metals in Group I increases on going down the group.

As the atomic radius increases/number of electron shells increases down the group, the effective nuclear charge/forces decreases as the valence electrons are further away from the nucleus [1]

There is a greater tendency of losing its valence electron to form the positively charged ions results in increased reactivity [1] [2]

(b) When chlorine gas is bubbled into sodium bromide solution, a reaction occurs.



This reaction is commonly known as a 'displacement reaction'.

(i) Write an ionic equation for the displacement reaction.

$Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$

[1] – correct chemical formulae
[1] – correct balancing and state symbols [2]

(ii) Explain your observations in **(i)**.

As chlorine is more reactive than bromine, it can displace bromine from sodium bromide [1] [1]

[Turn over

For Examiner's Use

(c) The radii of atoms and ions can be measured.

The table below shows some information about the atomic and ionic radii of Group I and Group VII elements.

element	number of shells of electrons in atom	atomic radius / *pm*	number of shells of electrons in ion	ionic radius / *pm*
Group I				
lithium (Li)	2	152	1	68
sodium (Na)	3	185	2	98
Group VII				
fluorine (F)	2	71	2	133
chlorine (C*l*)	3	99	3	181

[1 pm = 10^{-12} m]

(i) Suggest a reason for the difference in radius of a fluorine atom when it forms a fluorine ion.

As F forms F^-, an electron is added to the valence shell, the effective nuclear charge/forces decreases, resulting in the ionic radius is larger than its atomic radius [1]

(ii) Lithium and fluorine are found in the same period.

Suggest why the atomic radius decreases across a period.

As the number of protons and electrons increases across the period the effective nuclear charge/forces increases, thus the atomic radius decreases. [1] [1]

[Total: 7]

[Turn over

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.

B7 Read the information about the industrial electrolysis of brine.

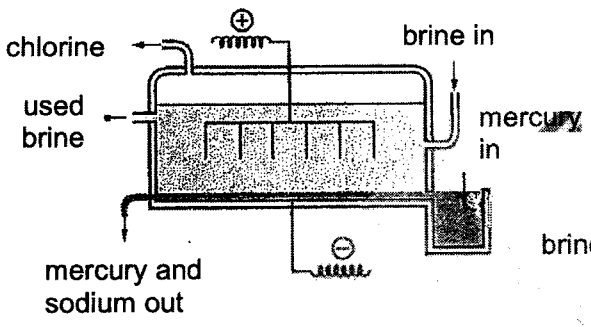
For Examiner's Use

Industrial Electrolysis of Brine

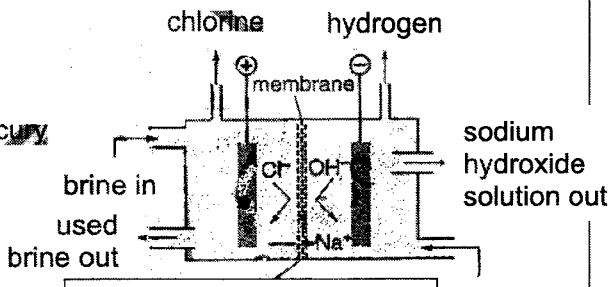
Brine is a concentrated solution of sodium chloride, containing about 25% by mass of sodium chloride. Electrolysis of brine produces chlorine, hydrogen and sodium hydroxide.

Industrial electrolysis of brine used to be carried out in mercury cells but is now mostly carried out in membrane cells. The diagrams below show how these cells work.

mercury cell



membrane cell



positive sodium ions move through the membrane but negative ions and water molecules cannot

The sodium and mercury mixture flows into another tank (not shown) where sodium reacts with water to make sodium hydroxide and hydrogen.

The membrane cell allows sodium hydroxide and chlorine to be produced in the same cell. Without the membrane, the sodium hydroxide would not be pure because it would contain chloride ions.

One other problem that the membrane cell solves is that it keeps the chlorine gas and hydroxide ions separate. Chlorine and hydroxide ions react together which would reduce the amount of chlorine gas made and create more impurities in the sodium hydroxide.

The table below shows some information of the two types of cell.

	mercury	membrane
overall energy consumption (kWh per tonne of chlorine) 1 tonne = 1 000 000 g	3360	2650
purity of sodium hydroxide produced	high purity	high purity
concentration of sodium hydroxide produced	50% concentration	30% concentration
other points	mercury is toxic and must be removed from used brine	low maintenance costs

[Turn over

For Examiner's Use

(a) (i) In the membrane cell, it is important that negative ions do not pass through the membrane.

Explain why.

