MODEL ANSWERS.

Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel International GCSE (9–1)

Centre Number | | | | | |

Candidate Number | | | | |

Thursday 9 January 2020

Morning (Time: 2 hours)

Paper Reference **4CH1/1CR 4SD0/1CR**

Chemistry

Unit: 4CH1

Science (Double Award) 4SD0

Paper: 1CR

You must have:
Calculator, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- 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 ☒.

Information

- The total mark for this paper is 110.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Write your answers neatly and in good English.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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Pearson

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.

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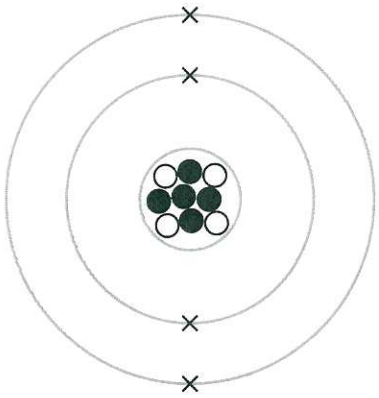
Answer ALL questions.

1 The diagram shows the particles in the atom of an element.



Key

○ particle Y

● particle Z

(a) Particle Y is a proton.

What is particle Z?

(1)

☐ **A** an electron

☐ **B** a molecule

☒ **C** a neutron

☐ **D** a nucleus

(b) Which of these has the smallest mass?

(1)

☒ **A** an electron

☐ **B** a neutron

☐ **C** a nucleus

☐ **D** a proton

(c) What is the mass number of this atom?

(1)

☐ **A** 4

☐ **B** 5

☒ **C** 9

☐ **D** 13

(d) What is the atomic number of this atom?

(1)

☒ **A** 4

☐ **B** 5

☐ **C** 9

☐ **D** 13

(e) (i) Identify the element that contains this atom.

(1)

Beryllium

(ii) State what is formed when this atom loses its outer shell electrons.

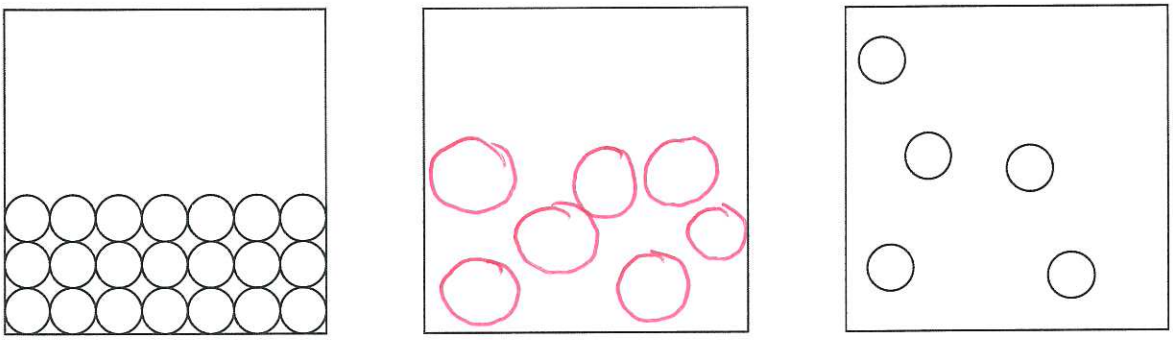
(1)

Positive ion.

(Total for Question 1 = 6 marks)

2 This question is about states of matter.

(a) The diagram shows how the particles of a substance are arranged in two different states.



solid liquid gas

(i) Complete the diagram to show how particles are arranged in the liquid state.

(1)

(ii) Identify the state of matter in which the particles have the most energy.

(1)

Gas

(b) The state symbols (s), (l), (g) and (aq) are often used in chemistry.

The table shows some physical changes.

Complete the table by giving the state symbol before and after each change.

(3)

Physical change	State symbol	
	before change	after change
water evaporates	(l)	(g)
crystals of iodine sublime	(s)	(g)
ice melts	(s)	(l)

(c) Explain why hot water evaporates more quickly than cold water.

(2)

The molecules in ht water have more energy which can be used to overcome the intermolecular forces between the water molecules.

(Total for Question 2 = 7 marks)

3 The Group 7 elements are called halogens.

Halogens form compounds called halides.

Three of the halogens are represented by the formulae X_2, Y_2 and Z_2

Solutions of these halogens are added separately to solutions of sodium halides, NaX, NaY and NaZ.

The table shows whether or not a reaction occurs.

	X_2	Y_2	Z_2
NaX	no	yes	yes
NaY	no	no	yes
NaZ	no	no	no

(a) Use the information in the table to deduce the order of reactivity of the halogens X_2, Y_2 and Z_2

(1)

most reactive Z_2

Y_2

least reactive X_2

(b) An aqueous solution of halogen Y_2 is orange.

