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 ✓

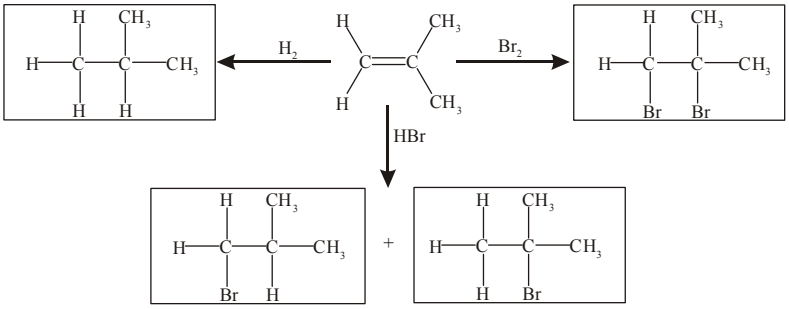
Develop ways of making polymers from plant-based substances
OR reduce the need to use finite raw materials such as crude oil ✓

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*

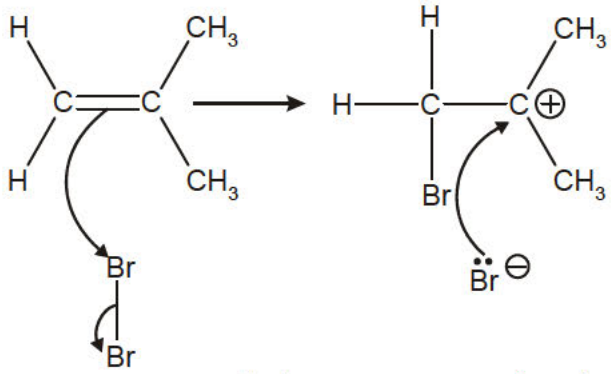
[4]

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

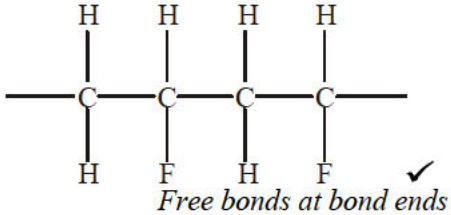
ALLOW *curly arrow from any part of bromide ion*
The bromide ion does not need to show a lone pair

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

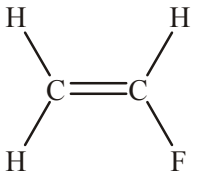
ALLOW *minor slip e.g. missing one hydrogen and left as a stick*

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

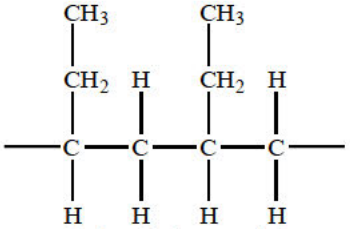
product: $CH_3CH_2CHBrCH_2Br$ **(1)**
equation: $CH_3CH_2CH=CH_2 + Br_2 \rightarrow CH_3CH_2CHBrCH_2Br$ **(1)**

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

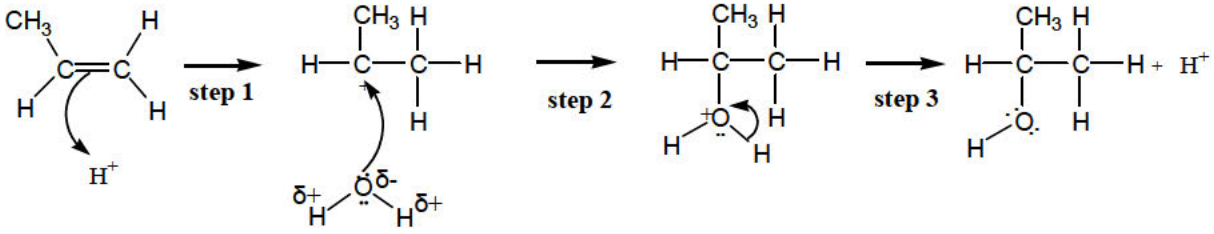
two **(1)** **(1)** from
energy from incineration
development of biodegradable polymers
cracking of waste polymers 2

[10]

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

(ii) lone/electron pair of electrons acceptor 1

(b) (i)



