

1. Propene ✓

ALLOW prop-1-ene ✓
DO NOT ALLOW prop-2-ene

[1]

2. (i) $\text{—CH}_2\text{CHCl—} + 2\frac{1}{2}\text{O}_2 \rightarrow 2\text{CO}_2 + \text{H}_2\text{O} + \text{HCl}$ ✓

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 ✓

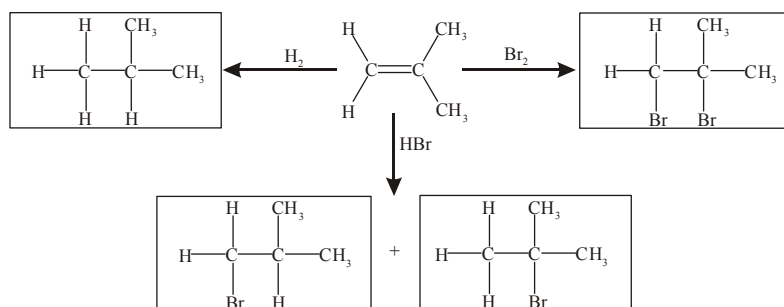
Designing processes with high atom economy

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** $(\text{CH}_3)_3\text{CH}$ ✓

ALLOW 1, 2-dibromo-methylpropane **OR**

$\text{CH}_2\text{BrCBr}(\text{CH}_3)_2$ ✓

ALLOW 1-bromo-methylpropane **OR** $\text{CH}_2\text{BrCH}(\text{CH}_3)_2$ ✓

ALLOW 2-bromo-methylpropane **OR** $\text{CH}_3\text{CBr}(\text{CH}_3)_2$ ✓

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

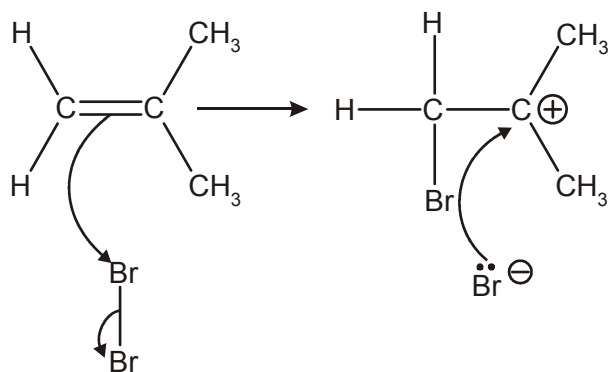
[4]

5. curly arrow from double bond to $\text{Br}^{\delta+}$ and curly arrow from $\text{Br}-\text{Br}$ bond pair to $\text{Br}^{\delta-}$ 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 $\text{Br}-\text{Br}$ bond

ALLOW curly arrow from any part of bromide ion

The bromide ion does not need to show a lone pair

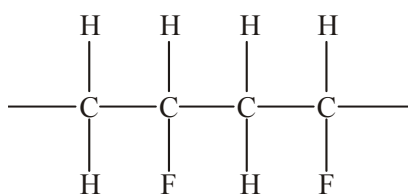
Dipole must be partial charge and not full charge

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. $^+\text{CH}_2\text{CBr}(\text{CH}_3)_2$

[4]

6. (i)



Free bonds at bond ends must be present

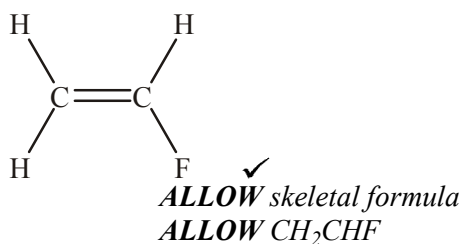
ALLOW minor slip e.g. missing one hydrogen and left as a stick

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)



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: CH₃CH₂CHBrCH₂Br (1)

equation: CH₃CH₂CH=CH₂ + Br₂ → CH₃CH₂CHBrCH₂Br (1)

products: CH₃CH₂CHBrCH₃ **and** CH₃CH₂CH₂CH₂Br (1)

(or statement that 2-bromo- is formed)

equation: CH₃CH=CHCH₃ + HBr → CH₃CH₂CHBrCH₃ (1)

(i.e. for one product)

products: CH₃CH₂CHOHCH₃ **and** CH₃CH₂CH₂CH₂OH (1)

