

# MCAT Formula Sheet

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# 1 Mechanics

## 1.1 Translational Motion

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$v_f = v_0 + a t$$

$$v_f^2 = v_0^2 + a t$$

## 1.2 Force

### Center of Mass

$$com = \frac{m_1 x_1 + m_2 x_2}{x_1 + x_2}$$

### Newtons 1st Law

inertia, momentum, impulse

### \*Newtons Second Law

$$F = ma$$

$$Weight = F_g = mg$$

### Frictional Force

$$f_{max} = \mu N$$

$$\mu_k < \mu_s \dots \text{always}$$

### Uniform Circular Motion

$$F_c = m a_{circ.} = \frac{mv^2}{r}$$

$$a_{circ.} = \frac{v^2}{r}$$

### Inclined Plan

$$F_{normal} = mg \cos \theta$$

## 1.3 Equilibrium

### Torque Forces

$$\tau = \mathbf{F} \times \mathbf{d}$$

$$= d F \sin \theta$$

$$= d F \text{ when perpendicular}$$

2

### Tension on Pendulum

$$T = mg \cos \theta$$

## 1.4 Work

### \* Work

$$W = F d \cos \theta$$

$$W_{total} = \Delta E$$

### \*Kinetic Energy

$$KE = \frac{1}{2} m v^2$$

Units: Joules = N\*m

### \*Potential Energy

$$U_{gravity} = mgh$$

$$U_{spring} = \frac{1}{2} k x^2$$

### Conservation of Energy

$$E_{total} = KE + U$$

$$\Delta E = \Delta K + \Delta U = 0$$

$$E = mc^2$$

### Power

$$P = \frac{\Delta W}{\Delta t}$$

Units: watt = J/s

### \*Spring Force and Work

$$F = -kx$$

$$W = \frac{1}{2} k x^2$$

## 2 Fluids

### 2.1 Hydrostatics

#### Specific Gravity

SG = % object submerged

$$SG = \frac{\rho_{\text{substance}}}{\rho_{\text{water}}} = \frac{\text{height above surf}}{\text{total height}}$$

$$\rho_{\text{water}} = \frac{1g}{cm^3} = \frac{10^3 kg}{m^3}$$

#### Archimedes Principle

$$F_{\text{buoy}} = \rho_{\text{fluid}} g V_{\text{submerged}}$$

= weight of volume of displaced fluid

$$V_{\text{submerged object}} = V_{\text{displaced fluid}}$$

#### Pressure

$$P = \frac{F}{A}$$

$$\text{units: Pa} = \frac{N}{m^2}$$

#### Static Pressure

- pressure of object submerged in fluid

$$P_{\text{fluid}} = \rho gh$$

h is height of fluid above object

#### Absolute Pressure

- adds atm pressure for open container

$$P_{\text{total}} = P_{\text{atm}} + P_{\text{fluid}} = P_{\text{atm}} + P_{\text{gauge}}$$

$$= P_{\text{atm}} + \rho gh$$

#### Gauge Pressure

- pressure due to liquid alone

$$P_{\text{gauge}} = P_{\text{total}} - P_{\text{atm}} = P_{\text{fluid}}$$

#### Weight

$$F_g = \rho g V = mg$$

#### Pascals Principle

$$P = \frac{F_1}{A_1} = \frac{F_2}{A_2} \text{ (equal pressure)}$$

$$A_1 d_1 = A_2 d_2 \text{ (same } \Delta V \text{)}$$

$$W = F_1 d_1 = F_2 d_2 \text{ (energy conserved)}$$

small force, small area, big distance

- large force, large area, small distance

#### Float or Sink?

$$\rho_{\text{fluid}} V_{\text{disp}} g = mg$$

$$\Rightarrow \rho_{\text{fluid}} V_{\text{disp}} = \rho_{\text{obj}} V_{\text{obj}}$$

$$\Rightarrow \frac{V_{\text{disp}}}{V_{\text{obj}}} = \frac{\rho_{\text{obj}}}{\rho_{\text{fluid}}}$$

