

Code : 102304

B.Tech 3rd Semester Exam., 2019
(New Course)

THERMODYNAMICS

Time : 3 hours

Full Marks : 70

Instructions :

- (i) The marks are indicated in the right-hand margin.
- (ii) There are **NINE** questions in this paper.
- (iii) Attempt **FIVE** questions in all.
- (iv) Question No. 1 is compulsory.
- (v) Students should be allowed to use the steam tables and Mollier diagram.

1. Choose the correct answer from the following
(any seven) : $2 \times 7 = 14$

(a) Ice kept in a wall-insulated thermoflask is an example of which system?

- ☒ (i) A closed system
- (ii) An isolated system
- (iii) An open system
- (iv) Non-flow adiabatic system

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(Turn Over)

(2)

(b) Which one of the following is the extensive property of a thermodynamic system?

- ☒ (i) Volume
- (ii) Pressure
- (iii) Temperature
- (iv) Density

(c) In a general compression process, 1 kJ of mechanical work is supplied to 2 kg of fluid and 400 J of heat is rejected to the cooling jacket. The change in specific internal energy would be

- (i) 700 J
- (ii) 350 J
- ☒ (iii) 300 J
- (iv) 600 J

(d) First law of thermodynamics defines

- (i) temperature
- (ii) enthalpy
- ☒ (iii) internal energy
- (iv) entropy

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(Continued)

(e) Under what conditions, the change in the enthalpy of a system equals the heat supplied?

- (i) Constant volume
- ~~(ii) Constant pressure~~
- ~~(iii) Constant temperature~~
- (iv) Standard temperature-pressure conditions

(f) In a Carnot cycle, the rejection of heat is

- (i) at constant pressure
- (ii) at constant volume
- ~~(iii) at constant temperature~~
- (iv) partly at constant pressure and partly at constant volume

(g) A Carnot cycle is having an efficiency of 0.75. If the temperature of the high temperature reservoir is 727 °C, what is the temperature of the low temperature reservoir?

- (i) 23 °C
- (ii) -23 °C
- ~~(iii) 0 °C~~
- (iv) 250 °C

(Turn Over)

(h) Second law of thermodynamics defines

- ~~(i) entropy~~
- (ii) enthalpy
- ~~(iii) efficiency~~
- (iv) internal energy

(i) For a thermodynamic cycle to be irreversible, it is necessary that

(i) $\oint \frac{\partial Q}{T} = 0$

~~(ii) $\oint \frac{\partial Q}{T} > 0$~~

~~(iii) $\oint \frac{\partial Q}{T} < 0$~~

(iv) $\oint \frac{\partial Q}{T} \geq 0$

(j) Which of the following parameters remains constant during superheating of steam?

- (i) Temperature
- (ii) Enthalpy
- (iii) Pressure
- ~~(iv) Internal energy~~

2. (a) State the first law of thermodynamics. What is PMM1?

(b) Define quasi-static process.

(c) The internal energy of a certain substance is given by the equation $u = 3.56pv + 84$, where u is given in kJ/kg, p is in kPa and v is in m^3/kg . A system composed of 3 kg of this substance expands from an initial pressure of 500 kPa and a volume of 0.22 m^3 to a final pressure 100 kPa in a process in which pressure and volume are related by $pv^{1.2} = \text{constant}$. If the expansion is quasi-static, find Q , ΔU , and W for this process. 4+2+8=14

3. (a) Derive an expression for conservation of energy for a steady flow process.

(b) Consider a nozzle which is used to increase the velocity of a steady flowing stream. At the inlet to the nozzle, the enthalpy of fluid is 3000 kJ/kg and the velocity is 50 m/s. At the exit of the nozzle, the enthalpy is 2700 kJ/kg. The nozzle is kept horizontal and is well-

insulated. (i) Find the velocity at the exit of the nozzle and the mass flow rate. (ii) If the inlet area is 0.12 m^2 and the sp. volume of the fluid at the inlet is $0.19 \text{ m}^3/\text{kg}$, find the exit area of the nozzle, if the specific volume of the fluid at the exit is $0.5 \text{ m}^3/\text{kg}$. 6+8=14

4. (a) State the Carnot theorem and explain with the help of suitable example.

(b) Two reversible heat engines A and B are arranged in series, engine A rejecting heat directly to engine B. Engine A receives 180 kJ at a temperature of 422°C from a hot source, while engine B is in communication with a cold sink at a temperature of 5.5°C . If the work output of A is twice that of B, find (i) the intermediate temperature between A and B, (ii) the efficiency of each engine and (iii) heat rejected to the cold sink. 6+8=14

5. (a) State the prove Clausius theorem.

(b) Show that there is a decrease in available energy, when heat is transferred through a finite temperature difference. 7+7=14

6. (a) Show that the adiabatic mixing of two fluids is irreversible.
- (b) "An adiabatic process need not be isentropic, but if the process is adiabatic and reversible, it must be isentropic." Is it true or false? Explain with proper justification.
- (c) A reversible power cycle operates with temperature limits 800 K and 300 K. If it takes 480 kJ of heat, then what would be the unavailable work? $6+4+4=14$
7. (a) What are various forms of energy?
- (b) Consider a system of cylinder and piston arrangement containing gas. Initially, the gas is at 500 kPa and occupies a volume of 0.2 m^3 . The force exerted by the spring is proportional to the displacement from its equilibrium position. Take ambient pressure as 100 kPa. The gas is heated until the volume becomes 0.4 m^3 and the pressure attained as 1 MPa. Determine the work done by the gas. Draw the schematic and p - V diagram. $4+10=14$

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8. (a) What is the critical state? Draw the phase equilibrium diagram for a pure substance on h - s plot with relevant constant property lines.
- (b) Why do the isobars on Mollier diagram diverge from one another?
- (c) What is quality of steam? What are the different methods of measurement of quality of steam? $6+4+4=14$
9. (a) Steam initially at 1.5 MPa, 300°C expands reversibly and adiabatically in a steam turbine to 40°C . Determine the ideal work output of the turbine per kg of steam.
- (b) With the help of suitable diagram, explain heating and humidification. $8+6=14$

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