Registration No. : | | | | | | | | | | |

*Total number of printed pages – 4*

B. Tech

BE 2103 (New)

# Second Semester (Back) Examination – 2013

## THERMODYNAMICS

**BRANCH : ALL**

**QUESTION CODE : B484**

**Full Marks – 70**

**Time : 3 Hours**

*Answer Question No. **1** which is compulsory and any **five** from the rest.*
*The figures in the right-hand margin indicate marks.*
*Steam Table is allowed.*

1. Answer the following questions with justification : 2 ×10

   (a) Convert the following units :

   (i) $10^8$ Joule to kWh

   (ii) 50 bar.$m^3$ to kJ.

   (b) There are two thermodynamic cyclic processes. Cycle-1 consists of two reversible processes and cycle-2 has four such processes. Which cycle will record maximum change in internal energy ?

   (c) Define the equation of state of a gas. Write the equation for an ideal gas.

   (d) A certain gas of mass 2 kg is enclosed in a container of volume 1.039 $m^3$ at a pressure of 200 kPa and temperature of 400 K. Identify the gas.

   (e) Define, Property of a gas. What is the difference between intensive and extensive properties properties of a system. Write the intensive and extensive properties from the following :

   (i) Work, (ii) internal energy, (iii) Temperature, (iv) specific entropy, (v) Specific Volume, (vi) Specific Weight.

   (f) In a particular process a system receives 50 kJ of energy as heat from a source and performs 10 kJ of work. Is it possible to restore the system to its initial state by following an adiabatic process ?

(g) A device has one inlet and one outlet. If the volume flow rates at the inlet and the outlet are the same, is the flow through the device necessarily steady ?

(h) Distinguish between a free expansion and a throttling. Give one example for each. What are the commonalties in these two processes ?

(i) A piston-cylinder device contains 0.06 $m^3$ of saturated water vapor at a presser of 350 kPa. Determine the temperature and the mass of vapor in kg inside the cylinder. Show the state of saturated water vapour on a P-V diagram for steam.

(j) An inventor claims to have developed an engine which absorbs 600 kJ of heat energy from a reservoir at 327 °C, delivers 450 kJ of work rejects 150 kJ of heat energy to a reservoir at 27 °C. Should the claim be theoretically feasible or not ? The schematic of the heat engine may be drawn.

2. (a What is the precise distinction between heat and work interactions of a system across its boundary ? 3



(b) A perfect gas undergoes a process in which $T \propto \frac{1}{v^{\frac{2}{5}}}$, where T is the absolute temperature and v is the specific volume. Calculate the work done by the gas during the process from state 1 to state 2. Given : Pressure at 1, $P_1 = 10\ N/m^2$, specific volume $v_1 = 4\ m^3/kg$ and at 2, $v_2 = 2\ m^3/kg$. Also calculate the final pressure at state 2 in $N/m^2$. 7

3. (a) A manometer is fitted to atank filled with a gas. the fluid used in the manometer has a sp.gravity of 0.85. The manometer column height is 60 cm. Local atmosphere pressure is 96 kPa. Determine the absolute pressure gas within the tank. What is the gage pressure in the tank ? Draw the schematic of the manometer fitted with the tank. Show data. 4

(b) A gas at a pressure of 14 bar and temperature 360 degree cent expanded adiabatically to a pressure of 1bar. The gas is then heated at constant volume until it attains the initial temperature and a pressure of 2.2 bar. The gas is then compressed isothermally until it attains the initial pressure. Draw the P-V diagram with the given data. Mass of the gas is 0.23 kg and $C_p = 1.005$ kJ/kg K. Find the following : 6

(i) The volume of adiabatic index (k)

(ii) Specific heat at constant volume, $C_v$

(iii) The change in internal energy during the adiabatic expansion

(iv) Temperature of the gas at the end of adiabatic expansion.

4. (a) What is the difference between classical and statically thermodynamics ? 2

(b) A system undergoes a cycle having 4 processes. The work and heat interactions and the change in internal energy for the process are tabulated below. Complete the table and find the network and net heat interaction. 8

| Process | Work(W) kJ | Heat (Q) kJ | U (kJ) |
|---|---|---|---|
| 1-2 | 100 | 100 | ——— |
| 2-3 | ——— | –150 | 200 |
| 3-4 | –250 | ——— | ——— |
| 4-1 | 300 | ——— | 50 |

5. (a) What is flow energy ? Derive an expression for the same in terms of pressure and volume when the flow of fluid take place in a pipe. Draw the required schematic. 3

(b) What is a nozzle ? Air expands from 3 bar to 1 bar in a nozzle. The initial velocity is 90 m/s, the initial temperature is 150 °C. Write the SFEE in general and reduce the same for a nozzle. Assume adiabatic conditions $C_p$ = 1.005 kJ/kg K. Find the velocity at the exit.Draw the schematic of the nozzle with given data. 7

6. (a) Define the Max Planck's and the Clausius statements of the 2nd law of thermodynamics. What are the devices concerned with these two laws ? 2



(b) Prove that no heat engine working on a cycle between two fixed reservoirs can be more efficient than a reversible heat engine working between the same two fixed reservoirs. 3

(c) Heat is transferred to a heat engine from a source at a rate of 80 MW.The rate of waste heat rejection to a river is 50 MW. Find the net power output and the thermal efficiency for the heat engine. Draw the schematic with data. 2

(d) Derive, from the 1st law of thermodynamics and the defining equation of entropy, an expression for change in entropy of an ideal gas in terms of pressure ratio and volume ratio during a process. 3

7. (a) Define a pure substance, give three examples. 1

(b) Are the following mixtures pure substances ? Justify. 1

(i) the mixture of liquid air and gaseous air

(ii) the mixture of liquid water and steam.

(c) Draw the T-h diagram for transformation of ice at –15 °C to superheated steam (205 °C) at atmospheric pressure. Show the latent heat of fusion, latent heat of vaporization, and heat of superheat on the diagram. What is the degree of superheat for this steam ? 3

(d) Steam is generated at 10 bar abs.pressure from water at 30°C. Determine the heat required to produce 1 kg of steam when,

(i) the dryness fraction is 0.9, (ii) the steam is dry saturated, (iii) the steam is superheated to 300 °C, (iv) the degree of superheat.

Given, $C_p$ of superheated steam = 2.093 kJ/kg K. Show the states of the above mentioned steam on the T-h diagram. 5

8. (a) What is a heat engine ? On what assumptions does it operate ? How do you distinguish between i.c engine & an external combustion engine ? Give examples of both. 3



(b) Considering a piston-cylinder device to operate as an i.c engine, define the following terms : 4

(i) T.D.C. and B.D.C.

(ii) Connecting rod

(iii) Crank

(iv) Crank shaft.

(c) Briefly describe the operation of a 4-stroke cycle i.c engine with a sketch. 3