

1 Allyl bromide, $\text{CH}_2=\text{CHCH}_2\text{Br}$, is used in the production of polymers.

(a) Part of the $\text{C}=\text{C}$ double bond in allyl bromide is called a π -bond.

Draw a labelled diagram to show the formation of the π -bond.

[2]

(b) Allyl bromide is a member of a homologous series. Compounds in this series have the same general formula.

(i) What is meant by the term *homologous series*?

.....
.....
.....
..... [2]

(ii) What is the general formula of the homologous series that has allyl bromide as a member?

..... [1]

(iii) Give the systematic name for allyl bromide.

..... [1]

(c) Reaction mechanisms use curly arrows and can involve electrophiles and nucleophiles.

(i) What does a *curly arrow* represent in mechanisms?

.....
..... [1]

(ii) What is meant by the term *nucleophile*?

.....
..... [1]

(d) Allyl bromide, $\text{CH}_2=\text{CHCH}_2\text{Br}$, reacts with aqueous sodium hydroxide.

(i) Outline the mechanism of this reaction.

Include curly arrows, relevant dipoles and final product(s).

[3]

(ii) Name the type of mechanism.

..... [1]

(e) Allyl bromide, $\text{CH}_2=\text{CHCH}_2\text{Br}$, reacts with bromine, Br_2 .

(i) Outline the mechanism of this reaction.

Include curly arrows, relevant dipoles and the structures of the intermediate and final product(s).

[4]

(ii) Name the type of mechanism.

..... [1]

2 1-Bromobutane, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$, reacts with methoxide ions, CH_3O^- , by nucleophilic substitution.

(a) Suggest how the methoxide ion can act as a nucleophile.

.....
..... [1]

(b) Using the 'curly arrow' model, suggest the mechanism for this reaction.

Show any relevant dipoles.

[3]

(c) 1-Iodobutane also reacts with methoxide ions.

Indicate, by placing a tick in one of the boxes, how the use of 1-iodobutane would affect the rate of reaction compared with that of 1-bromobutane.

1-Iodobutane does not change the rate	
1-Iodobutane increases the rate	
1-Iodobutane decreases the rate	

Explain your answer.

.....
.....
..... [1]

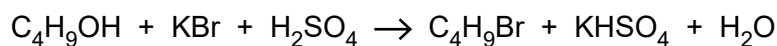
(d) The ethanoate ion, CH_3COO^- also acts as a nucleophile when reacting with 1-bromobutane in a substitution reaction.

Draw the skeletal formula and give the name of the organic product formed in this reaction.

skeletal formula

name of product [2]

- (e) 1-Bromobutane (M_r , 136.9) can be made from a reaction of butan-1-ol, C_4H_9OH , as shown in the equation below.



- (i) Calculate the atom economy for the formation of 1-bromobutane in this reaction.

atom economy = % [1]

- (ii) Suggest a reactant, other than a different acid, that could be used to improve the atom economy of making 1-bromobutane by the same method.

..... [1]

- (iii) A student prepares a sample of 1-bromobutane.

5.92 g of butan-1-ol are reacted with an excess of sulfuric acid and potassium bromide. After purification, 9.72 g of 1-bromobutane are collected.

Calculate the percentage yield.

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

percentage yield = % [3]

[Total: 12]

3 Chloroethene, CH_2CHCl , can be polymerised to form poly(chloroethene).

(a) Write an equation, using displayed formulae, to show the formation of this polymer.

[2]

(b) Incineration of plastics containing poly(chloroethene) produces waste gases that can damage the environment.

Incineration carried out in the presence of oxygen produces carbon dioxide, carbon monoxide and hydrogen chloride as waste gases and one other non-toxic product.

(i) Write an equation for the incineration of the monomer, chloroethene, with oxygen.

[1]

(ii) Chemists have developed ways of removing hydrogen chloride from these waste gases. Sodium hydrogencarbonate, $\text{NaHCO}_3(\text{s})$, is frequently used in industry for this purpose.

Explain how sodium hydrogencarbonate removes hydrogen chloride.

[1]

(c) Carbon dioxide is a greenhouse gas that is linked to global warming.

The greenhouse effect of carbon dioxide in the atmosphere is dependent on two factors.

What are these **two** factors?

1

.....

2

.....

[2]

(d) Chemists are trying to minimise climate change as a result of global warming.

One way is to use Carbon Capture and Storage (CCS). One method of CCS is to react the carbon dioxide with metal oxides.

(i) Write an equation to illustrate this method of CCS.

..... [1]

(ii) State one other method of CCS.

.....

..... [1]

[Total: 8]

4 Iodine monobromide, IBr, has a permanent dipole.

Alkenes react with IBr in a similar way to the reactions of alkenes with HBr.

(a) Propene reacts with IBr to make two possible organic products.

One of these products is 2-bromo-1-iodopropane.

(i) Using the curly arrow model, complete the mechanism to make 2-bromo-1-iodopropane.



(ii) What is the name of this mechanism?

..... [1]

(iii) Draw the structure of the other possible organic product of the reaction of propene with IBr.

[1]

5 The list shows the structural formulae of some halogenoalkanes.

N	CF_3CFCI_2	R	$\text{CH}_3\text{CH}_2\text{CHClCH}_3$
O	$\text{CH}_3\text{CH}_2\text{Br}$	S	$\text{CH}_3\text{CHBrCH}_2\text{CHICH}_3$
P	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$	T	$(\text{CH}_3)_3\text{CBr}$
Q	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{I}$		

(a) Choose from the list above, the **letter** of the halogenoalkane that is extremely unreactive.

..... [1]

(b) Halogenoalkanes react with hot $\text{KOH}(\text{aq})$ to make alcohols.

(i) Choose from the list above, the **letter** of the halogenoalkane which reacts with hot $\text{KOH}(\text{aq})$ to form a diol (a molecule with two OH groups).

..... [1]

(ii) Using the curly arrow model, describe the mechanism of the reaction between $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$ and hot $\text{KOH}(\text{aq})$ to make an alcohol.

Include relevant dipoles and the name of the mechanism.

name of mechanism [4]

(iii) Why is the reaction of **P** with hot $\text{KOH}(\text{aq})$ slower than the reaction of **Q** with hot $\text{KOH}(\text{aq})$?

.....
.....
..... [1]

- (c) Write one equation, using structural formulae, to show how but-2-ene can be converted into one of the listed halogenoalkanes, **N, O, P, Q, R, S** or **T**.

[2]

- (d) CFCs were once used as propellants but have now been replaced by biodegradable alternatives.

State **one** type of a biodegradable alternative.

..... [1]

[Total: 10]