AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

GCSE CHEMISTRY

H

Higher Tier Paper 2

Wednesday 12 June 2019 Morning Time allowed: 1 hour 45 minutes

Materials

For this paper you must have:
- a ruler
- a scientific calculator
- the periodic table (enclosed).

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- In all calculations, show clearly how you work out your answer.

Information
- The maximum mark for this paper is 100.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	

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Answer **all** questions in the spaces provided.

0 1 This question is about crude oil and hydrocarbons.

Figure 1 shows a fractionating column used to separate crude oil into fractions.

Figure 1

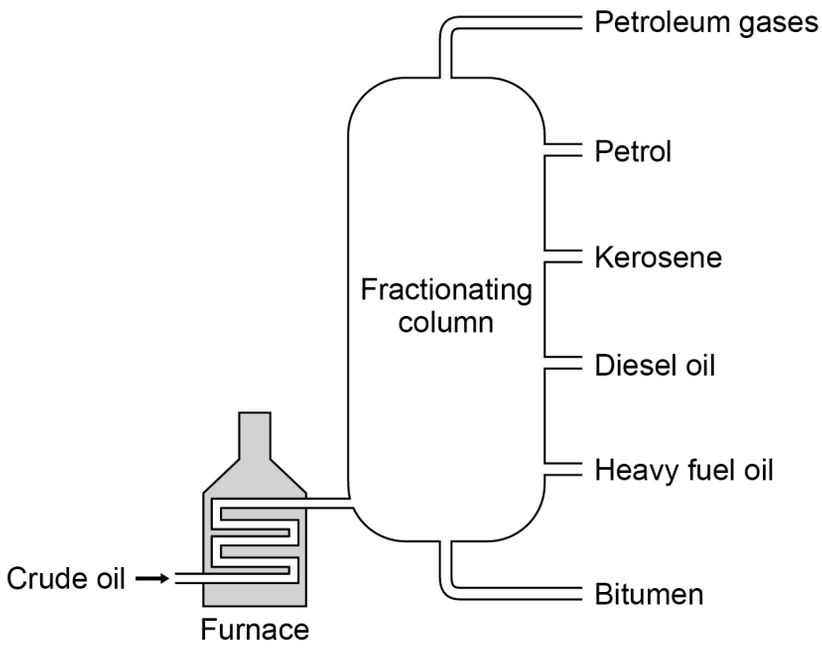

Table 1 gives information about some of the fractions.

Table 1

Fraction	Boiling point range in °C
Petroleum gases	Below 30
Petrol	40–110
Kerosene	180–260
Diesel oil	260–320
Heavy fuel oil	320–400
Bitumen	400–450

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0 1 . 1 Suggest a suitable temperature for the furnace in **Figure 1**.

[1 mark]

Bitumen has the highest boiling point of 400-450°C. so needs to be just higher.

400 – 500°C °C

0 1 . 2 Explain why diesel oil collects above heavy fuel oil but below kerosene in the fractionating column.

Use **Table 1**.

[2 marks]

Kerosene	180–260
Diesel oil	260–320
Heavy fuel oil	320–400

Diesel oil has a lower b.p. than heavy fuel oil but, higher b.p. than kerosene.

0 1 . 3 Suggest **two** reasons why bitumen is **not** used as a fuel.

[2 marks]

1 Bitumen is too viscous and not very flammable

2 The boiling point of bitumen is too high.

Question 1 continues on the next page

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0 1 . 4 Petrol contains mainly alkanes.

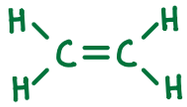
C_nH_{2n+2}

Which of the following compounds is an alkane?

[1 mark]

Tick (✓) **one** box.

C_2H_4 C_nH_{2n} alkene ☐



C_4H_8 C_nH_{2n} alkene ☐

C_6H_{14} ☑ C_nH_{2n+2} $n = 6$ C_6H_{14}

C_8H_{16} C_nH_{2n} alkene ☐

Large hydrocarbon molecules in the diesel oil fraction are cracked to produce smaller hydrocarbon molecules.

0 1 . 5 Describe the conditions needed to crack hydrocarbon molecules from the diesel oil fraction.

[2 marks]

High temperature and steam / catalyst

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0 1 . 6 Explain why large hydrocarbon molecules in the diesel oil fraction are cracked to produce smaller hydrocarbon molecules.

[2 marks]

There is greater demand for smaller molecules as they are more useful, e.g. as fuels and manufacturing polymers.

