**1.** Propene ✓

*__ALLOW__ prop-1-ene ✓*
*__DO NOT ALLOW__ prop-2-ene*

**[1]**

**2.** (i) $—CH_2CHCl— + 2½O_2 \longrightarrow 2CO_2 + H_2O + HCl$ ✓

**1**

(ii) Alkali **OR** base **OR** carbonate ✓

*__ALLOW__ correct formula of or named carbonate*
*__OR__ alkali __OR__ base*
*Correct name and wrong formula does __not__ score*

**1**

**[2]**

**3.** **Any two marks from the following:**

Develop photodegradable polymers ✓

Develop biodegradable polymers
**OR** develop compostable polymers ✓

Develop techniques for cracking polymers
**OR** develop use as a chemical feedstock ✓

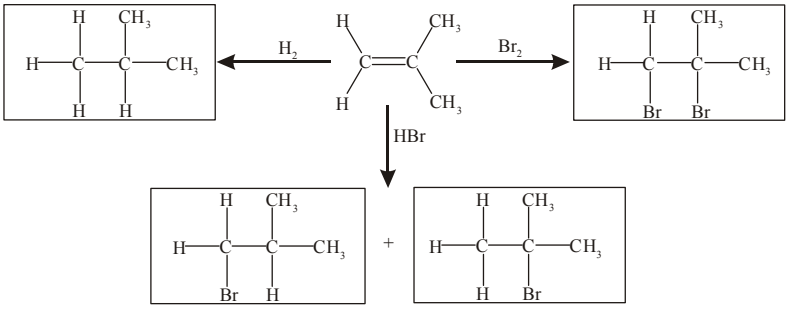
Develop ways of making polymers from plant-based substances
**OR** reduce the need to use finite raw materials such as crude oil ✓

Designing processes with high atom economy
**OR** reduce waste products during manufacture ✓

Develop ways of sorting **AND** recycling polymers ✓

**[2]**

**4.**




one mark for each correct structure ✓ ✓ ✓ ✓

***ALLOW*** *skeletal formula* ***OR*** *displayed formulae*
***IGNORE*** *molecular formulae*
***IF*** *two answers given e.g. name and structure then both must be correct to be given a mark*

***ALLOW*** *methylpropane* ***OR*** $(CH_3)_3CH$ ✓

***ALLOW*** *1, 2-dibromo-methylpropane* ***OR*** $CH_2BrCBr(CH_3)_2$ ✓

***ALLOW*** *1-bromo-methylpropane* ***OR*** $CH_2\,Br\,CH\,(CH_3)_2$ ✓

***ALLOW*** *2-bromo-methylpropane* ***OR*** $CH_3\,CBr\,(CH_3)_2$ ✓

***ALLOW*** *ecf if wrong carbon skeleton is used in all of the structures mark first structure wrong and then apply ecf for the rest*

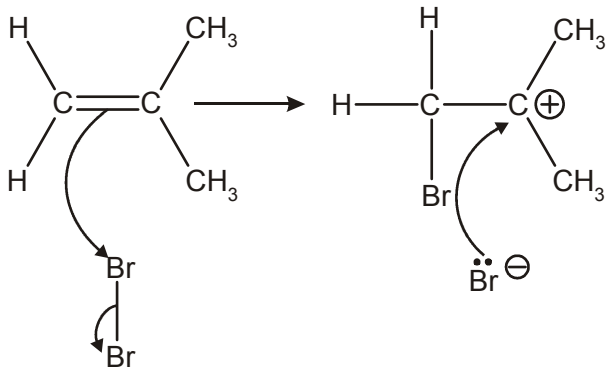
**[4]**

**5.** curly arrow from double bond to $Br^{\delta+}$ and curly arrow from Br—Br bond pair to $Br^{\delta-}$ in 1st step ✓

curly arrow in 2nd step from bromide ion ✓

correct dipole shown on $Br_2$ ✓

correct carbocation shown ✓




*Curly arrow must start from the double bond and not a carbon atom, other curly arrow must start from Br—Br bond*

