Shell

Chemistry

Summer 2022

Time: 1 hour 30 minutes

Name:……

Subject Teacher:……

Instructions

- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- Show all the steps in any calculations and state the units.
- Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Total Marks

Paper is out of 90

The Periodic Table of the Elements

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112–116 have been reported but not fully authenticated						

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

**** The lanthanoids (atomic numbers 58–71) and the actinoids (atomic numbers 90–103) have been omitted.***

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.

BLANK PAGE

A list of Common Ions

Positive Ions		Negative Ions	
Hydrogen	H^{1+}	Hydroxide	OH^{1-}
Silver	Ag^{1+}	Carbonate	CO_3^{2-}
Zinc	Zn^{2+}	Nitrate	NO_3^{1-}
Lead	Pb^{2+}	Sulfate	SO_4^{2-}
Copper(II)	Cu^{2+}		
Iron(II)	Fe^{2+}		
Iron(III)	Fe^{3+}		
Ammonium	NH_4^{1+}		

Answer ALL questions.

1 The box shows the names of some substances.

bromine	carbon dioxide	copper	iodine
methane	nitrogen	sulfur dioxide	water

(a) Complete the table by choosing substances from the box that match the description.

Each substance may be used once, more than once or not at all.

(5)

Description	Substance
a good conductor of electricity	
an element that has a basic oxide	
a substance used as a fuel	
a major cause of acid rain	
a non-metallic element that is a solid at room temperature	

(b) Describe a test for carbon dioxide.

(2)

.....

.....

.....

.....

(Total for Question 1 = 7 marks)

2 (a) Table 1 gives some information about three subatomic particles.

(i) Complete Table 1 by giving the missing information.

(3)

Subatomic particle	Relative mass	Relative charge
electron	0.0005	
proton		+1
neutron	1	

Table 1

(ii) Give the name of the part of the atom containing protons and neutrons.

(1)

.....

(b) Table 2 shows the numbers of protons, neutrons and electrons in the species U, V, W, X, Y and Z.

Species	Number of protons	Number of neutrons	Number of electrons
U	8	10	8
V	9	10	10
W	11	12	10
X	11	12	11
Y	12	12	12
Z	12	13	12

Table 2

Use the information in Table 2 to answer these questions.

Each species may be used once, more than once or not at all.

(i) Give the letter of the species that has six electrons in its outer shell.

(1)

.....

(ii) Give the mass number of Z.

(1)

.....

(iii) Give the letter of the species that is a positive ion.

(1)

.....

(Total for Question 2 = 7 marks)

3 Some sugar is added to cold water in a beaker.

After some time, all the sugar dissolves and spreads throughout the water.

(a) (i) Name the process that occurs which causes the sugar to spread throughout the water.

(1)

.....

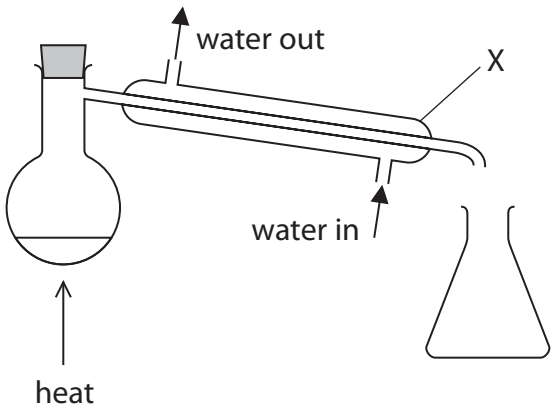
(ii) State two ways to make the sugar dissolve more quickly.

(2)

1 .....

2 .....

(b) Pure water can be obtained from the sugar solution using this apparatus.



(i) Name the process used to obtain pure water from the sugar solution.

(1)

.....

(ii) Explain the purpose of the piece of apparatus labelled X.

(2)

.....

.....

.....

.....