0 1 . 7 Complete the equation for the cracking of $C_{15}H_{32}$

[1 mark]

$$C_{15}H_{32} \rightarrow C_{12}H_{26} + C_3H_6$$

$C_{15}H_{32}$ → $C_{12}H_{26} + C_3H_6$

C: 12+3 = 15

H: 26+6 = 32

$C_{(15-12)}H_{(32-26)}$

11

Turn over for the next question

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0 2 This question is about lithium carbonate.

Lithium carbonate is used in medicines.

Figure 2 shows a tablet containing lithium carbonate.

Figure 2

0 2 . 1 Lithium carbonate contains lithium ions and carbonate ions.

A student tested the tablet for lithium ions and for carbonate ions.

The student used:

- a metal wire
- dilute hydrochloric acid
- limewater.

Plan an investigation to show the presence of lithium ions **and** of carbonate ions in the tablet.

You should include the results of the tests for the ions.

[6 marks]

Lithium:

Crush or dissolve tablet in water/acid
Clean wire and dip in solution
Place wire in roaring blue flame
Observe colour change.
Crimson flame indicates presence of Li

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Carbonate:

Add hydrochloric acid (HCl)
Effervescence observed
Bubble gas through limewater
Limewater becoming cloudy indicates CO_3^{2-}

0 2 . 2 The tablet also contains other substances.

The substances in tablets are present in fixed amounts.

What name is given to mixtures like tablets?

[1 mark]

Formulation

0 2 . 3 The tablet has a mass of 1.20 g and contains 700 mg of lithium carbonate.

Calculate the percentage by mass of lithium carbonate in this tablet.

[3 marks]

Mass of Li_2CO_3 = 700 mg = $\frac{700}{1000}$ = 0·7 g

Mass of tablet = 1·20 g

% by mass Li_2CO_3 = $\frac{0·7\text{ g}}{1·20\text{ g}}$ × 100% = 58·3%

Percentage by mass of lithium carbonate = 58·3 %

10

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0 3 This question is about rate of reaction.

A student investigated the rate of the reaction between magnesium and dilute hydrochloric acid.

The equation for the reaction is:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Solid Gas

0 3 . 1 Which state symbol in the equation for the reaction does **not** represent one of the three states of matter? – Solid / Liquid / Gas

[1 mark]

Aqueous (aq)

The student determined the rate of production of hydrogen gas.

0 3 . 2 What **two** pieces of measuring apparatus could the student use to find the rate of production of hydrogen gas?

[2 marks]

1 Calibrated gas syringe

2 Stopwatch

Question 3 continues on the next page

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Table 2 shows the results of the investigation.

