

Physics Formula Sheet

402-0023-01L Physics

2023/ 2024

Constants

Constant	Symbol	Value
Speed of light	c	3.00×10^8 m/s
Gravitational constant	G	6.674×10^{-11} N(m/kg) ²
Planck's constant	h	6.626×10^{-34} J.s
Mass of the electron	m_e	9.10939×10^{-31} kg
Mass of the proton	m_p	1.67262×10^{-27} kg
Charge of the electron	$-e$	-1.60218×10^{-19} C
Permittivity of free space	ϵ_0	8.85419×10^{-12} C ² /J m
Boltzmann constant	k_B	1.38066×10^{-23} J/ K
Avogadro's constant	N_A	6.022×10^{23} 1/mol

Classical Physics

Title	Equation
Bragg's Reflection	$n\lambda = 2d \sin(\theta)$
Diffraction (Single Slit)	$\lambda = d \sin(\theta)$
Young's Double Slit	$\frac{\Delta x}{L} = \frac{\lambda}{d} \approx \sin \theta$
Heat Transfer (Fourier's Law)	$\dot{Q} = mC_v \Delta T$
Continuity Equation	$\nabla \cdot \mathbf{J} = -\frac{dq}{dt}$
Force of Gravity	$F = G \frac{m_1 m_2}{r^2}$
Coulomb Force	$F = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}$
Special Relativity (Time Dilation)	$E^2 = (pc)^2 + (m_0 c^2)^2$

Nuclear and magnetic physics

Magnetic Field	$E_B = -\mu B,$ $\mu = \frac{e}{2m} \hbar$ $F_z = -\frac{\partial E}{\partial B} = \mu \frac{\partial B}{\partial z}$
Rigid rotator	$E_{rot} = \frac{L^2}{2I}$ $I = \frac{m_1 r_1^2 + m_2 r_2^2}{m_1 + m_2} R^2$
Radioactive decay	$N(t) = N(0) \exp^{-\lambda t} = N(0) (\frac{1}{2})^{t/\tau_{1/2}}$ $\tau_{1/2} = \ln(2)/\lambda$

Thermodynamics

0th law: If two objects are in thermal equilibrium with a third object, then all three objects are in thermal equilibrium with each other.

1st law: For any process concerning a given system, the change in internal energy ΔU of that system is equal to the sum of the heat Q transferred to that system and the work W performed on that system, or:

2nd law: Carnot: Wherever there exists a difference in temperature, motive power can be produced.

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$$\text{Transmission through a barrier : } T = \frac{4E(V_0 - E)}{4E(V_0 - E) + V_0^2 \sinh^2[\sqrt{2m(V_0 - E)} \frac{L}{\hbar}]}$$

$$T \approx \frac{16E(V_0 - E)}{V_0^4} e^{-2\rho_2 l}, \text{ with } \rho_2 = \sqrt{\frac{2m(V_0 - E)}{\hbar^2}}, \rho_2 \cdot l \gg 1$$

$$\text{De Broglie wavelength : } \lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$$

$$\text{Photoelectric effect : } h\nu - \phi_0 = \frac{1}{2}mv^2 = eV$$

$$\text{Bohr-Sommerfeldt condition : } \oint_C \mathbf{p} \cdot d\mathbf{s} = nh, \quad 2\pi r = nh(\text{circular orbit})$$

$$\text{Probability current : } j = \frac{\hbar}{2mi} (\psi^* \frac{\partial \psi}{\partial x} - \psi \frac{\partial \psi^*}{\partial x})$$

$$\text{Compton scattering : } \lambda_2 - \lambda_1 = \frac{h}{m_0 c} (1 - \cos \theta)$$

$$h\nu_1 + m_0 c^2 = h\nu_2 + \sqrt{m_0^2 c^4 + p_e^2 c^2}$$

Mathematical equations

Trigonometric functions:

$$\int \sin^n ax dx = -\frac{1}{a} \cos ax {}_2F_1 \left[\frac{1}{2}, \frac{1-n}{2}, \frac{3}{2}, \cos^2 ax \right]$$

$$\int \sin^2 ax dx = \frac{x}{2} - \frac{1}{4a} \sin 2ax + C \quad (1)$$

$$\int x \sin^2 ax dx = \frac{x^2}{4} - \frac{x}{4a} \sin 2ax - \frac{1}{8a^2} \cos 2ax + C \quad (2)$$

