1. (i) 120–130 **(1)** 1

(ii) boiling point increases with increase in *M*r/molecular formula/number of carbon atoms/chain length **(1)**
more intermolecular forces/electrons/surface area/
surface interactions/van der Waal forces **(1)**☐ 2

[3]

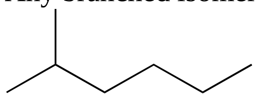
2. $C_{13}H_{28}$

[1]

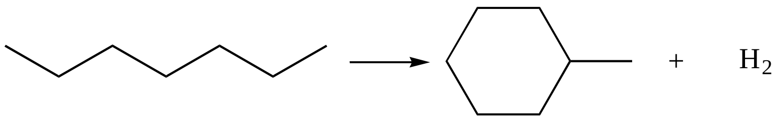
3. $C_9H_{20} \rightarrow C_7H_{16} + C_2H_4$ **(1)**

[1]

4. (i) Any branched isomer of heptane with correct name, e.g.



2-methylhexane **(1)** 2

(ii)  2

[4]

5. (i) species with an unpaired electron **(1)** 1

(ii) uv (light)/high temperature/min of 400° C/sunlight **(1)** 1

(iii) homolytic (fission) **(1)** 1

(iv) C_4H_{10} + C*l*• **(1)** → C_4H_9• + HC*l* **(1)**

C_4H_9• + Cl_2 **(1)** → C_4H_9C*l* + C*l*• **(1)** 2

[5]

6. (i) 8.72/136.9 = 0.0637 mol **(1)** 1

(ii) M_r butan-1-ol = 74(.0) **(1)**

moles = 4.28/74.0 = 0.0578 mol **(1)** 2

(iii) 0.0578/0.0637 × 100 = 90.7% **(1)** 1

[4]

7. **Availability of starting materials:**

availability

sugar is renewable because it can be grown **(1)**
ethane is finite because it is obtained by processing of crude oil **(1)**

energy:

fermentation: energy is required for distillation/
hydration: energy is required to generate steam **(1)**

atom economy and waste products:

atom economy for fermentation < atom economy hydration **(1)**
In fermentation, CO_2 is produced in addition to ethanol/ethanol is not the only product **(1)**
In hydration, ethanol is the only product/hydration is an addition reaction (1)
Atom economy of fermentation could be increased by finding a use CO_2 (1)

Atom economy linked to a chemical equation to show that hydration has 100% atom economy/fermentation has 51% atom economy **(1)** 7max

[7]

8. (i) M_r C_7H_{16} = 100 **(1)**
amount = 2000/100 = 20 mol **(1)** 2

(ii) energy saved = 20 × 4817 = 9634 kJ **(1)** 1

(iii) moles CO_2 = 7 × 20 = 140 mol **(1)**
decrease in CO_2 = 140 × 24 = 3360 dm^3 **(1)** 2

[5]

9. structural isomerism:
structural isomers: same molecular formula, different structural formula **(1)**
structural isomers of but-1-ene: but-2-ene **(1)** and methylpropene **(1)**

geometric isomerism
C=C prevents rotation of the double bond **(1)**
each C in the C=C double bond bonded to 2 different atoms or groups **(1)**

a clear statement that links non-rotation of the double bond to the idea of groups being trapped on one side of the double bond **(1)**

cis but-2-ene clearly identified **(1)**
trans but-2-ene clearly identified **(1)**

[7]

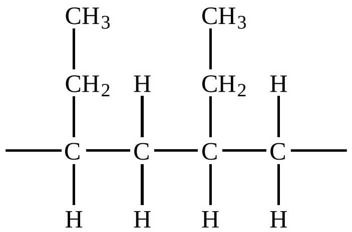
10. **1st bullet**

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

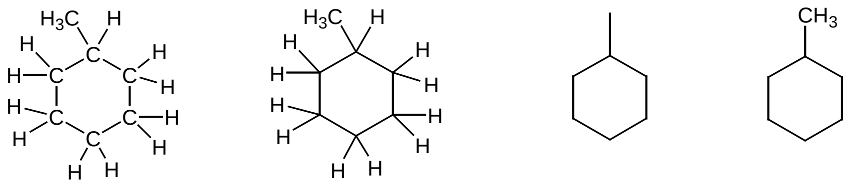
two **(1)** **(1)** from
energy from incineration
development of biodegradable polymers
cracking of waste polymers 2

[10]

11. separation by (differences in) boiling point 1

$C_7H_{16} \rightarrow C_4H_{10} + C_3H_6$ 1

(i) Any of 1



(ii) $C_7H_{16} \rightarrow C_7H_{14} + H_2$ (or by structural formula) 1

(i) 2,2-dimethylpentane 1

(ii) 3-methylhexane, 3,3 dimethylpentane or (3)-ethylpentane in any unambiguous form. 2

