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 ▶

©2023 Pearson Education Ltd.

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.

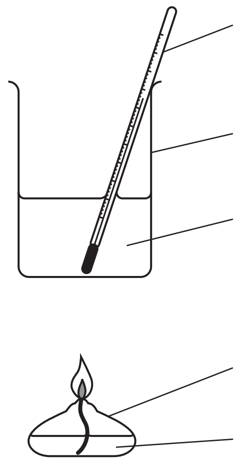


Figure 1

(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

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

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)

134.67 - 133.59 = 1.08 (1)

$\frac{(1.08)}{30}$ = 0.036 (1)

mass of butanol = 0.036 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

distance from beaker to {flame/wick/burner} (1)

variable 2

• size of wick (1)

(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

move beaker closer to spirit burner (1)

improvement 2

• use a metal {calorimeter/beaker} instead of glass (1)

(Total for Question 1 = 6 marks)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

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

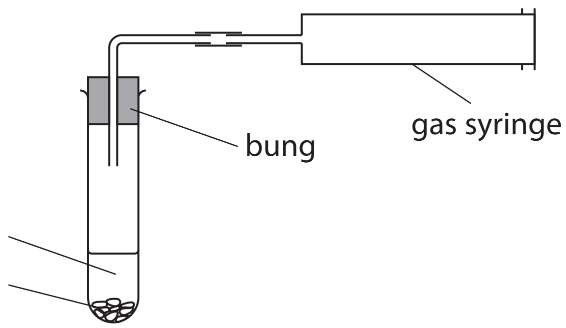


Figure 3

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

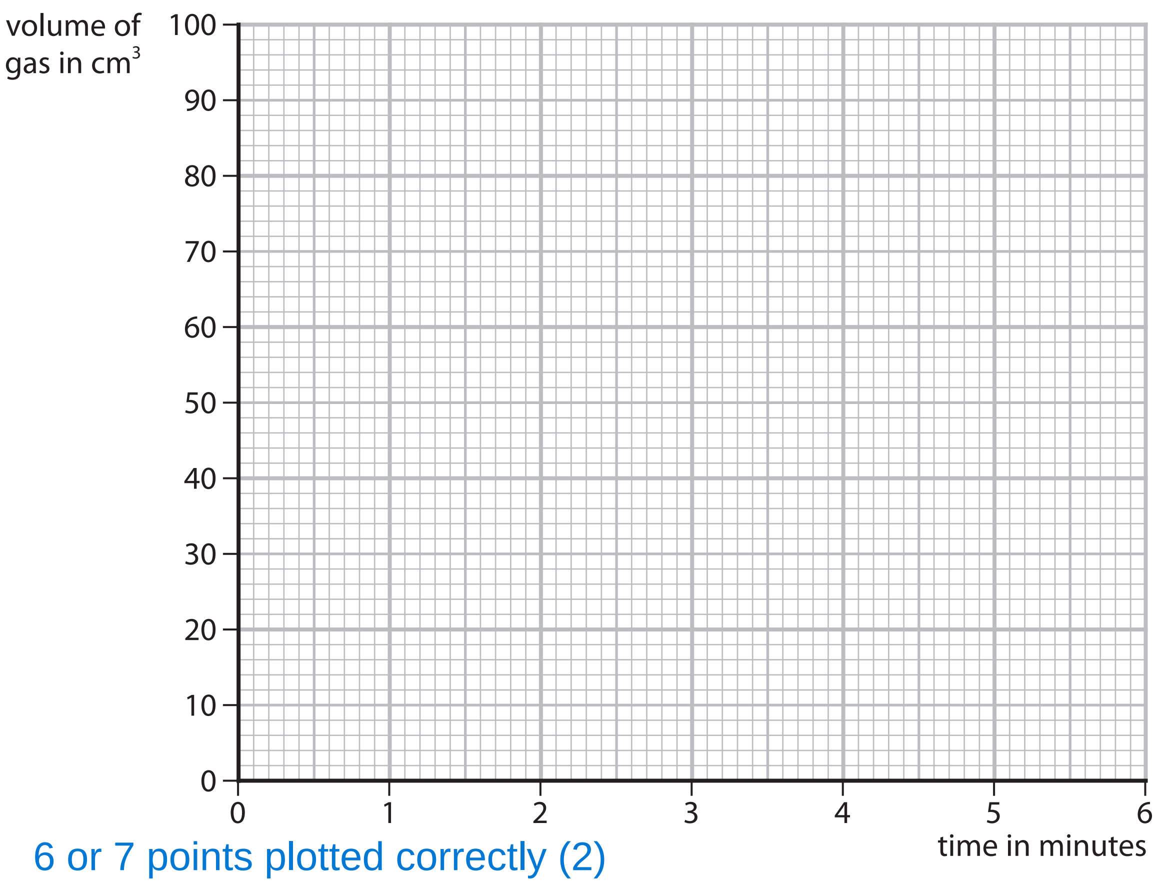
time in minutes	0	1	2	3	4	5	6
volume of gas in cm^3	0	52	78	91	97	100	100

