

Periodic Table of the Elements

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|--------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|--------------------|---------------------|----------------------|--------------------|--------------------|
| 1 H 1.01 | | | | | | | | | | | | | | | | | 2 He 4.00 | |
| 3 Li 6.94 | 4 Be 9.01 | | | | | | | | | | | 5 B 10.81 | 6 C 12.01 | 7 N 14.01 | 8 O 16.00 | 9 F 19.00 | 10 Ne 20.18 | |
| 11 Na 22.99 | 12 Mg 24.31 | | | | | | | | | | | 13 Al 26.98 | 14 Si 28.09 | 15 P 30.97 | 16 S 32.07 | 17 Cl 35.45 | 18 Ar 39.95 | |
| 19 K 39.10 | 20 Ca 40.08 | 21 Sc 44.96 | 22 Ti 47.87 | 23 V 50.94 | 24 Cr 51.99 | 25 Mn 54.94 | 26 Fe 55.85 | 27 Co 58.93 | 28 Ni 58.69 | 29 Cu 63.55 | 30 Zn 65.38 | 31 Ga 69.72 | 32 Ge 72.63 | 33 As 74.92 | 34 Se 78.97 | 35 Br 79.90 | 36 Kr 83.80 | |
| 37 Rb 85.47 | 38 Sr 87.62 | 39 Y 88.91 | 40 Zr 91.22 | 41 Nb 92.91 | 42 Mo 95.95 | 43 Tc 98.91 | 44 Ru 101.07 | 45 Rh 102.91 | 46 Pd 106.42 | 47 Ag 107.87 | 48 Cd 112.41 | 49 In 114.82 | 50 Sn 118.71 | 51 Sb 121.76 | 52 Te 127.6 | 53 I 126.90 | 54 Xe 131.29 | |
| 55 Cs 132.91 | 56 Ba 137.33 | 57-71 | | 72 Hf 178.49 | 73 Ta 180.95 | 74 W 183.84 | 75 Re 186.21 | 76 Os 190.23 | 77 Ir 192.22 | 78 Pt 195.09 | 79 Au 196.97 | 80 Hg 200.59 | 81 Tl 204.38 | 82 Pb 207.2 | 83 Bi 208.98 | 84 Po [208.98] | 85 At 209.99 | 86 Rn 222.02 |
| 87 Fr 223.02 | 88 Ra 226.03 | 89-103 | | 104 Rf [261] | 105 Db [262] | 106 Sg [266] | 107 Bh [264] | 108 Hs [269] | 109 Mt [278] | 110 Ds [281] | 111 Rg [280] | 112 Cn [285] | 113 Nh [286] | 114 Fl [289] | 115 Mc [289] | 116 Lv [293] | 117 Ts [294] | 118 Og [294] |
| | | | | | | | | | | | | | | | | | | |
| | | 57 La 138.91 | 58 Ce 140.12 | 59 Pr 140.91 | 60 Nd 144.24 | 61 Pm 144.91 | 62 Sm 150.36 | 63 Eu 151.96 | 64 Gd 157.25 | 65 Tb 158.93 | 66 Dy 162.50 | 67 Ho 164.93 | 68 Er 167.26 | 69 Tm 168.93 | 70 Yb 173.06 | 71 Lu 174.97 | | |
| | | 89 Ac 227.03 | 90 Th 232.04 | 91 Pa 231.04 | 92 U 238.03 | 93 Np 237.05 | 94 Pu 244.06 | 95 Am 243.06 | 96 Cm 247.07 | 97 Bk 247.07 | 98 Cf 251.08 | 99 Es [254] | 100 Fm 257.10 | 101 Md 258.1 | 102 No 259.10 | 103 Lr [262] | | |