$$\int x^2 \sin^2 ax dx = \frac{x^3}{6} - \left(\frac{x^2}{4a} - \frac{1}{8a^3} \right) \sin 2ax - \frac{x}{4a^2} \cos 2ax + C \quad (3)$$

$$\int \tan ax dx = -\frac{1}{a} \ln |\cos ax| + C = \frac{1}{a} \ln |\sec ax| + C \quad (4)$$

$$\int \frac{\cos ax}{x} dx = \ln |ax| + \sum_{k=1}^{\infty} (-)^k \frac{(ax)^{2k}}{2k(2k)!} + C \quad (5)$$

$$\int \cos^2 ax dx = \frac{x}{2} + \frac{1}{4a} \sin 2ax + C \quad (6)$$

$$\int \sin^3 ax dx = \frac{\cos 3ax}{12a} - \frac{3 \cos ax}{4a} + C \quad (7)$$

$$\int \tan^2 x dx = \tan x - x + C \quad (8)$$

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Kelvin: It is impossible for a self acting machine to convey heat from a colder body to a hotter.
Clausius: Heat cannot flow from a colder to hotter body without another process occurring, connected therewith, simultaneously.
 $T = (\frac{dU}{ds})_{V, N}$

Energy per mode: $\langle E_{\text{mode}} \rangle = \frac{3}{2} k_B T$

$$Q = C \Delta T \quad Q = \int_{T_1}^{T_2} C(T) dT$$

$$L = \frac{Q_{\text{latent}}}{m}$$

$$\gamma = \frac{C_p}{C_v} \quad dS = \frac{\delta Q_{\text{rev}}}{T}$$

Electrostatics and dynamics

$$\vec{F} = \sum_{i=1}^N \frac{q_i q_j (\vec{r} - \vec{r}_j)}{4\pi\epsilon_0 |\vec{r} - \vec{r}_j|^3}, \text{ Torque: } \vec{\tau} = \vec{p} \times \vec{E}$$

Energy of a dipole: $U(\theta) = -\vec{p} \cdot \vec{E}$

Gauss' law: $\phi = \oint_{\mathcal{V}} \mathbf{E} \cdot d\mathbf{A}$

Potential: $\Delta V \equiv \frac{\Delta U}{q} = - \int_C \vec{E} \cdot d\vec{l}$ Energy of a capacitor: $U = \frac{Q^2}{2C}$

Current: $I = \dot{Q}$

Potential: $V_b - V_a = - \int_a^b \vec{E} \cdot d\vec{l}$

Kirchhoff's rules: 1: $\sum_{j, \text{loop}} \Delta V_j$

2: $\sum_j I_{j, \text{into node}} = 0$

Magnetic force: $\vec{F} = q\vec{v} \times \vec{B}$

Black body:

$$D(k) dk = \frac{\partial N(k)}{\partial k} \frac{dk}{V} = \frac{k^2}{\pi^2} dk$$

$$D(\omega) d\omega = \frac{\omega^2}{\pi^2 c^3} d\omega$$

$$u(\omega) d\omega = \frac{\omega^2}{\pi^2 c^3} k_B T d\omega \text{ classical limit}$$

$$u(\omega) d\omega = \frac{\hbar \omega^3}{\pi^2 c^3} \frac{1}{\exp(\frac{\hbar \omega}{k_B T}) - 1} d\omega$$

$$I(\omega) = cu(\omega) d\omega$$

Quantum Mechanics

$$\text{Time-dependent Schrodinger's Equation : } i\hbar \frac{\partial}{\partial t} \Psi(\vec{r}, t) = \left[-\frac{\hbar^2}{2m} \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} \right) + V(x) \right] \Psi$$

$$\text{Energy of a photon : } E = hf$$

$$\text{Time-independent Schrodinger's Equation : } E\phi = \hat{H}\phi = \left(-\frac{\hbar^2}{2m} \nabla^2 + V(x) \right) \cdot \phi$$

$$\text{Energy of a photon : } E = hf$$

$$\text{Infinite potential well : } E_n = \frac{\hbar^2}{2m} k_n^2 = \frac{\hbar^2 \pi^2 n^2}{2mL^2} = n^2 E_0, \quad \psi_n(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right), \quad E_0 = \frac{\hbar^2 \pi^2}{2mL^2}$$

