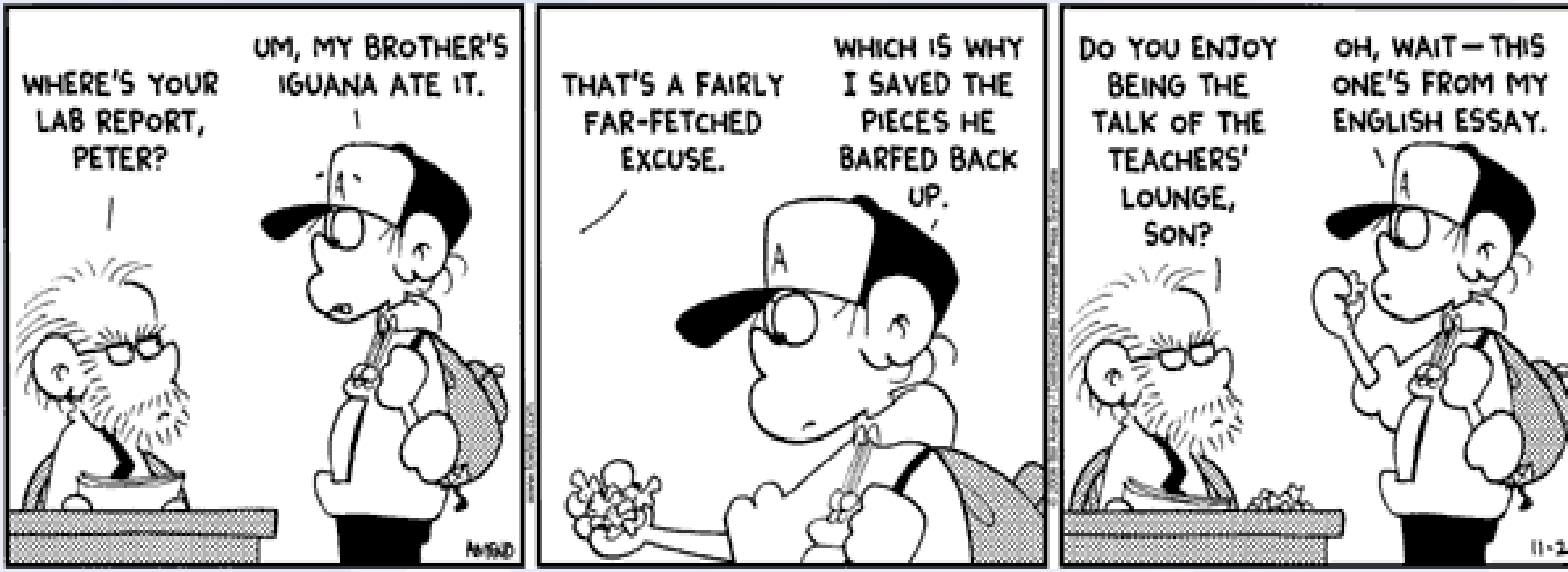
Review: Acid-Base Chemistry



“Basics”

- General properties of acids & bases
- Balance neutralization equations
  - SA + SB → water + salt
- Arrhenius vs. Bronsted-Lowry
  - BL plays “doubles tennis match” with H+)
  - Identify strong vs. weak

Conjugate A-B

- Identify conjugate acid-base pairs
  - HCl (SA), Cl- (conj B, but does not act as base)
  - F- (WB), HF (conj A, weak acid)

$$H_2PO_4 + CN^- \leftrightarrow HCN + HPO_4^-$$

A *B* *CA* *CB*

Strong acids & bases

- Ionize completely (100%) (→)
- Strong acids
  - Top 6 on **L-hand** side of BL table
  - Conjugate bases are SPECTATOR ions (have no effect on acid-base reactions)
- Strong bases
  - Bottom 2 (O^{2-} & NH_2^-) on **R-hand** side of BL table
  - Metal hydroxide salts (NaOH, KOH, $Ca(OH)_2$)
  - Conjugate acids never act as acids

BL relative strengths

- <u>ACIDS</u>
  - Weaker as you go DOWN L-hand side
  - Higher K_a = *stronger* acid (more ionization, so more H_3O^+ produced)
  - Lower K_a = *weaker* acid (less ionization, so less H_3O^+ produced)
- <u>BASES</u>
  - Weaker as you go UP the R-hand side
  - Higher K_b = *stronger* base (lower K_a of conj A)
  - Lower K_b = *weaker* base (higher K_a of conj A)

