$R = 0.08206$ liter atm K^{-1} mole^{-1} = 8.314 J K^{-1} mole^{-1} $N_o = 6.02 \times 10^{23}$ mole^{-1}

$J = kg\ m^2\ s^{-2}$ $h = 6.6262 \times 10^{-34}$ J s $\hbar = \frac{h}{2\pi}$ $c = 3 \times 10^{8}\ m\ s^{-1}$ $m_e = 9.11 \times 10^{-31}$ kg

Michaelis-Menten

Know when it is applicable!

$$\upsilon_o = \frac{k_2[E]_o}{1+\frac{K_m}{[S]}} = \frac{V_{\max}}{1+\frac{K_m}{[S]}} \qquad K_m = \frac{k_{-1}+k_2}{k_1}$$

De Broglie wave-particle duality

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

Heisenberg Uncertainty Principle

$$\Delta p \Delta x \geq \frac{1}{2}\hbar$$

Time-independent Schrödinger Equation

$$\mathsf{H}\psi = E\psi$$

One-dimensional Hamiltonian Operator

$$\mathsf{H} = -\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + U(x)$$

Special cases:

Particle in a box U(x)=0 inside, ∞ outside

$$\psi_n = \sqrt{\frac{2}{a}}\sin\frac{n\pi x}{a} \qquad E_n = \frac{h^2 n^2}{8ma^2}$$

Harmonic oscillator $U(x) = \frac{1}{2}kx^2$

$$\psi_n = skip\ it \qquad E_v = \left(v + \frac{1}{2}\right)h\nu_o \qquad \nu_o = \frac{1}{2\pi}\sqrt{\frac{k}{\mu}}$$

μ is the reduced mass of oscillator

Hydrogen atom $U(r) = \frac{q_{electron}q_{proton}}{4\pi\varepsilon_o r}$

$$\psi_n = skip\ it \qquad E_n = \frac{-2\pi^2\mu e^4}{h^2 n^2}$$

Transition dipole moment

$$\mu_{0A} = \int \psi_0 \mu \psi_A d\upsilon \qquad \mu = e\sum_i r_i$$

Dipole strength

What's it good for?

$$D_{0A} = |\mu_{0A}|^2$$

Heisenberg Uncertainty II

$$\Delta E \Delta t \geq \frac{1}{2}\hbar$$

Beer-Lambert

$$A = \varepsilon c l = \log\frac{I_o}{I_t}$$

Fluorescence decay constant / life time

Know the difference!!

$$k_d = \frac{1}{\tau} \qquad k_f = \frac{1}{\tau_o} \qquad \phi_f = \frac{\tau}{\tau_o}$$

Fluorescence Energy Transfer

$$Efficiency = 1 - \frac{\tau_{D+A}}{\tau_D} = \frac{r_o^6}{r_o^6 + r^6}$$

Circular Dichroism

$$\Delta A = A_L - A_R$$

NMR

$$E = -\gamma\hbar B_o m_z \qquad F = m_z \times B_1$$

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J = kg m^2 s^{-2} h = 6.6262 x10^{-34} J s

Kinetic Theory

$$\langle U_{tr} \rangle = \frac{3}{2}kT \qquad \langle u^2 \rangle = \frac{3RT}{M} = \frac{3kT}{m}$$

Collision Frequency (per molecule)

$$z = 4\sqrt{\pi}\,\frac{N}{V}\sigma^2\left(\frac{RT}{M}\right)^{\frac{1}{2}}$$

Total Collision Frequency (per volume)

$$Z = \left(\frac{N}{V}\right)\frac{z}{2} = 2\sqrt{\pi}\left(\frac{N}{V}\right)^2\sigma^2\left(\frac{RT}{M}\right)^{\frac{1}{2}}$$

Mean free path **rms displacement**

$$l = \frac{1}{\sqrt{2}\pi\left(\frac{N}{V}\right)\sigma^2} \qquad \langle d^2 \rangle^{\frac{1}{2}} = \sqrt{N}\,l$$

Diffusion Fick's 1st and 2nd

$$J_x = -D\left(\frac{dc}{dx}\right)_t \qquad \left(\frac{dc}{dt}\right)_x = D\left(\frac{d^2c}{dx^2}\right)_t$$

$$\mathrm{D} = \frac{\mathrm{kT}}{f} \qquad f = 6\pi\eta\mathrm{r} \qquad \eta = viscosity$$

$$V_{sphere} = \frac{4}{3}\pi r^3 \qquad V_{displaced} = \bar{v}_2\rho$$

Sedimentation

$$s = \frac{m(1-\bar{v}_2\rho)}{f} \qquad M = \frac{RTs}{D(1-\bar{v}_2\rho)}$$

Equilibrium Centrifugation

$$M = \frac{2RT}{\omega^2(1-\bar{v}_2\rho)}\frac{d(\ln c)}{d(x^2)} \qquad \omega = 2\pi\upsilon$$

$$[\eta] = \upsilon(\bar{v}_2 + \delta_1 v_1^0)$$

Boltzmann Distribution

$$P_i = \frac{N_i}{N} = \frac{g_i e^{-\frac{E_i}{kT}}}{\sum_j^{all\ energies} g_j e^{-\frac{E_j}{kT}}}$$

