



Name :

Roll No. :

Invigilator's Signature :

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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 : $10 \times 1 = 10$

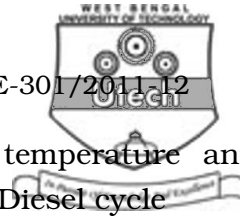
i) A heat engine is supplied with heat at the rate of 30000 J/s and gives an output of 9 kW. The thermal efficiency of the engine will be

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

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

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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%.

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

GROUP – B

(Short Answer Type Questions)

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

- Derive Maxwell's relations.
- 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.
- Deduce Clausius-Clapeyron's equation. Explain how the equation can be used to calculate latent heat of evaporation.

$3 + 2$

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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

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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
- reheat pressure
 - the pressure of steam at inlet to the H.P. turbine
 - the net work output per kg
 - 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

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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

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