Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel Level 1/Level 2 GCSE (9–1)

Tuesday 13 June 2023

Morning (Time: 1 hour 45 minutes)

Paper reference **1CH0/2H**

Chemistry

PAPER 2

Higher Tier

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.*
- Calculators may be used.
- Any diagrams may NOT be accurately drawn, unless otherwise indicated.
- You must **show all your working out** with **your answer clearly identified** at the **end of your solution**.

Information

- The total mark for this paper is 100.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- There is a periodic table on the back cover of the paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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N:1/1/1/1/1/

P 7 2 6 3 3 A 0 1 3 2

Pearson

Answer ALL questions. Write your answers in the spaces provided.

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 ☒.

1 Butanol is a liquid fuel.

A student investigated the mass of butanol needed to increase the temperature of 100 cm^3 of water by 1 °C.

The student used the following method.

step 1 add 100 cm^3 of water to a beaker

step 2 measure the mass of a spirit burner containing butanol

step 3 measure the initial temperature of the water in the beaker

step 4 place the spirit burner containing butanol under the beaker of water

step 5 light the wick of the burner and start to stir the water with the thermometer

step 6 stop heating the water when the temperature of the water has increased by 30 °C

step 7 remeasure the mass of the spirit burner containing butanol.

Figure 1 shows the apparatus used.

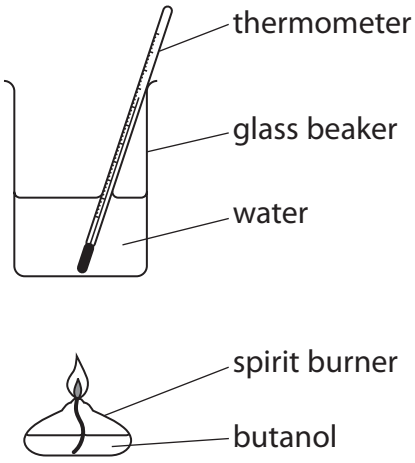


Figure 1

(a) Figure 2 shows the student's results.

mass of spirit burner at start in g	mass of spirit burner at end in g
134.67	133.59

Figure 2

In the student's investigation, the temperature of the 100 cm^3 water increased by 30 °C.

Calculate the mass of butanol needed to increase the temperature of the 100 cm^3 water by 1 °C.

(2)

.....

.....

mass of butanol = ... g

(b) The student investigated the effect of changing the fuel on the mass of fuel needed to heat the water.

The student used an identical spirit burner filled with pentanol, another liquid fuel.

Give **two** variables that the student should keep the same in this investigation.

(2)

variable 1

.....

.....

variable 2

.....

.....

(c) Suggest **two** improvements that the student could make to their apparatus so that more of the heat energy is transferred to the water.

(2)

improvement 1

.....

.....

improvement 2

.....

.....

(Total for Question 1 = 6 marks)

2 A student used the apparatus shown in Figure 3 to investigate the reaction between marble chips and dilute hydrochloric acid.

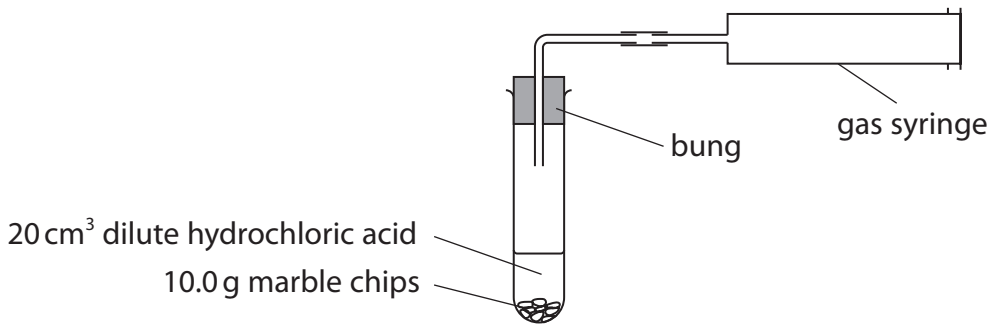


Figure 3

The student recorded the volume of gas every minute as shown in Figure 4.

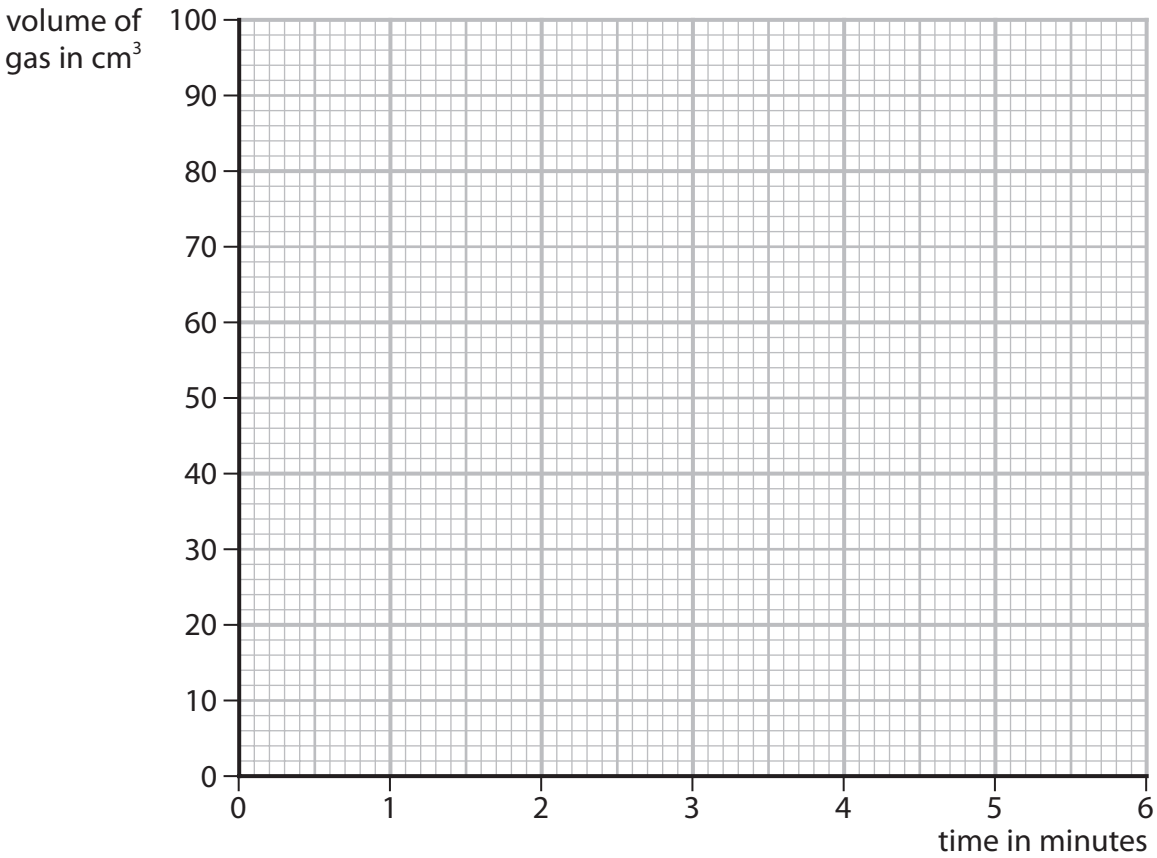
time in minutes	0	1	2	3	4	5	6
volume of gas in cm³	0	52	78	91	97	100	100

Figure 4

(a) On the grid, plot the results shown in Figure 4.

