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 × 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 then zero d) not defined.

viii) Which one is the correct selationship ?

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 × 5 = 15

2. Derive Maxwell's relations.

3. A 200 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 $W = 0{\cdot}622 \times \frac{p_w}{p - p_w}$ 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°C expands in an HP turbine till it is saturated vapour. It is reheated at constant pressure to 400°C and then expands in an L.P. turbine to 40°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 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250°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°C. The refrigerant flow rate is 0·133 kg/s. The vapour leaves the evaporator with 5°C superheat. Cooling water is available in plenty in 25°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°C temperature difference in the evaporator and condenser. 8

c) Saturated air at 2°C is required to be supplied to a room where the temperature must be held at 20°C with a relative humidity of 50%. The air is heated and then water at 10°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 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