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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belgaum)

Third Semester, B.E. - Mechanical Engineering

Semester End Examination; Dec. - 2015

Basic Thermodynamics

Time: 3 hrs *Max. Marks: 100*

***Note**: i) Answer **FIVE** full questions, selecting **ONE** full question from each **unit**.*
ii) Thermodynamic data hand book may be allowed.
iii) Assume missing data if any.

UNIT - I

1 a. Distinguish between :
(i) Open and closed system (ii) Microscopic and Macroscopic approach 6
(iii) Intensive and Extensive properties.

b. Classify each of the following in to an open or a closed system, 4
(i) Refrigerator (ii) Ceiling fan (iii) Tea kettle (iv) Carburettor

c. A platinum wire is used as a resistance thermometer. The wire resistance is found to be 10 ohms and 16 ohms at Ice and steam points respectively and 30 ohms at sulphur boiling point of 444.6ºC. Find the resistance of the wire at 500ºC, if the resistance varies with the relation $R = R_0(1+At+Bt^2)$. 10

2 a. Describe thermodynamic equilibrium. 6

b. Show that heat and work are path functions and not properties of the system. 6

c. A stationary mass of gas is compressed in a frictionless weight from 10^5 N/m^2 and 0.102 m^3 to 6×10^5 N/m^2 and 0.032 m^3, Assume that pressure and volume are related by $PV^n = C$. Find the index of compression and work done on the gas system. 8

UNIT - II

3 a. Show that energy is a property of the system. 6

b. Write the steady flow energy equation for a flow process and explain the various energy terms appearing in that equation. 6

c. During certain process the temperature of a system changes from 100ºC to 200ºC. The heat transfer per degree changes in temperature is given by $\frac{\partial Q}{dT} = 1.005 kJ/kg°K$ and the work done per degree change in temperature is given by $\frac{\partial W}{dT} = (4 - 0.12T) kJ/kg°K$. 8

Calculate the change in internal energy of the system during the process.

4 a. Write down the general energy equation for steady flow system and simplify when applied to following systems : 10

Contd…2

(i) Centrifugal Pump (ii) Reciprocating compressor

(iii) Nozzle (iv) Turbine

b. Steam enters a turbine at a pressure of 4826 k pascals, The specific internal energy is 2958 kJ/kg and specific enthalpy of 3263 kJ/kg. The corresponding values at the exit of the turbine are 20.7 k pascals, 2102 kJ/kg and 2232 kJ/kg. The mass flow rate of the steam is 6.3 kg/s. There is a heat loss of 23.3 kJ/kg due to radiation. Determine; 10

(i) Power produced (ii) Inlet specific volume (iii) exit velocity if exit area is 0.464 m^2.

UNIT - III

5 a. With a neat sketch brief the working of a separating and throttling calorimeter to determine the quality of steam. 6

b. Draw a phase equilibrium diagram for water on P.T. co-ordinates indicating triple and critical point. 4

c. A vessel of volume 0.040 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250ºC. The mass of the liquid present is 9 kg. Find the total mass, specific volume, specific enthalpy, specific entropy and specific internal energy. 10

6 a. Define ; (i) Sub-cooled liquid (ii) Dryness fraction 6

(iii) Latent Heat of vaporization (iv) Degree of superheat

b. Draw the enthalpy and entropy diagram for water and indicate the following on the same, 4

(i) Saturated vapour line (ii) Critical point.

c. The following data were obtained with a separating and throttling calorimeter :

Pressure in Pipeline = 1.5 MPa

Condition after throttling = 0.1 MPa, 110ºC 10

During 5 minute moisture collected in separator = 0.150 litre at 70ºC

Steam condensed after throttling during 5 minutes = 3.24 kg.

Find the quality of steam in the pipeline.

UNIT - IV

7 a. Define the following : (i) Heat engine (ii) Thermal reservoir (iii) Heat pump 6

b. State and prove Carnot theorem. 6

c. An inventor claims that his engine has following specifications. Power developed equal to 75 kW, Temperature limits 750ºC and 25ºC. Fuel burned per hour is 3.9 kg. Heating value of the fuel of 74500 kJ/kg. State whether his claim is valid or not. 8

8 a. Give Kelvin-plank and Classius statements of second law of thermodynamics and show that they are equivalent. 10

Contd…3

b. Two Carnot engines A and B are connected in series between two thermal reservoirs maintained at 1000ºK and 100ºK, Engine ‘A’ receives 1680 kJ of heat from high temperature reservoir and rejects heat engine ‘B’. The engine ‘B’ takes in heat rejected by engine ‘A’ and rejects heat to low temperature reservoir. If the efficiencies of ‘A’ and ‘B’ are same. Determine; 10

(i) The temperature at which heat rejected by engine ‘A’

(ii) Heat rejected by engine ‘B’

(iii) Work done during the process ‘A’ and ‘B’

UNIT - V

9 a. State and prove Classius Inequality. 6

b. Explain principle of increase of entropy of universe. 6

c. A rigid cylinder containing 0.004 m^3 of Nitrogen (molecular mass = 28) at 1 bar and 300 K is heated reversibly until the temperature becomes 400 K Take $\gamma = 1.4$ 8

Determine; (i) The heat supplied (ii) The entropy change

10 a. Show that entropy is a property of the system. 6

b. An ideal gas is heated from temperature T_1 and T_2 by keeping its volume constant. The gas is expanded back to its initial temperature according to the law PV^n = constant. If the entropy change in the two processes are equal. Find the value of ‘n’ in terms of the adiabatic index ‘γ’. 6

c. Determine the entropy change of 4 kg of a perfect gas whose temperature varies from 127ºC to 227ºC during a constant volume process. The specific heat varies linearly with absolute temperature and is represented by the relation $C_V = (0.48+0.0096T)$ kJ/kg K. 8

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