Table 2

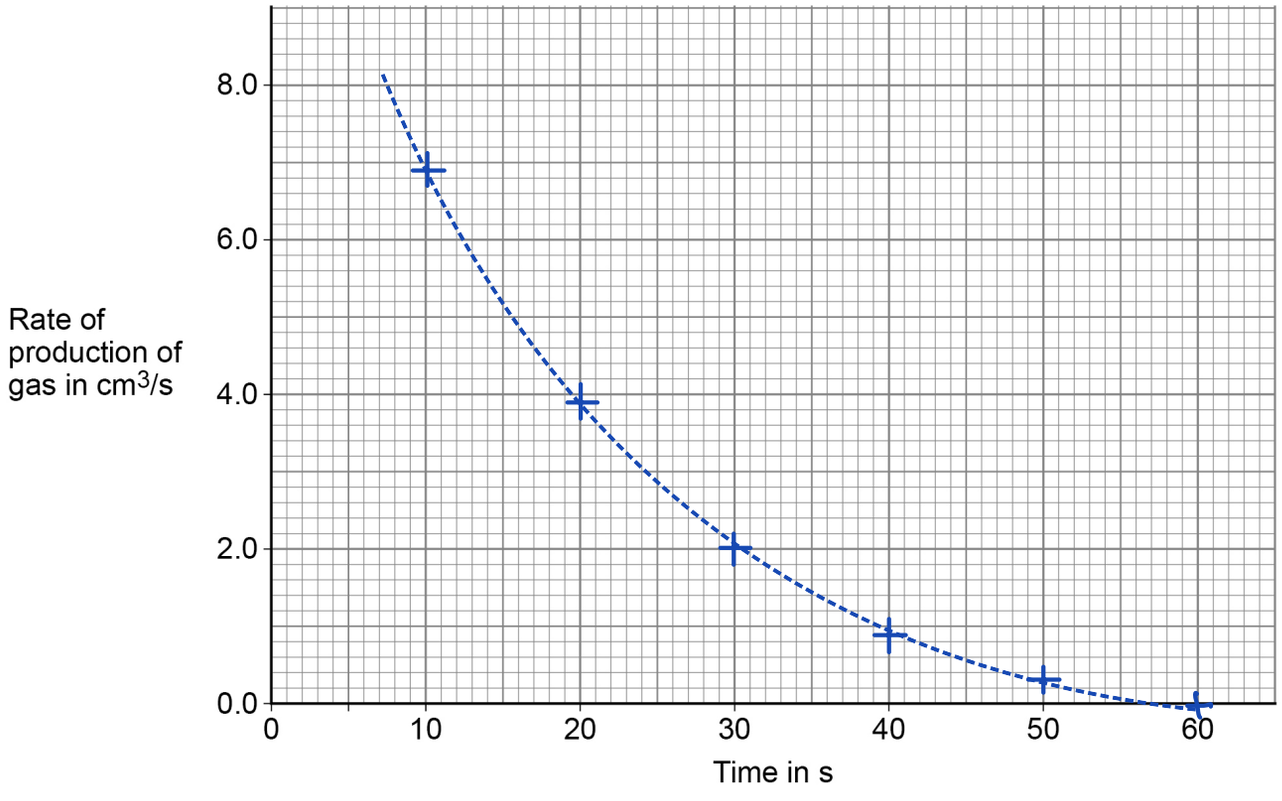
Time in s	Rate of production of gas in cm^3/s
10	6.9
20	3.9
30	2.0
40	0.9
50	0.3
60	0.0

0 3 . 3 Plot the data from **Table 2** on **Figure 3**.

You should draw a line of best fit.

[3 marks]

Figure 3



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0 3 . 4 Give **three** conclusions that can be drawn about the rate of reaction between magnesium and dilute hydrochloric acid in this investigation.

Use data from **Figure 3** and **Table 2**.

[3 marks]

1 Rate decreases as a function of time

2 Rate decreases more slowly as time increases

3 Rate becomes zero at $t = 60s$

0 3 . 5 The student repeated the investigation using dilute hydrochloric acid at a higher temperature.

All the other variables were kept the same.

Which **two** statements are correct?

[2 marks]

Tick (✓) **two** boxes.

More bubbles were produced in the first 10 seconds.	✓
The activation energy for the reaction was higher.	
The magnesium was used up more quickly.	✓
The reaction finished at the same time.	
The total volume of gas collected was greater.	

11

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0 4 This question is about the corrosion of metals.

The corrosion of iron is called rusting.

0 4 . 1 A student investigated the rusting of iron.

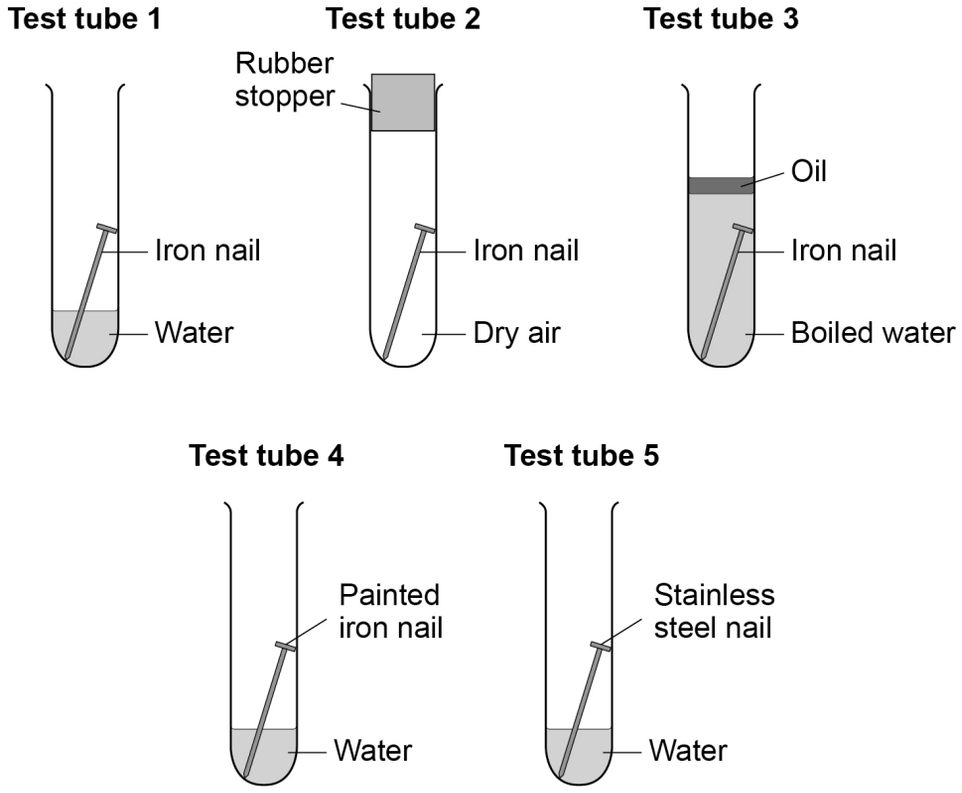
This is the method used.

