

Mark schemes

1

- (a) (i) (Compounds with the) same molecular formula
Allow same number and type of atom for M1
Ignore same general formula.

1

But different structural formula / different displayed formula / different structures
/ different skeletal formula

M2 dependent on M1

Not different positions of atoms / bonds in space.

1

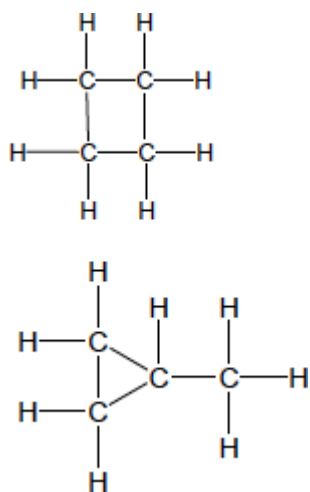
- (ii) But-2-ene
Allow but-2-ene.
Allow but 2 ene.
Ignore punctuation.

1

- (iii) (2)-methylprop-(1)-ene
Do not allow 2-methyleprop-1-ene.

1

(iv)



Do not allow skeletal formulae.

Penalise missing H and missing C

1

- (b) (i) $C_4H_8 + 2O_2 \rightarrow 4C + 4H_2O$
Accept multiples.

1

- (ii) Exacerbates asthma / breathing problems / damages lungs / smog / smoke /
global dimming
Ignore toxic / pollutant / soot / carcinogen.
Do not allow greenhouse effect / global warming / acid rain / ozone.

1

(c) (i) $C_{16}H_{34}$
Allow $H_{34}C_{16}$
C and H must be upper case. 1

(ii) Jet fuel / diesel / (motor) fuel / lubricant / petrochemicals / kerosene / paraffin / central heating fuel / fuel oil
Ignore oil alone.
Not petrol / bitumen / wax / LPG / camping fuel. 1

(d) (i) $C_8H_{18} + 25NO \rightarrow 8CO_2 + 12.5 N_2 + 9H_2O$
Accept multiples. 1

(ii) Ir / iridium
OR
Pt / platinum
OR
Pd / palladium
OR
Rh / rhodium 1

[11]

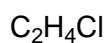
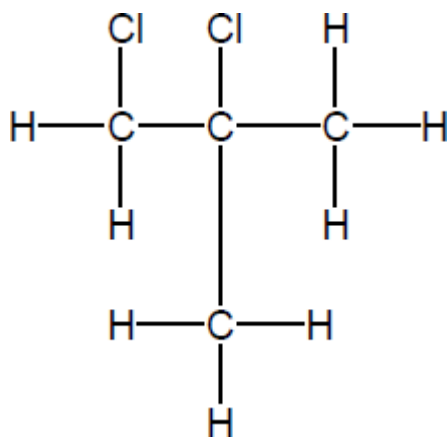
2

(a) 2-bromo-2,3-dimethylbutane
Ignore punctuation. 1

$C_nH_{2n+1}Br$ or $C_nH_{2n+1}X$ or $C_xH_{2x+1}Br$
Any order. 1

Stronger / more vdw (forces) between molecules (of 1-bromohexane)
QoL
Allow converse arguments for Z
Not just more IMF.
Ignore size of molecule. 1

(b)



Any order

1

1

[5]

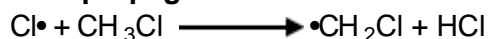
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(a) **Initiation**



Penalise absence of dot once only.

First propagation



Credit the dot anywhere on the radical.

Second propagation



Termination (must make 1,2-dichloroethane)



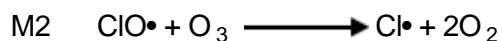
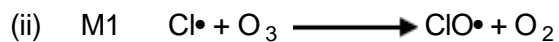
Penalise $C_2H_4Cl_2$

4

(b) (i) (chlorine free) radical

Ignore formula.

1



M1 and M2 could be in either order.

Credit the dot anywhere on the radical.

Penalise absence of dot once only.

Individual multiples acceptable but both need to be doubled if two marks are to be awarded.

