Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3410U20-1

Z22-3410U20-1

FRIDAY, 27 MAY 2022 – MORNING

CHEMISTRY – Unit 2:
Chemical Bonding, Application of Chemical Reactions and Organic Chemistry

FOUNDATION TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**9**	
2.	**7**	
3.	**7**	
4.	**13**	
5.	**10**	
6.	**6**	
7.	**8**	
8.	**6**	
9.	**7**	
10.	**7**	
Total	**80**	

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01

ADDITIONAL MATERIALS

In addition to this examination paper you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

Question **6** is a quality of extended response (QER) question where your writing skills will be assessed.

The Periodic Table is printed on the back cover of this paper and the formulae for some common ions on the inside of the back cover.

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Answer **all** questions.

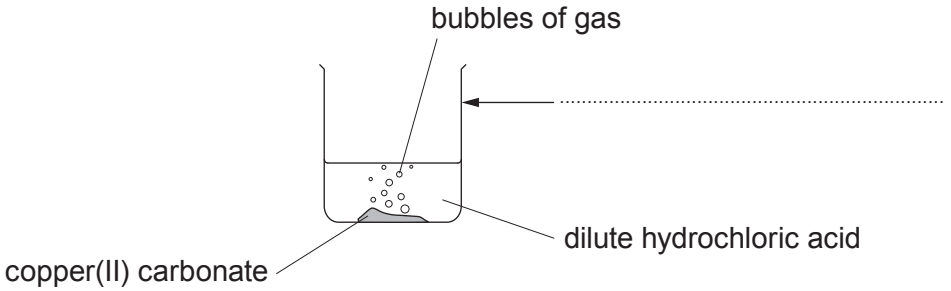
1. Selwyn carried out an experiment to prepare copper(II) chloride crystals.

The diagrams show the stages of the experiment he carried out.

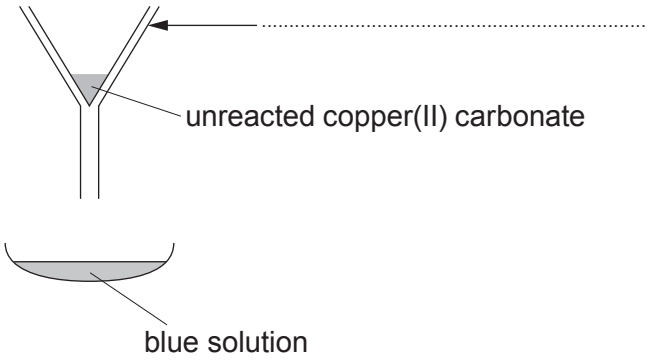
(a) Choose apparatus from the box to label the diagrams. [4]

evaporating basin	**conical flask**	**filter funnel**	**electronic balance**
filter paper	**beaker**	**test tube**	

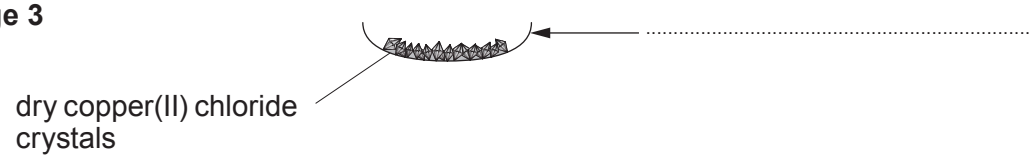
Stage 1



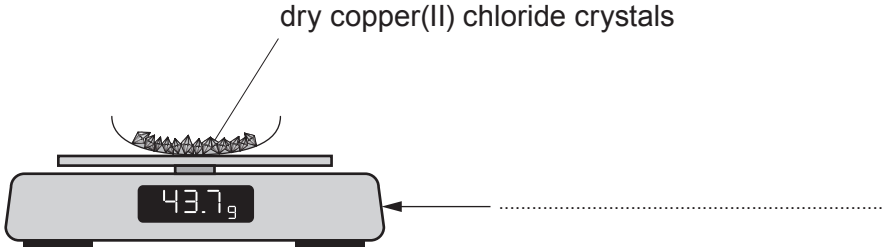
Stage 2



Stage 3



Stage 4



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(b) In **Stage 1** Selwyn added copper(II) carbonate until **all** the dilute hydrochloric acid was used up.

Tick (✓) the box next to the statement which best describes what Selwyn would see when all the acid had been used up. [1]

bubbling increases ☐

bubbling stops ☐

bubbling decreases ☐

(c) The gas formed in **Stage 1** turns limewater milky. Underline the name of this gas. [1]

oxygen **hydrogen** **carbon dioxide** **nitrogen**

(d) Choose words from the box to complete the following sentences. [2]

evaporation	**filtration**	**distillation**	**neutralisation**

The process used to remove the unreacted copper(II) carbonate in **Stage 2** is called

..... .

The process used to remove water in **Stage 3** is called ..... .

(e) The container holding the crystals has a mass of 29.8 g. Using the information given in **Stage 4**, calculate the mass of the crystals formed. [1]

Mass of crystals formed = ... g

9

Turn over.

Examiner only

2. (a) Crude oil is formed from simple marine organisms.

Tick (✓) the box next to the length of time it takes for the organisms to turn into crude oil.