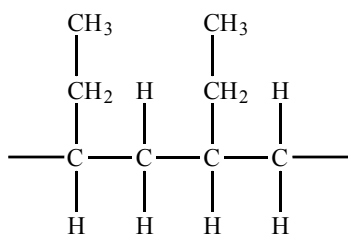
(or statement that 2-ol is formed)

equation: CH₃CH=CHCH₃ + H₂O → CH₃CH₂CHOHCH₃ (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

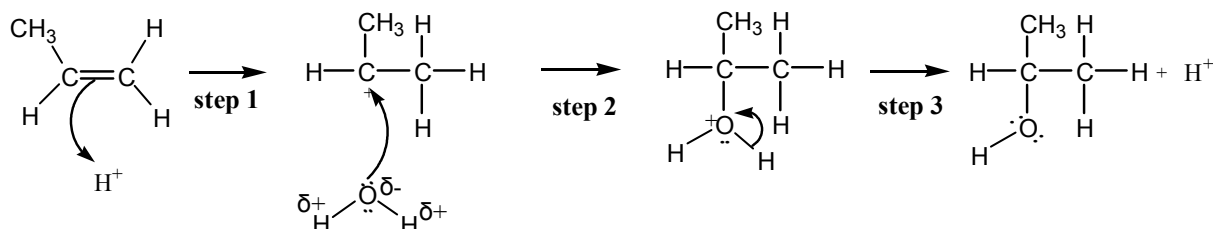
cracking of waste polymers

2

[10]

9. (a) (i) phosphoric acid/H⁺/sulphuric acid 1
 (ii) lone/electron pair of electrons acceptor 1

(b) (i)



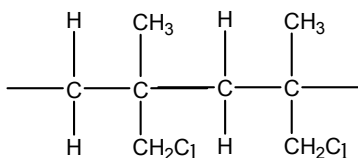
- Step 1 curly arrow from π -bond to H⁺ 1
 Step 2 curly arrow from lone pair on the O^{δ-} to C⁺ 1
 Step 3 curly arrow from O—H bond to O⁺ 1

- (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)

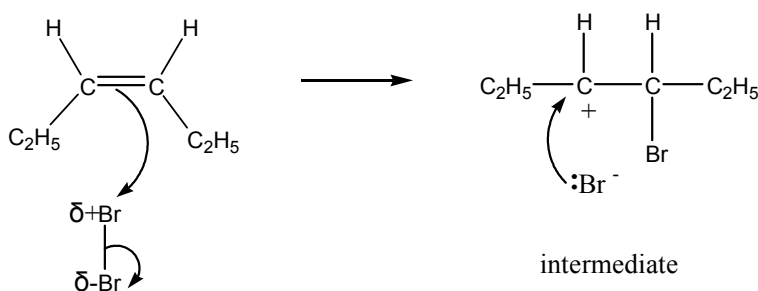


Backbone of 4 carbons and a reasonable attempt gets 1 mark.

2

[3]

11. (a)



curly 1
dipoles shown correctly on the Br-Br and curly arrow from the Br-Br 1
bond towards the Br^δ
correct intermediate shown 1
curly arrow from the lone pair or the negative charge on the Br⁻ to the 1
C+

- (b) (i) Hs are diagonal to each other in the *trans*/ 1
difference clearly shown in a diagram
- (ii) (the product is saturated hence) there is no restricted rotation/single 1
bonds allow rotation/because C=C prevents rotation

[6]

12. H₂ 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

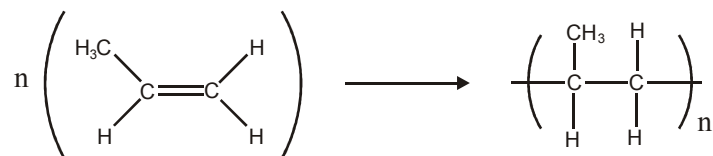
1

unsaturated vegetable oil/fat

1

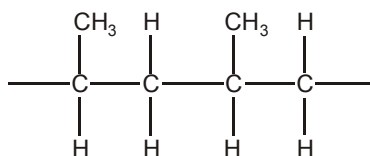
poly(propene)

