



Oxford Cambridge and RSA

Tuesday 06 October 2020 – Afternoon

AS Level Chemistry A

H032/01 Breadth in chemistry

Time allowed: 1 hour 30 minutes

You must have:

- the Data Sheet for Chemistry A

You can use:

- a scientific or graphical calculator
- an HB pencil



Please write clearly in black ink. **Do not write in the barcodes.**

Centre number

--	--	--	--	--

Candidate number

--	--	--	--

First name(s)

Last name

StemUp Model Solution

INSTRUCTIONS

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION

- The total mark for this paper is **70**.
- The marks for each question are shown in brackets [].
- This document has **20** pages.

ADVICE

- Read each question carefully before you start your answer.

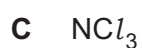
2
SECTION A

You should spend a maximum of 25 minutes on this section.

Answer **all** the questions.

Write your answer to each question in the box provided.

1 Which substance contains polar molecules?

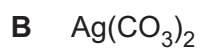


Your answer

C

[1]

2 What is the formula of silver carbonate?



Your answer

C

[1]

3 Which statement explains why ice is less dense than water?

A Hydrogen bonds are stronger in ice than in water.

B Hydrogen bonds hold H_2O molecules apart in ice.

C Ice is a solid but water is a liquid.

D Ice contains hydrogen bonds, but water does not contain hydrogen bonds.

Your answer

B

[1]

- 4 Some Group 2 compounds can be used to neutralise acid soils and to treat acid indigestion.

Which Group 2 compound would **not** be suitable for either use?

- A BaSO_4
- B CaCO_3
- C Ca(OH)_2
- D Mg(OH)_2

Your answer

A

[1]

- 5 Which p-block element contains atoms with one unpaired electron?

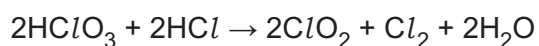
- A Al
- B Si
- C P
- D S

Your answer

A

[1]

- 6 The equation for a redox reaction is shown below.



Which statement is correct?

- A Cl is both oxidised and reduced.
- B Cl is oxidised and O is reduced.
- C O is both oxidised and reduced.
- D O is oxidised and Cl is reduced.

Your answer

A

[1]

- 7 Potassium ferrate(VI) contains two potassium ions for every ferrate(VI) ion.

What is the formula of the ferrate(VI) ion?

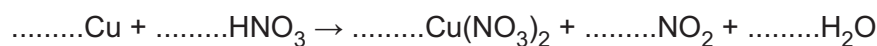
- A FeO_3^{2-}
B FeO_4^{2-}
C FeO_5^{2-}
D FeO_6^{2-}

Your answer

B

[1]

- 8 The unbalanced equation for the reaction of copper with concentrated nitric acid is shown below.



What is the number of moles of HNO_3 that react with 1 mole of Cu?

- A 2
B 3
C 4
D 6

Your answer

C

[1]

- 9 2.0 dm^3 of Cl_2 gas reacts with 2.0 dm^3 of ClF_3 gas to form 6.0 dm^3 of a gaseous compound. The reaction has 100% atom economy and all volumes are measured at the same temperature and pressure.

What is the molecular formula of the compound formed?

- A ClF
B Cl_2F_3
C Cl_3F_2
D Cl_3F_3

Your answer

A

[1]

10 Which sample contains the greatest number of molecules?

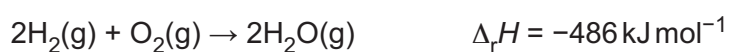
- A 1 g of methanol, CH₃OH
- B 2 g of nitrogen dioxide, NO₂
- C 3 g of phosphorus, P₄
- D 4 g of iodine, I₂

Your answer

B

[1]

11 Hydrogen and oxygen react as shown below.



Bond enthalpies are shown in the table.

Bond	H-H	O=O
Bond enthalpy / kJ mol ⁻¹	+436	+498

What is the bond enthalpy, in kJ mol⁻¹, for the O-H bond?

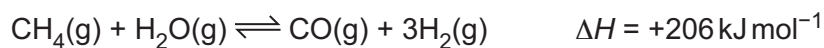
- A +221
- B +355
- C +464
- D +928

Your answer

C

[1]

12 Hydrogen gas can be produced as shown below.



Which conditions produce the greatest equilibrium yield of hydrogen?