This solution is decolourised when it reacts with an alkene.

Deduce the identity of halogen Y_2

(1)

Bromine.

(c) (i) The table shows some physical properties of the halogens.

Complete the table by predicting a boiling point for chlorine, the state of fluorine at room temperature and the colour of astatine.

(3)

Halogen	Boiling point in °C	State at room temperature	Colour
fluorine	−188	gas	yellow
chlorine	-100	gas	green
bromine	59	liquid	red-brown
iodine	sublimes	solid	grey
astatine	337	solid	dark grey

(ii) Why do the halogens have similar chemical properties?

(1)

- ☐ **A** they are non-metals
- ☐ **B** they are molecules
- ☒ **C** they have the same number of outer shell electrons
- ☐ **D** they are in the same period of the Periodic Table

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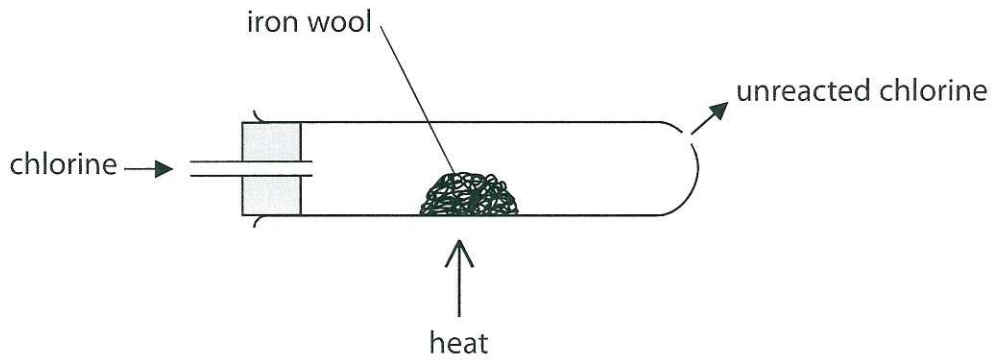
(d) A teacher uses this apparatus to demonstrate the reaction between chlorine gas and iron wool. The teacher does the reaction in a fume cupboard.



(i) Suggest why the teacher does the reaction in a fume cupboard.

(1)

Chlorine is toxic.

(ii) The product of the reaction between iron and chlorine is iron(III) chloride.

The ions in iron(III) chloride are Fe^{3+} and Cl^-

Use this information to give the chemical equation for this reaction.

(2)

$2Fe + 3Cl_2 \rightarrow 2FeCl_3$

(Total for Question 3 = 9 marks)

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4 This question is about ammonium chloride.

(a) Give the formula of the ammonium ion.

(1)

NH_4^+

(b) Describe a test to show that ammonium chloride contains ammonium ions.

(3)

Add Sodium hydroxide Solution to the ammonium Chloride and warm it. The gas evolved will turn damp red litmus blue.

(c) The equation shows the thermal decomposition of ammonium chloride.

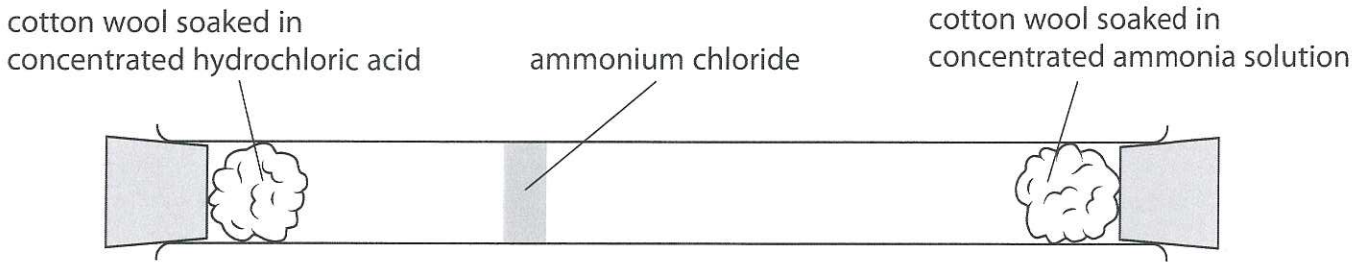
$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

State what the $\rightleftharpoons$ symbol indicates about this reaction.

(1)

The reaction is reversible.

(d) The diagram shows the formation of ammonium chloride in a glass tube.



(i) Explain how the mean speed of ammonia molecules compares with the mean speed of hydrogen chloride molecules.

(2)

The ammonia molecules move faster as the ammonium chloride forms nearer to the hydrochloric acid end.

(ii) Gas particles travel very quickly.

Give two reasons why it takes several minutes for the ammonium chloride to form.

