The Saylor Foundation's

ME103 Assessment, Unit 4: Guide to Responding

Instructions: Please answer each of the following questions to the best of your ability.

Questions:

1. Hot water at 84.3^{o}C is flowing a storage tank at a rate of 25 ton per hour. The water is passed through a heat exchanger, where it dissipates heat at a rate of 60,000 kJ/min. Calculate the temperature of water delivered to the storage tank.

2. 1 mole of air at 100 kPa and 300 K is heated up to 600 K. Calculate the changes in internal energy, enthalpy, and the work done and the heat supplied if the process is:

    a) a constant volume process

    b) a constant pressure process

    Consider air as an ideal gas, with C_p = 30 kJ/kmol K, C_v = 20 kJ/kmol K and molecular weight of air = 29.

3. Solve problem T3 on the following site:
http://web.mit.edu/16.unified/www/FALL/thermodynamics/HomeworkA/hw3.html

4. Solve problem T4 on the following site:

    http://web.mit.edu/16.unified/www/FALL/thermodynamics/HomeworkA/hw4.html

5. Solve problem T5 on the following site:

    http://web.mit.edu/16.unified/www/FALL/thermodynamics/HomeworkA/hw5.html

Solutions:

1. First let's assume that the changes in potential energy and kinetic energy of water are small compared to the change in enthalpy.

Thus, $\Delta m\ \Delta H = H_2 - H_1 = Q\ \Delta t$ where Δm is the amount of water flowing into the storage tank in a time interval of Δt, Q is the rate of heat exchange.

In other words, $\Delta H = C_p \Delta T = Q/(\Delta m/\Delta t) = 42{,}000$ kJ/min/(25 10^3 kg/60 min) = 144 kJ/kg

Or change in temperature $\Delta T = \Delta H/\ C_p$ = 144 kJ/kg/4.2 kJ/kgK = 34.3 K.

Thus the water temperature delivered to the storage tank is 84.3 – 34.3 = 50 ^{o}C.

2. a) Air changes from state 1 to state 2 in a constant volume process.

   At state 1, P_1= 100 kPa, T_1= 300 K and $V_1 = RT_1/P_1$

   At state 2, T_2= 600 K and $V_2 = V_1$

   Change in internal energy: $\Delta U = C_v\ \ \Delta T$ = 20 (600 – 300) = 6000 kJ

   Heat supplied: Q= ΔU = 6000 kJ

   Work done: $W = Q - \Delta U = 0$

   b) Air changes from state 1 to state 2 in a constant pressure process.

   At state 1, P_1= 100 kPa, T_1= 300 K and $V_1 = RT_1/P_1$

   At state 2, P_2 = 100 kPa, T_2 = 600 K

   Change in enthalpy: $\Delta H = C_p \Delta T$ = 30 (600-300) = 9000 kJ

   Heat supplied: Q = ΔH = 9000 kJ

   Change in internal energy:

   $\Delta U = \Delta H - \Delta(PV) = \Delta H - R\Delta T$ = 9000-8.314(600-300)=6506 kJ

   Work done: $W=Q- \Delta U = P\Delta V$ = 2494 kJ

3. The answer key to the problem is located at the bottom of the webpage at http://web.mit.edu/16.unified/www/FALL/thermodynamics/HomeworkA/hw3.html

4. The answer key to the problem is located at the bottom of the webpage at http://web.mit.edu/16.unified/www/FALL/thermodynamics/HomeworkA/hw4.html

5. The answer key to the problem is located at the bottom of the webpage at http://web.mit.edu/16.unified/www/FALL/thermodynamics/HomeworkA/hw5.html