Topic 6B - The pH Scale

Auto-ionization of Water

H_2O and NH_3 are examples of molecules that are amphiprotic (*i.e.*, can either donate or accept H^+):

$$OH^- \xleftarrow{-H^+} H_2O \xrightarrow{+H^+} H_3O^+ \qquad (K = 10^{-14})$$

$$NH_2^- \xleftarrow{-H^+} NH_3 \xrightarrow{+H^+} NH_4^+ \qquad (K = 10^{-33})$$

For that reason, proton transfer occurs in pure H_2O:

$$2\,H_2O\,(l) \rightleftarrows H_3O^+\,(aq) + OH^-\,(aq) \qquad \Delta H_r^\circ = +56\ kJ/mol$$

$$K_w = \frac{a_{H_3O^+}\,a_{OH^-}}{a^2_{H_2O}} = a_{H_3O^+}\,a_{OH^-}$$ (since $a_{H2O} \approx 1$ in dilute solutions)

$$\approx [H_3O^+][OH^-] = 1 \times 10^{-14}$$ (at 25°C)

Thus, in all aqueous solutions, $[H_3O^+] \times [OH^-]$ always equals 10^{-14} (at 25°C).

pH and pOH Scales

$$pH = -\log a_{H3O+} \approx -\log [H_3O^+]$$

$$[H_3O^+] = 10^{-pH}\ mol/L$$

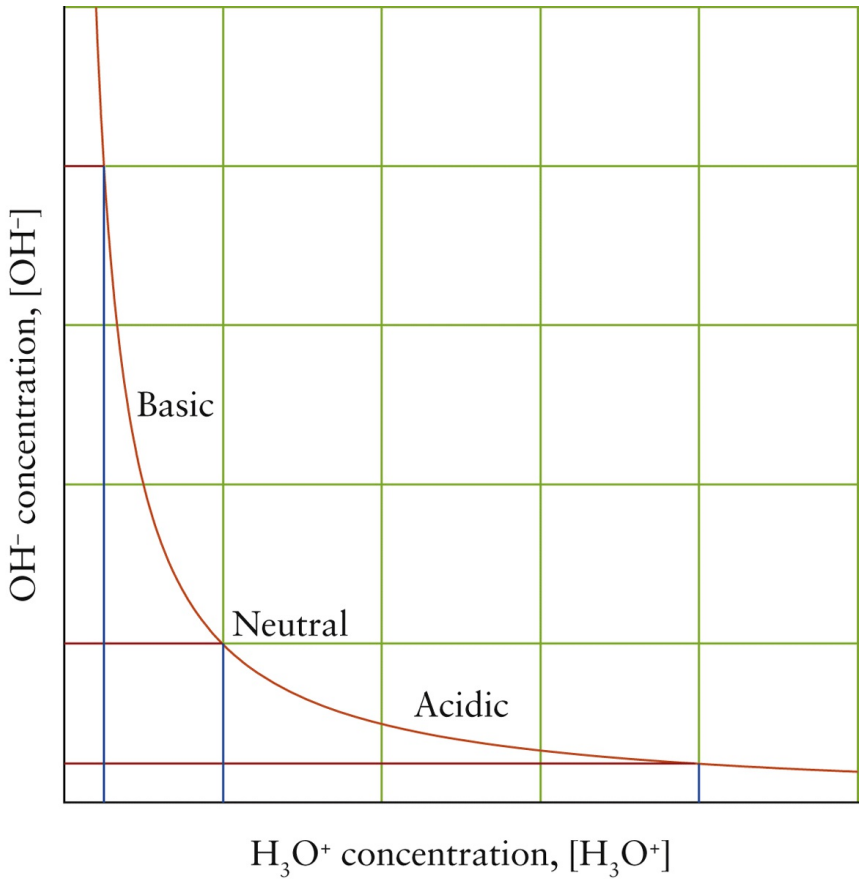
$$pOH = -\log a_{OH^-} \approx -\log [OH^-]$$

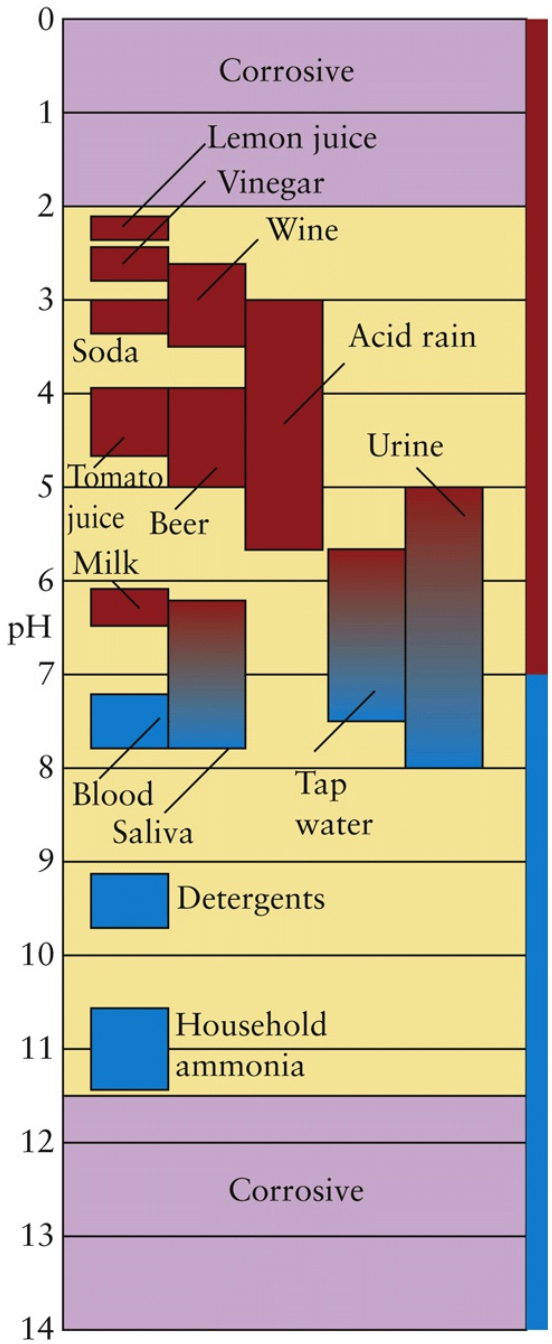
$$pK_w = pH + pOH = 14 \quad (at\ 25°C)$$

TABLE 10.1

TEMPERATURE DEPENDENCE OF K_w

t(°C)	K_w	pH of Water
0	0.114×10^{-14}	7.47
10	0.292×10^{-14}	7.27
20	0.681×10^{-14}	7.08
25	1.01×10^{-14}	7.00
30	1.47×10^{-14}	6.92
40	2.92×10^{-14}	6.77
50	5.47×10^{-14}	6.63
60	9.61×10^{-14}	6.51
100	51.3×10^{-14}	6.14




0
1
2
3
4
5
6
pH
7
8
9
10
11
12
13
14
Corrosive
Lemon juice
Vinegar
Wine
Soda
Acid rain
Urine
Tomato juice
Beer
Milk
Blood
Saliva
Tap water
Detergents
Household ammonia
Corrosive