MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

ME-301

APPLIED THERMODYNAMICS

Time Allotted: 3 Hours Full Marks: 70

The questions are of equal value.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.
All symbols are of usual significance.

GROUP A
(Multiple Choice Type Questions)

1. Answer *all* questions. 10×1 = 10

(i) In a reciprocating compressor, air is generally compressed
(A) adiabatically (B) isothermally
(C) polytropically (D) none of these

(ii) The saturation temperature at the partial pressure of water vapour in the air-water vapour mixture is called
(A) dry bulb temperature (B) wet bulb temperature
(C) dew point temperature (D) saturation temperature

(iii) The slope of constant pressure line on temperature diagram is given by
(A) C_p/T (B) T/C_p (C) S/T (D) T/S

(iv) During throttling process
(A) heat exchange does not takes place
(B) no work is done by expanding steam
(C) there is no change of internal energy of steam
(D) all of these

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(v) An engine operates between temperature limits of 900 K and T_2 and another between T_2 and 400 K for both to be equally efficient, T_2 will be equal to
(A) 600 K (B) 650 K (C) 625 K (D) 700 K

(vi) The air standard Otto cycle comprises
(A) two constant pressure processes and two constant volume processes
(B) two constant pressure processes and two isentropic processes
(C) two constant volume processes and two isentropic processes
(D) none of these

(vii) Which is an intensive property of a system among the following?
(A) Viscosity (B) Temperature (C) Density (D) None of these

(viii) $\left(\frac{\partial p}{\partial v}\right)_T \left(\frac{\partial v}{\partial T}\right)_p \left(\frac{\partial T}{\partial p}\right)_v$ is equals to
(A) zero (B) 1 (C) – 1 (D) infinity

(ix) For same maximum pressure and temperature and same heat rejection for an Otto and diesel cycle.
(A) Otto cycle is more efficient (B) Diesel cycle is more efficient
(C) Both are equal (D) Efficiencies can't be compared

(x) A positive value of Joule-Thomson co-efficient of a fluid means
(A) temperature drops during throttling
(B) temperature remain constant during throttling
(C) temperature rise during throttling
(D) none of these

GROUP B
(Short Answer Type Questions)

Answer any *three* questions. 3×5 = 15

2. Prove that volumetric efficiency of a single stage air compressor working in a maximum pressure P_2 and minimum pressure P_1 is given by 5

$$\eta_{vol} = 1 + C - C\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}}$$

Symbols have their own meaning.

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3. A mass of 5 kg of water at 30°C is mixed with 1 kg of ice at 0°C. The combined system is open to the atmosphere. Assuming the mixing process as adiabatic, find the entropy change of the universe. Latent heat of ice is 334.5 kJ/kg. 5

4. Show that the optimum intermediate pressure of a two reciprocating compressor, minimum work is the geometric mean of the suction and discharge pressure. 5

5. Air enter an air compressor at a temperature of 35°C and RH = 70% and leaves at DBT = 25°C and RH = 50%. Show that the intermediate processes on a representative psychometric chart. What is this processes called? 5

6. From the Tds equations prove that 5

$C_p - C_v = -T\left(\frac{\partial v}{\partial T}\right)_p^2\left(\frac{\partial p}{\partial v}\right)_T$. Symbols have their own meanings.

GROUP C
(Long Answer Type Questions)

Answer any *three* questions. 3×15 = 45

7. (a) Two reversible heat engines A and B are arranged in series, A rejecting heat directly to B. Engine A receives 200 kJ at a temperature of 421°C from a hot source, while engine B is in communication with a cold sink at a temperature of 4.4°C. If the work output of A is twice that of B, find (i) the intermediate temperature between A and B, (ii) the efficiency of each engine, (iii) the heat rejected to the clod sink. 8

(b) 10 gm of water at 20°C concerted into ice at –10°C at constant atmospheric pressure. Assuming at specific heat of liquid water to remain constant at 4.2 J/g K and that of ice to be half of this value, and taking the latent heat of fusion of ice at 0°C to be 335J/g, calculate the total entropy change of the system. 7

8. (a) Compare the efficiency of otto, diesel and dual cycle for same compression ratio and heat rejection with the help of P-V and T-S diagram.

(b) What do you understand by engine knock? How does it originate?

(c) In an air standard dual cycle has a compression ratio of 16, and compression begins at 1 bar, 50°C. The maximum pressure is 70 bar. The heat transferred to air at constant pressure is equal to that at constant volume. Estimate:

(i) The pressure and temperature at the cardinal points of the cycle
(ii) The cycle efficiency
(iii) m.e.p. of the cycle. Take C_p = 1.00 kJ/kg K, C_v = 0.718 kJ/kg K.

9. (a) What will be the velocity of a fluid leaving nozzle, if the velocity of approach is very small? 3

(b) A mass of wet steam at temperature 165°C is expanded at constant quality 0.8 to pressure upto 3 bar. It is then heated at constant pressure to a degree of superheat of 66.5°C. Find the enthalpy and entropy changes during expansion and during heating. Draw the *T*-*s* diagrams. 5

(c) Air flows steadily at the rate of 0.4 kg/s through an air compressor, entering at 6 m/s with pressure of 1 bar and 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 0.16m^3/kg. The specific internal energy of the air leaving is 88 kJ/kg greater than that of the air entering. Cooling water in the jacket surrounding the cylinder absorbs heat from the air at the rate of 59 kJ/s. Calculate the power required to drive the compressor and the inlet outlet pipe areas. 7

10.(a) Steam initially at 0.3 MPa, 250°C is cooled at constant volume. 9
(i) At what temperature will the steam become saturated vapor?
(ii) What is the quality at 80°C?
(iii) What is the heat transfer per kg of steam is cooled from 250°C to 80°C?

(b) A system maintain at constant volume is initially at temperature T_1 and a heat reservoir at the lower temperature T_0 is available. Show that the maximum work recoverable as the system is cooled to T_0 is 6

$$W = C_v[(T_1 - T_0) - T_0 \ln (T_1/T_0)].$$

11.(a) A heat engine operating between two reservoirs at 1000 K and 300 K is used to drive a heat pump which extracts heat from the reservoir at 300 K , at a rate twice that at which engine rejects heat to it. If the efficiency of the engine is 40% of the maximum possible and the coefficient of performance of the heat pump is 50% of the maximum possible, make calculations for the temperature of the reservoir to which the heat pump rejects heat. Also workout the rate of heat rejection from the heat pump if the rate of supply of heat to the engine is 50 kW. 6

(b) Derive Clausius-Clapeyron equation. 5

(c) Prove that the entropy is a property. 4