

PH and molarity

1 Formulas

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

→ pH为数值, 没单位

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

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

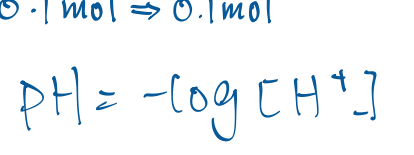
2 Mole concept 金句

- 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 n 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 cm³ distilled water. Find the pH of solution.

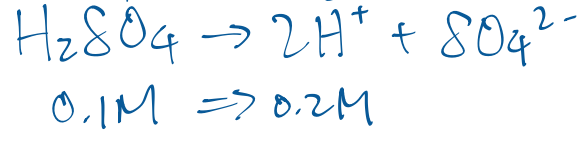


0.1 mol ⇒ 0.1 mol

$$pH = -\log [H^+] = -\log \left(\frac{0.1}{2} \right) = 0.301$$

LEVEL II

50 cm³ of 0.1M H₂SO₄ → find the solution pH.



0.1M ⇒ 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

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

molarity 不变 ⇒ volume 增加 H^+ 也会增加.

→ 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 ⇒ 0.1M

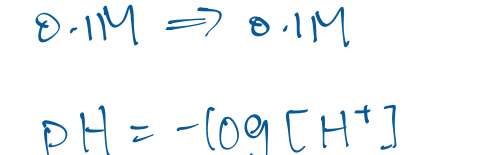
0.1M ⇒ 0.1M

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



0.1M ⇒ 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 ⇒ 0.1M

0.1M ⇒ 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 (∵ 两种 acid 的 $[H^+]$ 不同)

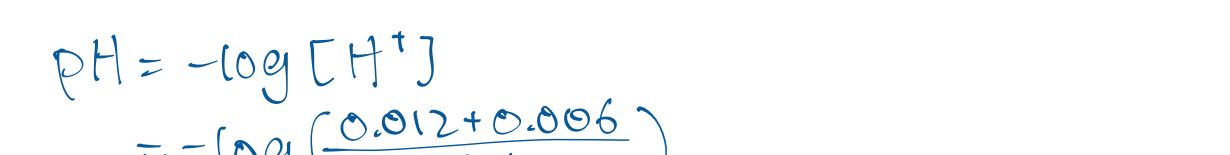


0.1 × 0.08 ⇒ 0.008 mol

0.1 × 0.08 ⇒ 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 × 0.04 ⇒ 0.012 mol

0.1 × 0.06 ⇒ 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?

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

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

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

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

$$0.005 = 0.0005 + 0.001v$$

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

The pH of 10 cm³ H₂SO₄ is 2.

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

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

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

$$0.01M \times 0.01 \text{ dm}^3 = 0.0001 \text{ mol} \rightarrow \text{不用因为 } H_2SO_4 \text{ 而乘 2!}$$

(已经计算了 H^+ 的浓度, 而非 H_2SO_4 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⁻³ (molarity)

→ g cm⁻³ (density)

→ 要懂得两种单位之间的互换

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

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

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

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

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

Find the density of HCl.

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

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

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

LEVEL VII

If 0.3g Na is reacted with 600 cm³ of 0.1M H₂SO₄.

find the resulting pH.



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

$$= 0.0130 \text{ mol} \quad = 0.06 \text{ mol}$$

$$\downarrow$$

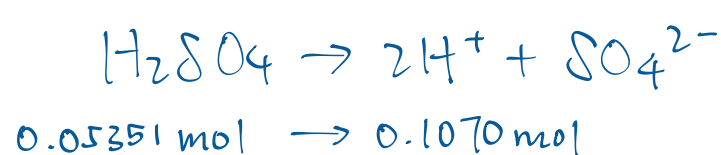
$$\text{required } H_2SO_4 = \frac{0.0130}{2} = 0.00649 \text{ mol}$$

$$\downarrow$$

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

$$\text{unused } H_2SO_4 = 0.06 - 0.00649$$

$$= 0.05351 \text{ mol}$$



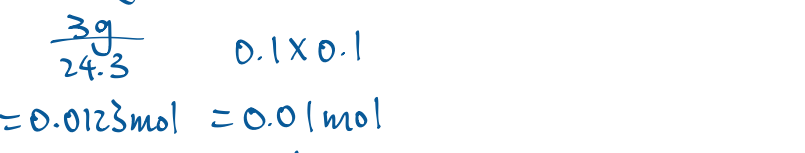
$$0.05351 \text{ mol} \rightarrow 0.1070 \text{ mol}$$

$$pH = -\log [H^+] = -\log \frac{0.1070}{0.6}$$

$$= 0.749$$

If 3g Mg is reacted with 100 cm³ of 0.1M HCl,

find the resulting pH.



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

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

$$\downarrow$$

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

$$\downarrow$$

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

$$\downarrow$$

$$pH = 7$$