Reg. No. : | | | | | | | | | | |

Question Paper Code: 31373

B.E. / B.Tech. DEGREE EXAMINATION, MAY 2016

Third Semester

Mechanical Engineering

01UME303 - ENGINEERING THERMODYAMICS

(Use of steam tables, charts may be permitted)

(Regulation 2013)

Duration: Three hours Maximum: 100 Marks

Answer ALL Questions

PART A - (10 x 2 = 20 Marks)

1. What is heat?
2. Prove that $Cp - Cv = R$.
3. State Zeroth law of thermodynamics. What is its application?
4. Deduce the relation between the COP of heat pump and refrigerator.
5. What is meant by thermodynamic temperature scale? How do you device such scale?
6. What do you understand by pure substance? Give some typical examples.
7. What is critical point? What are the properties of water at critical point?
8. What are the unique features of Van der Waals equation of state?
9. What is compressibility factor? What does it signify? What is its value for Van der Waals gas at critical point?

10. What is dew point temperature? How is it related to dry bulb and wet bulb temperature at the saturation condition?

PART - B (5 x 16 = 80 Marks)

11. (a) (i) Prove that internal energy is a property. (4)

(ii) 1 *kg* of gas at 1.1 *bar*, 27^oC is compressed to 6.6 *bar* as per the law $pv^{1.3}$ = Constant. Calculate work and heat transfer, if

(1) When the gas is ethane (C_2H_6) with molar mass of 30 *kg/k* mol and C_p of 2.1 *kJ/kgK*

(2) When the gas is argon *(Ar)* with molar mass of 40 *kg/k* mol and C_p of 0.52 *kJ/kgK*. (12)

Or

(b) (i) Derive the general energy equation for a steady flow system and apply the equation to a nozzle and derive an equation for velocity at exit. (8)

(ii) In an air compressor, air flows steadily at the rate of 0.5 *kg/sec*. At entry to the compressor, air has a pressure of 105 *kPa* and specific volume of 0.86 m^3/kg and at exit of the compressor those corresponding values are 705 *kPa* and 0.16 m^3/kg. Neglect Kinetic and potential energy change. The Internal energy of air leaking the compressor is 95 *kJ/kg* greater than that of air entering. The cooling water in the compressor absorbs 60 *kJ/s* of heat from the air. Find power required to derive the compressor. (8)

12. (a) (i) "Two reversible adiabatic lines cannot intersect". Is this statement true or false? Justify the answer. (4)

(ii) A reversible engine operates between a source at 972^oC and two sinks, one at 127^oC and another at 27^oC. The energy rejected is same at both the sinks. What is the ratio of heat supplied to the heat rejected? Also calculate the efficiency. (12)

Or

(b) (i) What are the conditions for reversibility? (2)

(ii) Differentiate between heat pump and refrigerator. (2)

(iii) 50 *kg* of water is at 313 *K* and enough ice at -5^oC is mixed with water in an adiabatic vessel such that at the end of the process all the ice melts and water at 0^oC is obtained. Find the mass of ice required and the entropy change of water and ice. Given C_p of water = 4.2 *kJ/kgK*, C_p of ice = 2.1 *kJ/kgK* and latent heat of ice = 335 *kJ/kg*. (12)

13. (a) (i) Draw the P – T diagram of a pure substance and label all the phases and phase changes. (4)

(ii) What do you understand by dryness fraction? What is its importance? (2)

(iii) A rigid tank of 0.03 m^3 capacity contains wet vapour at 80 *kPa*. If the wet vapour mass is 12 *kg*, calculate the heat added and the quality of the mixture when the pressure when the pressure inside the tank reaches 7 *MPa*. (10)

Or

(b) (i) What are the major problems of Carnot vapour cycle? (2)

(ii) What are the methods for improving the performance of Rankine cycle? (2)

(iii) Steam enters the turbine at 3 *MPa* and 400^oC and is condensed at 10 *kPa*. Some quantity of steam leaves the turbine at 0.6 *MPa* and enters open feed water heater. Compute the fraction of the steam extracted per *kg* of steam and cycle thermal efficiency. (12)

14. (a) (i) Write about Dalton's law of partial pressure and explain its importance. (8)

(ii) 0.45 *kg* of *CO* and 1 *kg* of air is contained in a vessel of volume 0.4 m^3 at 15^oC. Air has 23.3% of O_2 and 76.7% of N_2 by mass. Calculate the partial pressure of each constituent and total pressure in the vessel. Molar masses of *CO*, O_2 and N_2 are 28, 32 and 28 *kg/k* mol. (8)

Or

(b) (i) What is the use of Clapeyron equation? And write it down for liquid-vapour region. (6)

(ii) Explain the flow process of a real gas through a throttle value. Derive the expression for Joule Thomson coefficient and get its value for an ideal gas. (10)

15. (a) (i) Differentiate between

(1) Dry bulb temperature and Wet bulb temperature (4)

(2) Wet bulb depression and Dew point depression (4)

(ii) Air at $16^{o}C$ and 25% relative humidity passes through a heater and then through a humidifier to reach final dry bulb temperature of $30^{o}C$ and 50% relative humidity. Calculate the heat and moisture added to the air. What is the sensible heat factor? (8)

Or

(b) (i) In an adiabatic mixing of two streams, derive the relationship among the ratio of mass of streams, ratio of enthalpy change and ratio of specific humidity change. (8)

(ii) Saturated air at $20^{o}C$ at a rate of 1.167 m^3/s is mixed adiabatically with the outside air at $35^{o}C$ and 50% relative humidity at a rate of 0.5 m^3/s. Assuming adiabatic mixing condition at 1 atm, determine specific humidity, relative humidity, dry bulb temperature and volume flow rate of the mixture. (8)