- **As the OH^- moves to the anode, the discharge of OH^- ions forms oxygen gas and contaminates the chlorine gas collected [1]**
- **As the Cl^- ions move to the cathode, it acts an impurity, resulting in the formation of sodium chloride decreasing the purity of sodium hydroxide produced [1]**
- **Thus, purification is needed to obtain pure chlorine and pure sodium hydroxide [1]**

[3]

[Note: Importance of obtaining pure chlorine and sodium hydroxide. Avoid fully lifting from passage]

(ii) It is an advantage that negative ions do not pass through the membrane. Describe other advantages of using membrane cell instead of mercury cell.

- **For the same mass (1 tonne) of chlorine gas produced, overall energy consumption of the membrane cell is 710 kWh energy lesser than that of the mercury cell [1]**
- **Does not contain toxic substances such as mercury that must be removed from used brine [1]**
- **Has a lower maintenance cost [1]**

[2]

[Any for 2 m]
[Reject: It uses lesser energy and has low maintenance costs. Comparison must be made]

(iii) Describe the disadvantage of using membrane cell over mercury cell.

The concentration of sodium hydroxide produced is more diluted, giving rise to only 30% concentration as compared to the 50% concentration in mercury cell [1]

(b) Calculate the energy consumption of the membrane cell per mole of chlorine gas produced.

Give your answer to 3 significant figures.

No. of moles of Cl_2 = $\frac{100000}{2(35.5)}$ = 1.41 x 10^4 mol (3 s.f) [1]

Energy consumed per mole = $\frac{2650}{1.41 \times 10^4}$ ≈ 0.188 kWh (3 s.f) [1] [2]

(c) (i) Write the overall equation for the reaction in the membrane cell.

For Examiner's Use

$2NaCl + 2H_2O \rightarrow 2NaOH + Cl_2 + H_2$ [1]

(ii) Calculate the maximum mass of sodium hydroxide that can be produced from 1 tonne of concentrated brine.

Give your answer to 3 significant figures.

Mass of NaCl = $\frac{25}{100}$ x 1 000 000 = 0.25 x 10^6 g [1]

No. of moles of NaCl = $\frac{0.25 \times 10^6}{58.5}$ ≈ 4.27 x 10^3 mol (3 s.f)

Mole ratio of NaCl : NaOH → 2 : 2 → 1 : 1

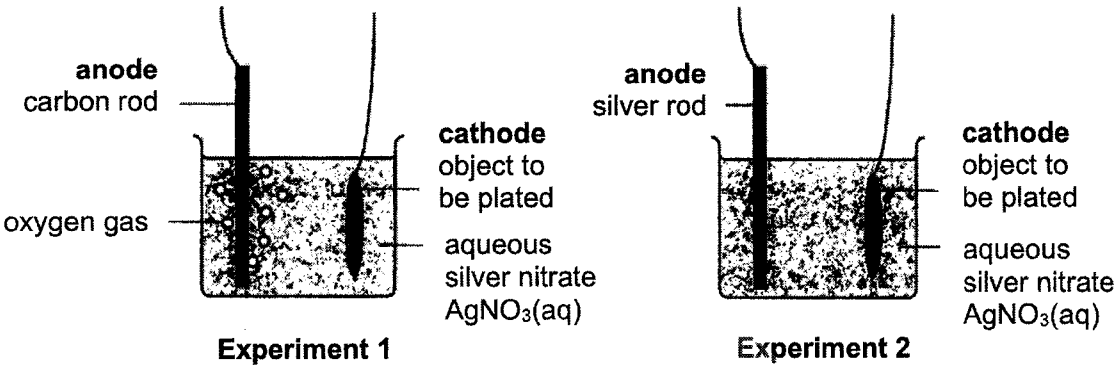
No. of moles of NaOH ≈ 4.27 x 10^3 mol (3 s.f) [1]

Maximum mass of NaOH produced = 4.27 x 10^3 x (23 + 16 + 1)
≈ 171 000 g (3 s.f) [1] [3]

[Total: 12]

B8 A student sets up two different experiments for electroplating an object with silver.

For Examiner's Use



(a) Write equations, with state symbols, to show the reactions that happen at the anode and cathode during each experiment.

experiment 1

anode: **$4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$ [1]**

cathode: **$Ag^+(aq) + e^- \rightarrow Ag(s)$ [0.5]**

experiment 2

anode: **$Ag(s) \rightarrow Ag^+(aq) + e^-$ [1]**

cathode: **$Ag^+(aq) + e^- \rightarrow Ag(s)$ [0.5]** [3]

(b) At the beginning of each experiment the student removes a sample of the electrolyte, aqueous silver nitrate, and puts it in a test-tube.

The student then adds a few drops of aqueous sodium chloride to the sample.

