1.	Thermodynamics Chapters 19, 20, 21 (HRW)	Conduction	PMT1.1, PF1
		Radiation	H1-19.62
		P-V Diagrams	MT1.3, PMT1.2
		1st Law of TD	MT1.2, PF2
		Engines	PMT1.3
		Entropy	H3-21.3
2.	Relativity Chapter 2	F-L Contraction	MT2.1
		Time Dilation	PMT2.1
		Addition of Velocities	PF3
		Rel. Doppler	H5-2.51
		Rel. Kinematics	MT2.2
3.	**Photons** **Chapters 1, 3, 5**	**X-rays**	**H6-3.43**
		Photoelectric Effect	**MT2.3, PF4**
		Compton Scattering	**PMT2.2**
		De Broglie	**PMT2.4**
		Bragg scattering	**H8-5.3**
4.	Quantum Theory Chapters 5, 6	Planck	H6-3.33
		Heisenberg	MT3.1
		Schrödinger	H9-6.5
		Square Well	MT3.2, PMT3.1, PF5
		Simple Harm. Osc.	H9-6.37
		Pot. barriers, Tunneling	H9-6.39
5.	**Atomic Theory** **Chapters 4, 7, 8**	**Bohr**	**H7-4.23**
		Rutherford	**MT2.4, PMT2.3**
		Atomic Q numbers	**PMT3.2**
		Zeeman effect	**MT3.3**
		J = L+S, spect. Notation	**MT3.4**
		Anom. Zeeman effect	**PMT3.3**
6.	Nuclear Properties Chapter 12	Nuclear composition	H12-12.4
		Binding energy	H12-12.17
		Sizes and shapes	H12-12.8
		Radioactive decay	H12-12.50
		Half lives	PF7
7.	**Nuclear Reactions** **Chapter 13**	**Reactions**	**PMT3.4**
		Q-values	**PF6**
		Fission	**H13-13.30**
		Fusion	
8.	**Elementary Particles** **Chapter 14**	**Fundamental forces**	
		Particle classification	**PF8**
		Quark structure	

Useful Constants:

1 calorie = 4.186 J

Latent heat of vaporization of water = 539 cal/g = 2256 kJ/kg

Latent heat of fusion of water = 79.5 cal/g = 333 kJ/kg

Specific heat of water = 1 cal/g = 4.19 kJ/kg

1 atmosphere = 1.01E5 Pa

Universal Gas Constant, R = 8.31 J/mol.K

Boltzmann's constant, k = 1.38E-23 J/K

Stefan-Boltzmann constant, σ = 5.67E-8 W/m^2K^4

Avogadro's number, N_A = 6.02E23 mol^{-1}

Coulomb's constant, $(1/4\pi\varepsilon_0)$ = 8.99E9 $N.m^2/C^2$

Speed of light, c = 3.00E8 m/s

Charge of an electron, -e = -1.6E-19 C

Mass of the electron, m_e = 9.1E-31 kg = 511 keV/c^2 = 5.49E-4 u

Mass of the proton, m_p = 1.67E-27 kg = 938.3 MeV/c^2 = 1.00728 u

Mass of the neutron, m_n = 1.675E-27 kg = 939.6 MeV/c^2 = 1.00866 u

Mass of the α particle, m_α = 3727.4 MeV/c^2 = 4.00151 u

Planck's constant, h = 6.63E-34 J.s = 4.14E-15 eV.s

Planck's reduced constant, $\hbar = h/2\pi$ = 1.05E-34 J.s = 6.58E-16 eV.s

Compton Wavelength of the electron, $\lambda_c = h/m_e c$ = 2.4263E-12 m

The Bohr Magneton, μ_B = 5.79E-5 eV/T

Atomic mass unit, u = 1.66E-27 kg = 931.5 MeV/c^2

1 Curie = 3.7E10 Bq

Useful Formulae

$\Delta Q = mc\Delta T$ where m = mass, c = specific heat.

Heat conduction, $I = \Delta T/R$ in Watts where R = thermal resistance = $\Delta x/kA$ and Δx = thickness, A = area and k = thermal conductivity of the material.

$P_{RAD} = \sigma\varepsilon A T^4$ where ε = emissivity and A = area.

