53 (ME 301) BTDM

2015

BASIC THERMODYNAMICS

Paper : ME 301

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

Answer Question No. ***1*** *and* ***any five*** *from the rest.*

"Use of Steam Table is permitted".

1. *(a)* Answer ***any five*** of the following : 1×5=5

   (i) What is the difference between *kg*-mass and *kg*-force ?

   (ii) Is it possible to have water vapour at –10°C ?

(iii) A heat pump is a device that absorbs energy from the cold outdoor air and transfer it to the warmer indoors. Is this a violation of the second law of thermodynamics ? Explain.

(iv) Why is excessive moisture in steam undesirable in steam turbine ?

(v) How will you calculate the piston swept volume of internal combustion engine ?

(vi) How is a steady-flow system characterized ?

(b) Fill in the blanks : ***(any five)*** 1×5=5

(i) The boundary work associated with constant-volume system is always _____ .

(ii) In petrol engine, heat addition takes place at constant _____ .

(iii) When the local atmospheric pressure is greater than the pressure in the system, then the term _____ pressure is used.

(iv) The dryness fraction of dry and saturated steam is _____.

(v) A device that violates the law of thermodynamics is known as _____.

(vi) In isochoric process, the _____ remains constant.

2. (a) What do you mean by thermodynamic equilibrium? Explain briefly the conditions requirement for attaining a state of thermodynamic equilibrium. 1+3=4

(b) What is the difference between the classical and the statistical approaches to thermodynamics? Explain briefly the concept of continuum. 2+3=5

(c) What is a quasi-equilibrium process? What is its importance in engineering? 1+2=3

(d) A manometer containing oil $(\rho = 850 kg/m^3)$ is attached to a task filled with air. If the oil-level difference between the two column is $60cm$ and the atmospheric pressure is $98kPa$, determine the absolute pressure of the air in the tank. 3

(e) The temperature of a system drops by $45°F$ during a cooling process. Express this drop in temperature in K, R and $°C$. 3

3. (a) Define thermodynamic definition of 'work'. What are the enthalpy and entropy? 2+4=6

(b) A piston-cylinder device initially contains $0 \cdot 4m^3$ of air at $100kPa$ and $80°C$. The air is now compressed to $0 \cdot 1m^3$ in such way that the temperature inside the cylinder remains constant. Determine the work done during this process. 2

(c) A piston-cylinder device initially contains $0 \cdot 07m^3$ of nitrogen gas at $130kPa$ and $120°C$. The nitrogen is now expanded polytropically to a state of $100kPa$ and $100°C$. Determine the boundary work done during this process. Given, the gas constant for nitrogen is $0 \cdot 2968kJ/kg.K$. 10

4. (a) Explain briefly the processes that make up the Carnot cycle with P-V diagram. 8

(b) A heat pump heats a house in the winter and then reverses to cool it in the summer. The interior temperature should be $20°C$ in the winter and $25°C$ in the summer. Heat transfer through the walls and ceilings is to be $2400kJ$ per hour per degree temperature difference between the inside and outside. 10

(i) If the winter outside temperature is $0°C$, what is the minimum power required to drive the heat pump?

(ii) For the same power as a part (i), what is the maximum outside summer temperature for which the house can be maintained at $25°C$?

5. (a) Define sensible heat of water and enthalpy of superheated steam. What do you mean by quality of steam? 3

(b) Steam at $5MPa$ and $400°C$ enters a nozzle steadily with a velocity of $80m/s$, and it leaves at $2MPa$ and $300°C$. The inlet area of the nozzle is $60cm^2$, and heat is being lost at a rate of $130kJ/s$. Determine

(i) The mass flow rate of the steam

(ii) The exit velocity of the steam

(iii) The exist area of the nozzle. 12

(c) A piston-cylinder device initially contains 50L of liquid water at 40°C and 200kPa. Heat is transferred to the water at constant pressure until the entire liquid is vapourized.

(i) What is the mass of the water?

(ii) What is the final temperature?

3

6. (a) Explain how can we increase the efficiency of ideal Rankine cycle?

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(b) Consider a steam power plant operating on the ideal Rankine cycle. Steam enters the turbine at 3MPa and 350°C and is condensed in the condenser at a pressure of 10kPa. Determine —

(i) The pump work

(ii) The thermal efficiency of this power plant

(iii) The thermal efficiency if steam is superheated to 600°C instead of 350°C.

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7. (a) Define the terms of an I.C. Engine.

1×4=4

(i) Stroke

(ii) Bottom Dead Centre (BDC)

(iii) Cubic Capacity (C.C.)

(iv) Compression Ratio.

(b) Compare four stroke engine with two-stroke engine (*Any four* comparisons). 4

(c) In S.I. engine, working on the ideal cycle has the compression ratio 6. The initial pressure and temperature of air are I *bar* and 37°C respectively. The maximum pressure in the cycle is 30 *bar*. For unit mass flow, calculate

(i) The pressure, volume and temperatures at various salient points of the cycle

(ii) The ratio of heat supplied to the heat rejected. 10

Assume, ratio of specific heats to be 1·4 for air,

No. of mole, $n = \frac{1}{29}$

$R = 8{\cdot}314 kJ/mol{\cdot}K$

$Cv = 0{\cdot}717 kJ/kg{\cdot}K$.
