

The Periodic Table of the Elements

1	2	3	4	5	6	7	0																																																																																																																																																																																																																																		
7 Li lithium 3	9 Be beryllium 4	11 Na sodium 11	12 C carbon 6	13 Al aluminium 13	14 N nitrogen 7	15 P phosphorus 15	16 O oxygen 8	17 F fluorine 9	18 Ne neon 10																																																																																																																																																																																																																																
19 K potassium 19	20 Ca calcium 20	23 Sc scandium 21	24 Ti titanium 22	25 V vanadium 23	26 Cr chromium 24	27 Mn manganese 25	28 Fe iron 26	29 Co cobalt 27	30 Ni nickel 28	31 Cu copper 29	32 Zn zinc 30	33 Ga gallium 31	34 Ge germanium 32	35 As arsenic 33	36 Se selenium 34	37 Br bromine 35	38 Sr strontium 38	39 Y yttrium 39	40 Zr zirconium 40	41 Nb niobium 41	42 Mo molybdenum 42	43 Tc technetium 43	44 Ru ruthenium 44	45 Rh rhodium 45	46 Pd palladium 46	47 Ag silver 47	48 Cd cadmium 48	49 In indium 49	50 Sn tin 50	51 Sb antimony 51	52 Te tellurium 52	53 I iodine 53	54 Xe xenon 54																																																																																																																																																																																																								
55 Cs caesium 55	56 Ba barium 56	57 La* lanthanum 57	58 Hf hafnium 72	59 Ta tantalum 73	60 W tungsten 74	61 Re rhenium 75	62 Os osmium 76	63 Ir iridium 77	64 Pt platinum 78	65 Au gold 79	66 Hg mercury 80	67 Tl thallium 81	68 Pb lead 82	69 Bi bismuth 83	70 Po polonium 84	71 At astatine 85	72 Rn radon 86	73 Fr francium 87	74 Ra radium 88	75 Ac* actinium 89	76 Rf rutherfordium 104	77 Db dubnium 105	78 Sg seaborgium 106	79 Bh bohrium 107	80 Mt meitnerium 109	81 Ds darmstadtium 110	82 Rg roentgenium 111	83 U uranium 92	84 Np neptunium 93	85 Pu plutonium 94	86 Am americium 95	87 Cm curium 96	88 Bk berkelium 97	89 Cf californium 98	90 Es einsteinium 99	91 Fm fermium 100	92 Mendelevium 101	93 Nobelium 102	94 Lr lawrencium 103																																																																																																																																																																																																		
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Elements with atomic numbers 112–116 have been reported but not fully authenticated																		[209]																		[210]																		[272]																		[271]																		[268]																		[277]																		[264]																		[266]																		[262]																		[261]																		[227]																		[226]																	

1
H
hydrogen
1

relative atomic mass
atomic symbol
name
atomic (proton) number

Key

* 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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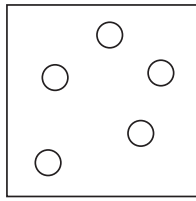
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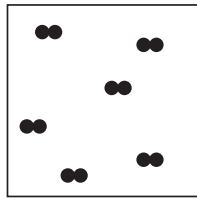


Answer ALL questions.

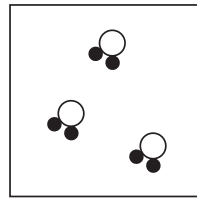
1 (a) The diagram shows the particles in four substances, A, B, C and D.



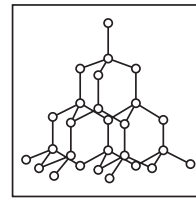
A



B



C



D

(i) Which substance contains single atoms of one element?

(1)

A

B

C

D

(ii) Which substance is a compound?

(1)

A

B

C

D

(iii) Which substance could have the formula H_2 ?

(1)

A

B

C

D

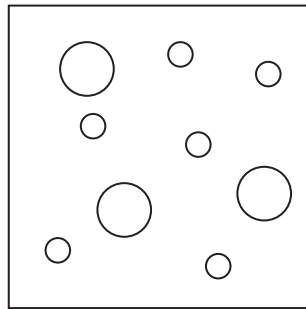
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(b) The diagram shows the particles in substance E.



E

Give two reasons why substance E is a mixture.

