

**THERMODYNAMICS AND HEAT POWER ENGINEERING  
(ELE2204)**

**Time Allotted : 2½ hrs**

**Full Marks : 60**

*Figures out of the right margin indicate full marks.*

*Candidates are required to answer Group A and  
any 4 (four) from Group B to E, taking one from each group.*

*Candidates are required to give answer in their own words as far as practicable.*

**Group – A**

1. Answer any twelve:

**12 × 1 = 12**

*Choose the correct alternative for the following*

- (i) The value of  $\oint (\delta Q - \delta W)$  for a cyclic process is
  - (a) always positive
  - (b) always negative
  - (c) always zero
  - (d) any non-zero value
- (ii) A reversible refrigerator has COP of 9 with the freezer temperature of  $-3^{\circ}\text{C}$ . The ambient temperature is
  - (a)  $27^{\circ}\text{C}$
  - (b)  $30^{\circ}\text{C}$
  - (c)  $35^{\circ}\text{C}$
  - (d)  $37^{\circ}\text{C}$
- (iii) The set of independent intensive properties that cannot be used to designate the state of a saturated liquid-vapour mixture is
  - (a) P and v
  - (b) P and T
  - (c) P and x
  - (d) T and v
- (iv) A pure substance must have homogeneous
  - (a) molecular structure
  - (b) chemical composition
  - (c) phase
  - (d) all of these.
- (v) In an impulse turbine, steam expands \_\_\_\_\_
  - (a) wholly in nozzle
  - (b) partly in the nozzle and partly in blades
  - (c) wholly in blades
  - (d) none of the mentioned.
- (vi) \_\_\_\_\_ is regulated in nozzle governing.
  - (a) Pressure
  - (b) Temperature
  - (c) Flow rate
  - (d) None of the mentioned
- (vii) The terms bleeding in a steam turbine refers to
  - (a) Leakage of steam
  - (b) Steam doing no useful work
  - (c) Steam extracted for preheating feed water
  - (d) Removal of wet steam in the low pressure of turbine.

- (viii) In case of Induced draught, where is the fan/blower installed?  
 (a) Near the base of chimney (b) At the top of the chimney  
 (c) At the grate (d) At the base of the boiler
- (ix) Which of the following is not a heat recovery equipment?  
 (a) Economizer (b) Air preheater  
 (c) Feed water heater (d) Steam separator.
- (x) Identify the boiler mounting  
 (a) Super heater (b) Feed check valve  
 (c) Feed pump (d) Economiser.

*Fill in the blanks with the correct word*

- (xi) Work done in a free expansion is -\_\_\_\_\_.
- (xii) Efficiencies of all reversible heat engines working between same pair of temperatures are \_\_\_\_\_.
- (xiii) An ideal Rankine cycle is composed of two isentropics and two \_\_\_\_\_.
- (xiv) An economiser is installed in a boiler primarily for \_\_\_\_\_ of fuel consumption.
- (xv) When the nozzle is operated with the maximum mass flow, the nozzle is said to be \_\_\_\_\_.

### **Group - B**

2. (a) Define a thermodynamic system and classify different systems. What is meant by a thermodynamic process? Give examples. [[CO1](Remember/LOCQ)]
- (b) Consider a gas enclosed in a piston-cylinder arrangement. The gas is initially at a pressure of 150 kPa and occupies a volume of  $0.03 \text{ m}^3$ . The gas is now heated until its volume increases to  $1.2 \text{ m}^3$ . Calculate the work done by the gas if the volume of the gas is inversely proportional to the pressure. [[CO3](Apply/IOCQ)]
- 6 + 6 = 12**
3. (a) Write the Kelvin Planck and Clausius statements of second law of Thermodynamics. Show that the violation of one leads to the violation of the other. [[CO1](Remember/IOCQ)]
- (b) A blower handles 1.5 kg/s of air at 20°C and consumes a power of 16 kW. The inlet and outlet velocities of air are 120 m/s and 170 m/s respectively. Find the exit air temperature, assuming adiabatic conditions. Given that,  $c_p$  of air = 1.005 kJ/(kg.K). [[CO4](Apply/IOCQ)]
- 6 + 6 = 12**