Amphiprotic Substances

- Can act as either ACID or BASE
  - H_2O and substances with extra H+ to donate and negative charge

$$H_2O \longrightarrow H^+ + OH^-$$

$$H_2O + H^+ \longrightarrow H_3O^+$$

- Find amphi-acid on left, look up K_a
- Find amphi-base on right, $K_b = K_w/K_a$ (conj a)
  - Ka > Kb, then acts as ACID
  - Ka < Kb, then acts as a BASE

A-B Equilibria

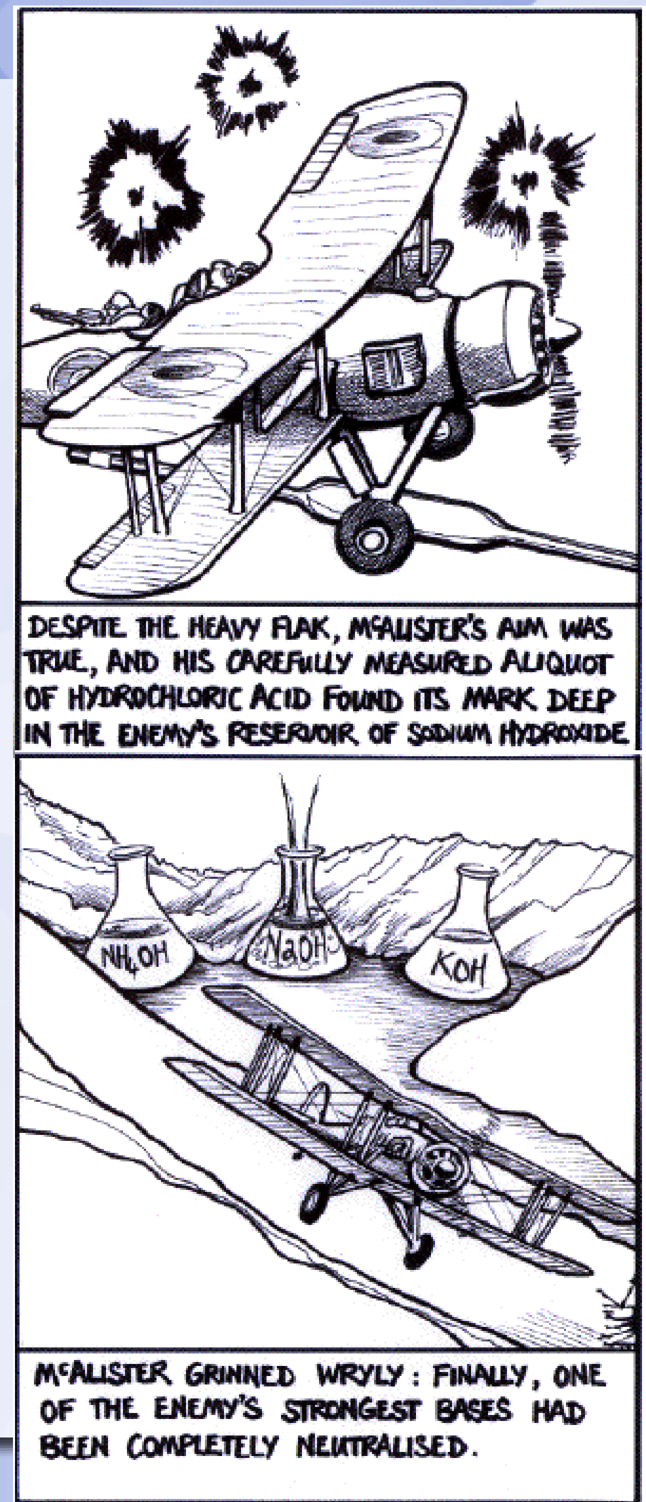
- Predict whether REACTANTS or PRODUCTS are favoured in A-B equilibrium
  - "Strong PUSH the weak"
- Identify which side has the SA & SB (same side), then the *other side* is favoured