(2)

1 The gas particles move in random directions.

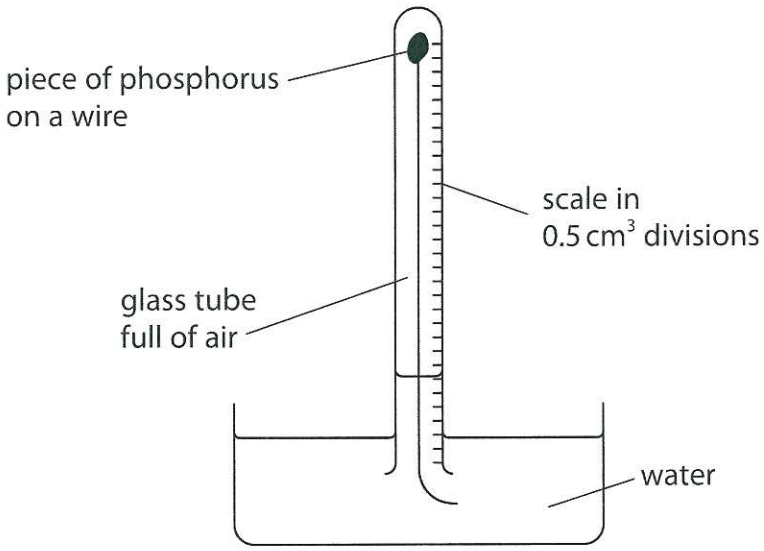
Gas particles collide with the walls of the tube.

2 The gas particles collide with other particles.

(Total for Question 4 = 9 marks)

5 A teacher uses the reaction between phosphorus and oxygen to calculate the percentage of oxygen in air.

She uses this apparatus and excess phosphorus.



The volume of gas in the tube decreases as the phosphorus reacts with oxygen.

The teacher measures the volume of gas in the tube at one-minute intervals.

The table shows the teacher's results.

Time in minutes	Volume of gas in tube in cm^3
0	48.5
1	41.0
2	38.0
4	37.5
5	37.0
6	37.0
7	37.0

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

(1)

The volume of gas in the tube remains constant after five minutes.

(b) Give one change to this experiment that would make the results more accurate.

(1)

Use a scale on the glass tube with smaller divisions.

(c) Use the results to calculate the percentage of oxygen in air.

Give your answer to one decimal place.

(3)

$V(O_2) = 48.5 - 37 = 11.5\,cm^3$

$\%(O_2) = \frac{11.5}{48.5} \times 100$

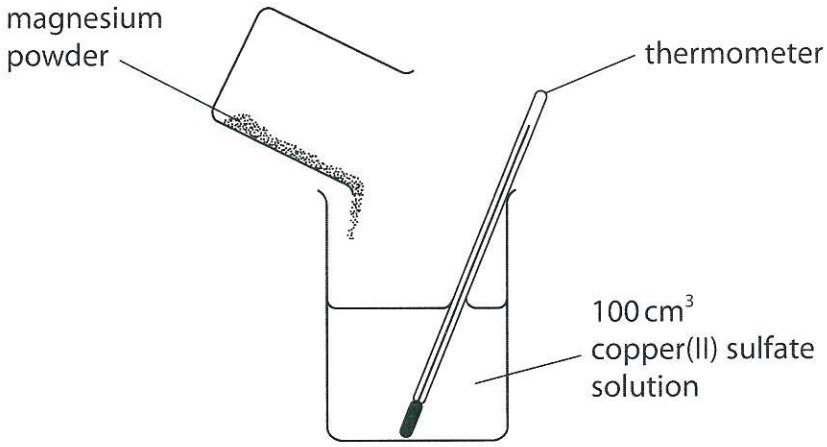
$= 23.7\ \%$

percentage = 23.7 (1 d.p.) %

(Total for Question 5 = 5 marks)

6 The reaction between magnesium and copper(II) sulfate solution is exothermic.

This apparatus is used to measure the temperature increase when excess magnesium is added to 100 cm^3 of copper(II) sulfate solution.



(a) (i) State why a reaction occurs when magnesium is added to copper(II) sulfate solution.

(1)

Magnesium is more reactive than Copper.

(ii) Complete the word equation for this reaction.

(1)

magnesium + copper(II) sulfate → magnesium Sulphate + Copper.

(b) The temperature at the start of the reaction is 20.2 °C.

The maximum temperature recorded is 56.3 °C.

(i) Calculate the heat energy change, in joules, for the reaction.

[mass of 1.00 cm^3 of solution = 1.00 g]

[c for the solution = 4.2 J/g/°C]

(2)

$Q = mc\Delta T$

$= 100(4.2)(56.3 - 20.2)$

$= 15162\ J$

heat energy change = 15162 J

(ii) Explain why it is better to use a polystyrene cup rather than a glass beaker in this experiment.

(2)

Polystyrene is an insulator so it will reduce heat loss to the surroundings, meaning the temperature rise will be closer to the true value.

(c) The reaction between zinc and copper(II) sulfate solution is also exothermic.