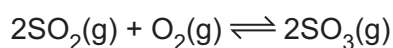
- A Low temperature and high pressure
- B Low temperature and low pressure
- C High temperature and high pressure
- D High temperature and low pressure

Your answer

D

[1]

13 The reversible reaction below is in equilibrium.



The equilibrium concentrations are shown in the table.

Substance	$\text{SO}_2(\text{g})$	$\text{O}_2(\text{g})$	$\text{SO}_3(\text{g})$
Equilibrium concentration / mol dm^{-3}	4.00	2.40	1.44

What is the numerical value of K_c ?

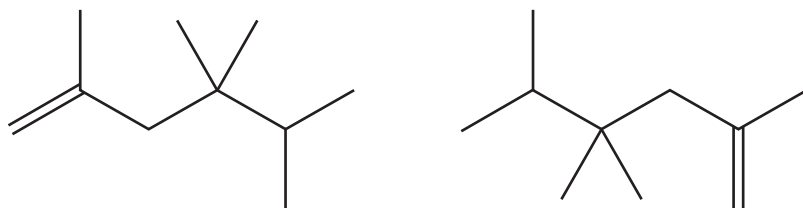
- A 0.0375
- B 0.0540
- C 0.150
- D 18.5

Your answer

B

[1]

14 Which statement is correct for the two structures below?



- A They have the same empirical formula.
- B They have different relative molecular masses.
- C They are structural isomers.
- D They have different functional groups.

Your answer

A

[1]

15 Which property explains the low reactivity of alkanes?

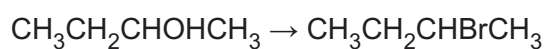
- A Electron pair repulsion between σ -bonds
- B Free rotation about σ -bonds
- C High C–C bond enthalpy
- D High polarity of the C–H bonds

Your answer

C

[1]

16 What are the correct reagents for the conversion below?



- A Br_2 and H_2SO_4
- B Br_2 and NaOH
- C NaBr and H_2SO_4
- D NaBr and NaOH

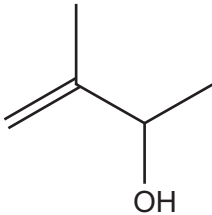
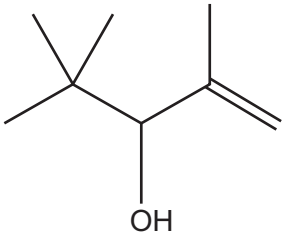
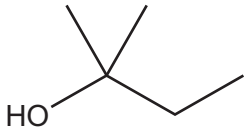
Your answer

C

[1]

17 Which compound could react with **both**

- $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}_2\text{SO}_4$ in an oxidation reaction **and**
- an acid catalyst (e.g. H_2SO_4) in an elimination reaction?

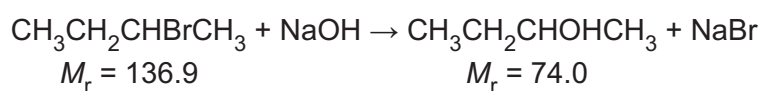
A	
B	
C	
D	

Your answer

A

[1]

18 A student reacts 24.24 g of 2-bromobutane in the reaction below.



The reaction produces 4.81 g of $\text{CH}_3\text{CH}_2\text{CHOHCH}_3$.

What is the percentage yield of $\text{CH}_3\text{CH}_2\text{CHOHCH}_3$?

- A** 10.7%
- B** 19.8%
- C** 36.7%
- D** 54.1%

Your answer

C

[1]

19 Which row describes a nucleophile?

A	electron pair donor	attracted to high electron density
B	electron pair donor	attracted to low electron density
C	electron pair acceptor	attracted to high electron density
D	electron pair acceptor	attracted to low electron density

