EXAM PAPERS PRACTICE

Boost your performance and confidence with these topic-based exam questions

Practice questions created by actual examiners and assessment experts

Detailed mark scheme

Suitable for all boards

Designed to test your ability and thoroughly prepare you

Time allowed
394 Minutes

Score /328

Percentage %

CHEMISTRY

OCR AS & A LEVEL

Mark Scheme

Module 4: Core organic chemistry

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]

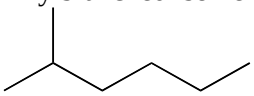
2. $C_{13}H_{28}$

[1]

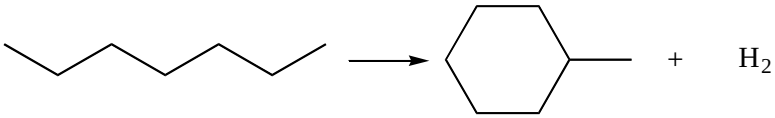
3. $C_9H_{20} \rightarrow C_7H_{16} + C_2H_4$ **(1)**

[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) $C_4H_{10} + Cl\bullet$ **(1)** $\rightarrow C_4H_9\bullet + HCl$ **(1)**

$C_4H_9\bullet + Cl_2$ **(1)** $\rightarrow C_4H_9Cl + Cl\bullet$ **(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]

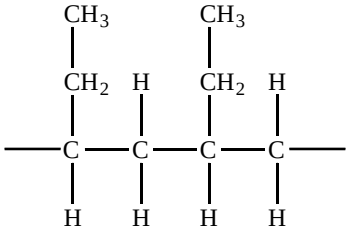
10. **1st bullet**

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

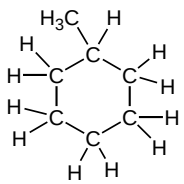
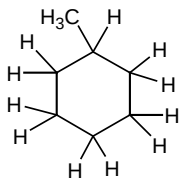
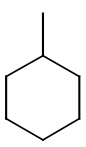
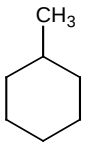
two **(1)** **(1)** from
energy from incineration
development of biodegradable polymers
cracking of waste polymers 2

[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

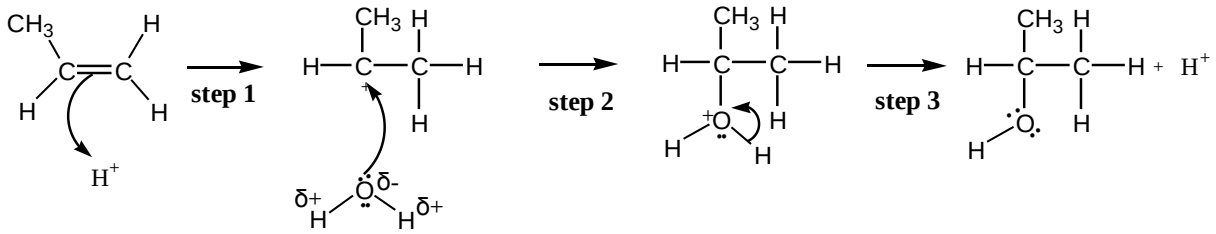
(iv) if branched, difficult to pack/less surface interaction/less points of contact 1
less van der Waals' forces/ less intermolecular bonds/less energy needed to boil 1

[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

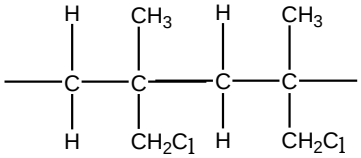
Step 3 curly arrow from O—H bond to O+ 1

(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

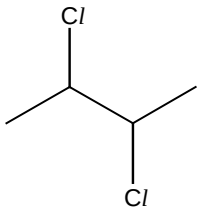
$\bullet C_4H_9/C_4H_9\bullet + Cl_2 \rightarrow C_4H_9Cl + Cl\bullet$ 1

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

(iv) homolytic (fission) 1

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

(ii) 1

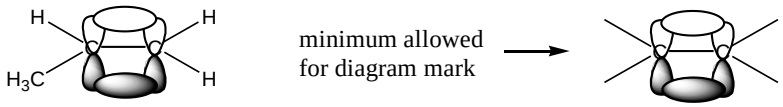


(iii) any dichlorobutane **except** 2,3-dichlorobutane. 1

[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



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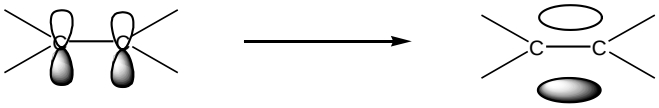