(i) Describe and explain what the student sees.

Include an ionic equation in your answer.

A white precipitate is observed as silver chloride is insoluble in water [1]

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ [1] [2]

For Examiner's Use

(ii) After some time, the student observes that no more silver is being deposited on the object in experiment 1 but more silver is still being deposited on the object in experiment 2.

Suggest a reason for this observation and describe how he could use aqueous sodium chloride to find out if his reasoning is correct.

In experiment 2, for every 1 mole of silver ion discharged at the cathode, 1 mole of silver ion is formed at the anode [1]

A white precipitate of silver chloride would be observed in experiment 2 only when sodium chloride is added to test for silver ions [1] [2]

(c) If an iron object is placed in a beaker of aqueous silver nitrate, a silver coating forms on the iron.

If a gold object is placed in aqueous silver nitrate, no reaction happens.

Explain why.

Iron is more reactive than silver in the reactivity series of metals, thus it is able to displace silver from aqueous silver nitrate/

Gold is less reactive than silver in the reactivity series of metals, thus is it unable to displace silver from aqueous silver nitrate [1]

[Any for 1m]

[Total: 8]

[Turn over

EITHER

For Examiner's Use

B9 Poly(propene) and nylon are both used to make strong, waterproof ropes.

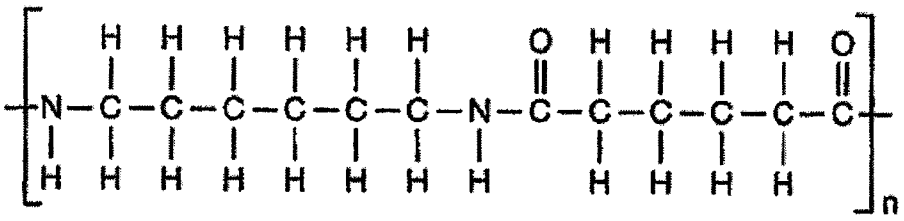
Poly(propene) is an addition polymer. Nylon is a condensation polymer.

(a) Describe the differences between addition polymers and condensation polymers.

- **Addition polymers are formed from the joining of monomers without the loss of any small molecules [1]**
- **Condensation polymers form through the joining of monomers with the loss of a small molecule in the form of water [1]**
- **Monomers of addition polymers must have a C=C double bond while monomers of condensation polymers must have two functional groups [1]** [3]

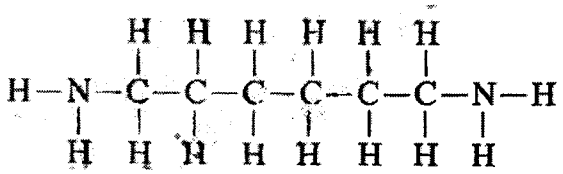
(b) There are several different types of nylon. One type of nylon is nylon-6,6.

This is the repeating unit of nylon-6,6.

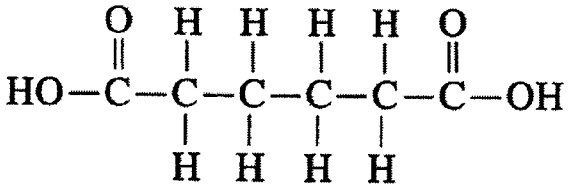


(i) Draw the structures of the two monomers that react to form nylon-6,6.

monomer 1



monomer 2



[2]

For Examiner's Use

(ii) During the manufacturing process, the chain length of the nylon is controlled so that the nylon polymer molecules have an average relative molecular mass in the range of 14 000 to 22 000.

What is the range of the average number of repeating units in the nylon-6,6 molecules?

Show your working.

M_r of 1 repeat unit = 12(12) + 22 + 2(16) + 2(14) = 226 [1]

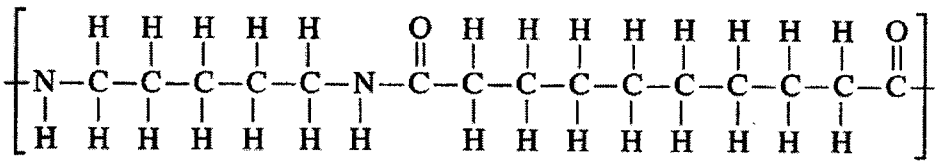
No. of repeat units in polymer of M_r (14 000) = $\frac{14\,000}{226} \approx 62$

No. of repeat units in polymer of M_r (22 000) = $\frac{22\,000}{226} \approx 97$

Range: between 62 to 97 [1] [2]

(c) Nylon-5,10 is made by reacting these two monomers together.

(i) Draw the repeating unit of nylon-5,10.



