

Types of Reactions

- Direct combination: (synthesis) is when two molecules combine, $A + B \longrightarrow AB$.
- Decomposition: a molecule splits into multiple, $AB \longrightarrow A + B$.
- Combustion: reaction with oxygen to produce heat.
- Single displacement: $AB + C \longrightarrow A + CB$
- Double displacement: $AB + CD \longrightarrow AD + BC$

First four are driven by transfer of electrons, redox, and the final is driven by the creation of a precipitate. Electron transfer can be recognized from change in charge, if charge increases then electrons are lost and vice versa.

Electrochemistry

Key idea is that chemical reactions can create electricity and take place because of electricity. Redox reactions since electrons are moving.

A reaction is spontaneous if cell potential is positive. Remember OILRIG, LEOGER, or just that electrons lower charge (if you are an intellectual). PANC, positive anode negative cathode and An Ox Red Cat are useful as well. The salt bridge is usually NaNO_3 . Simply add the potentials to calculate, remember it's intensive so scaling is not needed.

$$\Delta G = -nFE^\circ.$$

Terms

- electricity: movement of electrons, often through something
- oxidation number: charge
- oxidation: losing electrons
- reduction: gaining electron
- voltaic cell: (galvanic cell) used to set up electrochemical reactions
- anode: where oxidation happens
- cathode: where reduction happens
- PANC: positive anode, negative cathode
- OILRIG: oxidation is losing, reduction is gaining
- electromotive force: (emf) difference between anode and cathode
- cell potential: another term for emf, called E_{cell} in default conditions, E_{cell}° indicates default condition.
- standard hydrogen electrode: the reduction potential of hydrogen, 0V.
- ampere: (amp) measurement of current
- coulomb: $1C = A \times \text{sec}$, current times time..
- Faraday: (F) the amount of coulombs needed for a mole of electrons, 96,500.

An Ox, Red Cat to remember

- electrolysis: motivating a reaction with electricity

Oxidation Rules

- free elements have an oxidation number of 0, includes default molecular state.
- oxygen has an oxidation state of -2, except in peroxides (H_2O_2 , BaO_2 , Na_2O_2).
- hydrogen has an oxidation state of 1, except in metallic hydrides (CaH_2 , NaH).
- for nonmetals oxidation state is derived from group, equal to the amount needed to complete valence shell.
- charges add up to zero for default state, or the charge of an ion.

Ex: $\text{Fe}_2\text{O}_3 + \text{CO} \longrightarrow \text{Fe} + \text{CO}_2$ Oxygen has a charge of negative two everywhere, iron alone has a charge of 0. All else follows by assuming sum of zero. to determine redox split into pieces based on charges that changed, C and Fe.

Potential

Reduction series is the oxidation series reversed. Metals above hydrogen in the reduction series react with acids, metals below do not. Cell potential is an intensive property:

$$E_{\text{cell}} = E_{\text{red}}[\text{cathode}] - E_{\text{red}}[\text{anode}].$$

This looks rather terrifying, but remember that potential is an intensive property, so there is no need to balance the redox reaction, just take the absolute difference.

The Gibbs free energy for a redox reaction can be found using the equation

$$\Delta G = -nFE$$

where n is the number moles of electrons transferred, E is the cell potential and F is the Faraday constant, 96,485C/mol.

Cell Notation

Given the reaction $\text{Zn(s)} + \text{Cu}^{2+}(\text{aq}) \longrightarrow \text{Zn}^{2+}(\text{aq}) + \text{Cu(s)}$, the abbreviation is $|\text{Zn(s)}||\text{Zn}^{2+}||\text{Cu}^{2+}(\text{aq})|\text{Cu(s)}$. In a more general sense, the format is



with the double line representing the salt bridge.

Electrolysis

Electricity is used to force a non-spontaneous reaction to occur. Electrolytic cells occur when a galvanic cell is reversed, electrons flowing the opposite direction. Used to synthesis very reactive elements.

Stoichiometry

Convert given values to moles. To determine empirical formula put in terms of moles and divide by smallest.

Solutions

given molarity and quantity calculate moles and then grams from moles.

Titration

The equivalence point is where the moles of acid and base are equal. The endpoint is when color changes. Halfway to the equilibrium point $\text{pH} = \text{p}K_a$.

Buffers

Weak A/B with conjugate salt, examples being HF with NaF.

Gas

Conditions of an ideal gas are low pressure, high temperature and low molar mass. Note that there is deviation from the ideal gas law if any conditions are not met. Gases dissolve better at lower temperature, while solids dissolve better at high temperatures. A gas has more kinetic energy based on it's absolute temperature. Rate of effusion is dictated by square root of ratio, lower molar mass is faster. Also, remember the relationship between pressure, volume and temperature, PV/T stays consistent.

In general, whip out your ideal gas law, $PV = nRT$

States of matter

Change in state does not change temperature, breaks bonds.

Thermochemistry

Hess' Law exists, subtract reactants from products. (Generally remember this for chem). Given bond dissociation energies, follow good old Hess after drawing out molecules. Keep in mind, breaking bonds releases energy and making them takes energy.

Positive ΔH means endothermic, negative means exothermic. Positive ΔS means more disorder, negative means less, down to 0. Positive ΔG means non-spontaneous while negative means more spontaneous. $\Delta G = \Delta H - T\Delta S$. Keep in mind, positive entropy suggests spontaneity since the universe wants to minimize disorder. At equilibrium, ΔG is zero.

Kinetics

Catalyst lowers activation energy. Intermediate is produced and then consumed. Increasing the rate of reaction occurs when concentration is higher, a catalyst is added, pieces are smaller or temperature is higher.

Rates are products over reactants to coefficient powers. Unit is $M^{1-\text{Order}}\text{sec}^{-1}$. Half life is a first order reaction is $0.693/k$. The slowest step is rate determining.

Equilibrium

Equilibrium is when rates of reaction in each direction are the same. At that point amount of product and reactant stays constant.

All various constants are in the form products over reactants.

Le Chatelier's exists, generally be logical and think about what process would cause the change, and then invert.

Acids and Bases

If this comes up just accept that you are fucked. If you don't want to be fucked, remember your strong bases and acids.

Descriptive

Color comes from d-shell, specifically if the shell is not full.