CHBI 201 FALL 2015 PSB Friday

Name:

ID:

QUIZ 8 – CH7

1) You built a cabin in the woods and for electricity you decide to build a small hydroelectric generator under a 75-m high waterfall. The flow rate of the waterfall is 10 m /h, and you anticipate needing 750 kW h/wk to run your lights, air conditioner, and television. Calculate the maximum power theoretically available from the waterfall and see if it is sufficient to meet your needs.
(g = 9.82 m/s^2, 1 N = 1 kg.m/s^2, 1 J = 1 N.m, 1 J = 2.778x10^{-7} kW.h)

2) Oxygen at 150 K and 41.64 atm has a tabulated specific volume of 4.684 cm /g and a specific internal energy of 1706 J/mol. Calculate the specific enthalpy of O in this state.
(MW Oxygen = 32 g/mol, 1 L-atm = 101.32500 joules)

QUIZ SOLUTIONS:

1)

7.8

$$\Delta \dot{E}_p = \dot{m} g \Delta z = \begin{array}{c|c|c|c|c|c|c|c} 10^5 \text{ m}^3 & 10^3 \text{ L} & 1 \text{ kg H}_2\text{O} & 9.81 \text{ m} & -75 \text{ m} & 1 \text{ N} & 1 \text{ J} & 2.778 \times 10^{-7} \text{ kW} \cdot \text{h} \\ \hline \text{h} & 1 \text{ m}^3 & 1 \text{ L} & \text{s}^2 & & 1 \text{ kg} \cdot \text{m/s}^2 & 1 \text{ N} \cdot \text{m} & 1 \text{ J} \end{array}$$

$$= -2.04 \times 10^4 \text{ kW} \cdot \text{h/h}$$

The maximum energy to be gained equals the potential energy lost by the water, or

$$\begin{array}{c|c|c} 2.04 \times 10^4 \text{ kW} \cdot \text{h} & 24 \text{ h} & 7 \text{ days} \\ \hline \text{h} & 1 \text{ day} & 1 \text{ week} \end{array} = \underline{\underline{3.43 \times 10^6 \text{ kW} \cdot \text{h/week}}} \text{ (more than sufficient)}$$

2)

7.12

$$\hat{V} = \begin{array}{c|c|c} 32.00 \text{ g} & 4.684 \text{ cm}^3 & 10^3 \text{ L} \\ \hline \text{mol} & \text{g} & 10^6 \text{ cm}^3 \end{array} = 0.1499 \text{ L/mol}$$

$$\hat{H} = \hat{U} + P\hat{V} = 1706 \text{ J/mol} + \begin{array}{c|c|c} 41.64 \text{ atm} & 0.1499 \text{ L} & 8.314 \quad \text{J / (mol} \cdot \text{K)} \\ \hline & \text{mol} & 0.08206 \text{ L} \cdot \text{atm / (mol} \cdot \text{K)} \end{array} = \underline{\underline{2338 \text{ J/mol}}}$$

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TEAM WORK 8 – CH 7

1) Suppose you pour 1 gallon of water on a yowling cat 10 ft below your bedroom window.
   a) How much potential energy (ft lb) does the water lose?
   b) How fast is the water traveling (ft/s) just before impact?
   c) True or false: The kinetic energy of the water before impact must equal the kinetic energy of the cat after impact.

2) Methane enters a 3-cm ID pipe at 30^0C and 10 bar with an average velocity of 5.00 m/s and emerges at a point 200 m lower than inlet at 30^0C and 9 bar. Calculate the ΔK and ΔP assuming the methane behaves as ideal gas. (Hint: You need STP)

TEAM WORK SOLUTIONS:

1)

7.6 **(a)**

$$\Delta E_p = mg\Delta z = \frac{1\text{ gal}}{} \left| \frac{1\text{ ft}^3}{7.4805\text{ gal}} \right| \frac{62.43\text{ lb}_m}{1\text{ ft}^3} \left| \frac{32.174\text{ ft}}{\text{s}^2} \right| \frac{-10\text{ ft}}{} \left| \frac{1\text{ lb}_f}{32.174\text{ lb}_m\cdot\text{ft/s}^2} \right. = \underline{\underline{-83.4\text{ ft}\cdot\text{lb}_f}}$$

(b) $E_k = -\Delta E_p \Rightarrow \frac{mu^2}{2} = mg(-\Delta z) \Rightarrow u = [2g(-\Delta z)]^{1/2} = \left[2\left(32.174\frac{\text{ft}}{\text{s}^2}\right)(10\text{ ft})\right]^{1/2} = \underline{\underline{25.4\frac{\text{ft}}{\text{s}}}}$

(c) $\underline{\underline{\text{False}}}$

2) **7.7** Mass flow must be the same at the inlet to attain steady-state condition.

$$\Delta \mathbf{K} = \mathbf{m}/_2(\mathbf{v}_2^2 - \mathbf{v}_1^2) \text{ and } \Delta \mathbf{P} = \mathbf{mg}(\mathbf{h}_2 - \mathbf{h}_1)$$

Determine the mass flow:

Volumetric flow at the inlet = $\mathbf{v_1A}$

If methane behaves as an ideal gas:

$$V = v_1A = \frac{mRT}{(MW)(P)}$$

Solving for mass flow:

$$m = \frac{(v_1A)(MW)(P_1)}{RT_1} = 0.0225\,kg/s$$

$$\dot{m} = \frac{5\text{ m}}{\text{s}}\left|\frac{\pi(1.5)^2\text{ cm}^2}{}\right|\frac{1\text{ m}^3}{10^4\text{ cm}^2}\left|\frac{273\text{ K}}{303\text{ K}}\right|\frac{10\text{ bars}}{1.01325\text{ bars}}\left|\frac{1\text{ kmol}}{22.4\text{ m}^3\text{ (STP)}}\right|\frac{16.0\text{ kg CH}_4}{1\text{ kmol}}$$

$$= 0.0225\ \text{kg/s}$$

Solving for ΔP:

$$\Delta P = mg(h_2 - h_1) = \left(0.0225\frac{kg}{s}\right)\left(9.81\frac{m}{s^2}\right)(-200\,m)$$

$$\Delta P = -44.1\frac{J}{s} = -44\,W$$

Determine v_2:

$$P_1V_1 = P_2V_2$$

$$P_1(v_1A) = P_2(v_2A)$$

Solving for v_2:

$$v_2 = v_1\left(\frac{P_1}{P_2}\right) = 5.00\frac{m}{s}\left(\frac{10\,bar}{9\,bar}\right) = 5.555\,m/s$$

Solving for ΔK:

$$\Delta K = \frac{m}{2}\left(v_2^2 - v_1^2\right) = \frac{1}{2}\left(0.0225\frac{kg}{s}\right)\left(5.555^2 - 5.00^2\frac{m^2}{s^2}\right)$$

$$\Delta K = 0.0659\frac{J}{s} = 0.0659\,W$$