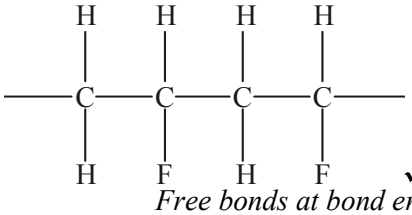
***ALLOW*** *curly arrow from any part of bromide ion*
*The bromide ion does not need to show a lone pair*

*Dipole must be partial charge and not full charge*
*Carbocation needs a full charge and not a partial charge (charges do not need to be surrounded by a circle)*

***ALLOW*** *carbocation on carbon 1 where electrophile attacks carbon 2 i.e.* $^{+}CH_2CBr(CH_3)_2$

**[4]**

**6.** (i)




✓

*Free bonds at bond ends must be present*

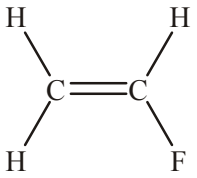
***ALLOW*** *minor slip e.g. missing one hydrogen and left as a stick*

***ALLOW*** *more than two repeat units but must be a whole number of repeat units*

***IGNORE*** *brackets, use of numbers and n in the drawn structure*

**1**

(ii)



✓

***ALLOW*** *skeletal formula*

***ALLOW*** *$CH_2CHF$*

1

**[2]**

**7. Any two from:**

separation into types and recycling **OR** sort plastics, melt and remould ✓

combustion for energy generation ✓

used for cracking **OR** feedstock for plastics or chemicals ✓

***IGNORE*** *biodegradable*

*used as a fuel is insufficient*
*releases energy is insufficient*
***ALLOW*** *burning plastics to release energy*

***ALLOW*** *organic feedstock / raw materials to make organic compounds*

**[2]**

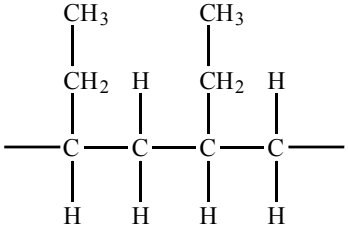
**8. 1st bullet**

product: $CH_3CH_2CHBrCH_2Br$ **(1)**
equation: $CH_3CH_2CH=CH_2 + Br_2 \rightarrow CH_3CH_2CHBrCH_2Br$ **(1)**

products: $CH_3CH_2CHBrCH_3$ **and** $CH_3CH_2CH_2CH_2Br$ **(1)**
(or statement that 2-bromo- is formed)
equation: $CH_3CH=CHCH_3 + HBr \rightarrow CH_3CH_2CHBrCH_3$ **(1)**
(*i.e.* for one product)

products: $CH_3CH_2CHOHCH_3$ **and** CH3CH2CH2CH2OH **(1)**
(or statement that 2-ol is formed)
equation: $CH_3CH=CHCH_3 + H_2O \rightarrow CH_3CH_2CHOHCH_3$ **(1)**
(*i.e.* for one product) 6

**2nd bullet**



1 mark for skeleton with two repeat units **(1)**
1 mark for correct groups on side chains **(1)** 2

**3rd bullet**

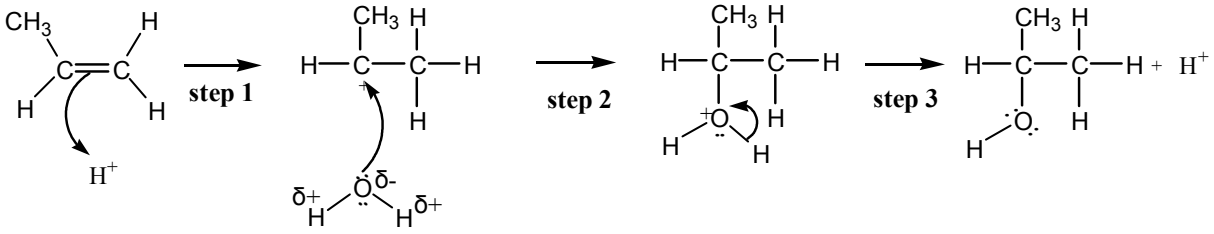
two **(1) (1)** from
energy from incineration
development of biodegradable polymers
cracking of waste polymers 2