(iii) 2,2,3-trimethylbutane 1

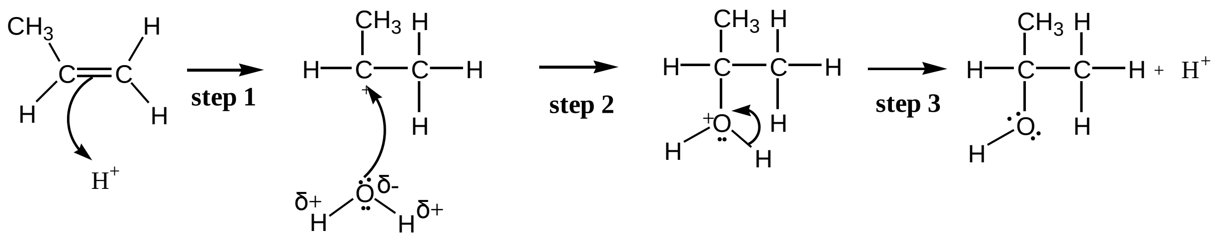
(iv) if branched, difficult to pack/less surface interaction/less points of contact 1
less van der Waals' forces/ less intermolecular bonds/less energy needed to boil 1

[10]

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

(ii) lone/electron pair of electrons acceptor 1

(b) (i)



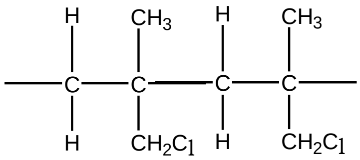
Step 1	curly arrow from π-bond to H^+	1
Step 2	curly arrow from lone pair on the $O^{\delta-}$ to C+	1
Step 3	curly arrow from O—H bond to O+	1

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

[6]

13. (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]

14. (a) (i) uv/sunlight/high temperature (range 400 – 700 °C) 1

(ii) $Cl_2 \rightarrow 2Cl\bullet$ 1

$C_4H_{10} + Cl\bullet \rightarrow HCl + \bullet C_4H_9/C_4H_9\bullet$ 1

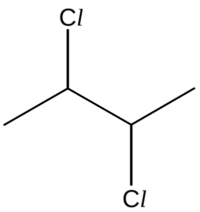
$\bullet C_4H_9/C_4H_9\bullet + Cl_2 \rightarrow C_4H_9Cl + Cl\bullet$ 1

(iii) any two free radicals from (a) (ii) 1

(iv) homolytic (fission) 1

(b) (i) 2,3-dichlorobutane 1

(ii) 1

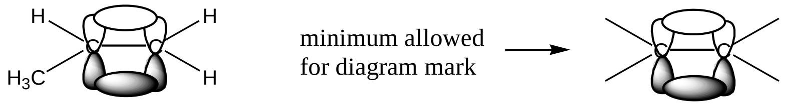


(iii) any dichlorobutane **except** 2,3-dichlorobutane. 1

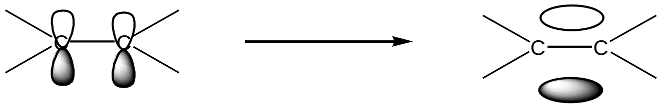
[9]

15. **Bonding:** π-bond formed by overlap of (adjacent) p-orbitals/π-bond labelled on diagram 1

diagram to show formation of the π-bond 1



or



Shape/bond angles:

tetrahedral around the CH_3 1

bond angle = 109°28/ (109-110°) 1

trigonal planar around each C in the C=C 1

bond angle = 120° (118-122°) 1

Cis-trans

cis & *trans* correctly labelled eg but-2-ene 1
require a double bond because it restricts rotation 1
each C in the C=C double bond must be bonded to two different atoms or groups 1

QWC Allow mark for well constructed answer and use of **three** terms like: orbital, tetrahedral, trigonal, planar, rotation, spatial, stereoisomers, geometric 1

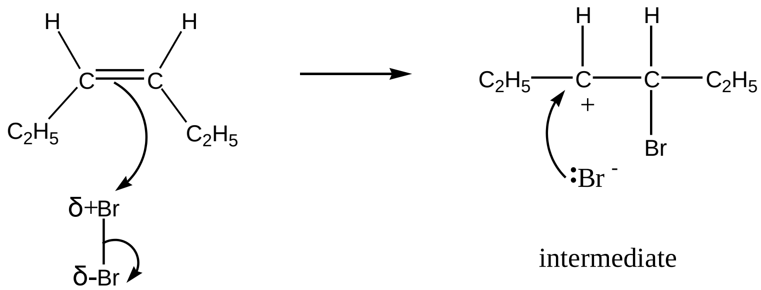
[10]

