

1. (i) Decane ✓

DO NOT ALLOW deceane

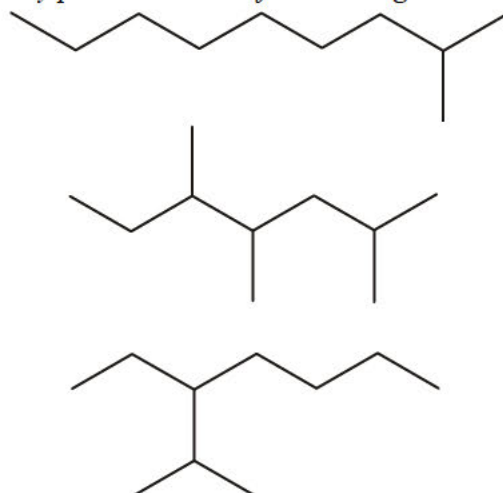
1

- (ii) Skeletal formula of branched $C_{10}H_{22}$ ✓

Formula **must** be skeletal

AND must not include any symbol, e.g. CH_3

Any possible skeletal formulae e.g.



1

- (iii) Decane has more surface contact

OR branched chains have less surface contact ✓

Both answers need to be comparisons

Assume 'it' refers to decane

IGNORE surface area

ALLOW straight chains can get closer together

OR branched chains cannot get as close to one another

IGNORE branched chain are more compact

Decane has more van der Waals' forces

OR branched chains have fewer van der Waals' forces ✓

ALLOW Decane has stronger van der Waals' forces

OR branched chains have weaker van der Waals' forces

More intermolecular forces is **not** sufficient

2

- (iv) Branched chains have more efficient combustion

OR decane has less efficient combustion ✓

ALLOW branched chains are easier to burn

OR easier to combust

OR burn better

OR more efficient fuel

OR less likely to produce pre-ignition or knocking

OR increases octane rating

ALLOW ORA for decane

Better fuel is **NOT** sufficient

Burns more cleanly is **NOT** sufficient

1

[5]

2. (i) $\frac{34.0}{267.4} \times 100$

267.4 ✓

12.7% ✓

First mark for 267.4 **OR** $(34.0 + 233.4)$ **OR** $(169.3 + 98.1)$ at bottom of fraction with or without $\times 100$

ALLOW from 2 sig figs up to calculator value

ALLOW full marks for 13 **OR** 12.7 **OR** 12.72 **OR** 12.715 up to calculator value with no working out

12.71 scores one mark only

NO ECF for this part from incorrect numbers in first expression

2

- (ii) **Any three from the following:**

Oxygen comes from air ✓

IGNORE hydrogen comes from the air

No poisonous materials formed

OR no poisonous materials involved ✓

IGNORE harmful

No waste products formed **OR** atom economy is 100% ✓

ALLOW higher atom economy

Anthraquinone is regenerated **OR** recycled **OR** used again

OR Anthraquinone acts as a catalyst ✓

3

[5]