Draw a curve of best fit.

(3)



(b) Rate of reaction can be calculated using

$$\text{rate of reaction} = \frac{\text{volume of gas produced in 1 minute}}{\text{1 minute}}$$

Figure 5 shows the rates of reaction calculated from the results of this experiment.

The rate of reaction for the time interval 2 to 3 minutes is missing.

time interval	0 to 1 minute	1 to 2 minutes	2 to 3 minutes	3 to 4 minutes	4 to 5 minutes
rate of reaction in $cm^3\ min^{-1}$	52	26		6	3

Figure 5

(i) Calculate the rate of reaction for the time interval 2 to 3 minutes.

(1)

rate of reaction = ... $cm^3\ min^{-1}$

(ii) State and explain what happens to the rate of reaction as the acid reacts with the marble chips in this experiment.

(3)

(c) The student repeated the experiment using the same volume of acid and the same mass of marble chips but used smaller marble chips.

All other conditions remained the same.

The student found that the reaction with the smaller marble chips was faster to start with but produced the same volume of gas.

Using this information, draw a line on the grid to show the results for the reaction with the smaller marble chips.

Label this line 'C'.

(2)

(Total for Question 2 = 9 marks)

3 Figure 6 shows some information about the group 1 metals.

group 1 metal	atomic number	relative atomic mass
lithium	3	7
sodium	11	23
potassium	19	39
rubidium	37	85
caesium	55	133

Figure 6

(a) Explain, in terms of their electronic configurations, why these metals are placed in group 1 of the periodic table.

(2)

.....

.....

.....

.....

(b) Which row shows two correct properties of group 1 metals?

(1)

		properties of group 1 metals	
☒	**A**	compounds are white in colour	high density
☒	**B**	low melting points	compounds are blue in colour
☒	**C**	soft enough to be cut by a knife	low melting points
☒	**D**	high density	conduct electricity

(c) The word equation for the reaction of potassium with bromine is

potassium + bromine → potassium bromide

Add the missing state symbol and balance the equation for this reaction.

(2)

..... K(.....) + Br_2(g) → ..... KBr(s)

(d) A sample of potassium contains three isotopes, potassium-39, potassium-40 and potassium-41.

(i) Explain the meaning of the term **isotopes**.

(2)

.....

.....

.....

.....

(ii) This sample of potassium contains

93.25% potassium-39

0.02% potassium-40

6.73% potassium-41

Calculate the relative atomic mass of this sample of potassium.

(2)

.....

.....

.....

.....

relative atomic mass = ...

(Total for Question 3 = 9 marks)

4 (a) Atoms, molecules, nanoparticles and protons are types of particle.

List these four types of particle in order of size from smallest to largest.

(2)

smallest .....

.....

.....

largest .....

(b) Nanoparticles have a large surface area to volume ratio.

Figure 7 shows a cube-shaped nanoparticle with sides of 90 nm.

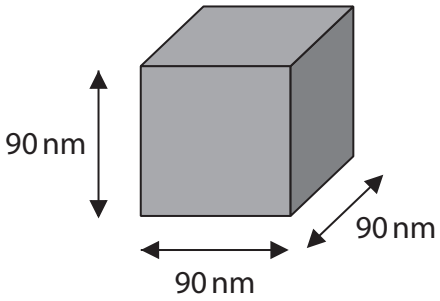


Figure 7

(i) What is 90 nm in metres?

(1)

☒ **A** 9.0×10^{-5}

☒ **B** 9.0×10^{-6}

☒ **C** 9.0×10^{-8}

☒ **D** 9.0×10^{-11}

(ii) Calculate the simplest surface area to volume ratio for the nanoparticle in Figure 7.

Show your working.

(3)

.....

.....

.....

.....

surface area to volume ratio = 1 : .....

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(c) Figure 8 shows the structure of a molecule of tetrafluoroethene.

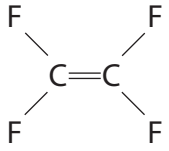

Figure 8

(i) Tetrafluoroethene can form the polymer poly(tetrafluoroethene).

Draw a diagram to show the structure of the repeating unit of this polymer.

(2)

(ii) Poly(tetrafluoroethene) is also known as Teflon™.

State one use of poly(tetrafluoroethene) and explain how one of its properties makes it suitable for that use.

(3)

use

.....

explanation

.....

.....

.....

.....

.....

(Total for Question 4 = 11 marks)

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5 (a) Figure 9 shows the percentage of three gases, **X**, **Y** and **Z**, in the Earth's early atmosphere.

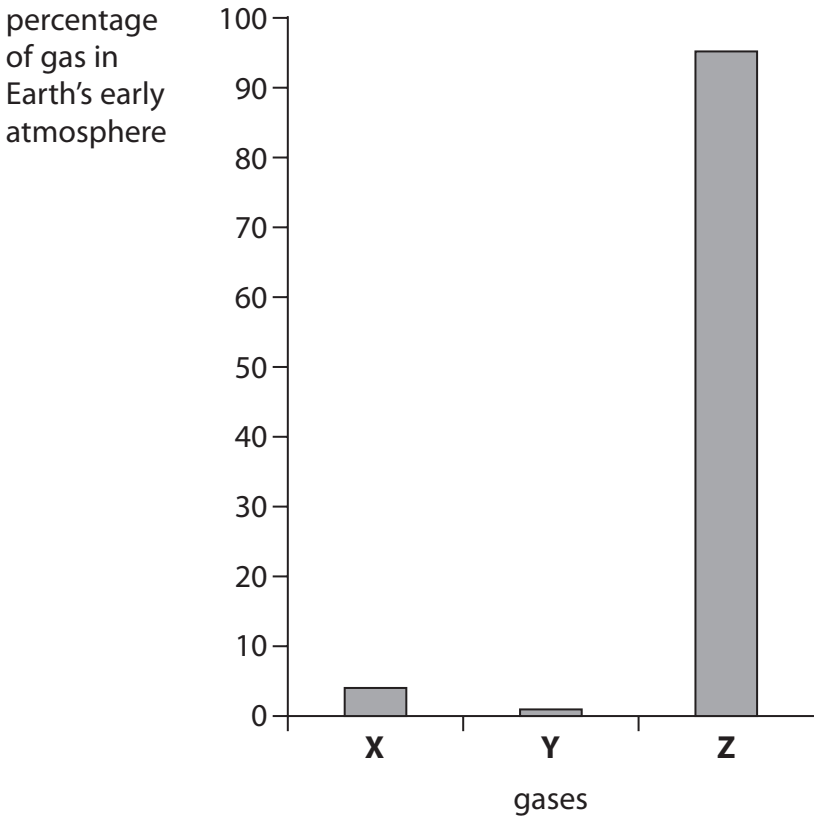

Figure 9

What is the name of gas **Z**?

(1)

- ☒ **A** argon
- ☒ **B** carbon dioxide
- ☒ **C** nitrogen
- ☒ **D** oxygen

(b) It is thought that small quantities of hydrogen sulfide, H_2S, were also in the Earth's early atmosphere.

