Time: 3 Hours **Total Marks: 80**

N. B. : (1) Question No. **1** is **compulsory**.
(2) Solve any **three** out of the remaining **five** questions.
(3) Assume suitable data if required and state it clearly.
(4) Use of Steam Table and Mollier diagram is permitted.

1. Attempt any **four** out of the following **20**
   (a) State Kelvin-Plank statement and Clausius statement of the second law of thermodynamics.
   (b) Draw a neat diagram of Roots blower and explain its working.
   (c) Show that energy is property of a system.
   (d) Draw a simple schematic diagram of a thermal power plant with one reheater. Also represent this on T-S diagram
   (e) Define dryness fraction, saturation temperature, work ratio and specific steam consumption.

2. (a) Steam enters a nozzle at a pressure of 7 bar and 200^0C with an initial enthalpy of 2850 kJ/kg and leaves at a pressure of 1.5 bar. The initial velocity of steam at the entrance is 40 m/s and the exit velocity from the nozzle is 700 m/s. The mass flow rate through the nozzle is 14000 kg/hr, the heat loss from the nozzle is 11705 kJ/hr. Find the final enthalpy of steam and the nozzle area at exit if the specific volume at exit is 1.24 m^3/kg. **10**
   (b) State and prove the Clausius inequality. **5**
   (c) What is available energy and unavailable energy? **5**

3. (a) A heat engine is used to drive a heat pump. The heat transfers from the heat engine and the heat pump are used to heat the water circulating through the radiators of a building. The efficiency of the heat engine is 27% and the COP of the heat pump is 4. Evaluate the ratio of the heat transfer to the circulating water to the heat transfer to the heat engine. **10**
   (b) Write Maxwell's equations. **5**
   (c) State and prove Clausius theorem. **5**

4. (a) In a Rankine cycle the stream at the inlet to the turbine is at 100 bar and 500^0C. If the exhaust pressure is 0.5 bar, determine the pump work, turbine work, condenser heat flow and Rankine efficiency. **10**
   (b) With the help of P-V and T-S diagram, compare the efficiencies of Otto, Diesel and Dual cycle for the same compression ratio and the same heat rejection. **5**

   (c) What do you understand by multistage compression? What are its merits over single stage compression? **5**

5. (a) 0.06 m^3 of air at 5 bar and 200^0C expands isentropically until the pressure becomes 2 bar. It is then heated at constant pressure until the enthalpy increase during this process is 80 KJ. Calculate the work done in each process and the total work done. **10**

(b) In an I.C. engine operating on the dual cycle, the temperature of the working fluid (air) at the beginning of the compression is 27^0C. The ratio of the maximum and minimum pressures of the cycle is 70 and compression ratio is 15. The amounts of heat added at constant volume and constant pressure are equal. Compute the air standard thermal efficiency of the cycle. **10**

6. (a) Derive an expression of air standard efficiency for diesel cycle. **10**

(b) A single stage reciprocating air compressor has a swept volume of 2000 cm^3 and runs at 800 rpm. It operates on a pressure ratio of 8, with a clearance of 5% of the swept volume. Assume NTP room conditions and at inlet (p = 101.3 kPa, T = 15^0C) and polytropic compression and expansion with n = 1.25. Calculate: **10**

(a) Indicated power
(b) Volumetric efficiency
(c) Mass flow rate
(d) Free air delivery
(e) Isothermal efficiency, and
(f) The actual power needed to drive the air compressor, if the mechanical efficiency is 85%