2

[7]

4

- (a) (i) C_nH_{2n} / C_xH_{2x} 1
- (ii) Fractional distillation / GLC / gas liquid chromatography / fractionation
Do not allow cracking / distillation 1
- (b) (i) But-1-ene / but1ene
Ignore hyphens and commas
Do not allow butene-1 / but-2-ene / butane / butane /alkene / C_4H_8 / propene / straight-chain alkene 1
- (ii) A structure of cyclobutane or methyl-cyclopropane
Allow skeletal formula. 1
- (c) (i) $C_{15}H_{32} \rightarrow 2C_4H_8 + C_7H_{16}$
Do not accept multiples. 1
- (ii) Thermal cracking
Not catalytic cracking or cracking. 1
- To produce products that are in greater demand / more valuable / more expensive / more profitable
The (unsaturated) alkene or the (unsaturated) molecule or X produced can be polymerised or can be made into plastics.
Ignore more useful products. 1
- (iii) Break (C–C or C–H) bonds
Allow to overcome the activation energy.
Allow to break the carbon chain.
Penalise breaking wrong bonds. 1
- (d) (i) H_2
Only. 1
- (ii) Fuel / LPG
Allow camping gas, lighter fuel, propellant, refrigerant, cordless appliances.
Do not allow petrol or motor fuel.
Ignore natural gas. 1

(iii) $C_4H_{10} + 2.5O_2 \rightarrow 4C + 5H_2O$
Accept multiples. 1

(iv) SO_2 / sulfur dioxide
If other sulfur oxides, mark on. 1

Calcium oxide / CaO / lime / quicklime
Allow $CaCO_3$ / allow $Ca(OH)_2$ or names.
Allow any solid base.
M2 dependent on M1.
Do not allow limewater. 1

(v) Neutralisation
Allow acid-base reaction.
Allow flue gas desulfurisation / FGD 1

(e) (Molecules) are similar sizes / have similar M_r / have similar number of electrons
Chemical error CE = 0/2 if breaking bonds.
Allow similar number of carbon and hydrogen atoms / similar surface area / similar chain length.
Can accept same number of carbon atoms.
Do not accept same number of H atoms / same number of bonds.
Ignore similar amount of bonds. 1

Similar van der Waals forces between molecules / similar intermolecular forces (IMF)
Not similar incorrect IMF eg dipole-dipole 1

[16]

5

(a) (i) Crude oil / oil / petroleum
Do not allow 'petrol' 1

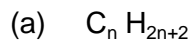
(ii) Fractional distillation / fractionation / fractionating
Not distillation alone 1

(b) (i) 5
Allow five / V 1

- (ii) Chain (isomerism)
Allow branched chain / chain branched / side chain (isomerism)
Ignore position (isomerism)
Do not allow straight chain / geometric / branched / function 1
- (c) (i) $C_{12}H_{26} / H_{26}C_{12}$
Only 1
- (ii) Thermal cracking
If not thermal cracking, CE = 0/2
If blank mark on 1
- High temperature
Allow 'high heat' for 'high temperature'
 $(400^{\circ}\text{C} \leq T \leq 900^{\circ}\text{C})$ or $(650 \text{ K} \leq T \leq 1200 \text{ K})$
Not 'heat' alone
If no T, units must be 650 – 900
- and**
- High pressure ($\geq 10 \text{ atm}$, $\geq 1 \text{ MPa}$, $\geq 1000 \text{ kPa}$) 1
- (iii) To produce substances which are (more) in demand / produce products with a high value / products worth more
Ignore 'to make more useful substances' 1
- (d) (i) Corrosive or diagram to show this hazard symbol
Ignore irritant, acidic, toxic, harmful 1
- (ii) $\left(\frac{120.5}{86 + 71} \times 100 \right)$
 $=76.75(\%)$ or $76.8(\%)$
Allow answers > 3 sig figs 1
- (e) 2,2-dichloro-3-methylpentane
Ignore punctuation
Any order 1
- C_3H_6Cl 1

[12]

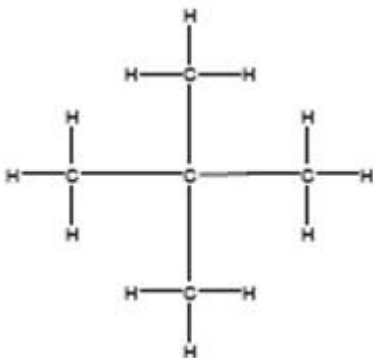
6



Allow x in place of n

1

(b)

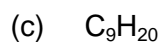


Chain

Must show every bond

Allow branched chain

2



Only

1

To break the (C-C and/or C-H) bonds

M2=0 if break C=C

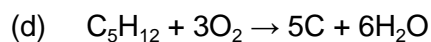
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To make products which are in greater demand / higher value / make alkenes

Not more useful products

Allow specific answers relating to question

1



Allow other balanced equations which give C and CO/CO₂

1

Causes global dimming / exacerbates asthma / causes breathing problems / makes visibility poor / smog

