d) A pressure cooker of $0.15m^3$ capacity contains dry and saturated steam at a pressure of 12 bar. Calculate the quantity of heat which must be rejected so that the quality of the steam becomes 40%. 7

OR

A steam boiler initially contains $5m^3$ of steam and $5m^3$ of water at 10 bar. Steam is taken out at constant pressure until $4m^3$ of water is left. What is the heat transferred during the process? 7

Unit - V

5. a) List the assumptions made in the analysis of air standard cycles. 2

b) Sketch Otto, diesel and dual cycle on the pressure-volume and temperature-entropy chart. 2

c) Explain the Daltons law of partial pressures and Amagat-Leduc law of partial volumes. 3

d) In an air-standard diesel cycle with compression ratio 17, the conditions of air at the start of compression stroke are 1 bar and 300K. After addition of heat at constant pressure, the temperature rises to 2700K. Determine the

i) Thermal efficiency of the cycle and

ii) Mean effective pressure. 7

OR

A vessel contains 12kg of oxygen, 10kg of nitrogen and 28kg of carbon dioxide at 375 K temperature and 250kPa pressure. Determine the

i) Capacity of the vessel, and

ii) Partial pressure of each gas present in the vessel. 7

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Roll No ....

AU/IP/IEM/ME/AE/PR - 304

B.E. III Semester

Examination, June 2014

Thermodynamics

Time : Three Hours

Maximum Marks : 70

Note: i) Answer five questions. In each question part A, B, C is compulsory and D part has internal choice.

ii) All parts of each question are to be attempted at one place.

iii) All questions carry equal marks, out of which part A and B (Max. 50 words) carry 2 marks, part C (Max. 100 words) carry 3 marks, part D (Max. 400 words) carry 7 marks.

iv) Except numericals, Derivation, Design and Drawing etc.

Unit - I

1. a) State and explain Zeroth law of thermodynamics. 2

b) State first law of thermodynamics for a closed system undergoing a cycle. What are its limitations. 2

c) Prove that during a polytropic process heat transfer is given by $\frac{\gamma - n}{\gamma - 1} \times$ work done, where γ is the ratio of specific heat and n is the polytropic index. 3

d) $0.3m^3$ of an ideal gas at a pressure of 2 MPa and 500 K is expanded isothermally to 4 times the initial volume. It is then cooled to 300 K at constant volume and then compressed back polytropically to its initial state. Determine the

i) Network done and

ii) Heat transfer during the cycle. 7

OR

In a gas turbine the gas enters at the rate of 5 kg/s with a velocity of 50 m/s and enthalpy of 860 kJ/kg and leaves the turbine with a velocity of 150 m/s and enthalpy of 350 kJ/kg. The loss of heat from the gases to the surroundings is 20 kJ/kg. Assume for gas R = 0.286 kJ/kg and c_p = 1.005 kJ/kgK and the inlet conditions to be at 100 kPa and 27°C. Determine the

i) Power output of the turbine and

ii) Diameter of the inlet pipe. 7

Unit - II

2. a) Define heat engines, refrigerator and heat pump. 2

b) State Clausius theorem. What do you understand by entropy principle? 2

c) Show that the efficiency of a reversible engine operating between two given constant temperatures is the maximum. 3

d) A heat pump working on the Carnot cycle takes in heat from a reservoir at 12°C and delivers heat to a reservoir which takes in heat from a reservoir at 850°C and rejects heat to a reservoir at 70°C. The reversible heat engine also drives a machine that absorbs 30kW. If the heat pump extracts 20kJ/s from the 12°C reservoir, determine the

i) Rate of heat supply from the 850°C source and

ii) Rate of heat rejection to the 70°C sink. 7

OR

Each of three identical bodies satisfies the equation $U=CT$, where C is the heat capacity of each of the bodies. Their initial temperatures are 200K, 270K and 500K. If C=8.4kJ/K, what is the maximum amount of work that can be extracted in a process in which these bodies are brought to a final common temperature. 7

Unit - III

3. a) Write down the Vander Waals equation of state. How does it differ from the ideal gas equation of state? 2

b) What is the law of corresponding states? 2

c) Derive Maxwell's relation and state their importance in thermodynamics. 3

d) One kg-mole of oxygen at 350K undergoes a reversible non-flow isothermal expansion and the volume increases from 0.08m³/kg to 0.20m³/kg. For oxygen, coefficients a and b are 139.35×10^3 Nm²/(kg-mol)² and 0.0314m³/kg-mol respectively. Using Vander Waals equation of state, calculate the

i) Final pressure and

ii) Work done during the process. 7

OR

Derive the following relations for the difference in heat capacities

$$C_p - C_v = -T\left(\frac{\partial v}{\partial T}\right)_p^2 \left(\frac{\partial p}{\partial v}\right)_T = \frac{vT\beta^2}{\alpha}$$

Where α and β are isothermal compressibility and volume expansivity respectively and other symbols have their usual meanings. 7

Unit - IV

4. a) Explain the process of steam generation with the help of neat diagram on the pressure volume chart. 2

b) Why cannot a throttling calorimeter measure the quality if the steam is very wet? How is the quality measured then? 2

c) What is the main feature of triple point? State the values of pressure and temperature at the triple point of water. 3