$$P_o P_v = (S \times H \times R) \times R$$

$$OP = QR$$

Flow  $\rightarrow$  Flow

### 2.2 Flow

#### Viscose Force

coefficient of viscosity,

$$F_{\text{viscosity}} = \eta A \frac{V}{d} \rightarrow \text{depth}$$

$$\text{Unit of } \eta = \frac{F d}{A V} = Pa \cdot s$$

$$1 \text{ Poise} = \frac{1}{10} Pa \cdot s$$

#### Poiseuille Flow

$$\frac{V}{t} = \frac{\Delta P \pi R^4}{8 \eta L}$$

Resistance

$$R = \frac{8 \eta L}{\pi r^4}$$

$$R = \frac{\Delta P}{(V/t)} \Rightarrow \Delta P = QR$$

#### \* Continuity Eqn

$$A v = \text{constant}$$

$$\rho A v = \text{constant}$$

$$A_1 V_a = A_2 V_2$$

#### Turbulence

$$V_{\text{critical}} = \frac{R \eta}{2 \rho r}$$

#### Surface Tension

#### Bernoulli's Equation

$$P + \frac{1}{2} \rho V^2 + \rho gh = \text{constant}$$

$$P_1 + \rho gh_1 + \frac{\rho V_1^2}{2} = P_2 + \rho gh_2 + \frac{\rho V_2^2}{2}$$

#### Venturi Effect

## 2.3 Gas Phase

### Kelvin Scale

### STP

0°C or 273K, 1 atm

1 mole @STP = 22.4L

### 2.3.1 Ideal

moles  $\rightarrow n = \frac{N}{N_A}$   $\leftarrow$  # molecules  
 $\leftarrow$  Avogadro's #

\* Ideal Gas Law  
 $PV = nRT$   
 $PV = Nk_B T$

$k_B = \frac{n}{N} R$

### \* Avogadro's Principle

$$\frac{n}{V} = k$$

### \* Boyle's Law

$$PV = k$$

$$P_1 V_1 = P_2 V_2$$

### \* Charles Law

$$\frac{V}{T} = k$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

### G-L Law

$$\frac{P}{T} = k$$

### Combined Gas Law

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

### 2.3.2 Non-ideal

### Vanderwalls Eqn of State

$$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$$

$$P_1 = P_0 + a \left[\frac{n}{V}\right]^2$$

$$V_1 = V_c - nb$$

n is # of moles

a is a +/- constant

b is a constant

### 2.3.3 Partial Pressure

### Mole Fraction

$$X_A = \frac{n_A}{n_T} = \frac{\text{moles } A}{\text{mole total}}$$

### Dalton's Law of Partial Pressures

$$P_T = P_A + P_B + P_C + \dots$$

$$P_A = P_T X_A$$

### Henry's Law?

### 2.3.4 Kinetic MT

### Average Molecular Speed

$$\frac{1}{2} m v^2 = \frac{3}{2} k_B T$$

$$k_B = \frac{n}{N} R = \frac{1}{N_A} R$$

### Root Mean Square

$$U_{rms} = \sqrt{\frac{3RT}{M}}$$

$$PV = Nk_B T$$

Heat Capacity @ constant volume

$$C_v = \frac{5}{2} Nk_B$$

$$C_v = \frac{5}{2} nR$$

Heat capacity @ constant pressure

$$C_p = \frac{Q}{\Delta T} = \frac{\Delta U - W}{\Delta T} = \frac{\frac{3}{2} nR \Delta T + P \Delta V}{\Delta T}$$

$$C_p = \frac{5}{2} nR$$

### 3 Electromagnetism

### 3.2 Magnetism

#### 3.1 Electrostatics

##### Coulombs Law

$$F = k_e \frac{q_1 q_2}{r^2}$$

##### Electric Field

$$E = \frac{F_e}{q} = \frac{kQ}{r^2}$$

Q is source charge of E field

q is the charge feeling the E field

Units:  $\frac{N}{C}$  or  $\frac{V}{m}$

##### Electric Potential Energy

$$U = q\Delta V = qEd = k_e \frac{qQ}{r}$$

"work to move to point from  $\infty$ "

##### Electric Potential

$$V = \frac{U}{q}$$

Units: J/C

Potential Difference (Voltage)

