The Definitive MCAT Equations Reference Guide

This guide contains a comprehensive list of equations relevant for the MCAT, organized by topic. Each equation is listed alongside its variable definitions for clarity and efficient studying. This list synthesizes formulas from standard prep materials and the AAMC content outline to ensure completeness.

NOT EVERY FORMULA IS IMPORTANT. Some are here for reference, or to make understanding easier. These formulas have been collected through doing thousands of questions. Some are obviously more high yield than others.

Physics: Kinematics & Dynamics

Equation	Variable Definitions
$Average\ Speed = \frac{Total\ Distance}{Total\ Time}$	Average speed (scalar quantity - total distance traveled)
$v_{avg} = \frac{\Delta x}{\Delta t}$	v_{avg} = Average velocity Δx = Displacement Δt = Time
$a = \frac{\Delta v}{\Delta t}$	a = Acceleration Δv = Change in velocity Δt = Time
$v_f = v_0 + at$	v_f = Final velocity v_0 = Initial velocity a = Acceleration t = Time
$d = v_0 t + \frac{1}{2}at^2$	d = Displacement v_0 = Initial velocity a = Acceleration t = Time

$v_f{}^2 = v_0{}^2 + 2ad$	v_f = Final velocity v_0 = Initial velocity a = Acceleration d = Displacement
$d = \left(\left(\frac{v_0 + v_f}{2}\right)\right) t$	d = Displacement v_0 = Initial velocity v_f = Final velocity t = Time
$F_{net} = ma$	F_{net} = Net force (N) m = Mass (kg) a = Acceleration (m/s^2)
$J = \Delta p = F\Delta t$	J = Impulse Δp = Change in momentum F = Force Δt = Time interval
$F_f \leq \mu_s F_N$	F_f = Static friction force μ_s = Coefficient of static friction F_N = Normal force
$F_f = \mu_k F_N$	F_f = Kinetic friction force μ_k = Coefficient of kinetic friction F_N = Normal force
$F_\parallel = mgsin\theta, F_\perp = mgcos\theta$	$F_\parallel$ = Force parallel to incline $F_\perp$ = Force perpendicular to incline θ = Angle of incline
$\tau = rFsin\theta$	τ = Torque r = Lever arm length F = Force θ = Angle between r and F

$$x_{cm} = \frac{m_1x_1 + m_2x_2 + \cdots}{m_1 + m_2 + \cdots}$$	x_{cm} = Center of mass m = Mass x = Position
$$a_c = \frac{v^2}{r}$$	a_c = Centripetal acceleration v = Velocity r = Radius of circular path
$$F_c = \frac{mv^2}{r}$$	F_c = Centripetal force m = Mass v = Velocity r = Radius

Physics: Momentum & Collisions

Equation	Variable Definitions
$$p = mv$$	p = Linear momentum m = Mass v = Velocity
$$p_{1i} + p_{2i} = p_{1f} + p_{2f}$$	p_{1i, p_2i} = Initial momenta of objects p_{1f, p_2f} = Final momenta of objects Conservation of momentum
$$v_{1f} = \frac{((m_1 - m_2))v_{1i} + 2m_2v_{2i}}{m_1 + m_2}$$	v_{1f} = Final velocity of object 1 m_{1, m_2} = Masses of objects v_{1i, v_2i} = Initial velocities Elastic collision (1D)
$$v_f = \frac{m_1v_{1i} + m_2v_{2i}}{m_1 + m_2}$$	v_f = Final velocity (objects stick together) m_{1, m_2} = Masses of objects v_{1i, v_2i} = Initial velocities Perfectly inelastic collision (1D)

Physics: Rotational Motion

Equation	Variable Definitions
$\omega = \frac{\Delta\theta}{\Delta t}$	ω = Angular velocity Δθ = Change in angle Δt = Time
$\alpha = \frac{\Delta\omega}{\Delta t}$	α = Angular acceleration Δω = Change in angular velocity
$I = \Sigma mr^2$	I = Moment of inertia m = Mass r = Distance from axis
$KE_{rot} = \frac{1}{2} I\omega^2$	KE_{rot} = Rotational kinetic energy I = Moment of inertia ω = Angular velocity
$L = I\omega$	L = Angular momentum I = Moment of inertia ω = Angular velocity
$v = r\omega$	v = Linear velocity r = Radius ω = Angular velocity
$\tau = I\alpha$	τ = Net torque I = Moment of inertia α = Angular acceleration

