

Mark schemes

1

- (a) Saturated – single bonds only / no double bonds

1

Hydrocarbon – contains carbon and hydrogen (atoms) only

1

- (b) $C_{16}H_{34} + 16.5O_2 \longrightarrow 16CO + 17H_2O$

Allow multiples

1

- (c) (On combustion) SO_2 produced

Allow equation to produce SO_2 . Ignore sulfur oxides.

1

Which causes acid rain

If formula shown it must be correct

M2 is dependent on M1. But if M1 is sulfur oxides, allow M2.

For M2 allow consequence of acid rain or SO_2 .

Ignore greenhouse effect and toxic

1

- (d) (i) $C_{16}H_{34} \longrightarrow C_8H_{18} + C_2H_4 + 2C_3H_6$

Allow multiples

1

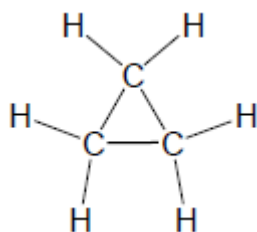
- (ii) polypropene / propan(-1 or 2-)ol / propane(-1,2-)diol / isopropanol / propanone / propanal

Accept alternative names

Ignore plastic and polymer

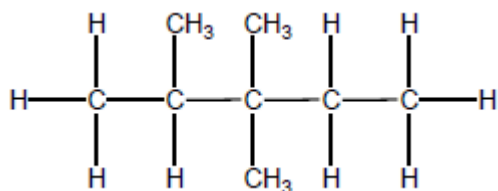
1

- (iii)



1

- (e)



Allow any unambiguous representation

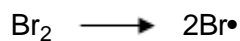
1

- (f) 2,4-dichloro-2,4-dimethylhexane
Only but ignore punctuation

1
[10]

2

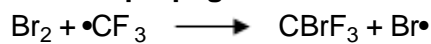
- (a) (i) **Initiation**



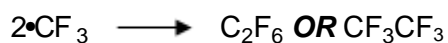
First propagation



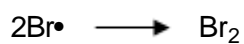
Second propagation



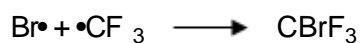
Termination



OR



OR



Penalise absence of dot once only

Credit the dot anywhere on the radical

4

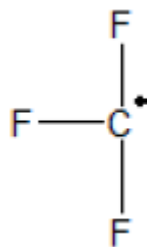
- (ii) Ultra-violet / uv / sunlight

OR

T > 100°C OR high temperature

1

- (b) (i)



Displayed formula required with the radical dot on carbon

1

- (ii) (The) C–Br (bond) breaks more readily / is weaker than (the) C–Cl (bond) (or converse)

OR

The C–Br bond enthalpy / bond strength is less than that for C–Cl (or converse)

Requires a comparison between the two bonds

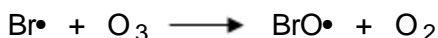
Give credit for an answer that suggests that the UV frequency / energy may favour C–Br bond breakage rather than C–Cl bond breakage

Ignore correct references either to size, polarity or electronegativity

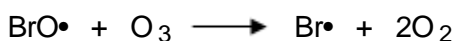
Credit correct answers that refer to, for example “the bond between carbon and bromine requires less energy to break than the bond between carbon and chlorine”

1

- (iii) **M1**



M2



M1 and M2 could be in either order

Credit the dot anywhere on the radical

Penalise absence of dot once only

Penalise the use of multiples once only

M3 One of the following

They / it / the bromine (atom)

- does not appear in the overall equation
- is regenerated
- is unchanged at the end
- has not been used up
- provides an alternative route / mechanism

3

[10]

3

- (a) Crude oil **OR** petroleum

Not petrol.

1

Fractional distillation / fractionation

Not distillation alone.

1

- (b) $\text{C}_{12}\text{H}_{26} + 12.5\text{O}_2 \longrightarrow 12\text{CO} + 13\text{H}_2\text{O}$

Allow balanced equations that produce CO_2 in addition to CO.