**[10]**

**9.** (a) (i) phosphoric acid/$H^+$/sulphuric acid 1

(ii) lone/electron pair of electrons acceptor 1

(b) (i)



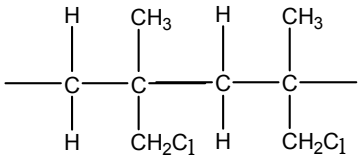

| | | |
|---|---|---|
| Step 1 | curly arrow from π-bond to $H^+$ | 1 |
| Step 2 | curly arrow from lone pair on the $O^{\delta-}$ to C+ | 1 |
| Step 3 | curly arrow from O—H bond to O+ | 1 |

(ii) catalyst … no marks because it is **not** consumed/used up in the reaction/owtte 1

**[6]**

**10.** (a) 3-chloro(-2-)methylprop-1-ene/1-chloro(-2-)methylprop-2-ene 1

(b)

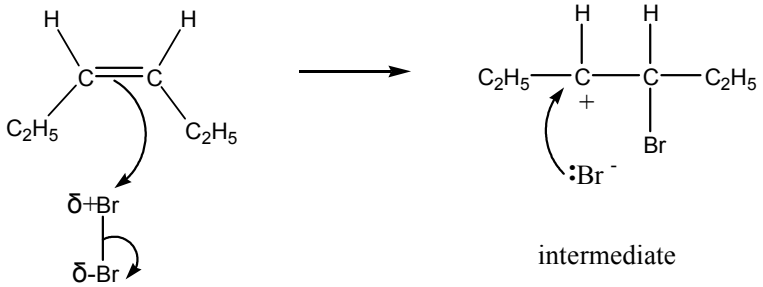


*Backbone of 4 carbons and a reasonable attempt gets 1 mark.*

2

**[3]**

**11.** (a)




intermediate

curly 1

dipoles shown correctly on the Br–Br and curly arrow from the Br–Br bond towards the $Br^{\delta}$ 1

correct intermediate shown 1

curly arrow from the lone pair or the negative charge on the $Br^-$ to the C+ 1

(b) (i) Hs are diagonal to each other in the *trans*/ difference clearly shown in a diagram 1

(ii) (the product is saturated hence) there is no restricted rotation/single bonds allow rotation/because C=C prevents rotation 1

**[6]**

**12.** $H_2$ 1

Ni/Pt/Pd (catalyst) 1

**[2]**

| | | | | |
|---|---|---|---|---|
| **13.** | (i) | alkene | 1 | |
| | | bromine | 1 | |
| | | decolourises | 1 | |
| | (ii) | 3-methylhex-2-en-1-ol/ 1-hydroxy-3-methylhex-2-ene | 1 | |
| | | | | **[4]** |

**14.** **margarine**

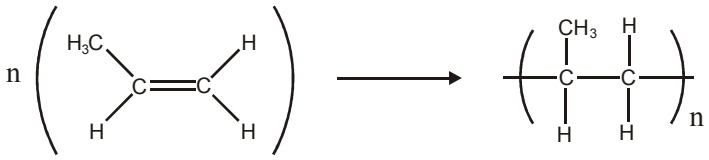
Ni catalyst 1

hydrogen/ hydrogenated 1

unsaturated vegetable oil/fat 1

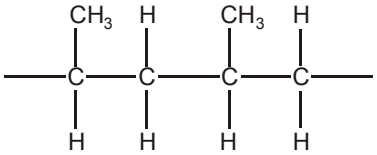
**poly(propene)**

equation




1

two repeat units




1

(Ziegler) catalyst / high temp/heat/use of an initiator

**Problems with disposal**

non-biodegradable/don't decompose/not broken down by bacteria etc 1

when burnt produces toxic fumes 1

**Future methods of disposal**

recycling (to produce new polymers) 1

incineration for energy (production) 1

cracking/owtte (to produce useful organic molecules)

use gas scrubbers to reduce toxic fumes

*any two*

*max = 9*

QWC

Answer is well organised/structure and using at least three of:

catalyst, hydrogenation, addition polymerisation, Ziegler, incineration, feedstock, recycling, non-biodegradable, initiator, monomer, unsaturated.

