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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

Make-up Examination; Jan / Feb - 2017

Basic Thermodynamics

Time: 3 hrs *Max. Marks: 100*

***Note**: i) Answer **FIVE** full questions, selecting **ONE** full question from each unit.*
ii) Assume suitably missing data, if any.
iii) Use of Thermodynamics data hand books is allowed.

UNIT - I

1 a. State and explain Zeroth Law of thermodynamics. 4

b. Distinguish the following and give at least one example for each :
i) Open system and Closed system
ii) Point function and Path function
iii) Extensive and Intensive properties. 6

c. With neat P-V diagram, derive an expression for work done in each case of the following :
i) Isothermal Process ii) Polytrophic Process. 10

2 a. Show that work is a path function. 4

b. Starting from a convenient common state on P-V diagram, show the four expansion processes for $n = 0$, $n = 1$, $n = \gamma$ (where γ is specific heat ratio) and $n = \infty$, what are each processes called? Indicate their names adjacent to the processes on the diagram. 6

c. A perfect gas is undergoing a process in which $T \propto V^{2/5}$. Calculate the work done by the gas, if gas going from state 1 in which the pressure is 100 bar and volume is 4 m^3 to the state 2 in which volume is 2 m^3. Also calculate the final pressure. 10

UNIT - II

3 a. State the first law of thermodynamics for cyclic process and show that energy is a property of a system. 10

b. A vertical cylinder of cross sectional area 0.1 m^2, fitted with a leak proof frictionless freely floating piston contains some air at a pressure of 1.2 bar, the air is agitated by a paddle wheel for 10 minutes. The shaft of the peddle wheel running at 250 rpm with a torque of 0.5 N-m is driven by an external prime mover. During the same period an electrical resistor housed in the cylinder and connected to an external 24 volt battery draws a current of 0.45 A to heat the air in the said period find the distance in cm, through which piston rises. Given that heat transfer from air is 5 kJ and internal energy of the air increased by 2 kJ. 10

Contd….2

4 a. Write the steady flow energy equation for an open system and explain the terms involved in it and simplify SFEE for; 6

i) Steam turbine (ii) Nozzle.

b. Air flowing in a 0.2 m diameter pipe at a uniform velocity of 0.1 m/s, the temperature and pressure are 27ºC and 150 kPa respectively. Determine the mass flow rate of the air assuming R to be 0.287 kJ/kg K. 4

c. A system receives 200 kJ of heat at constant volume and rejects 220 kJ of heat at constant pressure during which 40 kJ of work is done on the system. The system is brought back to its original state by an adiabatic process. Calculate the adiabatic work, if the initial internal energy is 240 kJ, then calculate the value of internal energy at all the states. 10

UNIT - III

5 a. What is pure substance? Can we treat air as a pure substance? 4

b. Draw T-V diagram with relevant details on the plot for pure water. 6

c. A vessel of volume 0.04 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 mass, the specific volume, the enthalpy and the entropy of the mixture. 10

6 a. Define dryness fraction of steam. What are the methods used to measure dryness fraction with neat sketch explain any one method. 10

b. A pressure cooker contains 1.5 kg of saturated steam at 5 bar, find the quantity of heat which must be rejected so as to reduce the quality to 60% dry. Determine the pressure and temperature of the steam in the new state. 10

UNIT - IV

7 a. What is refrigerator and heat pump?

Prove that $(cop)_{Heat\ pump} = (cop)_{refrigerator} + 1$. 6

b. Prove that Kelvin-Plank and Clausis statements of second law of TD are equivalent. 6

c. A reversible heat engine operates with two environments in the first it draws 12,000 kW from a source at 400ºC and in the second it draws 25,000 kW from a source at 100ºC. In both the operations, the engine rejects heat to a thermal sink at 20ºC. Determine the operation in which the engine delivers more power. 8

8 a. Define reversible process and mention the factors which render a process irreversible. 8

b. Two Carnot engines A and B are connected in series between two thermal reservoirs maintained at 1000 K and 100 K respectively. Engine A receives 1680 kJ of heat from high temperature reservoir and rejects heat to the Carnot engine B. Engine B takes in heat rejected by Engine A and rejects heat to the low temperature reservoir. If engine A and B have equal thermal efficiencies. Determine; 12

Contd….3

i) The heat rejected by engine B

ii) The temperature at which heat is rejected by engine A

iii) Work done by engine A and B

iv) If engine A and B delivers equal work, determine the efficiencies of the engines.

UNIT - V

9 a. State and prove Clausius inequality? What is the significance of Clausius inequality? 10

b. A 5 kg copper block at a temperature of 200ºC dropped into an insulated tank containing 100 kg oil at a temperature of 30ºC, find the increase in entropy of the universe due to this process when copper block and oil reach thermal equilibrium. Assume that the specific heat of copper and oil are respectively 0.4 kJ/kg K and 2.1 kJ/kg K. 10

10a. Define entropy and prove that it is a property of a system. 5

b. Using T.ds = du + P.dv relation obtain expression for change in entropy of an ideal gas. 5

c. A heat engine is supplied with :

i) 208 kJ/s of heat rejected

ii) 139 kJ/s of heat rejected 10

iii) 70 kJ/s of heat rejected

Classify which of the results report is reversible cycle, irreversible cycle or impossible cycle.

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