[1]

hundreds of years ☐

thousands of years ☐

millions of years ☐

(b) Crude oil can be separated into simpler mixtures called fractions.

Tick (✓) the box next to the method used to separate crude oil into fractions. [1]

fractional distillation ☐

filtration ☐

cracking ☐

polymerisation ☐

Examiner only

(c) The table shows properties of some fractions that are obtained from crude oil.

Fraction	Size of molecules (chain length)	Viscosity	Ease of ignition	Amount of smoke formed
petrol	$C_5 - C_{10}$	very runny	very easy	no smoke
naphtha	$C_8 - C_{12}$	fairly runny	quite easy	little smoke
kerosene	$C_{10} - C_{16}$	thick	quite hard	quite a lot of smoke
diesel oil	$C_{14} - C_{20}$	very thick	very hard	very smoky

Use only the information from the table to answer the following questions.

(i) Name the fraction which is the easiest to pour. ..... [1]

(ii) Name the fraction which is the hardest to burn. ..... [1]

(iii) Name the fraction with the smallest **range** of chain lengths. [1]

.....

(iv) Name the fraction which burns with the cleanest flame. Give the reason for your choice. [2]

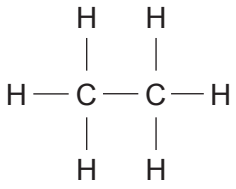
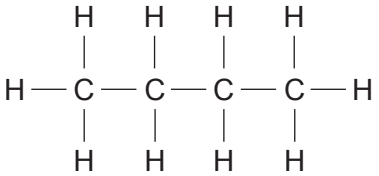
Fraction .....

Reason .....

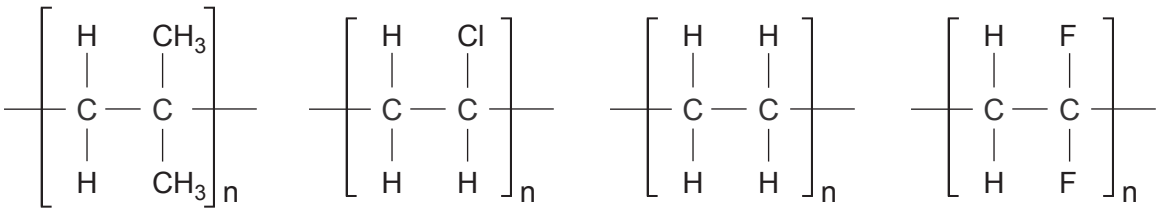
7

Examiner only

3. (a) Complete the table. [2]

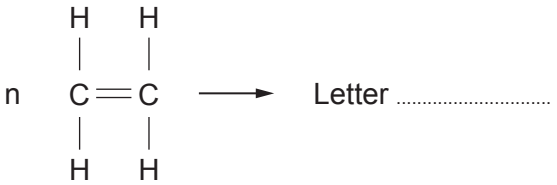
Name	Molecular formula	Structural formula
ethane	C_2H_6	
propane	C_3H_8	
butane	.....	

(b) The box contains four polymers **A**, **B**, **C** and **D**.



A **B** **C** **D**

Give the **letter** of the polymer formed during the polymerisation of ethene. [1]



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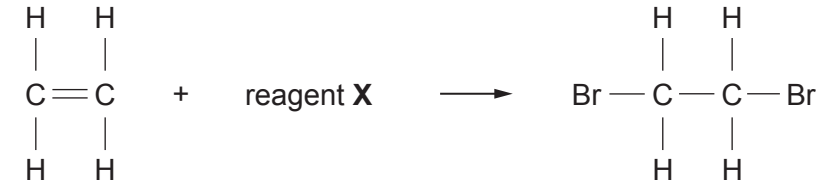
(c) The equation shows the reaction taking place when testing for a C=C bond.



bromine water	**potassium dichromate**	**universal indicator**	**barium chloride**

Choose the name of reagent **X** from the box above.

.....

[1]

(d) The equation shows the fermentation of glucose.

$$C_6H_{12}O_6 \xrightarrow{\text{yeast}} 2C_2H_5OH + 2CO_2$$

(i) Underline the chemical name for C_2H_5OH. [1]

sugar **biofuel** **ethanol** **alcohol**

(ii) Calculate the relative molecular mass, M_r, of C_2H_5OH. [2]

A_r(H) = 1 A_r(O) = 16 A_r(C) = 12

M_r = ...