in the correct context. 1

**[10]**

**15.** (a) (i) $C_5H_8$ 1

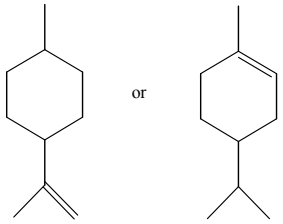
(ii) $C_5H_8$ 1

(b) (i) Ni/Pt/Pd 1

(ii) 1 mark for $C_5H_{12}$ 1

1 mark for correct balancing 1

(iii)

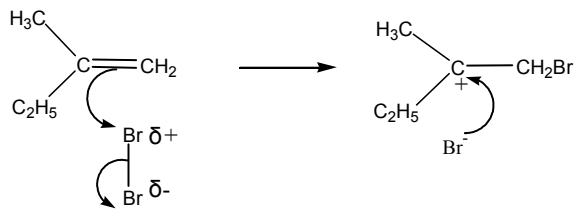



1

**[6]**

**16.** (i) electron/lone pair acceptor 1

(ii)




curly arrow from π-bond to $Br^{\delta+}$

Dipoles on the Br–Br bond
**and**
curly arrow from Br–Br bond to $Br^{\delta-}$

Curly arrow from $Br^-$ to $C^+$

1

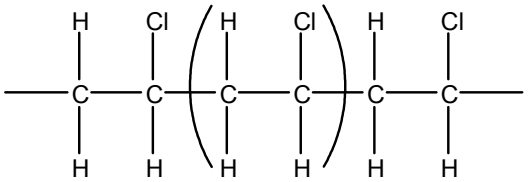
1

1

**[4]**

**17.** (i) correctly shows three repeat units with 'end bonds' 1

correctly identifies the repeat unit 1




(ii) harmful/toxic fumes are produced 1

(iii) recycle/remove HC*l* by using gas scrubbers or wtte/crack polymers/used a feedstock/ source of fuel (in an incinerator)/developing biodegradable alternatives. 2

**[5]**

**18.** (a) (i) 24.7/12 : 2.1/1: 73.2/35.5

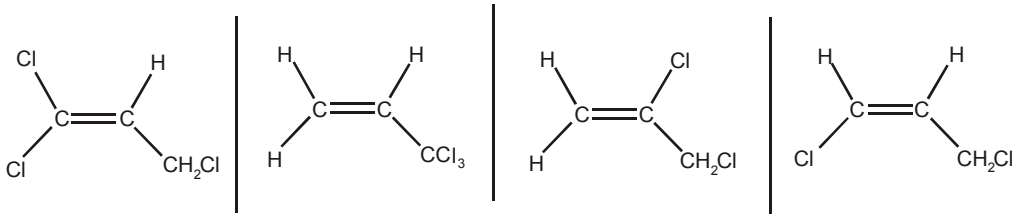
2.06 : 2.1 : 2.06 1

CHC*l* 1

(ii) (CHC*l* = 12 + 1 + 35.5 =) 48.5 1

48.5 × 3 = 145.5 1

(b) (i) Any two from 2




1,1,3 -trichloro 3,3,3 -trichloro 2,3,3 -trichloro 1,3,3 -trichloro

(ii) 1, 2,3-trichloropropene

*(trichloropropene scores 1 mark ✓)*

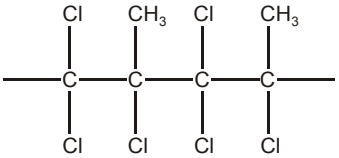
*3 marking points:*

- *correct numbers 1, 2,3*
- *trichloro*
- *propene/prop-1-ene*

*any two gets 1 mark*

2

(c) (i) 2




*1 mark if backbone contains 4 carbons with 'end-bonds' and a reasonable attempt has been made e.g used the wrong isomer…. max = 1 mark*