Figure 4

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

Draw a curve of best fit.

(3)



6 or 7 points plotted correctly (2)
or
4 or 5 points plotted correctly (1)
best fit curve starting at (0,0) (1)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

P 7 2 6 3 3 A 0 4 3 2

(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 = 13 $cm^3 min^{-1}$

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

(3)

rate of reaction decreases / reaction is slower (1)

• as {reactants /acid/ marble chips} are used up (1)

• so less frequent collisions (1)

(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'.

initial line steeper and to the left (1)

• line levelling off at 100 cm3 before 5 minutes (1)

(2)

(Total for Question 2 = 9 marks)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

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)

1 electron (1)

• in outer shell(s) (1)

(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

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

(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)

2 K(s) + Br_2(g) → 2 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)

(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)

(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)

93.25 x 39 + 40 x 0.02 + 6.73 x 41 = 3913.48 (1)

$\frac{3913.48}{100}$ = 39.1348 (1)

relative atomic mass = 39.1348

(Total for Question 3 = 9 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

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

proton

atom

molecule

nanoparticle

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

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

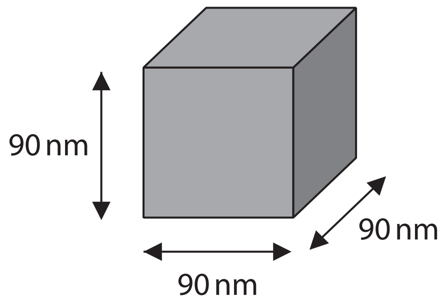


Figure 7

(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 = 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

surface area to volume ratio = 1 : 15

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

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

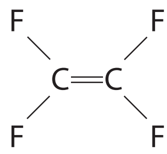
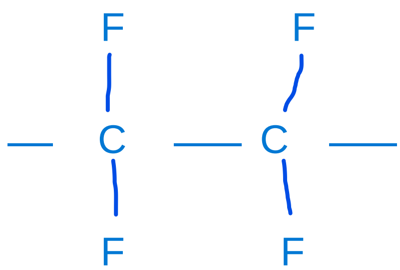


Figure 8

(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

Property (1)

explanation

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)

(Total for Question 4 = 11 marks)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