7

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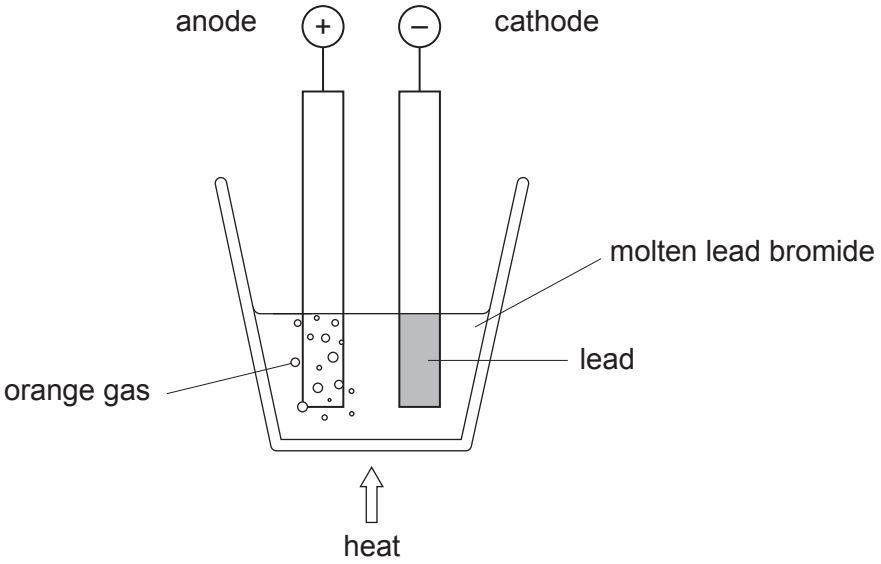
Examiner only

4. (a) The diagram shows the apparatus a teacher used to demonstrate what happens when an electric current is passed through molten lead bromide.



(i) Lead bromide contains the ions Pb^{2+} and Br^-.

Underline the correct formula of lead bromide. [1]

Pb_2Br **PbBr** **$PbBr^2$** **$PbBr_2$**

(ii) Give the state (solid, liquid or gas) of the lead bromide during the process. [1]

.....

(iii) Name the orange gas formed at the anode. ..... [1]

(iv) During the process each lead ion, Pb^{2+}, gains two electrons forming a lead atom at the cathode. [1]

Tick (✓) the box next to the equation for the reaction at the cathode.

$Pb + 2e^- \longrightarrow Pb^{2+}$ ☐

$Pb^{2+} - 2e^- \longrightarrow Pb$ ☐

$Pb^{2+} + 2e^- \longrightarrow Pb$ ☐

$Pb - 2e^- \longrightarrow Pb^{2+}$ ☐

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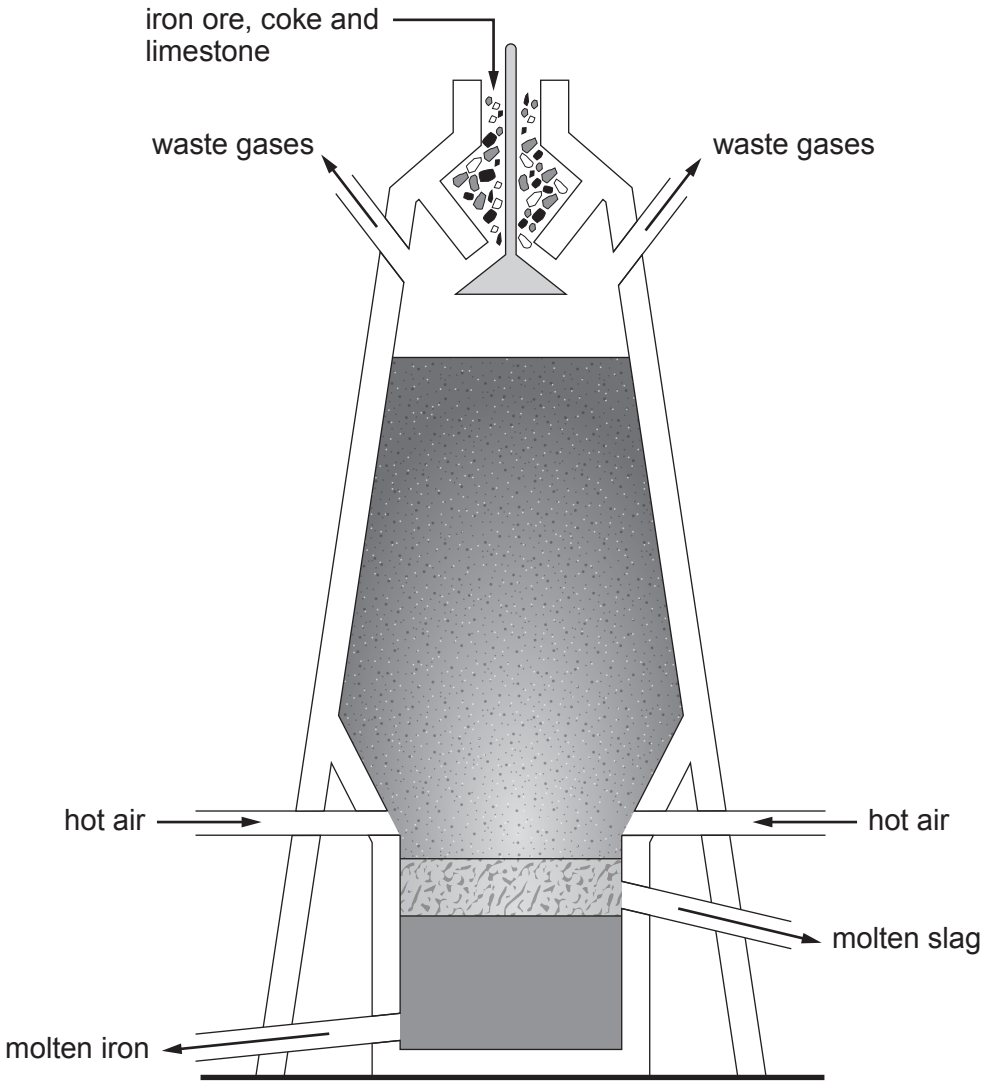
(b) Iron is extracted from its ore in the blast furnace. The diagram shows the materials which enter and leave the furnace.