K_w, K_a, and K_b

- Ionization constants (only affected by temperature)
- $Kw = [H_3O^+][OH^-] = 1.00 \times 10^{-14}$ (@ 25°C)
  - As temp ↑, Kw ↑ (more collisions)
- $Ka = \frac{[CB-][H_3O^+]}{[A]}$
- $Kb = \frac{[CA][OH-]}{[B]} = \frac{Kw}{Ka}$ (conj acid)
- Kw = Ka x Kb *(for conjugate pairs)*

Solution Concentrations

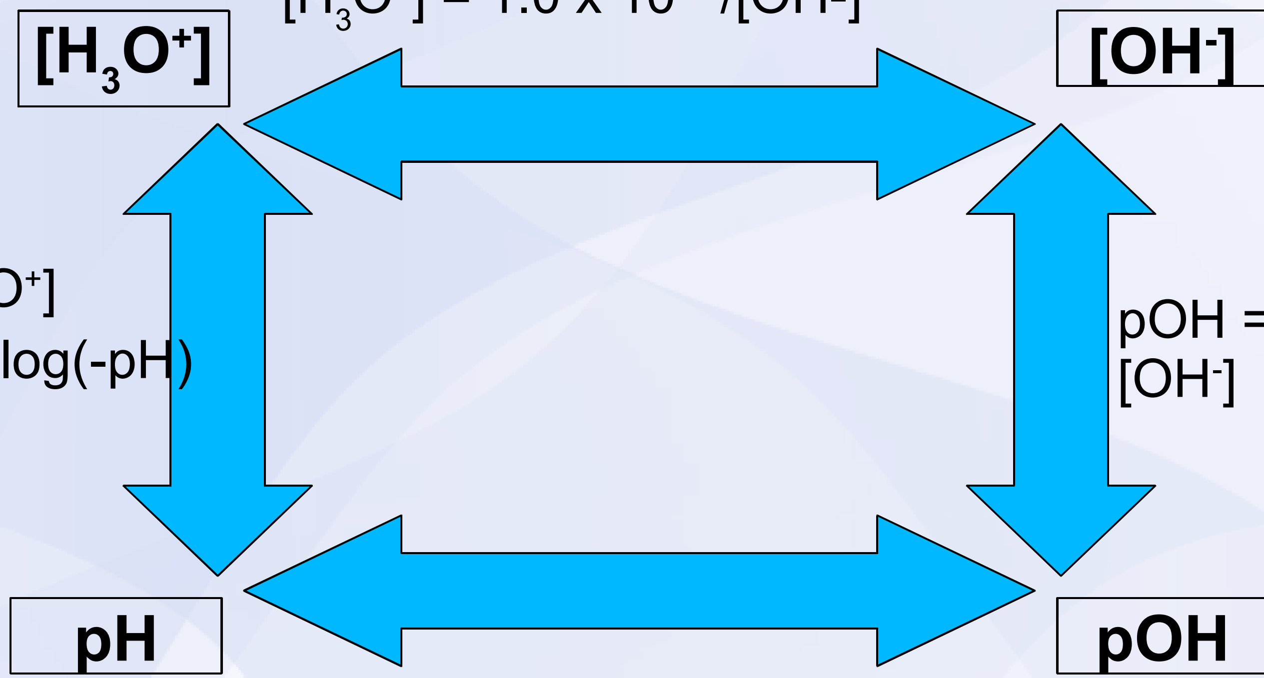
- Neutral: $[H_3O^+] = [OH-]$
  - pH = 7.0, pOH = 7.0
- Acidic: $[H_3O^+] > [OH^-]$
  - pH < 7.0, pOH > 7.0
- Basic: $[H_3O^+] < [OH^-]$
  - pH > 7.0, pOH < 7.0



Using "the SQUARE"

