

PHYSICS

- $F_{centripetal} = \frac{mv^2}{r}$
- $F_{gravity} = \frac{GMm}{r^2}$ (r=distance to center of M)
- **orbit:** $F_{gravity} = ma_{cp} \rightarrow v_{orbit} = \sqrt{\frac{GM}{r}}$
- **Frequency & period** of a pendulum UNAFFECTED by mass or amplitude
 - $T_{pendulum} = 2\pi\sqrt{\frac{L}{g}}$
- **Spring frequency & period** do depend on mass due to spring constant
 - $T_{spring} = 2\pi\sqrt{\frac{m}{k}}$
- 1st **resonance frequency** = difference between consecutive frequencies
- **Wave Frequency** is constant unless Doppler shifted
 - Wavelength will decrease in more dense medium
- Pitch = perceived frequency; volume = perceived amplitude
- **Work of friction** = $-f_{kinetic}x$
- **Power** = $\Delta W/t = Fd/t = Fv$
- **Intensity** = Power / Area = Energy / (Area*time)
 - $Intensity_{new} = Intensity_{old} * (distance_{old}^2 / distance_{new}^2)$
- **Photon Energy** = $h\nu = hc/\lambda = mc^2$
 - $\lambda = v/f$
 - Photoelectric effect: transition $n=2 \rightarrow 1$ emits more energy than $n=3 \rightarrow 2$
- **Alpha decay** loses 2 protons & 2 neutrons
 - **Beta decay** gains 1 proton, loses 1 neutron (e^- emitted)
 - **Electron capture** loses 1 proton & $1e^-$, gain 1 neutron
- **Electrostatic Force** = kq_1q_2/r^2
 - $V = Ed$
 - $W_{Electric} = qV = qEd$
 - $E = V/d = kq_{source}/r^2$
 - $F_{EField} = qE = qV/d$
 - $C = q/V = 2V^2/U = \epsilon A/d$ (A=plate area, d=distance between plates)
- **Resistance** inverse to Current ($V=IR$)
- **Series circuit** = constant I, reduced total capacitance, voltage drop at each resistor
- **Parallel circuit** = constant V, reduced total resistance, current splits at each branch
- Particle deflector radius of curvature: $F_{Bfield} = F_{cp} \rightarrow qvB = mv^2/r \rightarrow r = mv^2/qvB$
 - Particle deflector velocity required for linear motion: $F_{Efield} = F_{Bfield} \rightarrow qE = qvB \rightarrow v = E/B$
- **Buoyant force** = ρVg (no change with depth)
 - **Hydrostatic Pressure** = ρgh (changes with depth)
- **Apparent weight** of floating object = $N = mg - F_{Buoyant}$
- $a = \Delta v/t$ $v = d/t$ $v_f = v_i + at$ $\Delta x = v_0t + \frac{1}{2}at^2$ $v^2 = v_0^2 + 2a\Delta x$
- **Freefall** or constant accel unaffected by mass, cancels out if gravity's sole force ($F=ma \rightarrow mg=ma \rightarrow g=a$)
 - $t = \sqrt{\frac{2h}{g}}$ $h = \frac{1}{2}gt^2$
- **Ideal fluid** (no viscosity): Pressure $\propto 1/\text{height}$ from $P + \frac{1}{2}\rho v^2 + \rho gh = k$
 - $Q = Av$ $A_1v_1 = A_2v_2$ ($A = \pi r^2$) $A_1d_1 = A_2d_2$ (d = distance)
 - Decrease in area increases velocity, decreases pressure
 - fluid speed around edges of pipe is slower than center (laminar flow)
- **Real fluid** (viscosity): Pressure \propto length, flow rate, viscosity, $1/\text{radius}^4$ (from $\Delta P = 8Q\eta L / \pi r^4$)
- **Circumference of circle** = $2\pi r$; **area of circle** = πr^2