Kinetics (but know how to derive simple ones)

$$\frac{dc}{dt} = k \qquad c_2 - c_1 = k(t_2 - t_1)$$

$$-\frac{dc}{dt} = kc \qquad \ln\frac{c_2}{c_1} = -k(t_2 - t_1)$$

$$-\frac{dc}{dt} = kc^2 \qquad \frac{1}{c_2} - \frac{1}{c_1} = k(t_2 - t_1)$$

$$-\frac{dc}{dt} = kc_A c_B \qquad \frac{1}{c_{A_1} - c_{B_1}}\ln\frac{c_{A_2}c_{B_1}}{c_{A_1}c_{B_2}} = k(t_2 - t_1)$$

Kinetics – Arrhenius

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

Kinetics – Eyring (Transition State Theory)

$$k = \frac{k_B T}{h}e^{-\frac{\Delta G^\ddagger}{RT}} = \frac{k_B T}{h}e^{\frac{\Delta S^\ddagger}{R}}e^{-\frac{\Delta H^\ddagger}{RT}}$$

R = 0.08206 liter atm K^{-1} $mole^{-1}$ = 8.314 J K^{-1} $mole^{-1}$ $N_o = 6.02 \times 10^{23}$ $mole^{-1}$

F = 96,485 coulombs (mol electrons)$^{-1}$ = 96,485 J eV^{-1}

General

$$E_2 - E_1 = q + w$$

$$H = E + PV = E + nRT$$

$$G = H - TS$$

$$dE = -PdV + TdS$$

$$dH = VdP + TdS$$

$$dG = VdP - SdT$$

$$C = \frac{\partial q}{\partial T} \qquad dS = \frac{dq_{rev}}{T} \qquad S = k\ln N$$

Ideal Gas

PV = nRT

$$\bar{C}_v = \frac{3}{2}R \qquad \bar{C}_P = \frac{5}{2}R \quad \text{(monoatomic)}$$

Phase Transition at Equilibrium

$$\Delta S = \frac{\Delta H}{T} \ \text{(why?)}$$

Osmotic / Vapor Pressure / etc

$$\Pi = \frac{nRT}{V} = cRT \qquad \ln a_A = \frac{-\Pi \bar{V}_A}{RT}$$

$$\ln a_A = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_{boil}} - \frac{1}{T_o}\right) = \frac{\Delta H_{fus}}{R}\left(\frac{1}{T_o} - \frac{1}{T_{freeze}}\right)$$

Work

$$w = -\int_{V_1}^{V_2} P_{ex}\,dV \ \text{(gases, } PdV \text{ work)}$$

$$w = -EIt \ \text{(Electrical)} \qquad w = F\,d \ \text{(linear)}$$

PV Work only

$$E_2 - E_1 = q_v = n\int_{T_1}^{T_2} \bar{C}_v\,dT$$

$$H_2 - H_1 = q_P = n\int_{T_1}^{T_2} \bar{C}_P\,dT$$

Gibbs Free Energy

$$\frac{\Delta G(T_2)}{T_2} - \frac{\Delta G(T_1)}{T_1} = -\int_{T_1}^{T_2} \frac{\Delta H(T)}{T^2}\,dT$$

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

$$\Delta G_{\text{xfer phase 1 to phase 2}} = n\left[RT\ln\frac{a_A^{phase2}}{a_A^{phase1}} + FZV\right]$$

van't Hoff

$$\left[\frac{d(\ln K)}{d(1/T)}\right]_P = -\frac{\Delta H^\circ}{R}$$

$$\ln\frac{K_2}{K_1} = -\frac{\Delta H^\circ}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

Ligand Binding

$$\frac{\nu}{[A]} = K(n-\nu) \qquad \frac{f}{(1-f)} = K[A]^n$$

Solid H_2O at 0°C	**Liquid H_2O**	**Gaseous H_2O at 100°C**
Density = 0.915 g cm-3 Vapor Pressure = 4.579 Torr Absolute Molar Entropy = 41.0 J K^{-1} mol^{-1} Heat of melting = 333.4 kJ kg^{-1} = 6.007 kJ mol^{-1} Spec heat capacity = 2.113 kJ K^{-1} kg^{-1} Molar heat capacity = 38.07 J K^{-1} mol^{-1}	Density = 0.99 g cm^{-3} Absolute Molar Entropy ≈70 J K^{-1} mol^{-1} Spec heat capacity = 4.18 kJ K^{-1} kg^{1} Molar heat capacity = 75.4 J K^{-1} mol^{-1}	Density = 5.88 x 10^{-4} g cm^{-3} Heat of condensation = -2257 kJ kg^{-1} = -40.66 kJ mol^{-1} Spec heat capacity = 1.874 kJ K^{-1} kg^{-1} Molar heat capacity = 33.76 J K^{-1} mol^{-1}