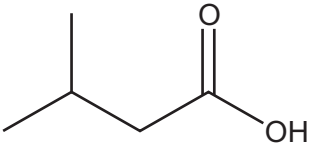
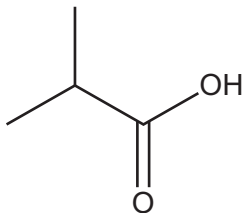
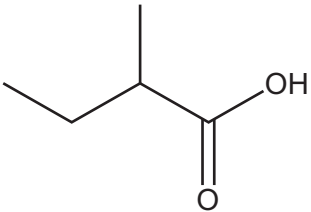
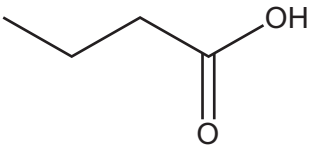
Your answer

B

[1]

20 The mass spectrum of a carboxylic acid contains peaks at $m/z = 29$ and $m/z = 102$.

Which compound could have produced the spectrum?

A	
B	
C	
D	

Your answer

C

[1]

SECTION B

Answer **all** the questions.

21 This question is about atoms, isotopes and mass spectrometry.

(a) Complete the table to show the number of electrons that can fill the first four shells.

Shell	1st shell	2nd shell	3rd shell	4th shell
Number of electrons	2	8	18	32

[1]

(b) Most elements contain atoms of different isotopes.

State any differences and similarities between the atomic structures of isotopes of the same element.

Differences *...Different numbers of neutrons...*

.....

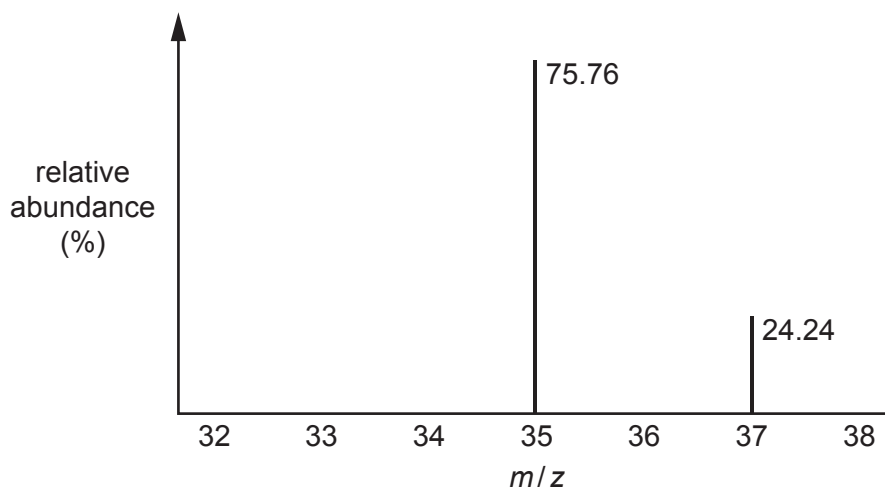
Similarities *...Same number of protons and same number of electrons...*

.....

[2]

- (c) Mass spectrometry can be used to identify the isotopes of chlorine.

Part of the mass spectrum of chlorine is shown below.



- (i) Calculate the relative atomic mass of chlorine.

Give your answer to **2** decimal places.

$$\begin{aligned}
 A_r &= [(35 \times 75.76) + (37 \times 24.24)] \div 100 \\
 &= (2651.6 + 896.88) \div 100 \\
 &= 35.4848
 \end{aligned}$$

relative atomic mass = ... 35.48 [2]

- (ii) The mass spectrum of chlorine, Cl_2 , also contains three molecular ion, M^+ , peaks. One of the M^+ peaks has an m/z value of 72.

Suggest why an M^+ peak at $m/z = 72$ is observed and predict the m/z values of the other two M^+ peaks.

Peak at $m/z = 72$ The Cl_2 molecule contains one chlorine-35 atom and one chlorine-37 atom: $^{35}\text{Cl}^{37}\text{Cl}^+$ ($35 + 37 = 72$).

m/z values of the other two M^+ peaks 70 and 74

[2]

22 This question is about compounds of bromine.

(a) Bromine reacts with phosphorus, P_4 , to form phosphorus tribromide, PBr_3 .

(i) Complete the electron configuration of a bromine atom.

$1s^2$ $2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^5$ [1]

(ii) Write the equation for the reaction of phosphorus with bromine.

