12 Calculations of pH

The pH of a solution can be calculated from its hydrogen ion concentration, expressed in moles per litre (moles/L or mol L^{-1}).

Sample Problems

1. Calculate the pH of a 0.1 mol L^{-1} solution of hydrobromic acid.
   Answer
   $HBr(aq) \rightarrow H^+(aq) + Cl^-(aq)$
   Hydrobromic acid is a strong acid, so in water it will completely ionise. If the concentration of the acid is 0.1 mol L^{-1}, then the hydrogen ion concentration will also be 0.1 mol L^{-1}.
   $[H^+] = 0.1$
   $pH = -\log [H^+]$
   $= -\log 0.1$
   $= 1$
2. Calculate the pH of a 0.1 mol L^{-1} solution of sulfuric acid if it completely ionises.
   Answer
   $H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$
   Sulfuric acid is a strong acid. It is also a diprotic acid so it has two protons to donate. If it completely ionises in water it will produce 2 moles of hydrogen ions from every 1 mole of acid. So if the concentration of the acid is 0.1 mol L^{-1}, then the hydrogen ion concentration will be 0.2 mol L^{-1}.
   $[H^+] = 0.2$
   $pH = -\log [H^+]$
   $= -\log 0.2$
   $= 0.70$
3. Calculate the pH of a 0.1 mol L^{-1} acetic acid solution if only 1.3% ionises.
   Answer
   For a weak acid only some molecules will ionise, so the hydrogen ion concentration will be less than the total acid concentration.
   $CH_3COOH(aq) \rightarrow CH_3COO^-(aq) + H^+(aq)$
   $[H^+] = 1.3\% \times 0.1 = 1.3 \times 10^{-3}$ mol L^{-1}
   $pH = -\log [H^+]$
   $= -\log 1.3 \times 10^{-3}$
   $= 2.9$
4. Calculate the pH of a 0.1 mol L^{-1} solution of potassium hydroxide.
   Answer
   For a base, calculate the hydroxide ion concentration, then use the ionic product of water to find the hydrogen ion concentration.
   $KOH(aq) \rightarrow K^+(aq) + OH^-(aq)$
   A solution which has 0.1 mol L^{-1} of KOH will all ionise, so the hydroxide ion concentration will also be 0.1 mol L^{-1}.
   $[OH^-] = 0.1$
   $[H^+] \times [OH^-] = 10^{-14}$
   $[H^+] = 10^{-14}/[OH^-]$
   $= 10^{-13}$
   $pH = -\log [H^+]$
   $= -\log 10^{-13}$
   $= 13$
   You could also solve this problem as follows:
   $[OH^-] = 0.1$
   so $pOH = 1$
   $pH = 14 - pOH$
   $= 14 - 1$
   $= 13$

For You To Do

1. Calculate the pH for solutions with the following hydrogen ion concentrations:
   (a) lemon juice 5.0×10^{-3}
   (b) tomato juice 6.1×10^{-5}
   (c) saliva 2.6×10^{-3}
2. Calculate the pH of hydrochloric acid solutions of the following molarities:
   (a) 0.01 mol L^{-1}
   (b) 0.001 mol L^{-1}
3. Calculate the pH of sulfuric acid solutions of the following molarities:
   (a) 0.01 mol L^{-1}
   (b) 0.001 mol L^{-1}
4. Calculate the pH of the following solutions:
   (a) 0.002 mol L^{-1} hydrochloric acid
   (b) 0.0005 mol L^{-1} sulfuric acid
   (c) 0.02 mol L^{-1} acetic acid (assume 3% is ionised in water)
   (d) 0.05 mol L^{-1} sodium hydroxide
   (e) 0.005 mol L^{-1} barium hydroxide (assume 95% is ionised in water).
5. Calculate the pH of the solutions produced by:
   (a) dissolving 3 g of HCl in water and making up the volume to 3 L
   (b) dissolving 2 g of NaOH and making up the volume to 2 L
   (c) mixing 50 mL of 0.1 mol L^{-1} HCl with 20 mL of 0.05 mol L^{-1} NaOH.