

pH and molarity

1 Formulas

$$pH = -\log [H^+] \quad \hookrightarrow \text{molarity}$$

\hookrightarrow pH 为数值, 没单位
 \hookrightarrow $M/mol\ dm^{-3}$
 $\text{molarity} = \frac{\text{mole}}{\text{volume}} \quad \begin{matrix} \nearrow \text{mol} \\ \searrow \text{dm}^3 \end{matrix}$
 $\hookrightarrow 1\ dm^3 = 1000\ cm^3$

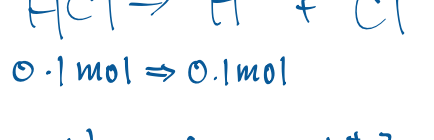
2 Mole concept 金句

- 加水不影响 no. of mole
- 加水至 n 倍 volume \rightarrow molarity 变至 $\frac{1}{n}$ 倍 (no. of mole 不变)
- 抽去倍 volume 的溶液 \rightarrow no. of mole 变至 $\frac{1}{n}$ 倍 (molarity 不变)

3 Questions

LEVEL I

0.1 mole of HCl completely dissolves in 200 cm³ distilled water. Find the pH of solution.

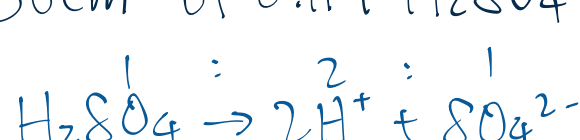


$$0.1\ mol \Rightarrow 0.1\ mol$$

$$pH = -\log [H^+] = -\log \left(\frac{0.1}{0.2} \right) = 0.301$$

LEVEL II

50 cm³ of 0.1M H₂SO₄ \rightarrow find the solution pH.



$$0.1M \Rightarrow 0.2M$$

$$pH = -\log [H^+] = -\log 0.2 = 0.699$$

LEVEL III

30 cm³ of 0.1M H₂SO₄ vs 50 cm³ of 0.1M H₂SO₄
Which one is more acidic?

same

$$\text{Both } [H^+] = 0.1M \times 2 = 0.2M$$

molarity 不变 \Rightarrow volume 增加 H^+ 也会增加.

\hookrightarrow 总体浓度还是一样

30 cm³ of 0.05M H₂SO₄ vs 80 cm³ of 0.1M HNO₃
Which one is more acidic?

same



$$0.05M \Rightarrow 0.1M$$



$$0.1M \Rightarrow 0.1M$$

LEVEL IV

80 cm³ of 0.1M HCl is mixed w/ 40 cm³ of 0.1M HCl
Find the resulting pH.

molarity 一样, volume 不同

\hookrightarrow 混在一起 molarity 不变



$$0.1M \Rightarrow 0.1M$$

$$pH = -\log [H^+] = -\log 0.1 = 1$$

80 cm³ of 0.1M HCl is mixed with 50 cm³ of 0.1M HNO₃
先算两边 H^+ 的浓度



$$0.1M \Rightarrow 0.1M$$



$$0.1M \Rightarrow 0.1M$$

$$pH = -\log [H^+] = -\log 0.1 = 1$$

80 cm³ of 0.1M HCl is mixed w/ 80 cm³ of 0.1M H₂SO₄
这道题得先算 H^+ 的 no. of mole (\because 两种 acid 的 $[H^+]$ 不同)



$$0.1 \times 0.08 \Rightarrow 0.008\ mol$$



$$0.1 \times 0.08 \Rightarrow 0.016\ mol$$

$$pH = -\log [H^+] = -\log \left(\frac{0.008 + 0.016}{0.016} \right) = 0.824$$

40 cm³ of 0.15M H₂SO₄ is mixed w/ 60 cm³ of 0.1M HNO₃



$$0.15 \times 0.04 \Rightarrow 0.012\ mol$$

$$= 0.006\ mol$$



$$0.1 \times 0.06 \Rightarrow 0.006\ mol$$

$$= 0.006\ mol$$

$$pH = -\log [H^+] = -\log \left(\frac{0.012 + 0.006}{0.1} \right) = 0.745$$

LEVEL V

The pH of 50 cm³ HCl is 1.

