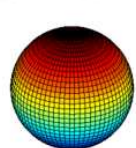


# Harmônicos Esféricos

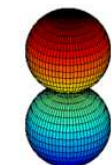
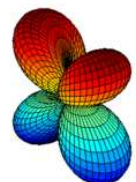
TABLE 3.7  
Some Spherical Harmonics

| Symbol       | Polar   | Cartesian                       | Normalization Constant        |
|--------------|---|---------------------------------|-------------------------------|
| $Y_{00}$     | 1   | 1                               | $\frac{1}{2}(1/\pi)^{1/2}$    |
| $Y_{10}$     | $\cos \theta$                                       | $z/r$                           | $\frac{1}{2}(3/\pi)^{1/2}$    |
| $Y_{1\pm 1}$ | $\mp(\sin \theta)e^{\pm i\phi}$                     | $\mp(x \pm iy)/r$               | $\frac{1}{2}(3/2\pi)^{1/2}$   |
| $Y_{20}$     | $(3 \cos^2 \theta - 1)$                             | $(3z^2 - r^2)/r^2$              | $\frac{1}{4}(5/\pi)^{1/2}$    |
| $Y_{2\pm 1}$ | $\mp(\sin \theta)(\cos \theta)e^{\pm i\phi}$        | $\mp z(x \pm iy)/r^2$           | $\frac{1}{2}(15/2\pi)^{1/2}$  |
| $Y_{2\pm 2}$ | $(\sin^2 \theta)e^{\pm 2i\phi}$                     | $(x \pm iy)^2/r^2$              | $\frac{1}{4}(15/2\pi)^{1/2}$  |
| $Y_{30}$     | $(5 \cos^3 \theta - 3 \cos \theta)$                 | $z(5z^2 - 3r^2)/r^3$            | $\frac{1}{4}(7/\pi)^{1/2}$    |
| $Y_{3\pm 1}$ | $\mp \sin \theta(5 \cos^2 \theta - 1)e^{\pm i\phi}$ | $\mp(x \pm iy)(5z^2 - r^2)/r^3$ | $\frac{1}{8}(21/\pi)^{1/2}$   |
| $Y_{3\pm 2}$ | $(\sin^2 \theta)(\cos \theta)e^{\pm 2i\phi}$        | $z(x \pm iy)^2/r^3$             | $\frac{1}{4}(105/2\pi)^{1/2}$ |
| $Y_{3\pm 3}$ | $\mp(\sin^3 \theta)e^{\pm 3i\phi}$                  | $\mp(x \pm iy)^3/r^3$           | $\frac{1}{8}(35/\pi)^{1/2}$   |

Douglas, Bodie E. and Hollingsworth, Charles A. *Symmetry in Bonding and Spectra - An Introduction* (Orlando, Florida: Academic Press, Inc., 1985) p. 88.



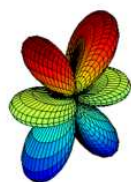
$${}^2Y_2^0 = \cos \theta \sin^2 \theta$$



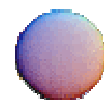
$$Y_3^0 = 5 \cos^3 \theta - 3 \cos \theta$$



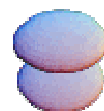
$${}^2Y_3^2 = (5 \cos^2 \theta - 1) \sin \theta \cos \theta$$



