

# pH and molarity

## 1 Formulas

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

→ pH为数值, 没单位

$$M / \text{mol dm}^{-3} \quad \text{molarity} = \frac{\text{mole}}{\text{volume}} \quad \rightarrow \text{mol} \quad \rightarrow \text{dm}^3$$

$$1 \text{ dm}^3 = 1000 \text{ cm}^3$$

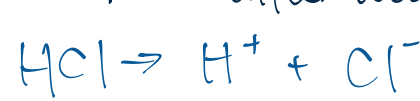
## 2 Mole concept 金句

- 加水不影响 no. of mole
- 加水至 n 倍 volume → molarity 变至 1/n 倍 (no. of mole 不变)
- 抽去倍 volume 的溶液 → no. of mole 变至 1/n 倍 (molarity 不变)

## 3 Questions

### LEVEL I

0.1 mole of HCl completely dissolves in 200 cm<sup>3</sup> distilled water. Find the pH of solution.



$$0.1 \text{ mol} \Rightarrow 0.1 \text{ mol}$$

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

### LEVEL II

50 cm<sup>3</sup> of 0.1M H<sub>2</sub>SO<sub>4</sub> → find the solution pH.



$$0.1M \Rightarrow 0.2M$$

$$\begin{aligned} pH &= -\log [H^+] \\ &= -\log 0.2 \\ &= 0.699 \end{aligned}$$

### LEVEL III

30 cm<sup>3</sup> of 0.1M H<sub>2</sub>SO<sub>4</sub> vs 50 cm<sup>3</sup> of 0.1M H<sub>2</sub>SO<sub>4</sub>

Which one is more acidic?

same

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

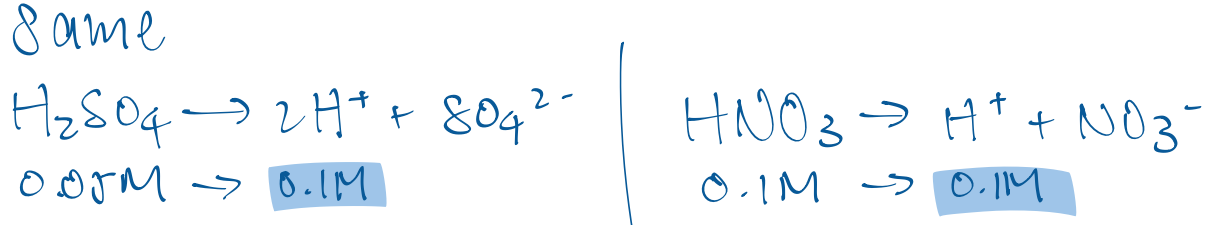
molarity 不变 → volume 增加 H<sup>+</sup> 也会增加.

→ 总体浓度还是一样

30 cm<sup>3</sup> of 0.05M H<sub>2</sub>SO<sub>4</sub> vs 80 cm<sup>3</sup> of 0.1M HNO<sub>3</sub>

Which one is more acidic?

same



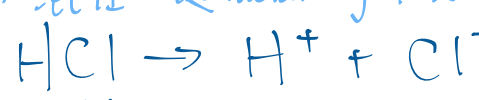
### LEVEL IV

80 cm<sup>3</sup> of 0.1M HCl is mixed w/ 40 cm<sup>3</sup> of 0.1M HCl

Find the resulting pH.

molarity 一样, volume 不同

→ 混在一起 molarity 不变



$$0.1M \Rightarrow 0.1M$$

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

80 cm<sup>3</sup> of 0.1M HCl is mixed with 50 cm<sup>3</sup> of 0.1M HNO<sub>3</sub>

先算两边 H<sup>+</sup> 的浓度



$$0.1M \Rightarrow 0.1M \quad 0.1M \Rightarrow 0.1M$$

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

80 cm<sup>3</sup> of 0.1M HCl is mixed w/ 80 cm<sup>3</sup> of 0.1M H<sub>2</sub>SO<sub>4</sub>