Physics: Simple Harmonic Motion

Equation	Variable Definitions
$T = 2\pi\sqrt{\left(\left(\frac{m}{k}\right)\right)}$	T = Period of mass-spring system m = Mass k = Spring constant

$T = 2\pi\sqrt{\left(\left(\frac{L}{g}\right)\right)}$	T = Period of simple pendulum L = Length g = Gravitational acceleration
$x((t)) = Acos((\omega t + \varphi))$	x(t) = Position in SHM A = Amplitude ω = Angular frequency φ = Phase constant
$\omega = \sqrt{\left(\left(\frac{k}{m}\right)\right)}$	ω = Angular frequency k = Spring constant m = Mass

Physics: Work, Energy, & Power

Equation	Variable Definitions
$W = Fdcos\theta$	W = Work (J) F = Force d = Displacement θ = Angle between F and d
$W = P\Delta V$	W = Work (isobaric process) P = Pressure ΔV = Change in Volume
$MA = \frac{F_{out}}{F_{in}}$	MA = Mechanical Advantage F_{out} = Output force F_{in} = Input force
$P = \frac{W}{t} = Fv$	P = Power (W) W = Work t = Time F = Force v = Velocity

$KE = \frac{1}{2}mv^2$	KE = Kinetic energy (J) m = Mass v = Velocity
$W_{net} = \Delta KE$	W_{net} = Net work done ΔKE = Change in kinetic energy
$U_{grav} = mgh$	U_{grav} = Gravitational potential energy m = Mass g = Gravity h = Height
$U_{elastic} = \frac{1}{2}kx^2$	$U_{elastic}$ = Elastic potential energy k = Spring constant x = Displacement
$F_{spring} = -kx$	F_{spring} = Hooke's Law k = Spring constant x = Displacement
$\Delta V = \beta V \Delta T$	ΔV = Volumetric thermal expansion β = Coeff. of volumetric expansion
$\Delta S = \frac{Q_{rev}}{T}$	ΔS = Change in entropy Q_{rev} = Heat in reversible process T = Temperature (K)

Physics: Fluids & Gases

Equation	Variable Definitions
$P = \frac{F}{A}$	P = Pressure F = Force A = Area

$\rho = \frac{m}{V}$	ρ = Density m = Mass V = Volume
$SG = \frac{\rho_{substance}}{\rho_{water}}$	SG = Specific Gravity
$F_{buoyant} = \rho_{fluid} V_{submerged} g$	$F_{buoyant}$ = Buoyant force
$\frac{F_1}{A_1} = \frac{F_2}{A_2}$	F_{1, F_2} = Forces applied to pistons A_{1, A_2} = Areas of pistons Pascal's Law - pressure transmitted equally
$P_{abs} = P_{atm} + \rho g z$	P_{abs} = Hydrostatic Pressure z = Depth
$Q = \frac{\pi r^4 \Delta P}{8 \eta L}$	Q = Flow rate (Poiseuille's Law) η = Viscosity
$A_1 v_1 = A_2 v_2$	A = Area v = Flow velocity (Continuity)
$P_1 + \frac{1}{2}\rho {v_1}^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho {v_2}^2 + \rho g h_2$	P_{1, P_2} = Pressure at points 1 and 2 ρ = Fluid density v_{1, v_2} = Flow velocities at points 1 and 2 g = Gravitational acceleration h_{1, h_2} = Heights at points 1 and 2 Bernoulli's Equation
$K = °C + 273.15$	K = Absolute Temperature (Kelvin)
$PV = nRT$	P = Pressure V = Volume n = Moles of gas R = Gas constant T = Temperature (K)

	Ideal Gas Law
$P_1V_1 = P_2V_2$	$P_{1,\ P\_2}$ = Pressures $V_{1,\ V\_2}$ = Volumes Boyle's Law (fixed T, n)
$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	Charles' Law (fixed P, n)
$\frac{V_1}{n_1} = \frac{V_2}{n_2}$	Avogadro's Law (fixed P, T)
$KE_{avg} = \frac{3}{2}k_BT$	KE_{avg} = Avg. kinetic energy per molecule k_B = Boltzmann's constant
$P_{total} = P_A + P_B + \cdots$	P_{total} = Total pressure $P_{A,\ P\_B}$ = Partial pressures of gases A, B, etc. Dalton's Law of Partial Pressures
$\left( )P + \frac{an^2}{V^2}) \right)((V - nb)) = nRT$	a, b = van der Waals constants

