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Question Paper Code: 43703

B.E. / B.Tech. DEGREE EXAMINATION, NOV 2018

Third Semester

Mechanical Engineering

14UME303 – ENGINEERING THERMODYNAMICS

(Regulation 2014)

Duration: Three hours

Maximum: 100 Marks

Answer ALL Questions

(Use of Steam table and Psychrometric chart are permitted)

PART A - (10 x 1 = 10 Marks)

- Which of the following is not an extensive property of a thermodynamic system?
 - Total mass
 - Total internal energy
 - Total Volume
 - Temperature
- The measurement of thermodynamic property known as temperature is based on
 - Zeroth law of thermodynamics
 - First law of thermodynamics
 - Second law of thermodynamics
 - None of the above
- Which of the following is correct?
 - $COP_{HP} = 1 + COP_{Ref}$
 - $COP_{Ref} = 1 + COP_{HP}$
 - $COP_{HP} + COP_{Ref} = 1$
 - none
- No engine which gives higher efficiency other than Carnot engine when working at same temperature limits is called
 - Kelvin statement
 - Clausius statement
 - Carnot theorem
 - Clausius inequality

5. The heat absorbed by water at its saturation temperature to get converted into dry steam at the same temperature is called
- (a) sensible heat (b) specific heat (c) total heat (d) latent heat
6. Determine the entropy per kg of steam at 2 MPa when the condition of the steam is dry saturated
- (a) 6.336 kJ/kgK (b) 5.2 kJ/kgK
(c) 7.233 kJ/kgK (d) 0 kJ/kgK
7. For a given mass of gas at constant pressure, its volume is directly proportional to the absolute temperature. It belongs to which law
- (a) Gay Lussa's law (b) Charle's law
(c) Joule's law (d) Boyle's law
8. Isothermal compressibility α
- (a) $\alpha = -\frac{1}{V} \left(\frac{\partial V}{\partial P} \right)_T$ (b) $\alpha = -\frac{1}{V} \left(\frac{\partial P}{\partial V} \right)_T$
(c) $\alpha = \frac{1}{V} \left(\frac{\partial V}{\partial T} \right)_P$ (d) $\alpha = -\frac{1}{V} \left(\frac{\partial V}{\partial P} \right)_T$
9. A humidification process means
- (a) Decrease in relative humidity (b) An increase in specific humidity
(c) A decrease in temperature (d) An increase in temperature
10. The relation between relative humidity (Φ) and degree of saturation (μ) is given by
- (a) $\mu = \frac{(P_b - P_v)}{(P_b - P_s)} \Phi$ (b) $\mu = \frac{(P_b - P_s)}{(P_b - P_v)} \Phi$ (c) $\mu = \frac{P_v}{(P_b - P_s)} \Phi$ (d) $\mu = \frac{(P_b + P_s)}{(P_b - P_v)} \Phi$

PART - B (5 x 2 =10 Marks)

11. State the first law for a closed system undergoing a process and a cycle.
12. Give the criteria of reversibility, irreversibility and impossibility of a thermodynamic cycle
13. What do you understand by triple point?
14. Define Dalton's law of partial pressure.
15. What is a psychrometer?

PART - C (5 x 16 = 80 Marks)

16. (a) (i) A steam power plant generates 180,000 kg/h of steam. Heat input required to raise this amount of steam in the boiler of the plant is 2600 kJ/kg of steam. The power output of the plant is 55 MW. What is the thermal efficiency of the plant? (8)
- (ii) In the above plant, if the coal consumption is 20,000 kg/h while the heat of combustion of the coal is 29,600 kJ/kg, determine
- (1) thermal efficiency of the steam generator (boiler)
 - (2) overall thermal efficiency of the power plant. (8)

Or

- (b) The compressor of a large gas turbine receives air from the ambient surrounding at 95 kPa and 20°C with a low velocity. At the compressor discharge, air exits at 1.52 MPa and 430°C with velocity of 90 m/s. The power input to the compressor is 5000 kW. Determine the mass flow rate of air through the unit. (16)
17. (a) A heat pump working on a Carnot cycle takes in heat from a reservoir at 5°C and delivers heat to a reservoir at 60°C. The heat pump is driven by a reversible heat engine which takes in heat from a reservoir at 840°C and rejects heat to a reservoir at 60°C. The reversible heat engine also drives a machine that absorbs 30 kW. If the heat pump extracts 17 kJ/s from the 5°C reservoir, determine (a) the rate of heat supply from the 840°C source, and (b) the rate of heat rejection to the 60°C sink. (16)

Or

- (b) 50 kg of water is at 313 K and enough ice at -5°C is mixed with water in an adiabatic vessel such that at the end of the process all the ice melts and water at 0°C is obtained. Find the mass of ice required and the entropy change of water and ice. Take C_p of water = 4.2 kJ/kgK, C_p of ice = 2.1 kJ/kgK and latent heat of ice = 335 kJ/kg. (16)
18. (a) Explain steam formation with relevant sketch and label all salient points and explain every point in detail. (16)

Or

(b) Calculate the increase in entropy of ice as it heated from -5°C to steam at 250°C at 1 atm . Use the following data

$$C_p \text{ of ice} = 2.093 \text{ kJ/kgK}$$

$$\text{Latent heat of fusion of ice} = 334.96 \text{ kJ/kg}$$

$$C_p \text{ of water} = 4.187 \text{ kJ/kgK}$$

$$\text{Latent heat of vaporization} = 2257 \text{ kJ/kg and}$$

$$C_p \text{ of steam at } 250^{\circ}\text{C} = 2.093 \text{ kJ/kgK} \quad (16)$$

19. (a) What is meant by phase change process? Derive Clausius-Clapeyron equation for a phase change process. Give the significance of this equation. (16)

Or

(b) (i) Prove that from the mathematical theorems, among the thermodynamics variables P , V and T , the following relation holds good

$$\left(\frac{\partial P}{\partial V}\right)_T \left(\frac{\partial V}{\partial T}\right)_P \left(\frac{\partial T}{\partial P}\right)_V = -1 \quad (8)$$

(ii) Show that $C_p - C_v = -T \left(\frac{\partial V}{\partial T}\right)_P^2 \left(\frac{\partial P}{\partial V}\right)_T$. (8)

20. (a) An industrial process requires an atmosphere having a RH of 88.4% at 22°C , and involves a flow rate of $2000 \text{ m}^3/\text{h}$. The external conditions are $44.4\% RH$, 15°C . The air intake is heated and then humidified by water spray at 20°C . Determine the mass flow rate of spray water and the power required for heating, if the pressure throughout is 1 bar . (16)

Or

(b) Explain the following with neat sketches

(i) Adiabatic saturation process

(ii) Adiabatic evaporative cooling

(iii) Cooling tower

(16)