

- M1.** (a) (i) chlorotrifluoromethane
Spelling must be correct but do not penalise “flouro”
Ignore use of 1– 1
- (ii) $\text{CF}_3\cdot$
May be drawn out with dot on C
OR if as shown dot may be anywhere 1
- (iii) An unpaired/non-bonded/unbonded/free/a single/one/lone electron
NOT “bonded electron” and NOT “paired electron”
NOT “pair of electrons”
NOT “electrons”
Ignore “(free) radical” 1
- (b) **M1** $\text{Cl}\cdot + \text{O}_3 \rightarrow \text{ClO}\cdot + \text{O}_2$
- M2** $\text{ClO}\cdot + \text{O}_3 \rightarrow 2\text{O}_2 + \text{Cl}\cdot$
Mark independently
Equations could gain credit in either position
The dot can be anywhere on either radical
Penalise the absence of a dot on the first occasion that it is seen and then mark on. Do not make the same penalty in the next equation, but penalise the absence of a dot on the other radical.
Apply the list principle for additional equations 2
- (c) (i) (If any factor is changed which affects an equilibrium), the (position of) equilibrium will shift/move so as to oppose the change.
- OR**
- (When a system/reaction in equilibrium is disturbed), the equilibrium shifts/moves in a direction which tends to reduce the disturbance

Must refer to equilibrium

Ignore reference to "system" alone

A variety of wording will be seen here and the key part is the last phrase.

An alternative to shift/move would be the idea of changing/altering the position of equilibrium

1

(ii) **M1** The (forward) reaction/to the right is endothermic or takes in heat

OR The reverse reaction/to the left is exothermic or gives out heat

M2 The equilibrium moves/shifts to oppose the increase in temperature

M2 depends on a correct statement for M1

For M2 accept

The equilibrium moves/shifts

- to take in heat/lower the temperature
- to promote the endothermic reaction and take in heat/ lower the temperature
- to oppose the change and take in heat/lower the temperature

(leading to the formation of more ozone)

2

(d) Any one of

- Pentane does not contain chlorine OR C-Cl (bond)
- Pentane is chlorine-free
- Pentane does not release chlorine (atoms/radicals)
Ignore reference to F OR C-F OR halogen
Ignore "Pentane is not a CFC"
Ignore "Pentane is a hydrocarbon"
Ignore "Pentane only contains C and H"
Ignore "Pentane is C₅H₁₂"

1

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- M2.** (a) **M1** (Free-) radical substitution
Both words needed 1
- M2** $\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$ 1
- M3** $\text{Cl}\cdot + \text{CH}_4 \rightarrow \cdot\text{CH}_3 + \text{HCl}$ 1
- M4** $\text{Cl}_2 + \cdot\text{CH}_3 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}\cdot$ 1
- M5** $\text{CH}_4 + 3\text{Cl}_2 \rightarrow \text{CHCl}_3 + 3\text{HCl}$
Penalise the absence of a radical dot once only
Ignore termination steps except, if and only if both M3 and M4 do not score, then accept for one mark
 $\text{Cl}\cdot + \cdot\text{CH}_3 \rightarrow \text{CH}_3\text{Cl}$ 1
- (b) **M1** UV (light)/ sunlight / light / UV radiation
- M2** C–Cl or carbon-chlorine bond breakage
OR
homolysis of C–Cl
OR
equation to show a chlorine-containing organic compound forming two radicals
For M1 and M2, ignore use of Cl_2 , but credit UV and C–Cl bond breakage if seen 1
- M3** $\text{Cl}\cdot + \text{O}_3 \rightarrow \text{ClO}\cdot + \text{O}_2$ 1
- M4** $\text{ClO}\cdot + \text{O}_3 \rightarrow \text{Cl}\cdot + 2\text{O}_2$
Ignore other equations
Penalise the absence of a radical dot once only
Accept radical dot anywhere on either radical. 1
- M5** Any one from
- Combination $2\text{O}_3 \rightarrow 3\text{O}_2$
 - Stated that $\text{Cl}\cdot$ / chlorine atom is regenerated / not used up
 - Stated that the $\text{Cl}\cdot$ / chlorine atom is unaffected by the process.
- For M5 accept $\text{Cl}\cdot$ on both sides of the equation* 1

M6 Stated that the role of the $\text{Cl}\cdot$ / chlorine atom is to find an alternative route **OR** lower E_a / activation energy

1

(c) **M1** Halothane contains C–Cl / Cl

OR

Desflurane does not contain C–Cl bonds / Cl

OR

Desflurane contains C–F / F as the only halogen

Mark independently.

For M1, credit the idea that desflurane contains C–F bonds that are difficult to break OR that halothane contains C–Cl bonds which are easy to break.

1

M2 Desflurane / molecules that have fluorine as the only halogen, cause no damage / do not deplete / do not react with the ozone (layer)

OR

Halothane / chlorine-containing molecules, damage / deplete / react with the ozone (layer)

1

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