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) C₅H₈

1

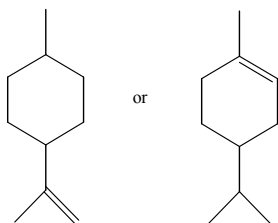
(ii) C₅H₈

1

(b) (i) Ni/Pt/Pd

1

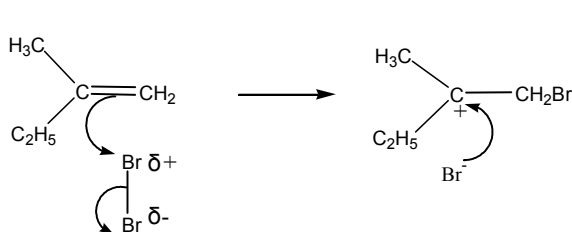
- (ii) 1 mark for C_5H_{12} 1
 1 mark for correct balancing 1
- (iii)



1
[6]

16. (i) electron/lone pair acceptor 1

(ii)



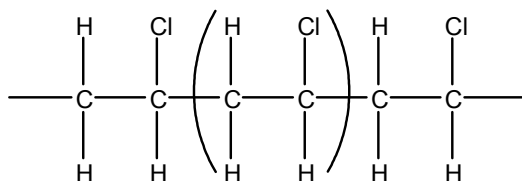
curly arrow from π -bond to $Br^{\delta+}$

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

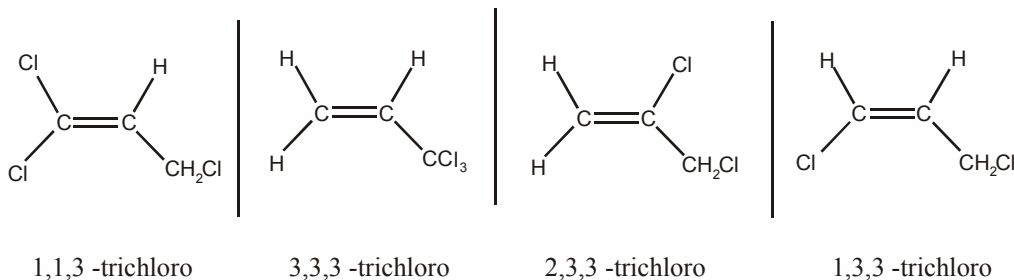


- (ii) harmful/toxic fumes are produced 1
- (iii) recycle/remove HCl by using gas scrubbers or wtte/crack polymers/used a feedstock/ source of fuel (in an incinerator)/developing biodegradable alternatives. 2

[5]

18. (a) (i) 24.7/12 : 2.1/1: 73.2/35.5
 2.06 : 2.1 : 2.06 1
 CHCl 1
 (ii) (CHCl = 12 + 1 + 35.5 =) 48.5 1
 48.5 × 3 = 145.5 1

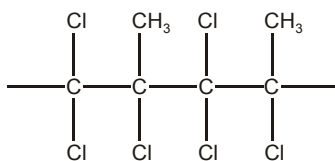
- (b) (i) Any two from 2



- (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

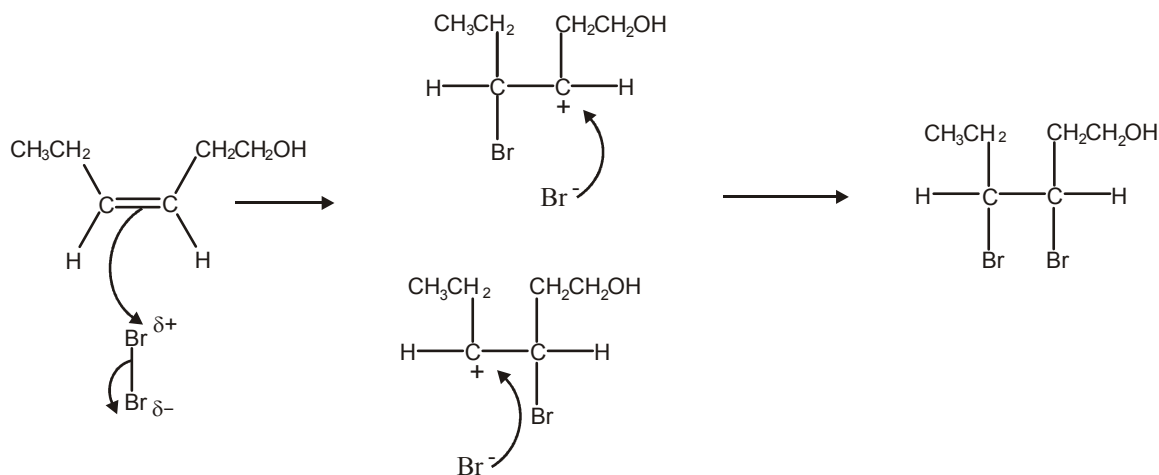


1 mark if backbone contains 4 carbons with 'end-bonds' and a reasonable attempt has been made
 e.g used the wrong isomer.... max = 1 mark

