

VC210 Final Review

Acid& Base &Solution

Electrochemistry

Acid & Base & Solution

Definition of Acid & Base

Brønsted–Lowry Acids and Bases

An **acid** is a proton donor

A **base** is a proton acceptor

Lewis Acids and Bases

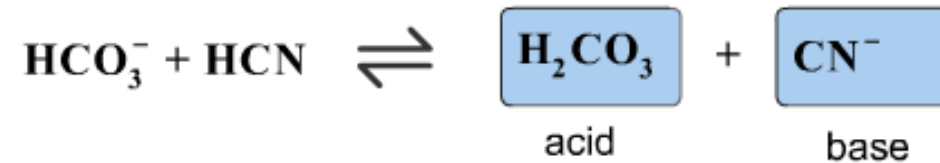
A **Lewis acid** is an electron pair acceptor.

A **Lewis base** is an electron pair donor.

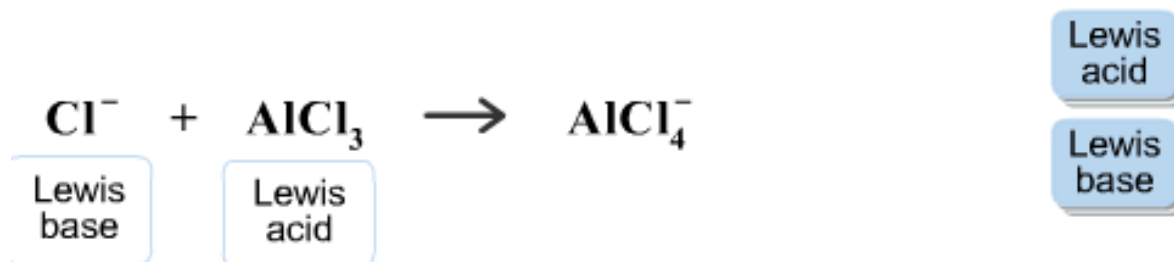
In these 2 definition, an **acid does not necessarily contain H^+** and a **base does not necessarily contain OH^-**

Definition of Acid & Base

Complete this Brønsted-Lowry reaction, placing each product by its appropriate label.



Identify the Lewis acid and Lewis base in each of the following reactions.

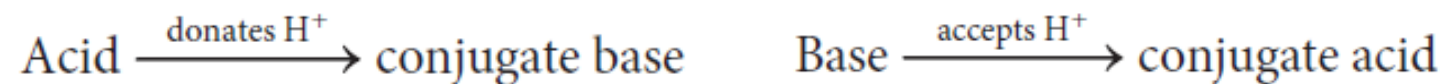


The pH Scale

- $\text{pH} = -\log [\text{H}_3\text{O}^+]$
- $[\text{H}_3\text{O}^+] = 10^{-\text{pH}} \text{ mol}\cdot\text{L}^{-1}$
- $\text{pOH} = -\log [\text{OH}^-]$
- $\overbrace{-\log [\text{H}_3\text{O}^+]}^{\text{pH}} + \overbrace{(-\log [\text{OH}^-])}^{\text{pOH}} = \overbrace{-\log K_w}^{\text{p}K_w}$
- Because $\text{p}K_w = 14.00$ at $25\text{ }^\circ\text{C}$, at that temperature
$$\text{pH} + \text{pOH} = 14.00$$

Conjugate

- The Conjugate Seesaw



- The stronger the acid, the weaker is its conjugate base
- The stronger the base, the weaker is its conjugate acid
- $K_a \times K_b = K_w$
- $\text{p}K_a + \text{p}K_b = \text{p}K_w$

Give the conjugate base for each compound below.

Acid	Conjugate Base
H_3PO_4	H_2PO_4^-
HPO_4^{2-}	PO_4^{3-}
NH_4^+	NH_3

Polyprotic Acids and Bases

- **Solutions of Salts of Polyprotic Acids**

- $\text{HS}^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{S}^{2-}(\text{aq}) \quad K_{\text{a}2} = 7.1 \times 10^{-15}; \text{p}K_{\text{a}2} = 14.15$
 $\text{HS}^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{S}(\text{aq}) + \text{OH}^-(\text{aq}) \quad K_{\text{b}1} = K_{\text{w}}/K_{\text{a}1} = 7.7 \times 10^{-8}; \text{p}K_{\text{b}1} = 7.11$
- $\text{pH} = \frac{1}{2}(\text{p}K_{\text{a}1} + \text{p}K_{\text{a}2})$
- Must check (where S is the initial concentration of the salt)

