B.E. (Mechanical Engineering / Power Engineering) Fourth Semester (C.B.S.)

Engineering Thermodynamics

P. Pages : 3 **NIR/KW/18/3369/3393**

Time : Three Hours *1331* Max. Marks : 80

Notes :
1. All questions carry marks as indicated.
2. Solve Question 1 OR Questions No. 2.
3. Solve Question 3 OR Questions No. 4.
4. Solve Question 5 OR Questions No. 6.
5. Solve Question 7 OR Questions No. 8.
6. Solve Question 9 OR Questions No. 10.
7. Solve Question 11 OR Questions No. 12.
8. Assume suitable data whenever necessary.
9. Illustrate your answers whenever necessary with the help of neat sketches.
10. Use of non programmable calculator is permitted.
11. Use steam table and Mollier chart are permitted.
12. Solution provided with appropriate P-V/T-S/h-s diagrams.

1. a) Explain the following terms : **6**

i) System ii) Thermodynamics property

iii) State

b) A non-flow reversible process follows the law $P = (V^2 + 8/V)$ where P is in bar and V is in m^3. Find the workdone during the process when the volume changes from $3m^3$ to $1m^3$. **5**

c) State zeroth law of thermodynamics & give its application. **3**

OR

2. a) Show that work is a path function and not a property. **5**

b) Why does free expansion have zero work transfer ? **3**

c) A gas in a piston cylinder assembly undergoes an expansion process for which the relation between pressure and volume is given by : PV^n = constant. The initial pressure is 3 bar and initial volume is 0.1 m^3 and the final volume is 0.2 m^3. Determine the workdone for the process if - **6**

i) n = 1.5 ii) n = 1 iii) n = 0

3. a) Which property of a system increases when heat is transferred : **6**

i) At constant volume &

ii) At constant pressure. Also give example.

b) A gas undergoes a thermodynamic cycle consisting of three processes beginning at an initial state where $P_1 = 1 \text{bar}$, $V_1 = 1.5 m^3$ and $U_1 = 512 \text{kJ}$. The processes are as follows : **7**

i) Process 1 – 2 : compression with PV = constant to $P_2 = 2 \text{bar}$, $U_2 = 690 \text{kJ}$

ii) Process 2 – 3 : $W_{23} = 0$, $Q_{23} = -150 \text{kJ}$ and

iii) Process 3 – 1 : $W_{31} = 50 \text{kJ}$, Determine the heat interaction Q_{12} and Q_{31}.

OR

4. a) State the general steady flow energy equation (SFEE). Apply it for **6**

i) Steam nozzle ii) Centrifugal pump

iii) Boiler

b) In an air compressor, air flows readily at the rate of 15 kg/min. The air enters the compressor at 5 m/s with pressure of 1 bar and specific volume $0.5\,m^3/kg$. It leaves the compressor at 7.5 m/s with pressure of 7 bar & specific volume $0.15\,m^3/kg$. The internal energy of air leaving the compressor is $16.5\,kJ/kg$ greater than that of air entering. Cooling water in compressor Jacket absorbs heat from air at the rate of $125\,kJ/s$. Find power required to drive the compressor? **7**

5. a) State and explain Kelvin – Planck and Clausius statement of II^{nd} law of thermodynamics. Prove that they are equivalence to each other. **6**

b) A refrigerator plant for a food store operates as a reversed Carnot heat engine. The store is to be maintained at a temperature of $-5°\,C$ and the heat transfer from the store to the cycle is at the rate of 5 kW. If the heat is transferred from the cycle to the atmosphere at a temperature of 25ºC, Calculate the power required to drive the plant. **7**

OR

6. a) What do you understand by entropy principle? State and prove Clausius theorem. **6**

b) A reversible heat engine operates between two reservoirs at temperature of 700ºC and 50ºC. The engine drives a reversible refrigerator which operates between temperatures of 50ºC and $-25°\,C$. The heat supplied to the engine is 2500 kJ and the net output of the combined engine – refrigerator plant is 400 kJ. Find the net heat transfer to the refrigerator and net heat transfer to the reservoir at 50ºC? **7**

7. a) Explain the following term on T – S diagram. **6**

i) Wet Steam ii) Triple point

iii) Superheated steam iv) Critical point.

b) Two boilers one with superheater and other without superheat are delivering equal quantities of steam into a common main. The pressure in the boilers and in the main is 20 bar. The temperature of steam from a boiler with a superheater is 350ºC and temperature of steam in the main is 250ºC. Determine the quality of steam supplied by the other boiler. Take $(C_p)_{sup} = 2.25\,kJ/kg\,K$. **7**

OR

8. a) Explain term "dryness fraction". Explain the method to measure dryness fraction of steam using throttling calorimeter. **6**

b) Find enthalpy and internal energy of 2 kg of steam at a pressure of 12 bar, when the condition of steam is : **7**

i) Wet with dryness fraction 0.85

ii) Superheated with degree of superheat 50ºC.

Take $(C_p)_{sup} = 2.25\,kJ/kg\,K$.

9. a) Explain component of steam power plant with T – S diagram. **4**

b) A steam power plant operates on the ideal Rankine cycle receives steam at 20 bar and 300ºC at rate of 3 kg/s and it is expanded to 0.1 bar. **9**

Determine :

i) Net workdone
ii) Steam rate
iii) Rankine efficiency

OR

10. A steam power plant uses the following cycle. **13**

Steam at boiler outlet = 120 bar, 400ºC

Reheat at 50 bar to 400ºC

Condenser pressure = 0.1 bar

Determine :

i) Quality of steam at turbine exhaust
ii) Cycle efficiency
iii) Steam rate

11. a) Derive an expression for thermal efficiency of Otto cycle. **5**

b) The diesel cycle with a compression ratio of 16 is having lowest pressure and lowest temperature in the cycle as 1 bar and 300 k respectively. The heat added per kg of fuel is 2550 kJ/kg. **9**

Determine :

i) Thermal efficiency
ii) Mean effective pressure

OR

12. a) Compare Otto, Diesel and dual cycle for following condition **6**

i) Same heat supplied

ii) Same compression ratio & heat rejection.

b) With the help of P-V and T-S, explain working of Stirling and Ericson cycle. **8**

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