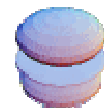
$|Y_0^0(\theta, \phi)|^2$



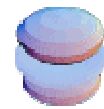
$|Y_1^0(\theta, \phi)|^2$



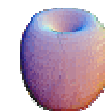
$|Y_2^0(\theta, \phi)|^2$



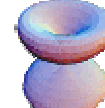
$|Y_3^0(\theta, \phi)|^2$



$|Y_1^1(\theta, \phi)|^2$



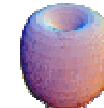
$|Y_2^1(\theta, \phi)|^2$



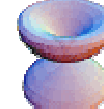
$|Y_3^1(\theta, \phi)|^2$



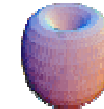
$|Y_2^2(\theta, \phi)|^2$



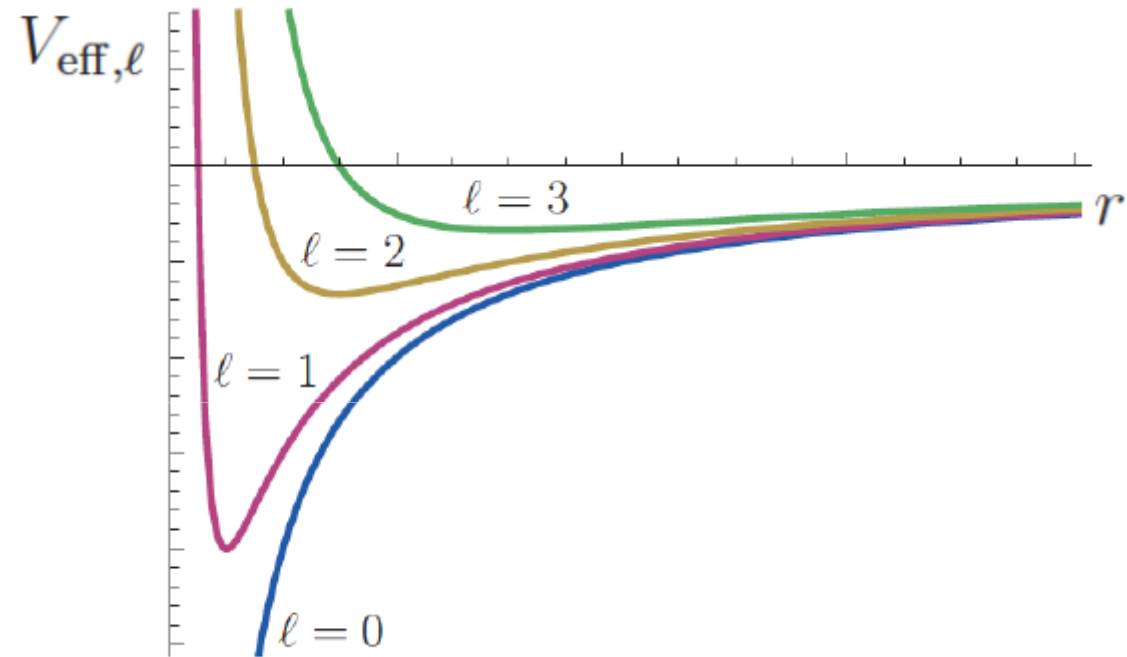
$|Y_3^2(\theta, \phi)|^2$



$|Y_3^3(\theta, \phi)|^2$



# Átomo de H: Potencial Efetivo



$$V_{\text{eff}}(r) = -\frac{e^2}{4\pi\epsilon_0 r} + \frac{\hbar^2 l(l+1)}{2\mu r^2}$$

# Funções de onda radiais - átomo H

|                           |                               |
|---------------------------|-------------------------------|
| $L_0^0 = 1$               | $L_0^2 = 2$                   |
| $L_1^0 = -x + 1$          | $L_1^2 = -6x + 18$            |
| $L_2^0 = x^2 - 4x + 2$    | $L_2^2 = 12x^2 - 96x + 144$   |
| $L_0^1 = 1$               | $L_0^3 = 6$                   |
| $L_1^1 = -2x + 4$         | $L_1^3 = -24x + 96$           |
| $L_2^1 = 3x^2 - 18x + 18$ | $L_2^3 = 60x^2 - 600x + 1200$ |

Alguns Polinômios associados de Laguerre

$$R_{nl}(r) = L_{n-l-1}^{2l+1}(2\lambda_n r)(\lambda_n r)^{l+1} \frac{e^{-\lambda_n r}}{r}$$