$Kw = [H_3O^+][[OH^-] = 1.0 \times 10^{-14}$

$[H_3O^+] = 1.0 \times 10^{-14}/[OH-]$



$pH = -\log[H_3O^+]$

$[H_3O^+] = \text{antilog}(-pH)$

$pOH = -\log[OH^-]$

$[OH^-] = \text{antilog}(-pOH)$

$14 = pH + pOH$

$pH = 14 - pOH$

*Remember: pH and pOH **sig figs** are based on numbers AFTER decimal point!*

Weak acid/base Equilibria

- Weak acids and bases don't ionize completely
  - On average, ionize only 5%

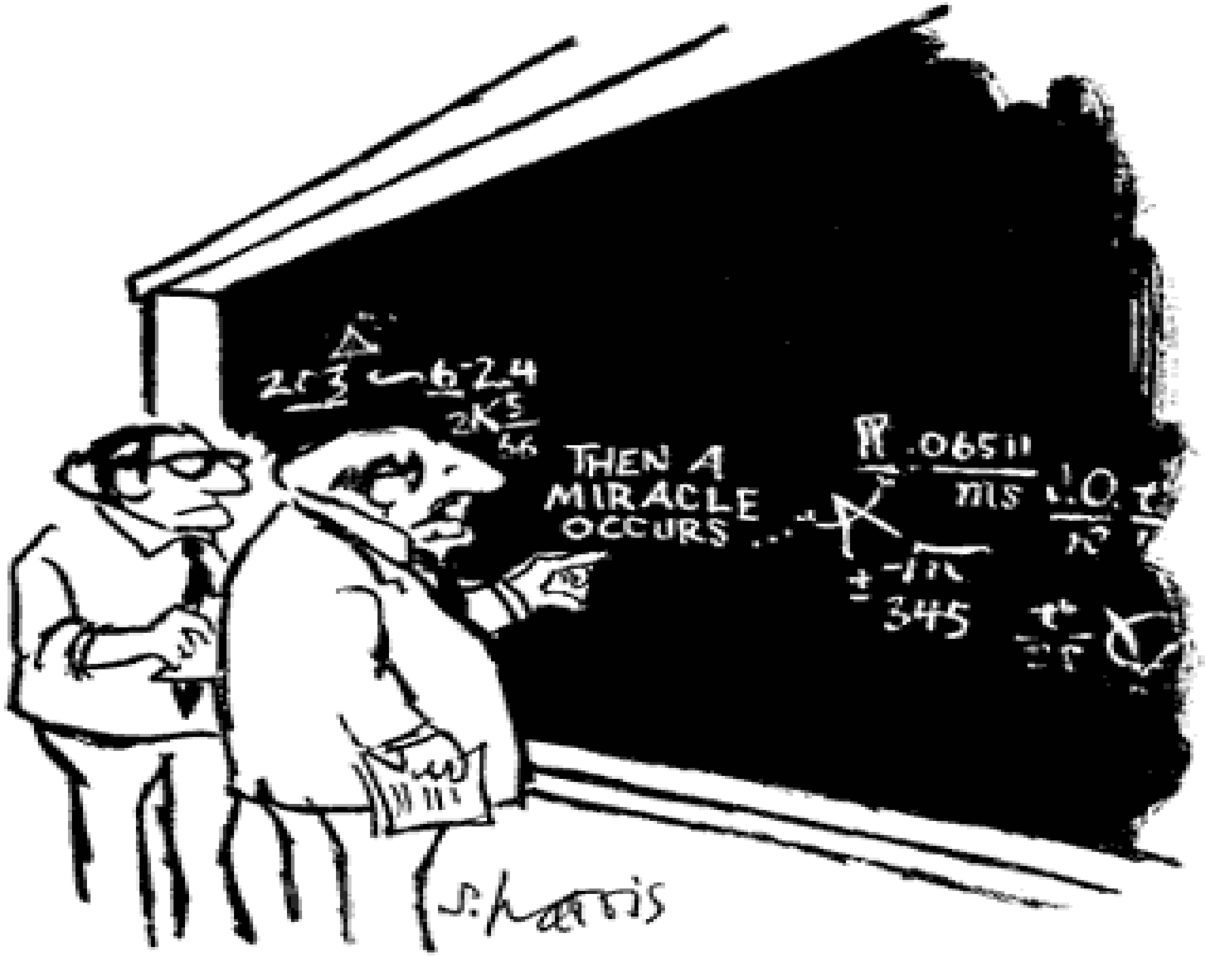
	HA +	H_2O <-->	H_3O^+ +	CB^-
Initial				
Change				
Equil				

- Assume change from initial concentration is negligible
  - *"Assume 1.0 – x = 1.0"; prove < 5% dissociation*

Weak acid/base Equilibria

- Be able to calculate:
  - Ka or Kb (no assumption necessary)
  - Use assumption to avoid quadratic:
    - $[H_3O^+]$ and [CB-] (use Ka), OR
    - $[OH^-]$ and [CA-] (use Kb)
    - Initial concentration of WA or WB