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Simple solubility rules

| Applies to | Rule | Exceptions |
|--|-----------|--|
| Li^+ , Na^+ , K^+ , Cs^+ , Rb^+ , NH_4^+ | Soluble | None |
| Acetate ($\text{C}_2\text{H}_3\text{O}_2^-$), NO_3^- | Soluble | None |
| Cl^- , Br^- , I^- | Soluble | Ag^+ , Pb^{2+} , Hg_2^{2+} e.g. AgCl , Hg_2Cl_2 , PbCl_2 , AgBr , HgBr_2 , PbBr_2 , AgI , HgI_2 , Hg_2I_2 , PbI_2 |
| SO_4^{2-} | Soluble | CaSO_4 , SrSO_4 , BaSO_4 , Ag_2SO_4 , Hg_2SO_4 , PbSO_4 |
| CO_3^{2-} , PO_4^{3-} , CrO_4^{2-} , $\text{C}_2\text{O}_4^{2-}$ | Insoluble | Group 1A and NH_4^+ salts |
| S^{2-} | Insoluble | Group 1A, Ba^{2+} , and NH_4^+ salts |
| O^{2-} | Insoluble | Group 1A and BaO |
| OH^- | Insoluble | Group 1A and marginally soluble $\text{Ba}(\text{OH})_2$, $\text{Sr}(\text{OH})_2$, $\text{Ca}(\text{OH})_2$ |

Physical constants

| | |
|-----------------------------|---|
| Avogadro's number | $N_A = 6.0221367 \times 10^{23} / \text{mol}$ |
| Electronic charge | $e = 1.60217733 \times 10^{-19} \text{ C}$ |
| Electron rest mass | $m_e = 9.1093897 \times 10^{-31} \text{ kg}$ |
| Proton rest mass | $m_p = 1.6726231 \times 10^{-27} \text{ kg}$ |
| Neutron rest mass | $m_n = 1.6749286 \times 10^{-27} \text{ kg}$ |
| Faraday constant | $F = 9.6485309 \times 10^4 \text{ C/mol}$ |
| Molar gas constant | $R = 0.0820578 \text{ L}\cdot\text{atm}/(\text{K}\cdot\text{mol})$ $= 8.314510 \text{ kPa}\cdot\text{dm}^3/(\text{K}\cdot\text{mol})$ $= 8.314510 \text{ J}/(\text{K}\cdot\text{mol})$ $= 1.98726 \text{ cal}/(\text{K}\cdot\text{mol})$ |
| Molar volume ideal gas, STP | $V_m = 22.41410 \text{ L/mol}$ |
| Planck's constant | $h = 6.62607015 \times 10^{-34} \text{ kg}\cdot\text{m}^2/\text{s}$ |
| Speed of light (in vacuum) | $c = 2.99792458 \times 10^8 \text{ m/s}$ |

SI base units

| Measurement | Unit, symbol |
|---------------------|--------------|
| Length | meter, m |
| Mass | kilogram, kg |
| Time | second, s |
| Temperature | kelvin, K |
| Amount of substance | mole, mol |
| Electric current | ampere, A |
| Luminous intensity | candela, cd |

| Conversion factors | |
|--------------------|---|
| Pressure | 1 atm = 1.01325×10^5 Pa = 760 mm Hg = 760 torr |
| Energy | 1 eV/molecule = 96.485 kJ/mol 1 MeV = 1.60218×10^{-13} J 1 J = $1 \text{ kg} \cdot \text{m}^2/\text{s}^2$ 1 calorie, cal = 4.184 J 1 L·atm = 101.3 J |
| Volume | 1 L = $1 \text{ dm}^3 = 10^{-3} \text{ m}^3$ |
| Atomic mass | 1 amu (u) = 1.661×10^{-27} kg |
| Distance | 1 angstrom, Å = 10^{-10} m |

| Imperial – SI Conversions | Imperial unit | SI unit |
|---------------------------|----------------------|-----------|
| Length | 1 inch, in (exact) | 2.54 cm |
| | 1 yard, yd | 0.9144 m |
| | 1 mile = 5280 ft | 1.609 km |
| Mass | 1 pound, lb = 16 oz | 0.4536 kg |
| | 1 ounce, oz | 28.35 g |
| Volume | 1 qt | 0.9464 L |
| | 1 gallon, gal = 4 qt | |