(2)

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2

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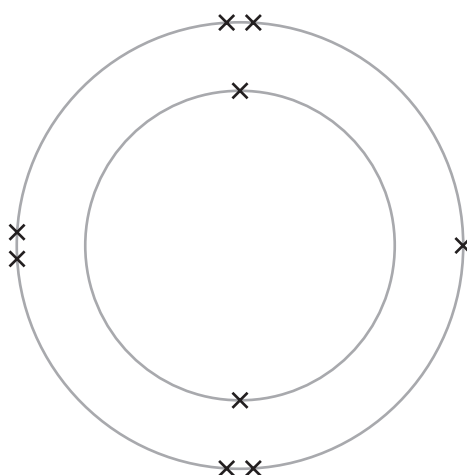
(Total for Question 1 = 5 marks)



2 This question is about Group 7 elements and their reactions.

(a) Fluorine has the smallest atoms in Group 7.

The diagram shows the electronic configuration of a fluorine atom.



(i) State why fluorine has the smallest atoms in Group 7.

(1)

(ii) Which row gives the correct number of occupied electron shells and the correct number of outer shell electrons in an atom of iodine?

Use the Periodic Table on page 2 to help you.

(1)

	Number of occupied electron shells	Number of outer shell electrons
<input type="checkbox"/> A	4	5
<input type="checkbox"/> B	5	6
<input type="checkbox"/> C	5	7
<input type="checkbox"/> D	7	5



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- (b) (i) The table gives descriptions of the reactions of some Group 7 elements with iron wool.
Complete the table by giving a description of the reaction of fluorine with iron wool. (2)

Element	Description of reaction with iron wool
fluorine	
chlorine	<ul style="list-style-type: none">• does not need heating• reacts quickly
bromine	<ul style="list-style-type: none">• needs heating• reacts slowly
iodine	<ul style="list-style-type: none">• needs heating• reacts very slowly

- (ii) State the relationship between the reactivity of the Group 7 elements and the size of their atoms. (2)

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(Total for Question 2 = 6 marks)



3 This question is about the rusting of iron.

(a) Water is needed for iron to rust.

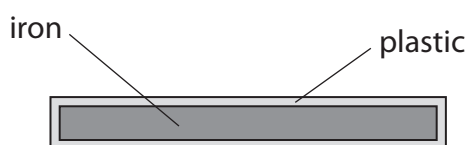
(i) Name one other substance needed for iron to rust.

(1)

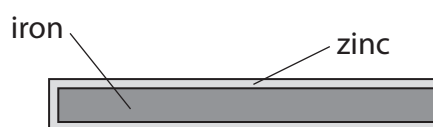
(ii) Give the chemical name for rust.

(1)

(b) The diagram shows two methods used to prevent iron from rusting.



Method A



Method B

Method A will only work if the plastic coating is not damaged.

Method B will work even when the zinc coating is damaged.

(i) Explain how method A prevents iron from rusting.

(2)

(ii) Give the name of method B.

(1)



(iii) Explain how method B prevents iron from rusting even when the zinc coating is damaged.

(2)

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(Total for Question 3 = 7 marks)



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4 (a) The table shows the number of protons, neutrons and electrons in species F, G and H.

	Species F	Species G	Species H
number of protons	7	7	7
number of neutrons	7	8	7
number of electrons	7	7	10

(i) Give the mass number of F.

(1)

(ii) Give the electronic configuration of G.

(1)

(iii) Explain why F and G are isotopes of the same element.

Refer to subatomic particles in your answer.

(2)

(iv) Explain why H is a negative ion.

Refer to subatomic particles and their charges in your answer.

(2)



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(b) A sample of carbon contains atoms of mass number 12 and 13

The table shows the percentages of these atoms in the sample.

Mass number	Percentage (%)
12	98.930
13	1.070

Calculate the relative atomic mass (A_r) of this sample of carbon.

Give your answer to two decimal places.