$P_4 + 6Br_2 \rightarrow 4PBr_3$ [1]

(b) A compound of bromine is a solid at room temperature. The electrical conductivity of the compound at different physical states is shown in the table.

Physical state	Electrical conductivity
solid	poor
liquid	good

Name the type of lattice in the compound at room temperature and explain the different electrical conductivities.

Name of lattice Giant ionic (lattice)

Explanation for different conductivities In the solid state the ions are fixed in position in the lattice and cannot move.

In the liquid state the ions are mobile and can move, so they carry the charge.

[2]

(c) Bromine reacts with fluorine to form compound **A**.

Compound **A** is a liquid at room temperature and pressure but can easily be vaporised.

When vaporised, 0.428 g of **A** produces 76.0 cm³ of gas at 1.00×10^5 Pa and 100 °C.

Determine the molar mass and molecular formula of compound **A**.

$$pV = nRT, \text{ so } n = pV \div RT$$

$$p = 1.00 \times 10^5 \text{ Pa}; \quad V = 76.0 \text{ cm}^3 = 76.0 \times 10^{-6} \text{ m}^3; \quad T = 100 + 273 = 373 \text{ K}$$

$$n = (1.00 \times 10^5 \times 76.0 \times 10^{-6}) \div (8.314 \times 373)$$

$$= 7.60 \div 3101.1 = 2.45 \times 10^{-3} \text{ mol}$$

$$M = m \div n = 0.428 \div 2.45 \times 10^{-3} = 174.6 \text{ g mol}^{-1}$$

$$\text{Br} = 79.9, \text{ so mass of F} = 174.6 - 79.9 = 94.7$$

$$\text{number of F atoms} = 94.7 \div 19.0 = 4.98 \approx 5$$

$$\text{BrF}_5: M = 79.9 + (5 \times 19.0) = 174.9 \text{ g mol}^{-1}$$

molar mass of **A** = ...174.6..... g mol⁻¹

molecular formula of **A** = ...BrF₅.....

[5]

23 This question is about barium hydroxide.

(a) Barium hydroxide is an alkali which releases hydroxide ions, OH^- , in aqueous solution.

A barium hydroxide solution contains 3.89 g of $\text{Ba}(\text{OH})_2$ in 100 cm^3 at 20°C .

Calculate the concentration of hydroxide ions, OH^- , in mol dm^{-3} , of this solution at 20°C .

Give your answer to **3** significant figures.

$$n(\text{Ba}(\text{OH})_2) = 3.89 \div 171.3 = 0.0227 \text{ mol } (0.02271)$$

$$n(\text{OH}^-) = 2 \times 0.02271 = 0.04542 \text{ mol in } 100 \text{ cm}^3$$

$$[\text{OH}^-] = 0.04542 \times (1000 \div 100) = 0.4542 \text{ mol dm}^{-3}$$

$$= 0.454 \text{ mol dm}^{-3} \text{ (3 s.f.)}$$

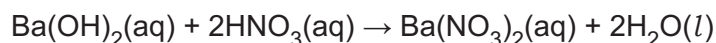
concentration of OH^- ions = ...0.454..... mol dm^{-3} [3]

(b) A student carries out a titration to determine the concentration of an aqueous solution of $\text{Ba}(\text{OH})_2$.

The student adds 25.0 cm^3 of the $\text{Ba}(\text{OH})_2(\text{aq})$ solution to a conical flask.

The student titrates this solution by adding 0.160 mol dm^{-3} $\text{HNO}_3(\text{aq})$ from the burette.

The equation is shown below.



The student repeats the titration until concordant titres are obtained.

The mean titre of 0.160 mol dm^{-3} $\text{HNO}_3(\text{aq})$ is 26.75 cm^3 .

(i) What is meant by concordant titres?

.....Titres that agree within 0.10 cm^3 of each other.....