Shape/bond angles:

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

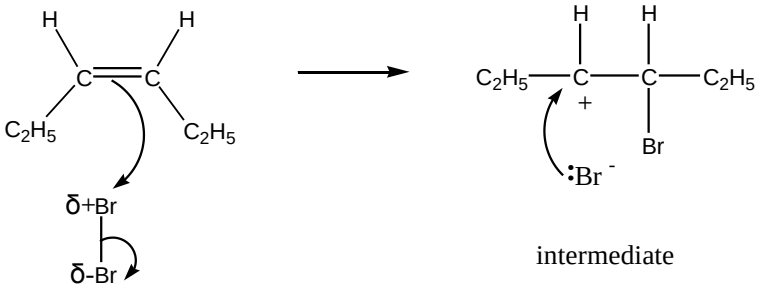
[10]

16. (i) (free radical) substitution 1

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

[4]

17. (a)



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]

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%

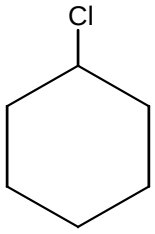
[4]

20. H_2 1

Ni/Pt/Pd (catalyst) 1

[2]

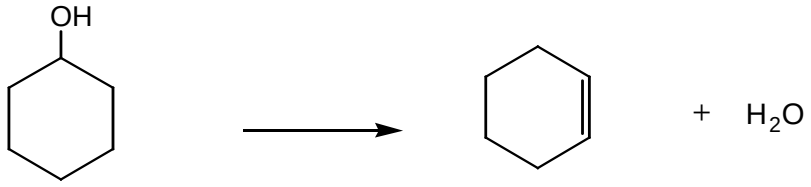
21. (a) (i) 1



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

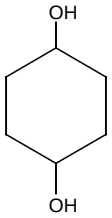
(H_2SO_4(aq) or dil H_2SO_4 loses the mark)

(iii) 1



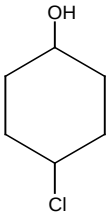
$C_6H_{11}OH$ / $C_6H_{12}O \rightarrow C_6H_{10} + H_2O$

(b) (i) 1



diol

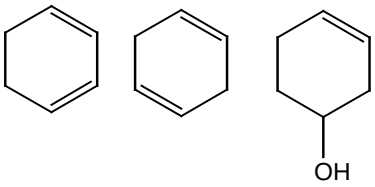
also allow



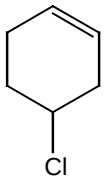
Cl-alcohol

(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

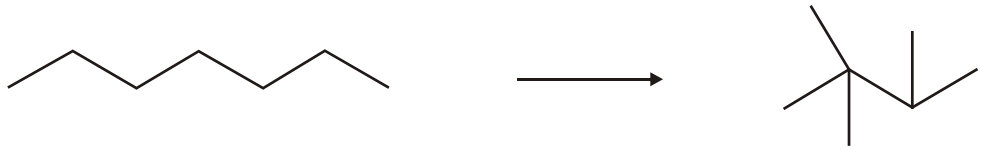
(v) six 1

(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

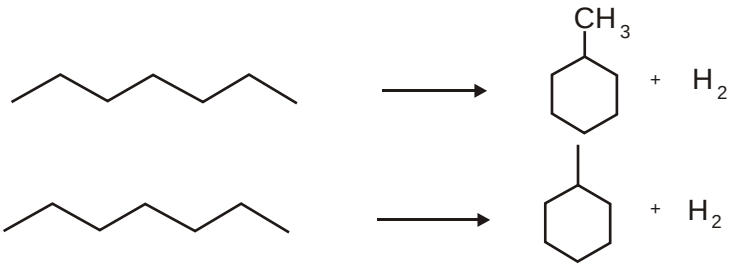
(d) (i)

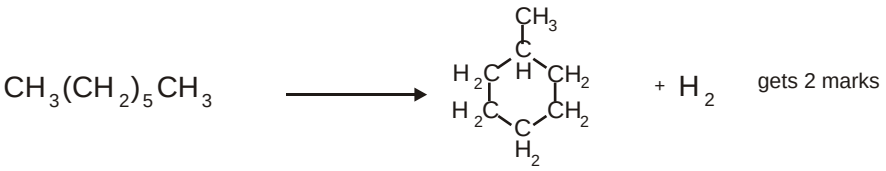


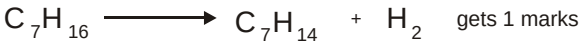
1 mark for correct reagent and 1 mark for correct product. 2