$$\lambda_n \cdot n = (a_B)^{-1}$$

$$l = 0, 1, 2, \dots, n - 1$$

$$R_{n0}(r) \propto e^{-\lambda_n r} \rightarrow R_{n0}(r = 0) = \text{const}$$

|  |
|--|
| $R_{10} = 2a^{-3/2} \exp(-r/a)$  |
| $R_{20} = \frac{1}{\sqrt{2}} a^{-3/2} \left(1 - \frac{1}{2} \frac{r}{a}\right) \exp(-r/2a)$  |
| $R_{21} = \frac{1}{\sqrt{24}} a^{-3/2} \frac{r}{a} \exp(-r/2a)$  |
| $R_{30} = \frac{2}{\sqrt{27}} a^{-3/2} \left(1 - \frac{2}{3} \frac{r}{a} + \frac{2}{27} \left(\frac{r}{a}\right)^2\right) \exp(-r/3a)$                                   |
| $R_{31} = \frac{8}{27\sqrt{6}} a^{-3/2} \left(1 - \frac{1}{6} \frac{r}{a}\right) \left(\frac{r}{a}\right) \exp(-r/3a)$   |
| $R_{32} = \frac{4}{81\sqrt{30}} a^{-3/2} \left(\frac{r}{a}\right)^2 \exp(-r/3a)$   |
| $R_{40} = \frac{1}{4} a^{-3/2} \left(1 - \frac{3}{4} \frac{r}{a} + \frac{1}{8} \left(\frac{r}{a}\right)^2 - \frac{1}{192} \left(\frac{r}{a}\right)^3\right) \exp(-r/4a)$ |
| $R_{41} = \frac{\sqrt{5}}{16\sqrt{3}} a^{-3/2} \left(1 - \frac{1}{4} \frac{r}{a} + \frac{1}{80} \left(\frac{r}{a}\right)^2\right) \frac{r}{a} \exp(-r/4a)$               |
| $R_{42} = \frac{1}{64\sqrt{5}} a^{-3/2} \left(1 - \frac{1}{12} \frac{r}{a}\right) \left(\frac{r}{a}\right)^2 \exp(-r/4a)$  |
| $R_{43} = \frac{1}{768\sqrt{35}} a^{-3/2} \left(\frac{r}{a}\right)^3 \exp(-r/4a)$  |

# Átomos H: Funções de onda radiais

$$R_{10} = 2a^{-3/2} \exp(-r/a)$$

$$R_{20} = \frac{1}{\sqrt{2}} a^{-3/2} \left(1 - \frac{1}{2} \frac{r}{a}\right) \exp(-r/2a)$$

$$R_{21} = \frac{1}{\sqrt{24}} a^{-3/2} \frac{r}{a} \exp(-r/2a)$$

$$R_{30} = \frac{2}{\sqrt{27}} a^{-3/2} \left(1 - \frac{2}{3} \frac{r}{a} + \frac{2}{27} \left(\frac{r}{a}\right)^2\right) \exp(-r/3a)$$

$$R_{31} = \frac{8}{27\sqrt{6}} a^{-3/2} \left(1 - \frac{1}{6} \frac{r}{a}\right) \left(\frac{r}{a}\right) \exp(-r/3a)$$

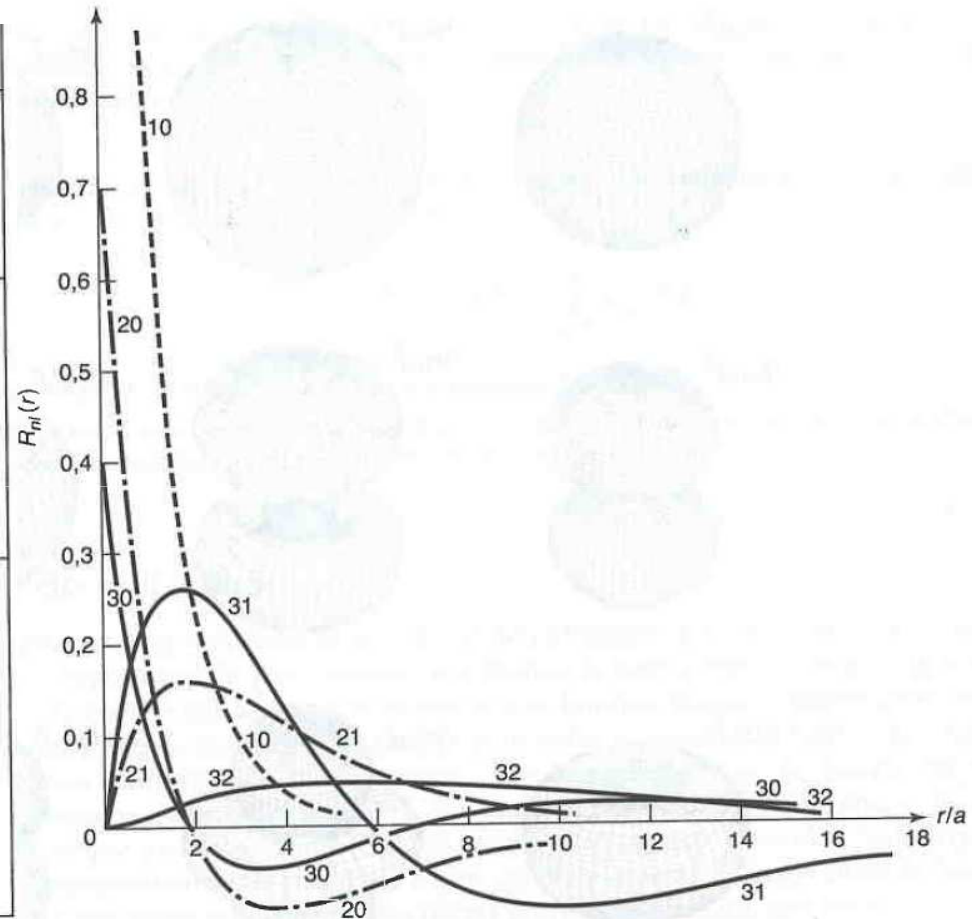
$$R_{32} = \frac{4}{81\sqrt{30}} a^{-3/2} \left(\frac{r}{a}\right)^2 \exp(-r/3a)$$