### **Group - C**

4. (a) Determine the state of steam, i.e., whether it is wet (with dryness fraction), dry or superheated (with degree of superheat), as the case may be in the following cases.
- (i) Steam at 10 bar with specific volume  $0.175 \text{ m}^3/\text{kg}$
- (ii) Steam at 15 bar and 220°C

- (iii) Steam at 300°C and enthalpy 2600 kJ/kg [[CO4](Apply/LOCQ)]
- (b) Two boilers are supplying steam with equal mass flow rate to a main pipe steadily. Boiler-1 is supplying superheated steam at 350°C while boiler-2 is supplying unsaturated steam. The pressure in the boilers and the main pipe is 20 bar. Temperature of the steam in main pipe is 250°C. Find the temperature and dryness fraction of the steam supplied by boiler-2. [[CO4](Apply/LOCQ)]
- 6 + 6 = 12**
5. (a) What are the four basic components of a steam power plant? What is the reversible cycle that represents the simple steam power plant? Draw the flow,  $P - v$ ,  $T - s$  and  $h - s$  diagrams of this cycle. [[CO3](Apply/IOCQ)]
- (b) A steam power generating station uses the following cycle:  
 Steam at boiler outlet --- 150 bar, 550°C  
 Reheat at 40 bar to 550°C  
 Condenser pressure is 0.1 bar. Using Mollier chart (or otherwise) and assuming ideal processes, find (i) quality at turbine exhaust, (ii) cycle efficiency, and (iii) steam rate. [[CO3](Analyse/IOCQ)]
- 6 + 6 = 12**

### Group - D

6. (a) Combustion gases expand in a propulsion nozzle from 3.8 bar and 450°C to a back pressure of 1 bar at the rate of 16 kg/s. Assuming the inlet velocity is negligible, and taking coefficient of discharge is 0.98 and a nozzle efficiency is 0.93, calculate the required throat and exit areas of the nozzle. Took  $C_p = 1.11$  kJ/kg K and specific heat ratio is 1.333. [[CO6](Evaluate/HOCQ)]
- (b) Define nozzle efficiency. [[CO1](Remember/LOCQ)]
- 10 + 2 = 12**
7. (a) Draw the velocity diagram of single stage impulse turbine and setup expression for the axial thrust, tangential force, work done and diagram efficiency. [[CO3](Apply/IOCQ)]
- (b) Make a comparison between the impulse and reaction steam turbines. [[CO1](Remember/LOCQ)]
- 6 + 6 = 12**

### Group - E

8. (a) The following data relate to a boiler trial: Mean temperature of flue gas 550 K, Temperature of cold air 300 K, Air supplied per kg of fuel is 18, Fuel consumption is 1800 kg/hr, Draught required is 100 mm of water, Mechanical efficiency is 80%.  
 Calculate motor power for forced and induced draught fans allowing 10% leakage of air in both the cases. Assume, specific volume of air at N.T.P =  $0.7734 \text{ m}^3/\text{kg}$ . [[CO6](Evaluate/HOCQ)]
- (b) State the advantages of water tube boiler over fire tube boiler. [[CO1](Remember/LOCQ)]
- 8 + 4 = 12**

9. (a) Exhaust steam having a quality of 0.9 enters a surface condenser at an absolute pressure of 0.13 bar and comes out as water at 45°C. The circulating water enters at 30°C and leaves at 40°C. Estimate the quantity of circulating water and the condenser efficiency. [[C05](Analyze/IOCQ)]
- (b) Write a short note on Surface condensers. [[C01](Remember/LOCQ)]

**6 + 6 = 12**

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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	35.42	45.83	18.75