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10ME/AU33

Third Semester B.E. Degree Examination, Dec.2015/Jan.2016
Basic Thermodynamics

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Use of thermodynamic data hand book and steam tables is permitted.***

PART – A

1 a. Differentiate between: (i) Control mass and control volume (ii) Intensive and extensive properties, and classify the following into intensive and extensive properties. (i) Enthalpy (ii) Quality of steam (iii) Entropy and (iv) Density. **(06 Marks)**

b. Define the zeroth law of thermodynamics and explain how this law forms the basis for temperature measurement. **(06 Marks)**

c. A constant volume gas thermometer containing helium gas gives readings of gas pressure 1000 mm and 1366 mms of mercury at the ice point and steam point respectively.
i) Express the gas thermometer Celsius temperature interms of gas pressure.
ii) The thermometer when left standing in the atmosphere, registers 1075 mm of mercury. Determine the atmospheric temperature. **(08 Marks)**

2 a. Write the thermodynamic definition of work. With suitable example explain how it is more general than the definition of work in mechanics. **(04 Marks)**

b. A gas expands quasi-statically in a piston cylinder arrangement against the atmosphere and a spring. Initial pressure and volume are 400 KPa and 0.2 m^3 respectively. The final volume of gas is 0.6 m^3. Determine the total work done by the gas if the spring force is proportional to volume of the gas. Assume the atmospheric pressure as 101.325 KPa. **(08 Marks)**

c. A spherical balloon of 1 m diameter contains a gas at 200 KPa. The gas inside the balloon is heated until the pressure reaches 500 KPa. During the process of heating, the pressure of the gas inside the balloon is proportional to the diameter of the balloon. Calculate the work done by the gas inside the balloon. **(08 Marks)**

3 a. Write the first law equation for a closed system undergoing a non cyclic process and show that internal energy is a property of a system. **(08 Marks)**

b. Modify the general steady flow energy equation (SFEE) for the following cases:
(i) Steam turbine with negligible potential energy change if the process is adiabatic.
(ii) Horizontal steam nozzle with negligible entrance velocity of steam, if the process is non-adiabatic.
(iii) Insulated horizontal throttle valve. **(06 Marks)**

c. In a centrifugal compressor, the suction and delivery pressures are 100 KPa and 550 KPa respectively. The compressor draws 15 m^3/min of air which has a specific volume of 0.77 m^3/kg. At the delivery the specific volume is 0.20 m^3/kg. The compressor is driven by a 40 KW motor, and heat lost to the surroundings during compression is 30 KJ/kg of air. Neglecting change in potential and kinetic energy, calculate increase in internal energy per kg of air. **(06 Marks)**

4 a. Write Kelvin-Planck and Clausius statements of second law of thermodynamics. Show that violation of Clausius statement leads to the possibility of a perpetual motion machine of second type. **(10 Marks)**

b. Mention the factors that make a process irreversible. **(04 Marks)**

c. Using a heat engine of thermal efficiency 30% to drive a refrigerator having a COP of 5, what is the heat received by the heat engine for each MJ of heat removed from the cold body of the refrigerator. **(06 Marks)**

PART – B

5 a. Derive Clausius unequality and prove that entropy is a property. **(10 Marks)**

b. Explain the principle of increase of entropy. **(04 Marks)**

c. Two copper blocks weighing 10 kg each are initially at temperatures of 227°C and 27°C respectively. What is the change in entropy when these two blocks are brought into contact with each other? Take specific heat of copper as 0.4 KJ/kgK. **(06 Marks)**

6 a. Define the following: (i) Pure substance (ii) Triple point (iii) Critical point. **(06 Marks)**

b. With neat sketch explain the measurement of dryness fraction of steam by using throttling calorimeter. **(08 Marks)**

c. Calculate the internal energy per kg of superheated steam at pressure of 10 bar and a temperature of 300°C. Also find the change in internal energy if this steam is expanded to 1.4 bar and dryness fraction 0.8. **(06 Marks)**

7 a. Starting from the relation $Tds = du + Pdv$, show that for an ideal gas undergoing a reversible adiabatic process, the law for the process is given by $TV^{\gamma-1}$=Constant. **(06 Marks)**

b. Clearly distinguish between ideal and real gases. **(04 Marks)**

c. A quantity of air at a pressure of 100 KPa, 27°C occupying a volume of 0.5 m^3 is compressed to a pressure of 500 KPa and volume of 0.12 m^3 according to the law PV^n = constant. Find (i) The value of index 'n' (ii) The mass of air (iii) Work transfer (iv) Heat transfer during the process (v) Change in entropy. **(10 Marks)**

8 a. Write the Vander Waals equation of state. In what ways, it is an improvement over the ideal gas equation. **(06 Marks)**

b. Explain the following:
i) Compressibility factor ii) Reduced properties iii) Law of corresponding states iv) Generalised compressibility chart. **(08 Marks)**

c. Determine the specific volume of hydrogen gas when its pressure is 60 bar and temperature is 100 K by using, (i) Compressibility chart (ii) Vander Waal's equation
Take for H_2 $T_C = 239.76^0C$, P_C = 12.92 bar, $a = 0.25105 \times 10^5$ $Nm^2/kgmol^4$, $b = 0.0262$ $m^3/kgmole$. **(06 Marks)**

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