Surname	Centre Number	Candidate Number
First name(s)		0

GCSE – CONTINGENCY

3410U40-1

Z22-3410U40-1

THURSDAY, 23 JUNE 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.	**5**	
2.	**10**	
3.	**9**	
4.	**8**	
5.	**10**	
6.	**9**	
7.	**9**	
8.	**9**	
9.	**11**	
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 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 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 **5**(a) 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.

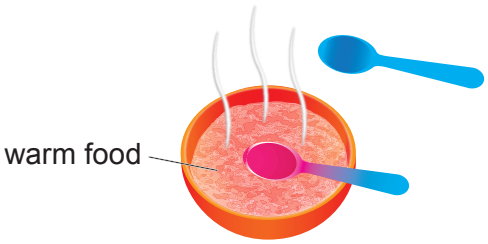
Answer **all** questions.

1. Smart materials are widely used in everyday life.

(a) The diagrams show some uses of smart materials which rely on their unusual properties.

nappies

baby-feeding spoon



summer T-shirts

cloudy sunny

car bumper

dent no dent

The box contains the names of four different types of smart material.

thermochromic pigment	**shape memory polymer**
hydrogel	**photochromic pigment**

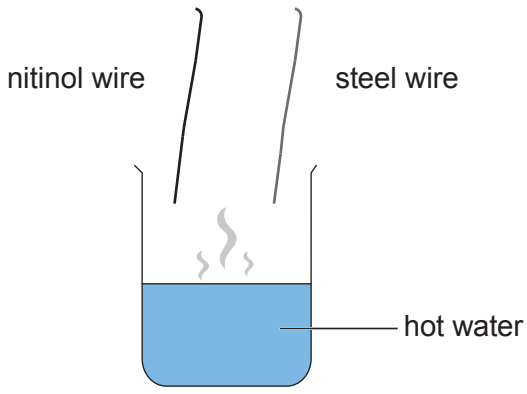
Examiner only

Use the information opposite to complete the table below. [4]

Unusual property	Use	Type of smart material
Able to absorb many times its own volume of water	nappies	hydrogel
Changes colour with changing temperature	.....	.....
Changes colour with changing light intensity	.....	.....

(b) Paperclips can be made from nitinol and from steel. Nitinol is a shape memory alloy but steel is not.

A student uncoiled both paperclips into straight wires and dropped them into hot water.



Put a **tick** (✓) in the box next to the statement that describes what happens. [1]

both wires reform into the shape of a paperclip ☐

only the nitinol wire reforms into the shape of a paperclip ☐

only the steel wire reforms into the shape of a paperclip ☐

neither wire reforms into the shape of a paperclip ☐

5

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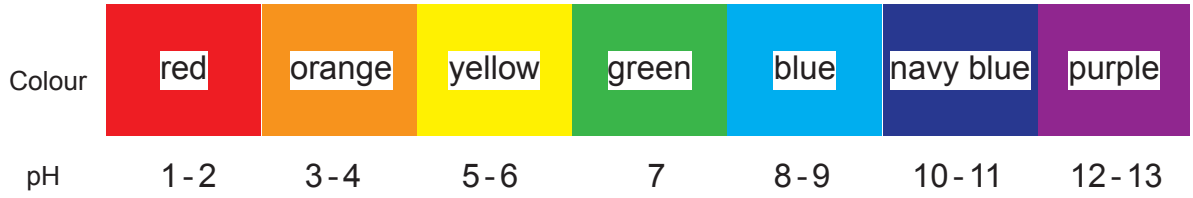
2. (a) The diagram shows the colours of universal indicator at different pH values.



(i) Sodium hydroxide solution turns universal indicator purple.

Put a **tick** (✓) in the box next to the correct statement. [1]

sodium hydroxide is a strong alkali ☐

sodium hydroxide is a weak alkali ☐

sodium hydroxide is a strong acid ☐

sodium hydroxide is a weak acid ☐

(ii) Ethanol is neutral. State the **colour** universal indicator would turn in ethanol. [1]

.....

Examiner only

(b) The word equations show reactions of acids with a metal, an alkali and a base.

Circle the correct substance in the box to complete each equation. [3]

magnesium + [hydrochloric acid / nitric acid / sulfuric acid] ⟶ magnesium nitrate + hydrogen

potassium hydroxide + hydrochloric acid ⟶ [potassium chloride / potassium sulfate / potassium nitrate] + water

[lead(II) oxide / copper(II) oxide / magnesium oxide] + sulfuric acid ⟶ copper(II) sulfate + water

(c) A student was asked how he would prepare a sample of zinc chloride crystals from zinc.