(ii) non-biodegradable 1

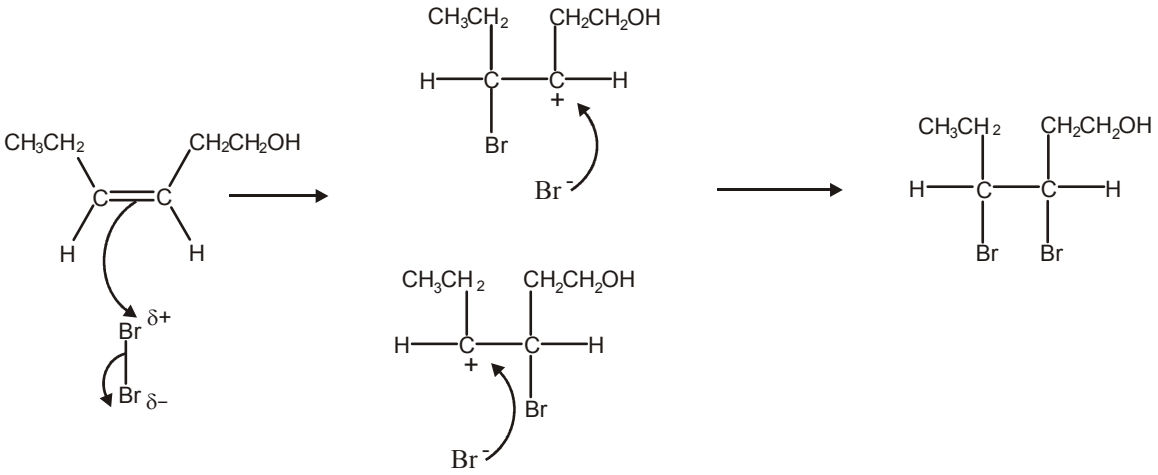
toxic fumes evolved <u>when burnt</u> 1

HC*l* or C*l*• or chlorinated organic compounds such as $COCl_2$ also evolved when burnt 1

**[13]**

**19.** (i) decolourises 1

(ii)




curly arrow from C=C bond to bromine 1

dipoles on $Br_2$ or curly arrow to show movement of bonded pair of electrons 1

intermediate carbonium ion/carbocation 1

curly arrow from lone pair on the Br- ion to carbonium ion ($Br^{\delta-}$ loses 1 mark) 1

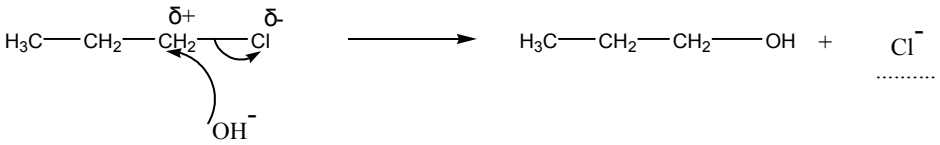
**[5]**

**20.** (a) (i) reaction 1 1

(ii) reaction 4 1

(iii) reaction 3 1

(b) (i) lone pair/electron pair donor 1




Correct dipole 1

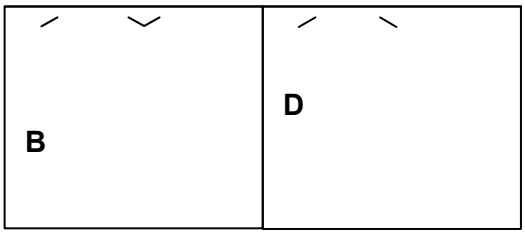
Curly arrow from the O in the $OH^-$ to C in the $CH_2$ 1

Curly arrow to show movement of bonded pair in the C-C*l* bond 1

C*l*$^-$ as a product 1

(c) (i) same molecular formula , different structure/arrangement of atoms. (same formula, different structure.) 2