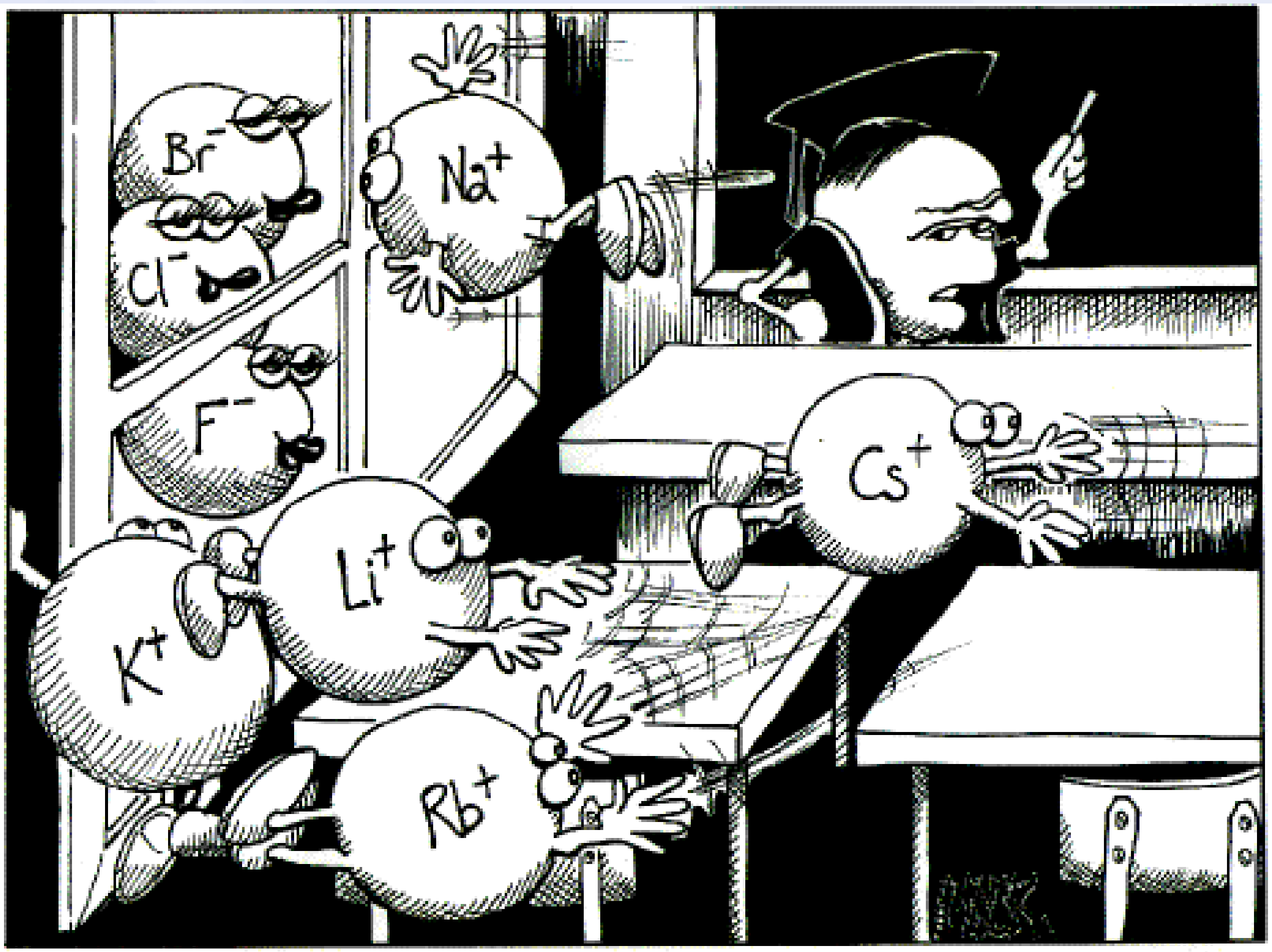
Show your work!



"I think you should be more explicit here in step two."

Hydrolysis

- Write dissociation of salts (put into ions)
- Hydrolysis: reaction of ion with water to produce acidic or basic solution
  - *Spectator ions*: **Don't participate**
  - Groups I and II on periodic table;
  - Conjugate bases of top 5 strong acids (R-hand side)



"Perhaps one of you gentlemen would mind telling me just what it is outside the window that you find so attractive...?"

