Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech(N)/ME/PE/PWE/AUE/SEM-3/ME-301/2012-13

2012

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 for the following : 10 × 1 = 10

   i) Which part of the vapour compression refrigeration cycle produces the refrigerating effect ?

   a) Throttle valve b) Evaporator

   c) Compressor d) Condenser.

   ii) Which one of the following is the correct relationship between enthalpy and entropy ?

   a) $dh = Tds - vdp$ b) $dh = Tds - pdv$

   c) $dh = Tds + pdv$ d) $dh = Tds + vdp$.

iii) Which is an intensive property of a system among the following ?

a) Viscosity b) Temperature

c) Density d) Potential energy.

iv) If a closed system is undergoing an irreversible process, the entropy of the system ?

a) must increase

b) always remains constant

c) must decrease

d) can increase, decrease or remain constant.

v) For same maximum pressure and temperature and same heat rejection for an Otto and diesel cycle

a) Otto Cycle is more efficient

b) diesel cycle is more efficient

c) both are equal

d) efficiencies cannot be compared.

vi) Work done is zero for which of he following processes ?

a) Constant volume b) Free expansion

c) Throttling d) All of these.

vii) Zeroth law of thermodynamics tells us about

a) Internal energy b) Enthalpy

c) Pressure d) Temperature.

viii) Change of enthalpy of a system is the heat supplied at

a) constant temperature

b) constant pressure

c) constant volume

d) constant entropy.

ix) A positive value of Joule-Thomson coefficient of a fluid means

a) Temperature drops during throttling

b) Temperature remains constant during throttling

c) Temperature rises during throttling

d) None of these.

x) On T-s diagram the state change during transformation of 0°C water to 100°C water at atmospheric pressure due to heat addition can be shown by

a) line with positive slope

b) vertical line

c) horizontal line

d) none of these.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. Prove that the volumetric efficiency of a single stage air compressor working in a maximum pressure p_2 and minimum pressure p_1 is given by

$$\eta_{vol} = 1 + C - C\left(\frac{p_2}{p_1}\right)^{\frac{1}{n}}$$ where C is the clearance.

3. a) Explain the main difference between petrol engine and diesel engine.

   b) Show that for same heat supplied and same compression ratio, Otto cycle is more efficient than diesel cycle. 2 + 3

4. Using an engine of 30% thermal efficiency to drive a refrigerator having a COP of 5 what is the heat input into the engine for each MJ heat removed from the cold body by the refrigerator ? Derive the relation between the COP of a refrigerator and heat pump. 3 + 2

5. Two reversible heat engines *A* and B are arranged in series. *A* is rejecting heat directly to *B*. Engine *A* receives 200 kJ at a temperature of 421°C from the hot source, while engine *B* is in communication with a cold sink at a temperature of 5°C. If the work of *A* is twice that *B*

   find :

   a) intermediate temperature between *A* and *B*

   b) the efficiency of each engine. 2 + 3

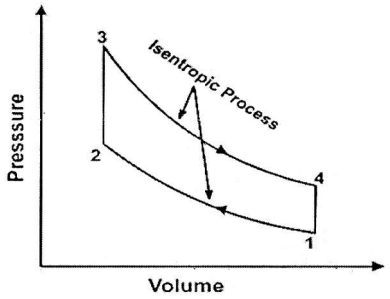
6. Air enters an air conditioner at a temperature of 35°C and RH of 70% and leaves at DBT = 25°C and RH = 50%. Show the intermediate processes on a representative psychrometric chart. What is this process called ? 4 + 1

GROUP – C

(Long Answer Type Questions)

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

7. Obtain the specific work done by an engine working on the Otto cycle (as shown in figure) in terms of the maximum (T_3) and minimum (T_1) temperatures of the cycle, the compression ratio r_k and gas constants of the working fluid (Assume the working fluid is an ideal gas). Then show that the optimum compression ratio for maximum specific work output is given by $(r_k)_{optimum} = \left(\frac{T_3}{T_1} \right)^{\frac{1}{2(1-\gamma)}}$ and at that time $T_2 = T_4 = \sqrt{T_3 T_1}$ and finally maximum specific work done is given by $w_{\max} = c_v \left(\sqrt{T_3} - \sqrt{T_1} \right)^2$



Then calculate the work done from the engine if it runs between T_3 = 1457 K and T_1 = 313 K for a mass flow rate of working fluid of 0·47 kg/sec.

8. a) Explain the advantages of multistage compression. Derive the ideal intermediate pressure for obtaining minimum work of compression. 2 + 4

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 volume 5 % of the swept volume. Assume NTP room condition and at inlet (p = 101·3 kPa, t = 15°C) and polytropic compression and expansion with n = 1·25.

Calculate :

i) indicated power

ii) volumetric efficiency

iii) mass flow rate

iv) FAD

v) isothermal efficiency. 9

9. a) What do you mean by steam reheating ? Why is it required ? 5

b) What is regeneration ? What are the advantages of regeneration ? 5

c) What should be the desirable characteristics of an ideal working fluid in vapour power cycle ? 5

10. a) An engine working on the Otto cycle is supplied with air at 0·1 MPa, 35°C. The compression ratio is 8. Heat supplied is 2100 kJ/kg. Calculate the maximum pressure and temperature of the cycle, efficiency and the mean effective pressure. (For air $C_p = 1 \cdot 005$, $C_v = 0 \cdot 718$ and R = 0·287 kJ/kg.K). 7

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 constant pressure process is 1480°C. Calculate :

(i) the cut-off ratio

(ii) the heat supplied per kg of air

(iii) the cycle efficiency

(iv) the m.e.p. 8

11. a) Steam initially at 0·3 MPa, 250°C is cooled at constant volume.

(i) At what temperature will the steam become saturated vapour ?

(ii) What is the quality at 80°C ?

(iii) What is the heat transferred per kg of steam in cooling from 250°C to 80°C ? 9

b) A system maintained at constant volume is initially at temperature T_1 and a heat reservoir at the lower temperature T_0 is available. Show that the maximum work recoverable as the system is cooled to T_0 is

$$W = C_v \left[(T_1 - T_0) - T_0 \, ln \frac{T_1}{T_0} \right]$$ 6