(2)

relative atomic mass =

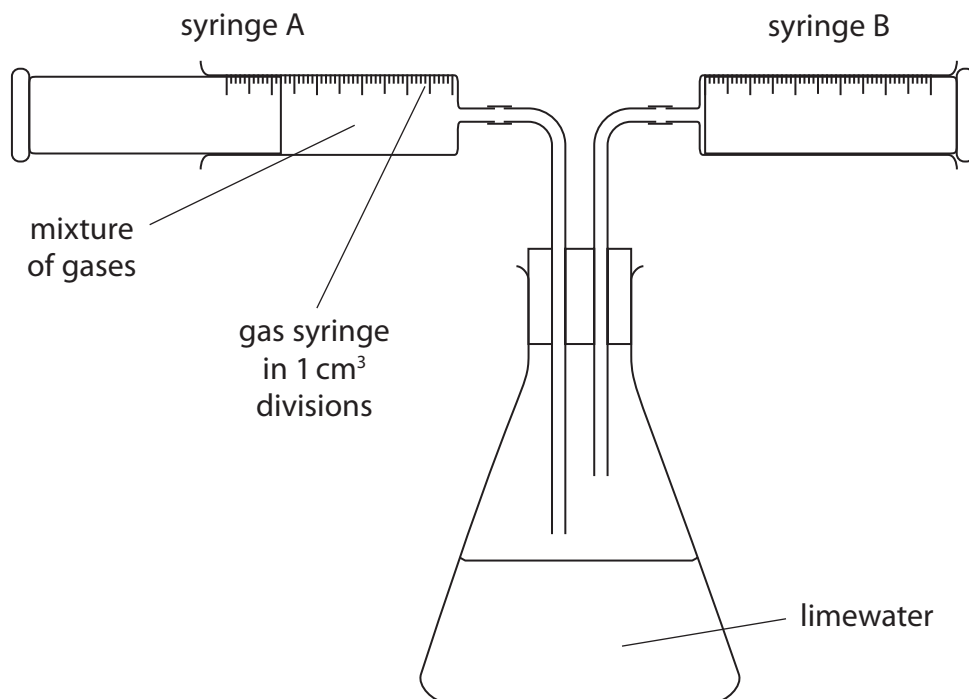
(Total for Question 4 = 8 marks)



5 Two experiments are done to determine the percentage composition by volume of a mixture of three gases, carbon dioxide, oxygen and argon.

(a) In experiment 1, a student bubbles the mixture of gases through limewater. Carbon dioxide reacts with limewater.

The diagram shows the apparatus the student uses.



The student pushes the mixture of gases out of syringe A, but no gas bubbles appear in the limewater.

Give one change the student needs to make to the apparatus for gas bubbles to appear in the limewater.

(1)

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(b) When the apparatus in experiment 1 is set up correctly, the mixture of gases is bubbled gently through the limewater so that all the carbon dioxide is removed.

The volume of the mixture of gases in syringe A at the start is 76 cm^3 .

The volume of the mixture of gases in syringe B at the end is 66 cm^3 .

(i) Calculate the percentage by volume of carbon dioxide in the mixture of gases in syringe A.

(2)

percentage of carbon dioxide =%

(ii) Give the change in the appearance of the limewater.

(1)

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(iii) Explain why the gas syringes in experiment 1 cannot be used to find the percentage of carbon dioxide in a typical sample of air.

(2)

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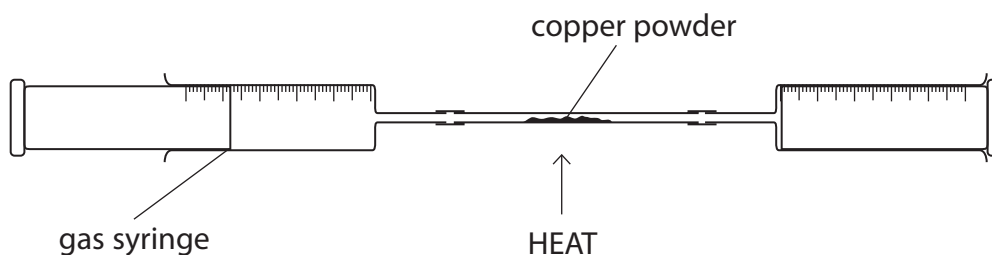
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(c) In experiment 2, a teacher pushes the remaining gases over hot copper powder.

The diagram shows the apparatus the teacher uses.



The copper powder turns black as it reacts with oxygen.

Argon is extremely unreactive, so it does not react with copper.

(i) Name the black substance that forms on the copper powder.

(1)

(ii) Suggest why the teacher uses copper powder instead of the same mass of large pieces of copper.

(1)

(iii) Explain why argon is extremely unreactive.