16. (i) (free radical) substitution 1

(ii) 1-bromohexane, 2-bromohexane and 3-bromohexane 3

[4]

17. (a)



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]

18. Recognises that either a catalyst or high temperature (heat is not sufficient) is required 1

cracking suitable balanced equation 1

reforming equation or statement indicating formation of a ring/cyclic compound

suitable balanced equation with H_2 1

(balanced equation showing formation of a ring scores both marks) 1

isomerisation suitable balanced equation

The **processed products** are: 1

- used in fuels/used in petrol
- better /more efficient fuels/increase octane number/rating
- alkenes (from cracking) produce polymers/alcohols
- H_2 used for Haber process/fuels/hydrogenation of oils 3

QWC SPAG – look for two complete sentence that present a coherent argument 1

[9]

19. (i) C_6H_{10} 1

(ii) C_3H_5 / ecf to (i) 1

(iii) M_r of cyclohexene = 82 1

% C = (72/82) × 100 = 88% 1

87.8% gets 1 mark

ecf to (i) and (ii) for both marks

Alternative calculation based on empirical formula:

Mass of empirical unit = 41, % C = (36/41) × 100 = 88%

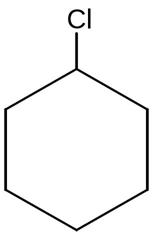
[4]

20. H_2 1

Ni/Pt/Pd (catalyst) 1

[2]

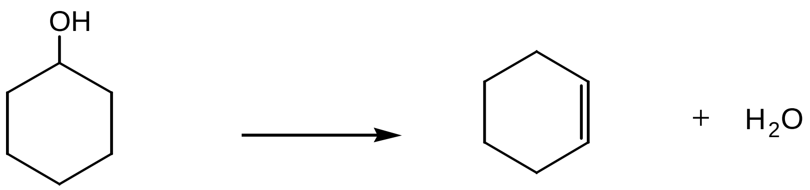
21. (a) (i) 1



(ii) H_2SO_4/Al_2O_3/(hot) pumice/H_3PO_4 1

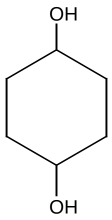
(H_2SO_4(aq) or dil H_2SO_4 loses the mark)

(iii) 1



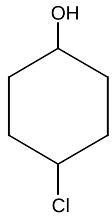
$C_6H_{11}OH$ / $C_6H_{12}O \rightarrow C_6H_{10} + H_2O$

(b) (i) 1



diol

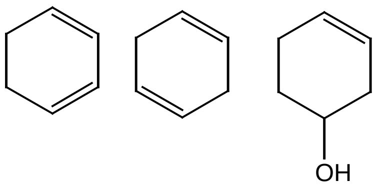
also allow



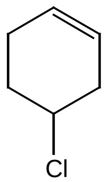
Cl-alcohol

(ii) 2

from the diol allow



from the Cl-alcohol allow



[6]

22. (a) (i) compound/molecule containing hydrogen and carbon **only** 1

(ii) $C_{10}H_{22}$ 1

(iii) C_5H_{11} {ecf from (ii)} 1

(b) (i) (a particle that) contains/has a single/unpaired electron 1

(ii) UV (light) /sunlight/high temp 1

(iii) homolytic (fission)/ homolysis 1

(iv) $C_{12}H_{26} + Cl\bullet \rightarrow \bullet C_{12}H_{25} + HCl$ 1

(the dot for the free radical does not have to be on the C)

$\bullet C_{12}H_{25} + Cl_2 \rightarrow C_{12}H_{25}Cl + Cl\bullet$ 1

(v) six 1

(c) (i) $C_{12}H_{26} \rightarrow 2C_2H_4 + 1C_8H_{18}$ 2

(1 mark for correct formula of octane or ethene)

(ii) octane/ ecf from (c) (i) 1

(d) (i)

1 mark for correct reagent and 1 mark for correct product. 2

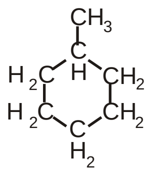
(ii) 1 mark for any unambiguous formula of cyclohexane 1

1 mark for $1H_2$ but check that formula of heptane is correct/equation balanced. 1

gets 2 marks

gets 2 marks

$CH_3(CH_2)_5CH_3$ ⟶



$+ H_2$ gets 2 marks

$C_7H_{16} \longrightarrow C_7H_{14} + H_2$ gets 1 marks

[16]

23. (a) (i) alkene 1

bromine 1

decolourises 1

(ii) 3-methylhex-2-en-1-ol/ 1-hydroxy-3-methylhex-2-ene 1

[4]

