Quantum Mechanics

Quantisation	$L = I\omega = m_e v_n r_n = n\hbar$
Balmer Series	$\nu = \frac{m_e e^4}{8\varepsilon_0^2 h^3}(\frac{1}{2^2} - \frac{1}{m^2})$
Heisenberg	$\Delta x \Delta p \geq \frac{\hbar}{2}$
Dispersion	$\omega = \frac{\hbar k^2}{2m}$, $\omega = ck$
Schrödinger	$-\frac{\hbar^2}{2m}\frac{\partial^2 \psi}{\partial x^2} + V\psi = E\psi$ $-\frac{\hbar^2}{2m}\frac{\partial^2 \psi(x,t)}{\partial x^2} + V(x,t)\psi(x,t) = i\hbar\frac{\partial \psi(x,t)}{\partial t}$
Tunnelling	Alpha decay (atom potential) Ammonia molecule (nitrogen atom penetrates plane of H) Tunnel diode (variable height voltage potential barrier) STM (tunnelling = distance)
Quantum Rotator	$J = j(j+1)\hbar^2$
Quantum Oscillator	$E_n = (n + \frac{1}{2})\hbar\omega$

Statistical Mechanics

Perfect Gas	$pV = NkT$, $p = nkT$
First Law	$dU = dQ + dW$
Constant V	$dU = dQ = (\frac{\partial Q}{\partial T})_V dT = C_V dT$
Constant P	$(\frac{\partial Q}{\partial T})_p = C_P = C_V + R$
Adiabatic	$dQ = 0$, $pV^{\frac{C_P}{C_V}} = C$
Boltzmann	$p(E)dE = Ag(E)\exp(-\frac{E}{kT})dE$
Kinetic Theory	Perfect gas (equation of state, no heat in a Joule expansion) Gases consist of small, hard, independent particles Velocity randomly distributed Temperature related to KE
1D Maxwell	$f_1(v_x)dv_x = \sqrt{\frac{m}{2\pi kT}} e^{-mv_x^2/2kT} dv_x$
3D Maxwell	$f(v)dv = (\frac{m}{2\pi kT})^{\frac{3}{2}} 4\pi v^2 e^{-mv^2/2kT} dv$ $\frac{1}{2}m\overline{v^2} = \frac{3}{2}kT$, $\bar{v} = \sqrt{\frac{8kT}{\pi m}}$
Pressure	$p = nm\overline{v_x^2} = \frac{1}{3}nm\overline{v^2}$
Partial Pressures	$\frac{\sigma_{M2}}{\sigma_{M1}} = (\frac{M_1}{M_2})^{1/2}$, $p = p_1 + p_2$
Flux Density	$J = \frac{\Delta N}{\Delta t} = n\int_0^\infty v_x f_1(v_x) dv_x = \frac{1}{4}n\bar{v}$
Mean Free Path	$\lambda = \frac{1}{\pi a^2 n}$, $p(x) = \exp(-\frac{x}{\lambda})$, $R = \lambda\sqrt{N}$
Equipartition	$E = \frac{f}{2}kT$, $(\frac{\partial Q}{\partial T})_v = C_v = \frac{f}{2}R$
Second Law	No process exists whose sole effect is the transfer of heat from a cooler to a hotter body $\ln g = N\ln(Q/N)$, Q quanta, N boxes, g = permutations Net energy exchange leads to an increase in the most probable number of ways in which the system can arrange itself
Entropy	$S = k\ln g$, $\frac{1}{T} = \frac{\partial S}{\partial E}$

Quantum Statistics

Raleigh-Jeans Body Radiation	$dN = \frac{8\pi v^2}{c^3}dv$, $u(v)dv = \overline{E}dN = \frac{8\pi v^2 kT}{c^3}dv$
Planck Black Body Radiation	$u(v)dv = \frac{8\pi hv^3}{c^3}\frac{1}{\exp(hv/kT)-1}dv$ $u = \int_0^\infty u(v)dv = (\frac{8\pi^5 k^4}{15c^3h^3})T^4$
Schottky Anomaly	A maximum in the heat capacity, where you run out of energy levels in which to store heat
Excitation Condition	$T >> \frac{E}{k}$
Einstein Solid Heat Capacity	$C = 3R(\frac{hv_E}{kT})^2 \frac{\exp(hv_E/kT)}{(\exp(hv_E/kT)-1)^2}$
Debye Solid Heat Capacity	$C \propto VT^3$ at low T by finding photon energies that will fit into a solid