Draw the dot and cross diagram for a molecule of hydrogen sulfide.

Show outer electrons only.

(2)

(c) Acid rain is caused by some pollutant gases present in the atmosphere.

Explain how impurities in fossil fuels can result in acid rain.

(3)

(d) A student investigates the effect of acid rain on cress plants.

The student uses this method.

step 1 grow 20 cress plants in each of two dishes, **A** and **B**

step 2 water the cress plants in dish **A** with 10 cm^3 of dilute hydrochloric acid with a pH of 2

step 3 water the cress plants in dish **B** with 10 cm^3 of pure water with a pH of 7

step 4 repeat steps 2 and 3 every day for one week

step 5 count how many plants are still alive after one week.

(i) State what piece of equipment the student could use to measure the pH of each liquid.

(1)

.....

(ii) Explain **one** improvement that the student could make to the method to make the results more valid.

(2)

.....

.....

.....

.....

(Total for Question 5 = 9 marks)

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6 Chlorine gas can be prepared by reacting concentrated hydrochloric acid with solid potassium manganate(VII).

Figure 10 shows the apparatus used.

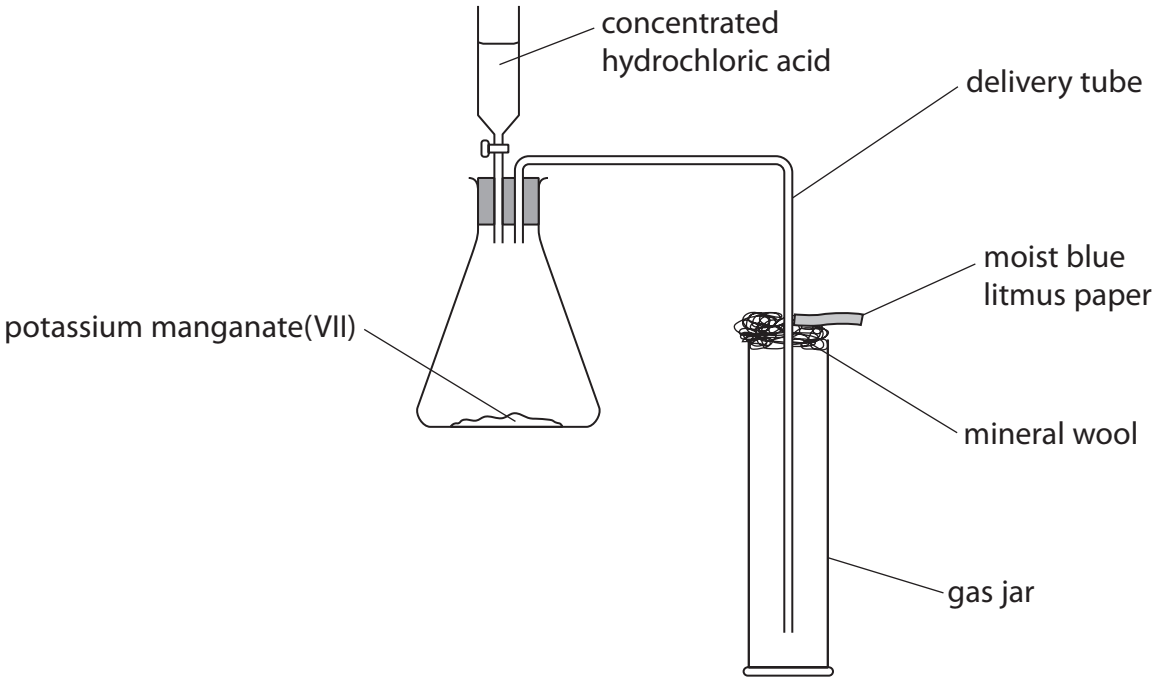

Figure 10

(a) Figure 11 shows the hazard symbols for concentrated hydrochloric acid, potassium manganate(VII) and chlorine gas.

substance	hazard symbol
concentrated hydrochloric acid	
potassium manganate(VII)	
chlorine gas	

Figure 11

Use the information in Figure 11 to help you answer (a)(i) and (a)(ii).

(i) What are the hazards associated with potassium manganate(VII)?

(1)

- ☒ **A** flammable, harmful and corrosive
- ☒ **B** flammable, toxic and hazardous to the environment
- ☒ **C** oxidising, harmful and hazardous to the environment
- ☒ **D** oxidising, toxic and corrosive

(ii) Explain **one** precaution that should be taken when preparing the sample of chlorine gas.

(2)

precaution

.....

.....

reason

.....

.....

(b) State the purpose of the delivery tube.

(1)

.....

.....

(c) Suggest why damp blue litmus is placed at the top of the gas jar.

(2)

.....

.....

.....

.....

.....

(d) In the reaction, potassium manganate(VII), $KMnO_4$, reacts with hydrochloric acid to form manganese chloride, $MnCl_2$, potassium chloride, chlorine and water.

Write the balanced equation for the reaction.

(3)

.....

(Total for Question 6 = 9 marks)

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7 Figure 12 shows the structure of the molecules of three organic compounds.

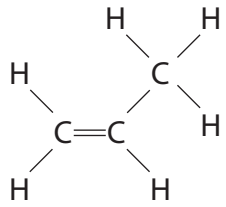
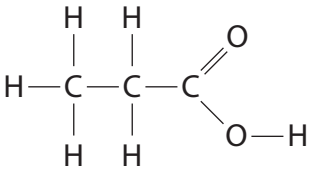
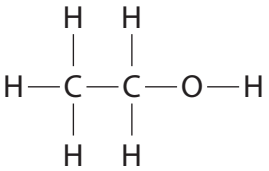
propene	propanoic acid	ethanol
		

Figure 12

(a) (i) Each molecule in Figure 12 contains a different functional group.

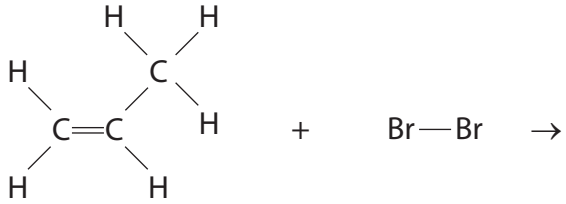
Circle the alkene functional group in **propene**.

(1)

(ii) Propene reacts with bromine water.

Complete the equation for the reaction of propene with bromine by drawing the structure of a molecule of the product.

(2)



propene **bromine** **product**

(iii) Propanoic acid reacts with calcium carbonate, $CaCO_3$, to form calcium propanoate, $Ca(C_2H_5COO)_2$, and two other products.

Name the **two** other products.

(2)

product 1 .....

product 2 .....

*(b) Glucose, $C_6H_{12}O_6$, is a carbohydrate.

A dilute solution of ethanol can be produced from glucose by fermentation.

The dilute solution of ethanol can then be processed to form a concentrated solution of ethanol.

Describe how the fermentation of glucose is carried out and how the dilute solution of ethanol produced can then be processed to form a concentrated solution of ethanol.

You may include diagrams in your answer.

(6)

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(Total for Question 7 = 11 marks)

8 Ammonia can be produced from the reaction of hydrogen with nitrogen.

(a) What is the percentage by mass of nitrogen in ammonia, NH_3?

