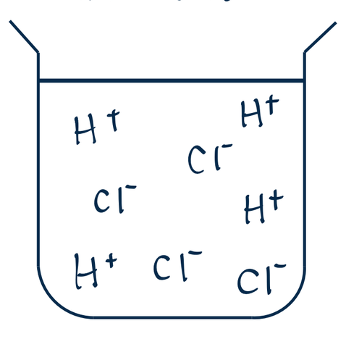
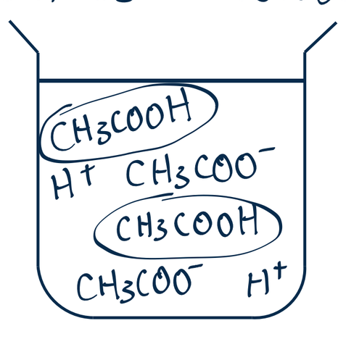
Attributes of acids affecting pH

1 Strong and weak acids

DEFINITION

Strong acids	Weak acids
completely ionizes in water	does not completely ionizes in water
	
$HA \rightarrow H^+ + A^-$ 单向的 reaction	$HB \rightleftharpoons H^+ + B^-$ reversible reaction
HCl, H_2SO_4, HNO_3	所有其他 acid
↓pH	↑pH
(basicity一样时, H^+更多)	(basicity一样时, H^+更少)

DISTINGUISHING STRONG AND WEAK ACIDS

- eg. HCl and CH_3COOH — basicity与concentration须一样才能比较

PHYSICAL METHOD

a. pH value

- Prepare same volume of 0.1M $HCl_{(aq)}$ and 0.1M $CH_3COOH_{(aq)}$
- Using pH paper, measure the pH value of both solutions
- 0.1M HCl has a lower pH value than 0.1M $CH_3COOH_{(aq)}$.
- strong acids → $[H^+]$↑ → pH↓

b. Electrical conductivity

- Prepare same volume of 0.1M $HCl_{(aq)}$ and 0.1M $CH_3COOH_{(aq)}$
- Using a light bulb, test the electrical conductivity of both solutions
- 0.1M $HCl_{(aq)}$ provides a brighter light bulb than 0.1M $CH_3COOH_{(aq)}$.
- strong acids → no. of mobile ions ↑ → electrical conductivity↑

CHEMICAL METHOD

a. Reaction rate

- React same mass of identical iron (→ metal / metal carbonate (会有气泡)) w/ same volume of excess 0.1M $HCl_{(aq)}$ and 0.1M $CH_3COOH_{(aq)}$ ($Fe + 2H^+ \rightarrow Fe^{2+} + H_2$)
- 0.1M $CH_3COOH_{(aq)}$ gives bubbles at a slower rate.
- H^+浓度↓ → 粒子碰撞频率↓ → reaction rate↓
- reaction is exothermic, 放出来的热会使 CH_3COOH 其他 molecules ionize (→ 温度↑, ionize 的 H^+↑) 最后所有required的 CH_3COOH (不包括excess)也会被ionize了 (→ ∴ final H_2 volume一样) 可是因为热用来了ionize, 达成 reaction 本身 activation energy 需时更久 Reaction rate↓

☆ 最后 H_2 的 volume 还是一样的 (limiting reactant 是铁)

b. Reaction temperature rise

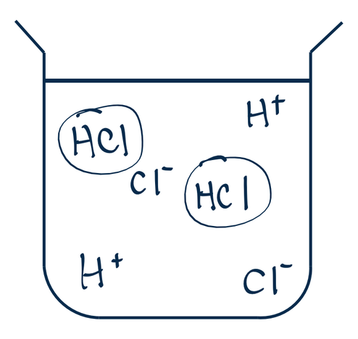
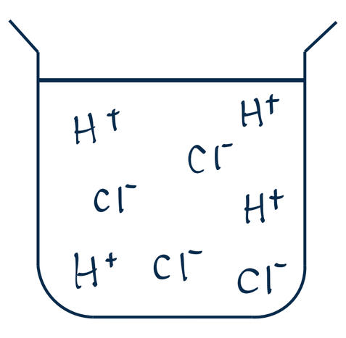
- 如上: react same mass of identical iron (→ base / metal (只要是 exothermic 都行)) w/ same volume of excess 0.1M $HCl_{(aq)}$ & 0.1M $CH_3COOH_{(aq)}$.
- Measure highest temperature reached by reaction mixture w/ thermometer.
- 0.1M $CH_3COOH_{(aq)}$ has lower highest temperature reached.
- 解释与上面一样 → ∵部分热用以 ionize CH_3COOH (ie break bonds) 整体温度上升↓

SHOWING ... IS STRONG/WEAK ACID

Prepare 0.1M of the acid. (→ assume basicity = 1: $HX \rightarrow H^+ + X^-$, 0.1M → 0.1M)
Measure its pH accurately w/ pH meter.
If acid is completely ionized, $pH = -\log[H^+] = -\log 0.1 = 1$
So, if pH = 1 → strong acid. If pH > 1 → weak acid