Physics: Thermodynamics

Equation	Variable Definitions
$\Delta U = Q - W$	ΔU = Change in internal energy Q = Heat added W = Work done by system
$q = mc\Delta T$	q = Heat transferred c = Specific heat
$q = mL$	q = Heat transferred (phase change) m = Mass L = Latent heat

$\Delta U = nC_v\Delta T, Q = nC_p\Delta T$	C_{v, C_p} = Molar specific heat at constant V and P
$\Delta H^\circ_{rxn} = \Sigma\Delta H^\circ_{f,products} - \Sigma\Delta H^\circ_{f,reactants}$	ΔH°_{rxn} = Standard enthalpy of reaction ΔH°_f = Standard enthalpy of formation Σ = Sum of all products/reactants
$\Delta H^\circ_{rxn} = \Sigma\Delta H_{bonds\ broken} - \Sigma\Delta H_{bonds\ formed}$	ΔH_{bonds} = Bond enthalpy
$\Delta G = \Delta H - T\Delta S$	ΔG = Gibbs Free Energy
$\Delta L = \alpha L\Delta T$	ΔL = Linear thermal expansion α = Coeff. of linear expansion
$\Delta V = \beta V\Delta T$	ΔV = Volumetric thermal expansion β = Coeff. of volumetric expansion

Physics: Waves, Sound, & Optics

Equation	Variable Definitions
$T = \frac{1}{f}$	T = Period f = Frequency
$v = f\lambda$	v = Wave speed f = Frequency λ = Wavelength
$I = \frac{P}{A}$	I = Intensity P = Power A = Area
$\beta = 10log\left((\frac{I}{I_0})\right)$	β = Sound Level (dB) I_0 = Threshold of hearing

$f' = f\frac{v \pm v_d}{v \mp v_s}$	f' = Observed freq. (Doppler Effect)
$f_{beat} = (\lvert f_1 - f_2 \rvert)$	f_{beat} = Beat frequency f1, f2 = Frequencies of two waves
$\lambda_n = \frac{2L}{n}$	Wavelength in open pipes / strings
$\lambda_n = \frac{4L}{n}$	Wavelength in closed pipes (n=1,3,5...)
$c = f\lambda$	c = Speed of light (3x10^8 m/s)
$E = hf$	E = Energy of a photon
$\theta_{incidence} = \theta_{reflection}$	Law of Reflection
$n = \frac{c}{v}$	n = Index of refraction v = Speed of light in medium
$n_1 sin\theta_1 = n_2 sin\theta_2$	n_{1, n_2} = Refractive indices of media θ_1 = Angle of incidence θ_2 = Angle of refraction Snell's Law
$\theta_c = sin^{-1}\left((\frac{n_2}{n_1})\right)$	θ_c = Critical Angle for Total Internal Reflection
$\frac{1}{f} = \frac{1}{o} + \frac{1}{i}$	f = Focal length o = Object distance i = Image distance
$m = -\frac{i}{o}$	m = Magnification

$P = \frac{1}{f}$	P = Lens power (diopters) f = Focal length (m)
$\frac{1}{f_{total}} = \frac{1}{f_1} + \frac{1}{f_2} + \cdots$	Focal length of lenses in series
$P_{total} = P_1 + P_2 + \cdots$	Power of lenses in series
$m_{total} = m_1 \times m_2 \times \cdots$	Magnification for system of lenses
$\frac{1}{f} = ((n-1))\left((\frac{1}{R_1} - \frac{1}{R_2})\right)$	f = Focal length n = Index of refraction R1, R2 = Radii of curvature
$v = \sqrt{\left((\frac{T}{\mu})\right)}$	v = Wave speed on string T = Tension μ = Linear mass density
$v_{sound} = \sqrt{\left((\frac{\gamma RT}{M})\right)}$	v_{sound} = Speed of sound in gas γ = Heat capacity ratio M = Molar mass

Physics: Electricity & Magnetism

Equation	Variable Definitions
$F_e = \frac{kq_1q_2}{r^2}$	F_e = Coulomb's Law
$E = \frac{F}{q} = \frac{kQ}{r^2}$	E = Electric Field
$U = \frac{kQq}{r}$	U = Electrical Potential Energy