(relative atomic masses: H = 1.0, N = 14)

(1)

☒ **A** 18%

☒ **B** 42%

☒ **C** 51%

☒ **D** 82%

(b) The reaction between hydrogen and nitrogen is exothermic.

Figure 13 shows the reaction profile of this exothermic reaction.

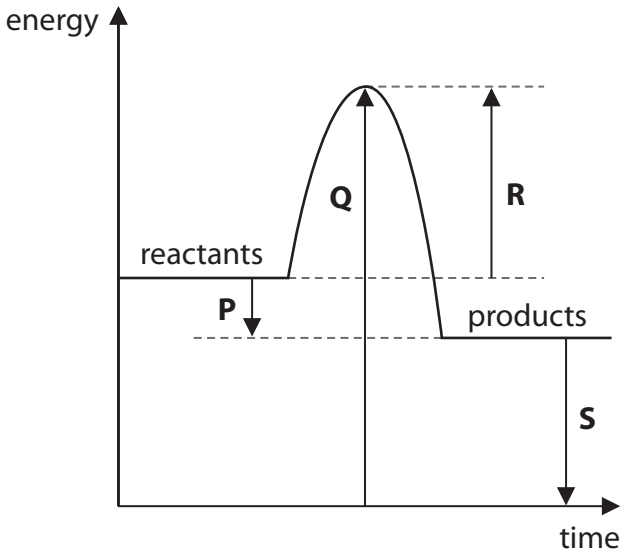


Figure 13

(i) Which arrow represents the activation energy for the reaction?

(1)

☒ **A** arrow **P**

☒ **B** arrow **Q**

☒ **C** arrow **R**

☒ **D** arrow **S**

(ii) Describe what the reaction profile shows about the energy involved in bond breaking and bond making in this reaction.

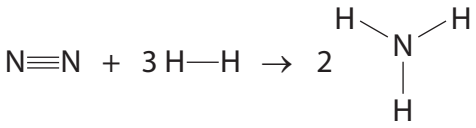
(2)

(iii) Figure 14 shows the energies of some bonds.

bond	bond energy in kJ mol^{-1}
N≡N	944
H—H	436
H—N	388

Figure 14

The equation for the reaction between nitrogen and hydrogen to form ammonia is



Calculate the energy change, in kJ mol^{-1}, for this reaction.

(4)

energy change = ... kJ mol^{-1}

(c) Ammonia, NH_3, and silicon dioxide, SiO_2, are both compounds that are made of two non-metallic elements.

Ammonia has a boiling point of –33 °C.
Silicon dioxide has a boiling point of 2230 °C.

Explain why the boiling points of ammonia and silicon dioxide are so different.

(3)

.....

.....

.....

.....

.....

.....

(Total for Question 8 = 11 marks)

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9 Crude oil is a mixture of hydrocarbons.

Crude oil can be separated into useful fractions by the process of fractional distillation in a fractionating column.

(a) Figure 15 shows a fractionating column, the fractions obtained and the trend in viscosity of the fractions.

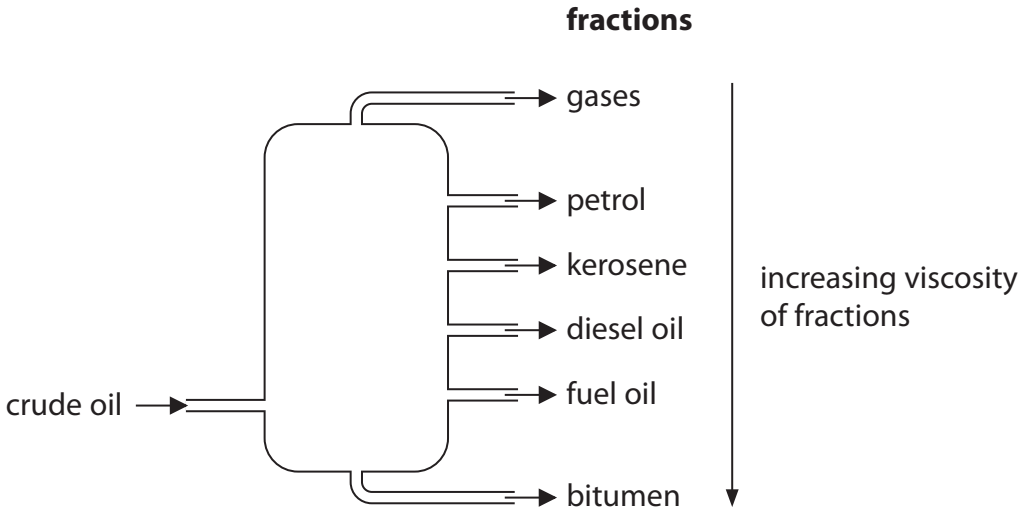

Figure 15

(i) Which row shows the correct uses for bitumen, diesel oil and fuel oil?

(1)

		bitumen	diesel oil	fuel oil
☒	**A**	fuel for large ships	surfacing roads	fuel for trains
☒	**B**	fuel for large ships	fuel for trains	surfacing roads
☒	**C**	surfacing roads	fuel for trains	fuel for large ships
☒	**D**	surfacing roads	fuel for large ships	fuel for trains

(ii) Explain the trend in the viscosity of the fractions.

(2)

(b) Hydrocarbon **X** was cracked to form one molecule of hexane, C_6H_{14}, and one molecule of alkene **Y**.

$$\mathbf{X} \rightarrow C_6H_{14} + \mathbf{Y}$$

The relative formula mass of **Y** is 56.
The empirical formula of **Y** is CH_2.

Deduce the molecular formula of hydrocarbon **X**.

Show your working.

(relative atomic masses: H = 1.0, C = 12)

(4)

molecular formula of **X** = ...

*(c) Large quantities of methane are used as a fuel.

Figure 16 shows a Bunsen burner.

Methane can be used as fuel for the Bunsen burner.

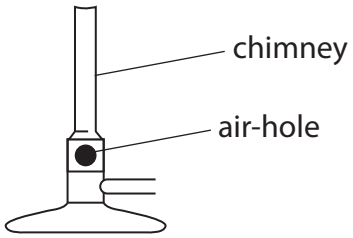

Figure 16

The air-hole on the chimney of the Bunsen burner can be opened and closed.

Explain the effect of opening and closing the air-hole of the Bunsen burner on the products of combustion of methane and the harm that using large quantities of methane as a fuel can cause.

(6)

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(Total for Question 9 = 13 marks)

10 (a) A student carried out a flame test on a sample of solid potassium chloride.

The student followed this method.

step 1 dip a dry wooden splint into water

step 2 then dip the wooden splint into the sample of potassium chloride

step 3 hold the wooden splint in a roaring Bunsen burner flame

step 4 observe the colour seen in the flame.

(i) The student made the following observation and conclusion.

'I saw that the flame colour was yellow so the sample must contain sodium ions.'

Due to the way the student carried out the experiment, this is not a valid conclusion.

Explain **one** improvement that the student could make to their method to obtain a valid conclusion.

(2)

improvement

.....

.....

reason

.....

.....

(ii) What colour should the student have seen in the flame if the test had been carried out correctly?

(1)

☒ **A** blue-green

☒ **B** lilac

☒ **C** orange-red

☒ **D** red

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DO NOT WRITE IN THIS AREA

(b) A sample of the potassium chloride was also tested for chloride ions.