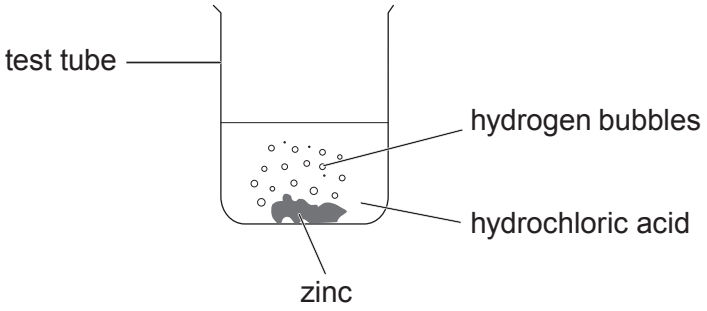
The word equation for the reaction is

zinc + hydrochloric acid ⟶ zinc chloride + hydrogen

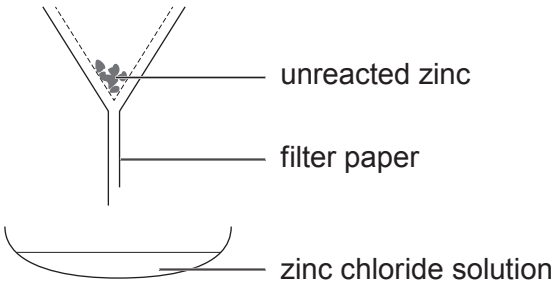
The diagrams below were taken from the student's work book.

There is **one** error in **each** of the student's diagrams.

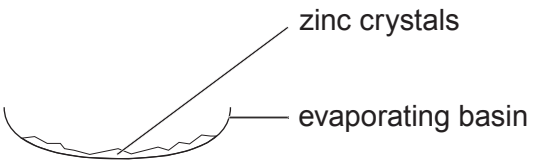
Step **1**



Step **2**



Step **3**



Examiner only

(i) **Circle** the error in each diagram. [3]

(ii) Zinc chloride contains the ions Zn^{2+} and Cl^-.

Underline the correct formula of zinc chloride. [1]

Zn_2Cl **Zn_2Cl_2** **$ZnCl$** **$ZnCl_2$**

(iii) Put a **tick** (✓) in the box next to the test to show that the gas given off is hydrogen. [1]

the gas pops with a lighted splint ☐

the gas turns limewater milky ☐

the gas relights a glowing splint ☐

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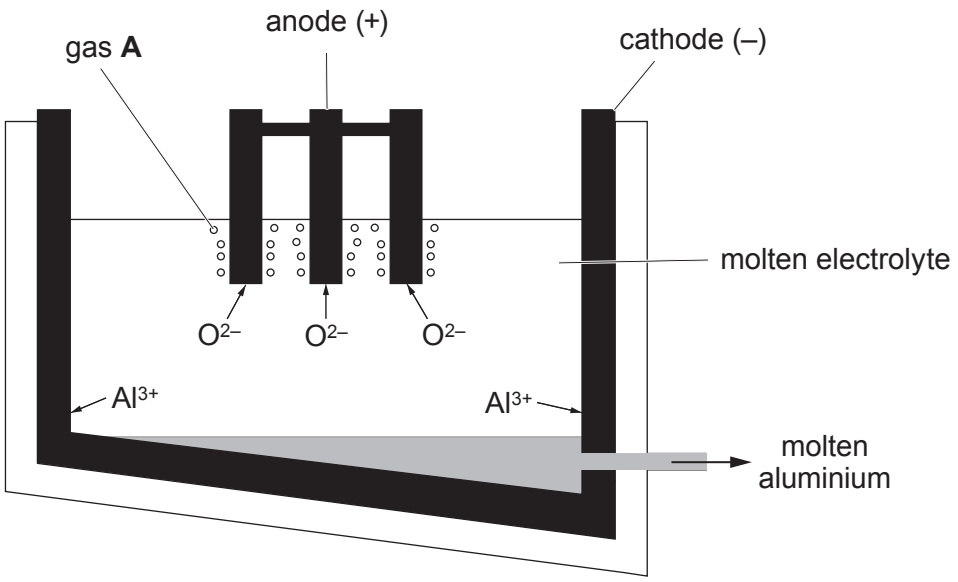
Examiner only

3. (a) The diagram shows a cell used in the extraction of aluminium from aluminium oxide.



positive	**oxygen**	**cryolite**	**negative**
aluminium	**hydrogen**	**steel**	**graphite**

(i) Choose words from the box to complete each of the following sentences. [4]

The electrolyte is a mixture of molten aluminium oxide and ..... .

Aluminium ions, Al^{3+}, are attracted to the electrode with a ..... charge.

Gas **A** is ..... .

The electrodes are made of ..... .

(ii) Balance the equation for the overall reaction. [1]

$$2Al_2O_3 \longrightarrow \square\ Al + 3O_2$$

Examiner only

(b) Calculate the relative formula mass (M_r) of aluminium oxide, Al_2O_3. [2]

$A_r(O) = 16$ $A_r(Al) = 27$

Relative formula mass = ...