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$$\int \sin ax \cos ax dx = -\frac{\cos^2 ax}{2a} + C \quad (9)$$

$$\int x \cos ax dx = \frac{\cos ax}{a^2} + \frac{x \sin ax}{a} + C \quad (10)$$

$$\int \cos ax dx = \frac{1}{a} \sin ax + C \quad (11)$$

$$\int x \sin ax dx = \frac{\sin ax}{a^2} - \frac{x \cos ax}{a} + C \quad (12)$$

$$\int (\sin ax)(\cos^n ax) dx = -\frac{1}{a(n+1)} \cos^{n+1} ax + C \quad (13)$$

Exponential functions:

$$\int_{-\infty}^{\infty} e^{-ax^2} dx = \sqrt{\frac{\pi}{a}} \quad (a > 0) \quad (14)$$

$$\int_{-\infty}^{\infty} x e^{-ax^2 + bx} dx = \frac{\sqrt{\pi b}}{2a^{3/2}} e^{\frac{b^2}{4a}} \quad (\Re(a) > 0) \quad (15)$$

$$\int_{-\infty}^{\infty} x^n e^{-ax} dx = \begin{cases} \frac{\Gamma(n+1)}{a^{n+1}} & (n > -1, a > 0) \\ \frac{n!}{a^{n+1}} & (n = 0, 1, 2, \dots, a > 0) \end{cases} \quad (16)$$

$$\int_{-\infty}^{\infty} x^2 e^{-ax^2} dx = \frac{1}{2} \sqrt{\frac{\pi}{a^3}} \quad (a > 0) \quad (17)$$

$$\int x e^{cx} dx = \left(\frac{x}{c} - \frac{1}{c^2} \right) e^{cx} \quad (18)$$

$$\int x^2 e^{cx} dx = \left(\frac{x^2}{c} - \frac{2x}{c^2} + \frac{2}{c^3} \right) e^{cx} \quad (19)$$

$$\int x^4 e^{-ax^2} dx = \sqrt{\frac{\pi}{a}} \frac{3}{4a^2} \quad (20)$$

Spherical coordinates

$$\begin{aligned} x &= r \sin \theta \cos \phi \\ y &= r \sin \theta \sin \phi \\ z &= r \cos \theta \end{aligned}$$

Volume fraction:

$$dV = r^2 \sin \theta dr d\theta d\phi$$

Solid angle:

$$d\Omega = \frac{dS_r}{r^2} = \sin \theta d\theta d\phi$$

Surface element:

$$dS_r = r^2 \sin \theta d\theta d\phi$$

$$\nabla f = \frac{\partial f}{\partial r} \hat{r} + \frac{1}{r} \frac{\partial f}{\partial \theta} \hat{\theta} + \frac{1}{r \sin \theta} \frac{\partial f}{\partial \phi} \hat{\phi} \quad (21)$$

$$\text{div } \mathbf{F} = \nabla \cdot \mathbf{F} = \frac{1}{r^2} \frac{\partial}{\partial r} (r^2 F_r) + \frac{1}{r \sin \theta} \frac{\partial}{\partial \theta} (\sin \theta F_\theta) + \frac{1}{r \sin \theta} \frac{\partial F_\phi}{\partial \phi} \quad (22)$$

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$$\begin{aligned}\nabla \times \mathbf{F} &= \frac{1}{r \sin \theta} \left(\frac{\partial}{\partial \theta} (A_\phi \sin \theta) - \frac{\partial A_\theta}{\partial \phi} \right) \vec{r} \\ &\quad + \frac{1}{r} \left(\frac{\partial A_r}{\sin \theta} \frac{\partial}{\partial \phi} - \frac{\partial}{\partial r} (r A_\phi) \right) \vec{\theta} \\ &\quad + \frac{1}{r} \left(\frac{\partial}{\partial r} (r A_\theta) - \frac{\partial A_r}{\partial \phi} \right) \vec{\phi}\end{aligned}\quad (23)$$

$$\begin{aligned}\nabla^2 f &= \frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial f}{\partial r} \right) + \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial \theta} \left(\sin \theta \frac{\partial f}{\partial \theta} \right) + \frac{1}{r^2 \sin^2 \theta} \frac{\partial^2 f}{\partial \phi^2} = \\ &\quad \left(\frac{\partial^2}{\partial r^2} + \frac{2}{r} \frac{\partial}{\partial r} \right) f + \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial \theta} \left(\sin \theta \frac{\partial f}{\partial \theta} \right) + \frac{1}{r^2 \sin^2 \theta} \frac{\partial^2 f}{\partial \phi^2}\end{aligned}\quad (24)$$

