

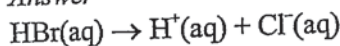
12 Calculations of pH

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

- Calculate the pH of a 0.1 mol L⁻¹ solution of hydrobromic acid.

Answer



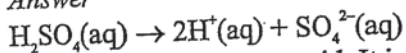
Hydrobromic acid is a strong acid, so in water it will completely ionise. If the concentration of the acid is 0.1 mol L⁻¹, then the hydrogen ion concentration will also be 0.1 mol L⁻¹.

$$[\text{H}^+] = 0.1$$

$$\begin{aligned} \text{pH} &= -\log [\text{H}^+] \\ &= -\log 0.1 \\ &= 1 \end{aligned}$$

- Calculate the pH of a 0.1 mol L⁻¹ solution of sulfuric acid if it completely ionises.

Answer



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.

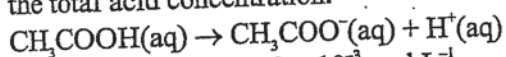
$$[\text{H}^+] = 0.2$$

$$\begin{aligned} \text{pH} &= -\log [\text{H}^+] \\ &= -\log 0.2 \\ &= 0.70 \end{aligned}$$

- 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.



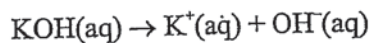
$$[\text{H}^+] = 1.3\% \times 0.1 = 1.3 \times 10^{-3} \text{ mol L}^{-1}$$

$$\begin{aligned} \text{pH} &= -\log [\text{H}^+] \\ &= -\log 1.3 \times 10^{-3} \\ &= 2.9 \end{aligned}$$

- 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.



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.

$$[\text{OH}^-] = 0.1$$

$$[\text{H}^+] \times [\text{OH}^-] = 10^{-14}$$

$$\begin{aligned} [\text{H}^+] &= 10^{-14} / [\text{OH}^-] \\ &= 10^{-13} \end{aligned}$$

$$\begin{aligned} \text{pH} &= -\log [\text{H}^+] \\ &= -\log 10^{-13} \\ &= 13 \end{aligned}$$

You could also solve this problem as follows:

$$[\text{OH}^-] = 0.1$$

$$\text{so pOH} = 1$$

$$\begin{aligned} \text{pH} &= 14 - \text{pOH} \\ &= 14 - 1 \\ &= 13 \end{aligned}$$

For You To Do

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