1. (i) Decane ✓

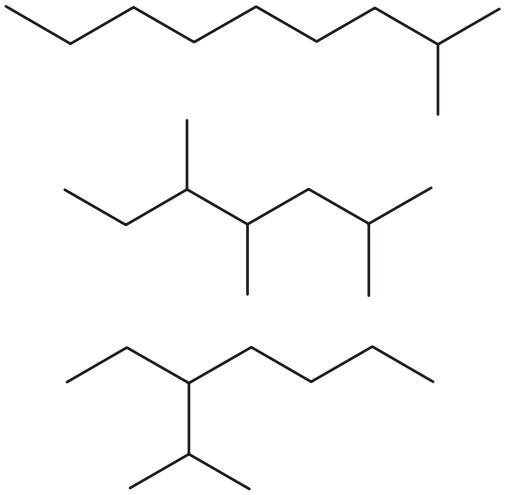
DO NOT ALLOW *deceane*

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) $\frac{34.0}{} \times 100$
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 × 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

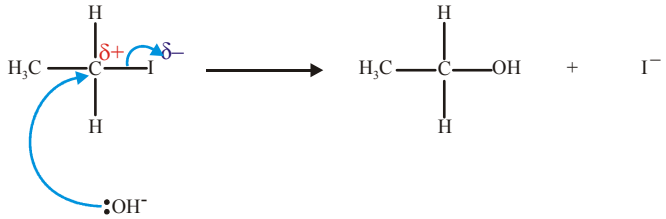
Nucleophilic substitution ✓
Example of nucleophilic substitution ✓
Heterolytic fission ✓
C–I curly arrow ✓
Correct dipole on C— I bond ✓
OH^- curly arrow from one lone pair on O of OH^- ion
OR from minus sign on OH^- ion ✓

OR

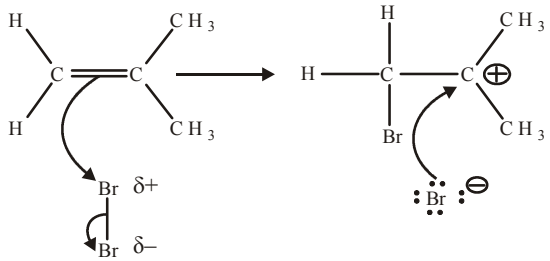
Electrophilic addition ✓
Example of electrophilic addition ✓
Heterolytic fission ✓
Curly arrow from C=C bond to Br—Br bond and
Dipole and curly arrow associated with Br_2 ✓
Correct carbocation ion ✓
Curly arrow from one lone pair on Br^- ion
OR from minus sign on Br^- ion ✓

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 halogenoalkaes*



***ALLOW** mechanisms for other halogens and hydrogen halides*

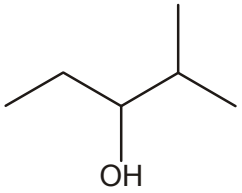
ALLOW

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 C=O carbon and breaking of C=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]

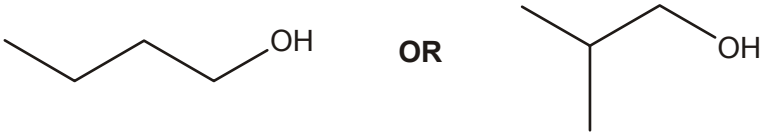
5. (i) Same **molecular** formula but different structural formulae ✓

***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

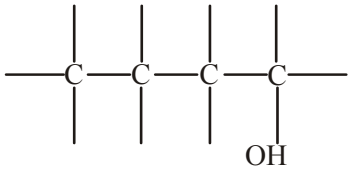
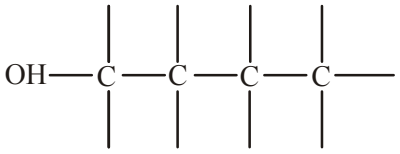
(ii) $CH_3CH_2CH_2CH_2OH$ **OR** $(CH_3)_2CHCH_2OH$ ✓

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. C_nH_{2n+2} ✓

ALLOW $C_nH_{2(n+1)}$ ✓

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(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 ÷ molar mass*

ALLOW *ecf from wrong amount in moles i.e. [0.0268 ÷ moles] × 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 than100% 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