(Total for Question 3 = 6 marks)

4 This question is about alkanes and alkenes.

(i) Complete the boxes by giving the missing information about the alkane with the molecular formula C_2H_6

(3)

molecular formula	C_2H_6
name	
empirical formula	
displayed formula	

(ii) Complete the chemical equation for the complete combustion of the alkane C_2H_6

(1)

.....C_2H_6 + ...O_2 → .....CO_2 + ...H_2O

(iii) Incomplete combustion occurs when the air supply is limited.

Give the names of two products of incomplete combustion.

(2)

1 .....

2 .....

(Total for Question 4 = 6 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

5 Use the Periodic Table to help you answer this question.

(i) Name the element with atomic number 14

(1)

.....

(ii) Name the element with a relative atomic mass of 11

(1)

.....

(iii) Name the element in Group 2 and Period 3

(1)

.....

(iv) State the electronic configuration of an aluminium atom.

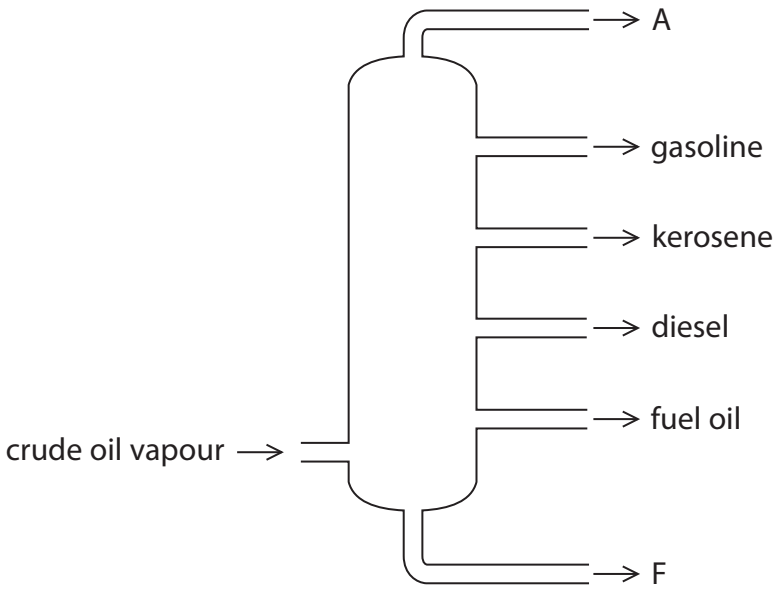
(1)

.....

(Total for Question 5 = 4 marks)

BLANK PAGE

6 The diagram shows the industrial equipment used to separate crude oil into fractions.



(a) (i) Give the name of the industrial equipment.

(1)

.....

(ii) Give one use of the fuel oil fraction.

(1)

.....

(iii) Give the names of fraction A and fraction F.

(2)

fraction A.....

fraction F.....

(b) One compound in the gasoline fraction is the alkane octane (C_8H_{18}) and one compound in the kerosene fraction is the alkane dodecane ($C_{12}H_{26}$)

These two alkanes are covalently bonded and have simple molecular structures.

(i) Give the general formula for the alkanes.

(1)

.....

(ii) Explain, in terms of their structures, why $C_{12}H_{26}$ has a higher boiling point than C_8H_{18}

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 6 = 8 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

7 A student investigates the solubility of potassium nitrate in water.
She measures the masses of potassium nitrate that dissolve in 25 cm^3 of water at different temperatures.

The table shows the student's results. One of the results is anomalous.

Temperature in °C	10	20	30	40	50	60	70
Mass of potassium nitrate in g	8.0	10.0	12.5	16.0	17.5	26.5	34.0

(a) (i) Plot the results on the grid.