(2)

(Total for Question 5 = 10 marks)



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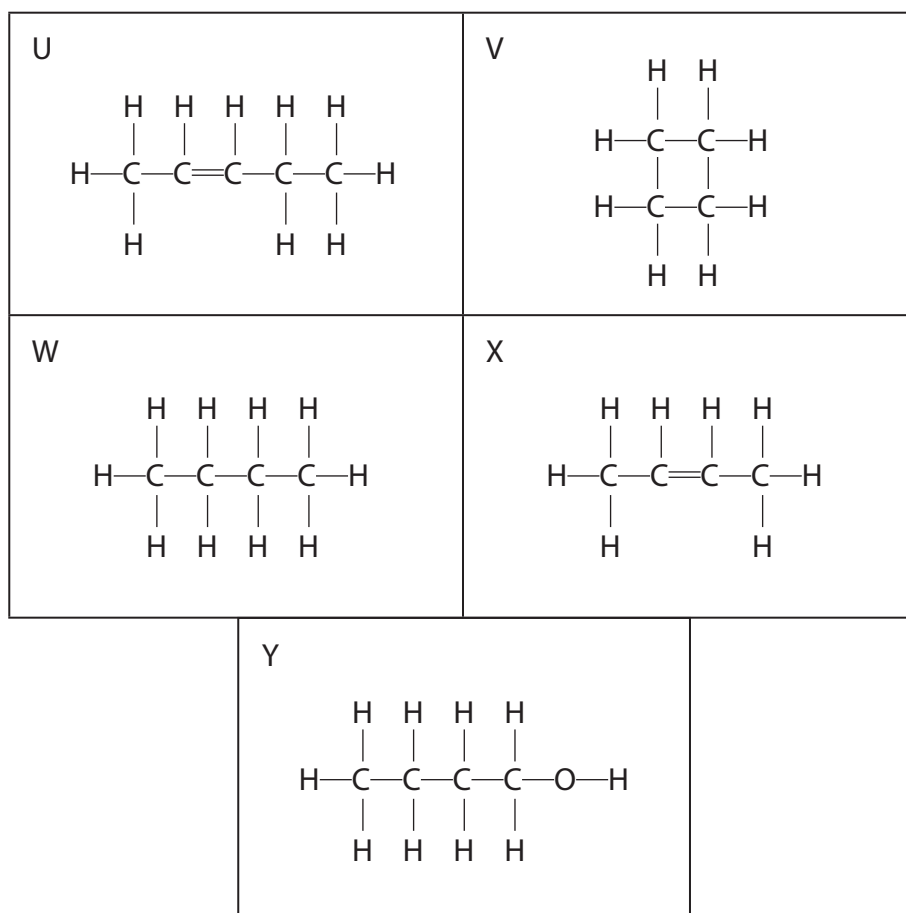
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6 This question is about organic compounds.

(a) The diagram shows the displayed formulae of five compounds, U, V, W, X and Y.



(i) Give the letter of the compound that is not a hydrocarbon.

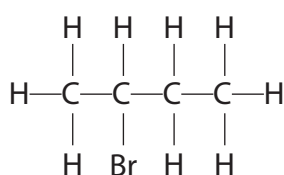
(1)

(ii) Give the letter of the compound that is a saturated hydrocarbon with the empirical formula CH_2

(1)

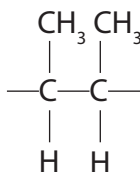
(iii) Give the letter of the compound that reacts with bromine in the presence of ultraviolet radiation to form this structure.

(1)



(iv) Give the letter of the compound that forms an addition polymer with this repeat unit.

(1)



(v) Give the displayed formula of an alkene that is an isomer of compound X.

(1)

(vi) Compounds U and X are members of the same homologous series.

Members of the same homologous series have the same functional group.

Give two other characteristics of compounds in the same homologous series.

(2)

1

.....

2

.....



(b) Compound Z contains 38.7% carbon, 9.7% hydrogen and 51.6% oxygen by mass.

(i) Show by calculation that the empirical formula of compound Z is CH_3O (2)

(ii) The relative formula mass (M_r) of compound Z is 62

Deduce the molecular formula of compound Z. (2)

molecular formula =

(Total for Question 6 = 11 marks)



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7 This question is about nitrogen and some of its compounds.

(a) Nitrogen and oxygen do not react together at room temperature.