- 1 radian = $180^\circ/\pi$

GENERAL CHEMISTRY

- **Thermo spontaneity:** $-\Delta S - \Delta H$ low temps; $+\Delta S + \Delta H$ high temps; $+\Delta S - \Delta H$ always; $-\Delta S + \Delta H$ never
- **$-\Delta H$ phase changes:** condensation, deposition, freezing
- $E_{\text{cell}} = E_{\text{cathode}} - E_{\text{anode}}$ (uses reduction potentials) = $E_{\text{oxidation}} + E_{\text{reduction}}$
 - $+E_{\text{cell}}$ for galvanic/voltaic, $-E_{\text{cell}}$ for electrolytic
 - **Salt bridge** cations go to cathode, anions to anode
- Cathode (REDCAT) = species w\ highest reduction potential
- **Echem grams plated** = charge ($q=It$) * 1 mole e^- / 96,500C * mole X / mole e^- xfered * g/mol X
- **Rate law** is REACTANTS ONLY given slow step equation: $\text{rate} = k[\text{reactants}]^{\text{coefficients}}$
 - given time $\text{rate} = \Delta\text{Products}/\Delta t = -\Delta\text{Reactants}/\Delta t$
 - rate is changed by activation energy (catalyst), temp, & steric orientation
- **Keq** only changed by temperature
- **Q** changed by P/V/concentrations, favors more moles when volume increased or pressure decreased
- **Rate of forward rxn** always increases with temp but how it affects Q depends on enthalpy
 - temp increased for exothermic will decrease Q (more reactants at equilibrium)
- **Rxn diagram profiles:** E_a =height of TS bump; ΔH =reactants – products
 - **rate determining step** = highest E_a or highest TS hump



- **Kinetic product** formed faster (lower E_a /TS height) but less stable, occurs with low temps
 - **Thermodynamic product** formed slower but more stable, occurs with high temps
- **Titration at half-equivalence point:** $\text{pH}=\text{pKa}$ & $[\text{A}^-]=[\text{HA}]$
 - $\text{pH}_{\text{buffer}} = \frac{1}{2}\text{pKa} - \log[\text{HA}] = \text{pKa} + \log[\text{A}^-/\text{HA}]$
 - **Equivalence pt:** $[\text{analyte}] = [\text{titrate}]$
- **Acidic cations:** Al, Fe, NH_4^+ , Zn, Cu, Be, Cr (*A Fact No Zebra Could Be Creepy*)
- **Water soluble ions (NAG SHAM):** Nitrates, Acetate (CH_3COO^-), Grp 1 metals, Sulfates (except PMS CaStro Bar), Halogens (except PMS), Ammonium
 - Adding solvent always increases solubility, changing temp may not depending on enthalpy of solvation
- $Q = mC\Delta T + \Delta H_{\text{phaseChange}} * \text{moles}$ (can use $^\circ\text{C}$ or K, $C=1$ for water)
- **Periodic trends:** atomic size decreases moving up & over; IE, E_a , EN, Z_{eff} all increase up & over
- **Weak acid pH estimate** = $\frac{1}{2}\text{pKa} - \frac{1}{2}\log[\text{HA}]$
- **Boiling point** increases (*MILnr*): molecular mass, IMF, linear molecular arrangement
- Arrhenius acid forms H_3O^+ & base forms OH^- (simplest definition)
 - Bronsted-Lowry acids donate protons & bases accept them (more complex definition based on particles)
 - Lewis bases donate e^- pairs and acids accept them (most nuanced)
- **Bond dissociation enthalpy** (specific bonds like O-H) = $(\sum \text{Reactants}) - (\sum \text{Products})$
- **Enthalpy of formation** (per compound) = $(\sum \text{Products}) - (\sum \text{Reactants})$
 - Elements in natural phase = 0 kJ/mol like gas diatomics except $\text{I}_2(\text{s})$ & $\text{Br}_2(\text{l})$
 - multiply both by coefficients or # moles

- **Orbitals and max e- per subshell:** s 1 orbital 2e-, p 3 orbitals 6e-, d 5 orbitals 10e-, f 7 orbitals 14e-
- **Non-ideal gas:** Kinetic Energy \propto molar mass
 - Rate of diffusion \propto 1/molar mass