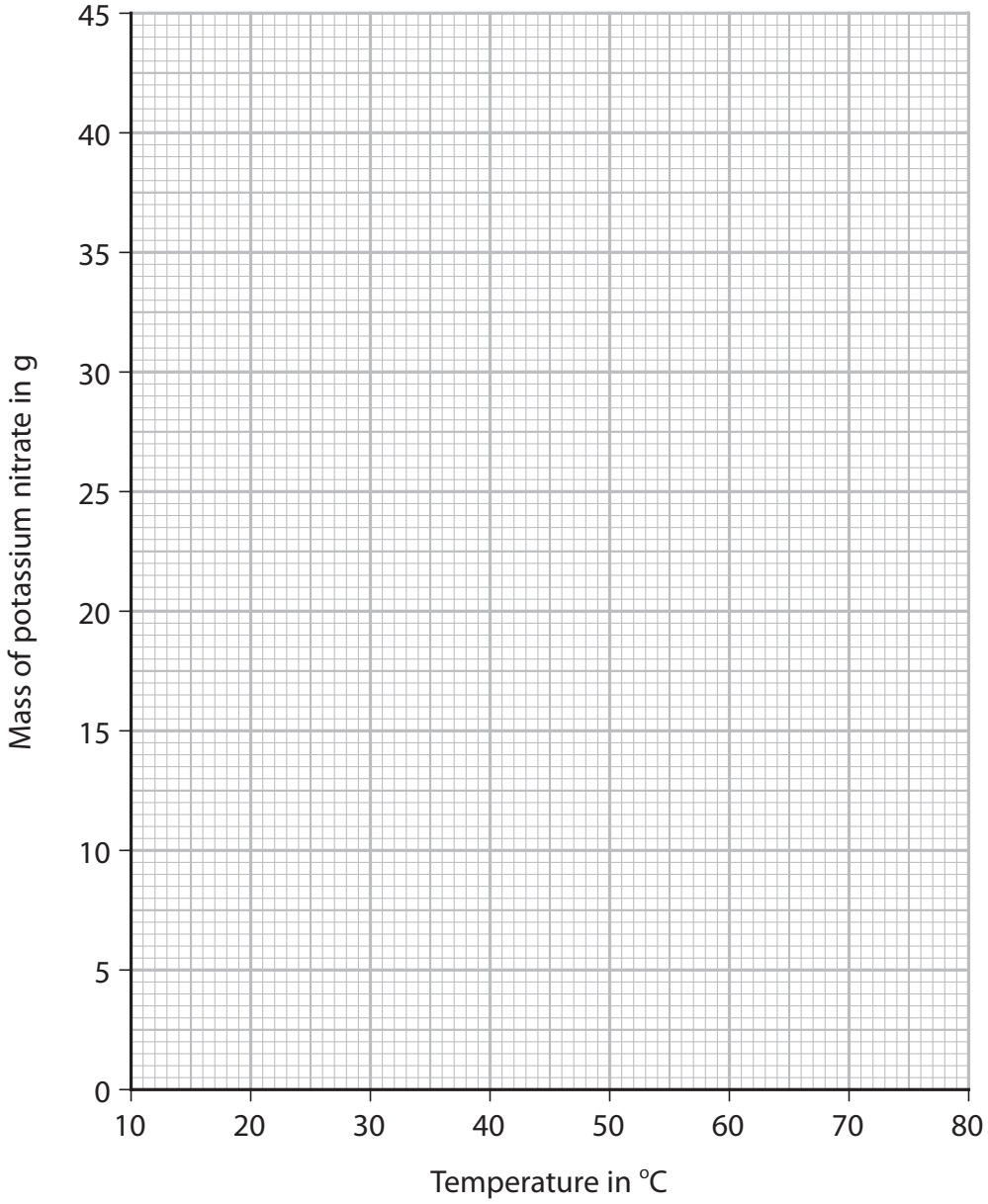
(1)

(ii) Draw a circle around the anomalous result.

(1)

(iii) Ignoring the anomalous result, draw a curve of best fit.

(1)



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b) Suggest **two** possible mistakes that could have caused the anomalous result.