Accept multiples.

1

- (c) (i) **M1** Nitrogen and oxygen (from air) react / combine / allow a correct equation

If nitrogen from petrol / paraffin / impurities CE = 0 / 2.

1

M2 at high temperatures

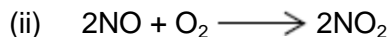
Allow temperatures above 1000 °C or spark.

Not just heat or hot.

M2 dependent on M1.

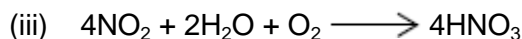
But allow 1 mark for nitrogen and oxygen together at high temperatures.

1



Allow multiples.

1

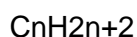


Allow multiples.

1

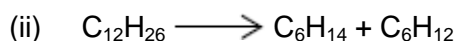


Allow $\text{C}_x\text{H}_{2x+2}$



Allow $\text{C}_x\text{H}_{2x+2}$

1



Only.

1



Only.

1

Zeolite / aluminosilicate(s)

Ignore aluminium oxide.

1

(iii) Larger molecule / longer carbon chain / more electrons / larger surface area

1

More / stronger van der Waals' forces between molecules

Allow dispersion forces / London forces / temporary induced dipole-dipole forces between molecules.

If breaking bonds, CE = 0 / 2.

1

(e) 2,2,3,3,4,4-hexamethylhexane

Only.

Ignore punctuation.

1

Chain

Ignore branch(ed).

1

(f) Cl₂

Only.

Cl-Cl

Not CL₂ or Cl2 or CL2 or Cl² or CL².

Ignore Chlorine.

1

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4

(a) (i) **M1 Initiation**



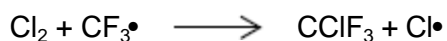
Penalise absence of dot once only.

M2 First propagation



Penalise + or - charges every time.

M3 Second propagation



Credit CF₃• with the radical dot above / below / to either side.

M4 Termination (must make C₂F₆)



Mark independently.

4

(ii) ultra-violet / uv / sun light

OR (very) high temperature

OR 500 °C ≤ T ≤ 1000 °C

OR 773 K ≤ T ≤ 1273 K

1

(b) (i) Cl• **OR** chlorine atom / chlorine (free-) radical / Cl (atom)

Not 'chlorine' alone.

Credit 'Cl' alone on this occasion.

1

(ii) 2O₃ → 3O₂

Or multiples.

Ignore state symbols.

If the correct answer is on the line OR clearly identified below some working, then ignore any working.

1

[7]

5

- (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

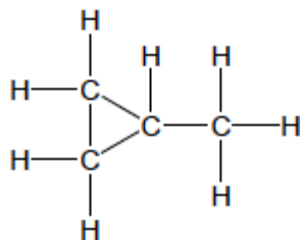
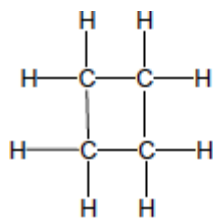
- (ii) But-2-ene
Allow but-2-ene.
Allow but 2 ene.
Ignore punctuation.

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]

6

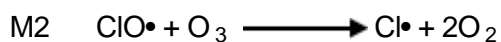
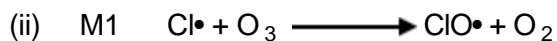
(a) **Initiation**
 $Cl_2 \longrightarrow 2Cl\cdot$
Penalise absence of dot once only.

First propagation
 $Cl\cdot + CH_3Cl \longrightarrow \cdot CH_2Cl + HCl$
Credit the dot anywhere on the radical.