Harmonic oscillator:

First four harmonic oscillator wavefunction	Hermite polynomials	E _n
$\psi_0(\xi) = \left(\frac{m\omega}{\pi\hbar}\right)^{\frac{1}{4}} e^{-\frac{1}{2}\xi^2}$	1	$\frac{1}{2}\hbar\omega$
$\psi_1(\xi) = \left(\frac{m\omega}{\pi\hbar}\right)^{\frac{1}{4}} \sqrt{2}\xi e^{-\frac{1}{2}\xi^2}$	2y	$\frac{3}{2}\hbar\omega$
$\psi_2(\xi) = \left(\frac{m\omega}{\pi\hbar}\right)^{\frac{1}{4}} \frac{1}{\sqrt{2}} (2\xi^2 - 1) e^{-\frac{1}{2}\xi^2}$	4y ² - 2	$\frac{5}{2}\hbar\omega$
$\psi_3(\xi) = \left(\frac{m\omega}{\pi\hbar}\right)^{\frac{1}{4}} \frac{1}{\sqrt{3}} (2\xi^3 - 3\xi) e^{-\frac{1}{2}\xi^2}$	8y ³ - 12y	$\frac{7}{2}\hbar\omega$
Harmonic oscillator	$\psi_n(x) = \frac{1}{\sqrt{2^n n!}} \left(\frac{m\omega}{\pi\hbar}\right)^{\frac{1}{4}} (a^\dagger)^n e^{-\frac{1}{2} \frac{m\omega}{\hbar} x^2} \psi_0(x)$	
Raising operator	$a^\dagger = \frac{1}{\sqrt{2\hbar m\omega}} (m\omega x - ip)$	
Lowering operator	$a = \frac{1}{\sqrt{2\hbar m\omega}} (m\omega x + ip)$	
$a^\dagger n\rangle = \sqrt{n+1} n+1\rangle$	$a n\rangle = \sqrt{n} n-1\rangle$	
Number operator	$\hat{N} = a^\dagger a, \hat{N} n\rangle = n n\rangle$	
Commutation relation	$[a, a^\dagger] = aa^\dagger - a^\dagger a = 1$	
Hamiltonian	$\hat{H} = \hbar\omega \left(\hat{N} + \frac{1}{2} \right)$	

Inner product and expectation

Expectation value (discrete)

$$\langle f_i \rangle = \sum_i P_i f_i$$

Expectation value (continuous)

$$\langle f(x) \rangle = \int_{-\infty}^{\infty} f(x) P(x) dx$$

$$\langle \hat{O} \rangle = \int \psi^*(\mathbf{r}) \hat{O} \psi(\mathbf{r}) d^3r$$

Inner product

$$\langle \psi | \phi \rangle = \int \psi^*(x) \phi(x) dx$$

Variance

$$\sigma_f^2 = \langle f^2 \rangle - \langle f \rangle^2$$

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$$L^2 = -\hbar^2 \left(\frac{1}{\sin \theta} \frac{\partial}{\partial \theta} \left(\sin \theta \frac{\partial}{\partial \theta} \right) + \frac{1}{\sin^2 \theta} \frac{\partial^2}{\partial \phi^2} \right)$$

Hund’s rule

- 1: All other thing being equal, the state with the highest total spin (S), will have the lowest.
- 2: For a given spin, the state the highest total orbital angular momentum (L), consistent with overall anti-symmetrization, will have the lowest energy.
- 3: If a subshell (n, l) is no more than half filled, then the lowest energy level has $J = |L - S|$: if it is more than half filled, then $J = L + S$ has the lowest energy.

Spin

Two particle spin states

$$\begin{aligned}|0, 0\rangle &= \frac{1}{\sqrt{2}} (|\uparrow\downarrow\rangle - |\downarrow\uparrow\rangle) \quad s = 0 \text{ singlet} \\ |1, 0\rangle &= \frac{1}{\sqrt{2}} (|\uparrow\downarrow\rangle + |\downarrow\uparrow\rangle), \quad s = 1 \text{ triplet} \\ |1, -1\rangle &= |\downarrow\downarrow\rangle\end{aligned}$$

$$S_x = \frac{\hbar}{2} \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \quad S_y = \frac{\hbar}{2} \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \quad S_z = \frac{\hbar}{2} \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \quad S^2 = \frac{3}{4}\hbar^2 \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \quad S_+ = \hbar \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix} \quad S_- = \hbar \begin{pmatrix} 0 & 0 \\ 1 & 0 \end{pmatrix}$$

