MCAT Equations

Name	Equation	Units
Mechanics & Energy		
Average speed	$\frac{\Delta x}{\Delta t}$	$\frac{m}{s}$
Average velocity	$\frac{\Delta d}{\Delta t}$	$\frac{m}{s}$
Acceleration	$\frac{\Delta v}{\Delta t}$	$\frac{m}{s^2}$
Newton's Second Law	$F_{net} = ma$	$1 \text{ Newton} = 1 \text{ kg} \cdot \frac{m}{s^2}$
Static Friction	$F_{f,max} = \mu_s F_N$	$1 \text{ Newton} = 1 \text{ kg} \cdot \frac{m}{s^2}$
Kinetic Friction	$F_f = \mu_k F_N$	$1 \text{ Newton} = 1 \text{ kg} \cdot \frac{m}{s^2}$
Force of gravity acting perpendicular to an inclined plane	$mg\cos\theta$	$1 \text{ Newton} = 1 \text{ kg} \cdot \frac{m}{s^2}$
Force of gravity acting parallel to an inclined plane	$mg\sin\theta$	$1 \text{ Newton} = 1 \text{ kg} \cdot \frac{m}{s^2}$
Torque	$\tau = rF\sin\theta$	$N \cdot m$
Work	$W = Fd\cos\theta$	$1 \text{ Joule} = N \cdot m$
Work (pressure-volume curve)	$W = P\Delta V$	J
Center of mass	$x = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$	
Mechanical Advantage	$MA = \frac{F_{out}}{F_{in}}$	
Power	$P = \frac{W}{t} = \frac{\Delta E}{t}$	$1 \text{ watt (W)} = \frac{J}{s}$
Power	$P = Fv$	W

Kinetic Energy	$KE = \frac{1}{2}mv^2$	J
Work-Kinetic Energy theorem	$W_{net} = \Delta KE = K_f - K_i$	J
Gravitational Potential Energy	$U = mgh$	J
Elastic Potential Energy	$U = \frac{1}{2}kx^2$	J
Hooke's Law	$F = -kx$	N
Frequency of a wave	$f = \frac{1}{T}$	$\frac{1}{s} = Hz$
Speed of a wave	$v = f\lambda$	$\frac{m}{s}$
Fluids		
Density	$\rho = \frac{m}{V}$	$\frac{g}{cm^3}$
Specific Gravity	$\frac{\rho_{object}}{\rho_{water}}$	
Buoyant Force	$F_B = mg = \rho_{fluid}Vg$	N
Pascal's Law	$\frac{F_1}{A_1} = \frac{F_2}{A_2}$	
Hydrostatic Pressure	$P = P_0 + \rho gz$	
Poiseuille's Law	$Q = \frac{\pi r^4 \Delta P}{8\eta L}$	
Continuity Equation	$A_1v_1 = A_2v_2$	
Bernoulli's Equation	$P_1 + \frac{1}{2}\rho v_1^2 + \rho gh_1 = P_2 \ldots$	
Gases		
Absolute Temperature	$K = {}^\circ C + 273$	
Pressure	$P = \frac{F}{A}$	

Ideal Gas Law	$PV = nRT$	
Boyle's Law	$P_1V_1 = P_2V_2$	
Charles' Law	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	
Avogadro's Law	$\frac{n_1}{V_1} = \frac{n_2}{V_2}$	
Average kinetic energy of a gas particle	$KE_{avg} = \frac{3}{2}k_BT$	J
Heat capacity at constant volume for an ideal monatomic gas	$C_V = \frac{3}{2}nR$	$\frac{J}{K}$
Heat capacity at constant pressure for an ideal monatomic gas	$C_P = \frac{5}{2}nR$	$\frac{J}{K}$
van der Waals equation of state	$P = \frac{nRT}{V - nb} - \frac{n^2a}{V^2}$	
Dalton's Law of Partial Pressures	$P_A = X_AP_T$ $P = P_A + P_B + P_C$	
Thermodynamics		
Heat transferred	$q = mc\Delta T$	$1\ \frac{cal}{g \cdot K} = 4.184\ \frac{J}{g \cdot K}$
Standard Heat of Reaction	$\sum \Delta H^{\circ}_{f,products} - \sum \Delta H^{\circ}_{f,reactants}$	
Standard Heat of Reaction	$\sum \Delta H^{\circ}_{bonds\ broken} - \sum \Delta H^{\circ}_{bonds\ formed}$	
Change in Gibbs Free Energy	$\Delta G = \Delta H - T\Delta S$	$\frac{kJ}{mol}$
Linear Expansion (Solids)	$\Delta L = \alpha L\Delta T$	
Volumetric Expansions (Solids & Liquids)	$\Delta V = \beta V\Delta T$	

Sound		
Sound Level	$\beta = 10\log\frac{I}{I_0}$	dB
Sound Level	$\beta_f = \beta_i + 10\log\frac{I_f}{I_i}$	dB
Intensity	$I = \frac{P}{A}$	$\frac{W}{m^2}$
Doppler Effect	$f' = f\frac{v \pm v_d}{v \mp v_s}$	Hz
Waves in Open Pipes	$\lambda = \frac{2L}{n}$ $f = \frac{v}{\lambda} = \frac{nv}{2L}$	
Waves in Closed Pipes	$\lambda = \frac{4L}{n}$ $f = \frac{v}{\lambda} = \frac{nv}{4L}$	
Light & Electromagnetic Radiation		
Speed of Light	$c = f\lambda$	$\frac{m}{s}$
Energy of Photon	$E = hf$	
Geometrical Optics		
Law of Reflection	$\theta_1 = \theta_2$	
Index of Refraction	$n = \frac{c}{v}$	
Snell's Law	$n_1\sin\theta_1 = n_2\sin\theta_2$	
Critical Angle	$\theta_c = sin^{-1}\left(\frac{n_2}{n_1}\right)$	