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(i) Underline the correct word(s) in the brackets to complete each sentence. [3]

The furnace is heated by burning (**coke** / **iron** / **iron ore**).

Hot air provides (**waste gases** / **oxygen** / **slag**) for burning to take place.

Impurities are removed by adding (**steel** / **hot air** / **limestone**) to the furnace.

(ii) The word equation shows the main reaction taking place in the blast furnace.

iron(III) oxide + carbon monoxide ⟶ iron + carbon dioxide

Give the **letter** next to the products which correctly balance the symbol equation for this reaction. [1]

$Fe_2O_3 + 3CO$

A $Fe + 3CO_2$

B $2Fe + 3CO_2$

C $3Fe + CO_2$

Letter .....

Turn over.

Examiner only

(c) Chemists have designed a wide variety of alloys for different uses.

Some alloys contain iron and carbon only, whereas others contain additional metals.

The table shows the composition and properties of some alloys.

Alloy	Composition	Properties
mild steel	iron plus 0.15 – 0.30 % carbon	malleable (easy to bend), ductile (easy to pull into wire) and soft (easy to scratch)
high carbon steel	iron plus 0.70 – 1.50 % carbon	strong, brittle and hard
cast iron	iron plus 2.00 – 5.00 % carbon	very strong, very brittle and very hard

Use only the information in the table above to answer parts (i)–(iii).

(i) Name the alloy that contains the **least** amount of carbon. [1]

.....

(ii) Underline the effect of increasing the percentage (%) of carbon in these alloys. [1]

strength decreases **hardness decreases**

softness increases **brittleness increases**

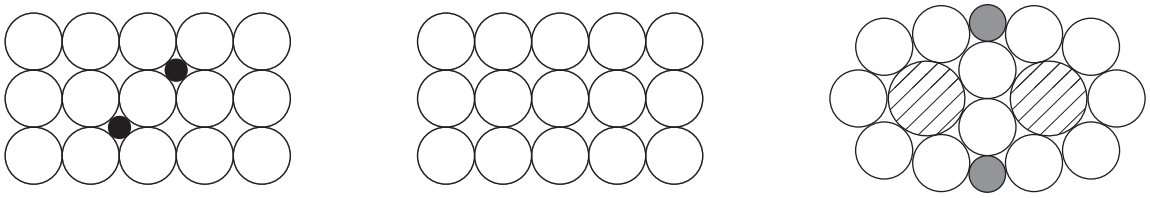
(iii) Give the property of mild steel which makes it useful for making car bodies. [1]

.....

Examiner only

(iv) Diagrams **A**, **B** and **C** are models showing the arrangement of atoms in pure iron and in two alloys, **but not necessarily in that order**.

Choose the **letter** of the model which best represents cast iron. Give the reason for your choice. [2]



A **B** **C**

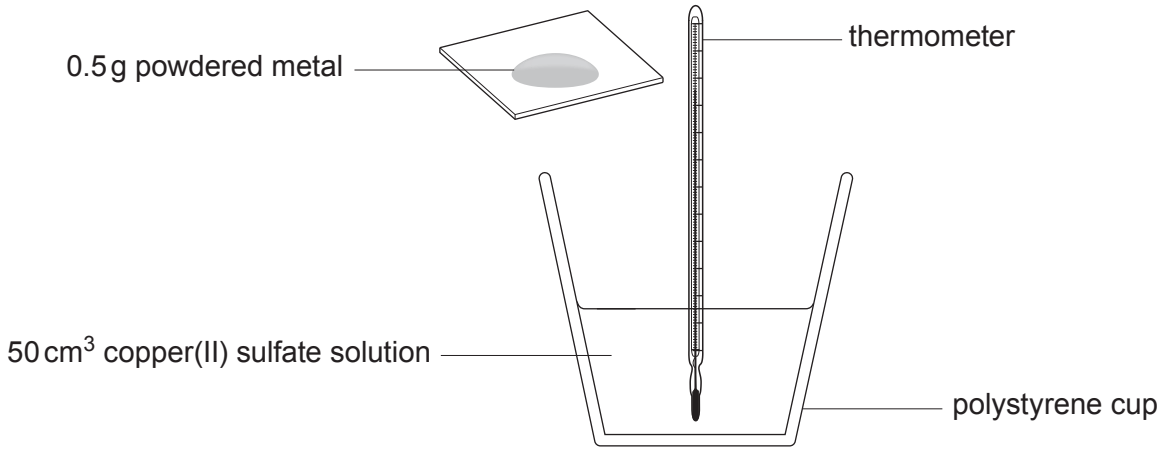
Letter .....

Reason .....

13

5. Joe, Alex and Megan were asked to investigate the temperature rise when four metals were added to excess copper(II) sulfate solution. 0.5 g of each metal was added to separate 50 cm^3 samples of copper(II) sulfate solution.

The temperature rise for each reaction was measured.