$$R_{40} = \frac{1}{4} a^{-3/2} \left(1 - \frac{3}{4} \frac{r}{a} + \frac{1}{8} \left(\frac{r}{a}\right)^2 - \frac{1}{192} \left(\frac{r}{a}\right)^3\right) \exp(-r/4a)$$

$$R_{41} = \frac{\sqrt{5}}{16\sqrt{3}} a^{-3/2} \left(1 - \frac{1}{4} \frac{r}{a} + \frac{1}{80} \left(\frac{r}{a}\right)^2\right) \frac{r}{a} \exp(-r/4a)$$

$$R_{42} = \frac{1}{64\sqrt{5}} a^{-3/2} \left(1 - \frac{1}{12} \frac{r}{a}\right) \left(\frac{r}{a}\right)^2 \exp(-r/4a)$$

$$R_{43} = \frac{1}{768\sqrt{35}} a^{-3/2} \left(\frac{r}{a}\right)^3 \exp(-r/4a)$$



# Funções de onda do átomo de H

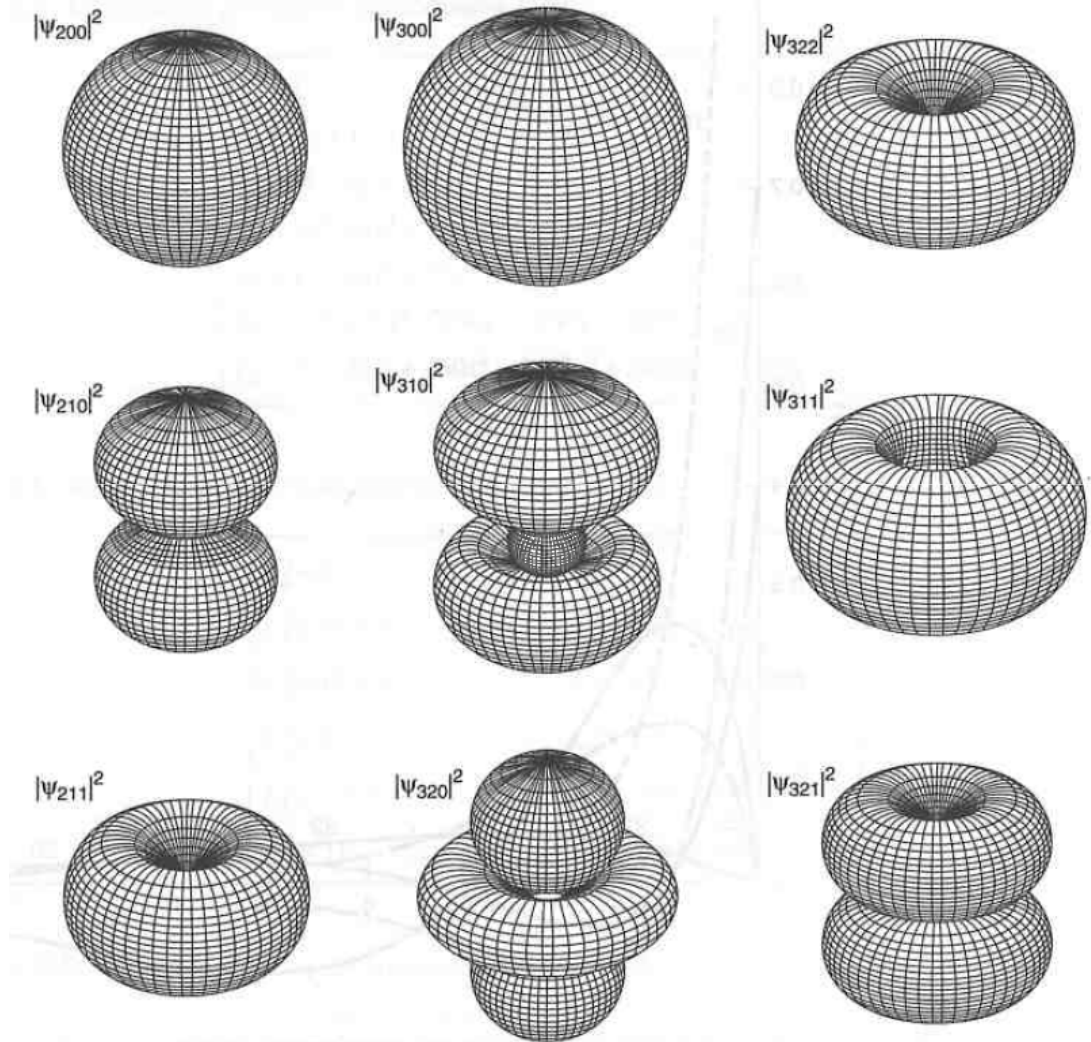
$$|\Psi_{nlm}(r)|^2$$

$$E_n = \frac{E_1}{n^2} = \frac{13.6 \text{ eV}}{n^2}$$

$$n = 0, 1, 2, \dots$$

$$l = 0, 1, 2, \dots, n - 1$$

$$-l \leq m \leq l$$



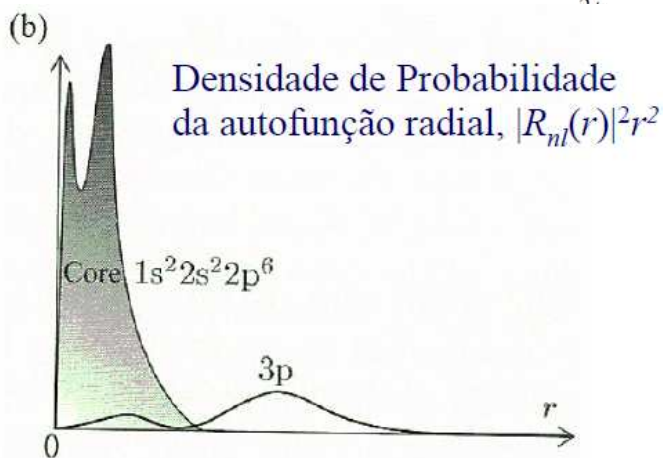
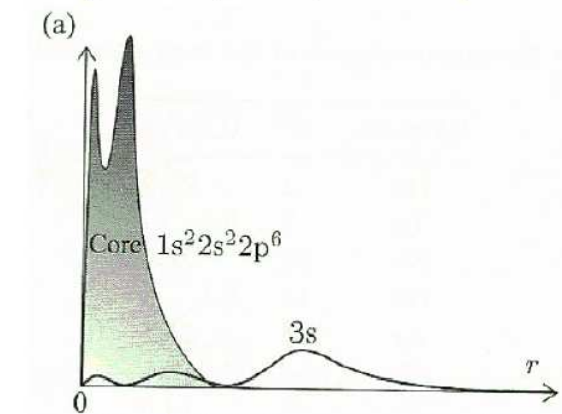