(2)

1 .....

.....

2 .....

.....

(c) Use your graph to find the maximum mass of potassium nitrate that dissolves in 25 cm^3 of water at 75 °C.

Show on your graph how you obtained your answer.

(2)

mass = ... g

(d) Use your graph to calculate the solubility of potassium nitrate in g per 100 g of water at 25 °C.

[1.0 cm^3 of water has a mass of 1.0 g]

(2)

solubility = ... g per 100 g of water

(Total for Question 7 = 9 marks)

8 This question is about states of matter.

(a) The box gives words relating to changes of state.

condensation	cooling	evaporation
freezing	melting	sublimation

Complete the table by giving the correct word from the box for each change of state.

(3)

Change of state	Name of change
solid to liquid	
solid to gas	
liquid to solid	

(b) When ammonia gas and hydrogen chloride gas mix, they react together to form a white solid called ammonium chloride.

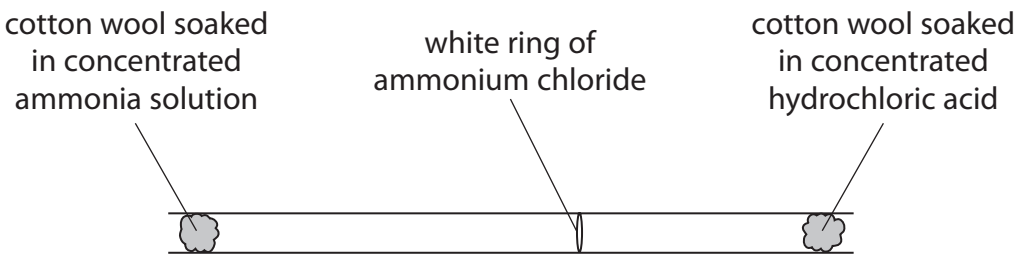
The equation for the reaction is

$$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$$

A teacher soaks a piece of cotton wool in concentrated ammonia solution and another piece of cotton wool in concentrated hydrochloric acid.

The teacher places the two pieces of cotton wool at opposite ends of a glass tube at the same time.

After several minutes, a white ring of solid ammonium chloride forms.



(i) State the name given to the spreading out of gas particles.

(1)

.....

(ii) State how the diagram shows that the particles of ammonia gas are travelling at higher speeds than the particles of hydrogen chloride gas.

(1)

.....

.....

(iii) Gas particles travel at high speeds.

Give a reason why the white ring of ammonium chloride takes several minutes to form.

(1)

.....

.....

(iv) Concentrated ammonia solution and concentrated hydrochloric acid are corrosive.

Give one safety precaution the teacher should take.

(1)

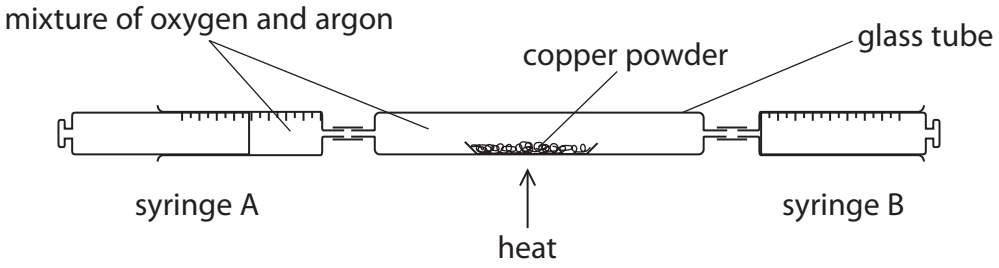
.....

.....

(Total for Question 8 = 7 marks)

BLANK PAGE

9 A teacher uses this apparatus to find the percentage of oxygen in a gaseous mixture of oxygen and argon.



This is the teacher's method.

