TA: Cheat sheet

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Chapter 1 - INTRODUCTION AND BASIC CONCEPTS

Variation of pressure with depth in a fluid:

$$p_2 - p_1 = -\rho g \left(z_2 - z_1\right) \tag{1}$$

Absolute, atmospheric, and gage pressures:

$$p_{\text{abs}} = p_{\text{atm}} + p_{\text{gage}} \tag{2}$$

Absolute, atmospheric, and vacuum pressures:

$$p_{\text{abs}} = p_{\text{atm}} - p_{\text{vac}} \tag{3}$$

Temperature scales:

$$T[K] = T[^\circ C] + 273.15 \tag{4}$$

$$T[^\circ F] = \frac{9}{5} \times T[^\circ F] + 32 \tag{5}$$

$$T[R] = T[^\circ F] + 459.67 \tag{6}$$

$$\Delta T[K] = \Delta T[^\circ C] \quad \text{and} \quad \Delta T[R] = \Delta T[^\circ F] \tag{7}$$

Density and specific volume:

$$\rho = \frac{m}{V} = \frac{1}{\nu} \quad \text{and} \quad \nu = \frac{V}{m} \tag{8}$$

Specific gravity:

$$SG = \frac{\rho}{\rho_{\text{water}}} \tag{9}$$

Chapter 2 - ENERGY, ENERGY TRANSFER, AND GENERAL ENERGY ANALYSIS

Mass and mass flow rate:

$$m = \rho V \quad \text{and} \quad \dot{m} = \rho \dot{V} \tag{10}$$

Change in kinetic energy:

$$\Delta KE = \frac{1}{2} m \left(v_2^2 - v_1^2\right) \tag{11}$$

Change in potential energy:

$$\Delta PE = mg \left(z_2 - z_1\right) \tag{12}$$

Change in internal energy:

$$\Delta U = m \left(u_2 - u_1\right) \tag{13}$$

Rate of mechanical energy:

$$\dot{E}_{\text{mech}} = \dot{m}e_{\text{mech}} = \dot{m}\left(\frac{p}{\rho} + \frac{v^2}{2} + gz\right) \tag{14}$$

Boundary work:

$$\delta W_b = pdV \quad \text{and} \quad W_b = \int pdV \tag{15}$$

Electrical work:

$$W_e = VI\Delta t \tag{16}$$

Chapter 3 - PROPERTIES OF PURE SUBSTANCES

Mass, mole, and molar mass:

$$n = \frac{m}{M} \tag{17}$$

Ideal gas law:

$$pV = nRT \quad \text{and} \quad pV = mR_xT \quad \text{and} \quad p\nu = R_xT \tag{18}$$

Quality (only for mixture liquid-vapor) where 0 means saturated liquid and 1 means saturated vapor:

$$x = \frac{m_{\text{vapor}}}{m_{\text{total}}} = \frac{m_{\text{vapor}}}{m_{\text{liquid}} + m_{\text{vapor}}} = \frac{\nu - \nu_{\text{f}}}{\nu_{\text{g}} - \nu_{\text{f}}} = \frac{\nu - \nu_{\text{f}}}{\nu_{\text{fg}}} \tag{19}$$

$$x = \frac{u - u_{\text{f}}}{u_{\text{g}} - u_{\text{f}}} = \frac{h - h_{\text{f}}}{h_{\text{g}} - h_{\text{f}}} = \frac{s - s_{\text{f}}}{s_{\text{g}} - s_{\text{f}}} \tag{20}$$

$$H \equiv U + pV \quad \text{and} \quad h = \frac{H}{m} = u + p\nu \tag{21}$$

Compressibility factor

$$Z = \frac{p\nu}{R_xT} \quad \text{and} \quad p\nu = ZR_xT \tag{22}$$

$$Z = \frac{\nu}{\nu_{ideal}} \tag{23}$$

Reduced pressure and temperature

$$p_R = \frac{p}{p_{CR}} \quad \text{and} \quad T_R = \frac{T}{T_{CR}} \tag{24}$$

Pseudo-reduced specific volume

$$\nu_R = \frac{\nu}{R_xT_{CR}/p_{CR}} \tag{25}$$

Chapter 4 - ENERGY ANALYSIS OF CLOSED SYSTEMS

First law (closed systems):

$$dE = dU + dKE + dPE = \delta Q - \delta W \quad \text{and} \quad d\dot{E} = d\dot{U} + d\dot{KE} + d\dot{PE} = \delta\dot{Q} - \delta\dot{W} \tag{26}$$

$$\Delta E = \Delta U + \Delta KE + \Delta PE = Q - W \quad \text{and} \quad \Delta\dot{E} = \Delta\dot{U} + \Delta\dot{KE} + \Delta\dot{PE} = \dot{Q} - \dot{W} \tag{27}$$

Isobaric or monobaric processes ($\Delta p = 0$):

$$W_b = p\left(V_2 - V_1\right) \tag{28}$$

Polytropic (k is a constant):

$$pV^{\gamma} = k \tag{29}$$

Specific heat capacity

$$c = \frac{\delta q}{dT} \quad \text{and} \quad c_v = \left(\frac{\partial u}{\partial T}\right)_v \quad \text{and} \quad c_p = \left(\frac{\partial h}{\partial T}\right)_p \tag{30}$$

For ideal gases (internal energy depends only on temperature):

$$\delta u = u_2 - u_1 = \int_1^2 c_v(T) dT \approx c_{v,\text{avg}} \left(T_2 - T_1\right) \tag{31}$$

$$\delta h = h_2 - h_1 = \int_1^2 c_p(T) dT \approx c_{p,\text{avg}} \left(T_2 - T_1\right) \tag{32}$$

For ideal gases:

$$C_p - C_v = nR \quad \text{and} \quad \gamma = \frac{C_p}{C_v} \tag{33}$$

For solids or liquids $\implies$ incompressible:

$$c_p \approx c_v \approx c \tag{34}$$