Chemical Engineering Cheatsheet

A comprehensive cheat sheet covering essential concepts and formulas in Chemical Engineering, useful for quick reference and exam preparation.

Thermodynamics

Fundamental Concepts

First Law of Thermodynamics	$\Delta U = Q - W$ • ΔU: Change in internal energy • Q: Heat added to the system • W: Work done by the system
Enthalpy (H)	$H = U + PV$ • U: Internal energy • P: Pressure • V: Volume
Second Law of Thermodynamics	$\Delta S \geq 0$ (for a closed system) • ΔS: Change in entropy
Gibbs Free Energy (G)	$G = H - TS$ • T: Temperature • S: Entropy • At constant T and P, $\Delta G < 0$ for a spontaneous process.
Helmholtz Free Energy (A)	$A = U - TS$ • At constant T and V, $\Delta A < 0$ for a spontaneous process.
Heat Capacity	$Cv = (\partial U/\partial T)v$ $Cp = (\partial H/\partial T)p$

Equations of State

Ideal Gas Law	$PV = nRT$ • P: Pressure • V: Volume • n: Number of moles • R: Ideal gas constant • T: Temperature
Van der Waals Equation	(P + a(n/V)^2)(V - nb) = nRT • a, b: Van der Waals constants
Peng-Robinson Equation	$P = (RT)/(V\_m - b) - (a\alpha)/(V\_m^{2 + 2bV\_m - b}2)$ • V_m: Molar volume • a, b, α: Peng-Robinson parameters

Thermodynamic Cycles

Carnot Cycle	$\eta = 1 - (Tc/Th)$ • η: Efficiency • Tc: Cold reservoir temperature • Th: Hot reservoir temperature
Rankine Cycle	Used in steam power plants. Includes pump, boiler, turbine, and condenser.

Fluid Mechanics

Fluid Properties

Density (ρ)	$\rho = m/V$ • m: Mass • V: Volume
Viscosity (μ)	Measure of a fluid's resistance to flow.
Surface Tension (σ)	Energy required to increase the surface area of a liquid.

Fluid Statics

Pressure (P)	$P = F/A$ • F: Force • A: Area
Hydrostatic Pressure	$P = \rho gh$ • ρ: Density • g: Acceleration due to gravity • h: Height
Buoyancy	Archimedes' principle: Buoyant force equals the weight of the fluid displaced.

Fluid Dynamics

Continuity Equation	$A1V1 = A2V2$ (for incompressible fluids) • A: Cross-sectional area • V: Velocity
Bernoulli's Equation	P + (1/2)ρV^2 + ρgh = constant • P: Pressure • ρ: Density • V: Velocity • g: Acceleration due to gravity • h: Height
Navier-Stokes Equations	Equations describing the motion of viscous fluid substances.
Reynolds Number (Re)	$Re = (\rho VD)/\mu$ • ρ: Density • V: Velocity • D: Diameter • μ: Viscosity
Friction Factor (f)	Used to calculate pressure drop in pipes.

Mass Transfer

Diffusion

Fick's First Law	J = -D (dC/dx) • J: Diffusion flux • D: Diffusion coefficient • C: Concentration • x: Distance
Fick's Second Law	$\partial C/\partial t = D (\partial^{2C/\partial x}2)$ • C: Concentration • t: Time • D: Diffusion coefficient • x: Distance

Mass Transfer Coefficient

Mass Transfer Coefficient (k)	Relates the mass transfer rate to the concentration difference. N = kΔC • N: Mass transfer rate • k: Mass transfer coefficient • ΔC: Concentration difference

Distillation

Relative Volatility (α)	α = (yA/xA) / (yB/xB) • yA, yB: Vapor mole fractions of components A and B • xA, xB: Liquid mole fractions of components A and B
McCabe-Thiele Method	Graphical method for designing distillation columns.
Fenske Equation	N_min = log((xA,D/xB,D) * (xB,B/xA,B)) / log(α) • N_min: Minimum number of trays • xA,D, xB,D: mole fractions of A and B in distillate • xA,B, xB,B: mole fractions of A and B in bottoms

Absorption

Stripping Factor (S)	S = (mG)/L • m: Slope of equilibrium line • G: Gas flow rate • L: Liquid flow rate

Chemical Reaction Engineering

Reaction Kinetics

Rate Law	-rA = k CA^n • -rA: Rate of disappearance of reactant A • k: Rate constant • CA: Concentration of A • n: Order of reaction
Arrhenius Equation	k = A exp(-Ea/RT) • k: Rate constant • A: Pre-exponential factor • Ea: Activation energy • R: Gas constant • T: Temperature

Reactor Types

Batch Reactor	Closed system; reactants are mixed and allowed to react for a certain time.
Continuous Stirred-Tank Reactor (CSTR)	Continuous flow of reactants and products; perfectly mixed.
Plug Flow Reactor (PFR)	Continuous flow; no mixing in the axial direction.

Reactor Design Equations

CSTR Design Equation	V = (FA0 XA) / (-rA) • V: Reactor volume • FA0: Molar flow rate of A at inlet • XA: Conversion of A • -rA: Rate of disappearance of A
PFR Design Equation	V = ∫(FA0 dXA) / (-rA) • V: Reactor volume • FA0: Molar flow rate of A at inlet • XA: Conversion of A • -rA: Rate of disappearance of A • Integration is performed over the range of conversion.