$$\Delta V = \frac{W}{q} = \frac{\Delta Q}{C}$$

units: J/C

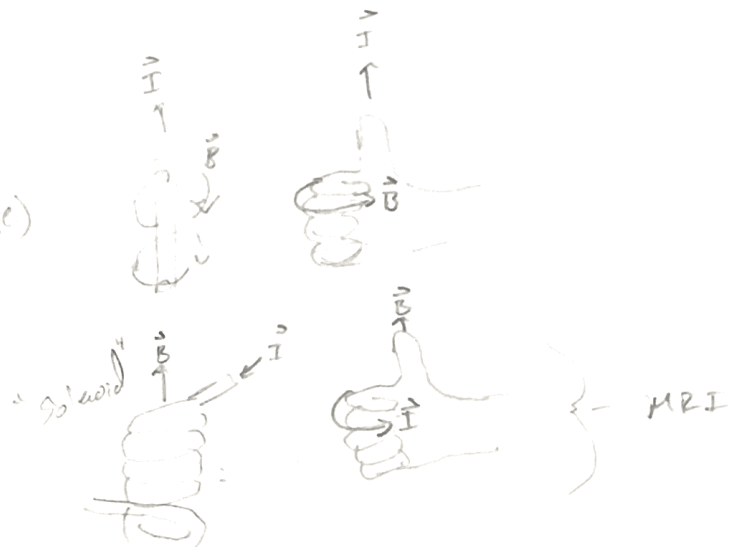
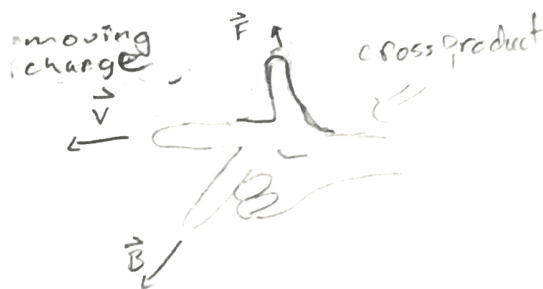
Definition of magnetic field B

Motion of charged particles in magnetic fields; Lorentz force

$$\text{Tesla} = \frac{N \cdot s}{C \cdot m}$$

$$N = C \cdot \frac{m}{s} \quad (\text{B units})$$

$$\vec{F} = Q \cdot (\vec{v} \times \vec{B}) = QvB \sin \theta$$



charge moving in circle

$$F = qvB = \frac{mv^2}{r}$$

current carry in wire

$$F = qvB \sin \theta = ILB \sin \theta$$

### 3.3 Circuits

#### \*Current

$$I = \frac{dq}{dt}$$

Units: Amps = C/s

#### Potential Difference (Voltage)

$$\Delta V = \frac{W}{q} = \frac{kQ}{r}$$

Units: J/c

Same as EMF in batteries

#### Kirchoff's Laws

???????? what do these mean

Conductivity: Metallic

Conductivity: Electrolytic

Meters

#### 3.3.1 Resistance

##### Resistivity

$$R = \frac{\rho L}{A}, \text{ where } \rho \text{ is some constant}$$

##### \* Ohms Law

$$V = IR$$

##### Serial Resistors

$$R_{equiv} = R_1 + R_2 + \dots$$

##### Parallel Resistors

$$\frac{1}{R_{equiv}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$

##### Power Dissipated by Resistors

$$P = IV = \frac{V^2}{R} = I^2 R$$

#### 3.3.2 Capacitance

##### Capacitance

$$C = \frac{Q}{V} \quad Q = CV$$

##### Parallel Plates

$$V = Ed$$

$$C = \frac{\epsilon_0 A}{d}$$

##### Energy Storage

$$U = \frac{1}{2} QV = \frac{1}{2} CV^2 = \frac{1}{2} \frac{Q^2}{C}$$

##### Parallel Capacitors

$$C_{eq} = C_1 + C_2 + \dots$$

##### Serial Capacitors

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$$

##### Dielectrics?

decreases  $\downarrow V$  w/out battery  
 $\uparrow Q$  w/ battery connected  
 $(V \text{ stays the same})$

$$C = k C_{orig} \quad \text{w/ dielectric}$$



"like electrolytic  
because cats are bad"

### 3.4 Electrochemistry

#### Galvanic vs Electrolytic

	Galvanic	Electrolytic
$\Delta G^\circ$	(-)	(+)
EMF	(+)	(-)
Sign of an	(-)	(+)
Sign of cat	(+)	(-)

For both types, "AnOx RedCat"

= Ox @ an, Red @ cat

$\Rightarrow e^-$  flow from an to cat

#### Standard Reduction Potential

$\uparrow E^\circ \Rightarrow \uparrow$  Probability its reduced

(see Gibbs Free Energy below)

#### Standard EMF (induced voltage)

$$E_{cell}^\circ = E_{red}^\circ + E_{cat}^\circ$$

measured under standard conditions

#### Gibbs Free Energy

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

$$\Delta G^\circ = -RT \ln K_{eq}$$

$$\Rightarrow E^\circ = \frac{RT}{nF} \ln K_{eq}$$

F = Faradays Constant  $\sim 10^5$

R = gas constant  $\sim 8$

n = moles of  $e^-$  transferred

RT/F has units of volts

#### Nernst Equation

$$E = E^\circ - \frac{RT}{nF} \ln Q$$

(comes from:  $\Delta G = \Delta G^\circ + RT \ln Q$ )