(c) The box below contains some properties of aluminium.

low density	**non-magnetic**	**resists corrosion**
good thermal conductor		**good electrical conductor**

Window frames can be made from different materials.

Choose **two** properties from the box which make aluminium a **better** material than iron for making window frames. [2]

Property 1 .....

Property 2 .....

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09

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Turn over.

Examiner only

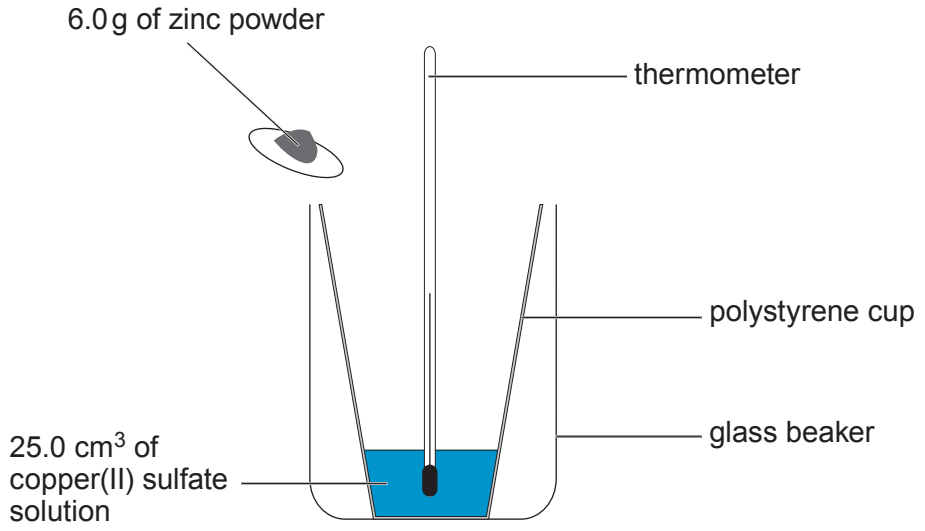
4. (a) The list shows part of the reactivity series.

magnesium
zinc
iron
copper

Underline the correct word(s) in the brackets to complete the following sentence. [1]

The reactivity of metals (**increases / stays the same / decreases**) down the list.

(b) Aled investigated the reaction between zinc and excess copper(II) sulfate solution.



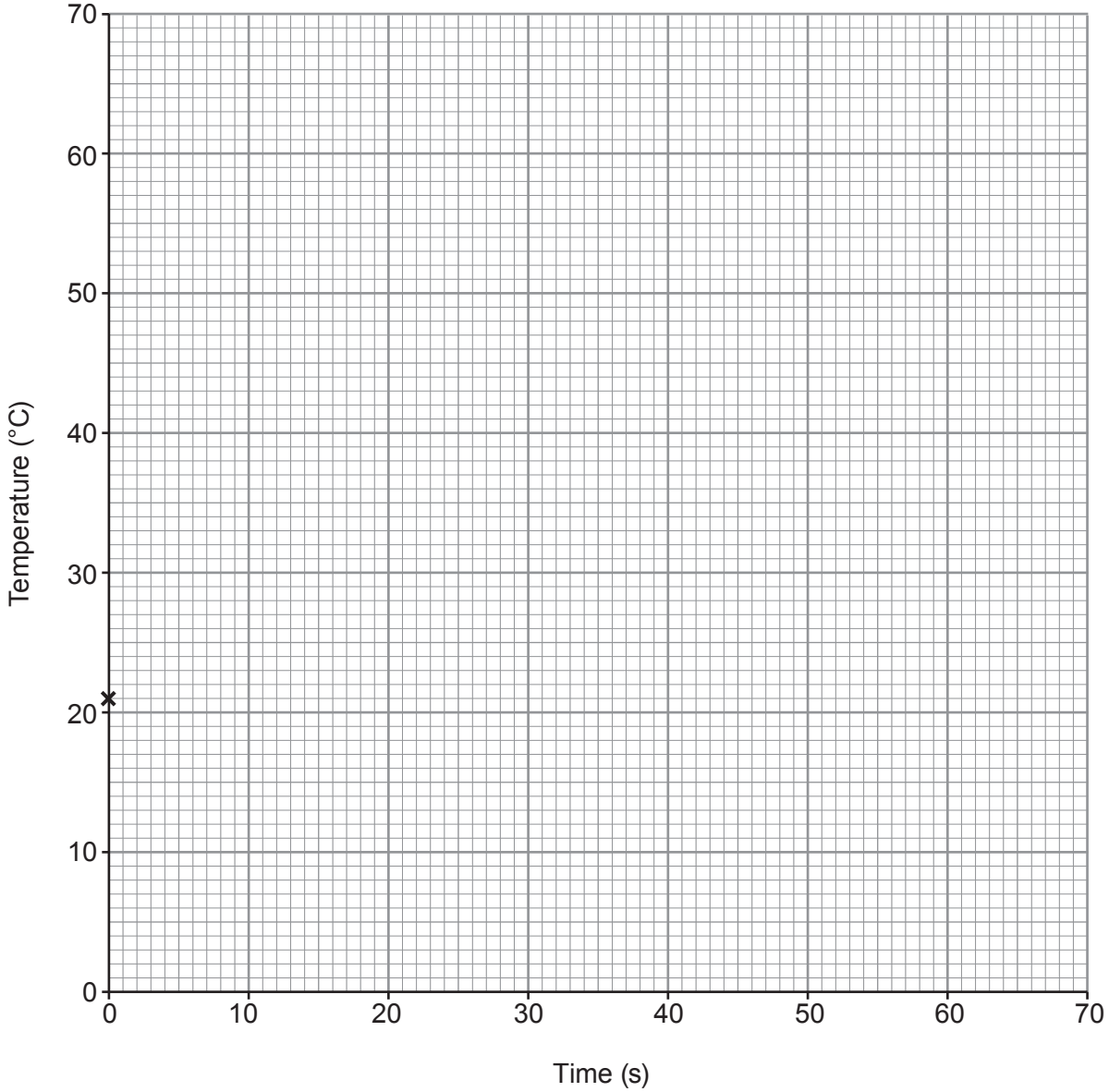
Aled put 25.0 cm^3 of copper(II) sulfate solution into a polystyrene cup and recorded its temperature. He added 6.0 g of zinc powder to the solution and recorded the temperature every 10 s for 70 s. His results are shown in the table.