BIOLOGY

- **Steroids** & tyrosine hormones act on nucleus, peptides act on cell membrane receptors \rightarrow cascade
- **Calcitonin** (thyroid) puts blood **calcium** into bone
 - **PTH** (parathyroid) increases blood calcium
- **Vasopressin/ADH** (peptide) always digs holes in collecting duct \rightarrow more water in blood \rightarrow increases BP
- **Slow twitch muscles** = type I red myoglobin mitochondria capillaries for aerobic endurance
 - **Fast twitch** = type II white cytoplasmic ATP anaerobic
- **Hemoglobin** O₂ curve shifts RIGHT from \uparrow [CO₂], \uparrow [H⁺], \uparrow temp, \uparrow DPG (so unloads O₂ in active muscles)
 - Hb-O₂ curve shifts LEFT from \uparrow [CO]
 - Hemoglobin cooperatively binds O₂ (induces conform. change)
 - **Myoglobin** does not shift nor cooperatively bind, no sigmoidal dissociation curve or changes
 - Fetal Hb has a higher affinity for O₂ than mother's Hb
- **Glycolysis** in cytosol: $2ATP + \text{glucose} + 2NAD^+ \rightarrow 2NADH + 2ATP + 2 \text{ pyruvate}$
 - **Fermentation** in cytosol: $\text{glucose} + 2ADP \rightarrow 2 \text{ lactate} + 2ATP$
 - **Pyruvate oxidation** in matrix: $3C \text{ Pyruvate} \rightarrow 2C \text{ Acetyl CoA} + CO_2 + NADH$
 - **Krebs cycle** in central matrix: $3NAD^+ + FAD + GDP + \text{acetyl-CoA} \rightarrow 3NADH + FADH_2 + GTP + CoA + 2CO_2$
- **Ames tests** mutagens by placing bacteria in conditions that cannot normally grow, any growth occurring is due to mutagen
- **Bacterial conjugation** (like conjugal visit) = sexual reproduction with pili, F+ plasmid donor to F- recipient
 - **Transduction** = lysogenic virus to transfer bacterial DNA
 - **Transformation** = extracellular plasmids or DNA fragments integrates into bacterial genome
- **Arteries** carry blood away, usually oxygenated except for pulmonary artery (to lungs)
- **Bile** produced in liver, stored in gallbladder, emulsifies fats for optimal lipase activity
- **Nondisjunction** = failure of chromatids to separate \rightarrow aneuploidy (mono- or trisomy)
- **Missense mutation** = "mistaken" AA coded for (base-pair substitution)
 - **Nonsense mutation** = "no sense" or no AA coded for (stop codon)
- **PCR** creates n² DNA copies where n = cycles
- **DNA polymerase** requires RNA primer & proofreads
 - RNA polymerase (transcription) does not use primers & does not proofread
- **DNA read 3'-5'** like we read but synthesized 5'-3' like building a pyramid
- **RNA transcribed** & processed in nucleus
 - introns spliced out (go in trash), 3' end gets poly-A tail, 5' end capped
 - **Alternative splicing** = varying removed introns to create multiple polypeptides per gene
- Deoxyribose + Nitrogenous base \rightarrow Nucleoside + Phosphate \rightarrow Nucleotides + pair + histones \rightarrow nucleosomes \rightarrow chromatin \rightarrow chromosomes
 - **Histone** positive charge bonds to phosphate negative
- **Proteins that go to the ER after translation:** secreted, integral membrane, lysosomal proteins
- **Cell cycle:** G1, S phase, G2, Mitosis, Cytokinesis (*Go Sally Go Make Children*)
- **Buffers:** $R-NH_3^+ (\text{alkyl ammoniums})^* \rightleftharpoons R-NH_2 (\text{alkyl amines})$
 - $H_2PO_4^- (\text{dihydrogen phosphate}) \rightleftharpoons HPO_4^{2-} (\text{phosphoric acid})^*$
 - $H_2CO_3 (\text{carbonic acid}) \rightleftharpoons HCO_3^- (\text{bicarbonate})^*$
 - **physiological form (pH 7.4)*
- CO₂ + carbonic anhydrase (in RBC) \rightarrow HCO₃⁻ + H⁺ (for transport) \rightarrow back to CO₂ for exhale