3. EITHER

Nucleophilic substitution ✓

Example of nucleophilic substitution ✓

Heterolytic fission ✓

C—I curly arrow ✓

Correct dipole on C—I bond ✓

OH^- curly arrow from one lone pair on O of OH^- ion

OR from minus sign on OH^- ion ✓

OR

Electrophilic addition ✓

Example of electrophilic addition ✓

Heterolytic fission ✓

Curly arrow from $\text{C}=\text{C}$ bond to $\text{Br}-\text{Br}$ bond and

Dipole and curly arrow associated with Br_2 ✓

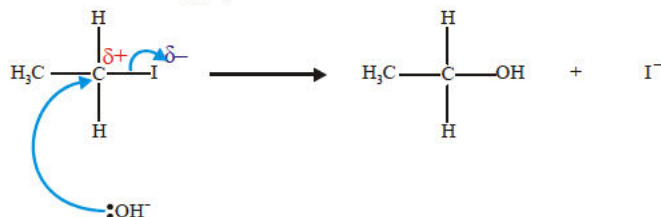
Correct carbocation ion ✓

Curly arrow from one lone pair on Br^- ion

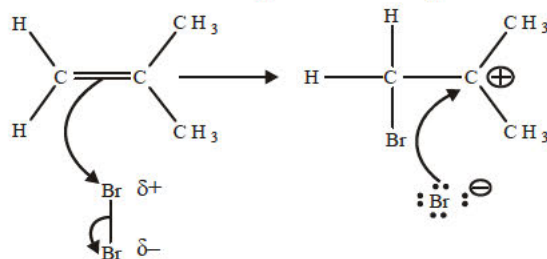
OR from minus sign on Br^- ion ✓

The example mark can be awarded as an example of the name of the mechanism given or if the name is wrong can be given as an example of a reasonably correct drawn mechanism

If curly half arrows drawn do not give a mark the first time used and then apply ECF



ALLOW mechanisms for other halogenoalkanes



ALLOW mechanisms for other halogens and hydrogen halides

ALLOW

Electrophilic substitution ✓

Example of electrophilic substitution ✓

Heterolytic fission ✓

Curly arrow from benzene ring to the electrophile (i.e. NO_2^+ OR Br^+) ✓

Correct intermediate ✓

Curly arrow to show loss of hydrogen ion ✓

ALLOW

Nucleophilic addition ✓

Example of nucleophilic addition ✓

Heterolytic fission ✓

Correct dipole on carbonyl group ✓

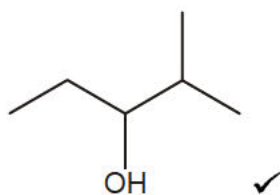
Curly arrow from lone pair on H^- ion

OR from minus sign on H^- to $\text{C}=\text{O}$ carbon and breaking of $\text{C}=\text{O}$ bond ✓

Curly arrow from carbonyl oxygen to either H^+ or H_2O ✓

[6]

4.



Formula **must** be skeletal **AND** not include any symbol except for OH

[1]

5. (i) Same **molecular** formula but different structural formulae ✓

ALLOW Same molecular formula but different arrangement of atoms

OR Same molecular formula but different structures

OR Same molecular formula but different displayed formulae

DO NOT ALLOW Same molecular formula but different spatial arrangement of atoms

1

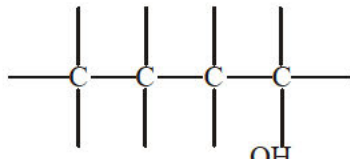
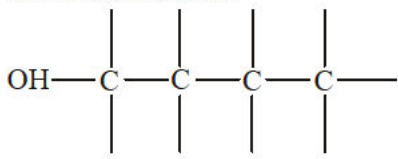
- (ii) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ **OR** $(\text{CH}_3)_2\text{CHCH}_2\text{OH}$ ✓

ALLOW



ALLOW displayed formula

ALLOW sticks (i.e. no H shown bonded to C)

ALLOW	DO NOT ALLOW OH shown as below
	
sticks OK and -OH is OK	sticks OK and OH- is not OK

ALLOW correct ethers

1

[2]

6. $\text{C}_n\text{H}_{2n+2}$ ✓

ALLOW $\text{C}_n\text{H}_{2(n+1)}$ ✓

IGNORE size of subscripts

[1]

7. skeletal formula of a branched isomer of C_8H_{18} ✓

skeletal formula of a cyclic hydrocarbon **OR** skeletal formula of substituted arene of C_8H_{10} ✓

ALLOW any ring between C_3 and C_8 with 8 carbon atoms per molecule

IGNORE wrong names

If two correct structural or displayed formulae drawn award one mark

[2]

8. (i) C_6H_{10} ✓

1

(ii) $M_r(\text{cyclohexanol}) = 100$ ✓

amount of cyclohexanol = 0.0765 mol ✓

percentage yield = 35.0% ✓

ALLOW full marks for correct answer with no or limited working out

ALLOW ecf from wrong molar mass i.e. $7.65 \div \text{molar mass}$

ALLOW ecf from wrong amount in moles i.e. $[0.0268 \div \text{moles}] \times 100$

ALLOW 35%

ALLOW two marks for 0.35%

If M_r of 82 is used then % yield will be 28.7 or 29 and this is worth two marks

3

[4]