Describe the test for chloride ions.

(3)

(c) (i) A student was asked to test a sample of aluminium sulfate for sulfate ions.

The student needed 25 cm^3 of barium chloride solution of concentration 83 g dm^{-3} for the test.

Calculate the mass of barium chloride that must be dissolved in water to make 25 cm^3 of solution of this concentration.

Give your answer to 2 significant figures.

(3)

mass of barium chloride = ... g

(ii) When the barium chloride solution was added to the aluminium sulfate solution, a precipitate was formed.

The balanced equation for this reaction is

$$3BaCl_2(aq) + Al_2(SO_4)_3(aq) \rightarrow 3BaSO_4(s) + 2AlCl_3(aq)$$

Write the ionic equation for this reaction.

(3)

(Total for Question 10 = 12 marks)

TOTAL FOR PAPER = 100 MARKS

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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

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

**** The elements with atomic numbers from 58 to 71 are omitted from this part of the periodic table.***

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

Pearson Edexcel

Mark Scheme (Results)

Summer 2023

Pearson Edexcel GCSE
In Chemistry (1CH0)
Paper 2H

Edexcel and BTEC Qualifications

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Summer 2023
Publications Code 1CH0_2H_2306_MS

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Mark schemes have been developed so that the rubrics of each mark scheme reflects the characteristics of the skills within the AO being targeted and the requirements of the command word. So for example the command word 'Explain' requires an identification of a point and then reasoning/justification of the point.
Explain questions can be asked across all AOs. The distinction comes whether the identification is via a judgment made to reach a conclusion, or, making a point through application of knowledge to reason/justify the point made through application of understanding. It is the combination and linkage of the marking points that is needed to gain full marks.
When marking questions with a 'describe' or 'explain' command word, the detailed marking guidance below should be consulted to ensure consistency of marking.

Assessment Objective		Command Word	
Strand	Element	Describe	Explain
AO1		An answer that combines the marking points to provide a logical description	An explanation that links identification of a point with reasoning/justification(s) as required
AO2		An answer that combines the marking points to provide a logical description, showing application of knowledge and understanding	An explanation that links identification of a point (by applying knowledge) with reasoning/justification (application of understanding)
AO3	1a and 1b	An answer that combines points of interpretation/evaluation to provide a logical description	
AO3	2a and 2b		An explanation that combines identification via a judgment to reach a conclusion via justification/reasoning
AO3	3a	An answer that combines the marking points to provide a logical description of the plan/method/experiment	
AO3	3b		An explanation that combines identifying an improvement of the experimental procedure with a linked justification/reasoning

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Question number	Answer	Additional guidance	Mark
1(a)	an answer of 0.036 / 0.04 with or without working scores 2 marks 134.67 - 133.59 = 1.08 (1) $\frac{(1.08)}{30}$ = 0.036 (1)	 1.08 with no working scores 1 mark allow ECF for MP2 if all 3 pieces of data have been used in MP1	**(2)** **AO2-1**

Question number	Answer		Mark
1(b)	any two from : • distance from beaker to {flame/wick/burner} (1) • size of wick (1) • volume of water (1) • temperature increase of water (1) • {size/shape/type} of beaker (1)	 allow type of wick allow amount or mass for volume allow initial temperature of water ignore time ignore same person ignore volume/mass of fuel	**(2)** **AO1-2**

Question number	Answer		Mark
1(c)	any two from : • move beaker closer to spirit burner (1) • use a metal {calorimeter/beaker} instead of glass (1) • use (draft) shields (1) • place a lid on the beaker (1) • insulate the (sides of the) beaker (1)	reject use a polystyrene beaker	**(2)** **AO3-3**

Question number	Answer	Additional guidance	Mark
2(a)	6 or 7 points plotted correctly (2) or 4 or 5 points plotted correctly (1) best fit curve starting at (0,0) (1)	allow +/- half a square for MP3, curve must be a single smooth curved line going through most or all of THEIR plotted points (ecf allowed), or if the points are not visible, through most or all of the correct values reject curves going above or below 100cm^3 by more than half a square reject straight line / dot to dot straight lines bar charts – max 2 marks for plotting points if time value is clear	**(3)** **AO2-1**

Question number	Answer	Additional guidance	Mark
2(b)(i)	13	answer may be given in table	**(1)** **AO2-1**

Question number	Answer	Additional guidance	Mark
2(b)(ii)	An explanation linking	Note: a comparison of the rate of marble chips with that of marble powder is ignored ignore anything about rate increasing at the beginning / starts fast	**(3)** **AO3-2**
	• rate of reaction decreases / reaction is slow**er** (1)	allow (rate of) reaction slows down ignore references to volumes of gas produced ignore reaction stops	
	• as {reactants /acid/ marble chips} are used up (1)	allow {concentration/amount} of acid decreases / marble chips getting smaller allow {marble chips <u>have</u> / acid <u>has</u>} react**ed** allow less {reactants/ marble chips/ acid} available ignore limiting factor/ reaction is ending	
	• so less frequent collisions (1)	allow fewer (successful) collisions ignore less particles have less energy	

Question number	Answer	Additional guidance	Mark
2(c)	graph to show • initial line steeper and to the left (1) • line levelling off at 100 cm^3 before 5 minutes (1)	there must be a line from part (a) to award these marks if lines are not labelled, make a reasonable assumption about which is C mark independently. line should start from start of original line all levelling off within half a square of original line	**(2)** **AO3-2**

Question number	Answer	Additional guidance	Mark
3(a)	An explanation linking • 1 <u>electron</u> (1) • in outer shell(s) (1)	 allow 1 is the last number of the electronic configuration (1) ignore electronic configurations written out reject incorrect number of electrons MP2 depends on MP1 for outer allow {highest energy / last} for shell allow ring, energy level, orbital allow: 1 outer electron (2) 1 valence electron (2) have to lose 1 electron to get full outer shell (2) same number of electrons in outer shell (1) forms a +1 ion by losing one electron (1)	**(2)** **AO1-1**

Question number	Answer	Mark
3(b)	**C** soft enough to be cut by a knife / low melting point is the only correct answer **A** and **D** are incorrect because alkali metals do not have a high density **B** is incorrect because alkali metal compounds are not blue in colour	**(1)** **AO1-1**

Question number	Answer	Additional guidance	Mark
3(c)	$2\ K(s) + Br_2(g) \rightarrow 2\ KBr(s)$ balancing (1) state symbol s (1)	allow multiples ignore 'two' ignore 'solid'	**(2)** **AO2-1**

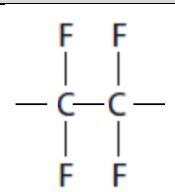
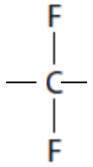
Question number	Answer	Additional guidance	Mark
3(d)(i)	An explanation linking • (atoms) {of same element / with same number of protons} / all contain 19 protons / same atomic number (1) • different number of neutrons / different mass number / have 20, 21, 22 neutrons (1)	reject compound/ molecule/ ion / element**s** once allow same protons ignore electrons reject different protons allow different / extra / more / fewer neutrons ignore different mass / relative atomic mass reject different electrons	**(2)** **AO1-1**