How much water do we need to add to increase its pH value to 3?

$$\begin{matrix} \text{original molarity} \\ 1 = -\log [H^+] \\ [H^+] = 0.1M \end{matrix}$$

$$\begin{matrix} \text{required molarity} \\ 3 = -\log [H^+] \\ [H^+] = 0.001M \end{matrix}$$

$$\hookrightarrow 0.1M \times 0.05\ dm^3 = 0.005\ mol$$

$$\frac{0.005\ mol}{0.05\ dm^3 + v} = 0.001M$$

$$0.005 = 0.0005 + 0.001v$$

$$v = 4.95\ dm^3$$

The pH of 10 cm³ H₂SO₄ is 2.

How much water do we need to add to increase its pH value to 4?

$$\begin{matrix} \text{original molarity} \\ 2 = -\log [H^+] \\ [H^+] = 0.01M \end{matrix}$$

$$\begin{matrix} \text{required molarity} \\ 4 = -\log [H^+] \\ [H^+] = 0.0001M \end{matrix}$$

$$\hookrightarrow 0.01M \times 0.01\ dm^3 = 0.0001\ mol \rightarrow \text{不用因为 } H_2SO_4 \text{ 而来!}$$

(已经计算了 H^+ 的浓度, 而非 H_2SO_4 的浓度)

$$\frac{0.0001\ mol}{0.01\ dm^3 + v} = 0.0001M$$

$$1 = 0.01 + v \quad \rightarrow \text{约 } 0.0001$$

$$v = 0.99\ dm^3$$

LEVEL VI

concentration 有两种单位

\hookrightarrow mol dm⁻³ (molarity)

\hookrightarrow g cm⁻³ (density)

\Rightarrow 要懂得两种单位之间的互換

0.1M HCl \rightarrow Find its density in g cm⁻³.

$$0.1M = \frac{0.1\ mol}{1\ dm^3}$$

$$= \frac{0.1(35.5+1)g}{1000\ cm^3} \quad \hookrightarrow M = \text{mol. Mr}$$

$$= 0.00365\ g\ cm^{-3}$$

80 cm³ of 0.1M impure HCl contains 83% HCl by mass.
Find the density of HCl.

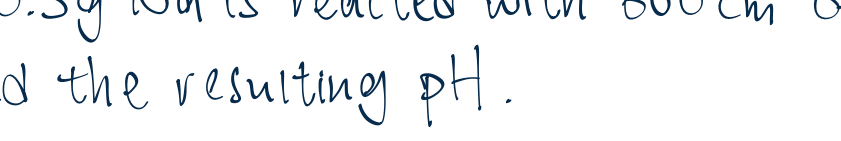
$$\text{mole of acids} = 0.08 \times 0.1 = 0.008\ mol$$

$$\text{mass of HCl} = \frac{0.008 \times 83\% \times 36.5}{\text{mole} \quad \text{Mr}} = 0.242g$$

$$\text{density of HCl} = \frac{0.242}{80} = 0.00303\ g\ cm^{-3}$$

LEVEL VII

If 0.3g Na is reacted with 600 cm³ of 0.1M H₂SO₄.
find the resulting pH.



$$\frac{0.3g}{23} \quad 0.6 \times 0.1$$

$$= 0.0123\ mol \quad = 0.06\ mol$$

$$\text{required } H_2SO_4 = 0.00615\ mol$$

\hookrightarrow H₂SO₄ is excess,

$$\text{unused } H_2SO_4 = 0.06 - 0.00615$$

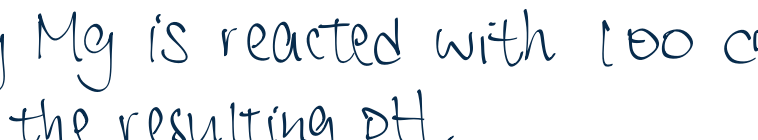
$$= 0.05385\ mol$$



$$0.05385\ mol \rightarrow 0.1077\ mol$$

$$pH = -\log [H^+] = -\log \frac{0.1077}{0.6} = 0.746$$

If 3g Mg is reacted with 100 cm³ of 0.1M HCl,
find the resulting pH.



$$\frac{3g}{24.3} \quad 0.1 \times 0.1$$

$$= 0.0123\ mol \quad = 0.01\ mol$$

$$\text{required } H_2SO_4 = 0.0246\ mol$$

\hookrightarrow All H₂SO₄ is used up

\hookrightarrow

$$pH = 7$$