At the high temperatures in a car engine, nitrogen and oxygen react to form nitrogen monoxide, NO

(i) Give a chemical equation for this reaction.

(1)

(ii) Give a reason why this reaction only occurs at high temperatures.

(1)

(iii) State why it is important that oxides of nitrogen are not released into the atmosphere.

(1)

(b) Nitrogen monoxide gas can be removed from car exhaust fumes when it reacts with carbon monoxide gas.

(i) The rate of the reaction is increased by passing the gases over a catalyst.

Explain how a catalyst increases the rate of a reaction.

(2)



(ii) Explain how increasing the pressure of gases increases the rate of reaction.

(3)

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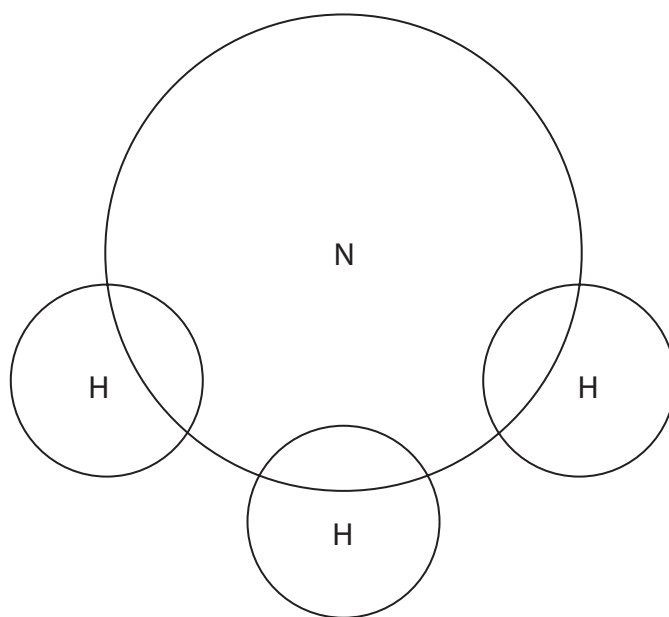
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(c) Ammonia is a simple molecule with the formula NH_3

(i) Complete the diagram to show the outer shell electrons in ammonia.

(2)



(ii) The bonds in ammonia are covalent.

Describe the forces of attraction in a covalent bond.

(2)

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(iii) Explain why ammonia has a low boiling point.

(2)

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(Total for Question 7 = 14 marks)

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(b) A colourless solution contains sodium carbonate and sodium sulfate.

Describe a test using barium chloride to show that the colourless solution contains sulfate ions.

(2)

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(Total for Question 8 = 8 marks)



9 A student investigates the reaction between solid hydrated sodium carbonate and dilute hydrochloric acid.

(a) She uses this method to investigate the temperature change during the reaction.

Step 1 pour 25.0 cm^3 of dilute hydrochloric acid into a polystyrene cup

Step 2 record the temperature of the dilute hydrochloric acid

Step 3 add 0.5 g of sodium carbonate and stir the mixture

Step 4 record the lowest temperature of the mixture

Step 5 add further 0.5 g portions of sodium carbonate, one portion at a time, stir the mixture and record the lowest temperature each time

The table shows the student's results.

Mass of sodium carbonate added in g	Temperature in $^{\circ}\text{C}$
0.0	17.0
0.5	15.6
1.0	14.1
1.5	13.0
2.0	12.9
2.5	12.2
3.0	11.8
3.5	11.5
4.0	11.2
4.5	11.0
5.0	11.0