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

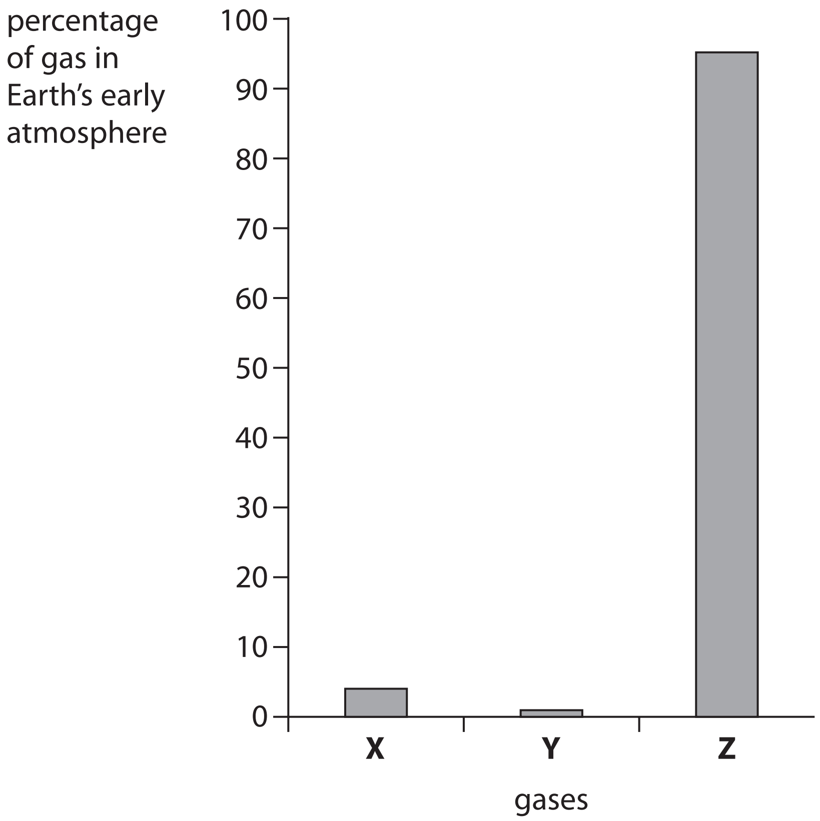


Figure 9

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

(1)

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

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

(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)

one shared pair of electrons between S atom and each of two H atoms (1)

rest of molecule correct (1)

(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)

sulfur/ S (is present as an impurity) (1)

- (when fuel burns) {impurity/sulfur} is {burned/ combusted/ oxidised/ reacts with oxygen} (1)
- sulfur dioxide/ SO2 (formed) (1)
- sulfur dioxide dissolves in {rain/ water/ clouds} (1)
- sulfuric acid is formed (1)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

(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)

pH meter

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

(2)

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

(Total for Question 5 = 9 marks)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

P 7 2 6 3 3 A 0 1 2 3 2

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

BLANK PAGE

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

Figure 10 shows the apparatus used.