(i) A mass of 0.500 g of zinc is reacted with an excess of copper(II) sulfate solution.

The heat energy change is 1.67 kJ.

Calculate the molar enthalpy change, ΔH, in kJ/mol.

Include a sign in your answer.

Give your answer to three significant figures.

(3)

$n(Zn) = \frac{mass}{Mr} = \frac{0.5}{65} = \frac{1}{130}$ mol

$\Delta H = \frac{Q}{n} = \frac{1.67}{\left(\frac{1}{130}\right)} = 217.1$ kJ mol^{-1}

$\Delta H =$ -217 kJ/mol (3 sig fig)

(ii) The ionic equation for the reaction between zinc and copper(II) sulfate is

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

Explain why this is a redox reaction.

(3)

Zinc loses electrons so is oxidised. Cu^{2+} gains electrons so is reduced. As both oxidation and reduction occur, the reaction is redox.

(Total for Question 6 = 12 marks)

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7 A student investigates the reaction between sodium hydroxide solution and hydrochloric acid.

He uses this method.

Step 1 add 50 cm^3 of dilute hydrochloric acid to a conical flask

Step 2 add a 5 cm^3 portion of sodium hydroxide solution to the conical flask

Step 3 test the pH of the mixture using both universal indicator paper and a pH meter

The student repeats step 2 and step 3 until a total of 50 cm^3 of sodium hydroxide solution has been added.

(a) (i) State the piece of apparatus that should be used to measure 50 cm^3 of hydrochloric acid.

(1)

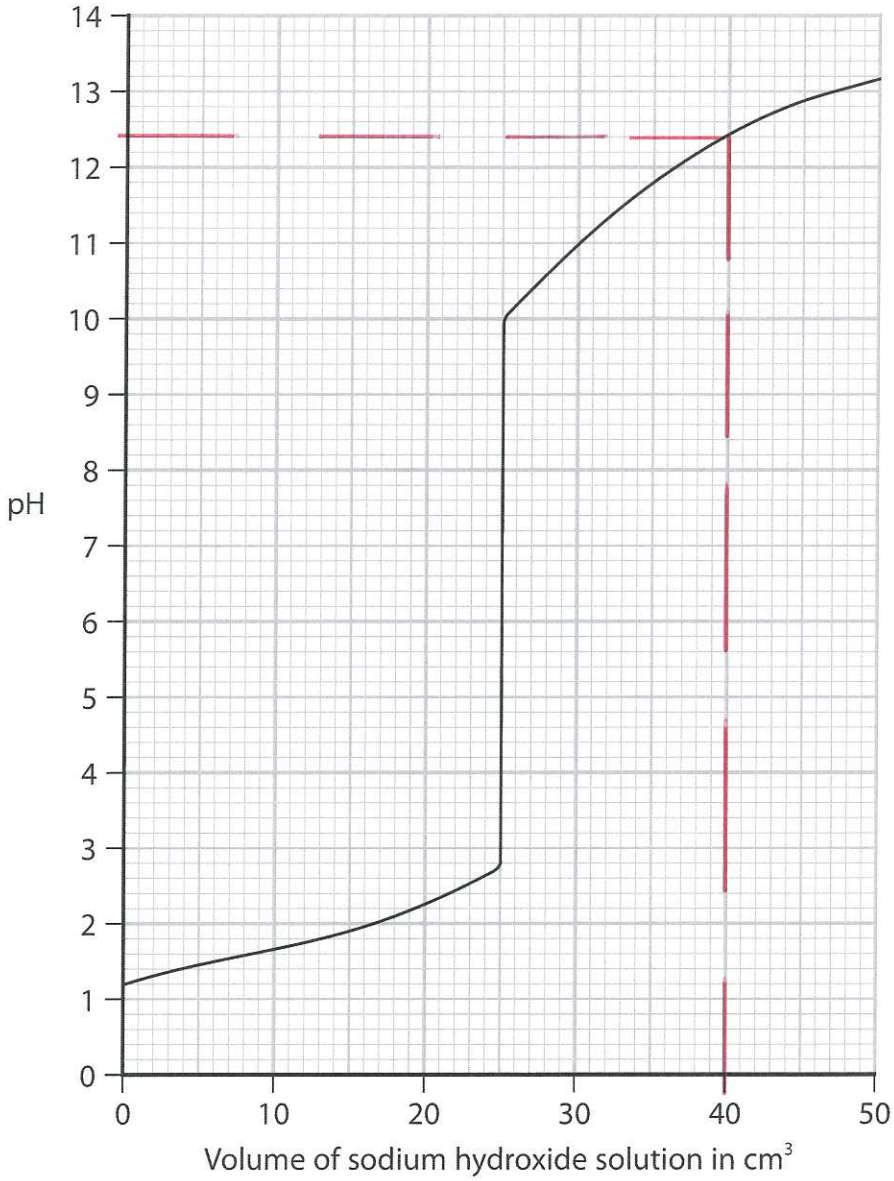
Volumetric pipette

(ii) Name the type of reaction that occurs between hydrochloric acid and sodium hydroxide.