9. (i) (sum of) the molecular masses of the desired product ÷
sum of molecular masses of all products
× 100 ✓

ALLOW (sum of) the molecular masses of the desired product ÷

sum of molecular masses of all reactants

× 100 ✓

1

- (ii) this preparation is addition **OR** has 100% atom economy **OR**
there is only one product ✓

preparation from cyclohexanol has less than 100% atom
economy **OR** H_2O is produced as well **OR** calculated atom
economy = 82% ✓

ALLOW no by products formed

*ALLOW other substances formed **OR** cyclohexene is not the only product*

2

[3]

10. **Structural isomer**

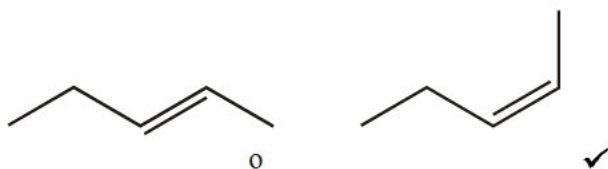
compounds with the same molecular formula ✓ but with different structural formulae ✓

Stereoisomer

compounds with the same structural formula ✓ but with different arrangements in space ✓

Evidence of using M_r of 70 to **calculate** molecular formula of C_5H_{10} ✓

F and G are



Correct identification of the E and Z isomers ✓



E/Z happens because

double bonds restrict rotation ✓

different groups on each carbon of the double bond ✓

ALLOW same molecular formula ✓ but different structures ✓

Second marking point is **DEPENDENT** on first mark

ALLOW compounds with the same structure

Second marking point is **DEPENDENT** on first mark

This is the QWC mark

IGNORE wrong names of F, G and H

ALLOW structural or displayed formulae for F, G and H

e.g. H is $CH_3CH_2CH_2CHCH_2$

ALLOW identification using trans and cis and

ALLOW this marking point as identification of another example of identifying E/Z or cis and trans if not done for F and G

ALLOW one mark if no structures drawn but correct names given for F, G and H i.e E-pent-2-ene, Z-pent-2-ene and pent-1-ene

ALLOW ecf on structures if wrong molecular formula used or consistent error or slip such as having just sticks

[11]

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

[1]

12. (i) $8.72/136.9 = 0.0637 \text{ mol (1)}$

1

(ii) M_r butan-1-ol = 74.0 (1)

moles = $4.28/74.0 = 0.0578$ mol (1)

2

(iii) $0.0578/0.0637 \times 100 = 90.7\%$ (1)

1

[4]

13. 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)

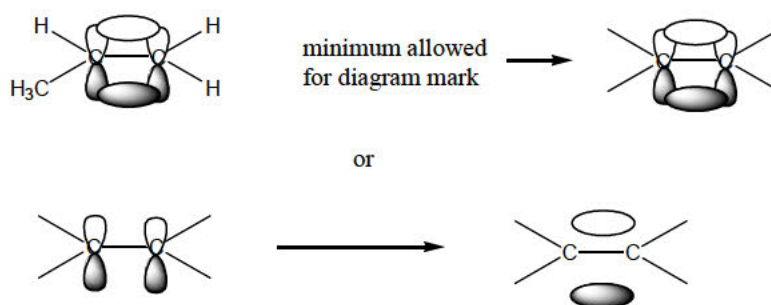
cis but-2-ene clearly identified (1)

trans but-2-ene clearly identified (1)

[7]

14. **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



Shape/bond angles:

tetrahedral around the CH_3 1

bond angle = $109^\circ 28'$ / (109 - 110°) 1

trigonal planar around each C in the $\text{C}=\text{C}$ 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 $\text{C}=\text{C}$ 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]

15. (i) C_6H_{10} 1

(ii) C_3H_5 / ecf to (i) 1

(iii) M_r of cyclohexene = 82 1

$\% \text{C} = (72/82) \times 100 = 88\%$ 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, $\% \text{C} = (36/41) \times 100 = 88\%$

[4]

16. (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]

17. Structural/chain/positional isomers have the same molecular formula, 1
 different structure
 but-1-ene/ but-2-ene/ methylpropene / cyclobutane/ methylcyclopropane 3
 (any three or two with correct structures and names)