Hydrolysis

- Predict if hydrolysis produces an acidic, basic, or neutral solution
  - $Cation^+ + H_2O \leftrightarrow H_3O^+ + CB-$
  - $Anion^- + H_2O \leftrightarrow OH^- + CA$
- Spectator ions produce *neutral* solutions
- If both ions undergo hydrolysis, compare Ka and Kb values *(greater value wins out)*
  - If Ka = Kb, then prediction would be neutral solution
- For amphiprotic ions, determine if Ka > Kb (acidic) or Ka < Kb (basic)

Indicators

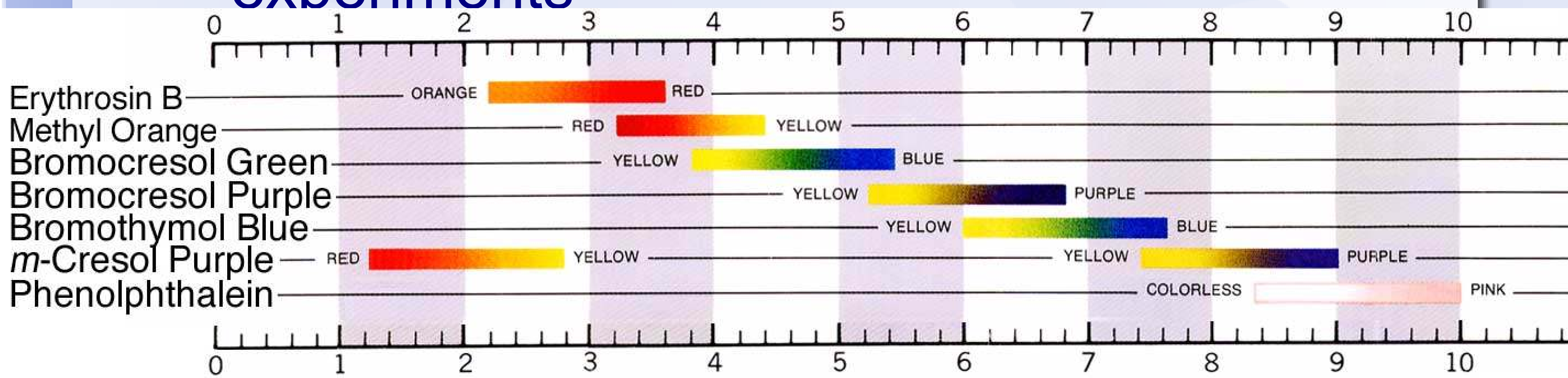
- Mixture of weak acid and conjugate base, each with distinguishing colours

$$HIn + H_2O \leftrightarrow In^- + H_3O^+$$

- Transition point: [HIn] = [In-]
  - Colour change occurs
  - Shift in equilibrium (Le Chatelier)
    - Add H_3O^+, shift LEFT to **HIn**
    - Add OH^-, shift RIGHT to **In^-**

Indicators

- Calculate transition point pH (mid-point of range)
- Calculate Ka of indicator
  - pH (@ TP) = pKa
- Suggest appropriate indicator for experiments