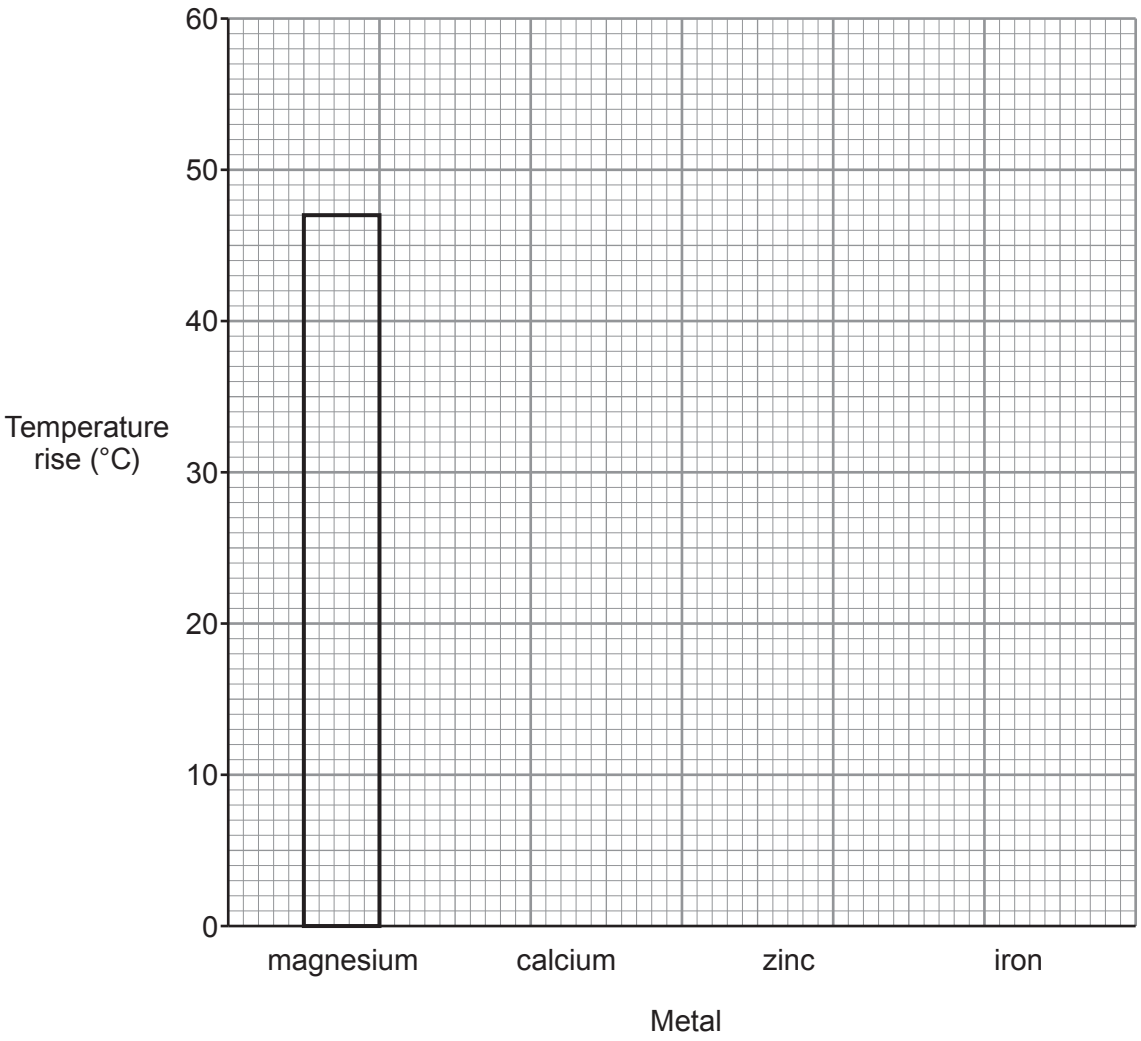


Their results are shown in the table below.

Metal	Temperature rise (°C)
magnesium	47
calcium	54
zinc	38
iron	25

Examiner only

(a) (i) Draw a bar chart on the grid to show the results. One bar has been drawn for you. [2]



(ii) Put the **four** metals in order of reactivity. [1]

Most reactive .....

.....

.....

Least reactive .....

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(iii) The temperature rise for each metal was lower than expected. The students were asked to suggest how the apparatus could be improved so that the temperature rise recorded for each metal was closer to the expected value.

Joe suggested wrapping the polystyrene cup in cotton wool.

Megan suggested putting a lid on the polystyrene cup.

Alex suggested using a cup made from copper.

Choose which student's suggestion would **not** result in the temperature rises being closer to the expected value. Explain your choice. [2]

Student .....

Reason .....

.....

.....

(iv) Complete the equation for the reaction between magnesium and copper(II) sulfate solution. [2]

$Mg + CuSO_4 \longrightarrow$ ..... + ...

Examiner only

(b) The students repeated the experiment using chromium and recorded a temperature rise of 30 °C.

What does the temperature rise of 30 °C tell you about the reactivity of chromium compared to the four metals in part (a)? [1]

.....

.....

(c) The energy given out by the reaction can be calculated using the formula below.