$\uparrow Q \Rightarrow \downarrow E$

#### Faradays Law of Electrolysis

$$It = nF$$

n = moles of  $e^-$

#### Oxidations Rules

- Elemental forms are always zero.
- Number given in table below are overridden when combined with an element of higher electronegativity

-don't confuse with formal charge

Element	ox #
G 1A	+1
G 2A	+2
H	+1 (w/ non-metal)
	-1 (w/ metal)
O	-1 (in peroxides $O_2^-$ )
	-2 (everything else)
G 7A	-1
Cl	-1 (except w/ O of F)
S	-2??

#### Common Oxidizing Agents

-oxidizing agents almost always contain oxygen

-reducing often contain metal ions of hydrides

Ox	Red
$O_2$	CO
$H_2O_2$	C
Halogens	B5H6
$H_2SO_4$	$Sn^{2+}$
$HNO_3$	Hydrazine
NaClO	Zn(Hg)
$KMnO_4$	Lindlars
$CrO_3$ , $Na_2Cr_2O_7$	$NaBH_4$
PCC	$LiAlH_4$
NAD <sup>+</sup> , FADH	NADH, FADH

Galvanic  
Cat = good  
electrolytic  
Cats = bad

## 4 Periodic Motion

### 4.1 Oscillatory Motion

#### Angular Frequency

$$\omega = \frac{\pi}{t}$$

$$\text{for SHM: } \omega = \sqrt{\frac{k}{m}}$$

units: radians/sec

#### Amplitude

-max displacement from equilibrium

$$A = \frac{x(t)}{\cos(\omega t)}$$

#### Period

$$T = \frac{2\pi}{\omega}$$

- the time it takes motion to repeat itself

#### Frequency

$$f = \frac{1}{T}$$

Unit: Hz = 1 oscillation/sec

#### Phase

$$x(t) = A \cos(\omega t + \phi)$$

$\phi$  = phase constant

$\phi > 0 \Rightarrow$  left shift

$\phi < 0 \Rightarrow$  right shift

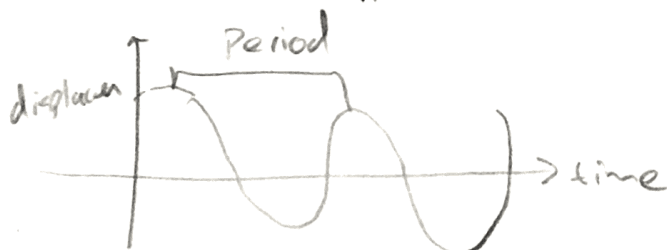
$\phi$  doesn't effect A or f

Strings:  $\lambda = \frac{2L}{n}$ ,  $n = 1, 2, 3$

↳ nodes @ end of string

open pipes:  $\lambda = \frac{2L}{n}$

closed pipes:  $\lambda = \frac{4L}{n}$



## 4.2 Wave Motion

### General definition of waves

a traveling disturbance that transports energy but not matter

### Longitudinal Wave

oscillation in same direction as propagation (e.g., sound)

### Transverse Wave

oscillation perpendicular direction of propagation (e.g., a stadium wave)

### Period

time over which wave pattern repeats

### Wavelength

distance over which pattern repeats

### Propagation Speed

$$v = \frac{\lambda}{T} = \lambda f$$

$$\uparrow f \Rightarrow \downarrow \lambda$$

$$f\lambda = \text{constant}$$

### 4.2.1 Sound

#### Intensity

$$dB = 10 \log_{10}\left(\frac{I}{I_0}\right)$$

$$I_0 = 10^{-12}$$

$$\frac{\text{Power}}{\text{Area}} = \frac{W}{m^2}$$

$$v = \sqrt{\frac{B}{\rho}}$$

compressibility

density

#### Doppler Effect\*

can actually apply to any wave

$$f' = f \frac{(v \pm v_D)}{(v \mp v_S)}$$

towards = +





## 5 Optics

### 5.1 Physical Optics

#### Properties of electromagnetic radiation:

Velocity equals constant  $c$ , in vacuo

Electromagnetic radiation consists of perpendicularly oscillating electric and magnetic fields; direction of propagation is perpendicular to both

