F322: Chains, Energy and Resources
Halogenoalkanes
Mark Scheme

1. **Any TWO from:**
   CFCs take many years to reach the ozone layer **OR** long residence time ✅
   CFCs are still being used ✅
   there are other ozone depleting substances ✅
   **IGNORE** because chlorine radicals stay in the stratosphere
   **ALLOW** other named ozone depleting substances e.g. NO and HFCs

2. (i) substitution/hydrolysis (1)
   (ii) electron pair donor (1)
   (iii)

   ![Chemical Reaction]

   correct dipole (1)
   curly arrow from the O in the OH- to C in the CH2 (1)
   curly arrow to show movement of bonded pair in the C–Br bond (1)
   Br⁻ as a product (1)

3. (a) (i)

   ![Chemical Structure]

   (ii) H₂SO₄/Al₂O₃/(hot) pumice/H₃PO₄
       (H₂SO₄(aq) or dil H₂SO₄ loses the mark)
(iii)  
\[
\begin{align*}
\text{OH} & \quad \text{C}_6\text{H}_{11}\text{OH} / \text{C}_6\text{H}_{12}\text{O} \rightarrow \text{C}_6\text{H}_{10} + \text{H}_2\text{O} \\
\end{align*}
\]

(b)  (i)  
\[
\begin{align*}
\text{OH} & \quad \text{OH} & \text{OH} \\
\text{Cl} & \quad \text{Cl} & \text{diol} & \text{Cl-alcohol} \\
\end{align*}
\]
also allow

(ii)  from the diol allow  
\[
\begin{align*}
\text{from the Cl-alcohol allow} & \\
\end{align*}
\]
4. (i) require an attempt at a 3D structure and bond angles must clearly not be 90°. require at least one ‘wedge’ bond or one ‘dotted’ bond

(ii) 108 – 111°

(iii) volatile/low boiling/gas/non-toxic/non-flammable/unreactive/liquefied under pressure/inert

(iv) homolytic = bonded pair split equally/ each retains 1 electron

fission = bond breaking

(v) C-Cl (no mark) because it is the weaker bond

(vi) Cl•

•CF₃ (allow CF₂•)

(lack of ‘dots’ penalise once)

5. (a) (i) reaction 1

(ii) reaction 4

(iii) reaction 3

(b) (i) lone pair/electron pair donor

Correct dipole

Curly arrow from the O in the OH⁻ to C in the CH₂

Curly arrow to show movement of bonded pair in the C-Cl bond

Cl⁻ as a product
(c) (i) same molecular formula, different structure/arrangement of atoms.
(same formula, different structure.)

(ii)

\[
\begin{array}{c}
\text{B} \\
\text{D}
\end{array}
\]

(d) (i) addition, (not additional)
(ii) poly(propene)/polypropene/polyprop-1-ene, polypropylene
(iii)

\[
\begin{array}{cccc}
\text{C} & \text{C} & \text{C} & \text{C} \\
\text{H} & \text{H} & \text{H} & \text{H} \\
\text{CH}_3 & \text{CH}_3 \\
\text{H} & \text{H} & \text{H}
\end{array}
\]

6. Essential marks:

**Order**
RI>RBr>RCI/owtte

**reason for the order**
C-I bond weakest/length/C-Cl bond strongest and
mention/intermolec forces loses the mark

**an equation**
\[\text{Ag}^+ + \text{X}^- \rightarrow \text{AgX} \text{ (solid or ppt)} \text{ or an equation for hydrolysis/using OH- or H}_2\text{O} \]

max = 3

Two possible methods of monitoring the reaction

**Method 1**

AgNO\(_3\)
Ethanol & Waterbath/
/hydroxide
temp 40 – 80°C
not heat/not bunsen
relative rate of
precipitation

**Method 2**

AgNO\(_3\)
NaOH/OH\(^-\) & neutralise with HNO\(_3\)
relative amount of
precipitation
7. Properties:

- Non-toxic/harmless
- non-flammable
- any two from:
  - (propellant in) aerosols because it is volatile/unreactive/non-toxic/easily compressed
  - blowing polystyrene because it is unreactive
  - dry cleaning because it is a good solvent for organic material
  - degreasing agent because it is a good solvent for organic material
  - fire extinguishers because it is non-flammable

QWC

- reasonable spelling, punctuation and grammar throughout

8. (a) Cl\(^-\) must be shown as a product

   (at least 1) lone pair of electrons on the O in the OH\(^-\) with curly arrow
   from the lone pair on the OH\(^-\) to the C(\(\delta^+\))
   dipoles on the C-Cl bond
   curly arrow from C-Cl bond to the C(\(\delta^-\))

   The mechanism below would get all 4 marks.

   \[
   \begin{align*}
   \text{CH}_3\text{CH}_2\text{CH}_2\text{H} & \quad \text{C} & \quad \text{Cl} & \quad \text{OH}^- \\
   \text{Cl} & \quad \delta^+ & \quad \delta^- & \quad \text{H} \\
   & \quad \text{H} & \quad \text{H} & \quad \text{+ Cl}^- \\
   \end{align*}
   \]

(b) (i) mark for method/dividing by \(A_r/\text{C}, 3.15; \text{H}, 6.3; \text{Cl}, 1.58\).

   divide by smallest to get \(\text{C}_2\text{H}_4\text{Cl}\)

   alternative method:
   % of each element \(\times 127 \div A_r\) of that element = molecular formula, hence deduce empirical formula

   (ii) \(\text{C}_4\text{H}_8\text{Cl}_2\)
(iii) any unambiguous form of: ✓

\[
\begin{align*}
\text{H} & \quad \text{H} & \quad \text{H} & \quad \text{H} \\
\text{H} & \quad \text{C} & \quad \text{C} & \quad \text{C} & \quad \text{C} & \quad \text{OH} \\
\text{H} & \quad \text{OH} & \quad \text{H} & \quad \text{H} \\
\end{align*}
\]

(iv) any unambiguous form of: ✓

\[
\begin{align*}
\text{H} & \quad \text{H} & \quad \text{H} & \quad \text{H} \\
\text{H} & \quad \text{C} & \quad \text{C} & \quad \text{C} & \quad \text{C} & \quad \text{Cl} \\
\text{H} & \quad \text{Cl} & \quad \text{H} & \quad \text{H} \\
\end{align*}
\]

ecf to (iii) provided that there are two OHs in (iii) [9]