..... [1]

- (ii) Calculate the concentration, in mol dm^{-3} , of the $\text{Ba(OH)}_2(\text{aq})$ solution.

$$n(\text{HNO}_3) = 0.160 \times 26.75 \div 1000 = 4.28 \times 10^{-3} \text{ mol}$$

$$n(\text{Ba(OH)}_2) = 4.28 \times 10^{-3} \div 2 = 2.14 \times 10^{-3} \text{ mol (in } 25.0 \text{ cm}^3\text{)}$$

$$\text{concentration} = 2.14 \times 10^{-3} \times (1000 \div 25.0)$$

$$= 0.0856 \text{ mol dm}^{-3}$$

concentration of $\text{Ba(OH)}_2(\text{aq}) = \dots\dots\dots 0.0856 \dots\dots\dots \text{mol dm}^{-3}$ [3]

- (c) A student plans to prepare a solution of Ba(OH)_2 from barium by two different reaction routes.

Outline 2 reaction routes for preparing a solution of Ba(OH)_2 from barium in the laboratory.

Include relevant equations.

Route 1: add barium to water. $\text{Ba} + 2\text{H}_2\text{O} \rightarrow \text{Ba(OH)}_2 + \text{H}_2$

Route 2: heat (burn) barium in oxygen to form barium oxide:.....

$2\text{Ba} + \text{O}_2 \rightarrow 2\text{BaO}$

then add the barium oxide to water: $\text{BaO} + \text{H}_2\text{O} \rightarrow \text{Ba(OH)}_2$

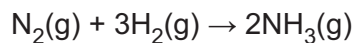
.....

.....

..... [4]

24 This question is about making ammonia, NH_3 .

(a) Ammonia is manufactured by reacting nitrogen with hydrogen:



Standard enthalpy changes of combustion, $\Delta_c H^\ominus$, are given in the table.

Substance	$\Delta_c H^\ominus / \text{kJ mol}^{-1}$
$\text{N}_2(\text{g})$	+180
$\text{H}_2(\text{g})$	-286
$\text{NH}_3(\text{g})$	-293

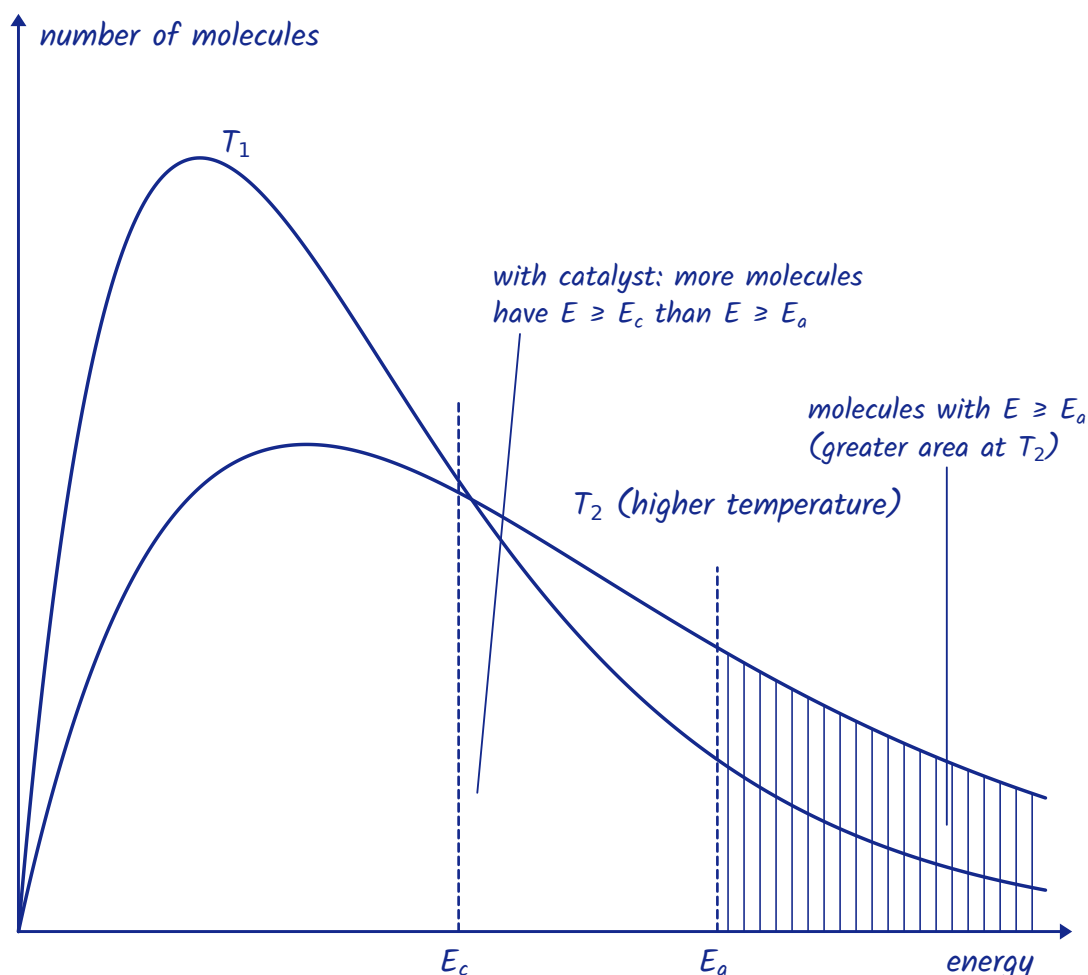
Calculate the standard enthalpy change of formation, $\Delta_f H^\ominus$, for $\text{NH}_3(\text{g})$.