Time (s)	0	10	20	30	40	50	60	70
Temperature (°C)	21	38	50	58	60	59	56	52

(i) Plot these results on the grid opposite. Draw a suitable line.

The first point has been plotted for you. [3]

Examiner only



(ii) **Circle** the time it took for **all** the zinc powder to be used up. [1]

30 s **40 s** **50 s** **70 s**

Turn over.

Examiner only

(iii) The word equation for the reaction between zinc and copper(II) sulfate solution is as follows.

zinc + copper(II) sulfate ⟶ zinc sulfate + copper

I. Complete the symbol equation for the reaction. [2]

$Zn + CuSO_4 \longrightarrow$ ..... + ...

II. Underline the type of reaction taking place. [1]

combustion **displacement** **neutralisation** **addition**

8

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5. (a) The table shows some properties of three plastics.

Plastic	Properties		
polycarbonate	high impact strength	good heat resistance	transparent
bakelite	rigid	good chemical resistance	good thermal insulator
coated nylon	good electrical insulator	flexible	waterproof

Use only the information in the table to answer this part-question.

State which plastic is used for making each of the following items.

Choose the **two** main properties that make the plastic suitable.

Give the reasons why these properties are important. [6 QER]

motorbike helmet visor

tent fabric

Examiner only

Turn over.

(b)

Recycling Plastics

Of all the materials we recycle, plastic is the most complex. The problem is that some plastic packaging is made from several different types of plastic. Different types of plastic are identified by different symbols.

Type of plastic	Symbol	Ease of recycling	Uses
PET		easy	soft drink bottles, rigid food packaging
HDPE		easy	milk cartons, cleaning product bottles, yoghurt pots
PVC		difficult	window frames, guttering
LDPE		difficult	food bags, shopping bags
PP		easy	margarine tubs, microwave meal trays
PS		difficult	some yoghurt pots, takeaway meal trays
other		cannot be recycled	mixed plastic products e.g. salad bags, crisp bags

Waste plastic is collected in different ways.

- Some local authorities collect all their recycling in one bin
- Others ask households to separate their plastics from the rest of their recycling

Sometimes plastic waste cannot be recycled and has to be sent to landfill or incinerated instead. This happens for several reasons.

- People are confused about which plastics can and cannot be recycled
- The plastic packaging is contaminated with food waste
- In areas where recycling materials are collected in one bin, one type of waste can contaminate another

Most plastic can be recycled – but it is not always economical to do so.

