Adsorption of Acetic Acid from Solution onto Activated Carbon

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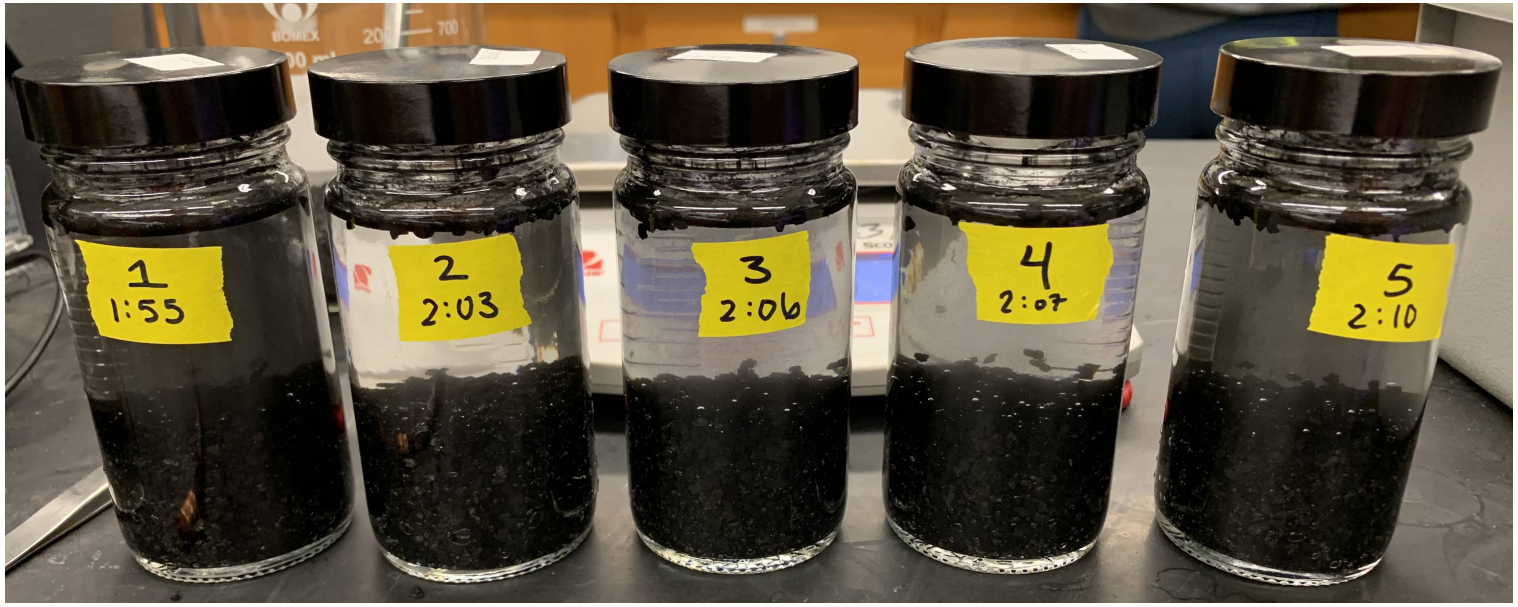
Adsorption of solute to solid surface can be physical or chemical

- **Adsorption** - interaction between solute in dilute solution and solid surface
  - **Adsorbate** - solute
  - **Adsorbent** - solid
- **Chemisorption** - interaction by chemical bonding
- **Physical adsorption** - interaction by can der Waals force



Titration determines the concentration of the acetic acid in the supernatant

- Acetic acid equivalence point has pH = 8.7 (Why?)
- Phenolphthalein turns from colorless to pink at pH = 8.2 ~ 10.0
- Calculating acid concentration at equivalence point