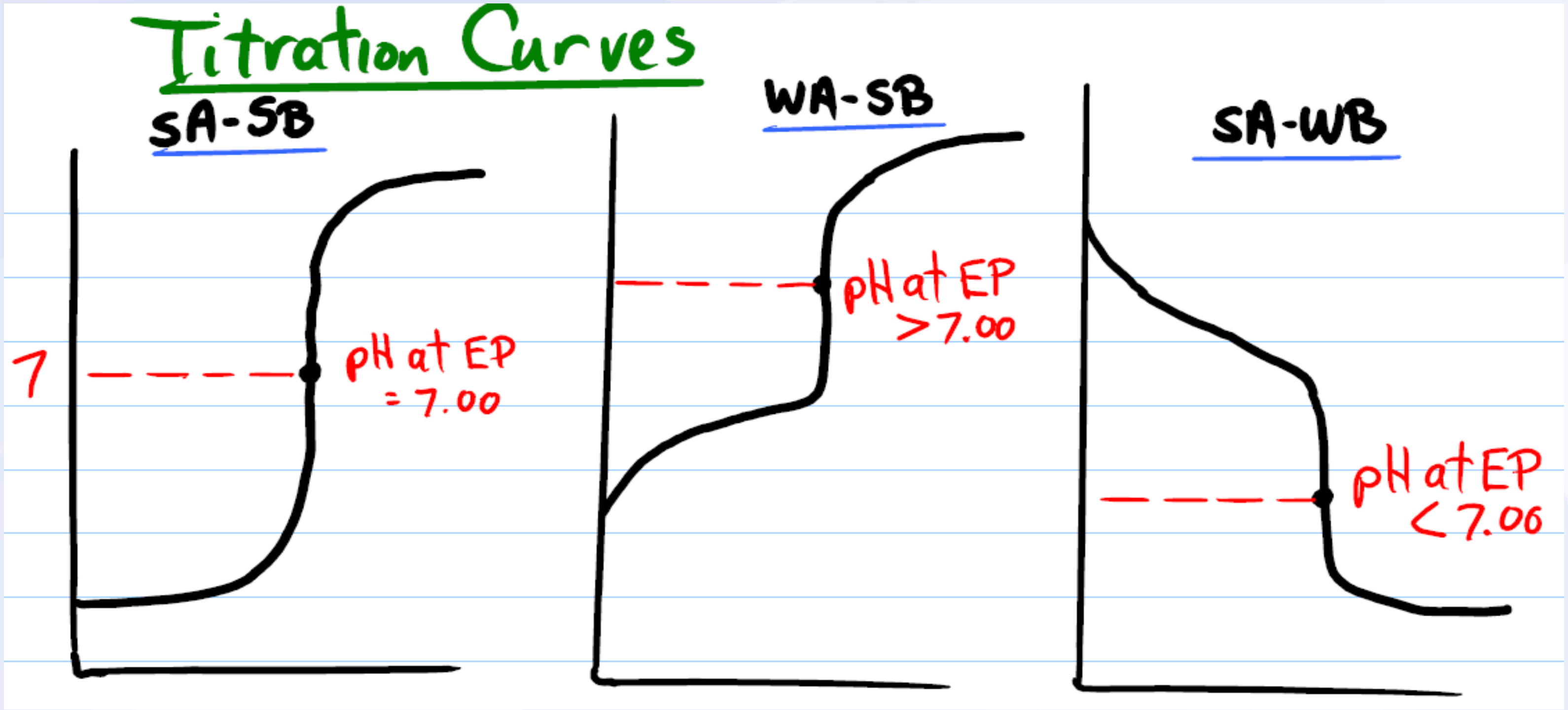


Acid-Base Titrations

- **Standard** solution – in buret (known conc & vol)
- **Sample** solution – in flask (+ indicator) (known vol, unknown conc)
- **Equivalence point** – moles acid = moles base; rapidly rising/falling pH
  - Choose indicator that has transition point (colour change) near equivalence point
- **pH ½** = pH at which half of volume of standard solution added
  - **pH ½** = pKa of acid

Titration curves

- Review titration curves
- Note initial rise/fall of pH in weak acid/weak base titrations (prior to equivalence point)



STANDARD SOL'N	SAMPLE SOL'N	EQUIVALENCE POINT	INDICATOR
Strong Acid	Strong Base	pH = 7.0	Bromothymol blue, phenol red, neutral red
Strong Base	Strong Acid	pH = 7.0	
Strong Acid	Weak Base	pH < 7.0	Bromocresol green, methyl orange/red
Strong Base	Weak Acid	pH > 7.0	Phenolphthalein

Buffers

- Buffers absorb addition of small amounts of acid or base without a big change in pH
- Mixture of weak acid and conjugate base in equilibrium
  - Acidic buffers have low pH
  - Basic buffers have high pH
- Outline procedure to prepare a buffer solution
  - Add sufficient conjugate base/acid as a soluble salt