(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







[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. **margarine**

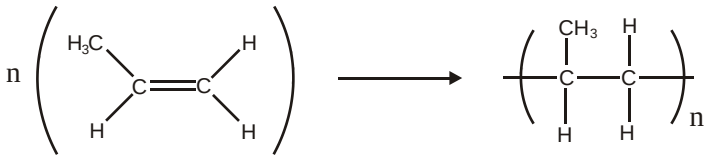
Ni catalyst 1

hydrogen/ hydrogenated 1

unsaturated vegetable oil/fat 1

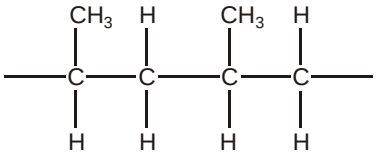
poly(propene)

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.

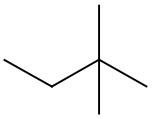
in the correct context. 1

[10]

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

(b) fractional distillation 1

(c) (i)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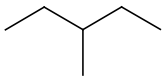
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2

(ii) 2-methylpentane 1

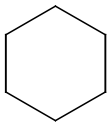
(iii) **C**, **B** and **A** 1

(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}



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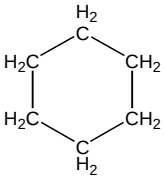

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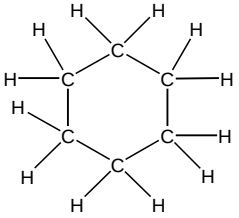


1

(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 = $(16/74) \times 100 = 21.6$ % 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

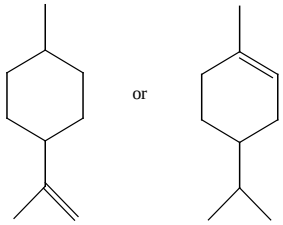
(ii) C_5H_8 1

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

(ii) 1 mark for C_5H_{12} 1

1 mark for correct balancing 1

(iii)

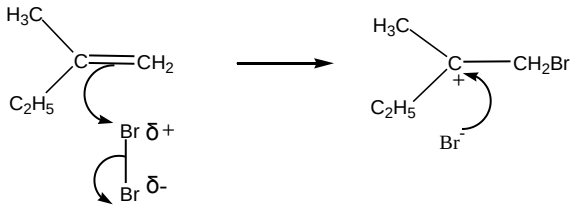


1

[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 $Br^{\delta-}$ } 1

Curly arrow from Br^- to C^+ 1

1

[4]

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

moles = 4.44/74 = 0.06 1

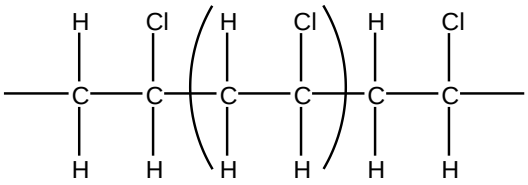
(ii) moles = 5.48/137 = 0.04 1

(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

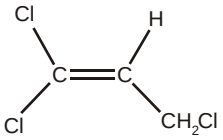
2.06 : 2.1 : 2.06 1

CHC*l* 1

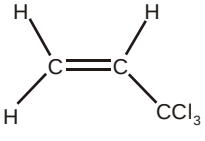
(ii) (CHC*l* = 12 + 1 + 35.5 =) 48.5 1

48.5 × 3 = 145.5 1

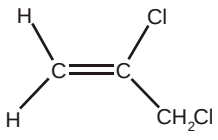
(b) (i) Any two from 2



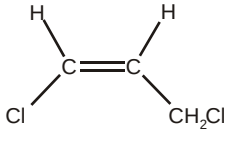
1,1,3 -trichloro



3,3,3 -trichloro



2,3,3 -trichloro



1,3,3 -trichloro

(ii) 1, 2,3-trichloropropene

(trichloropropene scores 1 mark ✓)

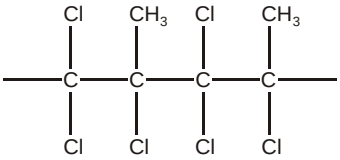
3 marking points:

- *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

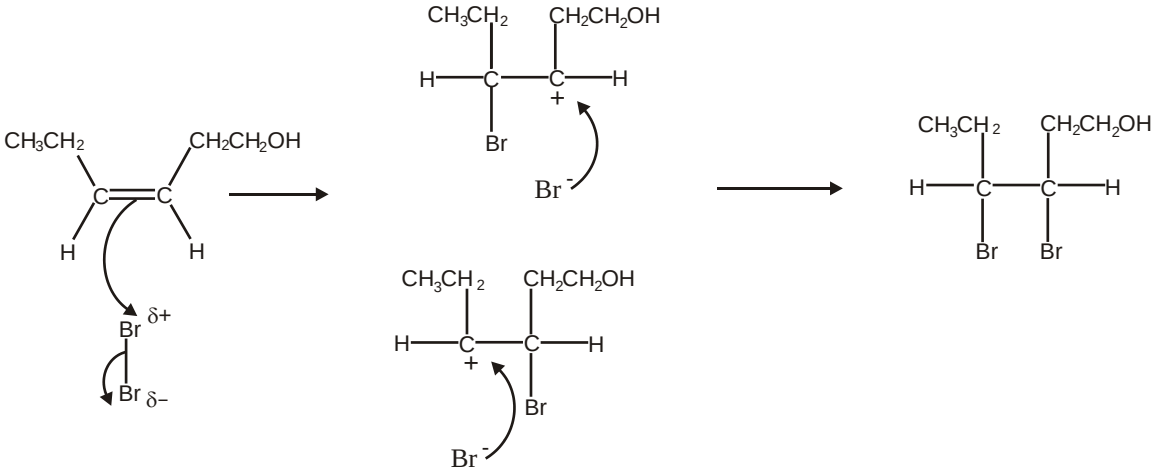
toxic fumes evolved <u>when burnt</u> 1

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

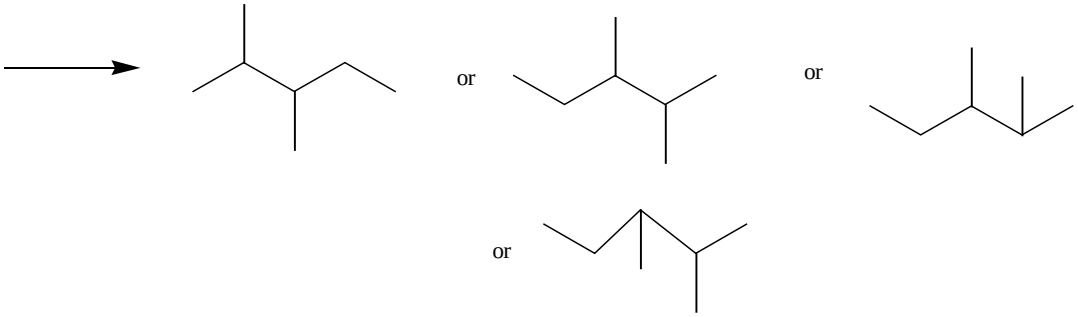
(ii) $C_2H_4 + H_2O \longrightarrow C_2H_5OH$ 1

temperature > 100 °C/ steam 1

phosphoric acid (catalyst) 1

[4]

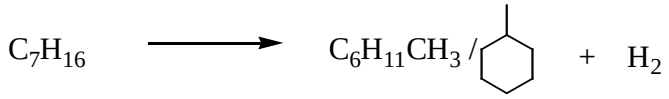
37. (a) (i) 1

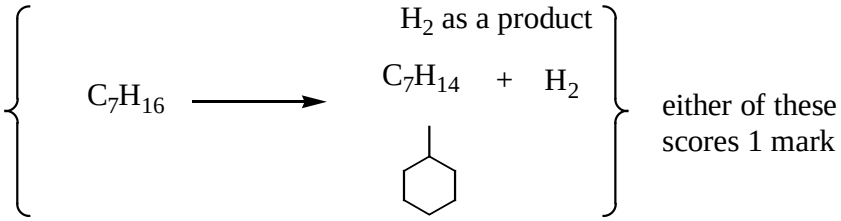


(ii) 85 –98 °C 1

2

(b)





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

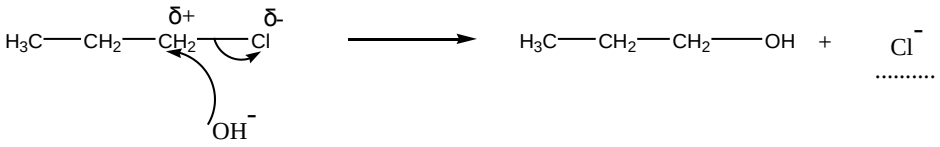
[5]