- Bottles attract the best prices, especially clear ones
- Coloured plastic is less desirable; the colour cannot be removed so its use is limited
- Polystyrene is almost never recycled because there is no market for it

Examiner only

Maximum price per tonne of used bottles (2018)

clear and colourless HDPE | clear and light blue PET | coloured HDPE | mixed plastics | coloured PET

(i) Put a **tick** (✓) next to the correct statement. [1]

all plastics are easy to recycle ☐

PET, HDPE and PP are easy to recycle ☐

PET, HDPE and PVC are difficult to recycle ☐

PVC, LDPE and PS cannot be recycled ☐

(ii) Put a **tick** (✓) in **two** boxes which explain why some plastic items have to go to landfill. [2]

the plastic items still contain food waste ☐

not enough plastic items have been collected to make recycling worthwhile ☐

the plastic item is made up of more than one type of plastic ☐

too many plastic items have been collected for recycling ☐

the plastic items are too large to fit in the incinerator ☐

(iii) **Circle** the type of plastic for which there is the greatest demand for recycling. [1]

coloured PET **clear and light blue PET**

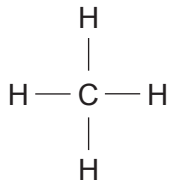
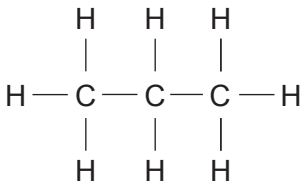
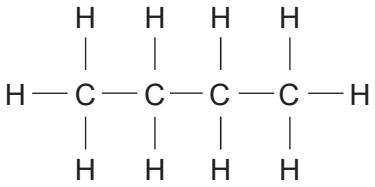
clear and colourless HDPE **coloured HDPE**

10

Examiner only

6. (a) The table shows the names, molecular formulae and structural formulae of some alkanes.

(i) Complete the table. [3]

Name	Molecular formula	Structural formula
.....	CH_4	
ethane	C_2H_6	
propane	.....	
butane	C_4H_{10}	

(ii) Give the **names** of the **two** elements present in all alkanes. [1]

..... and .....

(iii) The general formula for the alkanes is C_nH_{2n+2} .

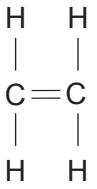
Circle the molecular formula for the alkane containing 6 carbon atoms. [1]

C_6H_6 **CH_6** **C_6H_{12}** **C_6H_{14}**

Examiner only

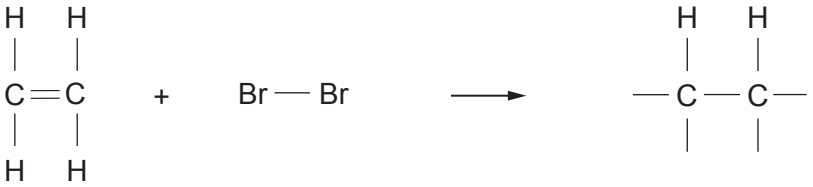
(b) Ethene belongs to a different family of hydrocarbons called the alkenes.

The structural formula of ethene is



The presence of the double bond in alkenes can be identified using bromine water.

(i) Complete the structural formula for the product of the reaction between ethene and bromine. [1]



(ii) Complete the sentence below by underlining the correct words in the brackets. [2]

Ethene turns (**purple / orange / green / colourless**) bromine water

(**green / milky / colourless / blue**).

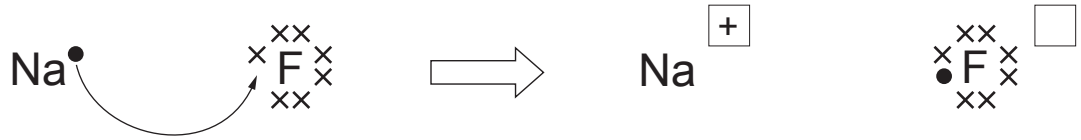
(c) Underline the name given to the type of reaction taking place when ethene reacts with bromine. [1]

addition **polymerisation** **oxidation** **neutralisation**

9

Examiner only

7. (a) The diagram shows the electronic changes that occur when sodium reacts with fluorine to form sodium fluoride. The ● and × symbols represent outer shell electrons.



sodium atom	fluorine atom	sodium ion	fluoride ion
(2,8,1)	(2,7)	(2,8)	(.....)

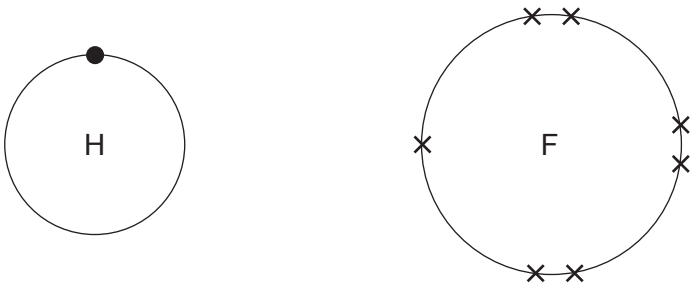
(i) **Complete the diagram** by writing the electronic structure of the fluoride ion in the brackets and its charge in the box. [2]

(ii) Complete and balance the equation for the reaction between sodium and fluorine to form sodium fluoride. [2]

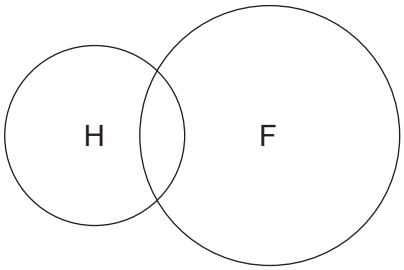
$$2Na + F_2 \longrightarrow \square \text{ .....}$$

(b) Hydrogen reacts with fluorine to form hydrogen fluoride, HF.