24. **<u>margarine</u>**

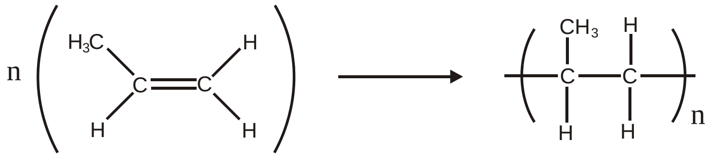
Ni catalyst 1

hydrogen/ hydrogenated 1

unsaturated vegetable oil/fat 1

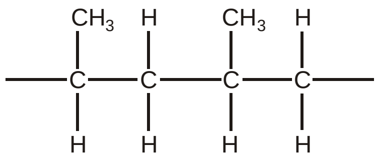
<u>poly(propene)</u>

equation



1

two repeat units



1

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

<u>Problems with disposal</u>

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

when burnt produces toxic fumes 1

<u>Future methods of disposal</u>

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.

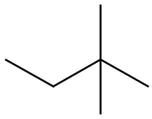
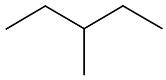
in the correct context. 1

[10]

25. (a) octane, 400 +/- 5 1
hexadecane. 545 +/- 5 1
if °C penalise once.

(b) fractional distillation 1

(c) (i)

 ✓  ✓

2

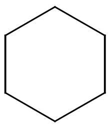
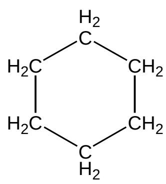
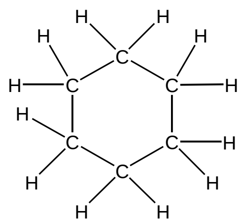
(ii) 2-methylpentane 1

(iii) **C**, **B** and **A** 1

(iv) the more branching/the shorter the chain… the lower the boiling point/ less energy needed to separate the molecules 1

long chain have greater surface area/surface interactions/more VdW forces or converse argument about short/branched chains. 1

(d) (i)

not just C_6H_{12}  or  or 

1

(ii) $C_6H_{14} \rightarrow C{=}H_{12} + H_2$ 1

(iii) <u>better</u> fuels/<u>more</u> volatile/<u>lower</u> boiling point/reduces knocking/ increases octane rating/used as (petrol) additives 1

(e) (i) M_r of $(CH_3)_3COH$ = 74 1

% oxygen = (16/74) × 100 = 21.6 % 1

(ii) $(CH_3)_3COH + 6O_2 \rightarrow 4CO_2 + 5H_2O$

1 mark for CO_2 and H_2O only 2

[16]

26. (a) (i) C_5H_8 1

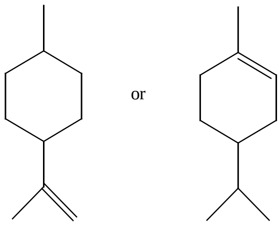
(ii) C_5H_8 1

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

(ii) 1 mark for C_5H_{12} 1

1 mark for correct balancing 1

(iii)

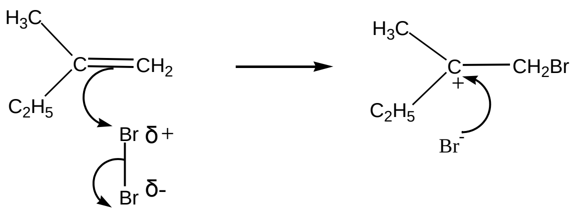


1

[6]

27. (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]

28. (i) M_r of 2-methylpropan-1-ol = 74 1

moles = 4.44/74 = 0.06 1

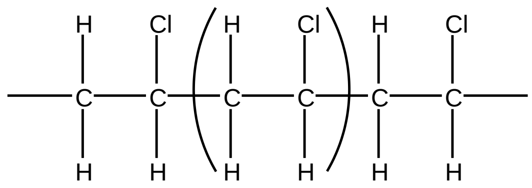
(ii) moles = 5.48/137 = 0.04 1

(iii) 66.7% 1

[4]

29. (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]

30. (i) $Cl_2 \rightarrow 2Cl\bullet$ 1

(ii) uv (light)/high temperature/min of 400 C/sunlight 1

(iii) $Cl\bullet + C_6H_{12} \rightarrow C_6H_{11}\bullet + HCl$

$C_6H_{11}\bullet + Cl_2 \rightarrow C_6H_{11}Cl + Cl\bullet$ 1

(iv) react with each other/suitable equation

solvent **W** = water/aqueous/aqueous ethanol 1

solvent **X** = ethanol/alcohol 1

[5]