1. Set up the test tubes as shown in **Figure 4**.

2. Leave the test tubes for 1 week.

3. Examine the nails for signs of rust.

Figure 4



Explain what would happen to the nails in each of the test tubes.

[5 marks]

Test Tube 1: Nail rusts as air (O_2) and water present

Test Tube 2: Nail does not rust because no water present

Test Tube 3: Nail does not rust because no air (O_2) present

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Test Tube 4: Nail does not rust because paint is a barrier to water / air.

Test Tube 5: Nail does not rust because Stainless Steel is resistant to corrosion

0 4 . 2 Magnesium is fixed to some steel ships.

Explain how this prevents the steel from rusting.

[2 marks]

Magnesium (Mg) is more reactive than iron (Fe)

Magnesium (Mg) provides sacrificial protection

0 4 . 3 Explain why aluminium window frames do **not** corrode after they are made.

[2 marks]

Aluminium forms a natural coating of aluminium oxide (Al_2O_3) which protects the metal from further corrosion.

9

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0 5 This question is about combustion of fuels.

0 5 . 1 Some central heating boilers use wood as a fuel.

Suggest **two** reasons why wood is more sustainable than natural gas as a fuel for central heating boilers.

[2 marks]

1 Wood is a renewable resource

2 Burning wood produces the same amount of carbon dioxide (CO_2) as the growing trees absorb.

Natural gas is mainly methane.

When methane burns it can produce both carbon monoxide and carbon dioxide.

0 5 . 2 Explain the process by which carbon monoxide can be produced when methane is burned.

[2 marks]

Carbon monoxide (CO) is produced rather than carbon dioxide (CO_2), when there is not enough oxygen, leading to incomplete combustion.

0 5 . 3 Balance the equation for the combustion of methane to produce carbon monoxide.

[1 mark]

2 $CH_4(g)$ + 3 $O_2(g)$ → 2 $CO(g)$ + 4 $H_2O(l)$

CH_4 + O_2 → CO + H_2O

CH_4 + O_2 → CO + $2H_2O$

CH_4 + $1\frac{1}{2}O_2$ → CO + $2H_2O$

×2 to remove fraction.

$2CH_4$ + $3O_2$ → $2CO$ + $4H_2O$

Do not write outside the box

0 5 . 4 Propane burns to form carbon dioxide and water.

The equation for the reaction is:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

5 : 3

3.60 dm^3 carbon dioxide is produced when a sample of propane is burned in 7.25 dm^3 oxygen.

Calculate the volume of unreacted oxygen.

Give your answer in cm^3

[4 marks]

3 moles of CO_2 require 5 moles of O_2

Volume CO_2 produced = 3.60 dm^3

Volume O_2 required = 3.60 dm^3 × 5/3

= 6.00 dm^3

Volume of Unreacted O_2 = 7.25 − 6.00

= 1.25 dm^3

1 dm^3 = 1000 cm^3 = 1.25 dm^3 = 1250 cm^3

Volume of unreacted oxygen = 1250 cm^3

9

Turn over for the next question

1 dm = 10 cm

1 dm^3 = 10 cm 10 cm 10 cm = 1000 cm^3

1 mole of any gas occupies 22.4 dm^3 at RTP

Can ratio gas volumes like no. moles.

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0 6 **Figure 5** shows a surfer on a surfboard.

Figure 5

Surfboards are made from polymers.

Surfboards have a poly(styrene) core and an outer skin.