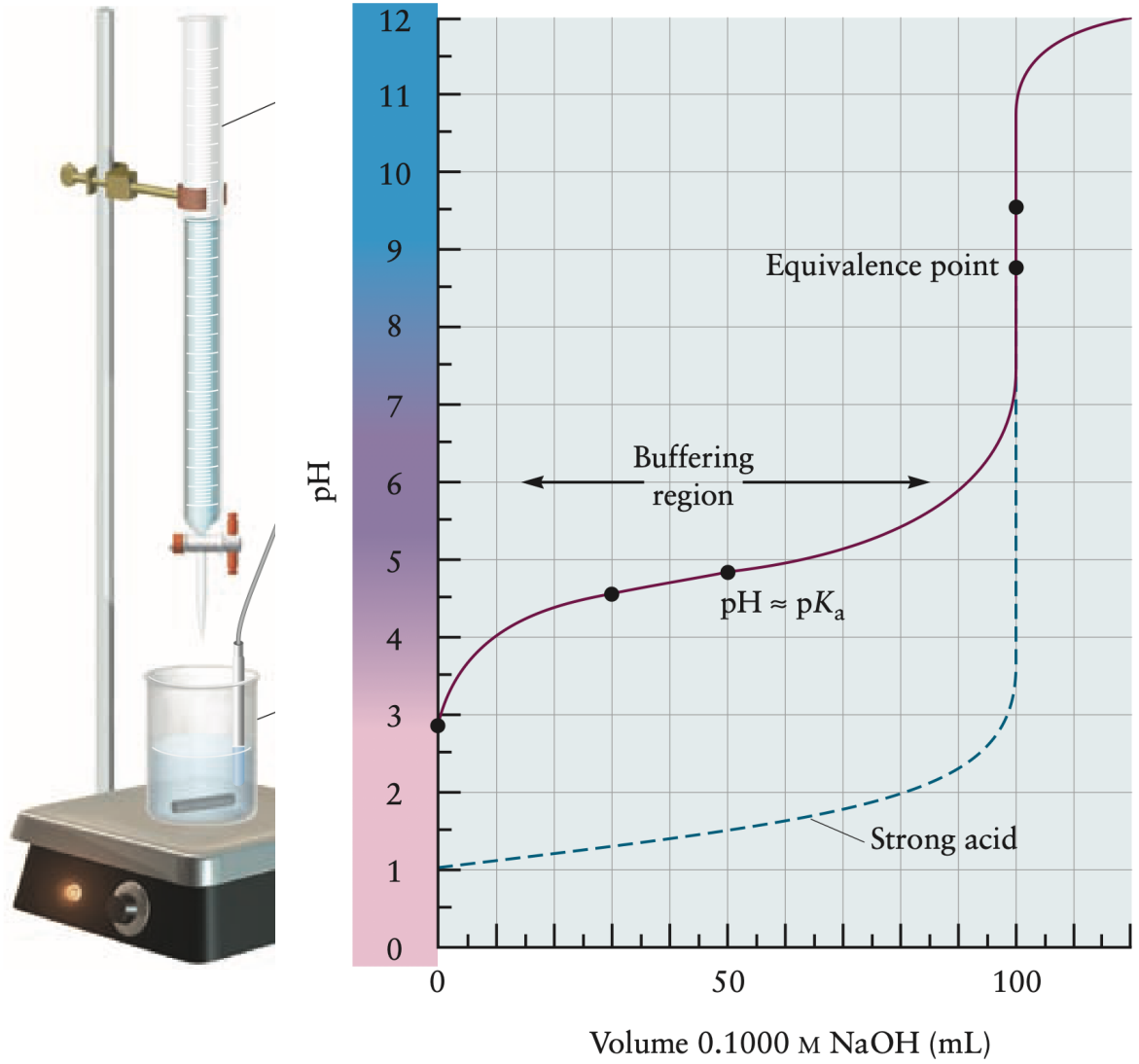
$$\text{mol acid} = \text{mol base}$$

$$C_a V_a = C_b V_b$$

$$C_a = \frac{C_b V_b}{V_a}$$

- Estimate maximum volume of base needed to reach equivalence point

$$V_b = \frac{C_a V_a}{C_b}$$



Oxtoby et al. *Principles of Modern Chemistry* 7th edition (2011).

Langmuir adsorption isotherm $\Gamma(C)$ describes monolayer with homogeneous energy

- Assumptions
  - Adsorption is restricted to a monolayer
    - Solid-solute interactions decays rapidly with distance
  - All adsorption sites are equivalent
    - Surface energy homogeneity - Energy of adsorption does not depend on extent of surface coverage
- Fraction of surface covered by adsorbed solute

$$\Theta = \frac{kC}{1+kC} = \frac{\Gamma}{\Gamma_m}$$

- Langmuir isotherm

$$\boxed{\Gamma = \Gamma_m \frac{kC}{1+kC}}$$

- Linear form of Langmuir isotherm

$$\frac{C}{\Gamma} = \frac{C}{\Gamma_m} + \frac{1}{k\Gamma_m}$$

- Lineweaver-Burk plot

$$\frac{1}{\Gamma} = \frac{1}{k\Gamma_m}\frac{1}{C} + \frac{1}{\Gamma_m}$$

Specific area of solid surface can be calculated from Langmuir isotherm

- Specific area of solid surface

$$\Sigma(\mathrm{m}^2/\mathrm{g}) = \Gamma_m(\mathrm{mol}/\mathrm{g}) N_A A_0(\mathrm{\AA}^2/\mathrm{molecule}) \times 10^{-20}$$

Freundlich isotherm $\Gamma(C)$ describes energy heterogeneity

- Assumptions
  - Surface energy heterogeneity - Energy of adsorption varies exponentially with extent of surface coverage
    - Low energy sites filled first
  - No limiting value of surface area - adsorption sites become less and less favorable
- Freundlich isotherm

$$\boxed{\Gamma = \alpha C^{\beta}}$$

- Linear form of Freundlich isotherm

$$\log \Gamma = \log \alpha + \beta \log C$$