# Blindagem e “camadas fechadas”

$$Z_{\text{eff}} = Z - \sigma$$

**Exemplo:** Na ( $Z = 11$ ):  $1s^2 2s^2 2p^6 3s^1 \equiv [\text{Ne}] 3s^1$

**Table 7.1** Values of  $Z_{\text{eff}} = Z - \sigma$  for neutral ground-state atoms



|    |         |         |         |         |         |         |         |         |
|----|---------|---------|---------|---------|---------|---------|---------|---------|
|    | H       |         |         |         |         |         |         | He      |
| 1s | 1       |         |         |         |         |         |         | 1.6875  |
|    | Li      | Be      | B       | C       | N       | O       | F       | Ne      |
| 1s | 2.6906  | 3.6848  | 4.6795  | 5.6727  | 6.6651  | 7.6579  | 8.6501  | 9.6421  |
| 2s | 1.2792  | 1.9120  | 2.5762  | 3.2166  | 3.8474  | 4.4916  | 5.1276  | 5.7584  |
| 2p |         |         | 2.4214  | 3.1358  | 3.8340  | 4.4532  | 5.1000  | 5.7584  |
|    | Na      | Mg      | Al      | Si      | P       | S       | Cl      | Ar      |
| 3s | 10.6259 | 11.6089 | 12.5910 | 13.5754 | 14.5578 | 15.5409 | 16.5239 | 17.5075 |
| 3p | 6.5714  | 7.3920  | 8.2136  | 9.0200  | 9.8250  | 10.6288 | 11.4304 | 12.2304 |
| 3d | 6.8018  | 7.8258  | 8.9634  | 9.9450  | 10.9612 | 11.9770 | 12.9932 | 14.0082 |
| 4s | 2.5074  | 3.3075  | 4.1172  | 4.9032  | 5.6418  | 6.3669  | 7.0683  | 7.7568  |
| 4p |         |         | 4.0656  | 4.2852  | 4.8864  | 5.4819  | 6.1161  | 6.7641  |

from E. Clementi and D.L. Raimondi, Atomic screening constants from SCF functions. IBM Res. Note NJ-27 (1963).

