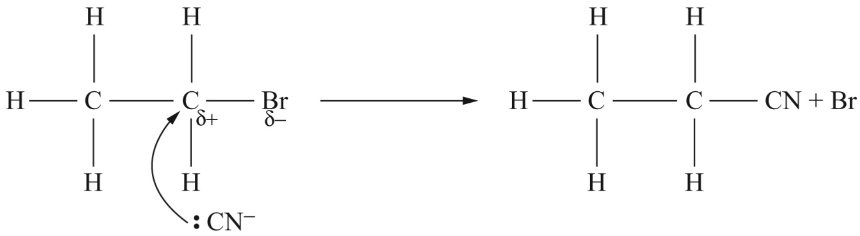
Chapter 16: Halogenoalkanes

Homework marking scheme

1 **a** add aqueous silver nitrate solution [1]
observe a pale cream precipitate [1]
which is partially soluble in ammonia solution, suggests bromide ions [1]
$Ag^{+}(aq) + Br^{-}(aq) \rightarrow AgBr(s)$ [1]

b number of moles
use $PV = nRT$, rearranged to give $n = \frac{PV}{RT}$ [1]
$n = \frac{1.01\times10^{5}\times61\times10^{-6}}{8.314\times373}$ [1]
$= 1.99 \times 10^{-3}$ mol [1]
molar mass
$= \frac{0.218}{1.99\times10^{-3}} = 109.6$ g mol^{-1} [1]
The relative molecular mass of CH_3CH_2Br is 109, which is close to the value above. [1]
Note the need to convert the temperature to an absolute temperature.

c **i** $CH_3CH_2Br + KCN \rightarrow CH_3CH_2CN + KBr$ [1]
ii The substitution of the Br by CN lengthens the carbon chain. [1]
iii



curly arrow from lone pair or negative charge on cyanide ion [1]
dipoles on the C–Br bond [1]
curly arrow from the C–Br bond onto the bromine [1]

d aqueous NaOH and reflux: [2]
$CH_3CH_2Br + NaOH(aq) \rightarrow CH_3CH_2OH + NaBr$ [1]
ethanolic NaOH; heat [2]
$CH_3CH_2Br + NaOH \rightarrow CH_2CH_2 + NaBr + H_2O$ [1]

e **i** $Cl_2 + 2Br^{-} \rightarrow 2Cl^{-} + Br_2$ [1]
ii The oxidation number of the chlorine has decreased from 0 to −1, therefore reduced. [1]
The oxidation number of the bromine increases from −1 to 0, therefore oxidised. [1]
iii Bromine is non-polar. [1]
The intermolecular forces between bromine molecules are weak van der Waal's forces. [1]
The intermolecular bonds between polar water molecules [1]
are much stronger hydrogen bonds. [1]

2 **a** In nucleophilic substitution, the nucleophile attacks the electron-deficient carbon. [1]
The greater the electronegativity of the halogen, the more electron-deficient the carbon. [1]
The easier it is for the nucleophile to attack the carbon. [1]

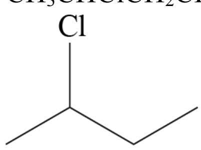
b I > Br > Cl [1]
The lower the bond enthalpy of the C–halogen bond, the easier it is to break it and hence the faster the reaction. [1]

c Use similar halogenoalkanes, e.g. 1-chlorobutane, 1-bromobutane and 1-iodobutane. [1]
Use aqueous silver nitrate mixed with ethanol (to dissolve both the silver nitrate and the halogenoalkane). [2]
Add equal (molar) amounts of halogenoalkane. [1]
Warm the mixture. [1]
Time how long it takes for a precipitate to form. [1]

d They are unreactive [1]
and volatile. [1]

e They lead to the destruction of the ozone layer. [1]

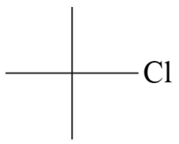
3 **a** $CH_3CHClCH_2CH_3$ [1]



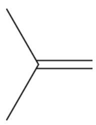
[1]

$(CH_3)_2CClCH_3$ (note that $(CH_3)_3CCl$ is acceptable) [1]

[1]

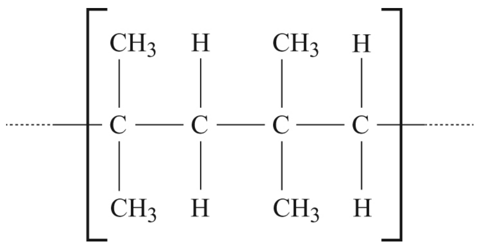


b **i** 2-methylpropene [1]



[1]

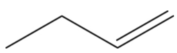
ii



the two methyl groups must be on the same carbon [1]
four-carbon section with lines (preferably dashed) on either side. [1]

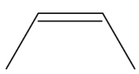
c but-1-ene [1]

[1]



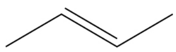
cis-but-2-ene [1]

[1]

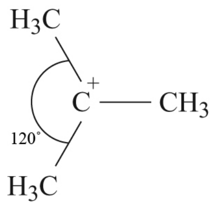


trans-but-2-ene [1]

[1]



d **i**



correct methyl groups and central +ve charge [1]
correct shape named as trigonal planar [1]
correct bond angle (120°). [1]

ii The three electron-donating methyl groups reduce the +ve charge density on the central carbon, making it more stable. [1]

iii $(CH_3)_2CClCH_3 \rightarrow (CH_3)_2C^+(CH_3) + Cl^-$ [1]
$(CH_3)_2C^+(CH_3) + OH^- \rightarrow (CH_3)_2C(OH)CH_3$ [1]

iv Heterolytic fission is the first step.
The C–Cl bond breaks unevenly, and both of the electrons from the bond go to the Cl [1]
to give two oppositely charged ions – a carbocation and a chloride ion. [1]