Question number	Answer	Additional guidance	Mark
3(d)(ii)	39.1348/39.135/ 39.13/ 39.1 with or without working scores 2 93.25 x 39 + 40 x 0.02 + 6.73 x 41 = 3913.48 (1) $\frac{3913.48}{100}$ = 39.1348 (1) OR $\frac{39 \times 93.25}{100}$ and $\frac{0.02 \times 40}{100}$ and $\frac{6.73 \times 41}{100}$ (1) 36.3675 + 0.008 + 2.7593 = 39.1348 (1)	Final answer of 39 with no working scores 0. Final answer of 39 rounded from correct working scores 2. allow rounding of values in the 3 sums allow ecf for MP2 if transcription error(s) e.g 93.52 allow ecf for MP2 if formula is correct but error in calculation	**(2)** **AO2-1**

Question number	Answer	Additional guidance	Mark
4(a)	proton atom molecule nanoparticle in the correct order (2)	allow proton molecule atom nanoparticle (1)	**(2)** **AO1-1**

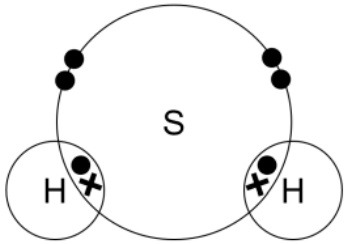
Question number	Answer	Mark
4(b)(i)	**C** 9.0×10^{-8} is the only correct answer **A** is incorrect as it is 90000 nanometres **B** is incorrect as it is 9000 nanometres **D** is incorrect as it is 0.09 nanometres	**(1)** **AO2-1**

Question number	Answer	Additional guidance	Mark
4(b)(ii)	1:15 with or without working 3 marks surface area = 90 x 90 x 6 = 48 600 (1) volume = 90 x 90 x 90 = 729 000 (1) $\frac{729\ 000}{48\ 600}$ = 15 (1) answer = 1 : 15	allow ecf $\frac{\text{surface area calculated}}{\text{volume calculated}}$ correctly evaluated (1) ratio 1:90 scores 2 $\frac{48600}{729000}$ = 0.066 (2) $\frac{729000}{8100}$ = 90 (2) $\frac{8100}{729000}$ = 0.011 (1)	**(3)** **AO3-2**

Question number	Answer	Additional guidance	Mark
4(c)(i)	 (2) OR repeat unit including: • no double bond (1) • rest of repeat unit with linking bonds (1)	allow lowercase f allow diagram to show 1, 2, 4 or 6 carbon atoms eg  2 marks ignore brackets around repeat unit and n	**(2)** **AO2-1**

Question number	Answer	Additional guidance	Mark
4(c)(ii)	Use (1) Property (1) Reason (1) (Property & reason **MUST** depend on use) Examples**:** • for coating (frying) pans (1) • because it is {slippery/non stick} (1) • food will not stick to the (frying) pan (1) OR • clothing /carpets (1) • because it is non-stick (1) • easy to clean / will not stain (1) OR • bottom of skis (1) • because it is slippery (1) • less friction on snow (1)	USES allow: pans / saucepans / tennis rackets / named kitchen equipment / piping / skis ignore: sports equipment (in general) / 'kitchenware' / windows / window ledge / toothpaste PROPERTIES allow: slippery / smooth / non-stick / unreactive / does not conduct electricity / non-toxic / high melting point ignore: strong / lightweight / high boiling point other reasonable uses include: lubricants - reduces friction graft material in surgery – inert/non-reactive prevent insects from climbing surfaces - slippery insulation of wiring & electrical circuits – does not conduct electricity/high melting point plumbers' tape – flexible/waterproof bottles – inert/non-reactive raincoat / rainjacket – waterproof Goretex™ clothing - waterproof Umbrella – water repellant flame retardant material (2) – high melting point hair straighteners – non-stick/no hair damage allow any reasonable use	**(3)** **AO1-1**

Question number	Answer	Mark
5(a)	**B** carbon dioxide is the only correct answer **A**, **C** and **D** are incorrect because the gas thought to be the highest percentage in the Earth's early atmosphere is carbon dioxide	**(1)** **AO3-2b**

Question number	Answer	Additional guidance	Mark
5(b)	 (2) OR one shared pair of electrons between S atom and each of two H atoms (1) rest of molecule correct (1)	for any marks must be molecule with two H and one S atom, but ignore shape/ bond angles unlabelled atoms can be assumed to be H and S max 1 mark if charge on molecule allow dots or crosses or a mixture of both allow with no circles ignore inner shells even if incorrect MP2 dependent on MP1	**(2)** **AO2-1**

Question number	Answer	Additional guidance	Mark
5(c)	An explanation linking any 3 from: • **sulfur/ S** (is present as an impurity) (1) • (when fuel burns) {impurity/sulfur} is {burned/ combusted/ oxidised/ reacts with oxygen} (1) • sulfur dioxide/ SO_2 (formed) (1) • sulfur dioxide dissolves in {rain/ water/ clouds} (1) • sulfuric acid is formed (1)	ignore any references to nitrogen oxides/ nitric acid $S + O_2 \rightarrow SO_2$ scores MP1, MP2 and MP3 allow sulfur dioxide <u>reacts</u> with {rain/ water/ clouds} ignore sulfur dioxide mixes with {rain/ water/ clouds} allow forms sulfurous acid. suitable equation forming H_2SO_3 or H_2SO_4 scores MP3, MP4 and MP5	**(3)** **AO1-1**

Question number	Answer	Additional guidance	Mark
5(d)(i)	pH meter	allow pH probe allow universal indicator/ UI reject any other indicators ignore pH paper/ pH strips/ pH scale/ pH indicator	**(1)** **AO3-3a**

Question number	Answer	Additional guidance	Mark
5(d)(ii)	An explanation linking one pair from : • use {sulfuric / sulfurous} acid (rather than hydrochloric acid) (1) • because acid rain contains {sulfuric / sulfurous} acid / does not contain hydrochloric acid (1) OR • use rainwater rather than pure water (1) • because rainwater {does not have a pH 7 of / is not pure water} (1) OR • use acid with a higher pH / a pH between pH 4 and pH 6 (1) • because acid rain has a higher pH than 2 (1)	allow formulae allow use a less concentrated acid allow use a range of pH values (1) so that the effect of different pH can be found (1) allow a specific control variable e.g: kept at same light levels (1) because the plants may grow faster in different light conditions (1) ignore: use more plants/ use a variety of plants / leave for a longer time / have several sets of the experiment / repeat the experiment / water every day	**(2)** **AO3-3b**

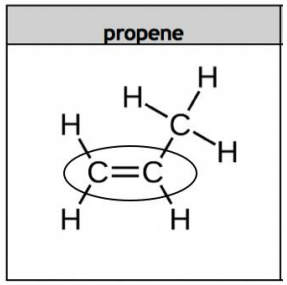
Question number	Answer	Mark
6(a)(i)	**C** oxidising, harmful and hazardous to the environment is the only correct answer **A**, **B** are incorrect because none of the substances are flammable **D** is incorrect because the third symbol does not mean corrosive	**(1)** **AO1-1**

