Selected Key Equations

Density (1.6)
$$d = \frac{m}{V}$$

Solution Dilution (4.4)
$$M_1V_1 = M_2V_2$$

Ideal Gas Law (5.4)
$$PV = nRT$$

Dalton's Law (5.6)
$$P_{total} = P_a + P_b + P_c + \ldots$$

Mole Fraction (5.6)
$$\chi_a = \frac{n_a}{n_{total}}$$

Average Kinetic Energy (5.8)
$$KE_{avg} = \frac{3}{2}RT$$

Root Mean Square Velocity (5.8)
$$u_{rms} = \sqrt{\frac{3\,RT}{\mathcal{M}}}$$

Effusion (5.9)
$$\frac{\text{rate A}}{\text{rate B}} = \sqrt{\frac{\mathcal{M}_B}{\mathcal{M}_A}}$$

Van der Waals Equation (5.10)
$$\left[P + a\left(\frac{n}{V}\right)^2\right] \times [V - nb] = nRT$$

Kinetic Energy (6.2)
$$KE = \frac{1}{2}mv^2$$

Internal Energy (6.3)
$$\Delta E = q + w$$

Heat Capacity (6.4)
$$q = m \times C_s \times \Delta T$$

Pressure-Volume Work (6.4)
$$w = -P\,\Delta V$$

Change in Enthalpy (6.6)
$$\Delta H = \Delta E + P\,\Delta V$$

Standard Enthalpy of Reaction (6.9)
$$\Delta H^\circ_{rxn} = \sum n_p\,\Delta H^\circ_f\,(\text{products}) - \sum n_r\,\Delta H^\circ_f\,(\text{reactants})$$

Frequency and Wavelength (7.2)
$$\nu = \frac{c}{\lambda}$$

Energy of a Photon (7.2)
$$E = h\nu$$
$$E = \frac{hc}{\lambda}$$

De Broglie Relation (7.4)
$$\lambda = \frac{h}{m\nu}$$

Heisenberg's Uncertainty Principle (7.4)
$$\Delta x \times m\,\Delta v \geq \frac{h}{4\pi}$$

Energy of Hydrogen Atom Levels (7.5)
$$E_n = -2.18 \times 10^{-18}\,\text{J}\left(\frac{1}{n^2}\right) \quad (n = 1, 2, 3\ldots)$$

Coulomb's Law (8.3)
$$E = \frac{1}{4\,\pi\epsilon_o}\frac{q_1q_2}{r}$$

Dipole Moment (9.6)
$$\mu = q\,r$$

Clausius–Clapeyron Equation (11.5)
$$\ln P_{vap} = \frac{-\Delta H_{vap}}{RT} + \ln\beta$$
$$\ln\frac{P_2}{P_1} = \frac{-\Delta H_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

Henry's Law (12.4)
$$S_{gas} = k_H P_{gas}$$

Raoult's Law (12.6)
$$P_{solution} = \chi_{solvent} P^\circ_{solvent}$$

Freezing Point Depression (12.6)
$$\Delta T_f = m \times K_f$$

Boiling Point Elevation Constant (12.6)
$$\Delta T_b = m \times K_b$$

Osmotic Pressure (12.6)
$$\prod = MRT$$

The Rate Law (13.3)
$$\text{Rate} = k[A]^n \quad \text{(single reactant)}$$
$$\text{Rate} = k[A]^m[B]^n \quad \text{(multiple reactants)}$$

Integrated Rate Laws and Half-Life (13.4)

Order	Integrated Rate Law	Half-Life Expression
0	$[A]_t = -kt + [A]_0$	$t_{1/2} = \frac{[A]_0}{2k}$
1	$\ln[A]_t = -kt + \ln[A]_0$	$t_{1/2} = \frac{0.693}{k}$
2	$\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$	$t_{1/2} = \frac{1}{k[A]_0}$

Arrhenius Equation (13.5)
$$k = A\,e^{\frac{-E_a}{RT}}$$
$$\ln k = -\frac{E_a}{R}\left(\frac{1}{T}\right) + \ln A \quad \text{(linearized form)}$$
$$k = p\,z\,e^{\frac{-E_a}{RT}} \quad \text{(collision theory)}$$

K_c and K_p (14.4)
$$K_p = K_c(RT)^{\Delta n}$$

pH Scale (15.5)
$$\text{pH} = -\log[H_3O^+]$$

Henderson–Hasselbalch Equation (16.2)
$$\text{pH} = \text{p}K_a + \log\frac{[\text{base}]}{[\text{acid}]}$$

Entropy (17.3)
$$S = k \ln W$$

Change in the Entropy of the Surroundings (17.4)
$$\Delta S_{surr} = \frac{-\Delta H_{sys}}{T}$$

