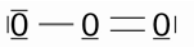
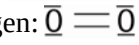
Marking scheme for AHL Worksheet – Option E

1 **a** ozone:  [1]

dioxygen:  [1]

b ozone has a delocalised structure with average bond order 1.5 [1]

O_2 has a double bond between oxygen atoms, which is stronger than the bond in O_3 [1]

shorter wavelength, higher energy radiation required to break the stronger bond [1]

c $\bullet Cl + O_3 \rightarrow ClO\bullet + O_2$ [1]

$ClO\bullet + O\bullet \rightarrow O_2 + Cl\bullet$ [1]

chlorine free radical regenerated – acts as a catalyst [1]

2 **a** volatile organic compounds [1]

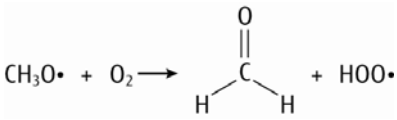
nitrogen oxides [1]

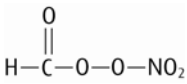
b  [1]

c $CH_4 + HO\bullet \rightarrow CH_3\bullet + H_2O$ [1]

$CH_3\bullet + O_2 \rightarrow CH_3OO\bullet$ [1]

$CH_3OO\bullet + \bullet NO \rightarrow CH_3O\bullet + \bullet NO_2$ [1]

 [1]

d  [1]

3 **a** $O_3 \xrightarrow{\text{UV light}} O\bullet + O_2$ [1]

$O\bullet + H_2O \rightarrow 2HO\bullet$ or $H_2O + O_3 \rightarrow 2HO\bullet + O_2$ [1]

b $HO\bullet + SO_2 \rightarrow HOSO_2\bullet$ [1]

$HOSO_2\bullet + O_2 \rightarrow HO_2\bullet + SO_3$ [1]

$SO_3 + H_2O \rightarrow H_2SO_4$ [1]

4 **a** **i** $K_{sp} = [Ni^{2+}(aq)][S^{2-}(aq)]$ [1]

ii $K_{sp} = [Ag^{+}(aq)]^2[SO_4^{2-}(aq)]$ [1]

iii $K_{sp} = [Fe^{3+}(aq)][OH^{-}(aq)]^3$ [1]

b **i** $BaSO_4(s) \rightarrow Ba^{2+}(aq) + SO_4^{2-}(aq)$
$K_{sp} = [Ba^{2+}(aq)][SO_4^{2-}(aq)]$ [1]

let the solubility of barium sulfate be s, therefore $K_{sp} = s^2$

$s = \sqrt{1.3 \times 10^{-10}}$ i.e. 1.14×10^{-5} mol dm^{-3} [1]

ii $[SO_4^{2-}(aq)] = 0.100$ mol dm^{-3} [1]

$1.3 \times 10^{-10} = [Ba^{2+}(aq)] \times 0.100$ [1]

solubility of $BaSO_4$ is 1.3×10^{-9} mol dm^{-3} [1]

c $Cr(OH)_3(s) \rightarrow Cr^{3+}(aq) + 3OH^-(aq)$
$K_{sp} = [Cr^{3+}(aq)][OH^-(aq)]^3$ [1]

concentration of $Cr^{3+}(aq)$ in a saturated solution $= \frac{2.54 \times 10^{-7}}{103.03}$

$= 2.47 \times 10^{-9}$ mol dm^{-3} [1]

concentration of $OH^-(aq)$ in a saturated solution $= 3 \times 2.47 \times 10^{-9}$ mol dm^{-3}
$= 7.40 \times 10^{-9}$ mol dm^{-3} [1]

$K_{sp} = (2.47 \times 10^{-9}) \times (7.40 \times 10^{-9})^3 = 1.00 \times 10^{-33}$ mol^4 dm^{-12} [1]

pH = 12 so $[OH^-(aq)] = 0.010$ mol dm^{-3} [1]

solubility at pH 12 is $1.00 \times 10^{-33} = [Cr^{3+}(aq)] \times 0.010^3$
$= 1.00 \times 10^{-27}$ mol dm^{-3} [1]

mass of $Cr(OH)_3$ dissolved in 100 cm^3 of pH 12 solution is $1.00 \times 10^{-27} \times 103.03 \times 0.1$
$= 1.03 \times 10^{-26}$ g [1]

mass of $Cr(OH)_3$ dissolved in 100 cm^3 of a saturated solution $= 2.54 \times 10^{-6}$ g [1]

amount that precipitates is $2.54 \times 10^{-6} - 1.03 \times 10^{-26}$
$= 2.54 \times 10^{-6}$ g [1]

5 **a** Cation-exchange capacity is a measure of the amount of exchangeable cations in soil. [1]

b At low pH more cation-exchange sites on clay minerals are occupied by H^+, therefore the ability of the soil to hold other ions is reduced. [1]

Surface OH groups on clay minerals are protonated, therefore cations are repelled. [1]