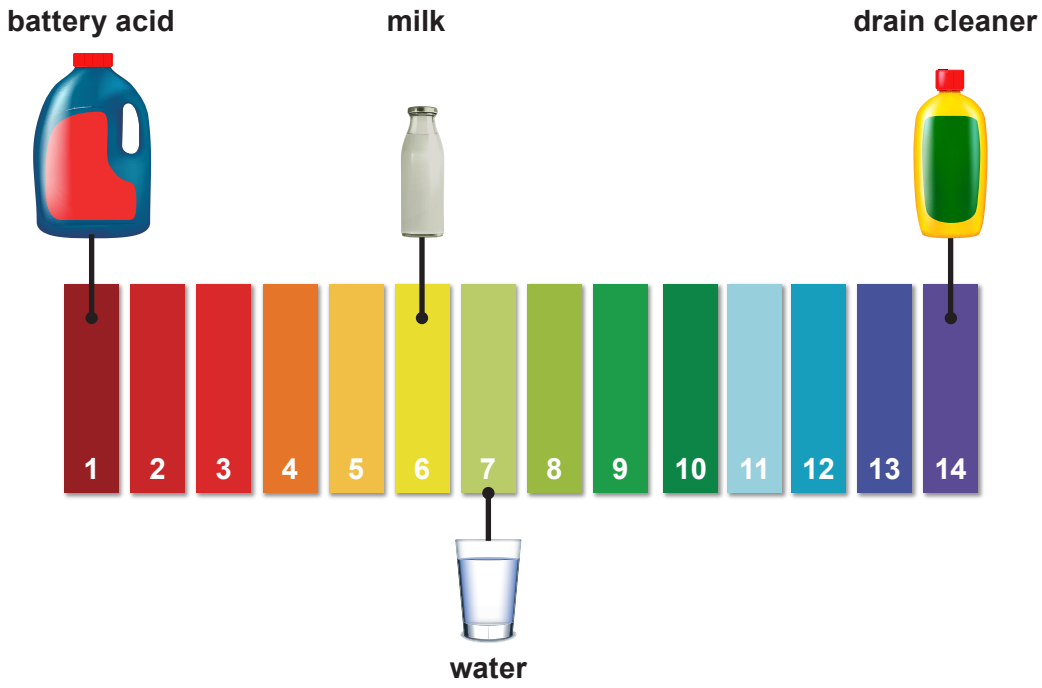
energy given out (J) = volume of solution (cm^3) × 4.2 × temperature rise (°C)

Calculate the energy given out during the displacement reaction between **iron** and copper(II) sulfate solution. [2]

Energy given out = ...J

10

6. The picture below shows the universal indicator pH colour chart and the position of some substances on the pH scale.



Examiner only

Describe what is meant by the pH scale and what it tells us about the substances shown in the picture. [6 QER]

6

7. (a) Skiers and mountaineers use hand warmers in very cold weather conditions. Hand warmers are small packets that produce heat when needed. Some ski clothing is specially designed to hold a hand warmer.

Table **1** describes how three types of hand warmers work.

A Air-activated (disposable)	**B** Battery powered (reusable)	**C** Supersaturated solution (reusable)
The packaging seal is broken allowing air to reach the chemicals causing a chemical reaction to occur. This type of hand warmer can only be used once. 	A metal coil heats up when the device is switched on. The device needs recharging. 	A metal button on the packaging is pressed. This causes crystals to form in the solution. The hand warmer can be reactivated by placing it in boiling water. 

Table 1

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Table **2** shows some information about each type of hand warmer.

Type of hand warmer	Cost (£)	Time to warm up after activation	Temperature after being activated and placed in a freezer (°C)				
			after 15 mins	after 30 mins	after 60 mins	after 90 mins	after 120 mins
A	1	less than 1 min	39	39	38	38	37
B	80	less than 1 min	32	29	28	27	26
C	24	less than 1 min	42	34	27	18	8

Table 2

(i) Tick (✓) the box next to the correct statement. [1]

Gloves need to be worn when using hand warmers ☐

Boiling water is used to recharge battery powered hand warmers ☐

Some chemical reactions give out heat energy ☐

All hand warmers are reusable ☐

(ii) Give **two** reasons why hand warmer **A** is the most popular choice. [2]

Reason 1 .....

.....

Reason 2 .....

.....

(b) An air-activated hand warmer contains several chemicals mixed together. One of these chemicals is iron.