(1)

Neutralisation.

(b) Graph 1 shows how the pH of the mixture changes as the sodium hydroxide solution is added.



Graph 1

(i) Determine the pH after 40 cm^3 of sodium hydroxide solution has been added.

(1)

12.4

(ii) Suggest the colour of the universal indicator paper when these volumes of sodium hydroxide solution have been added.

(2)

15 cm^3 Red / orange

30 cm^3 Blue / Purple

(iii) Give the formula of the ion that causes sodium hydroxide to be alkaline.

(1)

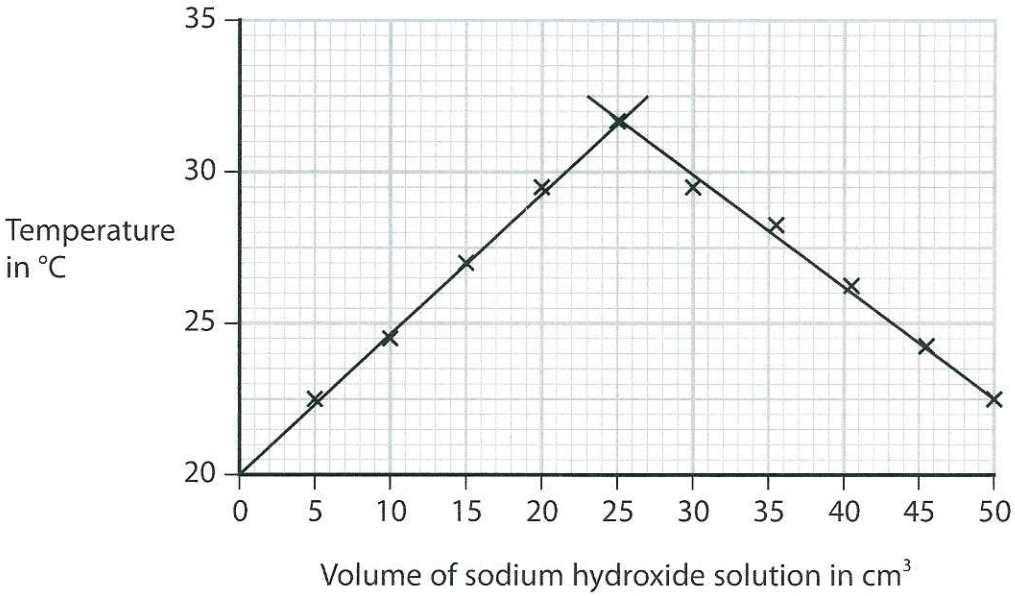
OH^-

(c) Another student investigates how the temperature changes when the sodium hydroxide solution is added to the hydrochloric acid.

The hydrochloric acid and the sodium hydroxide solution are at the same temperature at the start of the investigation.

The student records the temperature of the mixture after adding each 5 cm^3 portion of sodium hydroxide solution.

Graph 2 shows her results.



Graph 2

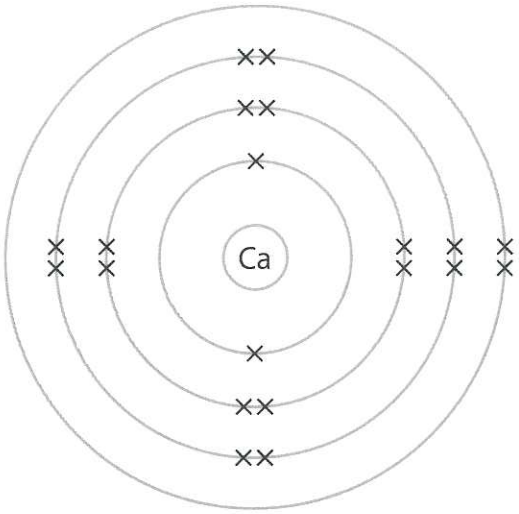
Explain the shape of graph 2.

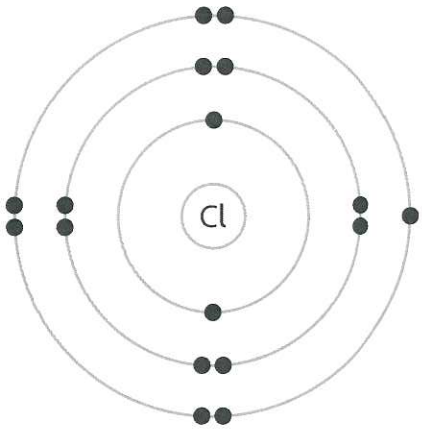
(3)

As the reaction is exothermic, the temperature initially rises. After 25cm^3 of Sodium hydroxide Solution has been added, the reaction is complete. Hence, further adding Sodium hydroxide causes the mixture to cool down.