$$S \gg K_{\text{w}}/K_{\text{a}2} \text{ and } S \gg K_{\text{a}1}$$

Very Dilute Solutions

- Very dilute: concentration is less than 10^{-6}
- Charge balance: $[\text{H}_3\text{O}^+] = [\text{Cl}^-] + [\text{OH}^-]$
- Material balance: $[\text{Cl}^-] = [\text{HCl}]_{\text{initial}} \quad [\text{OH}^-] = [\text{H}_3\text{O}^+] - [\text{HCl}]_{\text{initial}}$

$$\begin{aligned} K_w &= [\text{H}_3\text{O}^+] \overbrace{([\text{H}_3\text{O}^+] - [\text{HCl}]_{\text{initial}})}^{[\text{OH}^-]} \\ &= [\text{H}_3\text{O}^+]^2 - [\text{HCl}]_{\text{initial}}[\text{H}_3\text{O}^+] \end{aligned}$$

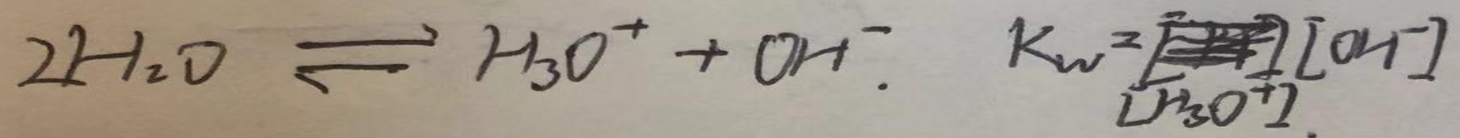
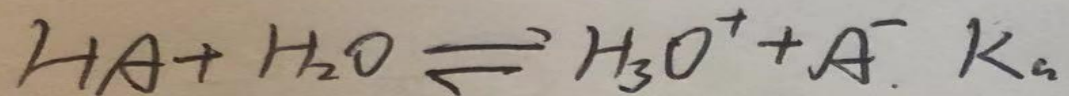
$$[\text{H}_3\text{O}^+]^2 - [\text{HCl}]_{\text{initial}}[\text{H}_3\text{O}^+] - K_w = 0$$

- **Very Dilute Solutions of Weak Acids**

- $$K_a = \frac{[\text{H}_3\text{O}^+]\left([\text{H}_3\text{O}^+] - \frac{K_w}{[\text{H}_3\text{O}^+]}\right)}{[\text{HA}]_{\text{initial}} - [\text{H}_3\text{O}^+] + \frac{K_w}{[\text{H}_3\text{O}^]}}$$

- $$[\text{H}_3\text{O}^+]^3 + K_a[\text{H}_3\text{O}^+]^2 - (K_w + K_a[\text{HA}]_{\text{initial}})[\text{H}_3\text{O}^+] - K_aK_w = 0$$

Derivation process of the formula



$$\text{Charge balance} = [H_3O^+] = [A^-] + [OH^-]$$

$$\Rightarrow [A^-] = [H_3O^+] - [OH^-] = [H_3O^+] - \frac{K_w}{[H_3O^+]}$$

$$\text{Material balance: } [HA]_{\text{initial}} = [HA] + [A^-]$$

$$\Rightarrow [HA] = [HA]_{\text{initial}} - \left([H_3O^+] - \frac{K_w}{[H_3O^+]} \right)$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]} \approx \sim$$

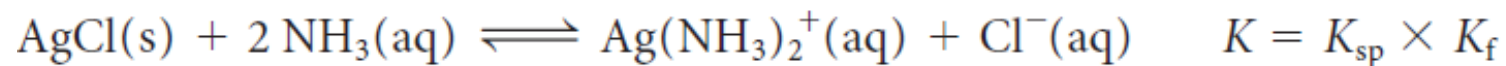
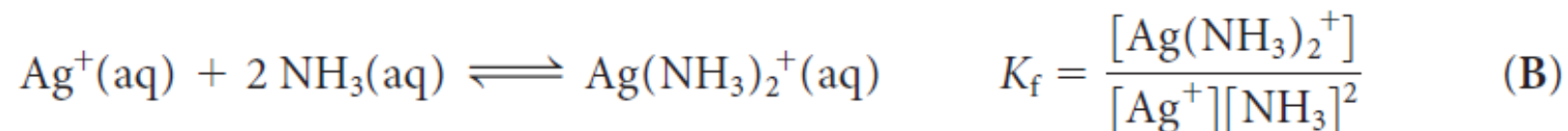
Buffers

- **Buffer capacity** is the maximum amount of acid or base that can be added before the buffer loses its ability to resist large changes in pH.
- A buffer is found experimentally to have a high capacity for stabilizing against the **addition of acid** when the amount of **weak base** present is at least **10%** of the amount of weak acid.

$$\text{pH} = \text{p}K_a + \log \frac{[\text{base}]}{10[\text{base}]} = \text{p}K_a + \overbrace{\log \frac{1}{10}}^{-1} = \text{p}K_a - 1$$