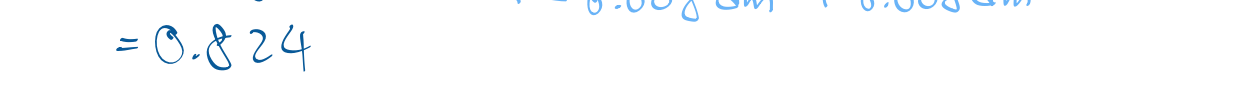
这道题得先算 H<sup>+</sup> 的 no. of mole (∵ 两种 acid 的 [H<sup>+</sup>] 不同)



$$0.1 \times 0.08 \Rightarrow 0.008 \text{ mol} \quad 0.1 \times 0.08 \Rightarrow 0.016 \text{ mol}$$

$$\begin{aligned} pH &= -\log [H^+] \\ &= -\log \frac{0.008 + 0.016}{0.016} \quad \leftarrow 0.008 \text{ dm}^3 + 0.008 \text{ dm}^3 \\ &= 0.824 \end{aligned}$$

40 cm<sup>3</sup> of 0.15M H<sub>2</sub>SO<sub>4</sub> is mixed w/ 60 cm<sup>3</sup> of 0.1M HNO<sub>3</sub>



$$0.15 \times 0.04 \Rightarrow 0.012 \text{ mol} \quad 0.1 \times 0.06 \Rightarrow 0.006 \text{ mol}$$

$$\begin{aligned} pH &= -\log [H^+] \\ &= -\log \left( \frac{0.012 + 0.006}{0.1} \right) \quad \leftarrow 0.04 \text{ dm}^3 + 0.06 \text{ dm}^3 \\ &= 0.745 \end{aligned}$$

### LEVEL V

The pH of 50 cm<sup>3</sup> HCl is 1.

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

original molarity

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

$$[H^+] = 0.1M$$

required molarity

$$3 = -\log [H^+]$$

$$[H^+] = 0.001M$$

$$\rightarrow 0.1M \times 0.05 \text{ dm}^3 = 0.005 \text{ mol}$$

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

$$0.005 = 0.0005 + 0.001v$$

$$v = 4.95 \text{ dm}^3$$

The pH of 10 cm<sup>3</sup> H<sub>2</sub>SO<sub>4</sub> is 2.

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

original molarity

$$2 = -\log [H^+]$$

$$[H^+] = 0.01M$$

required molarity

$$4 = -\log [H^+]$$

$$[H^+] = 0.0001M$$

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

(已经计算了 H<sup>+</sup> 的浓度, 而非 H<sub>2</sub>SO<sub>4</sub> 的浓度)

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

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

$$v = 0.99 \text{ dm}^3$$

### LEVEL VI

concentration 有两种单位

→ mol dm<sup>-3</sup> (molarity)

→ g cm<sup>-3</sup> (density)

⇒ 要懂得两种单位之间的互換

0.1M HCl → Find its density in g cm<sup>-3</sup>.

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

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

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

80 cm<sup>3</sup> of 0.1M impure HCl contains 83% HCl by mass.

Find the density of HCl.

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

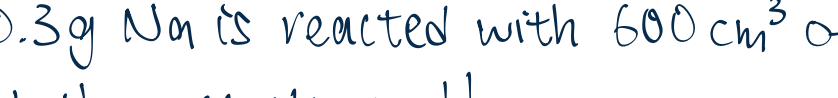
$$\text{mass of HCl} = \frac{0.008 \times 83\% \times 36.5}{\text{mole} \quad Mr} = 0.242g$$

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

### LEVEL VII

If 0.3g Na is reacted with 600 cm<sup>3</sup> of 0.1M H<sub>2</sub>SO<sub>4</sub>.

find the resulting pH.



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

$$= 0.0123 \text{ mol} \quad = 0.06 \text{ mol}$$

$$\downarrow$$

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

$$\downarrow$$

$$H_2SO_4 \text{ is excess,}$$

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

$$= 0.05385 \text{ mol}$$



$$0.05385 \text{ mol} \rightarrow 0.1077 \text{ mol}$$

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

$$= -\log \frac{0.1077}{0.6}$$

$$= 0.746$$

If 3g Mg is reacted with 100 cm<sup>3</sup> of 0.1M HCl,

find the resulting pH.



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

$$= 0.0123 \text{ mol} \quad = 0.01 \text{ mol}$$

$$\downarrow$$

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

$$\downarrow$$

$$\text{All } H_2SO_4 \text{ is used up}$$

$$\downarrow$$

$$pH = 7$$