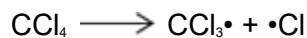
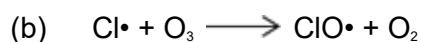


M1.(a) UV light

1



1



1



1

(c) M_r of $\text{CF}_3\text{Cl} = 104.5$

$$\text{Moles freon} = 1.78 \times 10^{-4} \times 10^3 / 104.5 = 1.70 \times 10^{-3}$$

1

$$\text{Number of molecules} = 1.70 \times 10^{-3} \times 6.02 \times 10^{23} = 1.02 \times 10^{21}$$

1

$$\text{Molecules in } 500 \text{ cm}^3 = (1.02 \times 10^{21} \times 500 \times 10^{-6}) / 100 = 5.10 \times 10^{15}$$

Allow answer in the range $5.10\text{--}5.13 \times 10^{15}$

Answer must be given to this precision

1

[7]

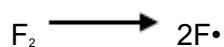
M2.(a) (i) (Free-) radical substitution

Both underlined words are required

Penalise a correct answer if contradicted by an additional answer

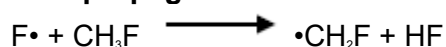
1

(ii) **Initiation**



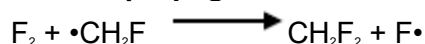
Penalise absence of dot once only

First propagation



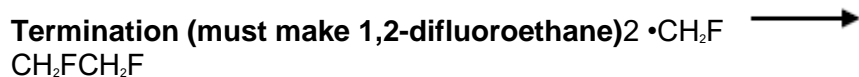
Penalise + or - charges every time

Second propagation



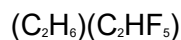
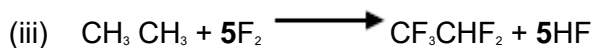
Accept dot anywhere on CH₂F radical

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"

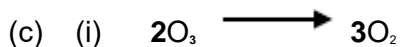
Penalise "flouro" and "floro", since QoL

OR

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

Ignore commas and hyphens

1

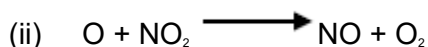


ONLY this equation or a multiple

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

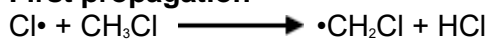
[9]

M3.(a) Initiation



Penalise absence of dot once only.

First propagation

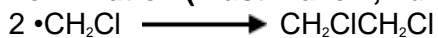


Credit the dot anywhere on the radical.

Second propagation



Termination (must make 1,2-dichloroethane)



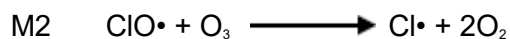
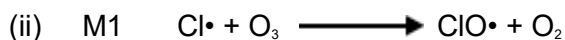
Penalise $\text{C}_2\text{H}_4\text{Cl}_2$

4

(b) (i) (chlorine free) radical

Ignore formula.

1



M1 and M2 could be in either order.

Credit the dot anywhere on the radical.

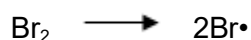
Penalise absence of dot once only.

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

2

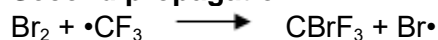
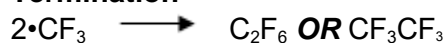
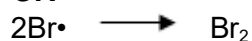
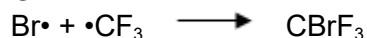
[7]

M4.(a) (i) Initiation



First propagation



Second propagation**Termination****OR****OR***Penalise absence of dot once only**Credit the dot anywhere on the radical*

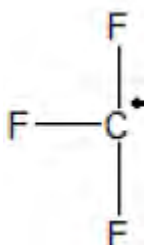
4

(ii) Ultra-violet / uv / sunlight

ORT > 100°C OR high temperature

1

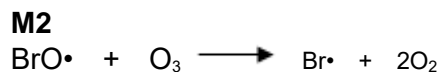
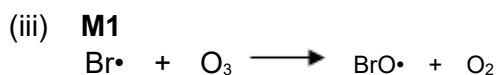
(b) (i)

*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



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

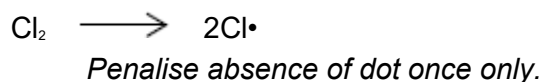
They / it / the bromine (atom)

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

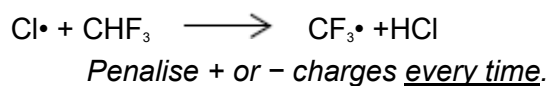
3

[10]

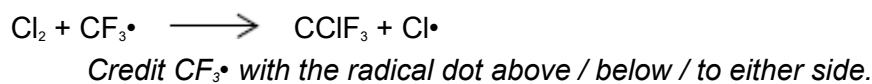
M5.(a) (i) M1 Initiation



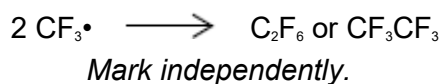
M2 First propagation



M3 Second propagation



M4 Termination (must make C_2F_6)



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

(ii) $2\text{O}_3 \longrightarrow 3\text{O}_2$

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]