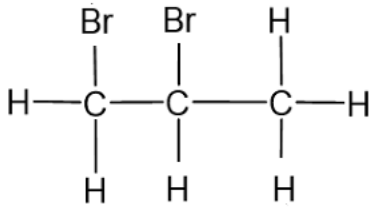
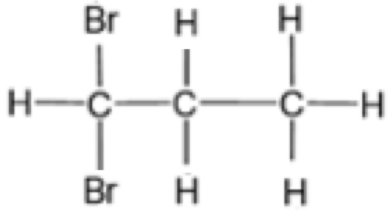
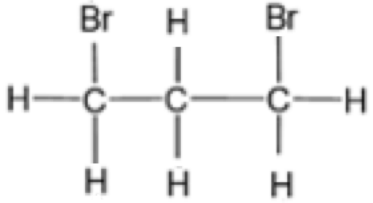
Question number	Answer	Additional guidance	Mark
6(a)(ii)	An explanation linking one pair from: • use a fume cupboard (1) • because (**chlorine/it)** is a toxic gas (1) OR • wear gloves/ goggles/ safety glasses (1) • because the concentrated **hydrochloric acid** is corrosive (1) OR • do not dispose of any reactants / products down the drain (1) • because {**potassium manganate/ chlorine /it**} is hazardous to the environment (1)	mark independently ignore any other suggestions not included in markscheme ignore masks/ breathing apparatus/ well ventilated room allow poisonous allow acids 'burns' skin/ eyes allow dispose of substances correctly allow specific hazards e.g. kills fish	**(2)** **AO2-2**

Question number	Answer	Additional guidance	Mark
6(b)	so {gas / chlorine} moves (from flask) to gas jar	ignore to deliver substances ignore to connect the apparatus / to stop gas escaping	**(1)** **AO1-1**

Question number	Answer	Additional guidance	Mark
6(c)	An explanation linking: • **chlorine** will turn the damp litmus paper (red then) white / bleached (1) • so that you can see when the jar is full (1)	reject chloride once reject bleaches then turns red for MP1 allow so you know {when to stop the reaction/ when enough chlorine has been made}/ to detect chlorine / to show that chlorine has been made / to see if chlorine is escaping allow gas for chlorine in MP2 reject to test pH for MP2	**(2)** **AO2-2**

Question number	Answer	Additional guidance	Mark
6(d)	$2KMnO_4 + 16HCl \rightarrow 2MnCl_2 + 2KCl + 5Cl_2 + 8H_2O$ all 6 formulae on correct sides of arrow (2) 4 or 5 formulae on correct sides of arrow (1) balancing of correct formulae only (1)	allow multiples do not penalise incorrect cases, subscripts e.g allow CL^2 ignore state symbols	**(3)** **AO2-1**

Question number	Answer	Additional guidance	Mark
7(a)(i)		ignore any circles drawn on other molecules must not include hydrogen	**(1)** **AO1-1**

Question number	Answer	Additional guidance	Mark
7(a)(ii)	 Br on neighbouring carbon atoms (1) rest of molecule correct with no double bond, two bromines and no extra products (1)	allow $CH_2BrCHBrCH_3$ (1) OR  (1) OR  (1) ignore the molecular formula	**(2)** **AO2-1**

Question number	Answer	Additional guidance	Mark
7(a)(iii)	water (1) carbon dioxide (1)	allow H_2O allow CO_2 allow answers in either order allow lowercase/non subscripts	**(2)** **AO2-1**

Question number	Indicative content	Mark
***7(b)**	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 6 marks** FERMENTATION • dissolve glucose in water to form a solution • place glucose solution in a suitable flask • add yeast to glucose solution • place fermentation mixture in warm room/water bath / 25-40°C • fit air lock or equivalent in neck of flask • reaction stops when bubbles stop • decant ethanol solution from yeast/ethanol mixture or filter out yeast CONCENTRATION • fractional distillation • place the dilute ethanol in round bottom flask /suitable vessel • add a fractionating column onto the round bottom flask /suitable vessel • and a thermometer on top of the of fractionating column • add condenser to top of fractionating column • run water into bottom of condenser • heat round bottom flask/vessel • to above boiling point of ethanol / below the boiling point of wate • collect concentrated ethanol from end of condenser Allow labelled diagrams	**(6)**

Level	Mark	Descriptor
	0	No rewardable material.
Level 1 a basic description of either process or a very basic description of both	1–2	add yeast to glucose (1) concentrate the ethanol using fractional distillation (1) add yeast to glucose then use fractional distillation (2) use fractional distillation, heat the ethanol solution to above boiling point of ethanol (2)
Level 2 A detailed description of one of the processes or a basic description of both processes	3–4	add yeast to glucose solution and keep in at 25-35°C then use fractional distillation to concentrate (3) mix glucose in water to form a solution and add yeast and keep warm, cotton wool in neck of flask, decant yeast when bubbles stop (4) Use fractional distillation, place the dilute ethanol in round bottom flask, add a fractionating column with a thermometer add condenser to top of fractionating column. Heat the round bottom flask to above boiling point of ethanol (4)
Level 3 both processes described with one described in detail	5–6	put glucose and yeast into conical flask and warm to 35°C, use an airlock to prevent oxygen, decant ethanol solution from mixture then use fractional distillation (5) put glucose solution and yeast into conical flask and warm to around 30°C, use an airlock to prevent oxygen entering flask, decant ethanol solution from mixture then use fractional distillation, place the dilute ethanol in round bottom flask, add a fractionating column onto the round bottom flask and heat, collect concentrated ethanol from top of fractionating column (6)

Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1) • Presents a description which is not logically ordered and with significant gaps. (AO1)
Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) • Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1) • Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)

Question number	Answer	Mark
8 (a)	**D** 82% is the only correct answer **A** is not correct as this is percentage of hydrogen in ammonia **B** is not correct as this is the mass of hydrogen multiplied by the mass of nitrogen **C** is not correct as this is the mass of hydrogen multiplied by the mass of ammonia	**(1)** **AO2-1**

Question number	Answer	Mark
8 (b)(i)	**C** arrow R is the only correct answer **A, B** and **D** are incorrect because they do not show the activation energy	**(1)** **AO2-1**

Question number	Answer	Additional guidance	Mark
8 (b)(ii)	A description to include: any two for 1 mark all three for 2 marks • energy is taken in breaking bonds (in the reactants) • energy is given out making bonds (in the products) • more energy is given out than taken in	 allow breaking bonds is endothermic allow forming bonds is exothermic allow less energy taken in than given out ignore products have less energy than reactants ignore reaction is exothermic / gives out energy alone for energy taken in allow : absorbed / needed / used /required for energy given out allow: released	**(2)** **AO1-1**

Question number	Answer	Additional guidance	Mark
8 (b)(iii)	-76 with or without working scores 4 BROKEN 944 + (3 x 436) = 2252 (1) MADE 2 x (3x388) = 2328 (1) DIFFERENCE (broken) 2252 – (made) 2328 (1) ANSWER = - 76 (1)	allow ecf ignore sign ignore sign MP3 for difference between their 2 values MP4 for correct evaluation, including correct sign, of <u>bonds broken – bonds made</u> using their values (+)76 scores 3 (+)1088 scores 3 (+)604 scores 3 (+)1476 scores 3 -1088 scores 2 -604 scores 2	**(4)** **AO2-1**