$$\begin{aligned}
 \Delta_r H &= \Sigma \Delta_c H(\text{reactants}) - \Sigma \Delta_c H(\text{products}) \\
 &= [(+180) + (3 \times -286)] - [2 \times (-293)] \\
 &= (-678) - (-586) = -92 \text{ kJ mol}^{-1} \text{ (for 2 mol of NH}_3\text{)} \\
 \Delta_f H(\text{NH}_3) &= -92 \div 2 = -46 \text{ kJ mol}^{-1}
 \end{aligned}$$

$$\Delta_f H^\ominus \text{ for NH}_3(\text{g}) = \dots\dots\dots -46 \dots\dots\dots \text{ kJ mol}^{-1} \text{ [3]}$$

- (b) The industrial manufacture of NH_3 from N_2 and H_2 is carried out at an increased temperature and in the presence of a catalyst.

Explain, using Boltzmann distributions, why increasing the temperature and using a catalyst both increase the reaction rate.



At a higher temperature (T_2) the curve shifts to the right with a lower peak, so a greater proportion of molecules have energy greater than or equal to the activation energy, E_a (greater area to the right of E_a), so more collisions are successful and the rate increases.

A catalyst provides an alternative pathway with a lower activation energy, E_c .

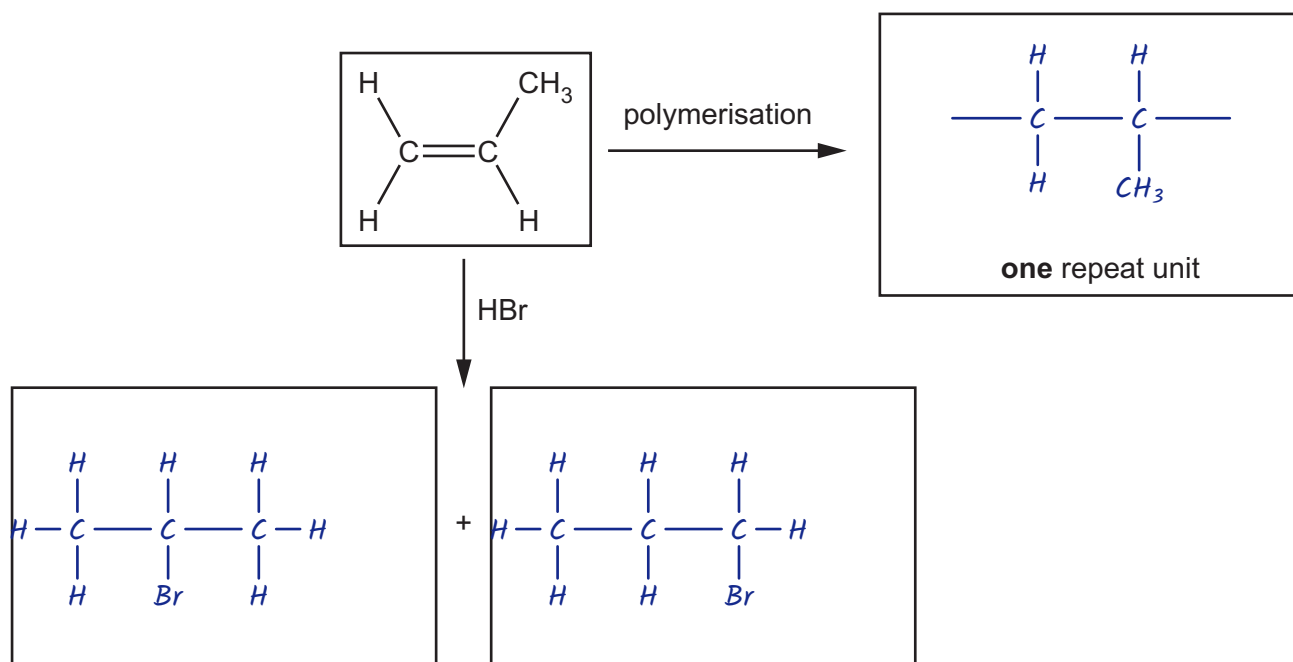
At the same temperature, more molecules have energy greater than or equal to E_c than to E_a , so more molecules have enough energy to react and the rate increases.