**Polarization of light:** linear and circular

#### 5.1.1 Interf and Diffrac

##### Interference Maxima

$$d \sin \theta = m \lambda$$

$d$ =distance btwn slits

$$m=1,2,3,\dots$$

##### Diffraction Limit (Rayleigh Criterion)

$$\theta_d = \frac{1.22 \lambda}{D}$$

$D$ =diamter of circular apature

$\theta$ =angle of seperation

##### X-ray diffraction

$$2d \sin \theta = m \lambda$$

##### Diffraction Grating

$$\frac{\lambda}{\Delta \lambda} = m N$$

#### 5.1.2 EMR Spectrum

Classification of electromagnetic spectrum

Visual spectrum, color

##### Photon Energy

$$E = hf$$

## 5.2 Spectroscopy

### Infrared

Vibration	Peak (cm <sup>-1</sup> )	Shape
O-H	3100-3500	broad
N-H	3100-3500	sharp
C=O	1700-1750	sharp

alcohols

amines

aldehydes - COOH  
ketones

\*Peaks given in wave numbers

\*Fingerprint: region below 1400 → (mostly bending oscillations which require less energy ⇒ ↓ f)

$$\text{Wave\#} = \frac{1}{\lambda} \propto f = \frac{c}{\lambda} = \frac{1}{T}$$

$$\text{Abs} = 2 - \log(\% \text{ Transmittance})$$

$$\Rightarrow \downarrow \%T \Rightarrow \uparrow \text{Abs}$$

f ∝ bond strength

for stretching  
↑ f ∝ ↑ bond energy

### NMR Spectroscopy

Group	δ (ppm)
Alky	0.3-0.5
Alkynes	2-3
Alkenes	4.6-6.5
Aromatics	6-8.5
Aldehydes	9-10
COOH	10.5-12



ketones: 2-2.5

Hydroxyl: 1-5.5 (always singlet)

Beer Lambert Law

# peaks = n + 1, where n is the number of H on a adjacent carbon  
~~ber of non-identical protons less than~~  
~~bonds away~~

area under peak(s) ∝ # identical H<sup>+</sup>  
chemical shift ∝ ↓ f ∝ ↓ |E<sub>x</sub> - E<sub>g</sub>|

### UV-Vis

(HOMO-LUMO ΔE of e<sup>-</sup> excitation)

$$\downarrow |HOMO - LUMO| \Rightarrow \downarrow f_{\text{absorption}}$$

$$\uparrow \text{conjugation} \Rightarrow \downarrow f_{\text{absorption}}$$

can be used to characterize:

- (1) Transition metal ions
- (2) organic compounds w/ lots of conjugation
- (3) charge transfer complexes

$$E = h\nu \quad c = \lambda f$$

$$h = \text{Planck's constant} \quad f = \frac{c}{\lambda}$$

$$E = \frac{hc}{\lambda}$$

$$\text{So } \uparrow \lambda \Rightarrow \downarrow f \Rightarrow \downarrow E \Rightarrow \downarrow \text{HOMO-LUMO gap}$$

## 5.3 Geometrical Optics

applies when object size  $\gg \lambda$

### 5.3.1 Reflec and Refrac

#### Refractive Index

$$n = \frac{c}{v}$$

#### \* Snell's Law

$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{v_1}{v_2} = \frac{n_2}{n_1} = \frac{\lambda_1}{\lambda_2}$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$\downarrow \lambda \Rightarrow \uparrow n \Rightarrow \downarrow$   
wavelength that

### 5.3.2 Thin Lenses

#### \* Spherical Lense Eqn

$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i}$$

#### Power

$$P = \frac{1}{f}$$

units: diapters,  $D = m^{-1}$

#### Magnification

$$M = \frac{-i}{o}$$

#### Image hieght

$$\frac{o}{i} = \frac{h_o}{h_i}$$

#### Radius of Curvature

$$R = 2f$$

### 5.3.3 Spherical Mirrors

#### Eqn

$$\frac{1}{f} = \frac{1}{i} + \frac{1}{o} = \frac{2}{R}$$

$$PV = NkT$$

$$P = \frac{NkT}{V}$$

## 6 Thermodynamics

### PV Diagrams

$W$  = -area on PV graph

$$W = \int_{\text{path}} \mathbf{F} \cdot d\mathbf{s} = \int P dv$$

### 6.1 Heat Eqns

#### First Law of Thermodynamics

$$\Delta U = Q + W_{\text{on system}}$$

$Q = 0$	Adiabatic
$W = 0$	Isovolumetric/Isochoric
$\Delta U = 0$	Isothermal
$\Delta P = 0$	Isobaric