Apply list principle

Ignore causes cancer / toxic

1

(e) $\frac{106.5}{143} \times 100$ 1

74.48%

Allow 74.5%

1

3

Only

1

(f) 2,3-dichloro-3-methylpentane
Ignore punctuation

1

C₅H₆Cl

Only

1

[13]

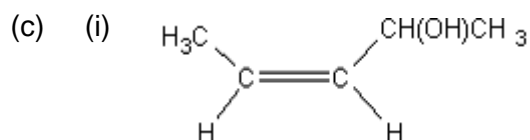
7

(a) Pentan-2-one
ONLY but ignore absence of hyphens

1

(b) Functional group (isomerism)
Both words needed

1



Award credit provided it is obvious that the candidate is drawing the Z / cis isomer

The group needs to be CHOHCH₃ but do not penalise poor C–C bonds or absence of brackets around OH

Trigonal planar structure not essential

1

(ii) Restricted rotation (about the C=C)

OR

No (free) rotation (about the C=C)

1

(d)

<p>M1 Tollens' (reagent) (Credit ammoniacal silver nitrate OR a description of making Tollens') (Do not credit Ag^+, AgNO_3 or $[\text{Ag}(\text{NH}_3)_2]^+$ or "the silver mirror test" on their own, but mark M2 and M3)</p>	<p>M1 Fehling's (solution) / Benedict's (Penalise $\text{Cu}^{2+}(\text{aq})$ or CuSO_4 but mark M2 and M3)</p>
<p>M2 <u>silver mirror</u> OR <u>black solid or black precipitate</u></p>	<p>M2 <u>Red solid/precipitate</u> (Credit <u>orange</u> or <u>brown solid</u>)</p>
<p>M3 (stays) colourless OR no (observed) change / no reaction</p>	<p>M3 (stays) blue OR no (observed) change / no reaction</p>

If **M1** is blank CE = 0, for the clip

Check the partial reagents listed and if M1 has a totally incorrect reagent, CE = 0 for the clip

Allow the following alternatives

M1 (acidified) potassium dichromate(VI) (solution); mark on from incomplete formulae or incorrect oxidation state

M2 (turns) green

M3 (stays) orange / no (observed) change / no reaction

OR

M1 (acidified) potassium manganate(VII) (solution); mark on from incomplete formulae or incorrect oxidation state

M2 (turns) colourless

M3 (stays) purple / no (observed) change / no reaction

In all cases for **M3**

Ignore "nothing (happens)"

Ignore "no observation"

3

(e) (i) **Spectrum is for Isomer 1**

or named or correctly identified

The explanation marks in (e)(ii) depend on correctly identifying Isomer 1.

The identification should be unambiguous but candidates should not be penalised for an imperfect or incomplete name. They may say "the alcohol" or the "alkene" or the "E isomer"

1

(ii) **If Isomer 1 is correctly identified, award any two from**

- (Strong / broad) absorption / peak in the range **2320 to 3550** cm^{-1} or specified value in this range or **marked correctly** on spectrum
and
(characteristic absorption / peak for) OH group / **alcohol** group
- No absorption / peak in range **1680 to 1750** cm^{-1} or absence marked correctly on spectrum
and
(No absorption / peak for a) **C=O** group / **carbonyl** group / **carbon-oxygen double bond**
- Absorption / peak in the range **1620 to 1680** cm^{-1} or specified value in this range or marked correctly on spectrum
and
(characteristic absorption / peak for) **C=C** group / **alkene** / **carbon-carbon double bond**

If 6(e)(i) is incorrect or blank, CE=0

Allow the words “dip” OR “spike” OR “trough” OR “low transmittance” as alternatives for absorption.

Ignore reference to other absorptions e.g. C-H, C-O

2

[10]

8

- (a)
- (Same) General formula/allow a named homologous series with its general formula
 - Chemically similar/same (chemical) reactions
 - Same functional group
 - Trend in physical properties/eg inc bp as M_r increases
 - (Molecules) increase by $\text{CH}_2/M_r = 14$

Any two points

2

(b) Fractional distillation/fractionation/chromatography

Allow GLC

1

- (c) (Molecules/compounds/substances) with the same molecular formula/same number and type of atoms
Allow alkanes with same molecular formula
Allow same chemical formula in M1 = 0 but can allow M2 1

but different structural formula/different displayed formula/different arrangement of atoms/different structures
Not different positions in space 1