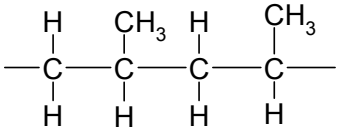
(ii) 2




(d) (i) addition, (not additional) 1

(ii) poly(propene)/ polypropene/ polypro-1-ene, polypropylene 1

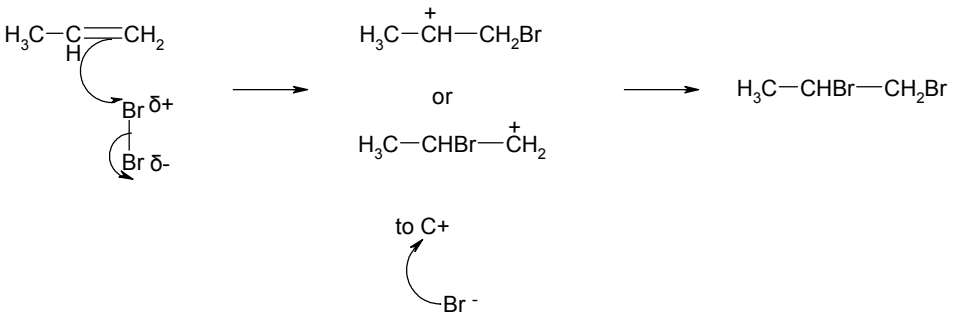
(iii) 1



**[15]**

**21.** (i) decolourises/not clear/not discolours 1

(ii)




curly arrow from C=C to $Br^{\delta+}$ 1

dipole on Br-Br **and** curly arrow showing movement of bonded pair of electrons 1

correct intermediate/carbonium ion/carbocation **and** curly arrow from $Br^-$ to C+ 1

1, 2-dibromopropane as product 1

**[5]**

**22.** $CH_3CBr_2CH_3$ 1

$CH_3CHBrCH_2Br$ 1

$CH_3CH_2CHBr_2$ 1

($CH_3CHBrCH_2Br$ has a chiral centre, hence optical isomers of 1, 2-dibromopropane are acceptable but must be drawn with 'wedge-shape' bonds and be non-superimposable mirror images)

**[3]**

**23.** (i) *unsaturated* contains a double/multiple/π bond ✓ 1

*hydrocarbon* contains hydrogen and carbon **only**. ✓ 1

(ii) angle **a** 109 –110° ✓ 1

angle **b** 117 –120° ✓ 1

(iii)

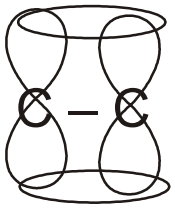


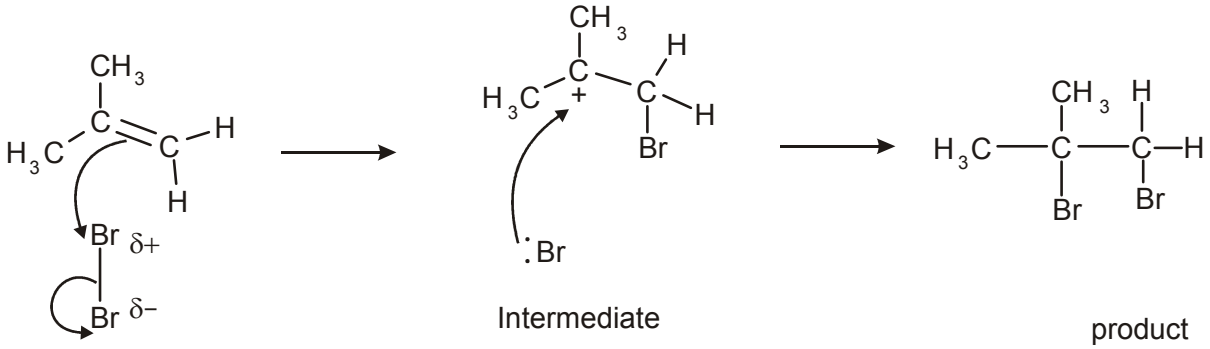
Diagram to show a minimum of 2 carbons, each with a σ-bond and p-orbitals ✓

Overlap of adjacent p-orbitals (in words or in diagram) ✓ 2

**[6]**

**24.** (i) *electrophile*: lone pair (of electrons) acceptor. ✓ 1

(ii)




essential mark intermediate carbocation/carbonium ion, accept primary /"triangular"/ ✓
essential mark product ✓

