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Paper Code : PC-ME301 Thermodynamics

UPID : 003491

Time Allotted : 3 Hours *Full Marks :70*

The Figures in the margin indicate full marks.
Candidate are required to give their answers in their own words as far as practicable

Group-A (Very Short Answer Type Question)

1. Answer any ten of the following : [1 x 10 = 10]

   (I) Equation of continuity comes from which conservation process?

   (II) Write down Clausius statement for 2nd law of Thermodynamics.

   (III) Entropy can be transferred to or from a system in which of the forms - heat transfer/mass flow?

   (IV) The efficiency of Carnot cycle is ____ than the efficiency of Rankine cycle.

   (V) For a process in which pV=C, work done is expressed as _____

   (VI) What is the limitation of the first law?

   (VII) In a cylinder, infinitesimal amount of work done by the gas on piston is given by _____.

   (VIII) What kind of energy can be present in molecules?

   (IX) Which of the following statement is true?
   a) between two saturated liquid lines is the compressed liquid region
   b) between saturated solid line and saturated liquid line with respect to solidification there exists the solid-liquid mixture region
   c) Both a and b
   d) None of the mentioned.

   (X) Write the steady flow energy equation for throttling device when potential energy and kinetic energy is taken as zero.

   (XI) A polytropic process (n = – 1) starts with P = 0, V = 0 and ends with P= 600 kPa, V = 0.01 m^3. Find the boundary work done.

   (XII) The slope of an isobar on h-s coordinates is equal to the absolute saturation temperature at that pressure - True or False?

Group-B (Short Answer Type Question)

Answer any three of the following [5 x 3 = 15]

2. Derive an expression for displacement work in a process where PV^n = constant. [5]

3. What is a pure substance? What is saturation temperature and saturation pressure? [5]

4. Discuss briefly about the concept of thermodynamic equilibrium and its importance in engineering thermodynamics. https://www.makaut.com [5]

5. What is a perpetual motion machine of first kind (PMM1)? Is it possible to manufacture a device based on PMM1? If not, explain why. [5]

6. Explain why efficiency of Rankine cycle is a function of mean temperature of heat addition. [5]

Group-C (Long Answer Type Question)

Answer any three of the following [15 x 3 = 45]

7. (a) 2 kg of a gas is contained in a piston–cylinder assembly at initial conditions of 2 m^3 and 100 kPa. The gas is allowed to expand to a final volume of 5 m^3. Determine the amount of work done when PV is a constant. [5]

   (b) Consider a gas contained in a piston–cylinder assembly as the system. The gas is initially at a pressure of 1000 kPa and occupies a volume of 0.1 m^3. The gas is taken to the final state where pressure is equal to 200 kPa, by the following two different processes. [10]

   (i) The volume of the gas is inversely proportional to the pressure.

   (ii) The process follows the path PV^n = constant, where n =1.4.

   Calculate the work done by the gas in each case.

8. One kg of fluid initially at 1000 kPa and 0.2 m^3 undergoes a quasi-equilibrium expansion to 200 kPa and 1.2 m^3 according to a linear relationship between pressure and volume. The internal energy of the fluid is given by the relation U = 2PV + 45 kJ. where P is in kPa and V is in m^3. Calculate the net work done, heat transfer, and the change in internal energy. [15]

9. An ideal Rankine cycle operating between temperature of 500 °C and 50 °C. Calculate the cycle efficiency and the quality of steam at the turbine outlet if the pump outlet pressure is 2 MPa. [at 2 MPa and 500°C h_1= 3467.6 h kJ/kg, s_1=7.4317 kJ/kgK; at 50 °C s_f= 0.7036 kJ/kgK, s_g=8.0771 kJ/kgK, h_3=h_f=209.3 kJ/kg; h_{fg}=2382.8 kJ/kg, v_3=v_f=0.001012 m^3/kg,P_2= 0.01235 MPa] [15]

10. (a) Sketch the P–V diagram for a pure substance and show the isotherms and constant quality lines on it. [5]

    (b) A rigid vessel of volume 0.2 m^3 contains 1 kg of steam at a pressure of 0.8 MPa. Evaluate the specific volume, dryness fraction, enthalpy and entropy of steam. [From the saturated steam table at 0.8 MPa the specific volume of saturated liquid and saturated vapour are v_f = 0.001115 m^3/kg and v_g = 0.2404 m^3/kg respectively. t_{sat} = 170.4 °C]. [10]

11. (a) Define dryness fraction of a liquid-vapour mixture in terms of enthalpy and entropy. [5]

    (b) A vessel of volume 0.08 m^3 contains a mixture of saturated water and saturated steam at a temperature of 200°C. The mass of the liquid present is 10 kg. Find the the mass, the specific volume, the enthalpy, the entropy and the internal energy of mixture. [From temperature based saturated steam table at 200 °C, saturation pressure is P_{sat} = 1.554 MPa ; is v_f = 0.001156 m^3/kg, v_g = 0.1274 m^3/kg; h_f = 852.4 kJ/kg; h_g = 2793.2 kJ/kg; s_f = 2.3313 kJ/kg-K; s_g = 6.4331 kJ/kg-K; u_f = 850.6 kJ/kg; u_g = 2595.3 kJ/kg] [10]