31. Structural/chain/positional isomers have the same molecular formula, different structure 1

but-1-ene/ but-2-ene/ methylpropene / cyclobutane/ methylcyclopropane (any three or two with correct structures and names) 3

4 marks for structural isomerism

Cis-trans /geometric isomerism 1

cis & trans but-2-ene clearly identified 1

C=C prevents rotation 1

each C in the C=C double bond must be bonded to two different atoms or groups 1

4 marks for cis-trans isomerism

QWC: Well organised answer making use of correct terminology to include any **three** from: structural, geometric, cis-trans, molecular formula, restricted, rotation, stereoisomerism, stereoisomers, chain isomerism, positional isomerism, if all isomers are correctly named 1

[9]

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

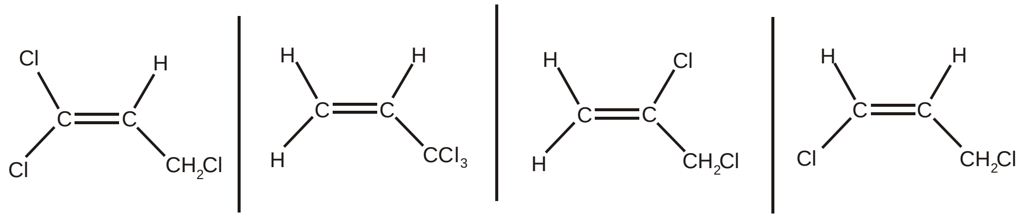
2.06 : 2.1 : 2.06 1

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 ✓)

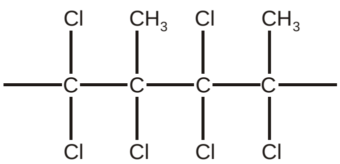
3 marking points:

- *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

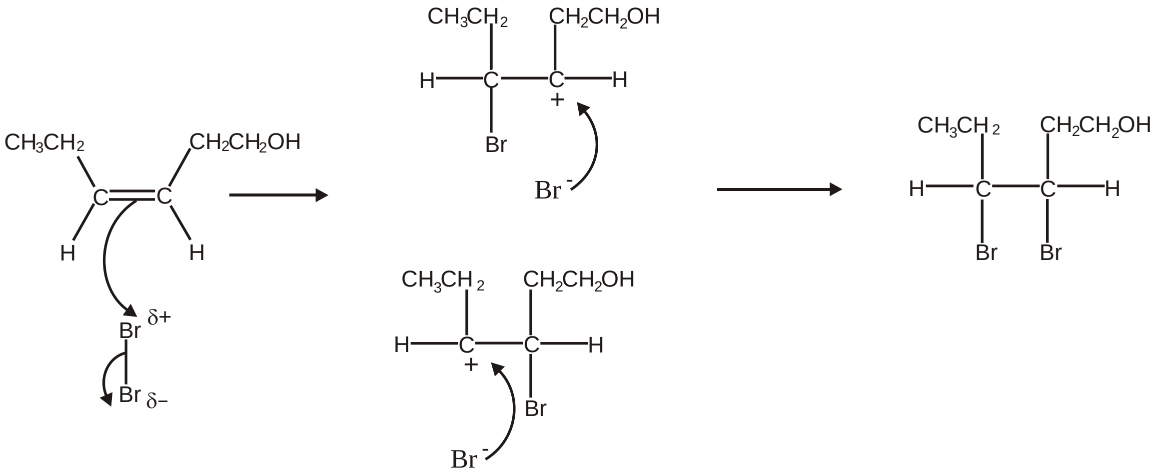
toxic fumes evolved <u>when burnt</u> 1

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

[13]

33. (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]

34. identifies the three process as cracking, reforming, isomerisation 1

recognises the need for high temperature or a catalyst 1

equation for cracking 1

equation for isomerisation 1

state that reforming converts chains into rings/cyclic compounds 1

equation for reforming (balanced with H_2 could score two marks) 1

oil is finite/non-renewable 1

ethanol is renewable/sustainable 1

from plants/crops/sugar cane/sugar beet/glucose/sugar/ fermentation 1

$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ 1

QWC

- organise relevant information clearly and coherently, using specialist vocabulary when appropriate (minimum of 4 from cracking/ isomerisation/ reforming/ renewable/ feedstock/ finite/fermentation/non-renewable/sustainable/zeolite/bimetallic catayst/ etc)
- reasonable spelling, punctuation and grammar throughout 1

[11]

35. (a) C_6H_{14} 1

(b) (i) boiling point increases with increase in M_R/molecular formula/N° of carbon atoms/chain length 1