# Tabela Periódica

| GROUP IA                         |  |  |  |  |  |  |  |  |  | GROUP IIA                        |  |  |  |  |  |  |  |  |  | GROUP IIIA                      |  |  |  |  |  |  |  |  |  | GROUP IVA                           |  |  |  |  |  |  |  |  |  | GROUP VA                     |  |  |  |  |  |  |  |  |  | GROUP VIA                      |  |  |  |  |  |  |  |  |  | GROUP VIIA                        |  |  |  |  |  |  |  |  |  | GROUP VIIIA                     |  |  |  |  |  |  |  |  |  | GROUP IIIB                          |  |  |  |  |  |  |  |  |  | GROUP IVB                      |  |  |  |  |  |  |  |  |  | GROUP VB                           |  |  |  |  |  |  |  |  |  | GROUP VIB                           |  |  |  |  |  |  |  |  |  | GROUP VIIB                           |  |  |  |  |  |  |  |  |  | GROUP VIII                         |  |  |  |  |  |  |  |  |  |                                       |  |  |  |  |  |  |  |  |  |                                |  |  |  |  |  |  |  |  |  |                                    |  |  |  |  |  |  |  |  |  |                                 |  |  |  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |  |  |  |                                  |  |  |  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                    |  |  |  |  |  |  |  |  |  |                                    |  |  |  |  |  |  |  |  |  |                                      |  |  |  |  |  |  |  |  |  |                                |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                 |  |  |  |  |  |  |  |  |  |                                  |  |  |  |  |  |  |  |  |  |                               |  |  |  |  |  |  |  |  |  |                                  |  |  |  |  |  |  |  |  |  |                                    |  |  |  |  |  |  |  |  |  |                                    |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                  |  |  |  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |  |  |  |                                    |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                    |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |  |  |  |                                  |  |  |  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |  |  |  |                                    |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                  |  |  |  |  |  |  |  |  |  |                               |  |  |  |  |  |  |  |  |  |                                    |  |  |  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                 |  |  |  |  |  |  |  |  |  |                                    |  |  |  |  |  |  |  |  |  |                                  |  |  |  |  |  |  |  |  |  |                                       |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                      |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                    |  |  |  |  |  |  |  |  |  |                                 |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                    |  |  |  |  |  |  |  |  |  |                                  |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                    |  |  |  |  |  |  |  |  |  |                               |  |  |  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |  |  |  |                                |  |  |  |  |  |  |  |  |  |