The diagrams show the outer shell electrons in an atom of hydrogen and an atom of fluorine.



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



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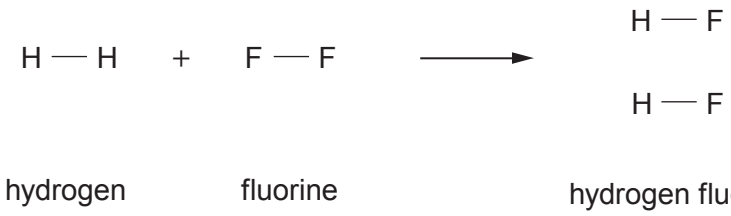
(c) The equation shows the bonds which are broken and the bonds which are formed when hydrogen reacts with fluorine to form hydrogen fluoride.



The relevant bond energies are shown in the table.

Bond	Bond energy (kJ)
H — H	436
F — F	154
H — F	565

(i) The total energy needed to break the bonds in the H—H and F—F molecules is 590 kJ. Use the information in the table to show how this value is obtained. [1]

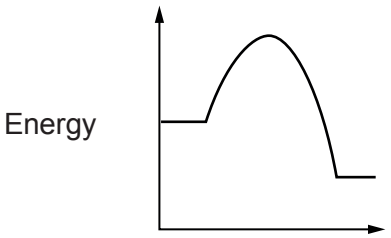
(ii) Use the information in the table to calculate the total energy released when the bonds in the **two** H—F molecules are formed. [1]

Energy = ... kJ

Examiner only

(iii) The formation of hydrogen fluoride is an exothermic reaction.

Put a **tick** (✓) in the box next to the energy profile diagram that shows an exothermic reaction. [1]



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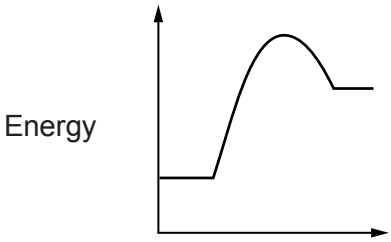

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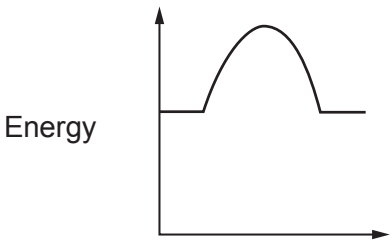

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Examiner only

8. (a) Crude oil can be separated into simpler mixtures called fractions. The table shows information about some of the main fractions obtained from crude oil by fractional distillation.

Fraction	Boiling point range (°C)	Number of carbon atoms present in the alkanes
petroleum gases	< 20	C_1–C_4
petrol	30–75	C_5–C_8
naphtha	70–180	C_9–C_{12}
kerosene	180–250	C_{13}–C_{16}
diesel oil	250–340	C_{17}–C_{20}
lubricating oil	340–500	C_{20}–C_{24}
fuel oil	490–580	C_{25}–C_{28}

(i) Decane has a boiling point of 174 °C. Give the name of the fraction which contains decane. [1]

