Assignment – 02

EN – 203, due date: 27-09-2004

Q.1 Water of volume 2 litre in a container is heated with a coil of 1 kW at 27℃. The lid of the container is open and energy dissipates at the rate of 160 J/sec. In how much time temperature will rise from 27℃ to 77℃? (Specific heat of water is 4.2 KJ/kgK)

Q.2 A fully charged car battery gradually discharges while lying on the shelf at a constant temperature. During discharging, it loses 250 kcal to the environment. The battery is then recharged slowly to its initial state. The charging process consumes 0.53 kWh of electricity. What is the heat transfer during the charging process?

Q.3 A tank contains 9 kg of liquid water at an initial temperature T_o ℃. A coil removes heat at the rate of $Q = K_1T$ from the tank. By constantly stirring, a paddle wheel maintains a uniform temperature in the tank. The rate of work input through the paddle wheel is $W= K_2T$. Temperature, T is in ℃ and K_1 and K_2 are constants. Derive the expression for the change in temperature w.r.t. time.

Q.4 A calorically perfect gas (specific heat at constant pressure 1000 J/kgK) enters and leaves a gas turbine with the same velocity. The temperature of the gas at turbine entry and exit are 1100 K and 400 K, respectively. The power produced is 4.6 MW, and heat escapes at the rate of 300 KJ/s through the turbine casing. The mass flow rate of the gas (in kg/s) through the turbine is?

Q.5 The heat capacity at constant pressure of a certain system is a function of temperature only and may be expressed as $C_p = 2.093 + 41.87/(t + 100)$ J/ ºC where t is the temperature of the system in ℃. The system is heated while it is maintained at a pressure of 1 atm. Until its volume increases from 2000 cm3 to 2400 cm3 and its temperature increases from 0℃ to 100℃.

(a) Find the magnitude of the heat interaction.

(b) How much does the internal energy of the system increase?

Q.6 Two reversible heat engines, E1 & E2, are working between temperatures T1, T2 and T3, respectively. Engine E1 takes heat at temperature T1 and rejects at temperature T2, whereas engine E2 takes heat at temperature T2 and rejects at temperature T3. Assume engine E2 takes all the heat rejected by engine E1. Derive the expression for Temperature T2 if:

a. Both the engines have same efficiency

b. Both the engine have same work output

Q.7 An inventor claims that heat engine has the following specifications

Power developed = 50 kW

Fuel burnt/hr = 3 kg

CV of fuel = 75,000 KJ/kg

Temperature limits = 627℃ and 27℃

Cost of fuel = ₹ 30/kg

Value of power = ₹ 5/kWh

Comment whether the engine is possible or not, if possible then is it economical to use such a engine ?

Q.8 Three engines A, B and C operating on Carnot cycle use working substances as argon, oxygen and air respectively. Which engine will have higher efficiency?

Q.9 An insulated storage tank, i.e. initially evacuated, is connected to a supply line carrying fluid at specific internal energy u_i and specific enthalpy h_i. The valve is opened, and the fluid flows into the tank from the supply line and reaches a pressure the same as that of the supply line. Show that the final specific internal energy of the fluid in the tank is equal to h_i

.**Q.10** It is proposed that solar energy be used to heat a large collector plate. The energy, in turn, is transferred as heat to a fluid within a heat engine, and the engine would reject energy as heat to the atmosphere. Experiments indicate that 0.5 kW/m2 of energy can be collected at the operating temperature of the plate, and the maximum efficiency of the engine is 0.2. What minimum collector area would be required for the plant to produce 1 KW of useful power?