USN

06ME33

Third Semester B.E. Degree Examination, Dec.08/Jan.09

Basic Thermodynamics

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions choosing at least two questions from each part.***

Part A

1 a. Mention the characteristics of a thermodynamic property. **(04 Marks)**

b. Explain thermodynamic equilibrium. **(08 Marks)**

c. The temperature t on a certain Celsius thermometric scale is given by means of a property through a relation $t = a\ln P + b$ where a and b are constants and P is the property of the fluid. If, at the ice point and steam points the values of P are found to be 4 and 20 respectively, what will be temperature reading corresponding to a reading of P = 16? **(08 Marks)**

2 As an engineering student suggest the most economical process when it is desired to compress one mole of air ($\gamma = 1.4$) from an initial state of 300 K and 1 bar to a final state of 300 K and 10 bar from among the following processes:

a. Isothermal compression.

b. Cooling at constant pressure followed by heating at constant volume.

c. Adiabatic compression followed by cooling at constant volume and

d. Heating at constant volume followed by cooling at constant pressure.

Take the value of R = 8.314 J/mol K. **(20 Marks)**

3 a. State the important consequences of the first law of thermodynamics and show that perpetual motion machine of the first kind is impossible. **(08 Marks)**

b. In a thermal power plant operating in a steady state an adiabatic steam turbine receives 1 kg/s of superheated steam at 3 MPa and 400°C. The steam enters the turbine with a velocity of 10 m/s at an elevation of 10 m above the ground level. The steam leaves the turbine at 0.1 bar with 10% moisture content. The velocity of steam at exit is 3 times that at inlet and the exit is at an elevation of 40% of inlet. Show that it is safe to ignore the changes in kinetic energy and potential energy.

Given : P = 3 MPa and t = 400°C; h = 3232.5 kJ/kg; P = 0.1 bar;

$h_f = 191.83$ kJ/kg ; $h_g = 2584.8$ kJ/kg **(12 Marks)**

4 a. Show that of all heat engines working between two given thermal reservoirs, the Carnot engine is the most efficient one. **(08 Marks)**

b. It is proposed to produce 1000 kg of ice per hour from liquid water at 0°C in summer when the ambient atmospheric temperature is 37°C. It is planned to use a heat engine to operate the refrigeration plant. Hot water at 70°C, produced by solar heating acts as a source to the heat engine which uses atmosphere as the sink. Calculate i) the power required by the refrigeration plant ii) the ratio of the energy extracted from freezing water to that absorbed by heat engine and iii) the rate of rejection of heat by both the devices. Take enthalpy of fusion of water at 0°C as 333.43 kJ/kg. **(12 Marks)**

Part B

5 a. Apply the Clausius inequality for a system undergoing an irreversible cyclic change and show that the entropy change of the system is given by $ds \geq \frac{\delta Q}{T}$ **(06 Marks)**

b. Two identical blocks of mass m are at temperatures T_1 and T_2 and act as source and sink for the operation of a heat engine. Determine the maximum amount of work that can be obtained if the specific heat of the blocks is C in both cases. **(06 Marks)**

c. An inventor claims to have designed a heat engine, which absorbs 260 kJ of energy as heat from a reservoir at 52°C and delivers 72 kJ of work. His claim includes that the engine rejects 100 kJ and 88 kJ of energy to the reservoirs at 27°C and 2°C respectively. Verify the claim. How is the temperature of the source to be altered in accordance with the verification, if necessary? **(08 Marks)**

6 a. Explain Availability. **(05 Marks)**

b. What is the availability function for a non-flow process? **(05 Marks)**

c. Explain second law efficiency. **(05 Marks)**

d. In a thermal power plant, superheated steam at 50 bar and 400°C enters an adiabatic turbine and leaves as wet steam of quality 0.9 at 1 bar to the atmosphere at 30°C. Calculate the second law of efficiency of the turbine.
Take for steam at 50 bar and 400°C
$h_1 = 3198.3$ kJ/kg and $S_1 = 6.6508$ kJ/kg K
and at 0.1 bar
$h_f = 191.83$ kJ/kg and $h_g = 2584.8$ kJ/kg
$S_f = 0.6493$ kJ/kg K and $S_g = 8.1511$ kJ/kg K **(05 Marks)**

7 a. Define : i) Isothermal compressibility ii) Isentropic compressibility and iii) Coefficient of volume expansion. **(06 Marks)**

b. Explain the terms: i) Saturated liquid ii) Saturated power iii) Saturation temperature iv) Saturation pressure. **(08 Marks)**

c. Sketch and explain the PT diagram for water. **(06 Marks)**

8 a. Derive Vander Waal's constants in terms of critical properties. **(12 Marks)**

b. Define compressibility factor and explain its significance. **(03 Marks)**

c. A cylinder of 0.01 m^3 volume is filled with 0.727 kg of n-octane (C_8H_{18}) at 427.85 K. Assuming that n-octane obeys the Vander Waal's equation of state calculate the pressure of the gas in the cylinder. Take the constants a and b as 3.789 Pa $(m^3/mol)^2$ and 2.37×10^{-4} m^3/mol respectively. **(05 Marks)**

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