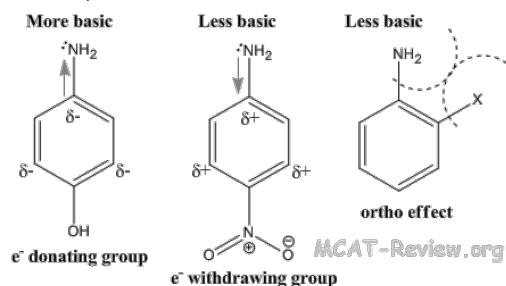
- **Blastula** implants then gastrulation makes the 3 germ layers:
 - **Ectoderm**: skin, neural tube, brain, eyes, ears
 - **Mesoderm**: organ systems, bones, coelom (cavity), notochord (backbone)
 - **Endoderm**: internal linings, glands
- **Ductus arteriosus** shunts blood away from the lungs, **Ductus venous** bypasses the liver, **foramen ovale** shunts from RA to LA
- **Pancreas** makes digestive enzymes & insulin
- **LH surge** = ovulation (middle of cycle), progesterone increase = luteal phase (end of cycle)
 - endometrium sloughs off due to progesterone decrease when cycle starts again
- **Humoral immunity** uses antibodies/B-cells for *extracellular* pathogens
 - **Cell-mediated** immunity uses cytokines/APC/MHC/T-cells for *intracellular* pathogens
- **Nerve fibers** (*SAME DAVE*): Sensory afferent dorsal (to back), motor efferent ventral (towards front)
- **Hyperpolarization** is *inhibitory* (goes negative), **depolarization** is *excitatory* (goes positive)
- **Anterior pituitary hormones** (*FLAT PEG*): FSH, LH, Adrenocorticotrophic, TSH, Prolactin, Endorphins, GH
- **Tendon** (*BTM*) = bone tendon muscle
 - **Ligament** = bone to bone
 - both are dense connective tissue containing collagen
- Exhalation is passive, respiration requires contraction of diaphragm (decreases intra-alveolar/intrapleural P)
- **Virus** protein capsid contains genome, can be enveloped by protein-lipid bilayer from host
- Cells that lack a nucleus: RBCs, platelets (not really a cell), prokaryotes
- Cells that do not divide: RBCs, neurons, muscles, osteocytes
- Cells multinucleated: skeletal muscle cells

ORGANIC CHEMISTRY

- **IR peaks**: OH broad 3300, NH₂ sharp 3400, CN 2200, alkene 3100/1600, alkyne 3300/2200
- HNMR n+1 peaks for each unique neighboring hydrogen
- **Amino acid deprotonated** when pH > pKa (basic solution deprotonates)
 - o *protonated* when pH < pKa (acidic solution protonates)
- **Fischer projection stereochem**: descending order by atomic #, if H is on horizontal bar it is sticking out so reverse R/S; carbohydrates = L(eft)S DR(ight)
- **Acid-base extraction**: 1. protonate base (amines) with strong acid
 - o 2. deprotonate strong acid with weak base (NaHCO₃)
 - o 3. deprotonate weak acids (phenol) with strong base, all go to aqueous layer after reacting (bottom layer unless using dichloromethane or other solvent denser than water)

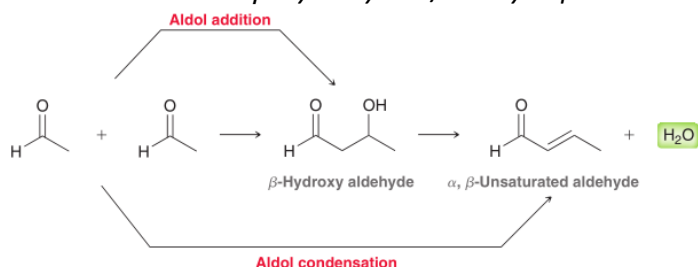
• Acetone  (CH₃)₂CO

- **Decarboxylation**: β-keto acid + heat, H₂O, H⁺ or OH⁻ → ketone (or enol) + CO₂
- Basicity of aromatic amines: OH more basic EDG, NO₂ less basic EWG



- NO₂ deactivates aromatic substitution, Cl deactivates, Methyl activates
- **Aldol reaction**: keto/enol → β-Hydroxyketo/aldehyde product

o **Aldol condensation:** β -Hydroxyketo/aldehyde product \rightarrow α,β -Unsaturated enone product



- **Saponification/ester hydrolysis:** OH^- attacks carbonyl, original OR group from ester, carboxylate formed (can be protonated by acid workup)
- LiAlH_4 reduces any carbonyl to OH
 - weaker NaBH_4 can only reduce aldehyde or ketone
- Stereoisomers $\# = 2^n$ where n is # of chiral carbons
- **Acid derivatives reactivity:** acid halide (best LG, EWG) > Anhydride > Thioester > Esters \approx Acids > Amides > Carboxylate (EDG, nucleophile)
- Hydrogen α to carbonyl more acidic; very acidic H in the middle of β -keto ester
- β -keto acid + heat \rightarrow ketone (or enol) + CO_2 (decarboxylation)
- α,β -unsaturated carbonyl + nucleophile \rightarrow addition at the β position
 - enol formed but usually tautomerizes back to keto
- 2x ester + base \rightarrow β -keto ester + alcohol (Claisen condensation)
 - base attacks α hydrogen