CBCS SCHEME

USN

BME304

Third Semester B.E./B.Tech. Degree Examination, June/July 2024
Basic Thermodynamics

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.
3. Use of the thermodynamic data book is permitted.

<table>
<tr><th colspan="3">Module – 1</th><th>M</th><th>L</th><th>C</th></tr>
<tr><td>Q.1</td><td>a.</td><td>Define Zeroth law of thermodynamics.</td><td>2</td><td>L1</td><td>CO1</td></tr>
<tr><td></td><td>b.</td><td>With neat diagram, explain the working of constant volume gas thermometer for measurement of temperature.</td><td>8</td><td>L1</td><td>CO1</td></tr>
<tr><td></td><td>c.</td><td>Two Celsius thermometers A and B agree at Ice Point and Steam point and the related equation is $T_A = L + MT_B + NT_B^2$, wehre L, M and N are constants. When both thermometers are immersed in fluid A reads $26^\circ C$ while B reads $25^\circ C$. Determine the reading of A when B reads $37.4^\circ C$.</td><td>10</td><td>L3</td><td>CO1</td></tr>
<tr><td colspan="6">OR</td></tr>
<tr><td>Q.2</td><td>a.</td><td>Distinguish between heat and work in Thermodynamics.</td><td>4</td><td>L1</td><td>CO1</td></tr>
<tr><td></td><td>b.</td><td>Derive an expression for the non-flow displacement work done during adiabatic process given by $PV^\gamma = C$. To a closed system 150 kJ of work is done on it.</td><td>6</td><td>L2</td><td>CO1</td></tr>
<tr><td></td><td>c.</td><td>If the initial volume is 0.6 m^3 and pressure of system varies as follows $P = (8 - 4V)$ where P is pressure in bar and V is volume in m^3. Determine the final volume and pressure of the system.</td><td>10</td><td>L3</td><td>CO1</td></tr>
<tr><th colspan="6">Module – 2</th></tr>
<tr><td>Q.3</td><td>a.</td><td>Show that energy is a property of the system. Define the specific heats at constant volume and constant pressure.</td><td>10</td><td>L2</td><td>CO2</td></tr>
<tr><td></td><td>b.</td><td>A piston and cylinder machine contains a fluid system, which passes through a complete cycle of four processes. During a cycle, the sum of all heat transfer is -170 kJ. The system completes 100 cycles per min. Complete the following table showing the method for each item, and compute the net rate of work output in KW.
<table>
<tr><th>Process</th><th>Q (KJ/min)</th><th>W(KJ/min)</th><th>$\Delta E(KJ/min)$</th></tr>
<tr><td>a – b</td><td>0</td><td>2,170</td><td>-</td></tr>
<tr><td>b – c</td><td>21,000</td><td>0</td><td>-</td></tr>
<tr><td>c – d</td><td>-2,100</td><td>-</td><td>-36,600</td></tr>
<tr><td>d – a</td><td>-</td><td>-</td><td>-</td></tr>
</table></td><td>10</td><td>L3</td><td>CO2</td></tr>
<tr><td colspan="6">OR</td></tr>
<tr><td>Q.4</td><td>a.</td><td>Apply steady flow energy equation to each of the following :
(i) Boiler
(ii) Nozzle
(iii) Centrifugal pump</td><td>6</td><td>L3</td><td>CO2</td></tr>
</table>

	b.	Air flows steadily at the rate of 0.5 kg/s through an air compressor, entering at 7 m/s velocity, 100 kPa pressure and 0.95 m^3/kg volume and leaving at 5 m/s, 700 KPa and 0.19 m^3/kg. The internal energy of the air leaving 93 kJ/kg greater than that of the air entering cooling water in the compressor jackets absorbs heat from the air at the rate of 58 kW. Compute the rate of shaft work input to the air in kW.	7	L3	CO2
	c.	Steam at rate of 0.42 kg/s and enthalpy of 2785 KJ/kg and a velocity of 33.3 m/s is supplied to a steadily operating turbine. The steam leaves the turbine at 100 m/s and an enthalpy of 2512 kJ/kg. The Inlet pipe is 3 m above the exit pipe. Rate of heat loss from the turbine casing is 0.29 kJ/s. What is the power output of the turbine?	7	L3	CO2
		Module – 3			
Q.5	**a.**	State the Kelvin-Planck and Clausius statements of II law of thermodynamics. Show that Kelvin-Planck statement is equivalent to Clausius statement.	10	L1	CO3
	b.	Prove that $COP_{Heat\ pump} = 1 + COP_{Refrigerator}$.	4	L2	CO3
	c.	What is thermal energy reservoir? Explain source and sink.	6	L1	CO3
		OR			
Q.6	**a.**	Show that entropy is a property of a system.	6	L1	CO3
	b.	State and prove Clausius inequality.	7	L1	CO3
	c.	A heat engine is supplied with 2512 KJ/min of heat at 650°C and the heat rejections takes place at 100°C. The following results were reported : (i) 867 kJ/min of heat rejected. (ii) 1015 kJ/min of heat rejected. (iii) 1494 kJ/min of heat rejected. Classify which of the results report a reversible cycle. Irreversible cycle or Impossible cycle.	7	L3	CO3
		Module – 4			
Q.7	**a.**	Define the following : (i) Available energy (ii) Unavailable energy (iii) Effectiveness (iv) Irreversibility	8	L1	CO4
	b.	Air expands through a turbine from 500 KPa 520°C to 100 KPa, 300°C. During expansion 10 kJ/kg of heat is lost to the surroundings which is at 98 KPa, 20°C. Neglecting the kinetic energy and potential energy changes. Determine per kg of air : (i) The decrease in availability (ii) The maximum work (iii) The Irreversibility. For air take $C_p = 1.005$ kJ/kgK, $h = C_pT$ where C_P is constant and T is in degree Kelvin.	12	L3	CO4
		OR			
Q.8	**a.**	Define dryness fraction. With a neat sketch, explain the measurement of dryness fraction of steam by using separating and throttling calorimeter.	8	L1	CO4
	b.	Define the following : (i) Pure substance (ii) Triple point (iii) Critical point	6	L1	CO4

	c.	A vessel of volume 0.04 m^3 contains a mixture of saturated water and saturated steam at a temperature of $250^\circ C$. The mass of the liquid present is 9 kg. Find the pressure, the mass, the specific volume, the enthalpy and the entropy.	6	L3	CO4
		Module – 5			
Q.9	a.	State and explain Dalton's law of partial pressure and Amagat's law of additive volumes.	8	L1	CO5
	b.	A mixture of 0.5 kg of CO_2 and 0.3 kg of N_2 is compressed from $P_1 = 1$ atm, $T_1 = 20^\circ C$ to $P_2 = 5$ atm in a polytropic process for which n = 1.3. Find, (i) Final temperature (ii) Work (iii) Heat transfer (iv) Change in entropy. Assume C_P for CO_2 is 0.821 kJ/kgK and C_P for N_2 is 1.017 KJ/kgK.	12	L3	CO5
		OR			
Q.10	a.	Explain the following : (i) Compressibility factor (ii) Reduced properties (iii) Law of corresponding states (iv) Generalized compressibility chart.	12	L1	CO5
	b.	One kg of CO_2 has a volume of 1 m^3 at $100^\circ C$. Compute the pressure using, (i) Vander Waal's equation (ii) Ideal gas equation.	8	L3	CO5

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