Heat of Fusion/Vaporization

$$Q = mL$$

#### Specific Heat

$$c = \frac{Q/\Delta T}{m}$$

$$c_{H_2O} \approx 4000 \frac{J}{kg \cdot C}$$

#### Heat Capacity

$$mc = \frac{Q}{\Delta T}$$

#### Heat of Absorption

$$Q = mc\Delta T$$

#### Heat of Transformation

$$Q = mL \quad \text{Heat of Fusion/Vaporization}$$

$$L = \Delta H_{\text{vap}}$$

#### Heat Transfer

Conduction = molec collisions

Convection = fluid motion

Radiation = electromag waves

#### Thermal Expansion

$$\Delta L_{\text{linear}} = \alpha L_0 \Delta T$$

$$\Delta A_{\text{area}} = ??$$

$$\Delta V_{\text{volume}} = \beta V_0 \Delta T$$

#### Entropy

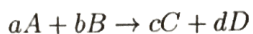
$$\Delta S = \frac{Q_{\text{rev}}}{T}$$

$Q_{\text{rev}}$  = heat lost in reverse rxn

$T$  = temp in kelvin

## 6.2 Chemical Equilibria

### General Rxn



### Equilibrium Constant

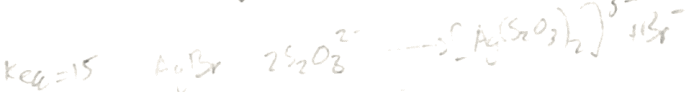
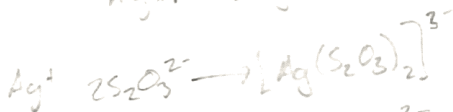
$$\text{rate}_{\text{forward}} = \text{rate}_{\text{reverse}}$$

$$K_c = K_{eq} = \frac{K_{\text{forw}}}{K_{\text{rev}}} = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

### Reaction Quotient

$$Q_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

when adding or combining eqns, equilibrium constants must be multiplied e.g.



$$K_{eq} = (K_{sp})(K_f)$$

$$\Delta G_{\text{rxn}} = \Delta G^\circ + RT \ln Q$$

$$\Delta G^\circ = -RT \ln K_{eq}$$

$$\Delta G = \Delta G^\circ + RT \ln Q$$

$$\Delta G^\circ = -RT \ln K_{eq} + RT \ln Q$$

$$\Delta G = RT \ln \frac{Q}{K_{eq}}$$

## 6.3 Isobaric Rxns

$$\Delta H = Q - p\Delta V + \Delta pV \Rightarrow \Delta H = Q$$

$$\Delta p = 0 \Rightarrow p\Delta V = \Delta pV$$

### Standard Conditions (°)

25°C or 298 K, 1 atm, 1 M concentra-

tion

### Physiological Conditions

....

### Heat of Reaction

$$\Delta H_{\text{rxn}}^\circ = \sum_i \Delta H_{f, \text{products}}^\circ$$

$$- \sum_i \Delta H_{f, \text{reactants}}^\circ$$

- same applies for entropy and all other state functions (e.g. pressure, density, temperature, volume, enthalpy, internal energy, free energy; see Hess's Law)

Enthalpy

### Bond Enthalpy

$$\Delta H_{\text{rxn}}^\circ = \sum_i \Delta H_{\text{broken}} - \sum_i \Delta H_{\text{formed}}$$

### Gibbs Free Energy

$$\Delta G = \Delta H - T\Delta S$$

$$\Delta G^\circ = -RT \ln(K_{eq})$$

$$\Delta G = \Delta G^\circ + RT \ln Q = RT \ln \frac{Q}{K_{eq}}$$

T is in Kelvin!

$$\Delta G = \Delta G^\circ + RT \ln Q$$

## 6.4 Isovolumetric

### Calorimetry

## 7 Kinetics

### General Rxn



### Definition of Rate

$$\text{rate} = \frac{\Delta[A]}{a} = -\frac{\Delta[B]}{b\Delta t} = \frac{\Delta[C]}{c\Delta t} = \frac{\Delta[D]}{d\Delta t}$$

for simplicity i will say rate = dP/dt,

where P=[Products]

$$\text{units: } \frac{\text{mol}}{\text{l}\cdot\text{s}} = \frac{\text{M}}{\text{s}}$$

### General Rate Law

$$\frac{dP}{dt} = k[A]^x[B]^y$$

k=rate constant of rxn

x and y must be determines experi-  
mentally for a given rxn at a given temp

example:

[A]	[B]	rate
1.0	1.0	2.0
1.0	2.0	8.1
2.0	2.0	15.9

$$\Rightarrow \text{rate} = k[A]^1[B]^2$$

$$(\Delta[\text{reactants}])^x = (\Delta\text{rate})$$

### Zero Order

$$\frac{dP}{dt} = k[A]^0[B]^0 = k$$

### First Order

$$\frac{dP}{dt} = k[A \text{ or } B]$$

### Second Order

$$\frac{dP}{dt} = k[A]^1[B]^1$$

$$\frac{dP}{dt} = k[A \text{ or } B]^2$$

### Broken Order

fractional exponents

### Mixed Order

rate constants vary over time

### Collision Theory

$$\text{rxn rate} = Z \times f$$

$$f = \frac{e^{-\frac{E_a}{RT}}}{e^{-\frac{E_a}{RT}}}$$

Z = total # collisions per time

f = fraction of effective collisions

(correct orientation + enough energy)

### Arrhenius Eqn

$$k = Ae^{-\frac{E_a}{RT}}$$

k = rate constant of rxn

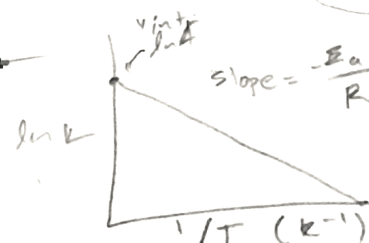
A = frequency of collisions (s<sup>-1</sup>)

E<sub>a</sub> = activation energy

R = ideal gas constant

T = temperature IN KELVIN

~~Mixed Order~~



↓ E<sub>a</sub> ⇒ ↑ e<sup>-E<sub>a</sub>/RT</sup> ⇒ ↑ f ⇒ ↑ effective collisions  
 ↓ ⇒ ↑ rxn rate

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{-E_a}{R} \left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$k_{cat} = \frac{\Delta\text{rate}}{\Delta t} = \frac{V_{max}}{[E_T]}$$

$$K_m \approx \text{binding strength}$$

14

M-M Eqn

$$V = k_2[E_T] \left( \frac{[S_T]}{K_m + [S_T]} \right)$$

## 8 Solution Chemistry 8.2 Colligative Properties

### 8.1 Definitions and Rules

#### Dilutions

$$M_i V_i = M_f V_f$$

#### Mole Fraction

$$X_A = \frac{\text{mole } A}{\text{total moles of all species}}$$

#### Molarity (M)

$$M = \frac{\text{moles solute}}{\text{liters solution}}$$

#### Molality (m)

$$m = \frac{\text{mole solute}}{\text{kg solvent}}$$

#### Normality

$$N = \frac{\# \text{ equivs of interest}}{\text{liters soln}}$$

? or is it "# g equivalent weights?"

"molarity of the 'stuff' of interest"

#### Osmolality

$$\text{Osmoles} = \frac{\# \text{ separate molecules}}{L_{\text{solution}}}$$

#### Solubility Rules

1. Water soluble IF cation = alkali metal (G1) or ammonium (NH<sub>4</sub><sup>+</sup>)

2. Water soluble IF anion = nitrate (NO<sub>3</sub><sup>-</sup>) or acetate (CH<sub>3</sub>COO<sup>-</sup>)

Refer to Kaplan text for additional rules to know...

#### Equivalentents

amnt of substance that will produce or react with 1 mole of H<sup>+</sup> or OH<sup>-</sup> ions

### Vapor Pressure Depression (Raoult's Law)

$$P_A = X_A P_A^\circ$$

### Boiling Point Elevation

$$\Delta T_b = i K_b m$$

i = # of particles into which compound dissociates

m = molality of soln

### Freezing Point Depression

$$\Delta T_f = i K_f m$$

"amount that normal freezing point is lowered"

### Osmotic Pressure

$$\Pi = i MRT$$

R = ideal gas constant

### Diffusion

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

r = diffusion rate

M = molar masses of gasses

### Henry's Law?

$$\frac{\text{solubility}}{\text{product constant}}$$

$$K_{sp} = [C]^c [D]^d$$

Molar Solubility  
Amnt of solid that dissolves in term of molarity (M)