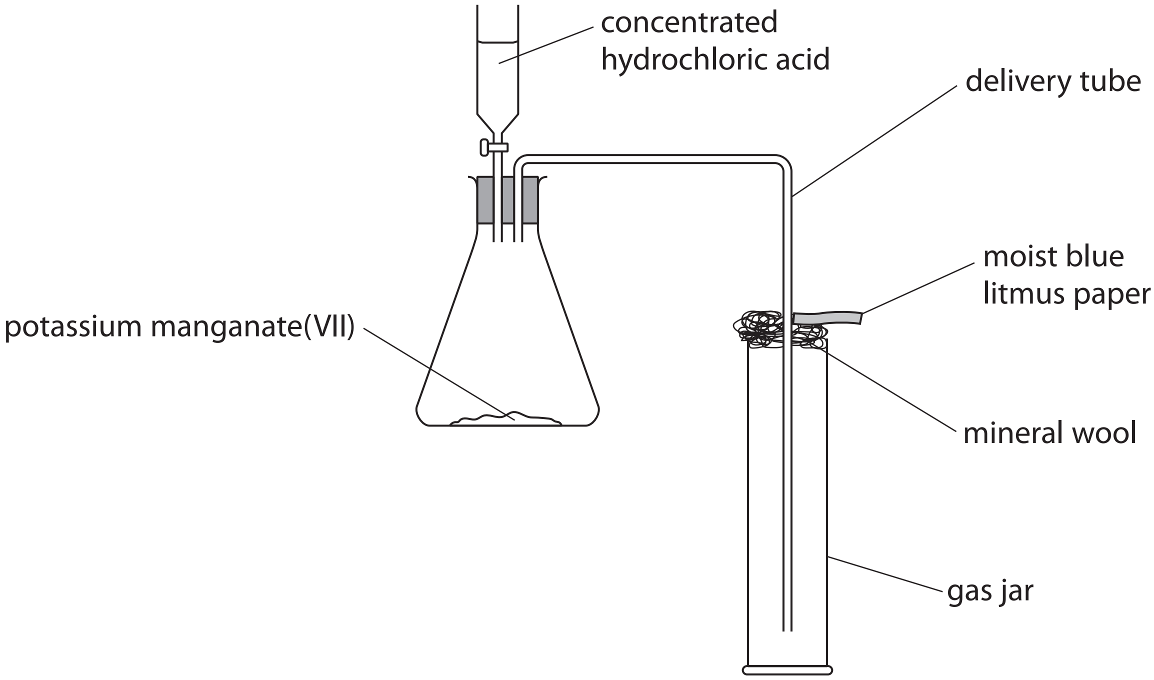


Figure 10

(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).

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

P 7 2 6 3 3 A 0 1 4 3 2

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(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

use a fume cupboard (1)

reason

• because (chlorine/it) is a toxic gas (1)

OR • wear gloves/ goggles/ safety glasses (1)

• because the concentrated hydrochloric acid is corrosive (1)

(b) State the purpose of the delivery tube.

(1)

so {gas / chlorine} moves (from flask) to gas jar

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

(2)

chlorine will turn the damp litmus paper (red then) white / bleached (1)

• so that you can see when the jar is full (1)

(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)

[redacted]

(Total for Question 6 = 9 marks)

P 7 2 6 3 3 A 0 1 5 3 2

Turn over ▶

BLANK PAGE

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

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

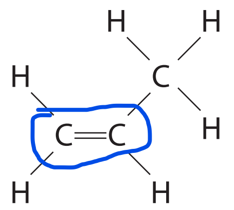
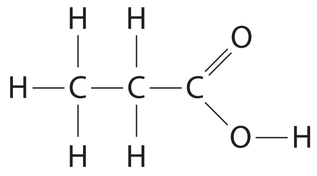
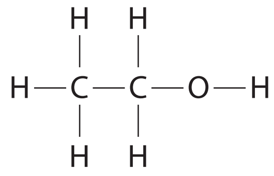
propene	propanoic acid	ethanol
		

Figure 12

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

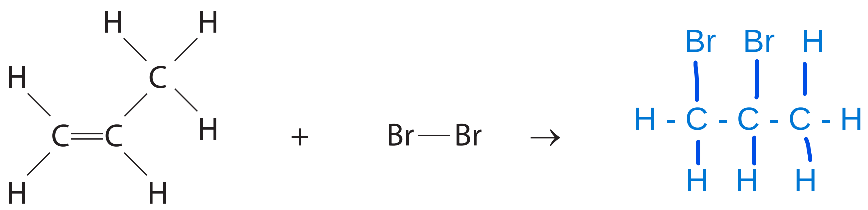
Circle the alkene functional group in **propene**.

(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 water (1)

product 2 carbon dioxide (1)

*(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)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(Total for Question 7 = 11 marks)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

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.

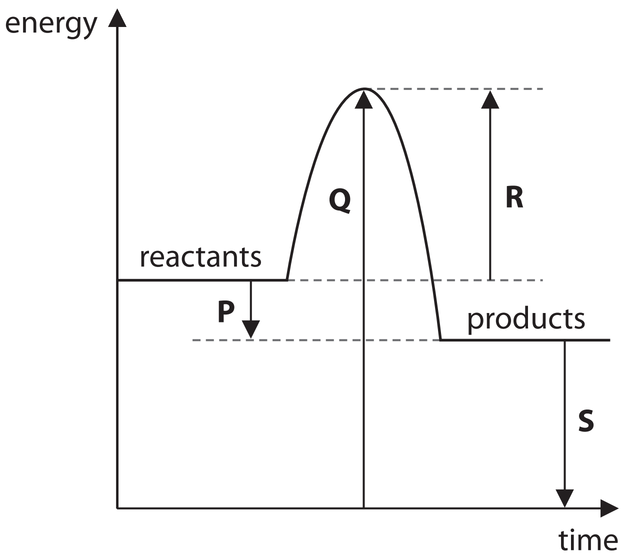


Figure 13

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

(1)

☐ **A** arrow **P**

☐ **B** arrow **Q**

☒ **C** arrow **R**

☐ **D** arrow **S**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

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

(2)

energy is taken in breaking bonds (in the reactants)