Solubility Equilibria

- **Complex Ion Formation**

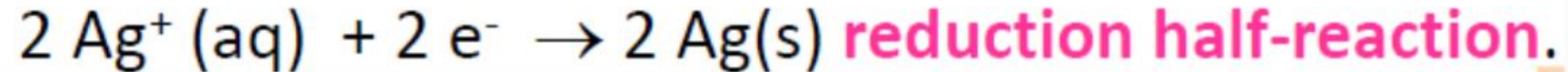
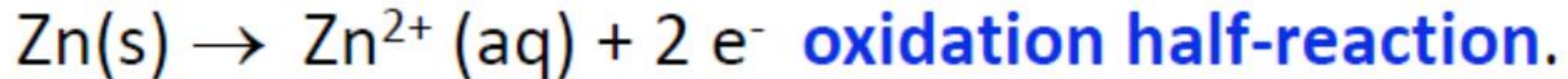
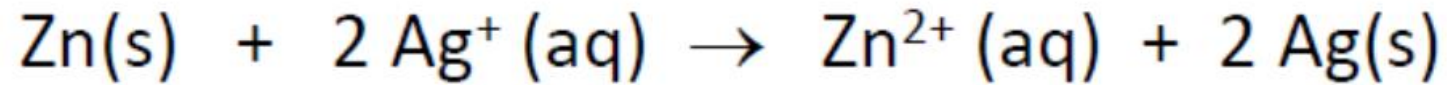


- The solubility of a salt increases if the salt can form a complex ion with other species in the solution.

Electrochemistry

Oxidation & Reduction

- Oxidation Reaction: Electrons are removed
- Reduction Reaction: Electrons are taken



Balancing redox reactions

Conservation of atom, charge

Surrounding/ pH:

acidic solution: OH^- would not appear in the reaction

basic solution: H^+ would not appear in the reaction

- Valence up, reductant, oxidized
- Valence down, oxidant, reduced
- In some reactions, more than one reductant/ oxidant may exist.

Galvanic cell

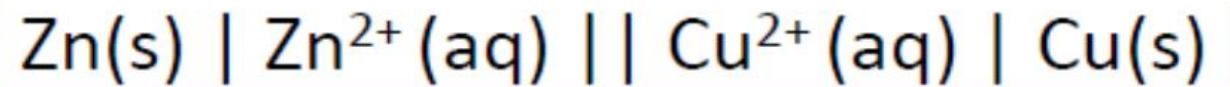
- Galvanic cells are spontaneous reactions generating current

Anode: Oxidation reaction occurs

Cathode: Reduction reaction occurs

- Notation:

Anode electrode | anode electrolyte || cathode electrolyte | cathode electrode



- Generally, the material of anode is more active than cathode
- Anode/ Cathode are not necessarily the reactant for the Redox reaction.

Galvanic Cell

- Standard reaction Gibbs free energy
- $\Delta G^{\circ} = -nFE_{cell}^{\circ}$
- $F = 9.6485 \times 10^4 \text{ C} \cdot \text{mol}^{-1}$

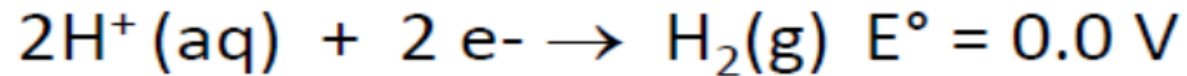
The value of E is the same regardless of how we write the equation
eg. Multiple the same constant with each side of the equation

Do not confuse it with the Hess's law

- $E_{cell}^{\circ} = E_{right}^{\circ} - E_{left}^{\circ}$

Galvanic Cell

Standard Hydrogen Electrode (SHE):



- Nernst Equation:

$$E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{RT}{nF} \ln Q$$

- At 298.15K, $RT/F=0.025693 \text{ V}$
- Can be applied to predict a cell's potential by concentration & temperature, and **vice versa**

Some applications:

Electrolytic Cells

Purification & Preservation of Metal

Corrosion

.....

You don't have to recite everything in the book

However, you'd better have a rough impression on these application, so that you can solve such problems faster

Calculation:

- Figure out the scenario of the problem(Polytopic. Very diluted, Buffer...) and use corresponding formula.
- Nearly all kinds of questions are covered in the final review materials on canvas. You are suggested to finish them by yourselves, and praise WYS after get A+

Some other suggestions:

- Significant Figure!!!
- Make sure you comprehend every concept correctly
(e.g. Enthalpy of formation/ Enthalpy of combustion in MID 2)
- Review the problems on sapling learning. Try to solve those typical problems without hint.
- If you make preparation seriously, the exam would be easy; if you don't prepare, the exam would be incredibly hard.

Thank you