Number of Questions 6(Six) *ME 201 ESE ET 1314_Set_1*

COLLEGE OF ENGINEERING, PUNE
2013-2014
End Semester Examination
ME-201: Engineering Thermodynamics

Programme: S.Y. B. Tech **Branch: Mechanical**

Time: ____to ____am/pm **Date __/11/2013** **Max. Marks: 60**

Instructions: 1. All questions are compulsory.
2. Illustrate your answer with neat sketches wherever necessary.
3. Assume suitable standard data, if necessary and mention it correctly
4. Figures to the right indicate full marks.
5. Use of steam table, Mollier chart and non-programmable electronic calculator is permitted.

Q1		**Answer any FIVE.**	
		(i) Gas at 1.5 bar and 295 K in a closed vessel is compressed to 10 bar. Its temperature then becomes 455 K. If the compression follows the law $pv^n = C$, find the value of n. (ii) 'In isochoric process all the heat supplied to the gas is utilized in increasing the internal energy of the gas.' Justify this statement. (iii) Steam at 1.4 MN/m^2 and of dryness fraction 0.7 is throttled to 0.11 MN/m^2. Determine the dryness fraction of the steam after throttling. (iv) State the significance of "Clausius inequality". (v) Explain with the help of sketch advantages of multi-staging of reciprocating compressor. (vi) In Modified Rankine cycle stroke length and hence cylinder size is reduced with the sacrifice of practically a quite negligible amount of work done.	10
Q2		**Answer any TWO.**	
	a)	A gas at a pressure of 1.4 MN/m^2 and temperature of 360 ^oC is expanded adiabatically to a pressure of 100 kN/m^2. The gas is then heated at constant volume until it again attains 360 ^oC, when its pressure is found to be 220 kN/m^2, and finally it is compressed isothermally until the original pressure of 1.4 MN/m^2 is attained. If the gas has a mass of 0.23 kg and Cp for the gas as 1.005 kJ/kg K, determine: (i) Sketch the p-v diagram for these processes and state whether it is a cycle. (ii) Value of the adiabatic index γ (iii) The change in internal energy during the adiabatic expansion (iv) Net work done	5
	b)	A vessel of 0.9 m^3 capacity contains 0.9 dry steam at 8 bar. Steam is blown off until the pressure drops to 4 bar. The valve is then closed and the steam is allowed to cool until the pressure falls to 3 bar. Assuming that the enthalpy of steam in the vessel remains constant during blowing off period, determine: (i) The mass of the steam blown off; (ii) The quality of the steam in the vessel after cooling; (iii) The heat lost by the steam per kg during cooling.	5

c) Write the Kelvin-Plank's and Claussius statements of Second Law of Thermodynamics. Prove the equivalence of these statements. Neat illustrative sketches are expected. **5**

Q3 a) A gas at a pressure of 1.4 MN/m^2 and temperature of 360 $^\circ$C is expanded adiabatically to a pressure of 100 kN/m^2. The gas is then heated at constant volume until it again attains 360 $^\circ$C, when its pressure is found to be 220 kN/m^2, and finally it is compressed isothermally until the original pressure of 1.4 MN/m^2 is attained. If the gas has a mass of 0.23 kg and Cp for the gas as 1.005 kJ/kg K, determine: **5**

(i) Sketch the p-v diagram for these processes and state whether it is a cycle.

(ii)Value of the adiabatic index γ

(iii) The change in internal energy during the adiabatic expansion

(iv) Net work done

b) Define 'an ideal gas.' State Boyle's law and Charle's Law and also write their expressions. Using Boyle's law and Charle's law derive the equation of state of a perfect gas. **5**

OR

c) Steam enters the condenser of a vapor power plant at 0.1 bar with a quality of 0.95 and condensate esxits at 0.1 bar and 45 $^\circ$C. Cooling water enters the condenser in a separate stream as a liquid at 20 $^\circ$C and exits as a liquid at 35°C with no change in pressure. Heat transfer from the outside of the condenser and changes in the kinetic and potential energies of the flowing streams can be ignored. For steady-state operation, determine: **5**

i) the ratio of the mass flow rate of the cooling water to the mass flow rate of the condensing stream.

ii) the rate of energy transfer from the condensing steam to the cooling water, in kJ per kg of steam passing through the con-denser.

