Quiz 2
Chemical Engineering Thermodynamics
January 29, 2015

1) Write the energy balance. Explain which part represents the system and which part represents interactions at the boundaries. Explain how the energy balance is written for a closed-system, open-system and for a system under steady state conditions.

2) Write the energy balance for the following situation: An inflated balloon slips from your fingers and flies across the room. System: Balloon and its contents.

3)
One mole of an ideal gas ($C_P = 7R/2$) in a closed piston/cylinder is expanded from $T^i = 700$ K, $P^i = 0.75$ MPa to $P^f = 0.1$ MPa by the following pathways. For each pathway, calculate ΔU, ΔH, Q, and W_{EC}: (a) isothermal; (b) constant volume; (c) adiabatic.

R = 8.314 J/(mole °K)

Answers Quiz 2
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1) Write the energy balance. Explain which part represents the system and which part represents interactions at the boundaries. Explain how the energy balance is written for a closed-system, open-system and for a system under steady state conditions.

Closed System:

$$d\left[U+\frac{v^2}{2g_c}+\frac{g}{g_c}z\right] = dQ+dW_S+dW_{EC} \qquad 2.16$$

The right terms are interaction with the environment. The left term represents the system.

Open System:

$$\frac{d}{dt}\left[m\left(U+\frac{v^2}{2g_c}+\frac{gz}{g_c}\right)\right] = \sum_{inlets}\left[H+\frac{v^2}{2g_c}+\frac{gz}{g_c}\right]^{in}\dot{m}^{in} - \sum_{outlets}\left[H+\frac{v^2}{2g_c}+\frac{gz}{g_c}\right]^{out}\dot{m}^{out} \qquad 2.33$$

$$+\dot{Q}+\dot{W}_{EC}+\dot{W}_S$$

Steady-State Open System:

$$0 = \sum_{inlets}\left[H+\frac{v^2}{2g_c}+\frac{gz}{g_c}\right]^{in}\dot{m}^{in} - \sum_{outlets}\left[H+\frac{v^2}{2g_c}+\frac{gz}{g_c}\right]^{out}\dot{m}^{out}+\dot{Q}+\dot{W}_S \qquad 2.24$$

2) Write the energy balance for the following situation: An inflated balloon slips from your fingers and flies across the room. System: Balloon and its contents.

(ANS. $d[m\bar{U}+\bar{m}v^2_{balloon}/2g_c]/dt = [H+v^2/(2g_c)]^{out}dm/dt+\underline{W}_{EC}$)

3)

2.4 One mole of an ideal gas ($C_P = 7R/2$) in a closed piston/cylinder is expanded from $T^i = 700$ K, $P^i = 0.75$ MPa to $P^f = 0.1$ MPa by the following pathways. For each pathway, calculate ΔU, ΔH, Q, and W_{EC}: (a) isothermal; (b) constant volume; (c) adiabatic.

R = 8.314 J/(mole °K)

(2.04) One mole of an ideal gas (T^i = 700 K, P^i = 0.75 MPa)...

a) $\underline{\Delta U = \Delta H = 0}$ since isothermal,

$Q = -W = RT\ln(P_1/P_2) = 8.314(700)\ln(0.75/0.1) = \underline{11{,}726 \text{ J/mol}}$

b) $\underline{W = 0}$, $T_2 = T_1(P_2/P_1) = 700/7.5 = 93.3$ K,

$\Delta U = Q = C_v(T_2 - T_1) = 20.79(93.3-700) = \underline{-12610 \text{ J/mol}}$

$\Delta H = C_p(T_2 - T_1) = 29.1(93.3-700) = \underline{-17654 \text{ J/mol}}$

c) $Q = 0$, $T_2 = T_1(P_2/P_1)^{R/Cp} = 700(0.1/0.75)^{2/7} = 393.6$K

$\Delta U = W = C_v(T_2 - T_1) = 20.79(393.6-700) = \underline{-6368 \text{ J/mol}}$

$\Delta H = C_p(T_2 - T_1) = 29.1(393.6-700) = \underline{-8915 \text{ J/mol}}$