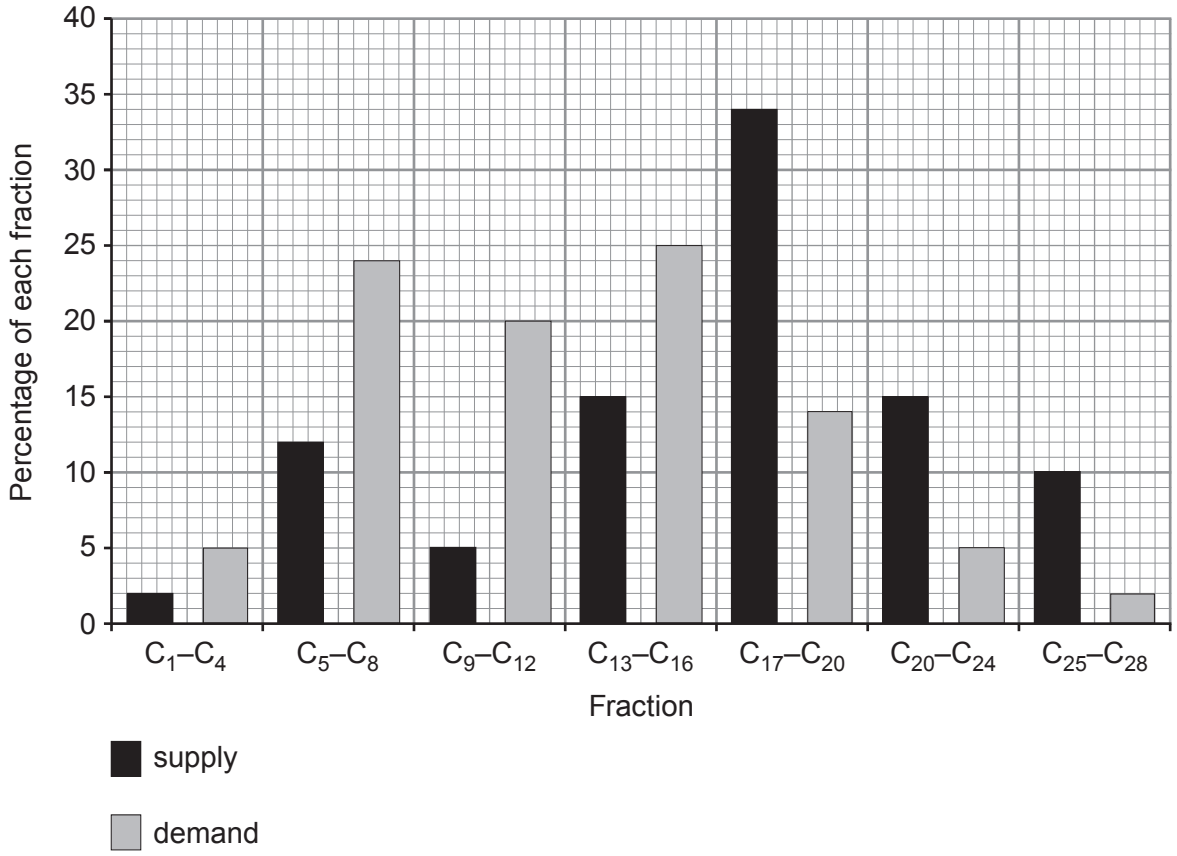
.....

(ii) One alkane is found in both diesel oil and lubricating oil. Give the number of carbon atoms in this alkane. [1]

.....

Examiner only

(b) The bar chart shows the supply and demand for some of the fractions obtained from crude oil.



(i) Give the fraction where the demand is 100 % greater than the supply. [1]

.....

(ii) Put a **tick** (✓) in the box next to the statement that best describes how the supply and demand of the fractions change as the chain length increases. [1]

supply is greater than demand for all fractions ☐

supply is greater than demand up to C_{16} after which demand is greater than supply ☐

demand is greater than supply up to C_{16} after which supply is greater than demand ☐

the difference between supply and demand increases up to C_{16} after which it decreases ☐

Examiner only

(iii) Oil companies have solved the problem of over-supply of some fractions using a process called cracking.

The alkane $C_{20}H_{42}$ can be cracked forming propene, nonene and **one molecule** of hydrocarbon **A**.

I. Complete the equation for the cracking of $C_{20}H_{42}$. [1]

$$C_{20}H_{42} \longrightarrow \underset{\text{propene}}{C_3H_6} + \underset{\text{nonene}}{C_9H_{18}} + \underset{\text{hydrocarbon } \mathbf{A}}{\text{.....}}$$

II. Propene is an important raw material in the production of polypropene.

Give the name of the process used to make polypropene from propene. [1]

.....

Examiner only

(c) Every year thousands of acres of forests are destroyed by wildfires. Fire-fighters use several different methods to put out this type of fire.

State **three** methods that are used to put out forest fires.

Give the part of the fire triangle being removed in each method.

Each method should refer to a different part of the fire triangle. [3]

Method 1 .....

Part of the fire triangle being removed .....

Method 2 .....

Part of the fire triangle being removed .....

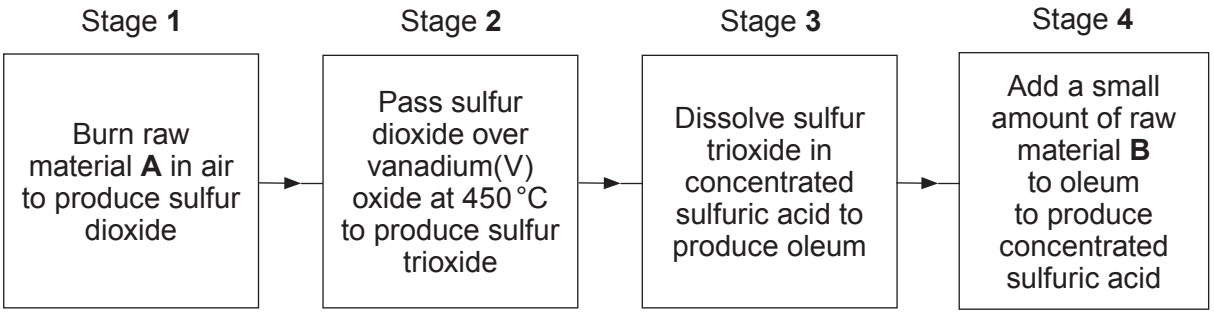
Method 3 .....