0 6 . 1 **Figure 6** shows the displayed structural formula of poly(styrene).

Figure 6

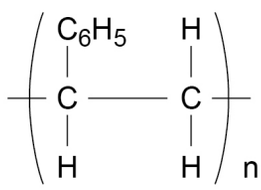
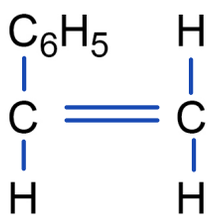


Figure 7 shows an incomplete displayed structural formula of the monomer styrene.

Complete **Figure 7**.

[2 marks]

Figure 7



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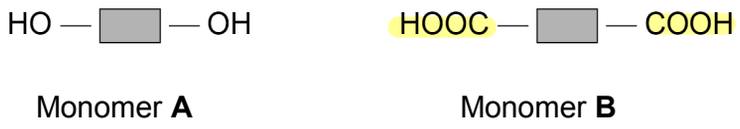
The outer skin of surfboards contains a polyester.

Two monomers, **A** and **B**, are needed to make the polyester.

Figure 8 shows how these two monomers are represented.

Figure 8

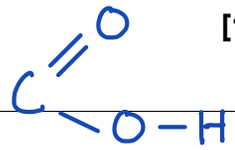


Monomer **A** Monomer **B**

0 6 . 2 Name the functional group in monomer **B**.

[1 mark]

Carboxylic acid group -COOH

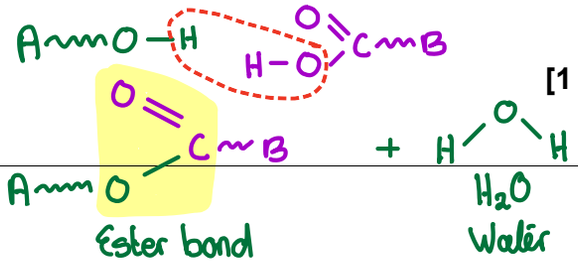


0 6 . 3 Monomers **A** and **B** join together to produce a polyester and a small molecule.

Name the small molecule.

[1 mark]

Water (H_2O)



0 6 . 4 Why does this type of polyester melt when it is heated?

[2 marks]

Polyester is thermosoftening and has no cross links

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The outer skin of surfboards is a composite material.

The composite material contains glass fibres surrounded by a polyester.

0 6 . 5 Draw **one** line from each material to the description of that material.

[2 marks]

Material	**Description of the material**
Glass fibres	Matrix
Polyester	Polypeptide
	Hydrocarbon
	Monomer
	Reinforcement

0 6 . 6 The outer skin makes the surfboard more expensive.

Suggest **two** reasons why an outer skin is added to the poly(styrene) core.

[2 marks]

1 Make the board more rigid

2 Make the board waterproof

10

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Turn over for the next question

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White precipitate forms which is soluble in excess NaOH

Do not write outside the box

0 7 A large amount of aluminium sulfate was accidentally added to the drinking water supply at a water treatment works.

0 7 . 1 Describe a test to show that the drinking water contained aluminium ions.

Give the result of the test.

[3 marks]

Test Add sodium hydroxide (NaOH) to water

Result White precipitate forms which is soluble in excess NaOH

$Al(H_2O)_3(OH)_3 \xrightarrow[NaOH]{\text{excess}} [Al(H_2O)_2(OH)_4]^-$

3+ 3x 1−

Charged complex → soluble

0 7 . 2 Describe a test to show that the drinking water contained sulfate ions.

Give the result of the test.

[2 marks]

Test Add barium chloride ($BaCl_2$) and dilute hydrochloric acid (HCl) to the water sample

Result White precipitate forms - barium sulfate $BaSO_4$

$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$

precipitate (insoluble)

Do not write outside the box

0 7 . 3 Plan an investigation to find the total mass of dissolved solids in a 100 cm^3 sample of the drinking water.

Your investigation should produce valid results.

[4 marks]

Weigh an evaporating basin
Add a measured volume of water
Weigh evaporating basin and water
Heat to evaporate water
Reweigh
Repeat heating until constant mass obtained
Subtract mass of basin from mass
Repeat and calculate a mean, discarding anomalous results
Calculate the mass in 100 cm^3 water

9

Turn over for the next question

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0 8 Titan is a moon of the planet Saturn.

Table 3 shows the percentages of the gases in the atmosphere of Titan.