Step 1 heat the copper powder

Step 2 push the plunger on syringe A to pass the mixture of oxygen and argon over the hot copper so that the mixture moves into syringe B

Step 3 push the plunger on syringe B to pass the mixture of oxygen and argon over the hot copper so that the mixture moves into syringe A

Step 4 record the reading on syringe A

Step 5 repeat Steps 2, 3 and 4 a number of times

The volume of gas decreases as the oxygen reacts with the copper.

Argon is unreactive so does not react with the copper.

The copper powder turns black.

(a) (i) Give a reason why the copper powder is heated.

(1)

.....

.....

(ii) State why argon is unreactive.

(1)

.....

.....

(iii) Give the name of the black powder that forms when the oxygen reacts with the copper.

(1)

.....

(b) The table shows the teacher's results.

Reading number	Reading on syringe A in cm^3
Start	78
1	70
2	67
3	65
4	63
5	61
6	60
7	59
8	58
9	58
10	58

(i) State how the results show that all the oxygen has reacted.

(1)

.....

.....

(ii) The volume of gas in the glass tube and connecting tubes is 175 cm^3.

Use this value and the results table to calculate the percentage of oxygen in the mixture of oxygen and argon.

(3)

percentage of oxygen = ... %

(iii) Suggest one reason why the calculated percentage of oxygen in the mixture may not be accurate.

(1)

.....

.....

(Total for Question 9 = 8 marks)

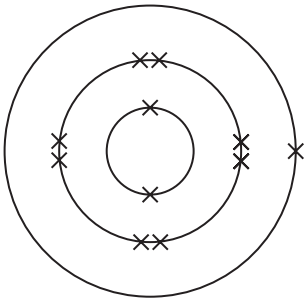
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

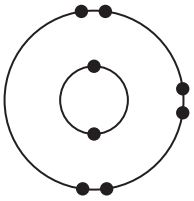
DO NOT WRITE IN THIS AREA

10 This question is about sodium oxide, Na_2O

(a) The diagram shows the electronic configuration of atoms of sodium and oxygen.



Sodium



Oxygen

Describe the changes in the electronic configuration of the atoms of sodium and oxygen to form the ions in sodium oxide.

(3)

.....

.....

.....

.....

.....

.....

(b) Calculate the relative formula mass (M_r) of sodium oxide, Na_2O, using information from the Periodic Table.

(1)

M_r = ...

(c) Calculate the relative formula mass (M_r) of calcium nitrate, $Ca(NO_3)_2$ using information from the Periodic Table.

(1)

M_r = ...

(d) Draw a diagram to show the bonding in magnesium chloride ($MgCl_2$).

(3)

You should show the outer electrons only.

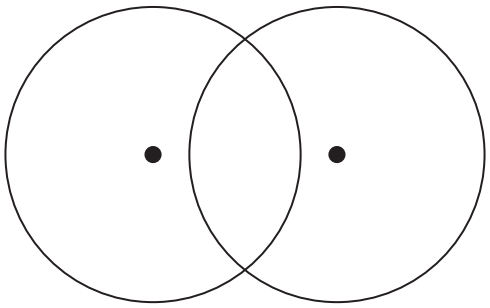
(Total for Question 10 = 8 marks)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

11 This question is about substances with covalent bonds.

(a) (i) Draw a dot and cross diagram to show the outer shell electrons in a molecule of nitrogen, N_2

(2)



(ii) Describe the forces of attraction in a covalent bond.

(2)

.....

.....

.....

.....

.....

(Total for Question 11 = 4 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

BLANK PAGE

12 This question is about acids, alkalis and indicators.

(a) Which of these is the colour of litmus indicator in an acidic solution?

(1)

- ☒ **A** blue
- ☒ **B** orange
- ☒ **C** red
- ☒ **D** yellow

(b) Which of these is the pH value of a neutral solution?

(1)

- ☒ **A** 0
- ☒ **B** 4
- ☒ **C** 7
- ☒ **D** 14

(c) Which of these describes a solution with a pH value of 9?