• energy is given out making bonds (in the products)

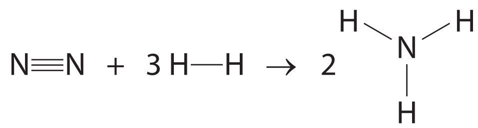
• more energy is given out than taken in

(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)

BROKEN
944 + (3 x 436) = 2252 (1)

MADE
2 x (3x388) = 2328 (1)

DIFFERENCE

(broken) 2252 – (made) 2328 (1)

ANSWER

= - 76 (1)

energy change = - 76 $kJ\,mol^{-1}$

(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)

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

(Total for Question 8 = 11 marks)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

P 7 2 6 3 3 A 0 2 2 3 2

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

BLANK PAGE

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.

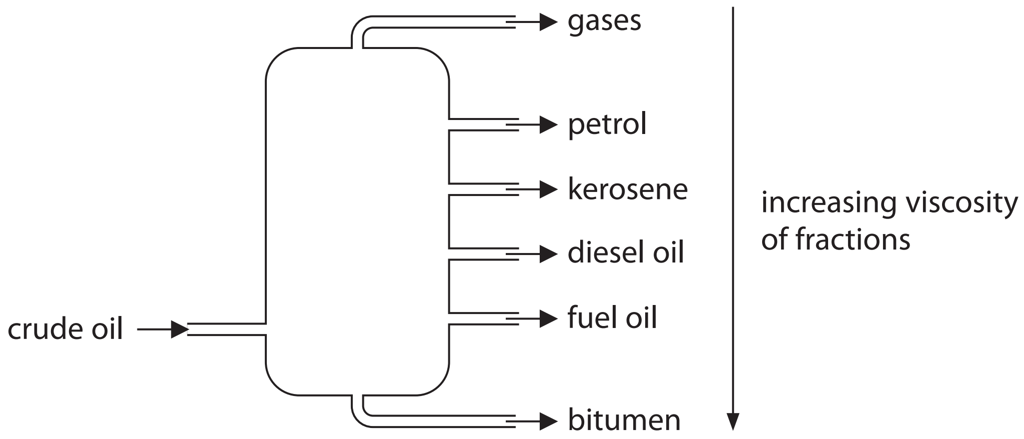


Figure 15

(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
☒ X	**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)

(viscosity increases down the column) as

molecules are {larger/ longer/ more carbons} (1)

• because there are stronger {intermolecular

forces / forces between molecules} (1)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(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)

Mr of CH2 = 12 + (2x1) = 14 (1)

$\frac{56}{14}$ = 4 (1)

formula of Y = 4 x CH2 = C4H8 (1)

formula of X = (C6H14 + C4H8 =) C10H22 (1)

molecular formula of **X** = C10 H 22

*(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.

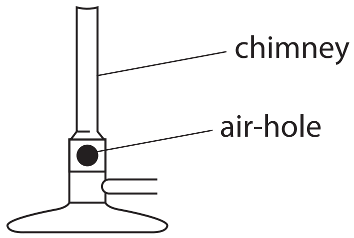


Figure 16

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)

DO NOT WRITE IN THIS AREA

(Total for Question 9 = 13 marks)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

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

use a (nichrome) wire instead of a wooden splint (1)

reason

• 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)

(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

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

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)

add (dilute) nitric acid (1)

• add silver nitrate (solution) (1)

• a white precipitate (1)

(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)

$\frac{25}{1000}$ = 0.025 (1)

0.025 x 83 = 2.075 (1)

= 2.1 (1)

mass of barium chloride = 2.1 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)

Ba2+ + SO42 ------> BaSO4 (3)

(Total for Question 10 = 12 marks)

TOTAL FOR PAPER = 100 MARKS

P 7 2 6 3 3 A 0 2 9 3 2

BLANK PAGE

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

BLANK PAGE

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

The periodic table of the elements

Key

- relative atomic mass
- **atomic symbol**
- name
- atomic (proton) number

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

***** 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.

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

P72633A03232