2 Concentrated and dilute acids

DEFINITION

Conc. acids	Dilute acids
13至15 M	零点几 - 1 M
	
水不够, 不能 completely ionize	(HCl: strong acid) Completely ionize

→ May have different acid R.A.s reaction

3 Basicity

DEFINITION

- max. no. of ionizible hydrogen atoms in an acid molecule

HCl
$HCl \rightarrow H^+ + Cl^-$
H – Cl
↳ monobasic

CH_3COOH
$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$
H_3C–C(=O)–OH
↳ monobasic

H_2SO_4
$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$
HO–S(=O)(=O)–OH
↳ dibasic

H_3PO_4
$H_3PO_4 \rightleftharpoons 3H^+ + PO_4^{3-}$
O=P(OH)₃
↳ tribasic

MOLE RATIO OF ACID-BASE REACTIONS

知识点

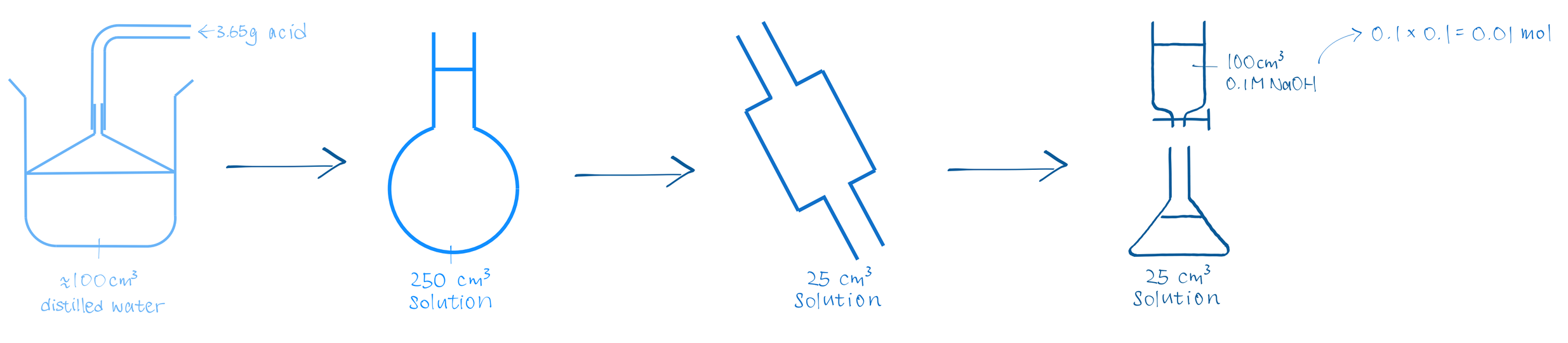
- 从 acid 的 basicity 和 base anion 的 charge 判断 mole ratio
- 把两个数字调转, 再约简

→ HCl + NaOH, basicity = 1, anion charge = -1 → 1 : 1
→ H_2SO_4 + NaOH, basicity = 2, anion charge = -1 → 1 : 2
→ H_3PO_4 + Na_2CO_3, basicity = 3, anion charge = -2 → 2 : 3

2g dibasic acid requires 30cm³ of 2.15M NaOH for complete neutralisation. Find its molar mass.

acid mole : NaOH mole = 1 : 2
$n : 2.15 \times 0.03 = 1 : 2$ (mole = molarity x volume)
$n = 0.0325$
$\frac{mass}{Mr} = mole$
$\frac{2}{Mr} = 0.0325$
$Mr = 62.0$

3.65g acid in gas state w/ Mr 36.5 is dissolved completely into 100cm³ distilled water. The sol. is poured into 250 cm³ volumetric flask for dilution. 25 cm³ of the sol. is pipetted out to a conical flask and titrated against 0.1M NaOH. If 100 cm³ of 0.1M NaOH is needed for complete neutralisation, find the basicity of the acid.



$\frac{3.65}{36.5} = 0.1$ mol → 0.1 mol (加水mol不变) → 0.01 mol (抽十分一 sol., mol 减至原本十分一) → 0.01 mol

mole of acid : mole of alkali
= 0.01 : 0.01
= 1 : 1
∴ monobasic

4 Mixed question types

WHICH IS MORE ACIDIC?

{0.1M CH_3COOH, 0.1M HCl} → fair test — conc./dilute一样; basicity一样; strong/weak不一样

{0.1M H_2CO_3, 0.1M HCl} → 理论上不可能知道 (x fair test) — conc./dilute一样; basicity不一样; strong/weak不一样 → 可是实际上 strength 影响更大 ← 在 weak acid 里, 只有几% 的 ionizable H atom 会 ionize