

- 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 C<sub>5</sub>H<sub>12</sub>"*

1

[9]

- 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<sub>2</sub>, 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 Cl• / chlorine atom is regenerated / not used up
  - Stated that the Cl• / chlorine atom is unaffected by the process.
- For M5 accept Cl• 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

[13]