- (ii) non-biodegradable 1
 toxic fumes evolved when burnt 1
 HCl or Cl• or chlorinated organic compounds such as COCl₂ also evolved when burnt 1

[13]

19. (i) decolourises 1
(ii)

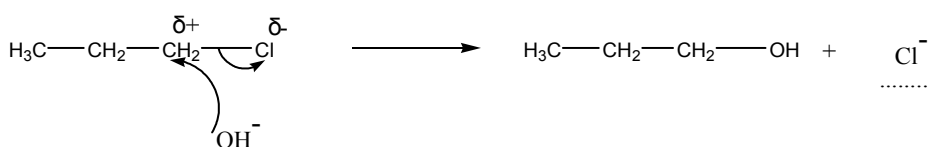


- curly arrow from C=C bond to bromine 1
dipoles on Br₂ or curly arrow to show movement of bonded pair of electrons 1
intermediate carbonium ion/carbocation 1
curly arrow from lone pair on the Br⁻ ion to carbonium ion (Br^{δ-} loses 1 mark) 1

[5]

20. (a) (i) reaction 1 1
(ii) reaction 4 1
(iii) reaction 3 1

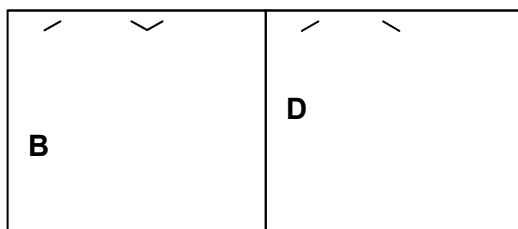
- (b) (i) lone pair/electron pair donor 1



- Correct dipole 1
Curly arrow from the O in the OH⁻ to C in the CH₂ 1
Curly arrow to show movement of bonded pair in the C-Cl bond 1
Cl⁻ as a product 1

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

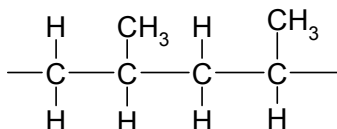
(ii) 2



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

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

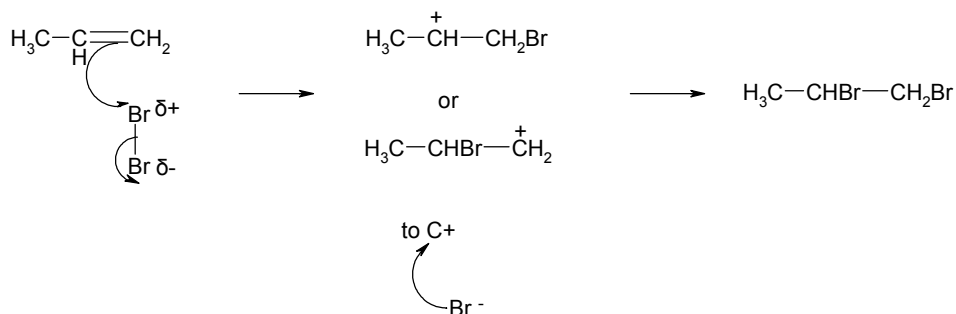
(iii) 1



[15]

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

(ii)



curly arrow from C=C to Br^{δ+} 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. $\text{CH}_3\text{CBr}_2\text{CH}_3$ 1
 $\text{CH}_3\text{CHBrCH}_2\text{Br}$ 1
 $\text{CH}_3\text{CH}_2\text{CHBr}_2$ 1

($\text{CH}_3\text{CHBrCH}_2\text{Br}$ 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** $109 - 110^\circ$ ✓ 1
angle **b** $117 - 120^\circ$ ✓ 1
(iii)