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

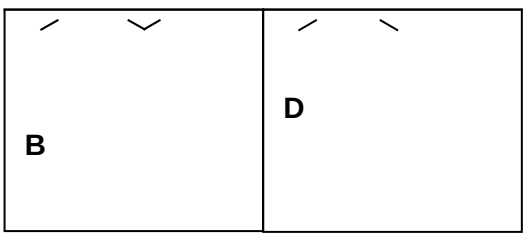
Curly arrow from the O in the OH^- to C in the CH_2 1

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

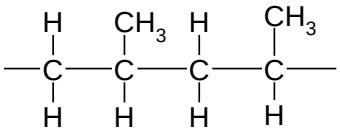
(ii) 2



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

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

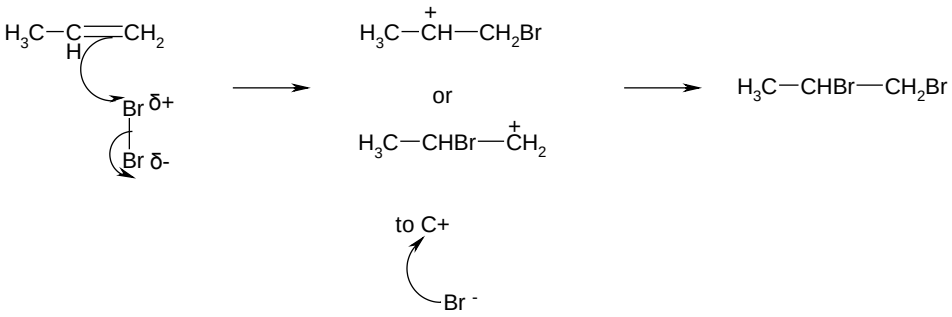
(iii) 1



[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)

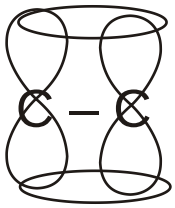


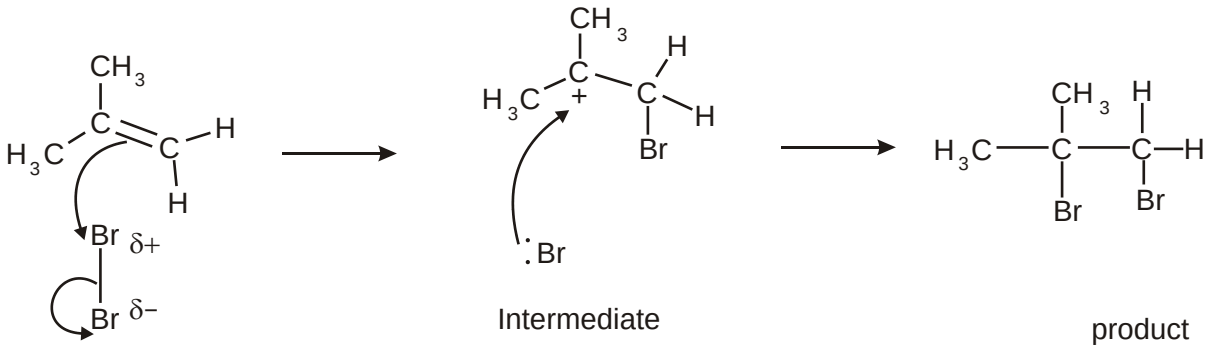
Diagram to show a minimum of 2 carbons, each with a σ-bond and p-orbitals ✓

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 ✓

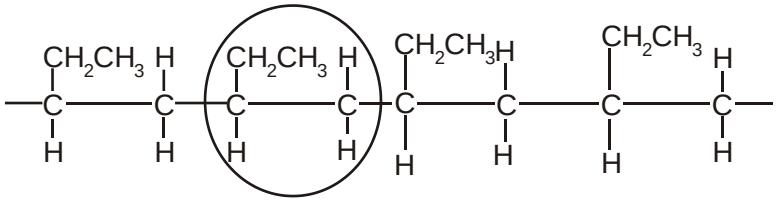
mark any errors first

5 max

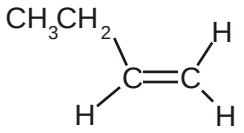
[5]