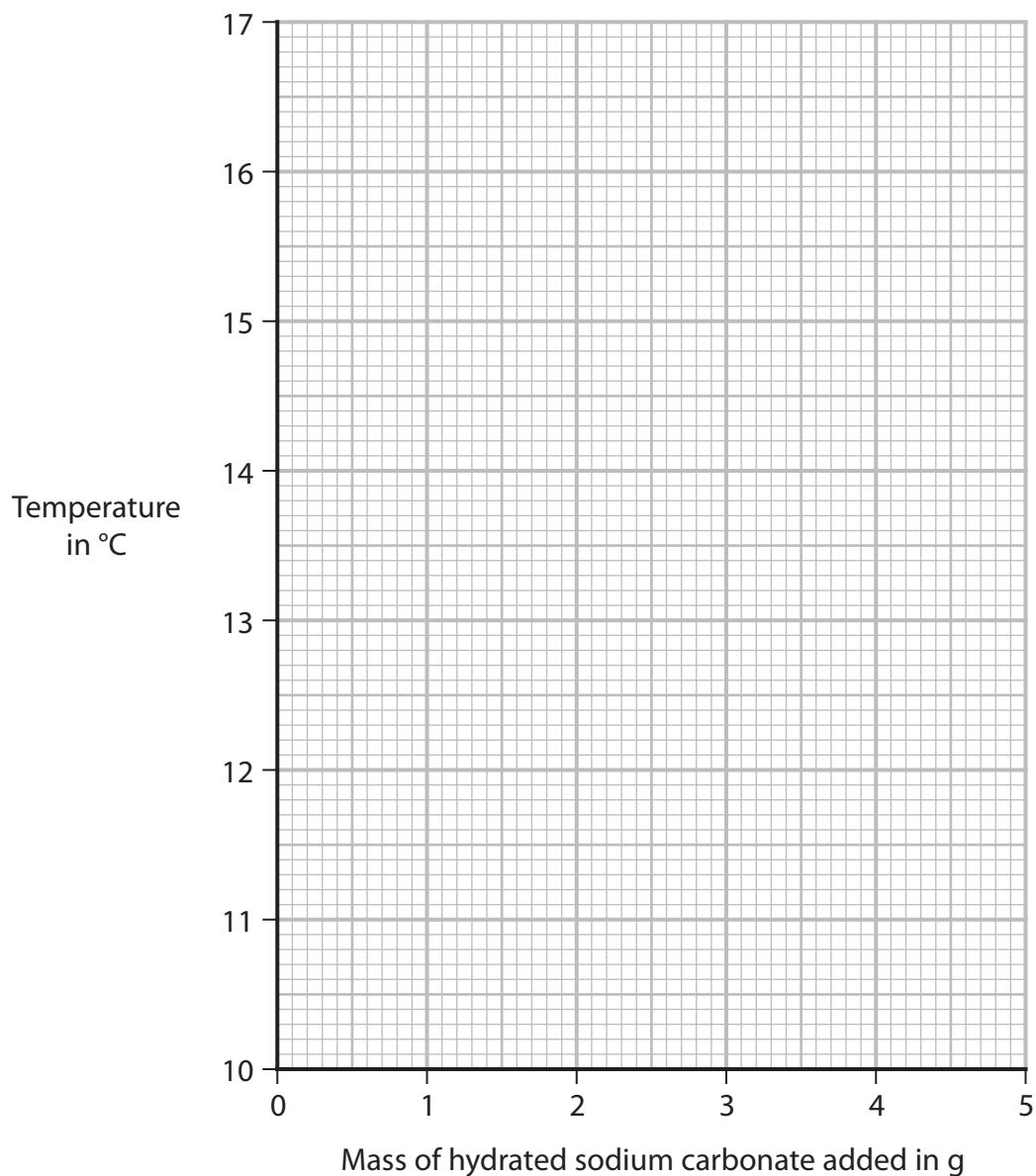


(i) Plot the student's results on the grid.

(2)

(ii) Draw a curve of best fit, ignoring the anomalous result.

(1)



(iii) Explain why it is better to use a polystyrene cup instead of a glass beaker in this experiment.

(2)

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(iv) Suggest a reason for the anomalous result.

(1)

(v) State how the results show that all the dilute hydrochloric acid has reacted.