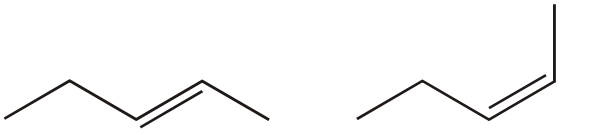
[3]

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 ✓

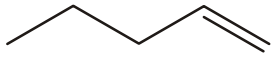
Evidence of using M_r of 70 to **calculate** molecular formula of C_5H_{10} ✓

F and **G** are



o ✓

Correct identification of the *E* and *Z* isomers ✓

H is  ✓

***E/Z* happens because**
double bonds restricts 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 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]

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)**

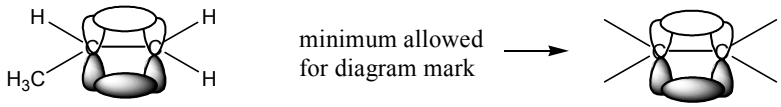
a clear statement that links non-rotation of the double bond to the idea of groups being trapped on one side of the double bond **(1)**

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

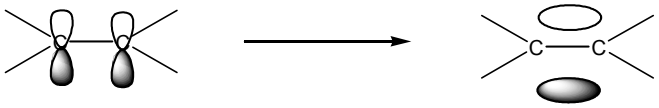
[7]

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



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]

15. (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]

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, 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

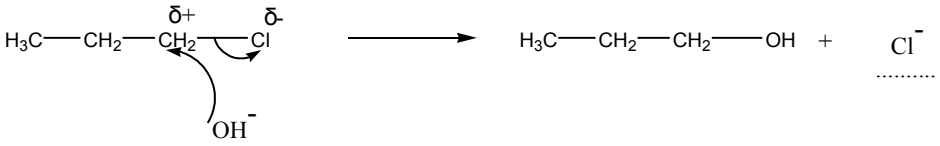
[9]

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

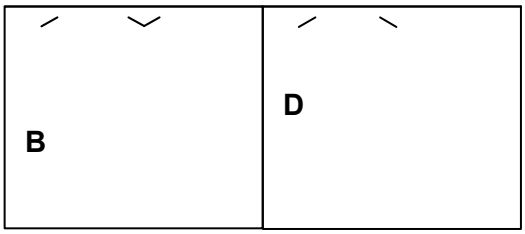
Curly arrow from the O in the OH^- to C in the CH_2 1

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

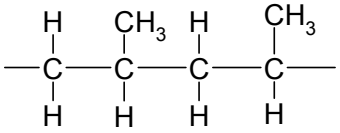
(ii) 2



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

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

(iii) 1



[15]

19. (a) (i) C_4H_{10} ✓ 1

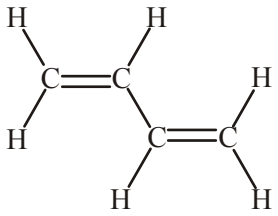
(ii) C_2H_5O ✓ 1

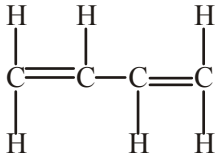
(iii) B and E ✓ 1

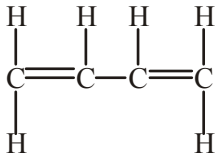
(iv) A and F ✓ 1

(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]

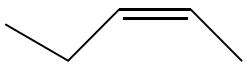
20. (a) Same <u>molecular formula</u>, different structure /displayed formula/ arrangement of atoms/bonds ✓✓ 2

(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

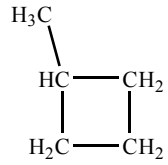
(ii) 2-methylbut-1-ene/2-methyl-1-butene ✓ 1

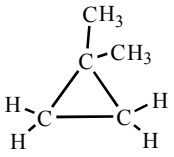
(iii) ✓ 1

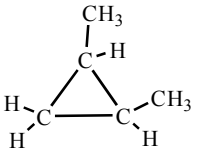


[6]

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







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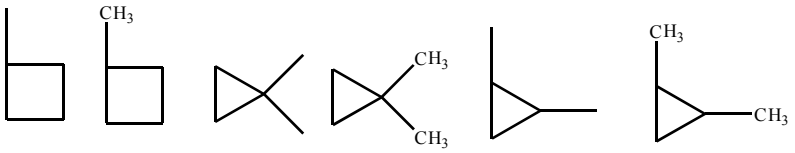
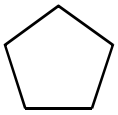


✓✓ 2

(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 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]