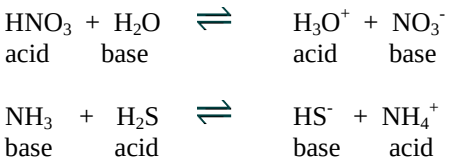
CH1011 Tutorial 8 Answers

1. Identify the acids and the bases in the following processes.



2. Define a Bronsted-Lowry acid and give an example of a weak Bronsted-Lowry acid.

A Bronstead-Lowry acid is a *proton donor - a substance that donates a* H^+ *ion*.

e.g. NH_4^+ + H_2O → $H_3O^+ + NH_3$
weak acid

3. Calculate the hydrogen ion concentration, pH and pOH for a 0.200 M solution of $HClO_4$.

Equation: $HClO_4 + H_2O \rightarrow ClO_4^- + H_3O^+$

$H^+ = 0.200M$ ($HClO_4$ is a strong acid)
$pH = -\log_{10}[H^+] = 0.70$
$pOH = 14 - pH$
$= 13.30$

4. SO_2 is the gas that is most responsible for acid rainfall events in most regions where this effect is pronounced. Calculate the concentration of SO_2 inside a raindrop that is at equilibrium with air that contains a concentration of 200ppm SO_2. $K_H\, SO_2 = 1.470$ mol dm^{-3} atm^{-1}

$\%_i = ppmv_i \times 10^{-4}$ $\quad p_i = (\%_i / 100)\, p_{atm}$
$\%_{SO2} = 200$ ppmv $\times 10^{-4}$ $\quad p_{SO2} = (2 \times 10^{-2} / 100) \times 1$ atm $= 2 \times 10^{-4}$ atm

$[SO_{2(aq)}] = p_{SO2}\, K_H = 2 \times 10^{-4} \times 1.470$ mol dm^{-3}
$= 2.94 \times 10^{-4}$ mol dm^{-3}

5. CFCs are responsible for the depletion of stratospheric ozone globally. Detail the chemistry involved and why man has managed to influence a global chemical reservoir – the ozone layer.

The ozone layer while a global reservoir in fact contains a relatively small amount of ozone. Each day 350kT are produced and eliminated in the natural cycle. The total amount at the nominal 10ppb concentration would only cover the earth to a depth of 3mm if all the ozone were brought to ground level at a pressure of 1atm.
CFCs are chlorofluorcarbons such as CFC-12 CF_2Cl_2. These chemicals were produced in large quantities (kt / y) for use as refrigerants, propellants and cleaning products from the 1930s to 1980s. Once released

into the atmosphere these halocarbons are quite inert in the troposphere and migrate upwards to the stratosphere over 3 - 10 years. The lifetime of the CFCs in the stratosphere is 110 yrs for CFC12 which means that the removal rate here is also quite slow.

The decay process is: $CF_2Cl_2 + h\nu \rightarrow CF_2Cl^{\cdot} + Cl^{\cdot}$ $\quad h\nu = 190 - 225$ nm

This generates he reactive Cl radical which catalytically removes ozone, 100 000 ozone molecules are removed per Cl radical:

$$Cl^{\cdot} + O_3 \rightarrow ClO^{\cdot} + O_2 \text{ (chlorine monoxide)}$$

$$ClO^{\cdot} + h\nu \rightarrow Cl^{\cdot} + O \text{ (net loss of } O_3\text{)}$$

Overall: $2O_3 + 2h\nu \rightarrow 3O_2$

$$\text{Rate} = k[Cl][O_3] \quad k = 7.2 \times 10^{9}\ M^{-1}\ s^{-1}$$

This is the general mechanism for the removal of ozone in the stratosphere which occurs globally.