Two particle Hamiltonian:

$$\hat{H} = -\frac{\hbar^2}{2m_1} \nabla_1^2 - \frac{\hbar^2}{2m_2} \nabla_2^2 + V(\mathbf{r}_1, \mathbf{r}_2)$$

Hamiltonian with an atom with atomic number Z:

$$\hat{H} = -\frac{\hbar^2}{2m_e} \nabla^2 - \frac{Ze^2}{4\pi\epsilon_0 r}$$

Commutation relations

$$\begin{aligned}[A, B] &= AB - BA \\ [AB, C] &= A[B, C] - [A, C]B \\ [x, p_x] &= i\hbar \\ [y, p_y] &= i\hbar \\ [x, y] &= [x, p_y] = [y, p_x] = 0\end{aligned}$$

Hydrogen atom

Fine structure constant:

$$\alpha = \frac{e^2}{4\pi\epsilon_0\hbar c} \approx \frac{1}{137}$$

Bohr radius:

$$a_0 = \frac{\hbar}{m_e c \alpha} \approx 0.529 \times 10^{-10} \text{m}$$

Bohr energy:

$$E_n = -\frac{2\pi^2 k^2 e^4 m_e}{\hbar^2 n^2}$$

Ground state energy:

$$E_1 = -13.6 \text{eV}$$

Wave function:

$$\psi_{nlm}(r, \theta, \phi) = R_{nl}(r) Y_{lm}(\theta, \phi)$$

Rydberg formula:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

Rydberg constant:

$$R_H \approx 1.097 \times 10^7 \text{m}^{-1}$$

Radial wavefunctions:

$$R_{nl}(r) = N_{nl} r^l e^{-r/a_0} L_{n-l-1}^{2l+1}(\rho)$$

Legendre polynomials

Angular momentum

$$L_+ = L_x + iL_y$$

$$L_- = L_x - iL_y$$

$$L^2 = L_x^2 + \frac{1}{2}(L_+ L_- + L_- L_+)$$

$$[L_x, L_y] = i\hbar L_z$$

$$[L^2, L_i] = 0 \quad \text{where } i = x, y, \text{ or } z$$

$$L_x = -i\hbar \left(\sin \phi \frac{\partial}{\partial \theta} + \cot \theta \cos \phi \frac{\partial}{\partial \phi} \right), \quad L_y = i\hbar \left(\cos \phi \frac{\partial}{\partial \theta} - \cot \theta \sin \phi \frac{\partial}{\partial \phi} \right), \quad L_z = -i\hbar \frac{\partial}{\partial \phi}$$

$$L_+ = \hbar e^{i\phi} \left(\frac{\partial}{\partial \theta} + i \cot \theta \frac{\partial}{\partial \phi} \right), \quad L_- = \hbar e^{-i\phi} \left(-\frac{\partial}{\partial \theta} + i \cot \theta \frac{\partial}{\partial \phi} \right)$$

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Clebsch-Gordan coefficients

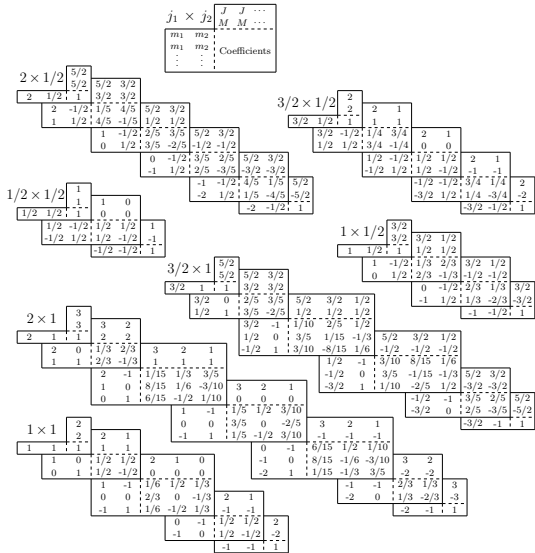


Figure 1: Clebsch-Gordan coefficients. A square root is understood on each coefficient, that is, $-1/3$ means $-\sqrt{1/3}$.

