Total number of printed pages – 7 B. Tech

BENG 1103/BE 2103

First Semester Examination – 2008

THERMODYNAMICS

Full Marks – 70

Time – 3 Hours

*Answer Question No. 1 which is compulsory and any **five** from the rest.*

The figures in the right-hand margin indicate marks.

Use of Steam table is allowed.

1. Answer the following questions : 2×10

   (a) What is the absolute pressure of the air in a tank when measured by a manometer containing oil of density 850 kg/m^3 and

P.T.O.

the difference between the two column is 60 cm. Atmospheric pressure is 98 kPa.

(b) During a heating process the temperature of body increased by 20°C. What will be the equivalent rise in temperature if measured in K, F and R ?

(c) Write four assumptions to consider a gas as an ideal gas.

(d) Write the difference between the microscopic and macroscopic from of energy.

(e) Show the phase diagram of a pure substance (except water) on P ~ T plane and spot the Triple Point and Critical Point.

(f) What do you mean by flow work in a Flow system ?

(g) In the absence of any friction and other irreversibilities, can a heat engine have an efficiency of 100% ? Justify.

(h) What is compressibility factor ?

(i) How the specific volume of a gas mixture is calculated ?

(j) What do you understand by the entropy principle ?

2. Air flows steadily at the rate of 0.4 kg/s through an air compressor, entering at 6 m/s with a pressure of one bar and a specific volume of 0.85 m^3/kg and leaving at 4.5 m/s with a pressure of 6.9 bar and a specific volume of 0.16 m^3/kg. The internal energy of air leaving is 88 kJ/kg greater than that of the air entering. Cooling water in a jacket sorrounding the cylinder absorbs heat from the air at the rate of 59 W. Calculate the power required to drive the compressor and the inlet and outlet cross-sectional area. 10

3. (a) Show that the efficiency of all reversible heat engine operating between the same temperature levels is the same. 5

(b) A reversible power cycle is used to drive a reversible heat pump cycle. The power cycle takes in Q_1 heat units at T_1 and rejects Q_2 at T_2. The heat pump abstracts Q_4 from the sink at T_4 and discharge Q_3 at T_3. Prove that

$$Q_4 / Q_1 = \frac{T_4}{T_1}\left(\frac{T_1 - T_2}{T_3 - T_4}\right)$$ 5

4. (a) Show that for an ideal gas $C_p - C_v = \frac{\bar{R}}{M}$.

Where

C_p = Specific heat at constant pressure,

C_v = Specific heat at constant volume

$\bar{R}$ = Universal gas constant

M = Molucular mass. 5

(b) Show that energy is a property of a system. 5

5. A mass of air is initially at 260°C and 700 kPa and occupies 0.025 m^3. The air is expanded at constant pressure to 0.08 m^3. A polytropic process with n = 1.35 is then carried out, followed by a constant temperature process which completes a cycle. All the processes are reversible. Find the heat received and heat rejected in the cycle and also calculate the efficiency of the cycle. 10

6. A mixture of ideal gases consists of 3 kg of CO_2 and 5 kg of N_2 at a pressure of 280 kPa and temperature of 25°C. Find (a) the mole fraction of each constituent, (b) the equivalent molecular weight of the mixture, (c) the

equivalent gas constant of the mixture, (d) the partial pressure and partial volumes, (e) the colume and density of the mixture, (f) C_p and C_v of the mixture. 10

7. One kg of ice at −5°C is exposed to the atmosphere which is at 27°C. The ice melts and comes into thermal equilibrium with atmosphere.

(a) Determine the entropy increase of the universe. 5

(b) What is the minimum amount of work necessary to convert the water back into ice at −5°C ? C_p of ice is 2.0 kJ/kg-k and latent heat of fusion is 333.3 kJ/kg. 5

8. Explain with neat sketch, the principle of operation of a power plant and a refrigerator. 10

Or

Two vessels A and B, each of volume 3 m^3 are connected by a tube of negligible volume. Vessel A contains air at 0.7 MPa, 95°C while vessel B contains air at 0.35 MPa, 205°C. Find the change of entropy when A is connected to B by working from the first principles and assuming the mixing to be complete and adiabatic.