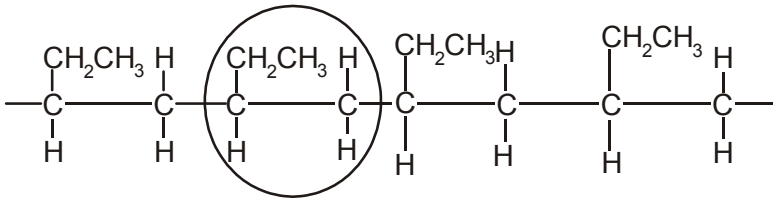
curly arrow from double bond to $Br_2$ ✓
curly arrow showing movement of electrons in the Br-Br bond **or** the dipole in the Br-Br ✓
curly arrow from lone pair of electrons in $Br^-$ to intermediate ✓
*mark any errors first*

5 max

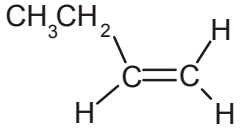
**[5]**

**25.** (i) Addition (not addition**al**) ✓ 1

(ii) ✓ 1




(iii) ✓ 1




or but-1-ene

(iv) Poly(but-1-ene) ✓ 1

**[4]**

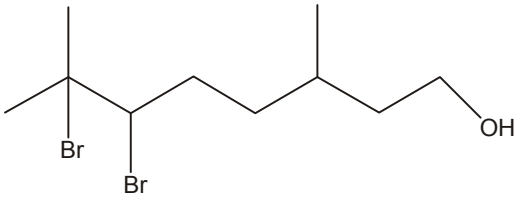
**26.** (a) (i) alkene ✓ 1

alcohol/hydroxy/hydroxyl ✓ 1

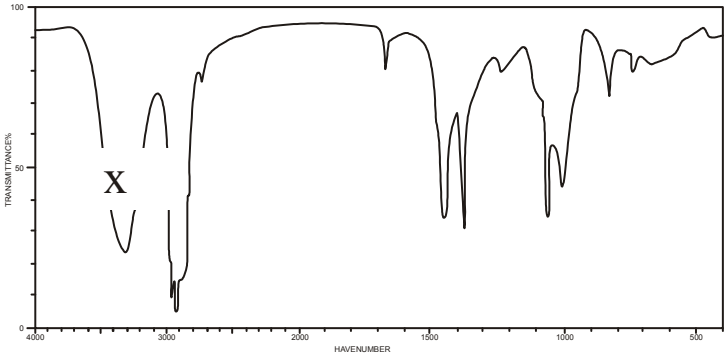
(b) (i) I = alkene & II = alcohol… both are needed ✓ 1

(ii) decolourised / colourless ✓ 1

(iii) ✓ 1




(iv) **X** as shown below ✓ 1



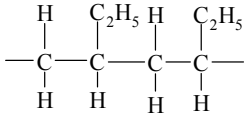

(c) (i) Ni/Pt/Rh/Pd ✓ 1

(ii) compound **B** is $C_{10}H_{22}O$ ✓ 1

(iii) $C_{10}H_{20}O + H_2 \rightarrow C_{10}H_{22}O$ ✓ 1

**[9]**

**27.**



*1 mark is available if the backbone consists of 4 C atoms and a reasonable attempt has been made* ✓✓

**[2]**

**28.** (a) (i) Alkene/C=C ✓ 1

Alcohol/ROH/hydroxy/hydroxyl/OH (not $OH^-$ or hydroxide) ✓ 1

(ii) One of the C in both C=C is joined to two atoms or groups that are the same ✓ 1

(b) Observation decolourisation (of $Br_2$) ✓ 1

Molecular formula $C_{10}H_{18}OBr_4$ ✓✓ 2

$C_{10}H_{18}OBr_2$ gets 1 mark

(c) reagent $CH_3COOH$ ✓ 1

catalyst $H_2SO_4/H^+/HCl$ (aq) *or dilute loses the mark* ✓ 1

(d) (i) $C_{10}H_{18}O + 2[O] \rightarrow C_{10}H_{16}O_2 + H_2O$ ✓✓ 2

1 mark for $H_2O$ and 1 mark for 2[O]

(ii) The infra-red spectrum was of compound **Y**

because absorption between 1680 – 1750 $cm^{-1}$ indicates a C=O ✓ 1

and the absence of a peak between 2500 – 3300 $cm^{-1}$ shows the absence of the OH hydrogen bonded in a carboxylic acid ✓ 1

**[12]**