(Total for Question 7 = 9 marks)

8 (a) The diagram shows the arrangement of electrons in an atom of calcium and in an atom of chlorine.





Describe, in terms of electrons, what happens when calcium reacts with chlorine to form the ionic compound calcium chloride, $CaCl_2$

(3)

The Calcium atom loses two outer electrons whilst each of the two Chlorine atoms gains an electron.

(b) Describe tests to show that an aqueous solution of calcium chloride contains calcium ions and chloride ions.

(4)

calcium ions Conduct a flame test. An orange-red flame colour is observed.

chloride ions Add Silver nitrate Solution. A white precipitate forms.

(c) Solid calcium chloride does not conduct electricity. Aqueous solutions of calcium chloride do conduct electricity.

A student uses this method to investigate how the conductivity of a solution changes when calcium chloride is dissolved in pure water.

Step 1 add 100 cm^3 of pure water to a beaker

Step 2 add one spatula of solid calcium chloride to the beaker

Step 3 stir the solution

Step 4 measure the conductivity of the solution

Step 5 repeat until nine spatulas of solid calcium chloride have been added

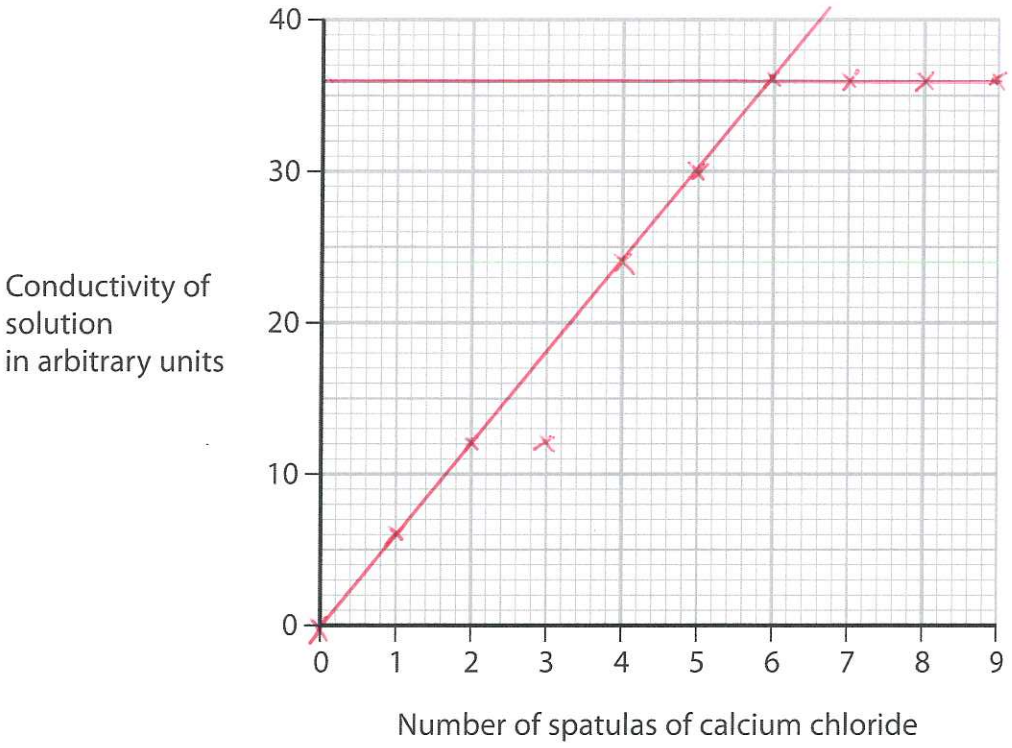
The table shows the student's results.

Number of spatulas of calcium chloride	Conductivity of solution in arbitrary units
0	0
1	6
2	12
3	12
4	24
5	30
6	36
7	36
8	36
9	36

(i) Plot the results on the grid and draw two straight lines of best fit.

Ignore the anomalous result.

(3)



(ii) State the trend shown on the graph for the first six spatulas of calcium chloride.

(1)

The Conductivity is directly proportional to the number of Spatulas of Calcium Chloride added.

(iii) Suggest an error the student could have made to cause the anomalous result.

(1)

The Student took the reading before adding the $CaCl_2$.

OR The Student forgot to Stir the mixture properly.

(d) Describe another way to make solid calcium chloride conduct electricity.

(2)

Heat the Calcium Chloride until it melts.

(Total for Question 8 = 14 marks)

9 This question is about alkenes and polymers.

(a) (i) Ethene (C_2H_4) can be represented by different types of formula.

Complete the table by giving the missing information.