(ii) more intermolecular forces/electrons/surface area/

surface interactions/van der Waal forces 1

(iii) 120 – 130 °C 1

[4]

36. (i) $C_9H_{20} \longrightarrow C_7H_{16} + C_2H_4$ 1

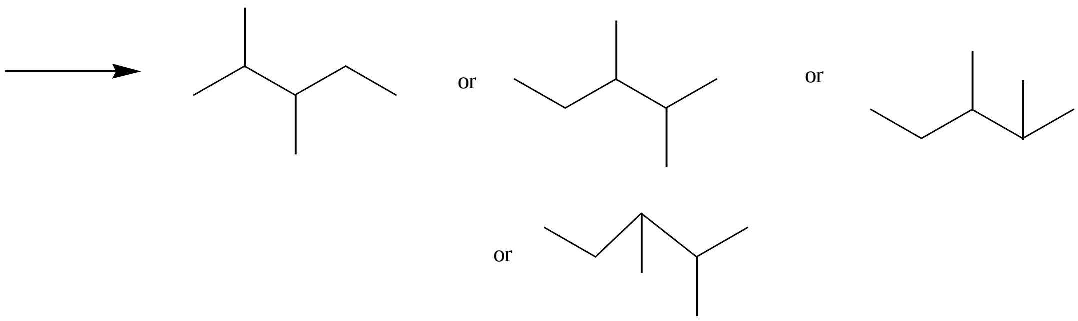
(ii) $C_2H_4 + H_2O \longrightarrow C_2H_5OH$ 1

temperature > 100 °C/ steam 1

phosphoric acid (catalyst) 1

[4]

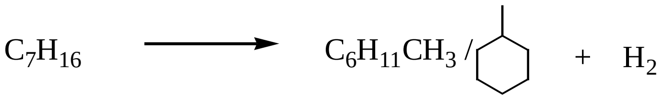
37. (a) (i) 1

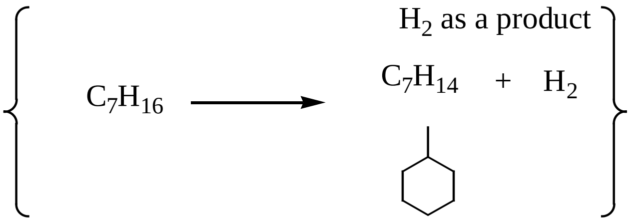


(ii) 85 –98 °C 1

2

(b)





either of these scores 1 mark

(c) more efficient fuel/better fuel/ higher octane number/reduces knocking/more volatile/lower boiling points/burn better/burn more easily/quicker ✓ 1

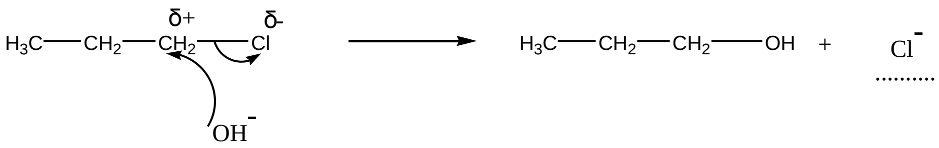
[5]

38. (a) (i) reaction 1 1

(ii) reaction 4 1

(iii) reaction 3 1

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



Correct dipole 1

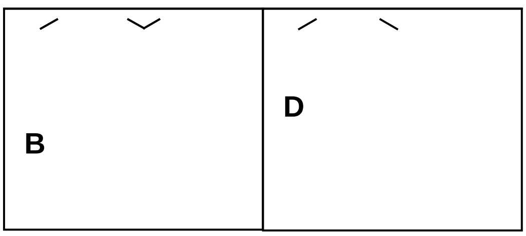
Curly arrow from the O in the OH^- to C in the CH_2 1

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

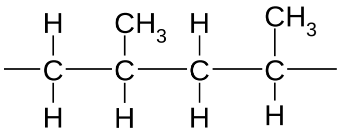
(ii) 2



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

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

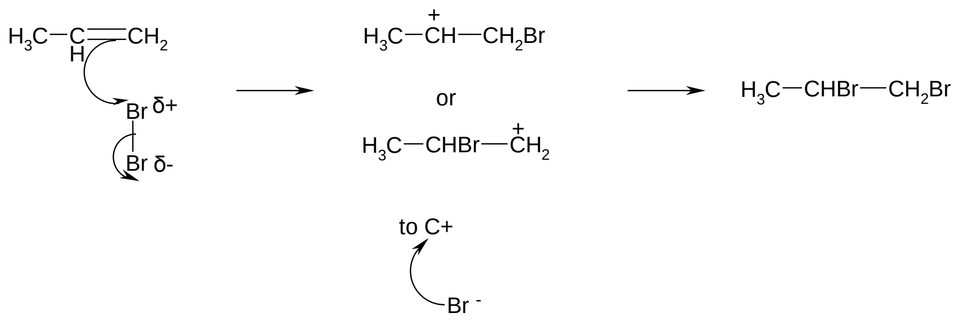
(iii) 1



[15]