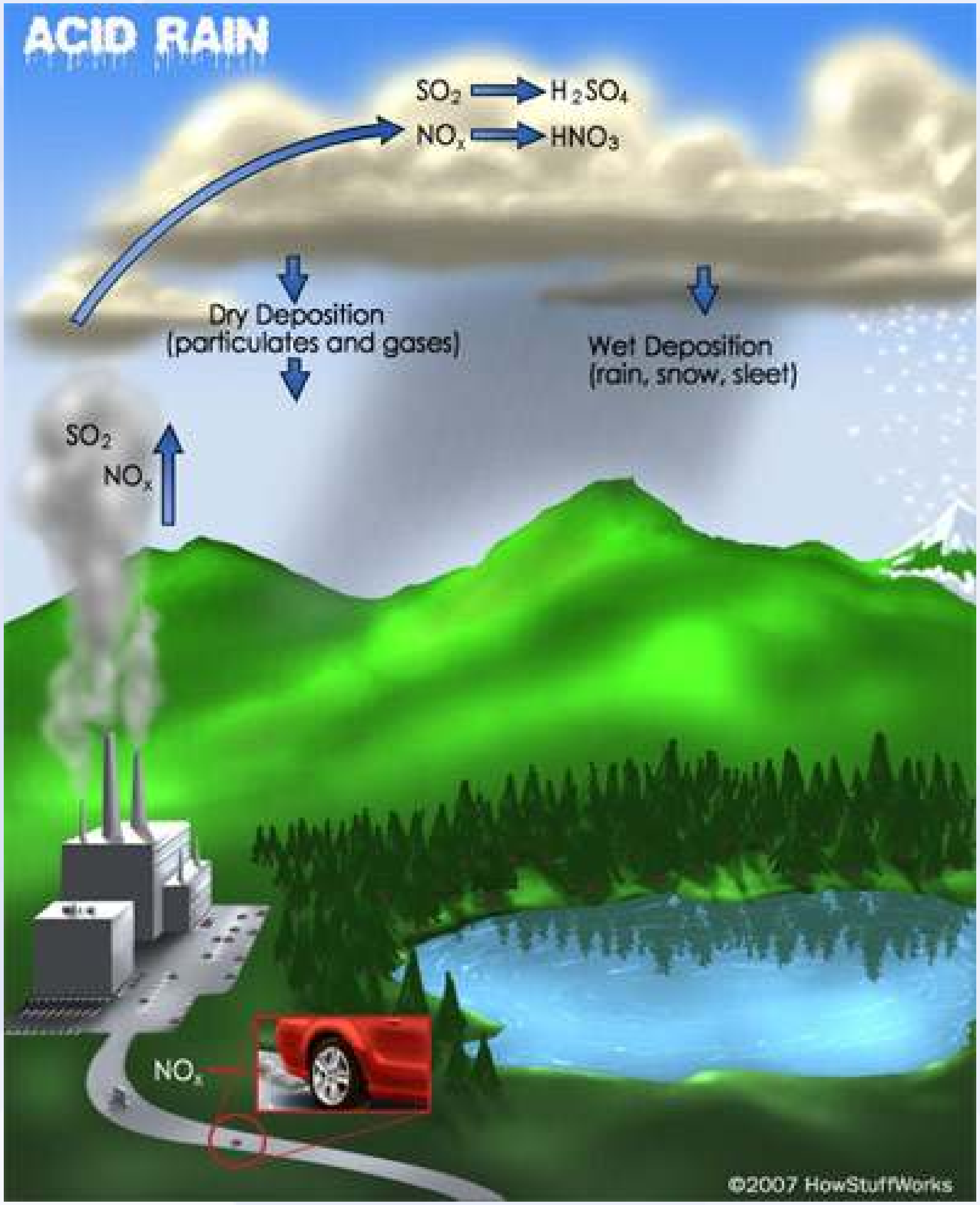
Buffers

- Describe equilibrium shifts as H_3O^+ or OH^- is added to buffer system
  - Draw equilibrium stress graph
  - Describe shift in equilibrium and net effect
- Biological buffers:
  - CO_2/HCO^{3-} in blood plasma
  - H_2PO^{4-}/HPO_4^{2-} in cell cytoplasm

Acid Rain

- Metal oxides form basic solutions
- Non-metal oxides form acidic solutions
- Acid rain due to excess NO_x and SO_x in atmosphere
  - $SO_2 + H_2O \text{ --> } H_2SO_3$
  - $SO_3 + H_2O \text{ --> } H_2SO_4$
  - $2NO_2 + H_2O \text{ --> } HNO_2 + HNO_3$

Singing in the Acid Rain.


ACID RAIN
SO_2 → H_2SO_4
NO_x → HNO_3
Dry Deposition
(particulates and gases)
Wet Deposition
(rain, snow, sleet)
SO_2
NO_x
NO_x
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