[5]

25 This question is about unsaturated hydrocarbons.

(a) Two reactions of propene are shown below.

In the boxes, show the structures of the organic products of the reactions.

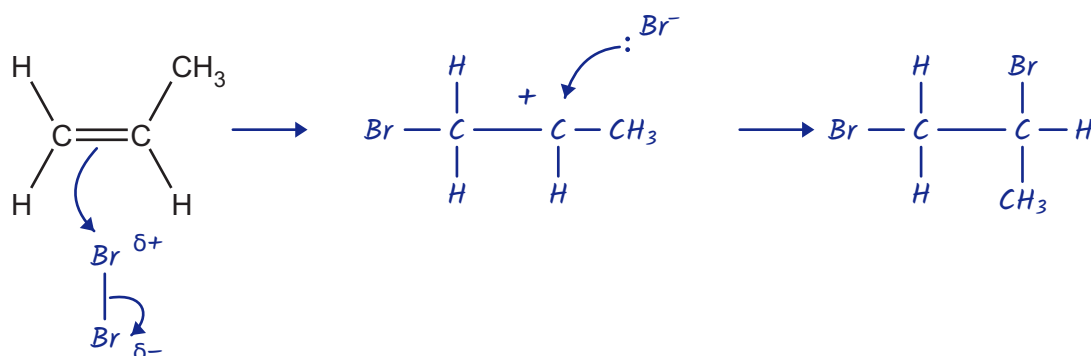


[3]

(b) Propene also reacts with bromine.

Outline the mechanism for the reaction of propene with bromine, Br₂.
The structure of propene has been provided.

Show curly arrows, relevant dipoles and product(s).



[4]

- (c) The 'alkynes' is a homologous series of hydrocarbons.

The table shows three alkynes.

Alkyne	Structural formula	Molecular formula
ethyne	$\text{HC}\equiv\text{CH}$	C_2H_2
propyne	$\text{CH}_3\text{C}\equiv\text{CH}$	C_3H_4
but-1-yne	$\text{CH}_3\text{CH}_2\text{C}\equiv\text{CH}$	C_4H_6

- (i) Explain what is meant by the term: **homologous series**.

A series of organic compounds with the same functional group and similar chemical reactions, in which each successive member differs by CH_2 . [2]

- (ii) Suggest the general formula of the alkynes.

$\text{C}_n\text{H}_{2n-2}$ [1]

- (iii) Propyne reacts with bromine to form a saturated compound.

Write an equation for the reaction, showing the structure of the organic product.



[2]

- (iv) But-1-yne is a structural isomer of C_4H_6 .

Draw the structures of 2 other structural isomers of C_4H_6 .

$\text{CH}_3\text{C}\equiv\text{CCH}_3$	$\text{CH}_2=\text{CHCH}=\text{CH}_2$
---	---------------------------------------

[2]

- (v) Draw the structure of 2,5-dimethylhept-3-yne.



[1]

END OF QUESTION PAPER

[illegible]

stemup.co.uk