AUIS ENGR 352 (Thermodynamics), Assignment 1

Submission deadline:[1] February 10, 2018

Tutorial discussion: February 22 and 25, 2018

1) The average atmospheric pressure $p_{atm}(z)$ as a function of altitude z can be approximated by

$$p_{atm}(z) = (1 - \alpha z)^{\beta}\, p_0,$$

where $\alpha = 2.2 \cdot 10^{-5}\,\text{m}^{-1}$, $\beta = 5.4$, and $p_0 = 101.3$ kPa is the average pressure at sea level ($z = 0$). Using this equation, calculate the average pressure difference between Sulaimani and Erbil.[2]

Air has a molar mass of $M = 28.97$ g mol^{-1}. Determine the altitude at a place where $V = 1$ m^3 of air, at a temperature of $T = 10$ °C, has a mass of $m = 1.1$ kg.

2) How much work needs to be done to a system to expand it isobarically from $V_1 = 5.20$ m^3 to $V_2 = 5.30$ m^3 at a pressure of $p = 1.5$ bar, assuming that the mass of the system is $m = 6.3$ kg?

3) A container with $m_{C6H6} = 200$ g liquid benzene, initially at a temperature of $T_1 = 285$ K, is placed inside a water bath (with $m_W = 1.0$ kg liquid water), initially at $T_2 = 300$ K. As a consequence, heat is transferred until thermal equilibrium is reached. How much heat is transferred from the water to the benzene during this process, if both the water and the benzene are at constant pressure $p = 101.3$ kPa, and what is the final temperature?

Neglect heat transfer to the surrounding air, etc., and only consider water and benzene. Assume constant molar isobaric heat capacities $c_{p,C6H6} = 132$ J K^{-1} mol^{-1} for benzene as well as $c_{p,W} = 75.4$ J K^{-1} mol^{-1} for water. The molar masses are $M_{C6H6} = 78.1$ g mol^{-1} for benzene as well as $M_W = 18.0$ g mol^{-1} for water.

4) An $m = 5$ kg mass of R134a, initially at $p_1 = 500$ kPa and $T_1 = 10$ °C (compressed liquid) is heated reversibly and isobarically until it reaches a superheated vapor state at $T_2 = 50$ °C. Use the log p – h diagram from the lecture to determine the amount of heat transferred to the fluid.

5) In a piston-cylinder device, a constant amount of R134a which is initially occupying a volume of $V_1 = 100$ ml in a saturated liquid state, is reversibly vaporized until the entire fluid has become (saturated) vapor. Using tabulated vapor-liquid equilibrium data, determine the work done, the heat transferred, and the total energy change of the fluid.

6) Wind is blowing steadily at a velocity of $\mathcal{V} = 12$ m s^{-1}, in normal direction, into a wind turbine with blades which have the diameter $d = 24$ m, offering a circular cross section area to the incoming flow of air. Determine the the power generated by a wind turbine with an energy conversion efficiency of $\eta = 30\%$ (where 100% would correspond to the total kinetic energy carried by the incoming air), assuming that the air has the density $\rho = 1.1$ kg m^{-3}.

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1 *Each problem contributes one credit to the overall grade. Submissions, individually or in groups of two, can be handed in on February 10 (at lecture time only), or deposited in the B-F2-01 mailbox by February 8.*

2 *Please look up the altitudes of the two cities from available resources.*