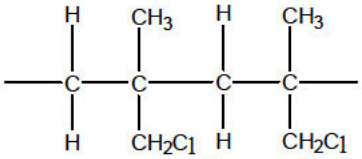
Step 1	curly arrow from π-bond to H^+	1
Step 2	curly arrow from lone pair on the $O^{\delta-}$ to C+	1
Step 3	curly arrow from O—H bond to O+	1

(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)

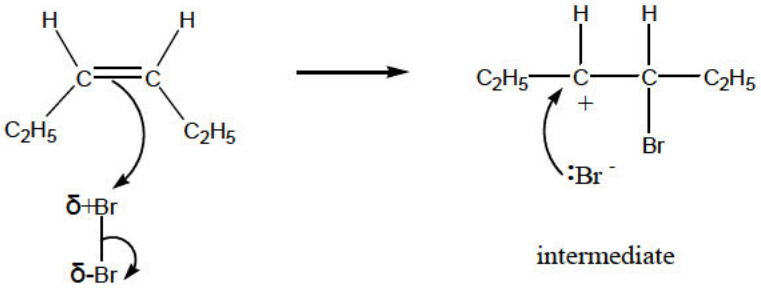


Backbone of 4 carbons and a reasonable attempt gets 1 mark.

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^{δ} 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**

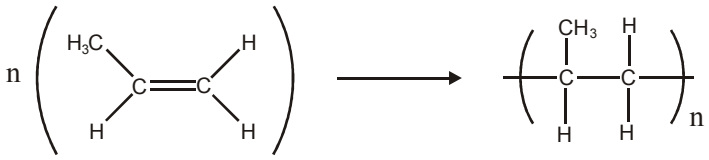
Ni catalyst 1

hydrogen/ hydrogenated 1

unsaturated vegetable oil/fat 1

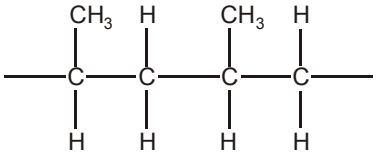
poly(propene)

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

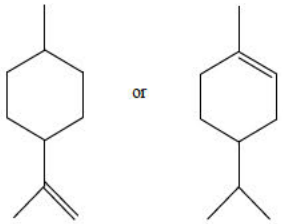
(ii) C_5H_8 1

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

(ii) 1 mark for C_5H_{12} 1

1 mark for correct balancing 1

(iii)

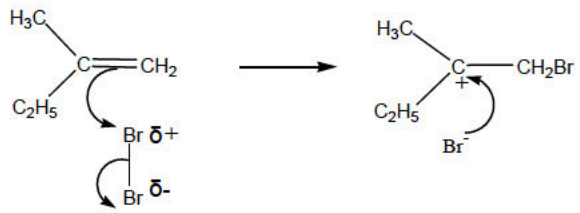


1

[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

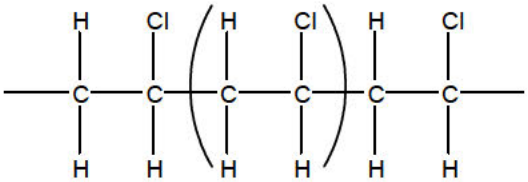
1

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

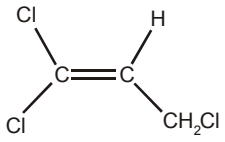
2.06 : 2.1 : 2.06 1

CHC*l* 1

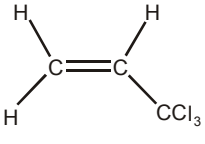
(ii) (CHC*l* = 12 + 1 + 35.5 =) 48.5 1

48.5 × 3 = 145.5 1

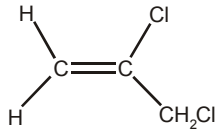
(b) (i) Any two from 2



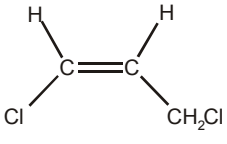
1,1,3 -trichloro



3,3,3 -trichloro



2,3,3 -trichloro



1,3,3 -trichloro

(ii) 1, 2,3-trichloropropene

(trichloropropene scores 1 mark ✓)

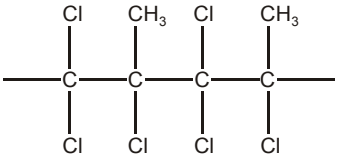
3 marking points:

- *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

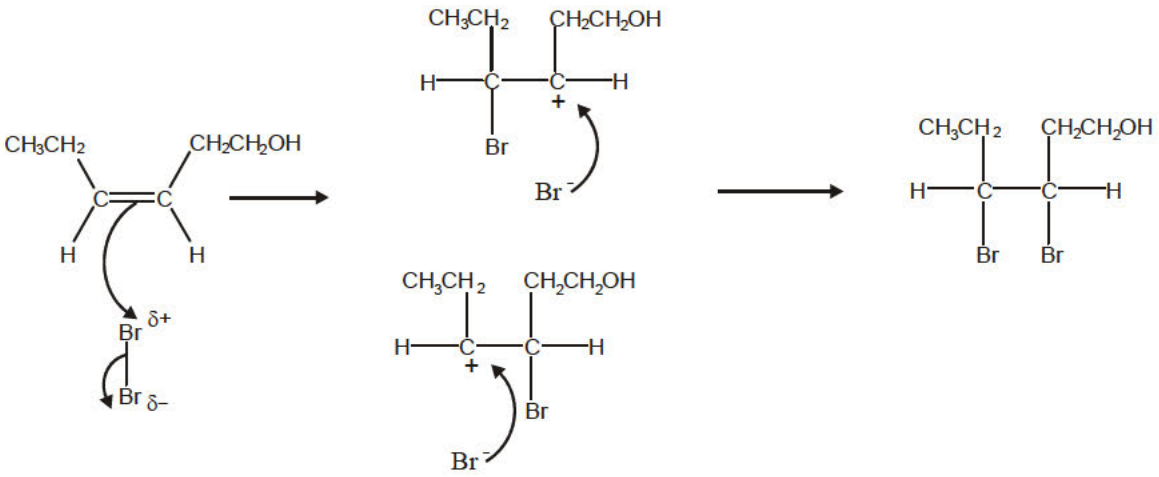
toxic fumes evolved <u>when burnt</u> 1

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

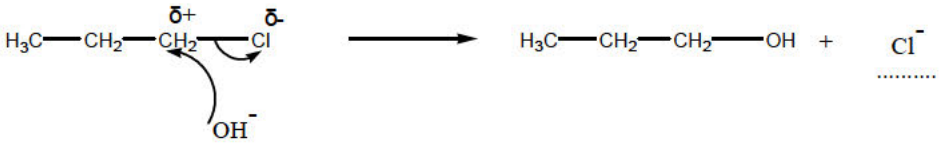
[5]

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

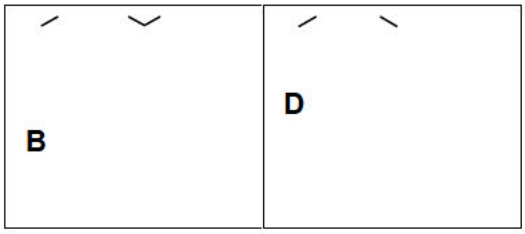
Curly arrow from the O in the OH^- to C in the CH_2 1

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

Cl^- as a product 1

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

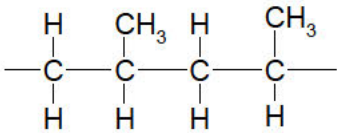
(ii) 2



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

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

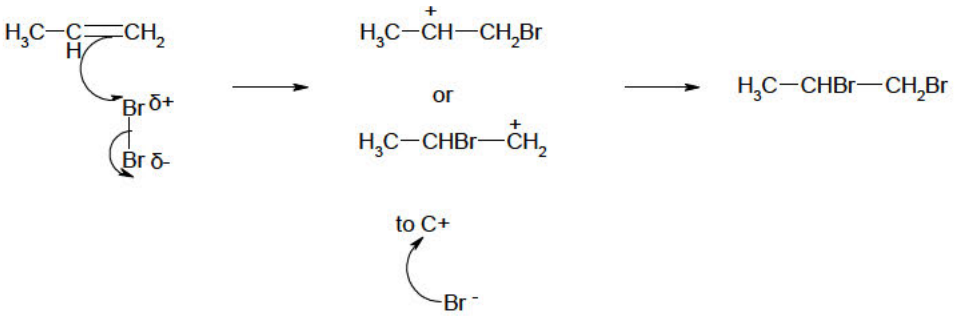
(iii) 1



[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)

