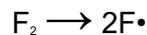


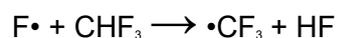


1

(ii) **M1 Initiation**



M2 First propagation



M3 Second propagation



M4 Termination (must make C_2F_6)



Penalise absence of dot once only.

Radical dot on $\cdot\text{CF}_3$ can be anywhere but if the structure is drawn out, the dot must be on the carbon atom. Penalise this error once only.

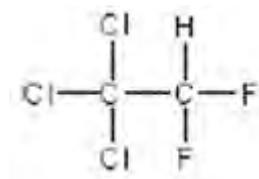
Penalise once only for a line and two dots to show a bond.

Penalise each of "F1" and lower case F, once only in this clip

4

(b) (i) Displayed formula

e.g.



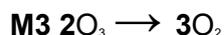
All bonds must be drawn out.

Ignore bond angles. Penalise "sticks"

1

(ii) **M1** C-Cl bond OR carbon-chlorine bond

M2 chlorine atom OR chlorine (free) radical



M1 NOT carbon-halogen

Penalise incorrect spelling of chlorine once only in this clip

M2 ignore formulae

Ignore Cl_2 or $\text{Cl}\cdot$ or $\text{ClO}\cdot$ balanced on both sides of the equation

Ignore other equations leading to the overall equation

3

[9]

M2.C

[1]

M3. (a) (i) **M1 Initiation**



Penalise absence of dot once only.

Penalise + or – charges every time

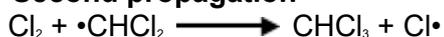
M2 First propagation



Accept dot anywhere on CHCl_2 radical but if the structure is drawn out, the dot must be on the carbon atom. Penalise this error once only

Penalise once only for a line and two dots to show a bond.

M3 Second propagation



Penalise once only for double headed curly arrows

Mark independently

3

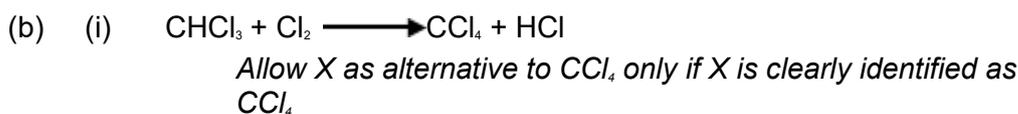
(ii) **M1 Condition**
ultra-violet / uv / sun light

OR high temperature

OR $400^\circ\text{C} \leq T \leq 900^\circ\text{C}$

M2 Type of mechanism
(free-) radical substitution (mechanism)

2



1

(ii) **M1** Trichloromethane / CHCl₃ has a C–H bond

OR

X / CCl₄ / it has no C–H bond

M1 *must refer to presence or absence of the C–H bond in a compound*

M2 The infrared spectrum shows
(absorption / peak for C–H in range) **2850 to 3300** (cm⁻¹) is missing
M2 *answer must refer to / imply the spectrum*

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

Ignore references to other absorptions.

2

(c) **M1 a statement about bond breakage / formation of Cl•**

C–Cl / carbon-chlorine bond breakage occurs

OR Cl• / chlorine (free) radical forms

OR correct equation $\text{CHClF}_2 \longrightarrow \text{Cl}\cdot + \cdot\text{CHF}_2$

Penalise M1, if Cl• is formed from Cl₂ as the only reaction or an additional reaction

Do not penalise an incorrect equation using CHClF₂ if correct reference is made to Cl• formation or C–Cl / carbon-chlorine bond breakage



M2 and **M3** either order

Penalise absence of dot once only.

Accept dot anywhere on ClO radical

M4 CHClF₂ / chlorine-containing compounds/ CFCs damage / react with / decrease the ozone layer

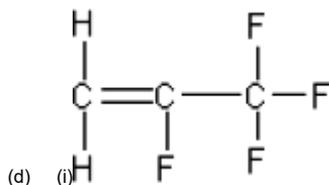
OR this overall decomposition occurs; $2\text{O}_3 \longrightarrow 3\text{O}_2$ **OR** without an ozone layer or with a decreased ozone layer, uv radiation is not being “filtered” / prevented from passing through the atmosphere or there is a concern about an increase in skin cancer etc. **OR** Cl• catalyses the decomposition of ozone / a single Cl• causes (chain) reaction / decomposition of many ozone molecules / ozone layer

Award **M4** for the general idea behind the EU justification for banning the use of CFCs as refrigerants

Penalise **M4** if overall ozone decomposition equation is incorrect

Ignore "greenhouse effect", "global warming" etc.

4



All bonds must be drawn out

1

- (ii) 2,3,3,3-tetrafluoropropene / it does not contain chlorine (atoms) / C-Cl (bonds)

Ignore "chlorine molecules"

ORIt does not produce Cl• / does not produce chlorine (free) radical(s) **OR**chlorodifluoromethane does contain chlorine / does

produce Cl• / does produce chlorine (free) radical(s) **OR**C-F is too strong and does not break / create radicals **OR**C-F is stronger than C-Cl

1

[14]

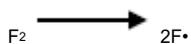
- M4.(a)** (i) (Free-) radical substitution

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

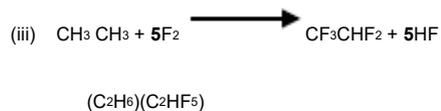


Accept dot anywhere on CH₂F radical
Mark independently



Use of half-headed arrows must be correct to score, but if not correct then penalise once only in this clip

4



1

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

Accept phonetic spelling eg "fluro, cloro"

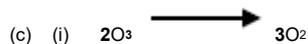
Penalise "flouro" and "floro", since **QoL**

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]

M5.(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 C₂H₄Cl₂

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.

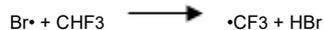
2

[7]

M6.(a) (i) **Initiation**



First propagation



Second propagation



Termination



OR



OR



Penalise absence of dot once only

Credit the dot anywhere on the radical

4

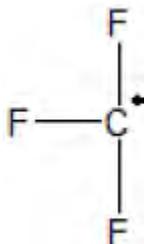
(ii) Ultra-violet / uv / sunlight

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]

M7.(a) (i) M1 Initiation



Penalise absence of dot once only.

M2 First propagation



Penalise + or - charges every time.

M3 Second propagation



Credit $\text{CF}_3\cdot$ with the radical dot above / below / to either side.

M4 Termination (must make C_2F_6)



Mark independently.

4

- (ii) ultra-violet / uv / sun light

OR (very) high temperature

OR $500\text{ }^\circ\text{C} \leq T \leq 1000\text{ }^\circ\text{C}$

OR $773\text{ K} \leq T \leq 1273\text{ K}$

1

- (b) (i) $\text{Cl}\cdot$ **OR** chlorine atom / chlorine (free-) radical / Cl (atom)

Not 'chlorine' alone.

Credit 'Cl' alone on this occasion.

1



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]