Homework 7 (Group) Due date: 12-Mar-2007

1. (Chapter 7, Prob. 7.38) Jets of high-speed steam are used in spray cleaning. Steam at 15.0 bar with 150^{o}C of superheat is fed to a well-insulated valve at a rate of 1.00 kg/s. As the steam passes through the valve, its pressure drops to 1.0 bar. The outlet stream may be totally vapour or a mixture of vapour and liquid. Kinetic and potential energy changes may be neglected.
   a) Draw and label a flowchart, assuming that both liquid and vapour emerge from the valve.
   b) Write an energy balance and use it to determine the total rate of flow of enthalpy in the outlet stream. Then determine if the outlet stream is in fact a mixture of liquid and vapour or if it is pure vapour. Explain your reasoning.
   c) What is the temperature of the outlet stream?

2. (Chapter 7, Prob. 7.30) During a period of relative inactivity, the average rate of transport of enthalpy by the metabolic and digestive waste products leaving the body minus the rate of enthalpy transport by raw materials ingested and breathed into the body is approximately ΔH = -300 k/h. Heat is transferred from the body to it surroundings at a rate given by

$$Q = hA(T_s - T_o)$$

   where A is area of the body surface (roughly 1.8 m^2 for an adult), T_s is the skin temperature (normally 34.2^{o}C), T_o is the temperature of the body surroundings, and h is a **heat transfer coefficient**. Typical values of h for the human body are:

$$h = 8 \frac{kJ}{m^2 h\,^oC} \text{ (fully clothed, slight breeze blowing)}$$

$$h = 64 \frac{kJ}{m^2 h\,^oC} \text{ (nude, immersed in water)}$$

   a) Write an energy balance on the body, making all appropriate simplifications. Find the surrounding temperature for which the energy balance is satisfied (i.e., at which a person would feel neither hot nor cold) for a clothed person and for a nude person immersed in water.
   b) In terms of what you calculated in part a) suggest why you feel colder on a windy day than on a day where the temperature is the same but there is no wind.

3. (Chapter 7, Prob. 7.43) Superheated steam at T_1 (^{o}C) and 10.0 bar is combined with saturated steam at T_2 (^{o}C) and 7.0 bar in a ratio 1.96 kg of steam at 10 bar to 1.0 kg of steam at 7 bar. The product steam is at 250^{o}C and 7.0 bar. The process operates at steady state.
   a) Calculate T_1 and T_2, assuming that the blender operates adiabatically (no heat loss or gain).
   b) If in fact heat is being lost from the blender to the surroundings, is your estimate of T_1 too high or too low? Briefly explain.

4. (Chapter 7, Prob. 7.26) Liquid water is fed to a boiler at 24^{o}C and 10 bar and is converted at constant pressure to saturated steam. Use the steam tables to calculate $\Delta \hat{H}\left(kJ/kg\right)$ for this process, and then calculate the heat input required to produce 15,000 m3/h of steam at the exiting conditions. Assume that the kinetic energy of the entering liquid is negligible and that the steam is discharged through a 15-cm pipe.