| SI derived units | | |
|------------------|-------------------------------|---|
| Quantity | Definition | Unit |
| Area | Length squared | m ² |
| Volume | Length cubed | m ³ |
| Density | Mass per unit volume | kg/m ³ ; g/cm ³ |
| Velocity (speed) | Distance per unit time | m/s |
| Acceleration | Velocity change per unit time | m/s ² |
| Force | Mass × acceleration of object | kg·m/s ² |
| Pressure | Force per unit area | kg/(m·s ²) = 1 pascal, Pa |
| Energy | Force × distance traveled | kg·m ² /s ² = 1 joule, J |

| SI prefixes | | |
|-------------------|--------|--------|
| Multiple | Prefix | Symbol |
| 10 ¹⁸ | exa | E |
| 10 ¹⁵ | peta | P |
| 10 ¹² | tera | T |
| 10 ⁹ | giga | G |
| 10 ⁶ | mega | M |
| 10 ³ | kilo | k |
| 10 ² | hecto | h |
| 10 ¹ | deka | da |
| 10 ⁻¹ | deci | d |
| 10 ⁻² | centi | c |
| 10 ⁻³ | milli | m |
| 10 ⁻⁶ | micro | μ |
| 10 ⁻⁹ | nano | n |
| 10 ⁻¹² | pico | p |
| 10 ⁻¹⁵ | femto | f |
| 10 ⁻¹⁸ | atto | a |

Light and atomic structure

$$c = \lambda \nu$$

$$E = h\nu$$

$$E_{\text{photon}} = h\nu = -(E_f - E_i)_e$$

$$E_e = h\nu - \phi = E_{\text{photon}} - E_0$$

$$\lambda = \frac{h}{m\nu}$$

$$E = (-2.18 \times 10^{-18} \text{ J}) \frac{Z^2}{n^2}$$

$$\Delta E = -2.18 \times 10^{-18} \text{ J} \left(\frac{Z^2}{n_f^2} - \frac{Z^2}{n_i^2} \right)$$

$$|\Delta E| = h\nu = \frac{hc}{\lambda}$$

Pressure

$$P = \frac{F}{A}$$

$$PV = nRT; PM_m = dRT$$

$$P_t = P_1 + P_2 + P_3 + \dots$$

$$P_t = (n_1 + n_2 + n_3 + \dots) \left(\frac{RT}{V} \right)$$

$$\text{Mole fraction of A, } X_A = \frac{n_A}{n_t} = \frac{P_A}{P_t}$$

$$\ln \left(\frac{P_2}{P_1} \right) = \frac{\Delta H_{\text{vap}}}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

$$K_P = K_C (RT)^{\Delta n}$$

Energy

$$E_k = \frac{1}{2} m \mathbf{v}^2$$

$$E = \frac{kQ_1Q_2}{r}$$

$$\Delta E = \sum nD_{(\text{broken})} - \sum nD_{(\text{formed})}$$

$$\Delta E_f^\circ = \sum n\Delta H_f^\circ (\text{prod.}) - \sum n\Delta H_f^\circ (\text{react.})$$

$$\Delta E = q + w$$

$$w = -P\Delta V$$

$$H = E + PV$$

$$\Delta H = q_P$$

$$q = C_s m \Delta T = sm \Delta T = Cn \Delta T$$

$$q_{\text{rxn}} = -C_{\text{cal}} \Delta T$$

Acid base equilibrium

$$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 10^{-14} \text{ (at } 25^\circ\text{C)}$$

$$\text{pH} = -\log[\text{H}^+] = -\log[\text{H}_3\text{O}^+]$$

$$\text{pOH} = -\log[\text{OH}^-]$$

$$\text{pH} + \text{pOH} = 14.00 \text{ (at } 25^\circ\text{C)}$$

Common strong acids and bases

Acids: HCl, HBr, HI, HNO₃, H₂SO₄, HClO₄, HBrO₄, HIO₄

Bases: LiOH, NaOH, KOH, Ca(OH)₂, Sr(OH)₂, Ba(OH)₂