Table 3

Gas	Percentage of gas in atmosphere (%)
Nitrogen	98.4
Methane	1.4
Other gases	0.2

0 8 . 1 Some scientists think that living organisms could have evolved on Titan.

Explain why these organisms could **not** have evolved in the same way that life is thought to have evolved on Earth.

Use **Table 3**.

[3 marks]

Titan has little or no oxygen

Therefore Photosynthesis has not occured on Titan

Thus little or no carbon dioxide is present

Do not write outside the box

0 8 . 2 Saturn has other moons.

The other moons of Saturn have no atmosphere.

Titan is warmer than the other moons of Saturn because its atmosphere contains the greenhouse gas methane.

Explain how this greenhouse gas keeps Titan warmer than the other moons of Saturn.

[3 marks]

Methane allows shorter wavelength radiation to pass through from the Sun.

This is re-emitted from the moon's surface as longer wavelength radiation.

This is absorbed by the methane in the atmosphere keeping Titan warmer.

$H_3C-CH_2=CH_2$

0 8 . 3 The atmosphere of Titan contains small amounts of propene.

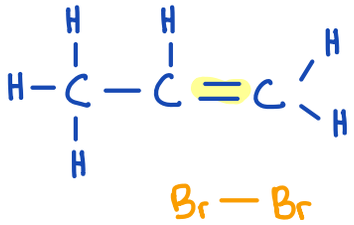
Describe a test to show that propene is an unsaturated hydrocarbon.

Give the result of the test.

[2 marks]

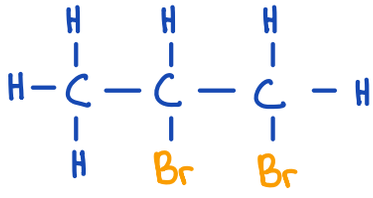
Test Add bromine water

Result Changes from orange to colourless.



$Br-Br$

Orange



Colourless

8

Turn over ►

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0 9 Some students investigated the rate of decomposition of hydrogen peroxide, H_2O_2

The equation for the reaction is:

$$2\,H_2O_2(aq) \rightarrow 2\,H_2O(l) + O_2(g)$$

The catalyst for the reaction is manganese dioxide.

0 9 . 1 Describe a test to identify the gas produced in the reaction.

Give the result of the test.

[2 marks]

Test For oxygen (O_2) use a glowing splint

Result The glowing splint relights

Do not write outside the box

Student **A** investigated the effect of the particle size of manganese dioxide on the rate of the reaction.

This is the method used.

1. Measure 25 cm^3 of 0.3 mol/dm^3 hydrogen peroxide solution into a conical flask.

2. Add a spatula of fine manganese dioxide powder to the conical flask.

3. Measure the volume of gas produced every minute for 10 minutes.

4. Repeat steps 1 to 3 with some coarse manganese dioxide lumps.

0 9 . 2 The method student **A** used did **not** give valid results.

What **two** improvements could student **A** make to the method to give valid results?

[2 marks]

Tick (✓) **two** boxes.

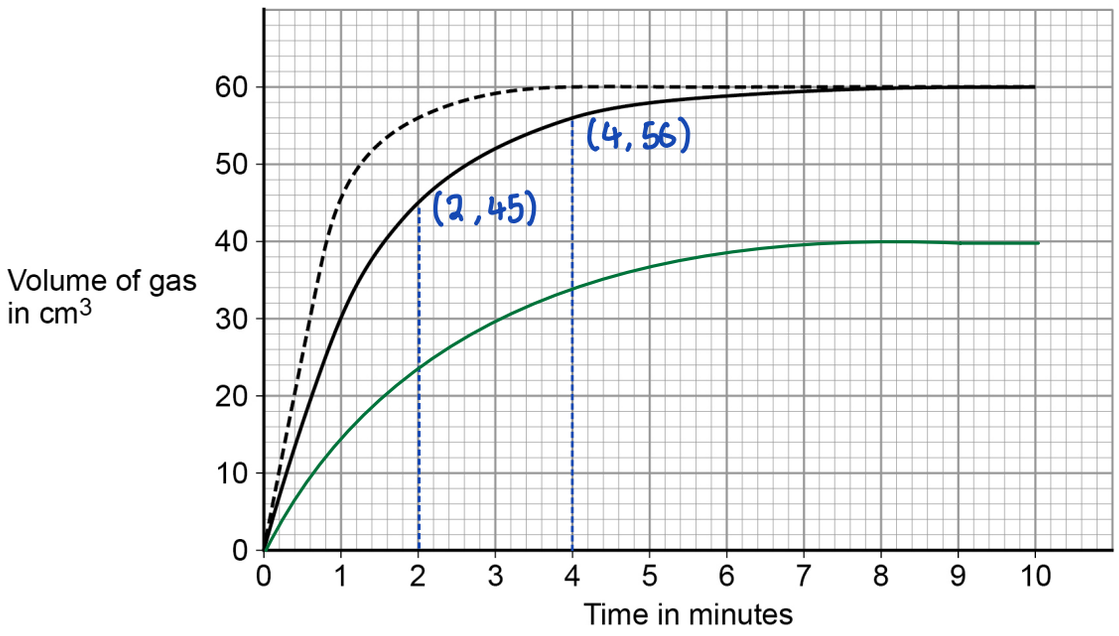
Measure the increase in mass of the conical flask and contents.	
Measure the volume of gas produced every 2 minutes.	
Place the conical flask in a water bath at constant temperature.	✓
Use 0.05 mol/dm^3 hydrogen peroxide solution.	
Use a mass of 1 g manganese dioxide each time.	✓