Common Polyatomic Ions to know

Phosphate: PO<sub>4</sub><sup>3-</sup>

chromate: CrO<sub>4</sub><sup>2-</sup>

Oxalate: C<sub>2</sub>O<sub>4</sub><sup>2-</sup>

Thiocyanate: SCN<sup>-</sup>

Hydrogen phosphate: HPO<sub>4</sub><sup>2-</sup>

Dichromate: Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup>

Peroxide: O<sub>2</sub><sup>2-</sup>

Phosphite: S<sub>2</sub>O<sub>3</sub><sup>2-</sup>

General Soluble compounds = CASH-N-GIA  
Chlorate, Acetates, Sulfates, Halides (not Fluorides), Nitrates, G1 metals, + Ammonium  
! see # rules for chlorate  
HAPPy  
Hg<sup>2+</sup>, Ag<sup>+</sup>, Pb<sup>2+</sup>  
Exceptions for GII metals:  
HAPPy + CBS  
Ca<sup>2+</sup>, Ba<sup>2+</sup>, Sr<sup>2+</sup>

### 8.3 Acids and Bases

#### Estimation

$$\log(n \times 10^m) \approx m + 0.n$$

$$k_a = \frac{[X]^2}{[IC]-X} \approx x^2, \text{ when acid is weak}$$

#### pH and pOH

$$pH + pOH = 14$$

#### Acid Disassociation

$$k_a = \frac{[H^+][A^-]}{[HA]}$$

#### Base Disassociation

$$k_b = \frac{[OH^-][HA]}{[A^-]}$$

#### Water Autoionization

$$k_w = [H^+][OH^-]$$

$$= k_a k_b$$

$$= (10^{-7})(10^{-7}) = 10^{-14}$$

#### Henderson-Hasselbalch

$$pH = pK_a + \log \frac{[A^-]}{[HA]}$$

$$pOH = pK_b + \log \frac{[HA]}{[A^-]}$$

- HA=weak acid and HB=weak base

- can only be used in buffer region

#### Neutralization w/ reactants 1:1

$$M_a V_a = M_b V_b$$

#### Equivalence Point for acidic (negative?) AA

$$\frac{pK_{aR-group} + pK_{aCOOH}}{2} \approx \frac{pK_{aR-group} + 9}{2}$$

#### Equivalence Point for basic (positive?) AA

$$\frac{pK_{aR-group} + pK_{aNH2}}{2} \approx \frac{pK_{aR-group} + 2}{2}$$

#### pH approximation

$$\log(m \times 10^n) \approx n + \frac{m}{10}$$

$$\Rightarrow pH = -\log([H^+]) \approx -n - \frac{m}{10}$$



## 9 Atomic Physics

### Atomic Structure

$$E_{\text{electron}} = \frac{-R_H}{n^2}$$

$$E_{\text{photon}} = \frac{hc}{\lambda}$$

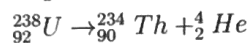
### Electronic Configuration

??? n+l rule

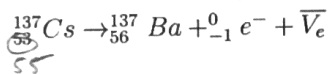
### Exponential Decay Formula

$$n = n_0 = e^{-\lambda t}$$

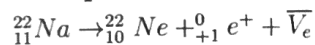
### Alpha Decay



### Beta-minus Decay



### Beta-plus Decay



## 9.1 Periodic Table

### Left to Right

↑  $Z_{\text{eff}}$

↓ *Atomic Radii*

↑ *IE & EA*

↓ *Ionic Radii* (except no  $\Delta$  for metalloids)

### Top to Bottom

slight ↓  $Z_{\text{eff}}$

↑ *Atomic Radii*

↑ *IE & EA*

↑ *Ionic Radii* (including metalloids)

## 10 Genetics

Recombination Frequency

Hardy Weinberg Equilibrium

Mendelian Inheritance

## 11 SI Units

### SI Prefixes

<i>Symbol</i>	<i>Prefix</i>	$10^x$
T	tera	12
k	kilo	3
–	–	0
c	centi	-2
m	milli	-3
$\mu$	micro	-6
n	nano	-9
p	pico	-12
f	femto	-15

## 12 Orgo Nomenclature

Group	Prefix	Suffix
COOH	carboxy-	-oic acid
Anhydrides	-alkanoyloxy	anhydride
	-carbonyl	
Esters	alkoxycarbonyl-	-oate
Amides	carbomoyl-	-amide
nitrile	cyano-	-nitrile
Aldehydes	oxo-	-al
Ketones	oxo- ket-	-one
Alcohols	hydroxy-	-ol
thiol	mercapto-	-thiol
amine	amino-	-amine
alkene	alkenyl	-ene
alkyne	alkynyl	-yne
alkane	alkyl	-ane
ether	alkoxy	-ane
alkyl halide	halo-	-ane
nitro	nitro	-ane

also for  
used for  
salts of carboxylic  
acids?

groups are in order of priority from  
top (highest) to bottom (lowest priority)