Part of the fire triangle being removed .....

9

Examiner only

9. (a) Sulfuric acid is produced by the contact process. The flow diagram shows the main stages in the process.



(i) Give the name of raw materials **A** and **B**. [2]

A .....

B .....

(ii) State the purpose of vanadium(V) oxide in stage **2**. [1]

.....

(iii) Complete and balance the equation for the reaction in stage **2**. [2]

$\square$ ..... + O_2 $\rightleftharpoons$ $2SO_3$

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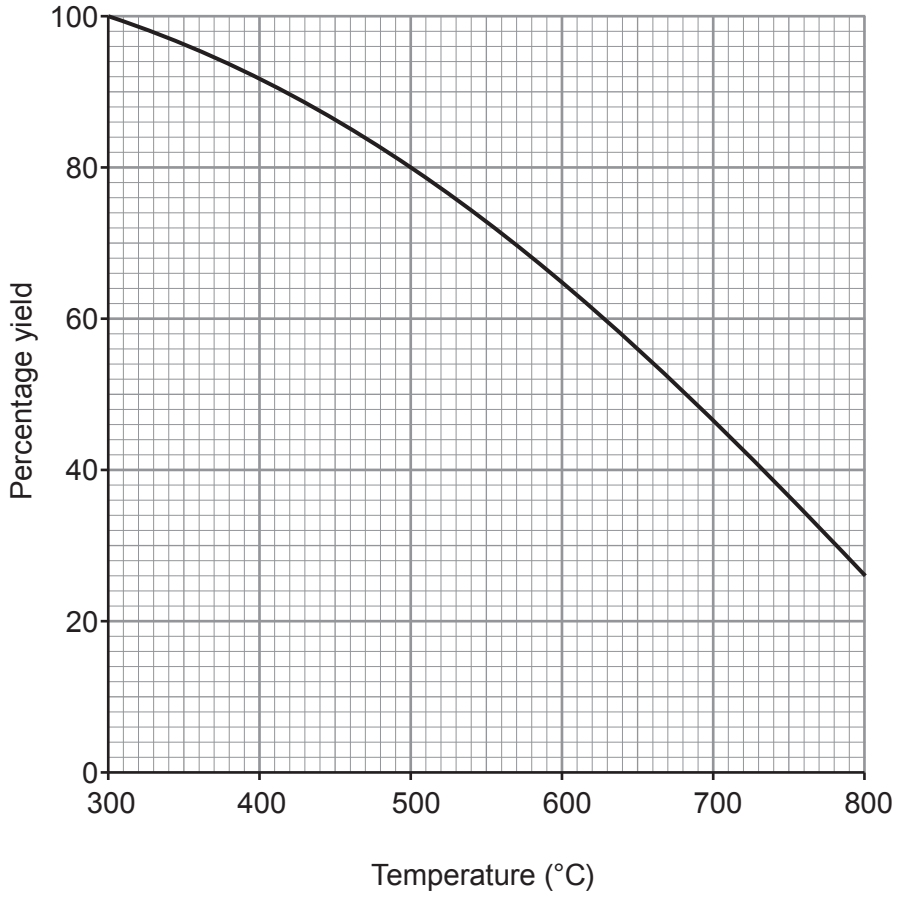
(iv) The graph shows how the percentage yield of sulfur trioxide changes with temperature between 300 °C and 800 °C.



Use the graph to answer parts I and II.

I. State the trend in the percentage yield of sulfur trioxide as the temperature increases. [1]

.....

II. Give the temperature **range** to be used to obtain a yield of sulfur trioxide greater than 80 %. [1]

..... to ..... °C

(v) One molecule of sulfur trioxide reacts with one molecule of sulfuric acid to form one molecule of oleum as the **only product**.

Complete the equation for this reaction by giving the formula of oleum. [1]

$SO_3 + H_2SO_4 \longrightarrow$ .....

Examiner only

(b) The photograph shows the exothermic reaction between concentrated sulfuric acid and sugar, $C_{12}H_{22}O_{11}$.

(i) Name the **two** products formed. [2]

..... and .....

(ii) State the type of reaction taking place. [1]

.....

END OF PAPER

11

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

Examiner only

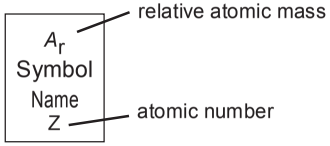
FORMULAE FOR SOME COMMON IONS

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
																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4						1 H Hydrogen 1					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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