2,4-dimethylhexane
M2 dependent on M1 1

C_4H_9
Ignore the absence of dash and/or commas 1

- (d) less surface contact/less surface area/less polarisable molecule 1

so fewer/weaker/less Van der Waals'/vdw forces
Allow more spherical or fewer points of contact
Not smaller molecule/not more compact molecule/not shorter chain
Allow converse arguments
Must be comparative answer ie not just few VDW forces
QoL
Assume 'it' refers to the branched isomer 1

[9]

9

- (a) (Different) boiling points
Ignore mp's, references to imf, different volatilities 1

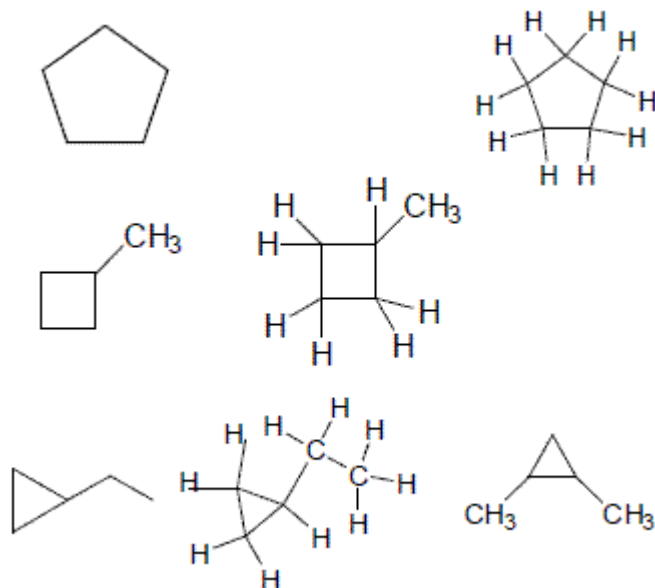
- (b) (i) Compound which have the same molecular formula
Accept same no and type of atom for M1
But If same (chemical) formula M1 = 0 but allow M2
If empirical formula CE = 0/2 1

but different structures/different structural formulae/different displayed formulae
M2 dependent on M1 1

- (ii) 3-methylbut-1-ene
only
ignore commas and hyphens

1

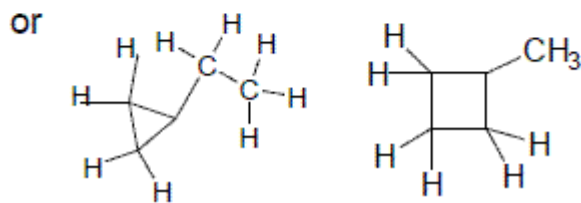
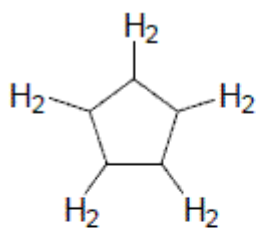
(iii)



Allow any correct structure with a cyclic alkane

1

Do not allow



i.e with an H missing on one C

(c) $C_{13}H_{28}$

only

1

Making plastics/used to make polymers or polythene/used to make antifreeze/make ethanol/ripening fruit/any named additional polymer

not used as a plastic/polymer/antifreeze

not just 'polymers' – we need to see that they are being made

1

[6]

10

(a) (i) single (C-C) bonds only/no double (C=C) bonds

1

Allow all carbon atoms bonded to four other atoms

Single C-H bonds only = 0

C=H CE

C and H (atoms) only/purely/solely/entirely

Not consists or comprises

Not completely filled with hydrogen

CH molecules = CE

Element containing C and H = CE

1

(ii) C_nH_{2n+2}

Formula only

C_xH_{2x+2}

1

(b) (i) $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$

Accept multiples

Ignore state symbols

1

(ii) gases produced are greenhouse gases/contribute to Global warming/effect of global warming/climate change

Allow CO_2 or water is greenhouse gas/causes global warming

Acid rain/ozone CE = 0

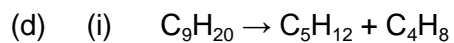
1

(c) carbon

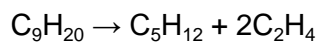
Allow C

Allow soot

1



OR



Accept multiples

1

(ii) Plastics, polymers

Accept any polyalkene/haloalkanes/alcohols

1

(iii) so the bonds break **OR** because the bonds are strong

IMF mentioned = 0

1

(e) (i) 1,4-dibromo-1-chloropentane/1-chloro-1,4-dibromopentane

Ignore punctuation

1

(ii) Chain/position/positional

Not structural or branched alone

1

[11]