[1]

(ii) Give one similarity and one difference between the structures of the repeating units of nylon-6,6 and nylon-5,10.

similarity **monomers are joined by amide linkages (-CONH-) [1]**

difference **the repeat unit of nylon-5,10 has a longer carbon chain than in nylon-6,6, thus it will have a larger relative molecular mass [1]** [2]

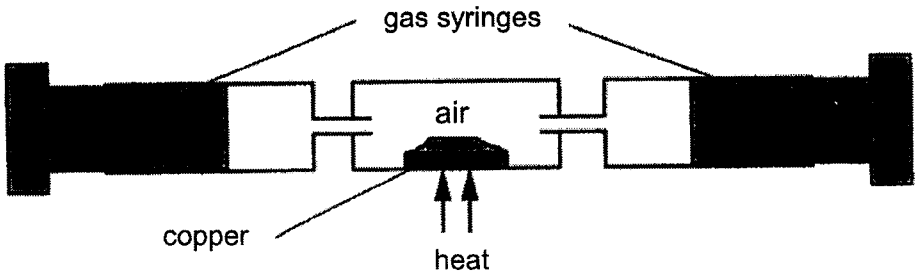
[Total: 10]

[Turn over

OR

For Examiner's Use

B10 An experiment (Experiment 1) was set up to heat copper in air.



At the start of Experiment 1, the apparatus contained a total of 200 cm^3 of air.

During heating, the copper reacted with oxygen in the air to form black copper(II) oxide.

The copper was heated until the volume of gas, measured at room temperature and pressure, remained constant.

(a) (i) Explain why it was important to continue heating until the volume remained constant.

To ensure that all the oxygen in the air sample has been used up/has reacted. [1]

(ii) The table shows some data about the mass change during the experiment.

mass of copper at the start of the experiment	mass of solid left at the end of the experiment
1.00 g	1.07 g

Use the data in the table to show that the solid left at the end of the experiment contains unreacted copper.

Show your working.

No. of moles of Cu = $\frac{1}{64}$ = 0.0156 mol [1]

$2Cu + O_2 \rightarrow 2CuO$

Mole ratio of Cu : CuO → 2 : 2 → 1 : 1

No. of moles of CuO = 0.0156 mol

Theoretical mass of CuO = 0.0156 x (64 + 16) = 1.248 g [1]

Since the actual mass obtained (1.07 g) is lower than the theoretical mass (1.248 g), there is some unreacted copper present [1] [3]

For Examiner's Use

(b) **(i)** Name the gas that is left in the gas syringes at the end of the experiment.

Nitrogen [1]

(ii) Estimate the total volume of gas left in the gas syringes at the end of the experiment.

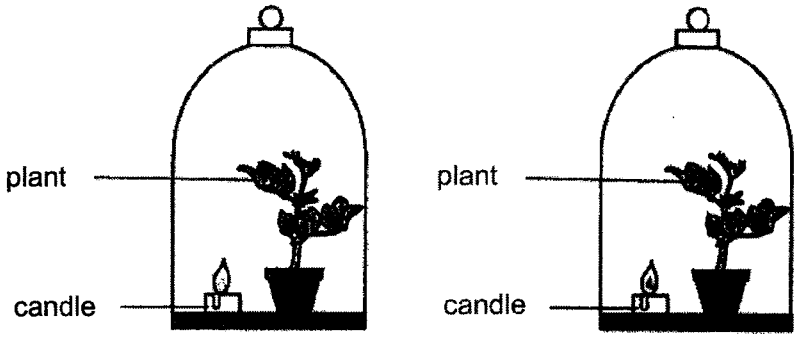
Explain your reasoning.

158 cm^3 is left [1] as

21% of air is made up of oxygen (42 cm^3) that reacts with copper [1] [2]

(c) A burning candle and a plant were placed in two jars of air.

Both jars were left in sunlight.



Jar A **Jar B**

A 200 cm^3 sample of air from Jar A was tested immediately after the candle burned out using the same procedure as in Experiment 1.

A 200 cm^3 sample of air from Jar B was tested a few days after the candle burned out using the same procedure as in Experiment 1.

Describe and explain how the results of the tests would differ for each jar.

- **The air in <u>Jar A contains lesser oxygen</u> than Jar B as it is <u>used (up) by the candle to support burning/combustion</u> [1]**
- **The air in <u>Jar B contains more oxygen</u> than Jar A <u>as photosynthesis occurred</u> during those few days after the candle burned out [1]**
- **Thus, the <u>mass of solid left at the end of the experiment would be greater in Jar B than Jar A</u> [1]** [3]

[Total: 10]

-End of Marking Scheme-

[Turn over