(2)

Molecular formula	C_2H_4
Empirical formula	CH_2
General formula	C_nH_{2n}

(ii) Ethene is a member of the homologous series of alkenes.

All members of the same homologous series have the same general formula.

Give two other characteristics of a homologous series.

(2)

1 Each Successive Member differs by CH_2.

Each member has the same functional group.

2 Each member has Similar Chemical properties.

There is a trend in physical properties between Successive members.

(b) Ethene is used to make poly(ethene).

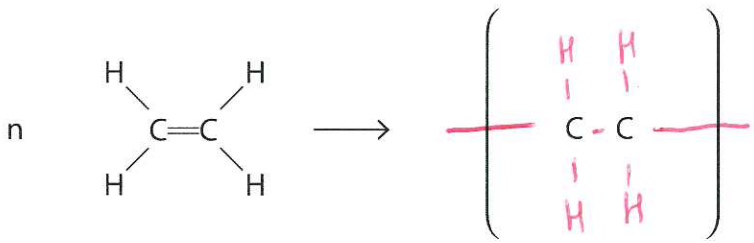
(i) State the type of polymerisation used to form poly(ethene).

(1)

Addition.

(ii) Complete the equation for the polymerisation of ethene.

(2)



(iii) Poly(ethene) is used to make plastic bags.

Corn starch from plants can also be used to make polymers for plastic bags.

The table gives some information about poly(ethene) and polymers made from corn starch.

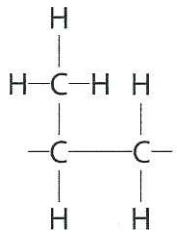
	Poly(ethene)	Polymers from corn starch
Cost per tonne	£1500	£3700
Relative strength	100	50
Time to decompose	estimated 450 years	3–6 months

Use the information in the table and your knowledge to discuss the advantages and disadvantages of using poly(ethene) to make plastic bags.

(5)

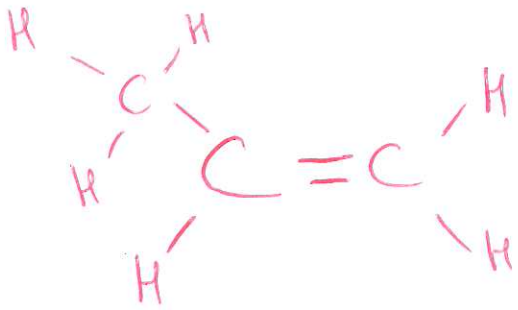
Poly(ethene) has a lower cost per tonne than corn starch.
Poly(ethene) is stronger than polymers from corn starch.
Poly(ethene) frees up land to grow food crops.
Poly(ethene) comes from cracking products of crude oil.
Poly(ethene) is non-renewable.
Poly(ethene) is inert.
Poly(ethene) is non-biodegradable.
Poly(ethene) takes longer to decompose.
Disposal of poly(ethene) is therefore a problem in landfill.
Poly(ethene) causes litter problems.
Burning poly(ethene) can produce toxic or greenhouse gases.

(c) The diagram shows the repeat unit of another polymer.



Draw the displayed formula of the monomer used to make this polymer.

(1)

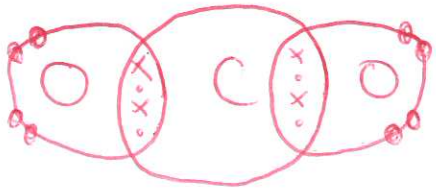


(Total for Question 9 = 13 marks)

10 This question is about carbon and its compounds.

(a) (i) Draw a dot-and-cross diagram to show the outer shell electrons in a molecule of carbon dioxide, CO_2

(2)



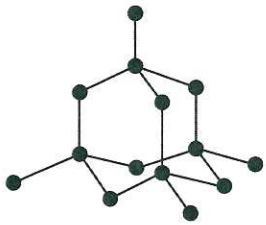
(ii) The atoms in carbon dioxide are held together by covalent bonds.

Describe the forces of attraction in a covalent bond.

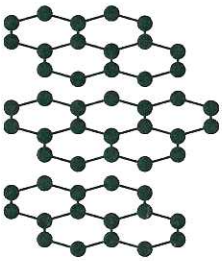
(2)

Shared pairs of electrons are attracted to two bonded nuclei.

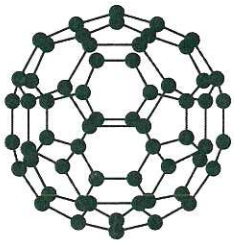
(b) The diagram shows three different structures of carbon.



diamond



graphite



C_{60} fullerene

(i) Explain why graphite conducts electricity.

(2)

Graphite has delocalised electrons which can move.

(ii) Explain why diamond has a much higher melting point than C_{60} fullerene.

Refer to structure and bonding in your answer.

(5)

Diamond has a giant Covalent Structure which requires many strong Covalent bonds to be broken on melting.