Question 9 continues on the next page

Student **B** used a method which gave valid results.

Figure 9 shows student **B**'s results.

Figure 9



Key

------ Fine manganese dioxide powder

——— Coarse manganese dioxide lumps

0 9 . 3 Determine the mean rate of reaction in cm^3/s between 2 and 4 minutes for coarse manganese dioxide lumps.

Give your answer to 2 significant figures.

Use data from **Figure 9**.

[3 marks]

2 min, 120 s Volume = 45 cm^3

4 min, 240 s Volume = 56 cm^3

Mean rate = $\frac{\Delta V}{\Delta t} = \frac{56 - 45\ cm^3}{240 - 120\ s} = 0.09166\ cm^3/s$

Mean rate of reaction = 0.092 cm^3/s (2 s.f.)

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Hydrogen peroxide molecules must collide with manganese dioxide particles for catalysis to take place.

0 9 . 4 Student **B** repeated the experiment with coarse lumps of manganese dioxide.

Student **B** used the same volume of 0.2 mol/dm^3 hydrogen peroxide instead of 0.3 mol/dm^3 hydrogen peroxide.

Sketch on **Figure 9** the curve you would expect to see.

Assume that the reaction is complete after 9 minutes.

[2 marks]

0 9 . 5 The rate of reaction is different when manganese dioxide is used as a fine powder rather than coarse lumps.

Explain why.

You should answer in terms of collision theory.

[2 marks]

Because the surface area of fine manganese dioxide powder is greater, so more collisions with hydrogen peroxide molecules per unit time

11

Turn over for the next question

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1 0 This question is about reversible reactions and equilibrium.

Hydrogen is used to produce ammonia in the Haber process.

The hydrogen is made in two stages.

Stage 1 is the reaction of methane and steam to produce carbon monoxide and hydrogen.

The equation for the reaction is:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

Atom Economy $= \frac{M_r\ (3H_2)}{M_r\ (CH_4 + H_2O)} \times 100$

1 0 . 1 Calculate the atom economy for the formation of hydrogen in **stage 1**.

Relative atomic masses (A_r): H = 1 C = 12 O = 16

[2 marks]

Atom Economy $= \frac{M_r\ (3H_2)}{M_r\ (CH_4 + H_2O)} \times 100 = \frac{3 \times 2}{16 + 18} \times 100$

$= \frac{6}{34} \times 100 = 17.647\ \%$

$= 17.6\ \%$

$M_r\ (H_2) = 1 \times 2 = 2$

$M_r\ (CH_4) = (12 + (1 \times 4)) = 16$

$M_r\ (H_2O) = ((1 \times 2) + 16) = 18$

Atom economy = 17.6 %

Atom Economy $= \frac{\text{Relative formula mass of desired product}}{\text{Relative formula mass of all reactants}} \times 100$

High Atom Economy is better for Profits and the Environment!

Do not write outside the box

1 0 . 2 Explain why a low pressure is used in **stage 1**.

$CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3H_{2(g)}$

1 + 1 = 2 mol

1 + 3 = 4 mol

Give your answer in terms of equilibrium.

[2 marks]

To obtain a higher yield of product. Equilibrium shifts to the right to oppose the reduction in pressure. Because more moles of gas on the right hand side.