Change in Gibbs Free Energy (17.5)
$$\Delta G = \Delta H - T\,\Delta S$$

The Change in Free Energy: Nonstandard Conditions (17.8)
$$\Delta G_{rxn} = \Delta G^\circ_{rxn} + RT \ln Q$$

ΔG°_{rxn} and K (17.9)
$$\Delta G^\circ_{rxn} = -RT \ln K$$

Temperature Dependence of the Equilibrium Constant (17.9)
$$\ln K = -\frac{\Delta H^\circ_{rxn}}{R}\left(\frac{1}{T}\right) + \frac{\Delta S^\circ_{rxn}}{R}$$

ΔG° and E°_{cell} (18.5)
$$\Delta G^\circ = -nF\,E^\circ_{cell}$$

E°_{cell} and K (18.5)
$$E^\circ_{cell} = \frac{0.0592\ \text{V}}{n}\log K$$

Nerst Equation (18.6)
$$E_{cell} = E^\circ_{cell} - \frac{0.0592\ \text{V}}{n}\log Q$$

Einstein's Energy-Mass Equation (19.8)
$$E = mc^2$$

Conversion Factors and Relationships

Length

SI unit: meter (m)

1 m = 1.0936 yd
1 cm = 0.39370 in
1 in = 2.54 cm (exactly)
1 km = 0.62137 mi
1 mi = 5280 ft
= 1.6093 km
1 Å = 10^{-10} m

Temperature

SI unit: kelvin (K)

0 K = −273.15 °C
= −459.67 °F
K = °C + 273.15
$°C = \frac{(°F - 32)}{1.8}$
°F = 1.8 (°C) + 32

Energy (derived)

SI unit: joule (J)

1 J = 1 kg · m^2/s^2
= 0.23901 cal
= 1 C · V
= 9.4781 × 10^{-4} Btu
1 cal = 4.184 J
1 eV = 1.6022 × 10^{-19} J

Pressure (derived)

SI unit: pascal (Pa)

1 Pa = 1 N/m^2
= 1 $kg/(m \cdot s^2)$
1 atm = 101,325 Pa
= 760 torr
= 14.70 lb/in^2
1 bar = 10^5 Pa
1 torr = 1 mmHg

Volume (derived)

SI unit: cubic meter (m^3)

1 L = 10^{-3} m^3
= 1 dm^3
= 10^3 cm^3
= 1.0567 qt
1 gal = 4 qt
= 3.7854 L
1 cm^3 = 1 mL
1 in^3 = 16.39 cm^3
1 qt = 32 fluid oz

Mass

SI unit: kilogram (kg)

1 kg = 2.2046 lb
1 lb = 453.59 g
= 16 oz
1 amu = 1.66053873 × 10^{-27} kg
1 ton = 2000 lb
= 907.185 kg
1 metric ton = 1000 kg
= 2204.6 lb

Geometric Relationships

π = 3.14159 . . .
Circumference of a circle = $2\pi r$
Area of a circle = πr^2
Surface area of a sphere = $4\pi r^2$
Volume of a sphere = $\frac{4}{3}\pi r^3$
Volume of a cylinder = $\pi r^2 h$

Fundamental Constants

Atomic mass unit	1 amu 1 g	= 1.66053873 × 10^{-27} kg = 6.02214199 × 10^{23} amu
Avogadro's number	N_A	= 6.02214179 × 10^{23}/mol
Bohr radius	a_0	= 5.29177211 × 10^{-11} m
Boltzmann's constant	k	= 1.38065052 × 10^{-23} J/K
Electron charge	e	= 1.60217653 × 10^{-19} C
Faraday's constant	F	= 9.64853383 × 10^4 C/mol
Gas constant	R	= 0.08205821 (L · atm/(mol · K) = 8.31447215 J/(mol · K)
Mass of an electron	m_e	= 5.48579909 × 10^{-4} amu = 9.10938262 × 10^{-31} kg
Mass of a neutron	m_n	= 1.00866492 amu = 1.67492728 × 10^{-27} kg
Mass of a proton	m_p	= 1.00727647 amu = 1.67262171 × 10^{-27} kg
Planck's constant	h	= 6.62606931 × 10^{-34} J · s
Speed of light in vacuum	c	= 2.99792458 × 10^8 m/s (exactly)

SI Unit Prefixes

a	f	p	n	μ	m	c	d	k	M	G	T	P	E
atto	femto	pico	nano	micro	milli	centi	deci	kilo	mega	giga	tera	peta	exa
10^{-18}	10^{-15}	10^{-12}	10^{-9}	10^{-6}	10^{-3}	10^{-2}	10^{-1}	10^3	10^6	10^9	10^{12}	10^{15}	10^{18}