



Name : .....

Roll No. : .....

Invigilator's Signature : .....

**CS/B.Tech(ME(N)/PE(N)/PWE(N)/AUE(N)/SEM-3/ME-301/2011-12**

**2011**

**APPLIED THERMODYNAMICS**

*Time Allotted : 3 Hours*

*Full Marks : 70*

*The figures in the margin indicate full marks.*

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

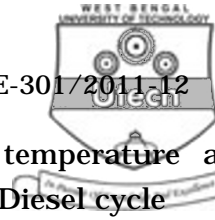
**GROUP - A**

**( Multiple Choice Type Questions )**

1. Choose the correct alternatives of the following :  $10 \times 1 = 10$

i) A heat engine is supplied with heat at the rate of 30000 J/s and gives an output of 9 kW. The thermal efficiency of the engine will be

- a) 33%
- b) 30%
- c) 45%
- d) 29%.



- ii) For same maximum pressure and temperature and same heat rejection for an Otto and a Diesel cycle
- a) Otto cycle is more efficient
  - b) Diesel cycle is more efficient
  - c) both are equally efficient
  - d) efficiencies cannot be compared.
- iii) COP of a heat engine, when operating between same two temperatures that of a refrigerator, is
- a) more than the COP of refrigerator
  - b) less than the COP of refrigerator
  - c) equal to the COP of refrigerator
  - d) none of these.
- iv) Joule-Thompson coefficient for an ideal gas, having equation of state  $PV = RT$ , is
- a) 1
  - b) infinite
  - c) 0.5
  - d) 0.
- v) With suction pressure and clearance unchanged, for increase in delivery pressure volumetric efficiency of a reciprocating air compressor
- a) increases
  - b) decreases
  - c) remains same
  - d) none of these.



vi) In a cogeneration cycle

- a) gas turbine cycle is topping cycle
- b) steam turbine cycle is topping cycle
- c) any one of gas or steam turbine cycle can act as topping cycle
- d) none of these.

vii) Value of dryness fraction of superheated vapour is

- a) unity
- b) greater than unity
- c) less than zero
- d) not defined.

viii) Which one is the correct relationship ?

- a)  $dh = Tds - vdp$
- b)  $dh = Tds + vdp$
- c)  $dh = Tds - pdv$
- d)  $dh = Tds + pdv$ .

ix) When dry bulb and wet bulb temperatures of air are same, the relative humidity will be

- a) 0%
- b) 50%
- c) 66 - 67%
- d) 100%.



- x) Optimum intermediate pressure in a two stage compressor is
- a) arithmetic mean of the suction and delivery pressure
  - b) geometric mean of the suction and delivery pressure
  - c) harmonic mean of the suction and delivery pressure
  - d) none of these.

**GROUP - B**

**( Short Answer Type Questions )**

Answer any *three* of the following.  $3 \times 5 = 15$

2. Derive Maxwell's relations.
3. A  $200 \text{ m}^3$  rigid tank contains compressed air at 1 MPa and 330 K. Determine how much work can be obtained from this air, if the environmental conditions are 100 kPa and 300 K.
4. Deduce Clausius-Clapeyron's equation. Explain how the equation can be used to calculate latent heat of evaporation.

3 + 2



5. What is specific humidity ? Show that  $W = 0.622 \times \frac{p_w}{p - p_w}$  where  $w$  is the specific humidity,  $p_w$  is the partial pressure of water vapour and  $p$  is the atmospheric pressure. 2 + 3
6. a) What do you mean by entropy generation ?
- b) Give the expression for the reversible work in a steady flow process under a given environment. 2 + 3

**GROUP - C**

**( Long Answer Type Questions )**

Answer any *three* of the following. 3 × 15 = 45

7. a) What do mean by engine knock ? How does it originate ? What is its consequence ? 6
- b) In an air standard Diesel cycle, the compression ratio is 16 and at the beginning of isentropic compression, the temperature is 15°C and the pressure is 0.1 MPa. Heat is added until the temperature at the end of the constant pressure process is 1480°C.
- i) Find the cut-off ratio
- ii) Find the heat supplied per kg of air
- iii) Find the cycle efficiency
- iv) Find the m.e.p. 9



8. a) In a reheat cycle, steam at  $550^{\circ}\text{C}$  expands in an HP turbine till it is saturated vapour. It is reheated at constant pressure to  $400^{\circ}\text{C}$  and then expands in an L.P. turbine to  $40^{\circ}\text{C}$ . If the moisture content at turbine exhaust is given to be 14.67%, find
- i) reheat pressure
  - ii) the pressure of steam at inlet to the H.P. turbine
  - iii) the net work output per kg
  - iv) cycle efficiency. 10
- b) i) What do you understand by the entropy principle ? 3
- ii) Why is the Carnot cycle on  $T$ - $S$  plot a rectangle ? 2
9. a) What is a pure substance ? 1
- b) What do you understand by triple point ? 1
- c) Draw the phase equilibrium diagram for a pure substance on  $T$ - $s$  plot with relevant constant property lines. 3
- d) A vessel of volume  $0.04 \text{ m}^3$  contains a mixture of saturated water and saturated steam at a temperature of  $250^{\circ}\text{C}$ . The mass of the liquid present is 9 kg. Find the pressure, the mass, the specific volume, the enthalpy, the entropy and the internal energy. 10



10. a) Why the gas cycle refrigeration is preferred in aircraft ? 2
- b) A 5 tonne R-12 plant maintains a cold store at  $-15^{\circ}\text{C}$ . The refrigerant flow rate is  $0.133\text{ kg/s}$ . The vapour leaves the evaporator with  $5^{\circ}\text{C}$  superheat. Cooling water is available in plenty in  $25^{\circ}\text{C}$ . A suction line heat exchanger subcools the refrigerant before throttling. Find (a) the compressor discharge temperature, (b) the COP, (c) the amount of sub-cooling in degree C and the dimension of compressor cylinder, if the speed is 900 rpm, stroke-to-bore ratio is 1.2 and volumetric efficiency is 95%. Allow approximately  $5^{\circ}\text{C}$  temperature difference in the evaporator and condenser. 8
- c) Saturated air at  $2^{\circ}\text{C}$  is required to be supplied to a room where the temperature must be held at  $20^{\circ}\text{C}$  with a relative humidity of 50%. The air is heated and then water at  $10^{\circ}\text{C}$  is sprayed in to give the required humidity. Determine the temperature to which the air must be heated and the mass of spray water required per  $\text{m}^3$  of air at room conditions. Assume that the total pressure is constant at 1.013 bar and neglect the fan power. 5
11. a) Prove that entropy is a property of the system. 7
- b) Prove that a reversible engine gives maximum efficiency while operating between same two temperatures. 8