Question number	Answer	Additional guidance	Mark
8 (c)	an explanation linking AMMONIA ammonia {is simple molecular / has weak intermolecular forces} SILICON DIOXIDE silicon dioxide is {giant **covalent** / has strong **covalent** bonds} (1) DIFFERENCE more {**heat / energy**} to break bonds in silicon dioxide than intermolecular forces in ammonia	Mark independently allow weak {forces / bonds} <u>between molecules</u> allow <u>intermolecular</u> bonds reject anything ionic for MP1 allow macromolecular reject anything ionic / simple molecular for MP2 in MP3 mark is for saying **more** energy/ heat needed to break the 'attractions' <u>in silicon dioxide</u> **than** <u>in ammonia</u>. The 'attractions' do not have to be correct. allow the **energy** required to break the attractions in ammonia is small **and** the energy required to break the attractions in silicon dioxide is large	**(3)** **AO1-1**

Question number	Answer	Mark
9(a)(i)	**C** surfacing roads fuel for trains fuel for large ships is the only correct answer **A** and **B** are incorrect as bitumen is not used as a fuel for large ships **D** is not correct as diesel oil is not used for fuel for large ships	**(1)** **AO1-1**

Question number	Answer	Additional guidance	Mark
9(a)(ii)	An explanation linking • (viscosity increases down the column) as molecules are {larger/ longer/ more carbons} (1) • because there are stronger {intermolecular forces / forces **between** molecules} (1)	allow ORA allow stronger **intermolecular** bonds/ forces of attraction/ (surface area of) contact allow more **intermolecular** forces	**(2)** **AO1-1**

Question number	Answer	Additional guidance	Mark
9(b)	M_r of CH_2 = 12 + (2x1) = 14 (1) $\frac{56}{14}$ = 4 (1) formula of Y = 4 x CH_2 = C_4H_8 (1) formula of X = (C_6H_{14} + C_4H_8 =) $C_{10}H_{22}$ (1)	allow ecf throughout MP1 must be for CH_2 allow 14 x 4 = 56 allow Y has 4C and 8H C_4H_8 without working scores MP3 only. C_4H_8 = (4 x 12) + (8 x 1) = 56 scores MP1, 2 and 3 for MP4 must be written as formula $C_{10}H_{22}$ without working scores MP4 only ecf can be awarded for MP4 as long as working for alkene to be added is seen ignore formula of X = (C_6H_{14} + CH_2 =) C_7H_{16}	**(4)** **AO3-1**

Question number	Indicative content	Mark
9(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (3 marks) and AO2 (3 marks)** Ignore any issues with methane itself e.g. it is a greenhouse gas. Ignore different colours of flame with open/ closed air hole. OPEN AIR-HOLE • air-hole open, allows lots of oxygen to mix with methane • therefore complete combustion takes place • $CH_4 + 2O_2 \rightarrow 2H_2O + CO_2$ • carbon dioxide and water are produced. CLOSED AIR-HOLE • air-hole closed, less oxygen can enter to mix with methane • therefore incomplete combustion takes place • e.g $2CH_4 + 3O_2 \rightarrow 2CO + 4H_2O$ (allow other correct examples) • carbon monoxide can be produce HARMFUL EFFECTS • CO is odourless and colourless • carbon monoxide combines with haemoglobin in place of oxygen/ reduces capacity of blood for oxygen • therefore toxic • carbon/ soot can also be produced • can aggravate asthma / respiratory problems • soot makes buildings dirty • carbon dioxide and water are greenhouse gases • absorb heat energy radiated from Earth which is re-radiated back into the atmosphere • increases greenhouse effect • causes global warming/ climate change • melt polar ice caps / sea levels rise	**(6)**

Level	Mark	Descriptor
	0	No rewardable material.
Level 1 A description of open or closed air -hole or description of one harmful effect	1–2	closed air-hole gives less oxygen (1) closed air-hole gives less oxygen, open air-hole gives more oxygen (1) closed air-hole gives incomplete combustion (1) closed air-hole has less oxygen so incomplete combustion (2) complete combustion gives carbon dioxide (1) when the air-hole is open, oxygen allows complete combustion gives carbon dioxide and water (2)
Level 2 Description of two of: open air-hole/ closed air hole/ harmful effect	3–4	A closed air-hole gives less oxygen which produces soot and carbon monoxide which is toxic because it bonds to haemoglobin. (3) More oxygen gives carbon dioxide and water and incomplete combustion gives carbon monoxide and water. (4) Complete combustion produces carbon dioxide and water which are both greenhouse gases. Greenhouse gases absorb heat energy radiated from the earth and re-radiates it, this causes global temperatures to rise and leads to an increase in polar ice caps melting. (4)
Level 3 All **three aspects must be covered** Description of all three of: open air-hole/ closed air-hole/ harmful effect(s)	5–6	Incomplete combustion makes carbon monoxide but complete combustion produces carbon dioxide and water which are both greenhouse gases. Greenhouse gases absorb heat energy radiated from the earth and re-radiates it, this causes global temperatures to rise and leads to an increase in polar ice caps melting. (5) A closed air-hole gives incomplete combustion which produces carbon monoxide which is an odourless and colourless toxic gas. Complete combustion produces carbon dioxide and water which are both greenhouse gases. Greenhouse gases absorb heat energy radiated from the earth and re-radiates it, increases the greenhouse effect and temperature of the Earth’s atmosphere. (6)

Level	Mark	Descriptor
	0	• No awardable content
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Question number	Answer	Additional guidance	Mark
10 (a)(i)	An explanation linking one pair from: • use a (nichrome) wire instead of a wooden splint (1) • so the wood does not burn / as the wire will not interfere with the flame colour (1) OR • leave the wooden splint to soak in water longer (1) • so that the wooden splint does not burn when testing the sample (1)	allow metal loop / metal rod / platinum loop / (metal) inoculating loop allow use hydrochloric acid (instead of water) (1) so that the sample vaporises more easily (1) ignore (use hydrochloric acid) to remove impurities / sterilise ignore use a photometer	**(2)** **AO3-3b**

Question number	Answer	Mark
10 (a)(ii)	**B** lilac is the only correct answer **A** is incorrect as this is the colour for copper **C** is incorrect as this is the colour for calcium **D** is incorrect as this is the colour for lithium	**(1)** **AO1-1**

Question number	Answer	Additional guidance	Mark
10 (b)	A description including : • add (dilute) nitric acid (1) • add silver nitrate (solution) (1) • a white <u>precipitate</u> (1)	 ignore warming reject hydrochloric acid /sulfuric acid for MP1 MP3 is dependent on addition of silver nitrate	**(3)** **AO1-1**

Question number	Answer	Additional guidance	Mark
10 (c)(i)	2.1 scores 3 with or without working $\frac{25}{1000}$ = 0.025 (1) 0.025 x 83 = 2.075 (1) = 2.1 (1)	allow ECF throughout	**(3)** **AO2-1**

Question number	Answer	Additional guidance	Mark
10 (c)(ii)	$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ (3) **Ba^{2+}** (1) **SO_4^{2-}** (1) **$\rightarrow BaSO_4$** (1)	allow $3Ba^{2+} + 3SO_4^{2-} \rightarrow 3BaSO_4$ incorrect balancing of correct species max 2 reject Cl^- reject Al^{3+} reject $AlCl_3$ ignore any state symbols even if incorrect	**(3)** **AO2-1**