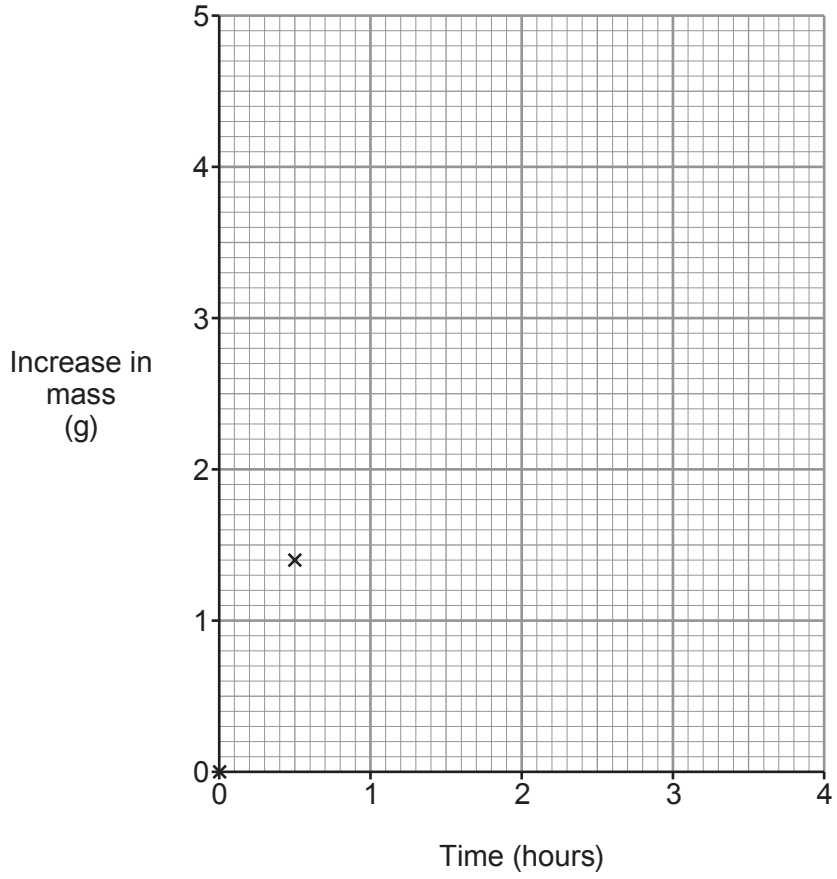
When the pack is opened, a reaction takes place between iron and oxygen in the air, causing an increase in mass.

A student investigated the increase in mass of the opened pack over several hours. The results are shown below.

Time (hours)	Increase in mass (g)
0.0	0.0
0.5	1.4
1.0	2.6
1.5	3.7
2.0	4.4
2.5	4.7
3.0	4.8
3.5	4.8
4.0	4.8

Examiner only

(i) Plot the mass increase of the pack against time on the grid and draw a suitable line. Two plots have been done for you. [3]



(ii) Tick (✓) the box next to the time it takes for the reaction to finish. [1]

2 hours ☐ 3 hours ☐ 4 hours ☐ 5 hours ☐

(iii) Tick (✓) the box next to the statement that best explains the shape of the graph. [1]

Iron reacts with oxygen forming iron oxide until all the oxygen is used up ☐

Heat formed expands the iron ☐

Iron oxide loses oxygen, forming iron ☐

Iron reacts with oxygen forming iron oxide until all the iron is used up ☐

8

Examiner only

8. (a) The table shows the electronic structure of the elements present in potassium fluoride.

Element	Electronic structure
potassium	2,8,8,1
fluorine	2,7

The diagram shows the electron transfer that occurs when potassium reacts with fluorine to form potassium fluoride. The ● and × symbols are outer shell electrons.

(2,8,8,1) (2,7)

A student was asked to draw a diagram showing the electronic structures and charges on the ions formed. There are **two** mistakes in the student's answer.

Student's answer

(2,8,8) (2,8,8)

(i) Circle the **two** mistakes in the student's answer. [2]

(ii) Name the type of bonding found in potassium fluoride. [1]

.....

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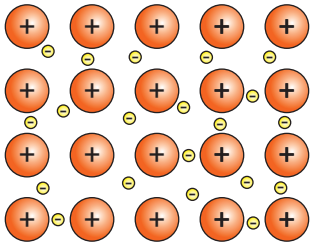
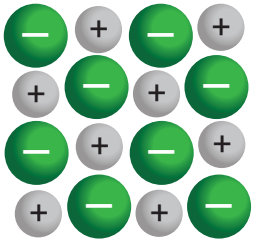
(iii) The diagrams show four different structures. Give the **letter** of the structure most likely to represent potassium fluoride. [1]

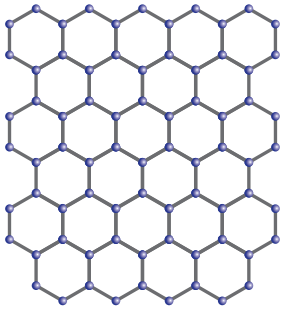


A

B



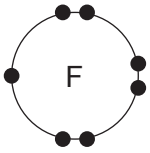
C



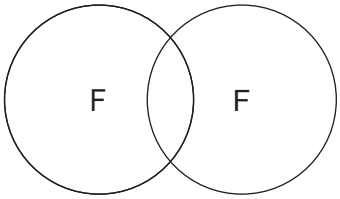
D

Letter .....

(b) The diagram shows the electrons in the outer shell of an atom of fluorine.