Condensed Matter

Free electron gas:

$$\psi_{n_x, n_y, n_z}(\mathbf{r}) = \sqrt{\frac{8}{V}} \sin\left(\frac{n_x \pi x}{L_x}\right) \sin\left(\frac{n_y \pi y}{L_y}\right) \sin\left(\frac{n_z \pi z}{L_z}\right), \quad E(\mathbf{k}) = \frac{\hbar^2 k^2}{2m}$$

Fermi energy of a metal:

$$E_F = \frac{\hbar^2 k_F^2}{2m}, \quad \rho \equiv \frac{N_q}{V}, \quad N_q = \text{number of electrons in volume } V, \quad n_e = n_i \exp\left(\frac{E_F - E_i}{k_B T}\right)$$

Density of states:

$$3D: g(E) = \frac{V m}{2\pi^2 \hbar^3} \sqrt{2mE}, \quad 2D: g(E) = \frac{m}{\pi \hbar^2}$$

Distribution functions:

$$\begin{array}{ccc} \text{Maxwell-Boltzmann} & \text{Fermi-Dirac} & \text{Bose-Einstein} \\ f(E) = e^{-\frac{E}{k_B T}} & f(E) = \frac{1}{e^{\frac{E}{k_B T}} + 1} & f(E) = \frac{1}{e^{\frac{E}{k_B T}} - 1} \end{array}$$

First order perturbation theory:

$$\Delta E_n^{(1)} = \langle \psi_n^0 | \hat{H}' | \psi_n^0 \rangle, \psi_n^{(1)} = \sum_{m \neq n} \frac{\langle \psi_m^0 | \hat{H}' | \psi_n^0 \rangle}{E_n^{(0)} - E_m^{(0)}} \psi_m^{(0)}$$

1 IA																18 VIIIA						
1	H Hydrogen																2 He Helium					
2	Li Lithium	Be Beryllium															3 B Boron	4 C Carbon	5 N Nitrogen	6 O Oxygen	7 F Fluorine	8 Ne Neon
3	Na Sodium	Mg Magnesium	3 IIIA	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13 IIIA Al Aluminum	14 IVA Si Silicon	15 VA P Phosphorus	16 VIA S Sulfur	17 VIIA Cl Chlorine	18 VIIIA Ar Argon				
4	K Potassium	Ca Calcium	Sc Scandium	Ti Titanium	V Vanadium	Cr Chromium	Mn Manganese	Fe Iron	Co Cobalt	Ni Nickel	Cu Copper	Zn Zinc	Ga Gallium	Ge Germanium	As Arsenic	Se Selenium	Br Bromine	Kr Krypton				
5	Rb Rubidium	Sr Strontium	Y Yttrium	Zr Zirconium	Nb Niobium	Mo Molybdenum	Tc Technetium	Ru Ruthenium	Rh Rhodium	Pd Palladium	Ag Silver	Cd Cadmium	In Indium	Sn Tin	Sb Antimony	Te Tellurium	I Iodine	Xe Xenon				
6	Cs Cesium	Ba Barium	La-Lu Lanthanum-Lutetium	Hf Hafnium	Ta Tantalum	W Tungsten	Re Rhenium	Os Osmium	Ir Iridium	Pt Platinum	Au Gold	Hg Mercury	Tl Thallium	Pb Lead	Bi Bismuth	Po Polonium	At Astatine	Rn Radon				
7	Fr Francium	Ra Radium	Ac-Lr Actinium-Lutetium	Rf Rutherfordium	Db Dubnium	Sg Seaborgium	Bh Bohrium	Hs Hassium	Mt Meitnerium	Ds Darmstadtium	Rg Roentgenium	Uub Ununbium	Uut Ununtrium	Uuq Ununquadium	Uup Ununpentium	Uuh Ununhexium	Uus Ununseptium	Uuo Ununoctium				
<div><div>Alkali Metals</div><div>Alkaline Earth Metals</div><div>Transition Metals</div><div>Inner Transition Metals</div><div>Nonmetals</div><div>Metals</div><div>Halogens</div><div>Noble Gases</div><div>Lanthanides</div><div>Actinides</div><div>Radioactive Elements</div></div>																						
<div><div>Symbol</div><div>Atomic Number</div><div>Atomic Weight</div><div>Element Name</div><div>Element Category</div></div>																						
<div><div>Ac</div><div>Th</div><div>Pa</div><div>U</div><div>Np</div><div>Pu</div><div>Am</div><div>Cm</div><div>Bk</div><div>Cf</div><div>Es</div><div>Fm</div><div>Md</div><div>No</div><div>Lr</div></div>																						