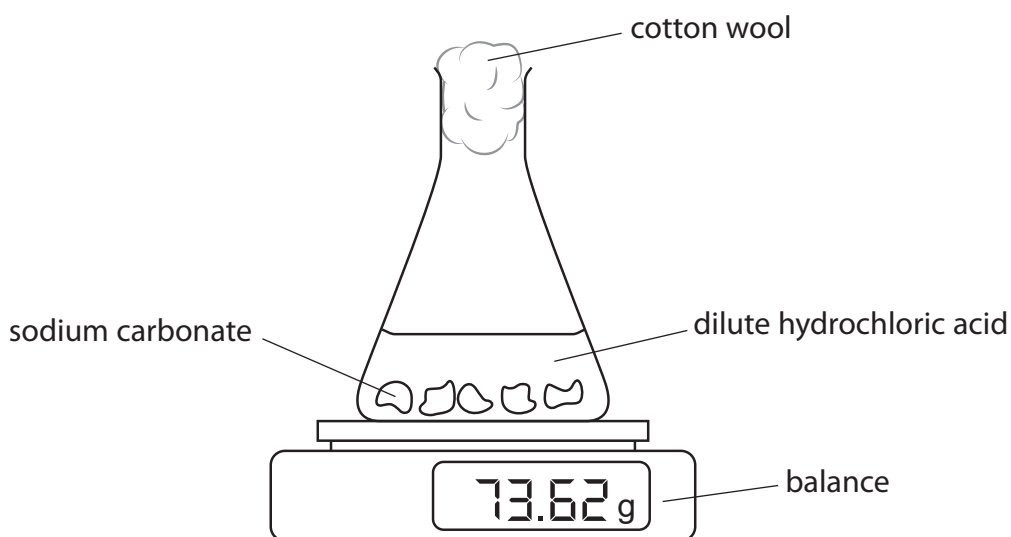
(1)

(vi) Use the results of the experiment to explain the type of reaction that occurs when sodium carbonate is added to dilute hydrochloric acid.

(2)

(b) The student does another experiment using the same reaction.

The diagram shows the student's apparatus.



The mass on the balance decreases as carbon dioxide gas escapes.

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(i) Give a reason for the cotton wool plug in the conical flask.

(1)

(ii) The student adds 2.12 g of sodium carbonate to an excess of dilute hydrochloric acid.

The chemical equation for the reaction is



Calculate the maximum mass, in g, of carbon dioxide formed in the reaction.

(3)

mass = g

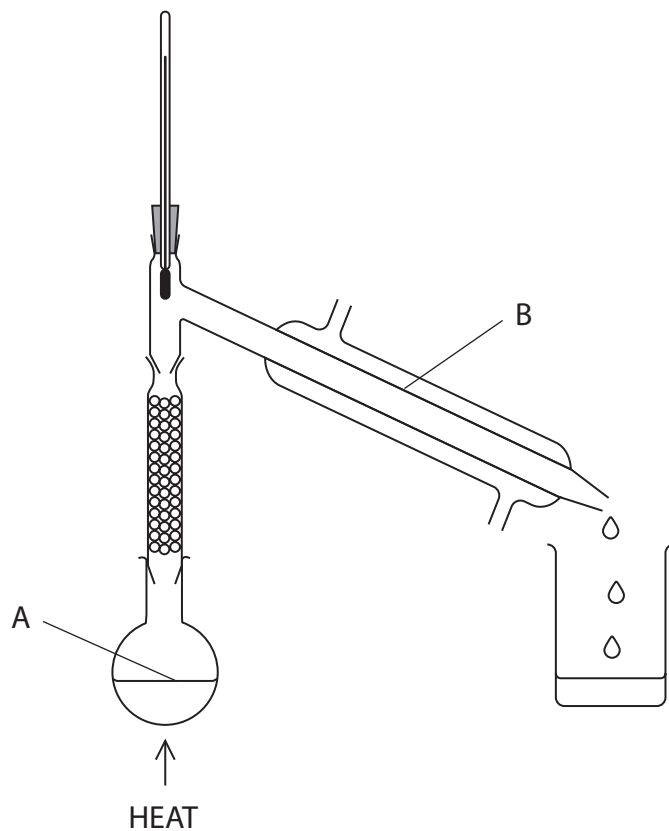
(iii) Suggest why the mass of carbon dioxide produced is less than the calculated maximum mass.

(1)

(Total for Question 9 = 14 marks)



10 A teacher uses this apparatus to separate a mixture of ethanol and water.



(a) (i) Name this method of separation.

(1)

(ii) Name the change of state taking place at A.

(1)

(iii) Name the change of state taking place at B.

(1)

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(b) The mixture contains 15.5 cm^3 of ethanol.

1.0 cm^3 of ethanol has a mass of 0.79 g .

One mole of ethanol contains 6.00×10^{23} molecules.

$[M_r \text{ of ethanol} = 46]$

(i) Calculate the amount, in moles, of ethanol in 15.5 cm^3 of ethanol.

(2)

amount = mol

(ii) Calculate the number of molecules of ethanol in 15.5 cm^3 of ethanol.

(1)

number of molecules =

(c) After five minutes, the teacher collects a sample of colourless liquid in a new beaker.

