AREN 2110: In class exercises

1st Law

1. 7.2 MJ of work is put into a gas at 1 MPa and 150 C while heat is removed at the rate of 1.5 kw. What is the change in internal energy of the gas after one hour?
   a. –5.7 MJ
   b. 1.8 MJ
   c. 8.7 MJ
   d. 13 MJ

2. One kg air is compressed from a volume of 1.0 m^3 and a pressure of 100 kPa to a volume of 0.147 m^3 and a pressure of 1000 kPa. Assuming the compression follows the relation Pv^n = constant, find the work done on the gas during the compression process.
   a. -70 kJ
   b. -100 kJ
   c. -118 kJ
   d. -235 kJ

3. Steam enters an adiabatic nozzle at 1 MPa, 30 m/s, and 250 C. At a point down stream in the nozzle, the enthalpy of the steam has decrease by 40 kJ/kg from the inlet value. What is the velocity at that point?
   a. 31 m/s
   b. 110 m/s
   c. 250 m/s
   d. 280 m/s

4. A boiler feedwater pump receives saturated liquid water at 50 C and compresses it isentropically to 1 MPa. For a water flow rate of 100 Mg/hr, estimate the pump power.
   a. -20 kw
   b. -28 kw
   c. -35 kw
   d. -39 kw

5. Calculate the power required to compress 10 kg/s air flow from 1 atm and 37 C to 2 atm and 707 C. For T = 310K, H = 290.4 KJ/KG AND FOR T = 980 K, h = 1023 kJ/kg.
   a. –5260 kw
   b. –7020 kw
   c. –7260 kw
   d. –7330 kw

6. Which of the following is true for an polytropic steady-flow process?
   a. $\frac{P_2}{P_1} = \left(\frac{v_1}{v_2}\right)^n \ldots$
   b. $w = - v(P_2 – P_1)$
   c. $P_1V_1 = P_2V_2$
   d. $P_1T_2 = P_2T_1$

7. Air is compressed from 100 kPa and 40 C to 1500 kPa and 130 C in a steady flow process. During the compression, each kilogram of air loses 90 kJ as heat to the surroundings. Air leaves the compressor at a rate of 10 m^3/min. What is the power requirement for the compressor?
    a. –126 kw
    b. –180 kw
    c. –195 kw
    d. –391 kw

8. Which of the following statements is the best expression of the first law of thermodynamics?
    a. The mass within a closed system does not change.
    b. The net energy crossing the system boundary equals the change in energy inside the system.
    c. The change of total energy is equal to the rate of work performed.
    d. All real process tent toward increased entropy.

2nd Law

1. A Carnot heat engine receives 100 kJ of heat from a high temperature reservoir at 370 C and rejects 37 kJ heat. Determine the temperature of the low temperature reservoir.
    a. –35 C
    b. 100 C
    c. 130 C
    d. 230 C

2. What is the maximum thermal efficiency possible in a power cycle operating between 600 C and 110 C?
    a. 47%
    b. 56%
    c. 63%
    d. 74%

3. A refrigeration cycle has a coefficient of performance of 80% of the COP for a Carnot refrigerator operating between the reservoir temperatures of 50 C and –5 C. For 3 kw of cooling, what is the required power input?
    a. 0.53 kw
    b. 0.62 kw
    c. 0.77 kw
    d. 0.89 kw

4. A heat pump takes heat from groundwater at 7 C and maintains a room at 21 C. What is the maximum COP possible for the heat pump?
    a. 1.4
    b. 2.8
    c. 5.6
    d. 21

5. An inventor claims that an engine produces 130 kw with a fuel consumption of 20 kg/h. The energy content of the fuel is 40,000 kJ/kg. The energy is received at a mean temperature of 500 C and rejected at a mean temperature of 50 C. Which laws of thermodynamics are violated?
    a. First law only
    b. Second law only
    c. Both first and second laws
    d. Neither first nor second laws

6. A Carnot cycle operates between the temperature limits of 800 K and 300 K. If the entropy of the low temperature reservoir increases 2.34 kJ/K, the cycle work is?
    a. 230 kJ
    b. 440 kJ
    c. 670 kJ
    d. 1200 kJ

7. 1 kg steam is initially at 400 C and 800 kPa (state 1). The steam expands adiabatically to 200 C and 400 kPa (state 2) in a closed process, performing 450 kJ work. The properties of the steam at the two states are: state 1, u_1 = 2959 kJ/kg, h_1 = 3267.1 kJ/kg, s_1 = 7.5716 kJ/kgK; state 2, u_2 = 2646.8 kJ/kg, h_2 = 2860.5 kJ/kg, s_2 = 7.1706 kJ/kgK. Which law(s) of thermodynamics does this process violate?
    a. Zeroth law
    b. First law
    c. Second law
    d. First and second laws

8. In a particular power cycle, 350 MJ of heat is transferred to the system each cycle. The heat rejected from the system is 297.5 MJ per cycle. What is the thermal efficiency of the cycle?
    a. 1% b. 5% c. 7.5% d. 15%