$V = \frac{U}{q} = \frac{kQ}{r}$	V = Electrical Potential (Voltage)
$\Delta V = \frac{W}{q} = Ed$	ΔV = Voltage Difference (uniform E field)
$I = \frac{Q}{\Delta t}$	I = Current
$V = IR$	V = Voltage I = Current R = Resistance Ohm's Law
$P = IV = I^2R = \frac{V^2}{R}$	P = Electric Power
$R = \frac{\rho L}{A}$	R = Resistance ρ = Resistivity L = Length A = Area
$R_s = R_1 + R_2 + \cdots$	R_s = Resistors in series
$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$	R_p = Resistors in parallel
$C = \frac{Q}{V}$	C = Capacitance
$U = \frac{1}{2}CV^2$	U = Energy in capacitor
$C_p = C_1 + C_2 + \cdots$	C_p = Capacitors in parallel

$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$	C_s = Capacitors in series
$F_B = qvBsin\theta$	F_B = Magnetic Force
$F_L = qE + qvB$	F_L = Lorentz Force

Chemistry: Atomic & Molecular Structure

Equation	Variable Definitions
$Max\ e^- = 2n^2$	n = Principal quantum number
$KE_{photoelectron} = hf - \Phi$	Φ = Work Function
$FC = V - N_{nonbonding} - \frac{1}{2}N_{bonding}$	FC = Formal Charge V = Valence e^- N = Number of e^-
$p = qd$	p = Dipole moment q = Magnitude of charge d = Displacement vector
$([\alpha]) = \frac{\alpha_{obs}}{c \cdot l}$	[α] = Specific rotation α_{obs} = Observed rotation c = Concentration (g/mL) l = Path length (dm)
$Wavenumber = \frac{1}{\lambda}$	λ = Wavelength

Chemistry: Stoichiometry & Solutions

Equation	Variable Definitions
$Molarity = \frac{moles\ solute}{L\ solution}$	M = Molarity (mol/L) Concentration in moles per liter
$Molality = \frac{moles\ solute}{kg\ solvent}$	m = Molality (mol/kg solvent) Temperature-independent concentration
$Normality = \frac{equivalents}{L\ solution}$	Normality (N)
$M_1V_1 = M_2V_2$	M_{1, M_2} = Initial and final molarity V_{1, V_2} = Initial and final volume Dilution equation
$ppm = \frac{mass\ solute}{mass\ solution} \times 10^6$	ppm = Parts per million
$moles = \frac{mass\ ((g))}{molar\ mass\ ((g/mol))}$	Moles calculation

Chemistry: Colligative Properties

Equation	Variable Definitions
$\Delta T_b = K_b \times m \times i$	ΔT_b = Boiling point elevation K_b = Ebullioscopic constant m = Molality i = van't Hoff factor
$\Delta T_f = K_f \times m \times i$	ΔT_f = Freezing point depression K_f = Cryoscopic constant m = Molality i = van't Hoff factor

$P_{solution} = \chi_{solvent} \times P^{\circ}_{solvent}$	χ = Mole fraction P° = Vapor pressure of pure solvent (Raoult's Law)
$\Pi = iMRT$	Π = Osmotic pressure i = van't Hoff factor M = Molarity R = Gas constant T = Temperature

Chemistry: Nuclear Chemistry

Equation	Variable Definitions
$N((t)) = N_0 e^{-\lambda t}$	N(t) = Number of nuclei at time t N_0 = Initial number of nuclei λ = Decay constant
$t_{1/2} = \frac{ln((2))}{\lambda}$	$t_{1/2}$ = Half-life λ = Decay constant
$A = \lambda N$	A = Activity (disintegrations/time) λ = Decay constant N = Number of nuclei
$E = mc^2$	E = Energy m = Mass defect c = Speed of light (Mass-Energy Equivalence)

Chemistry: Kinetics & Equilibrium

Equation	Variable Definitions
$rate = k([A])^x([B])^y$	rate = Reaction rate k = Rate constant [A], [B] = Concentrations x, y = Reaction orders Rate Law

$k = Ae^{\frac{-E_a}{RT}}$	k = Rate constant A = Pre-exponential factor E_a = Activation energy R = Gas constant T = Temperature (K) Arrhenius Equation
$K_{eq} = \frac{([C])^c([D])^d}{([A])^a([B])^b}$	K_{eq} = Equilibrium constant [A], [B] = Reactant concentrations [C], [D] = Product concentrations a, b, c, d = Stoichiometric coefficients Law of Mass Action