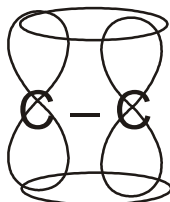


Diagram to show a minimum of 2 carbons, each with a σ -bond and p-orbitals ✓

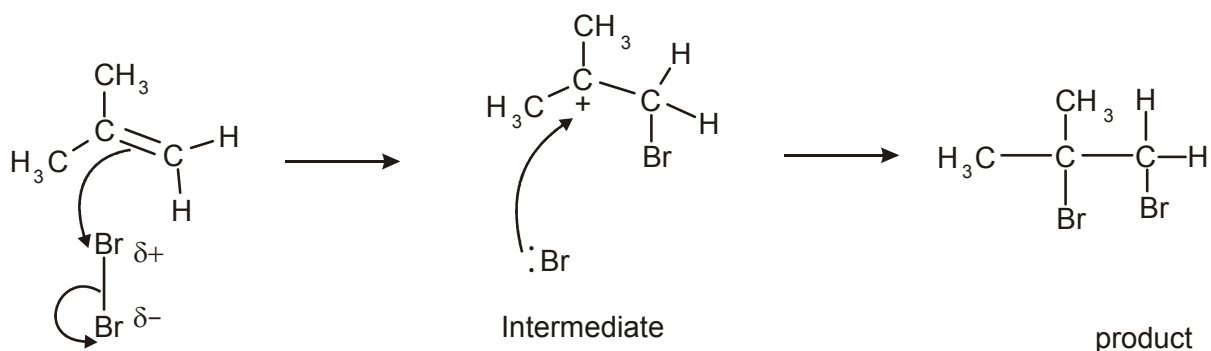
Overlap of adjacent p-orbitals (in words or in diagram) ✓ 2

[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

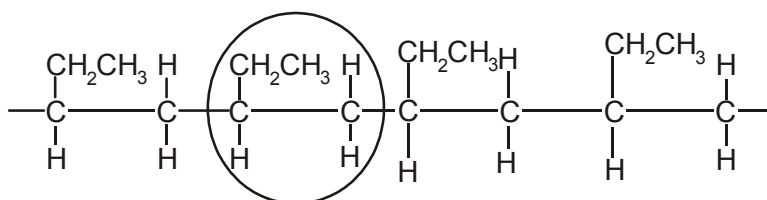
[5]

25. (i) Addition (not additional) ✓

1

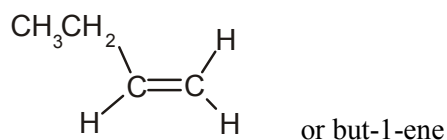
(ii) ✓

1



(iii) ✓

1



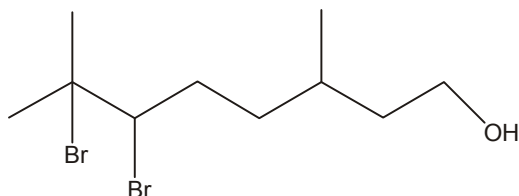
(iv) Poly(but-1-ene) ✓

1

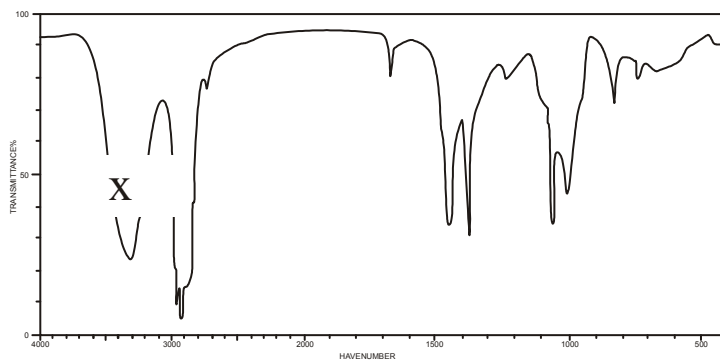
[4]

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



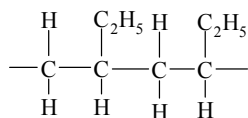
(iv) X as shown below ✓ 1



(c) (i) Ni/Pt/Rh/Pd ✓ 1
 (ii) compound B is C₁₀H₂₂O ✓ 1
 (iii) C₁₀H₂₀O + H₂ → C₁₀H₂₂O ✓ 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 Br₂) ✓ 1
 Molecular formula C₁₀H₁₈OBr₄ ✓✓ 2
 C₁₀H₁₈OBr₂ gets 1 mark
- (c) reagent CH₃COOH ✓ 1
 catalyst H₂SO₄/H⁺/HCl (aq) *or dilute loses the mark* ✓ 1
- (d) (i) C₁₀H₁₈O + 2[O] → C₁₀H₁₆O₂ + H₂O ✓✓ 2
 1 mark for H₂O 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]