(i) Describe a chemical test to show that the colourless liquid contains water.

(2)

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(ii) Describe a physical test to show if the colourless liquid is pure water.

(2)

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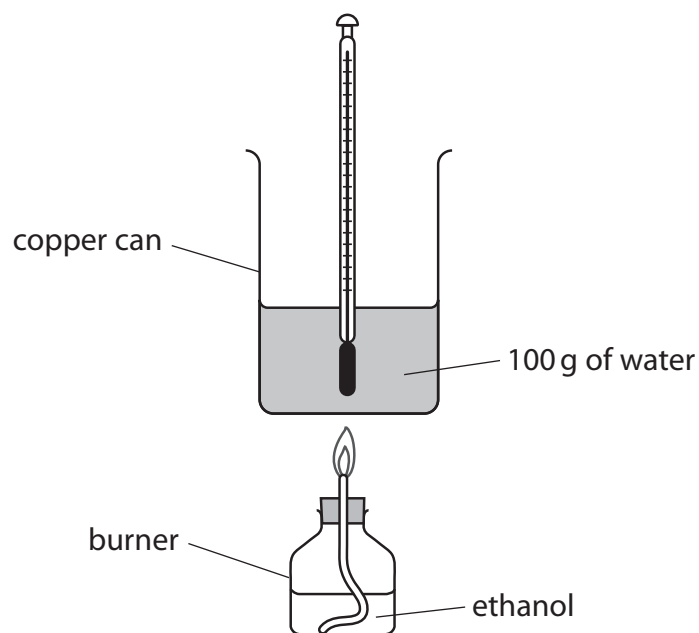
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(d) The teacher uses this apparatus to heat 100 g of water.



He records the temperature of the water before and after heating.

temperature of water before heating = 21.0°C

temperature of water after heating = 70.5°C

(i) Calculate the heat energy change (Q) in joules.

[specific heat capacity of water is $4.2 \text{ J/g}^{\circ}\text{C}$]

(3)

$Q = \dots\dots\dots \text{ J}$



(ii) The student burns 0.0200 mol of ethanol.

Use this information and your value for Q to calculate the molar enthalpy change (ΔH), in kJ/mol, for the combustion of ethanol.

Include a sign in your answer.

(2)

$\Delta H = \dots\dots\dots$ kJ/mol

(Total for Question 10 = 15 marks)



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11 This question is about the reactivity of metals.

- (a) Table 1 shows whether a reaction occurs between a metal and an aqueous solution of a metal sulfate.

Metal	Metal sulfate	Does a reaction occur?
manganese	chromium sulfate	yes
tin	cadmium sulfate	no
chromium	cadmium sulfate	yes

Table 1

- (i) Name the type of reaction that occurs between manganese and chromium sulfate. (1)

- (ii) Use the information in Table 1 to complete the order of reactivity. (1)



(b) Table 2 shows the colours of four metals and the colours of their metal sulfate solutions.

Metal	Colour of metal	Colour of metal sulfate solution
copper	brown	blue
iron	dark grey	green
magnesium	silvery	colourless
zinc	light grey	colourless

Table 2

When a metal is added to a metal sulfate solution there may be a colour change on the surface of the metal and in the solution.

Use the information in Table 2 and your knowledge of the reactivity series to explain any colour changes in these two experiments.

(5)

copper added to magnesium sulfate solution.....

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zinc added to iron sulfate solution.....

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(c) A different experiment can be used to place metals in order of reactivity.

This is the method.

Step 1 add 1 g of a metal to 25 cm³ of dilute sulfuric acid

Step 2 measure the volume of gas produced in one minute

(i) Give two variables that should be controlled in this experiment.

(2)

1

2

(ii) A small piece of calcium is added to some dilute sulfuric acid in a beaker.

One of the products of the reaction, calcium sulfate, is insoluble in water.

Suggest why the reaction stops after a short time, even though the beaker still contains calcium and dilute sulfuric acid.

(1)

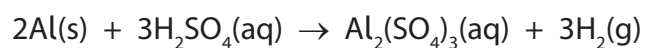
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(d) 1.00 g of aluminium is added to 0.0600 mol of dilute sulfuric acid.

The equation for the reaction is



Show by calculation that the sulfuric acid is in excess.

(2)

(Total for Question 11 = 12 marks)

TOTAL FOR PAPER = 110 MARKS



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