|----------------------------------|--|--|--|--|--|--|--|--|--|----------------------------------|--|--|--|--|--|--|--|--|--|---------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|--|--|--|------------------------------|--|--|--|--|--|--|--|--|--|--------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|---------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|--|--|--|--------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|--|--|--|--------------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|---------------------------------------|--|--|--|--|--|--|--|--|--|--------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|---------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|--|--|--|----------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|--------------------------------------|--|--|--|--|--|--|--|--|--|--------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|---------------------------------|--|--|--|--|--|--|--|--|--|----------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------|--|--|--|--|--|--|--|--|--|----------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|----------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|--|--|--|----------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|----------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|---------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|----------------------------------|--|--|--|--|--|--|--|--|--|---------------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|--------------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|---------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|----------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--|--|--|--------------------------------|--|--|--|--|--|--|--|--|--|
| 1 1,0079<br><b>H</b><br>Hydrogen |  |  |  |  |  |  |  |  |  | 2 4,00260<br><b>He</b><br>Helium |  |  |  |  |  |  |  |  |  | 3 6,941<br><b>Li</b><br>Lithium |  |  |  |  |  |  |  |  |  | 4 9,01218<br><b>Be</b><br>Beryllium |  |  |  |  |  |  |  |  |  | 5 10,81<br><b>B</b><br>Boron |  |  |  |  |  |  |  |  |  | 6 12,011<br><b>C</b><br>Carbon |  |  |  |  |  |  |  |  |  | 7 14,0067<br><b>N</b><br>Nitrogen |  |  |  |  |  |  |  |  |  | 8 15,9994<br><b>O</b><br>Oxygen |  |  |  |  |  |  |  |  |  | 9 18,998403<br><b>F</b><br>Fluorine |  |  |  |  |  |  |  |  |  | 10 20,179<br><b>Ne</b><br>Neon |  |  |  |  |  |  |  |  |  | 11 22,98977<br><b>Na</b><br>Sodium |  |  |  |  |  |  |  |  |  | 12 24,305<br><b>Mg</b><br>Magnesium |  |  |  |  |  |  |  |  |  | 13 26,98154<br><b>Al</b><br>Aluminum |  |  |  |  |  |  |  |  |  | 14 28,0855<br><b>Si</b><br>Silicon |  |  |  |  |  |  |  |  |  | 15 30,97376<br><b>P</b><br>Phosphorus |  |  |  |  |  |  |  |  |  | 16 32,06<br><b>S</b><br>Sulfur |  |  |  |  |  |  |  |  |  | 17 35,453<br><b>Cl</b><br>Chlorine |  |  |  |  |  |  |  |  |  | 18 39,948<br><b>Ar</b><br>Argon |  |  |  |  |  |  |  |  |  | 19 39,0983<br><b>K</b><br>Potassium |  |  |  |  |  |  |  |  |  | 20 40,08<br><b>Ca</b><br>Calcium |  |  |  |  |  |  |  |  |  | 21 44,9559<br><b>Sc</b><br>Scandium |  |  |  |  |  |  |  |  |  | 22 47,90<br><b>Ti</b><br>Titanium |  |  |  |  |  |  |  |  |  | 23 50,9415<br><b>V</b><br>Vanadium |  |  |  |  |  |  |  |  |  | 24 51,996<br><b>Cr</b><br>Chromium |  |  |  |  |  |  |  |  |  | 25 54,9380<br><b>Mn</b><br>Manganese |  |  |  |  |  |  |  |  |  | 26 55,847<br><b>Fe</b><br>Iron |  |  |  |  |  |  |  |  |  | 27 58,9332<br><b>Co</b><br>Cobalt |  |  |  |  |  |  |  |  |  | 28 58,70<br><b>Ni</b><br>Nickel |  |  |  |  |  |  |  |  |  | 29 63,546<br><b>Cu</b><br>Copper |  |  |  |  |  |  |  |  |  | 30 65,38<br><b>Zn</b><br>Zinc |  |  |  |  |  |  |  |  |  | 31 69,72<br><b>Ga</b><br>Gallium |  |  |  |  |  |  |  |  |  | 32 72,59<br><b>Ge</b><br>Germanium |  |  |  |  |  |  |  |  |  | 33 74,9216<br><b>As</b><br>Arsenic |  |  |  |  |  |  |  |  |  | 34 78,96<br><b>Se</b><br>Selenium |  |  |  |  |  |  |  |  |  | 35 79,904<br><b>Br</b><br>Bromine |  |  |  |  |  |  |  |  |  | 36 83,80<br><b>Kr</b><br>Krypton |  |  |  |  |  |  |  |  |  | 37 85,4678<br><b>Rb</b><br>Rubidium |  |  |  |  |  |  |  |  |  | 38 87,62<br><b>Sr</b><br>Strontium |  |  |  |  |  |  |  |  |  | 39 88,9059<br><b>Y</b><br>Yttrium |  |  |  |  |  |  |  |  |  | 40 91,22<br><b>Zr</b><br>Zirconium |  |  |  |  |  |  |  |  |  | 41 92,906<br><b>Nb</b><br>Niobium |  |  |  |  |  |  |  |  |  | 42 95,94<br><b>Mo</b><br>Molybdenum |  |  |  |  |  |  |  |  |  | 43 98<br><b>Tc</b><br>Technetium |  |  |  |  |  |  |  |  |  | 44 101,07<br><b>Ru</b><br>Ruthenium |  |  |  |  |  |  |  |  |  | 45 102,9055<br><b>Rh</b><br>Rhodium |  |  |  |  |  |  |  |  |  | 46 106,4<br><b>Pd</b><br>Palladium |  |  |  |  |  |  |  |  |  | 47 107,868<br><b>Ag</b><br>Silver |  |  |  |  |  |  |  |  |  | 48 112,41<br><b>Cd</b><br>Cadmium |  |  |  |  |  |  |  |  |  | 49 114,82<br><b>In</b><br>Indium |  |  |  |  |  |  |  |  |  | 50 118,69<br><b>Sn</b><br>Tin |  |  |  |  |  |  |  |  |  | 51 121,75<br><b>Sb</b><br>Antimony |  |  |  |  |  |  |  |  |  | 52 127,60<br><b>Te</b><br>Tellurium |  |  |  |  |  |  |  |  |  | 53 126,9045<br><b>I</b><br>Iodine |  |  |  |  |  |  |  |  |  | 54 131,30<br><b>Xe</b><br>Xenon |  |  |  |  |  |  |  |  |  | 55 132,9054<br><b>Cs</b><br>Cesium |  |  |  |  |  |  |  |  |  | 56 137,33<br><b>Ba</b><br>Barium |  |  |  |  |  |  |  |  |  | 57 138,9055<br><b>La</b><br>Lanthanum |  |  |  |  |  |  |  |  |  | 58 178,49<br><b>Hf</b><br>Hafnium |  |  |  |  |  |  |  |  |  | 59 180,9479<br><b>Ta</b><br>Tantalum |  |  |  |  |  |  |  |  |  | 60 183,85<br><b>W</b><br>Tungsten |  |  |  |  |  |  |  |  |  | 61 186,207<br><b>Re</b><br>Rhenium |  |  |  |  |  |  |  |  |  | 62 190,2<br><b>Os</b><br>Osmium |  |  |  |  |  |  |  |  |  | 63 192,22<br><b>Ir</b><br>Iridium |  |  |  |  |  |  |  |  |  | 64 195,09<br><b>Pt</b><br>Platinum |  |  |  |  |  |  |  |  |  | 65 196,9665<br><b>Au</b><br>Gold |  |  |  |  |  |  |  |  |  | 66 200,59<br><b>Hg</b><br>Mercury |  |  |  |  |  |  |  |  |  | 67 204,37<br><b>Tl</b><br>Thallium |  |  |  |  |  |  |  |  |  | 68 207,2<br><b>Pb</b><br>Lead |  |  |  |  |  |  |  |  |  | 69 208,9804<br><b>Bi</b><br>Bismuth |  |  |  |  |  |  |  |  |  | 70 (209)<br><b>Po</b><br>Polonium |  |  |  |  |  |  |  |  |  | 71 (210)<br><b>At</b><br>Astatine |  |  |  |  |  |  |  |  |  | 72 (222)<br><b>Rn</b><br>Radon |  |  |  |  |  |  |  |  |  |

† The names and symbols of elements 104 - 106 are those recommended by IUPAC as systematic alternatives to those suggested by the purported discoverers. Berkeley (USA) researchers have proposed Rutherfordium, Rf, for element 104 and Hafnium, Hf, for element 105. Dubna (USSR) researchers, who also claim the discovery of these elements have proposed different names (and symbols).

\* Estimated Values

includes mainly the longer-lived radioactive isotopes, many others have been prepared. Isotopes known to be radioactive but with half-lives exceeding 10<sup>4</sup> y have not been included. Symbols describing the principal mode (or modes) of decay are as follows (these processes are generally accompanied by gamma radiation):  
 α alpha particle emission  
 β<sup>-</sup> beta particle (electron) emission  
 β<sup>+</sup> positron emission  
 EC orbital electron capture  
 IT isomeric transition from upper to lower isomeric state  
 SF spontaneous fission