39. (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]

40. $CH_3CBr_2CH_3$ 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]

41. (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)

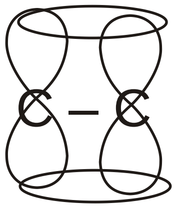


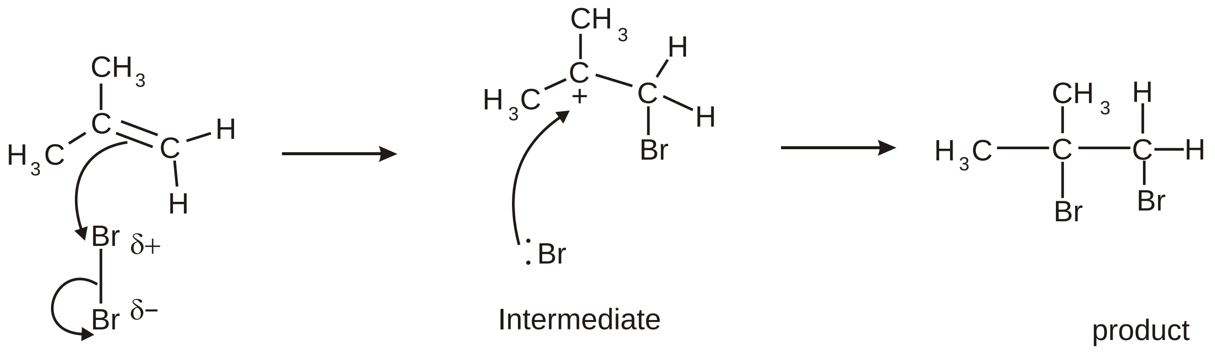
Diagram to show a minimum of 2 carbons, each with a σ-bond and p-orbitals ✓

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

[6]

42. (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 ✓

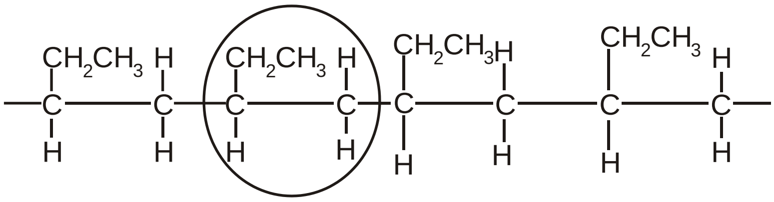
mark any errors first

5 max

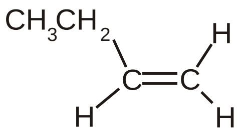
[5]

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

(ii) ✓ 1



(iii) ✓ 1



or but-1-ene

(iv) Poly(but-1-ene) ✓ 1

[4]

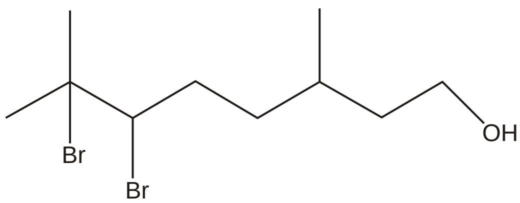
44. (a) (i) alkene ✓ 1

alcohol/hydroxy/hydroxyl ✓ 1

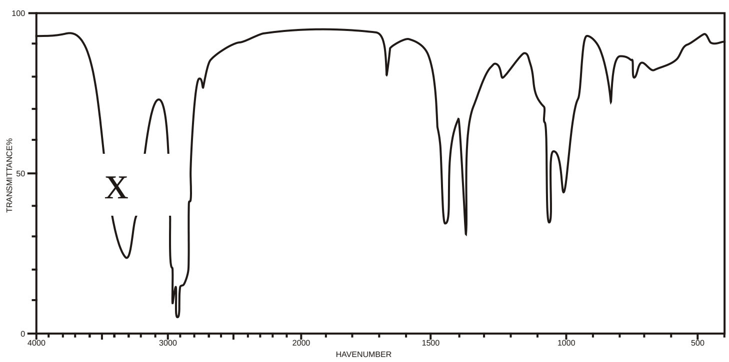
(b) (i) I = alkene & II = alcohol… both are needed ✓ 1

(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]