Chemistry: Solutions & Acids/Bases

Equation	Variable Definitions
$K_w = ([H^+])([OH^-]) = 1.0 \times 10^{-14}$	K_w = Autoionization of water
$pH = -log([H^+])$	[H+] = Hydrogen ion concentration pH definition
$pOH = -log([OH^-])$	pOH
$pK_a = -log(K_a)$	K_a = Acid Dissociation Constant
$pK_b = -log(K_b)$	K_b = Base Dissociation Constant
$pH = pK_a + log\left(\left(\frac{([A^-])}{([HA])}\right)\right)$	$[A^-]$ = Conjugate base [HA] = Acid (Henderson-Hasselbalch)
$K_{sp} = ([A^{n+}])^m([B^{m-}])^n$	K_{sp} = Solubility Product for A_mB_n

$mol\ M = \frac{It}{nF}$	mol M = Moles of metal deposited I = Current t = Time n = Electron equivalents F = Faraday constant
$E^{\circ}_{cell} = E^{\circ}_{red,cathode} - E^{\circ}_{red,anode}$	E°_{cell} = Standard cell potential
$\Delta G^{\circ} = -RTlnK$	ΔG° = Standard Gibbs free energy K = Equilibrium constant
$\Delta G = \Delta G^{\circ} + RTlnQ$	ΔG = Gibbs free energy Q = Reaction quotient

Biochemistry & Biology

Equation	Variable Definitions
$v = \frac{v_{max}([S])}{K_m + ([S])}$	Michaelis–Menten Equation
$R_f = \frac{distance\ spot\ moved}{distance\ solvent\ moved}$	R_f = Retardation factor (chromatography)
$([A]) = K_H \times P_A$	[A] = Concentration of gas A K_H = Henry's Law constant P_A = Partial pressure of A
$v = \frac{Ez}{f}$	v = Migration velocity (electrophoresis) E = Electric field z = Net charge f = Frictional coefficient
$p + q = 1$	p = Freq. of dominant allele q = Freq. of recessive allele

$p^2 + 2pq + q^2 = 1$	p^2, 2pq, q^2 = Hardy-Weinberg Genotype Frequencies
$E_{ion} = \frac{RT}{zF} ln\left(\left(\frac{([ion])_{out}}{([ion])_{in}}\right)\right)$	E_{ion} = Nernst Equation (Membrane Potential) z = Charge of the ion
$\Pi = iMRT$	Π = Osmotic Pressure i = van't Hoff factor M = Molarity
$\frac{1}{v} = \frac{K_m}{V_{max}} \frac{1}{([S])} + \frac{1}{V_{max}}$	Lineweaver-Burk equation
$Recombination\ Frequency = \frac{Recombinants}{Total\ Offspring} \times 100\%$	Recombination frequency
$Map\ Distance = Recombination\ Frequency$	Map distance (centiMorgans)
$\Delta G = \Delta G^{\circ} + RTln\left(\left(\frac{([products])}{([reactants])}\right)\right)$	ΔG = Gibbs free energy (biochemical)
$ATP\ Hydrolysis: \Delta G^{\circ} = -30.5\ kJ/mol$	ATP hydrolysis energy
$A = \varepsilon bc$	A = Absorbance ε = Molar absorptivity b = Path length c = Concentration (Beer-Lambert Law)
$K_d = \frac{([E])([S])}{([ES])}$	K_d = Dissociation constant E = Enzyme S = Substrate ES = Enzyme-substrate complex

Math & Statistics (MCAT Relevant)

Equation	Variable Definitions
$\sigma = \sqrt{\left(\left(\frac{\Sigma((x-\mu))^2}{N}\right)\right)}$	σ = Standard deviation μ = Population mean N = Population size
$SE = \frac{\sigma}{\sqrt{n}}$	SE = Standard error σ = Standard deviation n = Sample size
$y = mx + b$	y = Dependent variable m = Slope x = Independent variable b = y-intercept
$CI = \bar{x} \pm z\frac{\sigma}{\sqrt{n}}$	CI = Confidence interval $\bar{x}$ = Sample mean z = Critical value
$r^2 = \frac{Explained\ Variance}{Total\ Variance}$	r^2 = Coefficient of determination

Important Constants for MCAT

Equation	Variable Definitions
$R = 8.314\ J/(mol \cdot K)$	R = Universal gas constant
$N_A = 6.022 \times 10^{23}\ mol^{-1}$	N_A = Avogadro's number
$h = 6.626 \times 10^{-34}\ J \cdot s$	h = Planck's constant
$c = 3.00 \times 10^{8}\ m/s$	c = Speed of light in vacuum
$k_B = 1.381 \times 10^{-23}\ J/K$	k_B = Boltzmann constant

$F = 96{,}485\ C/mol$	F = Faraday constant
$g = 9.8\ m/s^2$	g = Gravitational acceleration (Earth)