Q4 **Answer any TWO**

a) Two Carnot refrigerators A and B are arranged in series. Refrigerator works in lower temperature T_3 and upper limit T_2 and Refrigerator B works in lower temperature T_2 and upper temperature T_1. W_A and W_B are the work input to refrigerator A and B respectively. If a composite Carnot refrigerator C works in the temperature limit of T_3 and T_1, prove that **5**

$$COP_C = \frac{COP_A x COP_B}{1+COP_A+COP_B}$$

If refrigerator A works in the temperature limits of -40 $^\circ$C and -12 $^\circ$C, Refrigerator B works in limits of -12 $^\circ$C and 35 $^\circ$C, determine the COP of the composite Carnot refrigerator working in the limits of -40 $^\circ$C and 35 $^\circ$C.

b) 0.06 m^3 of a perfect gas (molecular weight 30), at 6.9 bar and 60 $^\circ$C, is allowed to expand isentropically to a pressure of 1.05 bar and a temperature of 107 $^\circ$C. Calculate the work done during expansion. The gas is then compressed to 6.9 bar according to law $pv^{1.4}$=C. Calculate the final temperature of the gas, the heat transfer and the change of entropy during the compression. Represent both processes on *p-v* and *T-s* diagrams. **5**

c) What do you mean by multi-stage compression? State its advantages. Prove that the work done in two stage compressor per kg of air delivered with perfect inter-cooling is given by: **5**

$$W/kg = \frac{2n}{n-1} RT_1 \left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{2n}} - 1 \right]$$

Where the notations carry the usual meaning and units.

Q5 **Answer any TWO**

a) Using the law of conservation of energy, prove that for a polytropic process: **5**

$$(s_2 - s_1) = C_v \left(\frac{n-\gamma}{n-1} \right) . \ln \left(\frac{T_2}{T_1} \right) \text{ per kg of gas.}$$

Where the notations carry the usual meaning and units.

b) With the help of neat *p-v* and *T-s* diagram explain the working of Dual Combustion Cycle. Define explosion (pressure) ratio and cut-off ratio. Write the expression for efficiency of dual cycle. State any two reasons for actual thermal efficiency being different from the theoretical value. **5**

c) A steam turbine plant operates on the Rankine cycle. Steam is delivered from the boiler to the turbine at a pressure of 3.5 MN/m^2 and with a temperature of 350 ^{0}C. Steam from the turbine exhausts into a condenser at a pressure 10 kN/m^2. Condensate from the condenser is returned to the boiler using a feed pump. Neglecting losses, determine: **5**

i) the energy supplied in the boiler per kilogram of steam generated

ii) dryness fraction of the steam entering the condenser

iii) the Rankine efficiency

Q6 Answer ant TWO

a) Explain P-v-T surface in brief and Draw neat labelled sketch of P-v-T surface of a substance that expands on freezing and contracts on freezing. **5**

b) Draw *p-v* and *T-s* plot of Brayton Cycle and prove that the thermal efficiency, **4**

$$\eta_{th} = 1 - \frac{1}{(r_p)^{\frac{\gamma-1}{\gamma}}}$$ where the notations have the usual meaning.

An air standard Brayton cycle works in the pressure limits of 3.5 bar and 1 bar. If C_p and C_v of air are 1.0425 kJ/kg.K and 0.7662 kJ/kg.K respectively and remains constant in the cycle. determine efficiency of the cycle. **1**

c) Prove that minimum work required for a two stage reciprocating air compressor with complete inter-cooling is twice the work required for each stage. **5**