EXAM REVIEW

HESI A2 Cheat Sheet

CHEMISTRY

Chemistry Basics

Scientific notation

The decimal point is placed **after the first digit**, followed by **x 10 to the power of how many places you move the decimal point.**

Eg. 5.7899×10^3

The metric system

Conversions:

- **m to cm**, multiply by 100
- **cm to mm**, multiply by 10
- **km to m**, multiply by 1000
- **kg to grams**, multiply by 1000
- **grams to mg**, multiply by 1000
- **liters to kiloliters**, divide by 1000
- **ml to liters**, divide by 1000

Temperature scales

Celsius scale: the freezing point of water is 0°C and the boiling point is 100°C.
Fahrenheit scale: the freezing point of water is 32°F and the boiling point is 212°F.
Kelvin scale- the absolute temperature scale: the freezing point of water is 273.15 K and the boiling point is 373.15 K.

! Temperature differences are the same in units of kelvins and degrees Celsius.

Formula: $\Delta T(^\circ C) = \Delta T(K)$

Conversion:

- Celsius to Fahrenheit: $F = \frac{9}{5}C + 32$
- Fahrenheit to Celsius: $C = \frac{5}{9}(F - 32)$
- Celsius to Kelvin: $K = C + 273.15$
- Kelvin to Celsius: $C = K - 273.15$
- Fahrenheit to Kelvin: $K = \frac{5}{9}(F - 32) + 273.15$
- Kelvin to Fahrenheit: $F = \frac{9}{5}(K - 273.15) + 32$

Periodic table groups:

- Group 1 - **Alkali Metals** *(Li, Na, K, Rb, Cs, Fr)*
- Group 2 - **Alkali Earth Metals** *(Be, Mg, Ca, Sr, Ba, Ra)*
- Groups 3-11 - **Transition Metals** *(Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Y, Zr, Nb, Mo, Tc, Ru, Rh, Pd, Ag, Cd, Hf, Ta, W, Re, Os, Ir, Pt, Au, Hg, Rf, Db, Sg, Bh, Hs)*
- Group 15 - **Pnictogens** *(N, P, As, Sb, Bi)*
- Group 16 - **Chalcogens** *(O, S, Se, Te, Po)*

Atomic Structure

Atoms

- Negatively charged electrons follow a random pattern within defined energy shells around the nucleus.
- The nucleus contains more than 99.9% of the mass of the atom.
- Nuclei are made of positively charged protons and electrically neutral neutrons held together by a nuclear force.
- A = Z + N (mass number of nucleus = atomic number + number of neutrons).

Subatomic Particles:

- Proton: positively charged particle; charge is equal but opposite to the negative charge of the electron; the number of protons in the nucleus of an atom determines what kind of chemical element it is.
- Neutron: carries no electrical charge and has the same mass as the proton; not repelled by the cloud of electrons or by the nucleus.
- Electron: negatively charged particle.

Important Chemical Equations

Combustion of Methane:

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Photosynthesis (Simplified):

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Acid-Base Neutralization:

$HCl + NaOH \rightarrow NaCl + H_2O$

Formation of Water:

$2H_2 + O_2 \rightarrow 2H_2O$

Combustion of Hydrogen:

$2H_2 + O_2 \rightarrow 2H_2O$

Rusting of Iron:

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Formation of Ammonium Chloride:

$NH_3 + HCl \rightarrow NH_4Cl$

Decomposition of Sodium Chloride:

$2NaCl \rightarrow 2Na + Cl_2$

Synthesis of Ammonia (Haber Process):

$N_2 + 3H_2 \rightarrow 2NH_3$

Combustion of Propane:

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

Chemical Reactions

- **Combustion:** the formation of CO2 and H2O from the reaction of a chemical and O2.
- **Combination (synthesis):** the addition of 2 or more simple reactants to form a complex product.
- **Decomposition:** complex reactants are broken down into simpler products.
- **Single Displacement**: an element from one reactant switches with an element of the other to form two new reactants.
- **Double Displacement:** two elements from one reactant switch with two elements of the other to form two new reactants.
- **Acid-Base:** two reactants form salts and water.

Reversibility

Reversible Reactions - The reactants and products are never fully consumed; they are each constantly reacting and being produced.

Formula: $A + B \rightleftharpoons C + D$ ***Eg.*** $2NO_2 \rightleftharpoons N_2O_4$

Irreversible Reactions - Reactants convert to products and the products cannot convert back to the reactants.

Formula: $A + B \rightarrow C + D$ ***Eg.*** $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Reaction rate: Rate $= -\frac{1}{a}\frac{d[A]}{dt} = -\frac{1}{b}\frac{d[B]}{dt} = \frac{1}{c}\frac{d[C]}{dt} = \frac{1}{d}\frac{d[D]}{dt}$

Formula *(balanced chemical reaction):* $aA + bB \rightarrow cC + dD$

Oxidation - Reduction

Determining oxidation states - guidelines:

- The oxidation state of an individual atom is 0.
- The total oxidation state of all atoms in a neutral species is 0 and in an ion is equal to the ion charge.
- Group 1 metals have an oxidation state of +1 and Group 2 an oxidation state of +2.
- The oxidation state of fluorine is -1 in compounds.
- Hydrogen generally has an oxidation state of +1 in compounds.
- Oxygen generally has an oxidation state of -2 in compounds.
- In binary metal compounds, Group 17 elements have an oxidation state of -1, Group 16 elements of -2, and Group 15 elements of -3.

Concentration of solutions

Determining percent concentration:

- the mass of the solute divided by the mass of the solution

Formula: $\textit{Mass Percent} = \left(\frac{\textit{Mass of solute (g)}}{\textit{Total mass of solution (g)}}\right) \times 100$

- the volume of the solute divided by the volume of the solution

Formula: $\textit{Volume Percent} = \left(\frac{\textit{Volume of solute (mL)}}{\textit{Total volume of solution (mL)}}\right) \times 100$

- the mass of the solute divided by the volume of the solution

Formula: $\textit{Mass/Volume Percent} = \left(\frac{\textit{Mass of solute (g)}}{\textit{Volume of solution (mL)}}\right) \times 100$

Molarity - The number of moles of solute dissolved in one liter of solution: $M = \frac{n}{V}$

Dilutions - Calculating the molarity of a diluted solution: $M_1V_1 = M_2V_2$

Equivalents - One equivalent is equal to one mole of charge in an ion. The value of the equivalents is always positive regardless of the charge.

Chemical equilibrium

Conditions and properties of a system at equilibrium:

- The system must be closed, meaning no substances can enter or leave the system.
- Equilibrium is a dynamic process. Even though we don't necessarily see the reactions, both forward and reverse are taking place.
- The rates of the forward and reverse reactions must be equal.
- The amount of reactants and products do not have to be equal. However, after equilibrium is attained, the amounts of reactants and products will be constant.

Nuclear chemistry

Types of nuclear reactions:

- **Nuclear decay reactions** - Occur spontaneously under all conditions.

  Alpha: $^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$ *Gamma:* $^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}e^{+} + \nu_e$

  Beta: $^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e^{-} + \bar{\nu}_e$

- **Nuclear transmutation reactions** - Occur only under special conditions (the collision of a beam of highly energetic particles with a target nucleus or in the interior of stars).

  Formula (general representation): $^{A}_{Z}X + {}^{a}_{z}x \rightarrow {}^{A+a}_{Z+z}Y + \textit{other products}$