(1)

- ☒ **A** strongly acidic
- ☒ **B** strongly alkaline
- ☒ **C** weakly acidic
- ☒ **D** weakly alkaline

(d) Which of these is the chemical formula of an acid?

(1)

- ☒ **A** HNO_3
- ☒ **B** H_2O
- ☒ **C** NaCl
- ☒ **D** NaOH

(e) Name the type of reaction that occurs when an acid reacts with an alkali.

(1)

.....

(f) Name the two products of the reaction between hydrochloric acid and potassium hydroxide.

(2)

1 .....

2 .....

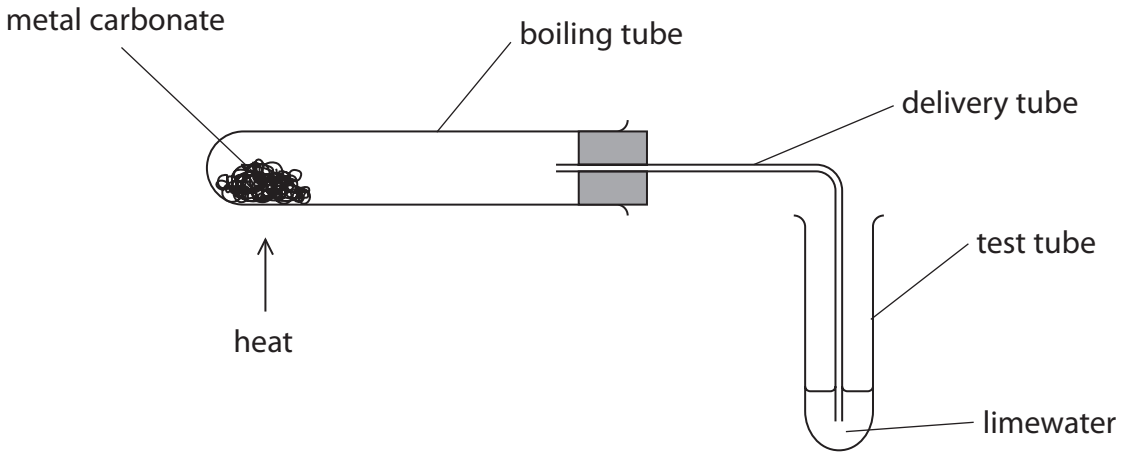
(Total for Question 12 = 7 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

13 A student uses this apparatus to investigate the effect of heat on different solid metal carbonates.



This is the student's method.

- use a spatula to put some metal carbonate in the boiling tube
- fit the delivery tube into position
- pour some limewater into the test tube
- start a timer and immediately begin to heat the metal carbonate
- record the time when a change first occurs in the limewater

The student repeats the method using different metal carbonates.

When a metal carbonate is heated a reaction sometimes occurs.

The equation for the reaction is

$$\text{metal carbonate} \rightarrow \text{metal oxide} + \text{carbon dioxide}$$

(a) State the name given to this type of reaction.

(1)

.....

(b) State two variables that the student should control in this investigation.

(2)

1 .....

.....

2 .....

.....

(c) Suggest why bubbles appear in the limewater immediately after heating has started but before there is any change to the metal carbonate.

(1)

.....

.....

.....

(d) Explain the purpose of limewater in this investigation.

(2)

.....

.....

.....

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(e) The table shows some of the results for the student's investigation.

Metal carbonate	Colour change of solid	Time taken for any change in limewater
calcium carbonate	remains white	90 seconds
sodium carbonate	remains white	no change
copper(II) carbonate		50 seconds

(i) State the colour change that occurs for copper(II) carbonate.

(2)

from ..... to .....

(ii) Give a chemical equation for this reaction of copper(II) carbonate.

(1)

.....

(Total for Question 13 = 9 marks)

TOTAL FOR PAPER = 90 MARKS

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

BLANK PAGE

BLANK PAGE