2006-JADAVPUR UNIVERSITY

I B.E II SEMESTER MECHANICAL ENGINEERING

THERMODYNAMICS-I

TIME-3HOUR
MARKS-100

ANSWER ANY FIVE QUESTIONS ALL QUESTIONS CARRY EQUAL MARKS

1 (a) Define critical point and triple point for a pure substance.

(b) A vessel having a volume of 0.4m3 contains 2.0 kg of a liquid water and water vapor mixture in equilibrium at a pressure of 600 kPa. Calculate the volume and mass of vapor

(c) A rigid vessel having a volume of 15 Litres contains 10 kg of water (liquid + vapor) at 30°C. The vessel is now slowly heated. Will the liquid level inside eventually rise to the top or drop to the bottom of the vessel? What if the vessel contains 1 kg instead of 10 kg?

2. (a) Show the similarities and differences, if any between heat and work.

(b) Air is contained in a piston cylinder arrangement. The initial volume inside the cylinder is 100 Litres, at which state the pressure inside is 100 kPa. The spring is touching the piston at this state but exerts no force on it. [Turn over] Heat is now transferred to the system, causing it to expand until the volume is doubled, at which state the pressure in the cylinder is 300 kPa. During the process the spring force is proportional to the displacement of the piston from its initial position.

(i) Show the process on a P-V diagram.

(ii) Considering the air inside the cylinder as the system, calculate the work done by the system. What percentage of this work is done against the spring?

(c) Explain the concept of continuum?

3 (a) Starting from the equation of the First Law of Thermodynamics for a control volume, develop the equations for a steady state steady flow (SSSF) process and also for an uniform state uniform flow (USUF) process.

(b) Super heated vapour steam enters a turbine nozzle at

3 MPa, 350°C with a low velocity and exits the nozzle at 1.6 MPa with a velocity of 550 m/s. The steam mass flow rate is 0.5 kg./s. Calculate the quality of steam if it is wet saturated at nozzle exit or the temperature of the steam exiting the nozzle if it is super heated. Also find the exit area of the nozzle.

4. (a) Show that the Kelvin-Planck and Clausius statements of the Second Law of Thermodynamics are equivalent. Also prove that all engines operating in the Carnot cycle between two given constant temperature reservoirs have the same efficiency.

(b) Two reversible heat engines A and B are arranged in series. Engine A receives 200KJ at a temperature of 421°C from a high temperature thermal source and isrejecting heat directly to another thermal reservoir from which the engine B. receives heat and reject to a cold sink at temperature 4.4°C. If the work output of engine A is twice that of engine B, find (a) the temperature of the thermal reservoir between A and B

(b) the efficiency of each engine, and (c) the heat rejected to the cold sink.

5 Prove that the change of entropy for any process can be expressed as an equality of the form, where terms have their usual meanings.

7 Write short notes on any four of the following :

(a) Clausius inequality

(b) Generalised Compressibility Chart

(c) Availability of a system

(d) Proof of Maxwell relation (?v / ?T)P = –(?s / ?P)T

(e) First law of thermodynamics as a rate equation

(f) Assumptions of SSSF and USUF processes.