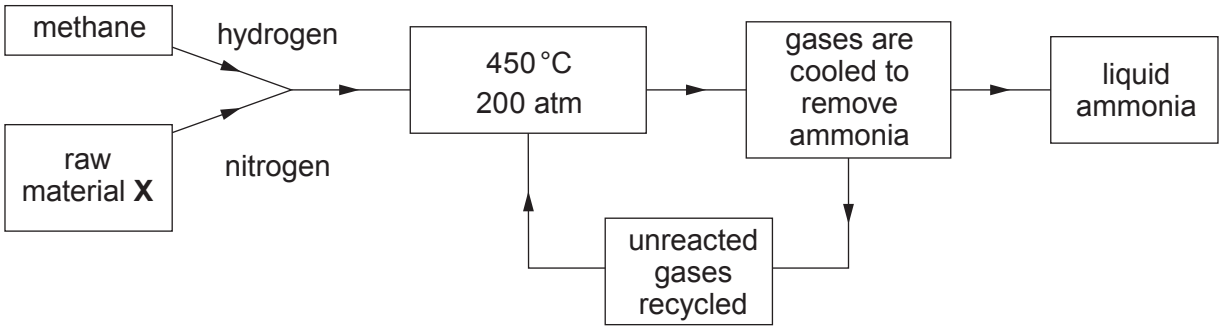
Complete the diagram to show the outer shell electrons in a molecule of fluorine. [2]



6

Examiner only

9. (a) The diagram outlines the manufacture of ammonia by the Haber process.



(i) Name the raw material **X**. ..... [1]

(ii) The pressure used in the Haber process is 200 atm. State why a higher pressure is **not** used. [1]

.....

(iii) At 450 °C, the reaction is very slow. Iron is used in the process to speed up the reaction. Give the name for a substance used to speed up a chemical reaction. [1]

.....

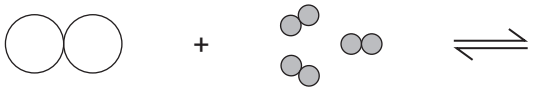
(iv) The reaction between nitrogen and hydrogen is represented by the equation below.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Complete the equation below using the key: [2]

 nitrogen gas, N_2

 hydrogen gas, H_2



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(b) One of the main uses of ammonia is in the manufacture of fertilisers.

The table shows the results obtained when tests were carried out on three different fertilisers **A**, **B** and **C**.

Fertiliser	Test for positive ion	Test for negative ion
A	On adding sodium hydroxide solution and warming, a pungent smelling gas is formed which turns red litmus blue	On adding barium chloride solution a white precipitate forms
B	Lilac flame test	On adding silver nitrate solution a white precipitate forms
C	On adding sodium hydroxide solution and warming, a pungent smelling gas is formed which turns red litmus blue	On adding silver nitrate solution a white precipitate forms

Give the **letter** of the fertiliser which is ammonium sulfate. [1]

Letter .....

(c) Ammonia reacts with chlorine to form nitrogen and hydrogen chloride.

Complete the balancing of the equation for this reaction. [1]

$$2NH_3 + 3Cl_2 \longrightarrow N_2 + \square HCl$$

7

Examiner only

10. (a) The list below shows part of the reactivity series.

sodium

aluminium

(carbon)

tin

copper

silver

(i) Tin is extracted from its ore by heating with carbon. Aluminium is extracted from its ore using a different method. Give the name of the method used to extract aluminium. [1]

.....

(ii) The equation shows the extraction of tin from tin oxide using carbon.

$$SnO_2 + C \longrightarrow Sn + CO_2$$

Tick (✓) the box next to the correct statement. [1]

Carbon is reduced ☐

Tin is oxidised ☐

Tin oxide is reduced ☐

Carbon dioxide is oxidised ☐

(iii) When aluminium and copper(II) oxide are heated together, aluminium oxide and copper are formed.

Complete and balance the equation for this reaction. [3]

2Al + 3 ..... (copper(II) oxide) ⟶ ..... (aluminium oxide) + ☐ Cu

Examiner only

(b) A teacher wanted to find out the position of four metals **A**, **B**, **C** and **D** in the reactivity series.

She heated each metal in turn with oxides of the other three. The results were as follows.

A reduced the oxide of **C**

B reduced the oxide of **A**

B reduced the oxide of **C**

D reduced the oxide of **B**

Place the metals in order of reactivity. [2]

Most reactive .....

.....

.....

Least reactive .....

7

END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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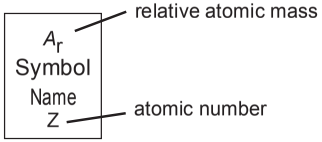
FORMULAE FOR SOME COMMON IONS

POSITIVE IONS		NEGATIVE IONS	
Name	**Formula**	**Name**	**Formula**
aluminium	Al^{3+}	bromide	Br^{-}
ammonium	NH_4^{+}	carbonate	CO_3^{2-}
barium	Ba^{2+}	chloride	Cl^{-}
calcium	Ca^{2+}	fluoride	F^{-}
copper(II)	Cu^{2+}	hydroxide	OH^{-}
hydrogen	H^{+}	iodide	I^{-}
iron(II)	Fe^{2+}	nitrate	NO_3^{-}
iron(III)	Fe^{3+}	oxide	O^{2-}
lithium	Li^{+}	sulfate	SO_4^{2-}
magnesium	Mg^{2+}		
nickel	Ni^{2+}		
potassium	K^{+}		
silver	Ag^{+}		
sodium	Na^{+}		
zinc	Zn^{2+}		

THE PERIODIC TABLE

1	2	Group										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
86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 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	179 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	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key



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