1 0 . 3 **Stage 2** uses the carbon monoxide produced in **stage 1**.

The carbon monoxide is reacted with more steam to produce carbon dioxide and more hydrogen.

The equation for the reaction in **stage 2** is:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

1 + 1 = 2 mol

1 + 1 = 2 mol

What is the effect of increasing the pressure on the equilibrium yield of hydrogen in **stage 2**?

[1 mark]

No effect on yield as equal number of moles on both sides of the reaction equilibrium.

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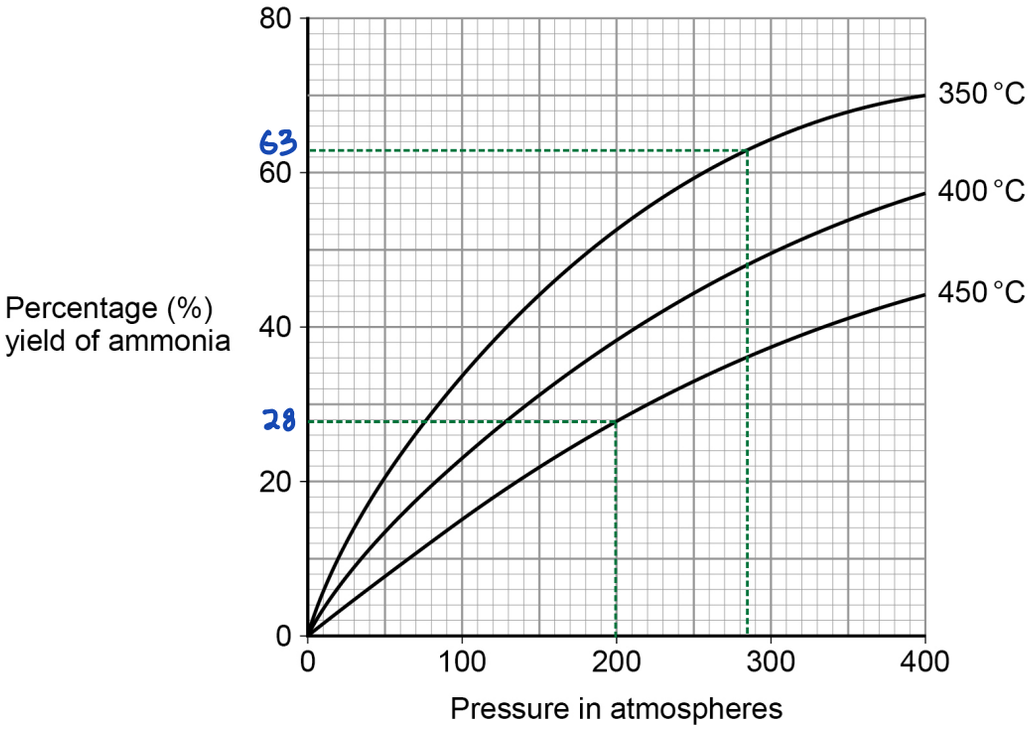
Figure 10 shows the percentage yield of ammonia produced at different temperatures and pressures in the Haber process.

Figure 10



A temperature of 450 °C and a pressure of 200 atmospheres are used in the Haber process.

1 0 . 4 A student suggested that a temperature of 350 °C and a pressure of 285 atmospheres could be used instead of those used in the Haber process.

Determine how many times greater the percentage yield of ammonia obtained would be.

Use **Figure 10**.

[3 marks]

% Yield @ 200 atm / 450°C = 28%

% Yield @ 285 atm / 350°C = 63%

Times greater % Yield = $\frac{63}{28}$ = 2.25 (x greater)

Percentage yield = 2.25 times greater

Do not write outside the box

1 0 . 5 A pressure of 285 atmospheres is **not** used in the Haber process instead of 200 atmospheres.

Give **one** reason why.

[1 mark]

Higher energy costs to produce higher pressure
(Higher pressure could be more dangerous)

1 0 . 6 How does **Figure 10** show that the forward reaction in the Haber process is exothermic?

[1 mark]

Higher temperatures produce a lower yield.

1 0 . 7 World production of ammonia is now about 30 times greater than it was in 1950.

Suggest why the demand for ammonia has increased.

[2 marks]

Ammonia is used in the manufacture of fertiliser.
Demand has increased as more crops need to be grown to feed the increased world population.

12

END OF QUESTIONS

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