43. (i) Addition (not additional) ✓ 1

(ii) ✓ 1



(iii) ✓ 1



or but-1-ene

(iv) Poly(but-1-ene) ✓ 1

[4]

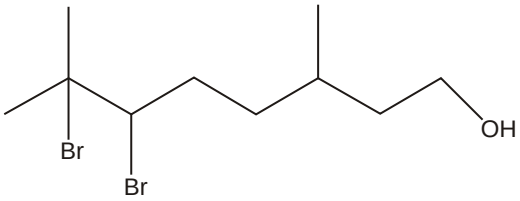
44. (a) (i) alkene ✓ 1

alcohol/hydroxy/hydroxyl ✓ 1

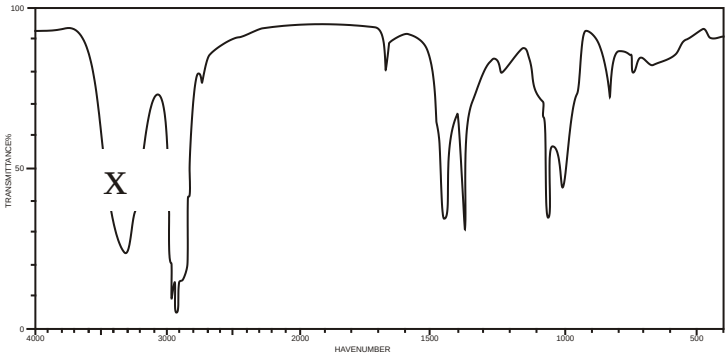
(b) (i) I = alkene & II = alcohol… both are needed ✓ 1

(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

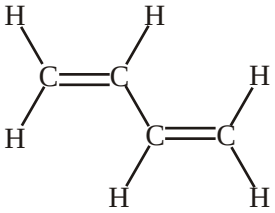
(ii) C_2H_5O ✓ 1

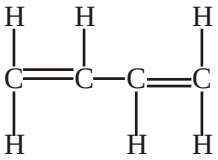
(iii) B and E ✓ 1

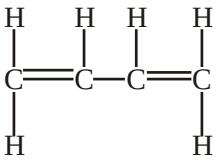
(iv) A and F ✓ 1

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

(c) any unambiguous formula: ✓ 1







$CH_2CHCHCH_2$

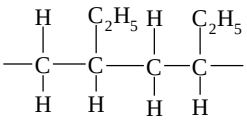
$CH_2CHCHCH_2$

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]

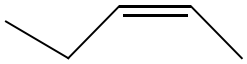
47. (a) Same <u>molecular formula</u>, different structure /displayed formula/ arrangement of atoms/bonds ✓✓ 2

(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

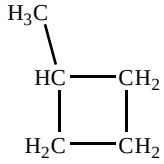
(ii) 2-methylbut-1-ene/2-methyl-1-butene ✓ 1

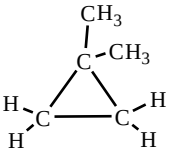
(iii) ✓ 1

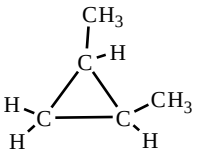


[6]

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







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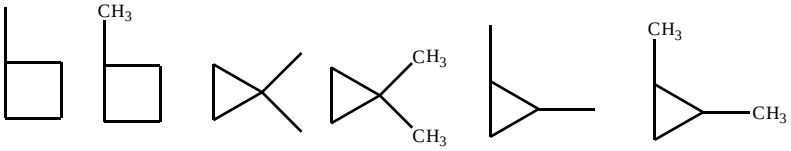
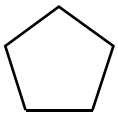


✓✓ 2

(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 $H_2SO_4/H^+/HCl$ (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]

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

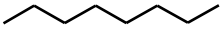
straight chains can pack closer together/ straight chains have greater surface area/ ✓ 1

more van der Waals forces /more intermolecular forces/ more surface interactions

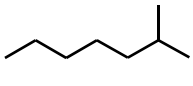
Isomerisation **(max = 4 marks)**

(produces) branched chain alkanes ✓ 1

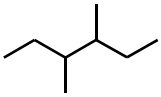
equation to illustrate any isomerisation (of octane) ✓ 1



into any one of



or



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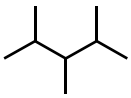

or any other branched isomer of octane

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]