C_{60} has a Simple molecular Structure meaning that on melting the weak intermolecular forces between the C_{60} molecules are overcome.

More energy is needed to break the Covalent bonds on melting diamond than is needed to overcome the weak intermolecular forces between C_{60} molecules. Hence, diamond has a much higher melting point than C_{60} fullerene.

(Total for Question 10 = 11 marks)

11 This question is about the reduction of metal oxides.

(a) Solid oxides of copper can be reduced by reacting them with methane gas.

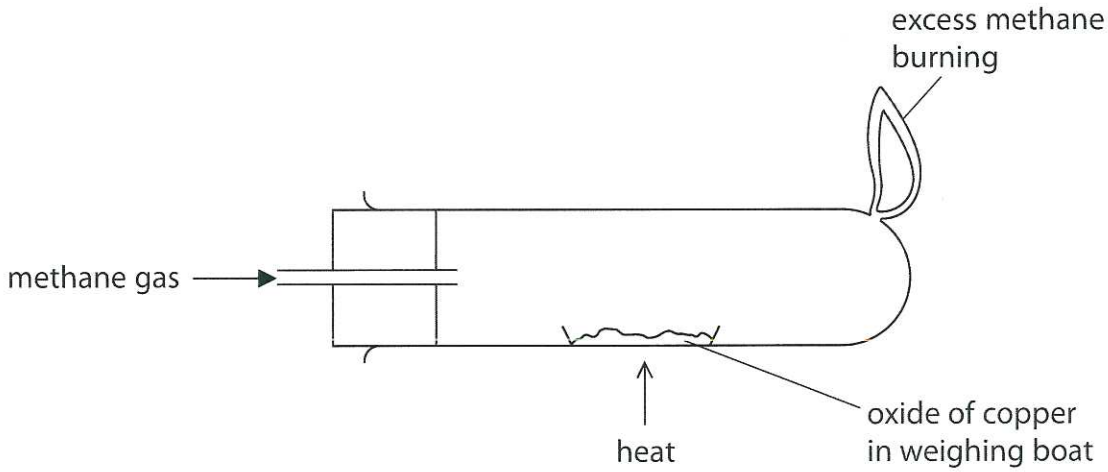
Complete the equation for the reaction between copper(II) oxide and methane.

Include state symbols.

(2)

4 CuO(s) + CH_4(g) → 4 Cu(s) + CO_2(g) + 2 H_2O(g)

(b) A teacher uses this apparatus to demonstrate the reaction between a different oxide of copper and methane.



(i) The teacher heats the oxide of copper until the reaction is complete.

The table shows the teacher's results.

	Mass in g
empty weighing boat	15.05
weighing boat + oxide of copper	18.63
weighing boat + copper	18.23

Use the teacher's results to show that the empirical formula of this oxide of copper is Cu_2O

(4)

Cu O

mass / Mr: 18.23 − 15.05 / 63.5 : 18.63 − 18.23 / 16

= 0.050 / 0.025 : 0.025 / 0.025

Smallest

= 2 : 1

∴ Empirical formula = Cu_2O

(ii) The teacher wears safety glasses and a lab coat during the demonstration.

Give one other safety precaution that she should take.

(1)

- Use a Safety Screen
- Position the Class Some distance from the apparatus.
- Do the experiment in a fume Cupboard.
- Set fire to the excess methane gas Straight away.

(c) Iron forms when iron(III) oxide is heated with carbon.

The equation for the reaction is

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

(i) State how the equation shows that iron(III) oxide is reduced.

(1)

Iron (III) oxide loses oxygen.

(ii) State why carbon monoxide should not be released into the atmosphere.

(1)

It reduces the blood's capacity to carry oxygen.

(iii) Calculate the maximum mass, in tonnes, of iron that can be produced when 30.0 tonnes of iron(III) oxide are reacted with an excess of carbon.

[1 tonne = 1.0×10^6 g]

(4)

$n(Fe_2O_3) = \frac{mass}{Mr} = \frac{30 \times 10^6}{56(2)+3(16)} = 187500$ mol

$n(Fe) = 2 \times 187500 = 375000$ mol

$m(Fe) = 56 \times 375000 = 21 \times 10^6$ g

$= 21$ tonnes

mass = 21 tonnes

(iv) A mixture of 25 000 mol of iron(III) oxide and 840 000 g of carbon is heated.

Use this equation to show that the iron(III) oxide is in excess.

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

(2)

$n(C) = \frac{840\,000}{12} = 70\,000$ mol

$\therefore n(Fe_2O_3)_{required} = \frac{70\,000}{3} = 23333.3$ mol $< 25\,000$ mol

$\therefore$ Iron (III) oxide is in excess.

(Total for Question 11 = 15 marks)

TOTAL FOR PAPER = 110 MARKS

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