Thermodynamics Formulas - Chapters 19 and 20

1 First Law of Thermodynamics

Energy Conservation:

$$\Delta E_{\text{th}} = W + Q \tag{1}$$

where:

- ΔE_{th} = Change in thermal energy (J)
- W = Work done on the system (J)
- Q = Heat added to the system (J)

1.1 Work Done on an Ideal Gas

$$W = -\int_{V_i}^{V_f} P\,dV \tag{2}$$

1.2 Calorimetry Equation (Heat Transfer)

$$Q = mc\Delta T \tag{3}$$

where:

- Q = Heat energy transferred (J)
- m = Mass (kg)
- c = Specific heat capacity (J/kg·K)
- ΔT = Temperature change (K)

1.3 Heat of Transformation (Phase Change)

$$Q = \pm mL \tag{4}$$

where:

- L = Latent heat (J/kg)
- L_f = Heat of fusion (solid $\leftrightarrow$ liquid)
- L_v = Heat of vaporization (liquid $\leftrightarrow$ gas)

2 Heat Transfer Mechanisms

2.1 Conduction

$$\frac{dQ}{dt} = kA\frac{\Delta T}{L} \tag{5}$$

2.2 Radiation

$$\frac{dQ}{dt} = e\sigma AT^4 \tag{6}$$

3 Ideal Gases and Heat

3.1 Ideal Gas Law

$$PV = nRT \tag{7}$$

3.2 Internal Energy of an Ideal Gas

$$E_{\text{th}} = \frac{f}{2}nRT \tag{8}$$

3.3 Root-Mean-Square (RMS) Speed

$$v_{\text{rms}} = \sqrt{\frac{3k_BT}{m}} \tag{9}$$

4 Thermodynamic Processes

Isothermal Process:

$$W = -nRT\ln\left(\frac{V_f}{V_i}\right) \tag{10}$$

Adiabatic Process:

$$PV^\gamma = \text{constant} \tag{11}$$

$$TV^{\gamma-1} = \text{constant} \tag{12}$$

Heat Capacities:

$$C_P = C_V + R \tag{13}$$

For a monatomic gas:

$$C_V = \frac{3}{2}R, \quad C_P = \frac{5}{2}R \tag{14}$$

For a diatomic gas:

$$C_V = \frac{5}{2}R, \quad C_P = \frac{7}{2}R \tag{15}$$