1st Law of Thermodynamics: $\Delta Q = \Delta W + \Delta U$

Ideal gas law: $PV = nRT$ Work done, $\Delta W = \int P dV$ $v_{rms} = \sqrt{(3RT/M)}$

Molar specific heats: $C_V = \Delta U/n\Delta T$ $C_P = \Delta Q/n\Delta T$ $C_P = C_V + R$ $\gamma = C_P/C_V$

Adiabatic ==> $\Delta Q = 0$, and PV^γ = constant. Entropy change: $\Delta S = \int dQ/T$

Carnot engine efficiency, $\varepsilon_C = 1 - Q_C/Q_H = 1 - T_C/T_H$

Pot. energy lost by a charge q in a potential difference of V is $U = qV$

Wave relation: $v = \nu\lambda$ where v = velocity, ν = frequency, λ = wavelength.

$\beta = v/c$ $\gamma = 1/\sqrt{(1-\beta^2)}$ Length Contr.: $L' = L/\gamma$ Time Dilation, $T' = \gamma T$

Addition of Velocities: $v' = (v + u)/(1 + vu/c^2)$

Rel. Doppler Effect: $$\nu' = \frac{\sqrt{(1-\beta)}}{\sqrt{(1+\beta)}}\nu$$

Momentum – Energy relations: $E^2 = p^2c^2 + m^2c^4$

$E = \gamma mc^2$ $p = \gamma mv$ $K = E - mc^2$

Planck's Relation: $E = h\nu$ Einstein's Photoelectric Law: $h\nu = K + \phi$

Compton Effect: $\Delta\lambda = \lambda' - \lambda = (1 - \cos\theta)h/m_ec$

Elec. potential at a distance R from a charge Q: $V = (1/4\pi\varepsilon_0)Q/R$

Bohr Quantization Relation: $L = mvr = n\hbar$

Atomic Radii: $r_n = n^2 a_0/Z$ where a_0 = 5.29E-11 m

Atomic Energies: $E_n = -Z^2E_0/n^2$ where E_0 = 13.6 eV

Impact parameter: $$b = \frac{Z_1 Z_2 e^2}{8\pi\varepsilon_0 K}\cot(\theta/2)$$ $n = \rho N_A/A$

Fraction of α's scattered through θ or greater: $f = \pi b^2 nt$

Rutherford Scattering: $$N(\theta) = \frac{N_i\, n\, t\, e^4 Z_1^2 Z_2^2}{16\,(4\pi\varepsilon_0)^2\, r^2 K^2 \sin^4(\theta/2)}$$

de Broglie wavelength: $\lambda = h/p$ **Bragg's Law:** $n\lambda = 2d\sin\theta$

Heisenberg Uncertainty Principle: $\Delta p_x \Delta x \geq \hbar/2$ $\Delta E \Delta t \geq \hbar/2$

Probability = ψ^2 Normalization condition: $\int \psi^2 dx = 1$

Infinite Square Well Pot. in 1-dim: $\psi = \sqrt{2/L}\,\sin(n\pi x/L)$ $E_n = n^2\pi^2\hbar^2/2mL^2$

Infinite Square Well Pot. in 3-dims: $$E = \frac{\pi^2\hbar^2}{2m}\left(n_1^2/L_1^2 + n_2^2/L_2^2 + n_3^2/L_3^2\right)$$

Simple Harmonic Oscillator: $V = \frac{1}{2}kx^2$ $\omega^2 = k/m$ $E_n = (n+\frac{1}{2})\hbar\omega$

Q number relations: $n > 0$ $l < n$ $L = \sqrt{l(l+1)}\,\hbar$ $|m_l| \leq l$ $L_z = m_l\hbar$

$s = \pm\frac{1}{2}$ $S = \sqrt{s(s+1)}\,\hbar$ $J = L + S$ $j = l \pm s$

	S	P	D	F	G
L =	0	1	2	3	4

Spectroscopic Notation: $n^{2s+1}L_j$

Zeeman Effect: $V_B = -\mu.B = \mu_B B m_l$ or $2\mu_B B m_s$

Anomalous Zeeman Effect: $V_B = \mu_B B g m_j$

where g = Landé g-factor $$= 1 + \frac{J(J+1)+S(S+1)-L(L+1)}{2J(J+1)}$$

Radioactive decay law: $N = N_0 e^{-\lambda t}$ with $t_{1/2} = 0.693/\lambda$

Activity: $R = \lambda N$ 1 Becquerel (Bq) = 1 decay/s

Q-value: $Q = (M_x + M_X - M_y - M_Y)c^2$