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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

January / February 2025 Semester End Main Examinations

Programme: B.E. **Semester: III**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 23CH3PCTD1 / 22CH3PCTD1 **Max Marks: 100**
Course: Process Engineering Thermodynamics-I

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	*CO*	*PO*	**Marks**
1	a)	Explain the scope and applications of thermodynamics in detail.	*CO 1*	*PO 2*	**10**
	b)	Nitrogen gas is confined in a cylinder and the pressure of the gas is maintained by a weight placed on the piston. The mass of the piston and the weight together is 50 kg. The acceleration due to gravity is 9.81 m/s^2 and the atmospheric pressure is 1.01325 bar. Assume frictionless piston. Determine: i) The force exerted by the atmosphere, the piston, and the weight on the gas if the piston is 100 mm in diameter ii) The pressure of the gas. iii) If the gas is allowed to expand pushing up the piston and the weight by 400 mm, what is the work done by the gas in J? iv) What is the change in the potential energy of the piston and the weight after the expansion in (iii).	*CO 1*	*PO 2*	**10**
		OR			
2	a)	The potential energy of a body of mass 10.0 kg is 1.5 kJ. What is the height of the body from the ground? If a body of mass 10 kg is moving at a velocity of 50 m/s, what is its kinetic energy?	*CO 1*	*PO 2*	**5**
	b)	A man whose weight is 600 N takes 2 min for climbing up a staircase. Determine the power developed in him, if the staircase is made up of 20 stairs each 0.18 m in height.	*CO 1*	*PO 2*	**5**
	c)	Illustrate the following terms with examples : i) Heat and work ii) Intensive and extensive properties iii) State and path functions iv) Internal energy and enthalpy	*CO 1*	*PO 2*	**10**

			UNIT - II			
	3	a)	Derive the first law of thermodynamics for a flow process with a neat diagram.	*CO 2*	*PO 3*	**10**
		b)	A system consisting of a gas confined in a cylinder is undergoing the following series of processes before it is brought back to the initial conditions: *Step* 1: A constant pressure process when it receives 50 J of work and gives up 25 J of heat. *Step* 2: A constant volume process when it receives 75 J of heat. *Step* 3: An adiabatic process. Calculate heat, work, changes in internal energy, enthalpy for each step and for whole cycle.	*CO 2*	*PO 3*	**10**
			OR			
	4	a)	Illustrate the concept of a reversible process with an example. State the drawbacks and applications of the concept.	*CO 2*	*PO 2*	**10**
		b)	Water at 368 K is pumped from a storage tank at the rate of 25 m^3/h. The motor for the pump supplies work at the rate of 2 hp. The water passes through a heat exchanger, where it gives up heat at the rate of 42000 kJ/min and is delivered to a second storage tank at an elevation of 20 m above the first tank. Determine the temperature of the water delivered to the second storage tank. Assume that the enthalpy of water is zero at 273 K and the specific heat of water is constant at 4.2 kJ/kg K.			**10**
			UNIT - III			
	5	a)	Explain the PVT behavior of water with neat phase diagrams.	*CO 3*	*PO 2*	**10**
		b)	Calculate the compressibility factor and molar volume for methanol vapor at 500 K and 10 bar, using the following equations. Experimental values of virial coefficients are: $B = -2.19\times 10^{-4}\ m^3/mol$; $C = -1.73 \times 10^{-8}\ m^6/mol^2$. The critical temperature and pressure of methanol are 512.6 K and 81 bar. i) Virial equation ii) Redlich–Kwong equation.	*CO 3*	*PO 3*	**10**
			OR			
	6	a)	Derive the expressions for the constants of van der Waal's equation.	*CO 3*	*PO 3*	**10**
		b)	Calculate the volume occupied by one mole of oxygen at 300 K and 100 bar using: i) The ideal gas law. ii) The van der Waals equation. Take $a = 0.1378\ N\ m^4/mol^2$ and $b = 3.18\times10^{-5}\ m^3/mol$.	*CO 3*	*PO 3*	**10**

			UNIT - IV			
	7	a)	Derive an expression for the work done by an ideal gas in an adiabatic expansion process.	*CO 4*	*PO 3*	**10**
		b)	An ideal gas is undergoing a series of three operations: The gas is heated at constant volume from 300 K and 1 bar to a pressure of 2 bar. It is expanded in a reversible adiabatic process to a pressure of 1 bar. It is cooled at constant pressure of 1 bar to 300 K. Determine the heat and work effects for each step. Assume C_P = 29.3 kJ/kmol K.	*CO 4*	*PO 3*	**10**
			OR			
	8	a)	Derive an expression for work done by an ideal gas in isothermal expansion process	*CO 4*	*PO 3*	**5**
		b)	Air is compressed from an initial state of 1 bar, 298.15 K, to final state of 5 bar and 298.15 K by three different processes in a closed system. i) Heating at constant volume followed by cooling at constant pressure ii) Adiabatic compression followed by cooling at constant volume iii) Isothermal compression Determine the changes in internal energy, enthalpy, work and heat for each and Step and for entire cycle. Data: C_p =2.5 R, C_v= 1.5 R	*CO 4*	*PO 3*	**15**
			UNIT - V			
	9	a)	State the limitations of First law of thermodynamics and define the various definitions of second law of thermodynamics.	*CO5*	*PO2*	**10**
		b)	An inventor claims to have developed a refrigeration unit which maintains the refrigerated space at 270 K while operating in a room where the temperature is 300 K and which has a coefficient of performance of 9.5. How do you evaluate his claim?	*CO5*	*PO2*	**5**
		c)	A new engine is claimed to be having a power output of 4.5 hp while receiving a heat input of 6.25 kW and working between the source and sink temperature limits of 1000 K and 500 K. Determine the efficiency of the proposed engine. Is the claim for the engine admissible?	*CO5*	*PO2*	**5**
			OR			
	10	a)	Derive an expression for the efficiency of a Carnot engine. State the assumptions made.	*CO5*	*PO3*	**10**
		b)	A steel casting at a temperature 725 K and weighing 35 kg is quenched in 150 kg oil at 275 K. If there are no heat losses, determine the change in entropy. The specific heat (C_P) of steel is 0.88 kJ/kg K and that of oil is 2.5 kJ/kg K.	*CO 5*	*PO 3*	**10**

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