1.

(a) $-\log_{10}(0.05) = 1.3$

(b) $-\log_{10}(0.20) = 0.70$

(c) $\text{pOH} = -\log_{10}(0.04) = 1.4$

$\text{pH} + \text{pOH} = 14$

$\therefore \text{pH} = 12.6$

(d) $-\log_{10}\left(5.4\times10^{-5}\right) = 4.3$

(e) $\text{pOH} = -\log_{10}\left(3.7\times10^{-7}\right) = 6.4$

$\text{pH} + \text{pOH} = 14$

$\therefore \text{pH} = 7.6$

2.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

$$H_2CO_3 \xrightarrow{(partially)} 2H^+ + CO_3^{2-}$$

3.

(a) Acid rain forms when oxides of nitrogen or sulfur react with water.

$$2NO_{2(aq)} + H_2O_{(l)} \rightarrow HNO_{3(aq)} + HNO_{2(aq)}$$

$$SO_{2(aq)} + H_2O_{(l)} \rightarrow H_2SO_{3(aq)}$$

$$SO_{3(aq)} + H_2O_{(l)} \rightarrow H_2SO_{4(aq)}$$

These acids then partially ionise, lowering the pH of the rain.

(b) Limestone is a metal carbonate and will therefore react with an acid to produce a neutral solution of metal ions.

$$2H^+_{(aq)} + CaCO_{3\,(s)} \rightarrow Ca^{2+}_{(aq)} + H_2O_{(l)} + CO_{2\,(g)}$$

4. Acid in acid rain corrodes the metal: it reacts to dissolve the metal into solution. The metal ions are then washed away with the rain.

$$2H^+_{(aq)} + Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + H_{2\,(g)}$$

$$6H^+_{(aq)} + 2Al_{(s)} \rightarrow 2Al^{3+}_{(aq)} + 3H_{2\,(g)}$$

5. The hydrogen ions in the rain displace the toxic metal cations adsorbed to soil particles. The toxic metal cations are then in solution in soil water.

$$Al^{3+}_{(soil)} + H^+_{(aq)} \rightarrow Al^{3+}_{(aq)} + H^+_{(soil)}$$

6.

(a) Combustion in car engines

(b) Traffic (and therefore combustion in car engines) is high as people drive to and from work.

(c) UV breaks oxygen away from NO_2, and this atomic oxygen reacts with O_2 to form ozone. Excess energy is absorbed by a stabilising molecule.

$$NO_2 \xrightarrow{UV} NO + O$$

$$O + O_2 \rightarrow O_3$$

(d) Levels of UV are highest then.

(e) Ozone is produced by a reaction of a primary pollutant in the atmosphere, it is not emitted directly.

7.

(a) Atmospheric nitrogen is present in the air used during combustion. The high temperature of combustion allows N_2 to react with O_2 to form NO. This can then react with O_2 to form NO_2.

$$N_{2\,(g)} + O_{2(g)} \xrightarrow{heat} 2NO_{(g)}$$

$$2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2\,(g)}$$

(b) Tropospheric ozone is a secondary pollutant produced by NO_x and UV. The two equations reduce the amount of NO_2 (convert it into N_2 which is generally unreactive) which therefore doesn't exist to produce ozone.

8. Salts containing Al^{3+} are added to the water. Clay particles in water are negatively charged so the cations will attract them and join them together in larger clumps which are too large to stay suspended and will settle. The clay can then be removed as a sediment or filtered out.

9.

(a) Hypochlorite (ions)

(b) $ClO^- + H_2O \rightarrow HOCl + OH^-$

Since OH^- is produced, the pH is being raised.

(c) $[H^+] = 10^{-pH} = 3.16\times10^{-8}$ mol L^{-1}

10. Chlorine gas reacts with water to form hypochlorous acid and hydrogen ions. This gives low pH (acidic) conditions. Adding a base will correct the pH closer to ideal (7.5)