45. (a) (i) C_4H_{10} ✓ 1

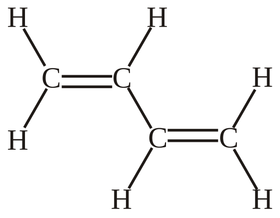
(ii) C_2H_5O ✓ 1

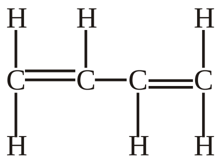
(iii) B and E ✓ 1

(iv) A and F ✓ 1

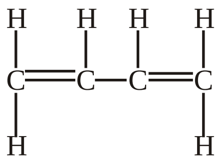
(b) $(C_4H_9OH \rightarrow)\ C_4H_8 + H_2O$ ✓ 1

(c) any unambiguous formula: ✓ 1





$CH_2CHCHCH_2$



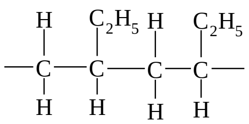
$CH_2CHCHCH_2$

buta-1,3-diene ✓ 1

name ecf to the structure only if structure above has formula C_4H_6

[7]

46.



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

[2]

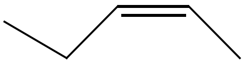
47. (a) Same <u>molecular formula</u>, different structure /displayed formula/ arrangement of atoms/bonds ✓✓ 2

(Same <u>formula</u>, different structure/displayed formula/arrangement of atoms ✓

(b) (i) 3-methylbut-1-ene and 2-methylbut-2-ene (any unambiguous structure/formula is acceptable) ✓✓ 2

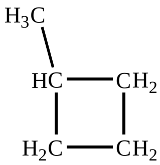
(ii) 2-methylbut-1-ene/2-methyl-1-butene ✓ 1

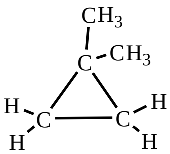
(iii) ✓ 1

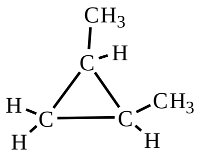


[6]

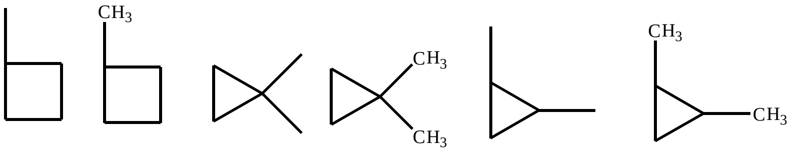
48. (i) any two from methylcyclobutane, 1,1-dimethylcyclopropane and 1,2-dimethylcyclopropane







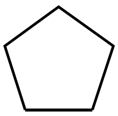
allow



✓✓ 2

(ii) cyclopentane ✓ 1

(iii) ✓ 1



[4]

49. (i) homolytic ✓ 1

(ii) $Cl_2 \rightarrow 2Cl\bullet$ *(need • on the Cl… penalise only once in the 3 equations)* ✓ 1

(iii) I $(C_5H_{10}) + \underline{Cl\bullet} \rightarrow (\bullet C_5H_9) + \underline{HCl}$ ✓ 1

II $(\bullet C_5H_9) + \underline{Cl_2} \rightarrow \underline{C_5H_9Cl} + \underline{Cl\bullet}$ ✓ 1

[4]

50. (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^+/HC*l* (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]

51. Variation in boiling points. **(max = 4 marks)**

As chain length increases, boiling point increases ✓ 1

due to increased number of electrons/ surface area/ more van der Waals forces / intermolecular forces/ more surface interactions ✓ 1

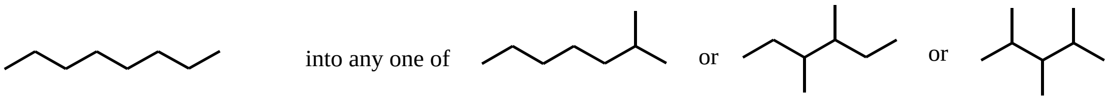
As branching increases, boiling point decreases ✓ 1

straight chains can pack closer together/ straight chains have greater surface area/ ✓ 1
more van der Waals forces /more intermolecular forces/ more surface interactions

Isomerisation **(max = 4 marks)**

(produces) branched chain alkanes ✓ 1

equation to illustrate any isomerisation (of octane) ✓ 1



or any other branched isomer of octane

Branched chains are better/more efficient fuels/used as additives ✓ 1

because they are more volatile/easier to ignite/burn more easily/higher octane number(rating)/lower boiling points/reduces knocking (pinking) ✓ 1

QWC mark

- use of suitable chemical terms such as van der Waals, intermolecular forces/ intermolecular bonds/volatile/ knocking/ pinking/pre-ignition
- reasonable spelling, punctuation and grammar throughout ✓ 1

[9]