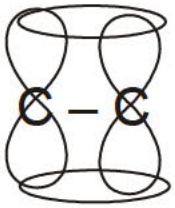


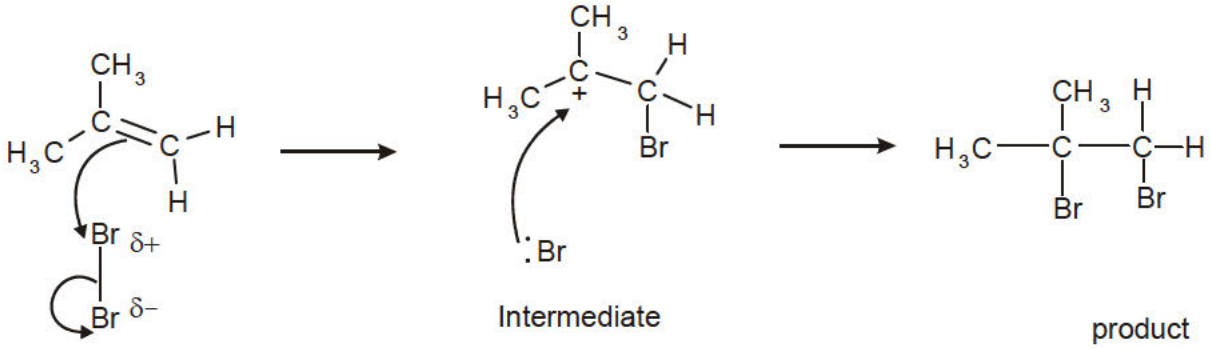
Diagram to show a minimum of 2 carbons, each with a σ-bond and p-orbitals ✓

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

[6]

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

(ii)



Intermediate product

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

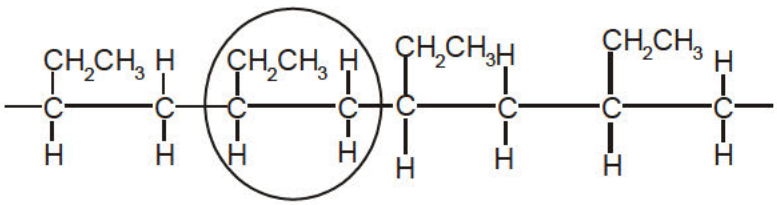
curly arrow from double bond to Br_2 ✓
curly arrow showing movement of electrons in the Br-Br bond **or** the dipole in the Br-Br ✓
curly arrow from lone pair of electrons in Br^- to intermediate ✓
mark any errors first

5 max

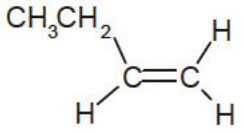
[5]

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

(ii) ✓ 1



(iii) ✓ 1



or but-1-ene

(iv) Poly(but-1-ene) ✓ 1

[4]

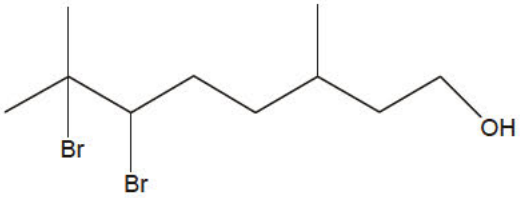
26. (a) (i) alkene ✓ 1

alcohol/hydroxy/hydroxyl ✓ 1

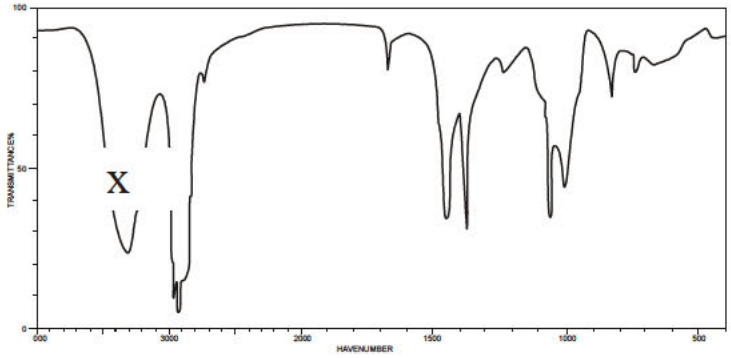
(b) (i) I = alkene & II = alcohol… both are needed ✓ 1

(ii) decolourised / colourless ✓ 1

(iii) ✓ 1



(iv) **X** as shown below ✓ 1



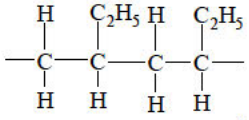
(c) (i) Ni/Pt/Rh/Pd ✓ 1

(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]