

## MCAT Chemistry Study List

### Atoms, Molecules, and Quantum Mechanics

- Know the charges and approximate masses of protons, neutrons, and electrons.
- Understand isotopes and the way they are represented with atomic number and mass number ( ${}^A_Z\text{E}$ ).
- Know the definitions of molar mass and Avogadro's Number.
- Understand moles and be able to do calculations with moles.
- Be familiar with the periodic table and know the groups: alkali metals, alkaline earth metals, halogens, and noble gases.
- Know which parts of the periodic table represent metals, nonmetals, and metalloids, and also representative elements and transition elements.
- Know the basic characteristics of metals and nonmetals.
- Know that cations are formed by losing electrons from the highest energy shell first.
- Know that representative elements will form ions so as to acquire the stable noble gas electron configuration.
- Understand the concept of effective nuclear charge.
- Know the trends across the periodic table and within groups of the periodic table for: ionization energy, electronegativity, electron affinity, atomic radius, and metallic character.
- Know the prefixes to indicate multiples and submultiples of SI units (e.g., Mega, nano, etc.)
- Know that energy is always needed to break a bond and energy is always released when a bond is formed.
- Be able to calculate the empirical formula from percent composition and vice versa.
- Be able to calculate molecular formula from percent composition and molar mass.
- Know the nomenclature of inorganic compounds.
- Be able to balance chemical equations.
- Know the symbols that are used in chemical equations.
- Understand the concepts of limiting reagent and percent yield and be able to do calculations with them.
- Know the fundamental reaction types: combination, decomposition, single and double displacement.
- Know the meanings of the four quantum numbers and the values that they can assume.
- Know the Pauli Exclusion Principle, the Heisenberg Uncertainty Principle, the Aufbau Principle, and Hund's Rule.
- Understand electron configurations and be able to give electron configurations for atoms and ions.
- Know the relationship between energy, frequency, and wavelength.

### Gases

- Know the meaning of Standard Temperature and Pressure (STP).
- Know the postulates of the Kinetic Molecular Theory.
- Know the ideal gas law and the molar volume of 22.4 L at STP. (Remember to always use absolute temperature in gas calculations.)
- Understand the partial pressure of a gas and know Dalton's Law of partial pressures.

- Understand Graham's Law of Effusion and know how to do calculations with it.
- Understand deviations from the ideal gas law and their effects.

### Chemical Kinetics

- Understand the distinction between kinetics and equilibrium.
- Understand activation energy and how it relates to reaction rates.
- Know that reaction rates generally increase with temperature.
- Understand rate equations.
- Be able to derive the rate equation from rate data, and predict the effect of changing concentrations on the reaction rate.
- Understand reaction order and be able to recognize zeroth, first, second, and third order reactions.
- Understand that, in a multi-step reaction, the slowest step determines the overall rate.
- Know what catalysts are and that they increase the rate of a reaction (by lowering activation energy) but they do not change equilibrium.

### Chemical Equilibrium

- Understand that at equilibrium, chemical reactions have not stopped, but are going on at equal rates in the forward and reverse directions.
- Know how to do calculations involving the equilibrium constant ( $K$ ) and / or the reaction quotient ( $Q$ ).
- Be able to predict the direction of a reaction based on  $Q$  and  $K$ .
- Be able to use Le Chatelier's Principle to predict the effect on a reaction of changing concentrations or temperature (or pressure for gases).

### Thermodynamics

- Know the difference between a system and its surroundings.
- Know the meanings of open, closed, and isolated systems.
- Know the definition of state function and know what properties are state functions.
- Know what heat is and understand its three forms: conduction, convection, and radiation.
- Be aware that work and heat are not state functions and be able to do calculations on PV work.
- Know the first and second laws of thermodynamics and how they relate to heat engines (devices that convert heat to work).
- Understand the concept of temperature (as a substance gets hotter, its molecules are moving faster) and know how to use the Celsius and Kelvin (absolute) temperature scales.
- Know the meaning and definition of enthalpy.
- Understand the meaning of standard state for a substance (not the same as STP).
- Be able to use Hess' Law to calculate enthalpies of reactions from other reactions, including using the standard enthalpies of formation.
- Know the meaning and definition of entropy and the third law of thermodynamics.
- Know the meaning of Gibbs Free Energy and its relation to the spontaneity of a reaction.
- Understand the concept of heat capacity.
- Understand calorimeters (constant volume and constant pressure) and be able to do calculations of heat of reaction.

- Understand phase diagrams and know the meaning of triple point and critical point.

### Solutions

- Know the difference between solutions and colloids.
- Understand and be able to apply the concept of “like dissolves like.”
- Know the definition of electrolyte and be familiar with the common strong electrolytes.
- Know the definitions of the concentration units: molarity, molality, mole fraction, mass percent, and parts per million.
- Be able to do calculations with the concentration units.
- Understand the concept of heat of solution.
- Know the meaning of vapour pressure and its relation to boiling point.
- Understand Raoult’s Law.
- Be able to work with plots of vapour pressure vs. mole fraction for ideal and nonideal solutions.
- Know the meaning of saturated and unsaturated solutions.
- Know the definition of solubility product constant.
- Be able to calculate solubility from solubility product constant.
- Understand the common ion effect and how it affects solubility.
- Understand Henry’s Law.
- Know the effect of temperature on the solubility of solids and gases.
- Be able to do calculations of boiling point elevation and freezing point depression.
- Understand the effects of osmotic pressure.
- Be able to do calculations of osmotic pressure.

### Acids and Bases

- Know the Arrhenius, Bronsted-Lowry, and Lewis definitions of acids and bases.
- Know the definition of pH and be able to do calculations relating pH to concentration.
- Know the meaning of conjugate acid and conjugate base.
- Understand the concept of strong vs. weak acids (and bases).
- Know the common strong acids and bases.
- Understand how molecular polarity influences acidity.
- Know the trend of increasing acidity with increasing oxygen in oxyacids.
- Know the trends of acidity / basicity across the periodic table for binary hydrides.
- Know the value of the autoionization constant for water and be able to do calculations with it.
- Know the definition of acid dissociation constant and base dissociation constant.
- Be able to do calculations with  $pK_a$  and  $pK_b$ .
- Be able to calculate the pH given the concentration of weak acids or bases.
- Understand titration curves for strong or weak acids or bases and polyprotic acids or bases.
- For titration curves, know the definitions of equivalence point, half equivalence point and end point.
- Be able to use the Henderson – Hasselbalch equation to calculate pH or  $pK_a$ .
- Understand what buffers are and which part of a titration curve has maximum buffering.
- Understand how indicators work and be able to do calculations of their pH range.

### Electrochemistry

- Know the definitions of oxidation and reduction.
- Know the oxidation states of hydrogen, oxygen and fluorine.
- Be able to calculate the oxidation state of an element in a molecule or ion.
- Know the meaning of oxidizing agent and reducing agent.
- Know that reduction and oxidation always occur together.
- Understand standard reduction potentials and be able to predict the spontaneity of a reaction from them.
- Know the difference between galvanic (or voltaic) cells and electrolytic cells.
- Know the definition of concentration cell.
- Know that reduction always occurs at the cathode and oxidation always occurs at the anode.
- Know the relationship between Gibbs free energy and cell potential.
- Know the relationship between equilibrium constant and Gibbs free energy.