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

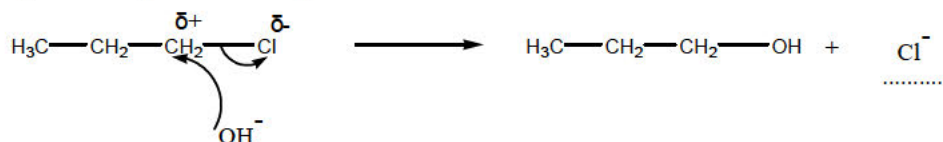
4 marks for cis-trans isomerism

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

[9]

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

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



Correct dipole 1

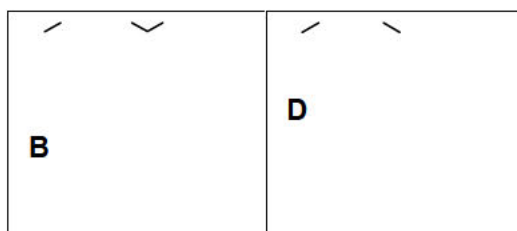
Curly arrow from the O in the OH⁻ to C in the CH₂ 1

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. 2
(same formula, different structure.)

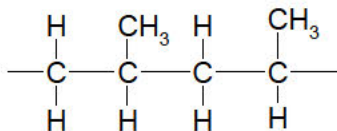
- (ii) 2



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

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

- (iii) 1



[15]

19. (a) (i) C_4H_{10} ✓ 1

- (ii) $\text{C}_2\text{H}_5\text{O}$ ✓ 1

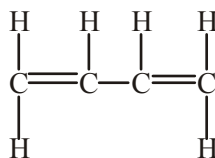
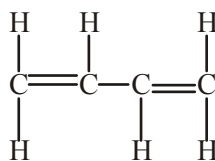
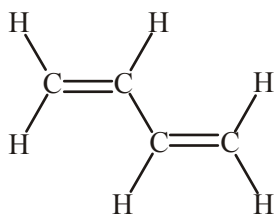
- (iii) B and E ✓ 1

- (iv) A and F ✓ 1

- (b) $(\text{C}_4\text{H}_9\text{OH} \rightarrow) \text{C}_4\text{H}_8 + \text{H}_2\text{O}$ ✓ 1

(c) any unambiguous formula: ✓

1



buta-1,3-diene ✓

1

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

[7]

20. (a) Same molecular formula, different structure /displayed formula/ arrangement of atoms/bonds ✓✓

2

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

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

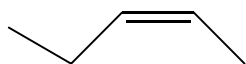
2

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

1

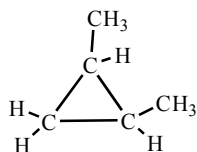
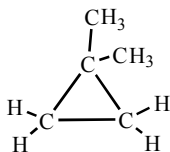
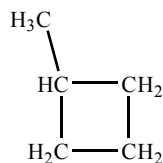
(iii) ✓

1

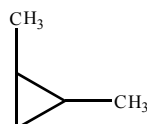
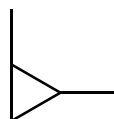
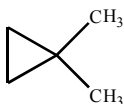
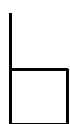


[6]

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



allow



✓✓

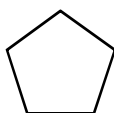
2

- (ii) cyclopentane ✓

1

- (iii) ✓

1



[4]

22. (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) $\text{C}_{10}\text{H}_{18}\text{O} + 2[\text{O}] \rightarrow \text{C}_{10}\text{H}_{16}\text{O}_2 + \text{H}_2\text{O}$ ✓✓ 2
 1 mark for H_2O and 1 mark for $2[\text{O}]$
- (ii) The infra-red spectrum was of compound **Y**
 because absorption between $1680 - 1750 \text{ cm}^{-1}$ indicates a $\text{C}=\text{O}$ ✓ 1
 and the absence of a peak between $2500 - 3300 \text{ cm}^{-1}$ shows the absence
 of the OH hydrogen bonded in a carboxylic acid ✓ 1

[12]