Second propagation
 $Cl_2 + \cdot CH_2Cl \longrightarrow CH_2Cl_2 + Cl\cdot$

Termination (must make 1,2-dichloroethane)
 $2 \cdot CH_2Cl \longrightarrow CH_2ClCH_2Cl$
Penalise $C_2H_4Cl_2$

(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]

7

(a) Fractional distillation / fractionation / GLC / gas liquid chromatography

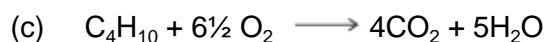
1

(b) C_4H_{10}

Need C_4H_{10} **and** the reason for the mark

Because it has a higher bp / has stronger IMF / larger molecule / longer chain / larger surface (area)

1



Accept multiples

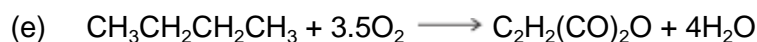
Ignore state symbols

1

(d) CO_2 or H_2O evolved is a greenhouse gas / CO_2 or H_2O evolved contribute to global warming / the products are greenhouse gases

Ignore climate change

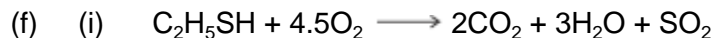
1



Accept multiples

Allow with or without a number 1 before the organic molecules

1



Accept multiples

1

(ii) Calcium oxide / calcium carbonate

Allow any base or alkali

Allow correct formulae

1

Neutralises the SO_2 / acid base reaction / it is a base

Can only score M2 if base or alkali used in M1

Allow M2 if blank in M1

1

- (iii) Ethanol contains hydrogen bonding
Breaking covalent bonds CE = 0 / 2

Which is stronger than IMF (VDW / dipole-dipole forces) in ethanethiol / (H bonding) is the strongest IMF

Only award M2 if M1 given, but allow IMF in ethanol are stronger than in ethanethiol for maximum 1 mark

1

- (g) (i) (2,2-)dimethylpropane
Ignore punctuation

1

- (ii) Because molecule is smaller / less polarisable / has less surface (area) / is more spherical / molecules can't get as close to one another (to feel the vdW forces)

Allow converse answers referring to straight chain isomers CE = 0 / 2 if breaking bonds

1

vdW intermolecular forces or vdW force between molecules are weaker or fewer

Need vdW rather than just IMF

1

- (iii) 1 or one

1

- (h) (i) C_9H_{20}
 $H_{20}C_9$

1

- (ii) Thermal (cracking)
If not thermal cracking CE = 0 / 2

1

High pressure AND high temperature

If blank mark on

Allow high P and T

1

OR

Pressure of ≥ 10 atm, ≥ 1 MPa ≥ 1000 kPa

AND temp of $400\text{ }^\circ\text{C} \leq T \leq 1000\text{ }^\circ\text{C}$ or $650\text{ K} \leq T \leq 1300\text{ K}$

Do not allow high heat

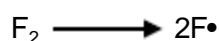
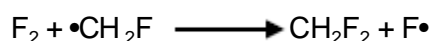
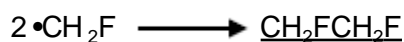
If no units for T, then range must be 650 – 1000

1

[17]

8(a) (i) (Free-) radical substitution*Both underlined words are required**Penalise a correct answer if contradicted by an additional answer*

1

(ii) **Initiation***Penalise absence of dot once only***First propagation***Penalise + or - charges every time***Second propagation***Accept dot anywhere on CH₂F radical**Mark independently***Termination (must make 1,2-difluoroethane)***Use of half-headed arrows must be correct to score, but if not correct then penalise once only in this clip*

4

 (C_2H_6) (C_2HF_5)

1

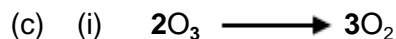
(b) 1,1,1,2-tetrachloro-2,2-difluoroethane

*Accept phonetic spelling eg "fluro, cloro"**Penalise "flouro" and "floro", since **QoL*****OR**

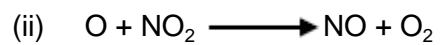
1,2,2,2-tetrachloro-1,1-difluoroethane

Ignore commas and hyphens

1

*ONLY this equation or a multiple**Ignore NO over the arrow**Other species must be cancelled*

1



*ONLY this answer and NOT multiples
Ignore any radical dot on the O atom*

1
[9]