Optics Equation	$\frac{1}{f} = \frac{1}{o} + \frac{1}{i} = \frac{2}{r}$	
Magnification	$m = \frac{-i}{o}$	
Lens Power	$P = \frac{1}{f}$	diopters
Focal length of lenses in a series	$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + \cdots + \frac{1}{f_n}$	
Power of lenses in a series	$P = P_1 + P_2 + P_3 + \cdots + P_n$	diopters
Magnification for a system of lenses	$m = m_1 \times m_2 \times m_3$	
Electrostatics		
Coulomb's Law	$F_e = \frac{kq_1q_2}{r^2}$	N
Electric Field	$E = \frac{F_e}{q} = \frac{kQ^2}{r^2}$	$\frac{N}{C}$ or $\frac{V}{m}$
Electrical Potential Energy	$U = \frac{kQq}{r}$	J
Electrical Potential	$V = \frac{U}{q} = \frac{kQ}{r}$	$1\ V = 1\ \frac{J}{C}$
Intensity of Uniform Electric Field	$\frac{V}{d}$	$\frac{V}{m}$
Voltage (Potential Difference)	$\Delta V = V_b - V_a = \frac{W_{ab}}{q}$	Volts
Power	VI	W
Power	$\frac{V^2}{R}$	W
Power	I^2R	W
Circuits		
Current	$I = \frac{Q}{t}$	$1\ A = 1\ \frac{C}{s}$
Ohm's Law	$V = IR$	

Resistors in Series	$R_s = R_1 + R_2 + R_3$	Ohms (Ω)
Resistors in Parallel	$\frac{1}{R_1} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$	Ω
Resistivity	$\varrho = \frac{R \cdot A}{L}$	Ohm-meter ($\Omega \cdot m$)
Capacitance	$C = \frac{Q}{V} = \varepsilon_o \left(\frac{A}{d}\right)$	$1\ F = 1\frac{C}{V}$
Energy of a Charged Capacitor	$U = \frac{Q^2}{C} = \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2$	
Capacitors in Series	$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$	F
Capacitors in Parallel	$C_P = C_1 + C_2 + C_3$	F
Magnetism		
Magnetic Force	$F_B = qvB\sin\theta$	$1\ T = 1\ \frac{N \cdot s}{m \cdot C}$
Lorentz Force	$F = qE + qvB\sin\theta$	
Atomic Structure & Stoichiometry		
Maximum number of electrons in a shell	$2n^2$	
Kinetic Energy of a Photoelectron	$hf - \phi$	eV
Bonding & Reactions		
Formal Charge	$FC = V - NB - \frac{1}{2}B$	
Dipole Moment	$p = q \cdot d$	$C \cdot m$
Specific rotation	$[\alpha] = \frac{\alpha_{obs}}{c \times l}$	degrees
Electrochemistry		
Electrodeposition Equation	$\text{mol } M = \frac{It}{nF}$	

Cell potential	$\text{cell pot.} = \text{red. pot} - \text{ox. pot}$	
Kinetics		
Rate law	$\text{rate} = k[A]^x[B]^y$	
Arrhenius Equation	$k = Ae^{\frac{-E_a}{RT}}$	
Law of Mass Action	$k_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$	
Molecular Structure & Absorbance Spectra		
Wavenumber	$\frac{1}{\lambda}$	cm^{-1}
Solutions		
Autoionization of water	$K_w = [H_3O^+][OH^-] = 10^{-14}$	
pH	$-\log[H^+]$	
pOH	$-\log[OH^-]$	
Acid Dissociation Constant	$k_a = \frac{[H_3O^+][A^-]}{[HA]}$	
Base Dissociation Constant	$k_b = \frac{[B^+][OH^-]}{[BOH]}$	
pK_a	$-\log K_a$	
pK_b	$-\log K_b$	
Henderson-Hasselbalch	$pH = pK_a + \log\frac{[\text{Conj. base}]}{[\text{acid}]}$	
Point of Inflection	$pH = pK_a$ or $14 - pK_b$	
Solubility Product Constant	for A_mB_n: $K_{sp} = [A^{n+}]^m[B^{m-}]^n$	

Separations & Purifications		
Retardation factor	$R_f = \frac{\text{distance spot moved}}{\text{distance solvent front moved}}$	
Circulation & Respiration		
Henry's Law	$[A] = K_H \times P_A$	
Amino Acids & Proteins		
Electrophoresis (migration velocity of a molecule)	$v = \frac{Ez}{f}$	
Genetics		
Hardy-Weinberg	$p + q = 1$ $p^2 + 2pq + q^2 = 1$	
Enzymes		
Michaelis-Menten	$v = \frac{v_{max}[S]}{K_m + [S]}$	
Plasma Membrane & Nervous System		
Nernst Equation	$E_{cell} = E^{\circ}_{cell} - \frac{RT}{nF}\ln(Q)$	
Osmotic Pressure	$\Pi = iMRT$	