SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF MECHANICAL ENGINEERING

QUESTION BANK

III - SEMESTER

ME3363 ENGINEERING THERMODYNAMICS

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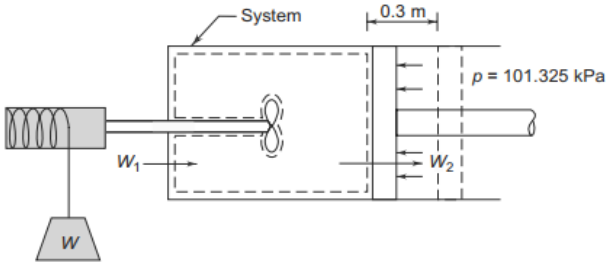
Prepared by

Dr. K.Venkatesan,

Assistant Professor (Sr.G)/Mech

UNIT 1 - BASIC CONCEPTS AND FIRST LAW			
Basic concepts - Thermodynamic systems, Properties and processes. Thermodynamic Equilibrium - Displacement work - P-V diagram. Heat and work transfer. Zeroth law – concept of temperature and temperature scales –First law of thermodynamics – application to closed and open systems – steady and unsteady flow processes.			
PART - A (2 MARKS)			
Sl.No	QUESTIONS	BT LEVEL	COMPETENCE
1	Define thermodynamic system.	BT-1	Understanding
2	Name the different types of system.	BT-2	Understanding
3	Summarize thermodynamic equilibrium.	BT-2	Understanding
4	Differentiate between point function and path function.	BT-2	Understanding
5	Define the term enthalpy.	BT-1	Remembering
6	What is the convention for positive and negative work?	BT-1	Remembering
7	Should the automobile radiator be analysed as a closed system or as an open system?	BT-1	Remembering
8	Enlist the similarities between heat and work.	BT-1	Remembering
9	Define Zeroth law of Thermodynamics.	BT-1	Remembering
10	Why does free expansion have zero work transfer?	BT-2	Understanding
11	What is perpetual motion machine of first kind [PMM1]?	BT-1	Remembering
12	Give the limitations of first law of thermodynamics.	BT-2	Understanding
13	Show the difference in specific heat capacities equal to Cp - Cv =R.	BT-1	Remembering
14	Explain homogeneous and heterogeneous system.	BT-2	Understanding
15	Differentiate intensive and extensive properties.	BT-2	Understanding
16	What do you mean by quasi static process?	BT-2	Understanding
17	Define the term State and Process.	BT-1	Remembering
18	How there is no change in internal energy in an isolated system?	BT-1	Remembering
19	Show the practical application of steady flow energy equation.	BT-1	Remembering
20	What is meant by reversible and irreversible process?	BT-2	Understanding
21	Show that the energy of an isolated system remains constant.	BT-1	Remembering
22	What are the conditions for steady flow process?	BT-1	Remembering
23	Define specific heat capacity at constant volume.	BT-2	Understanding
24	State that First law of thermodynamics for a non-flow process and for a cycle.	BT-1	Remembering
25	Show any four reasons for irreversibility in a process.	BT-2	Understanding

PART - B (16 MARKS)				
Sl.No	QUESTIONS	MARKS	BT LEVEL	COMPETENCE
1.i	Convert the following readings of pressure to kPa assuming that barometer reads 760 mm of Hg. Discover: (i) 80 cm of Hg (ii) 30 cm Hg vacuum (iii) 1.35 m H_2O gauge (iv) 4.2 bar.	8	BT-4	Analyzing

1.ii	A tube contains an oil of specific gravity 0.9 to a depth of 120 cm. Plan the gauge pressure at this depth (in kN/m^2).	8	BT-3	Applying
2	A piston and cylinder machine containing a fluid system has a stirring device in the cylinder in Fig. The piston is frictionless, and it is held down against the fluid due to the atmospheric pressure of 101.325 kPa. The stirring device is turned 10,000 revolutions with an average torque against the fluid of 1.275 mN. Meanwhile the piston of 0.6 m diameter moves out 0.8 m. Determine the network transfer for the system. 	16	BT-5	Evaluating
3	A fluid at a pressure of 3 bar, and with specific volume of 0.18 m^3/kg, contained in a cylinder behind a piston expands reversibly to a pressure of 0.6 bar according to a law, $P = C/v^2$ where C is a constant. Calculate the work done by the fluid on the piston.	16	BT-5	Evaluating
4	Explain in detail the following terms path functions, point functions, intensive, extensive properties of the system.	16	BT-2	Understanding
5	Explain the pdv-work in various Quasi - Static process with neat sketch.	16	BT-2	Understanding
6	Drive the Relationship Between Two Specific Heats.	16	BT-3	Applying
7	With a help of PV diagram explain the following processes Constant Volume, Constant pressure, Constant temperature, Polytropic process.	16	BT-2	Understanding
8	Helium is contained in a cylinder of 10 litres at a pressure of 10 MPa and 300 K. Helium starts leaking into the atmosphere until the gas pressure in the cylinder becomes half. Assume that the temperature of the cylinder and the gas remains at 300 K all the time. If the atmospheric pressure and temperature are 100 kPa and 300 K, respectively, is there any energy transfer as work? If yes, determine the work done by helium. Assume that helium obeys the relation pV = nRT, where R = 8.314 kJ/k mol K and n is the number of moles.	16	BT-5	Evaluating

9	A spherical balloon of 2 m diameter is filled with a gas at 200 kPa and 300 K. The gas inside the balloon is heated. Finally, the pressure reaches 1 MPa. During the process of heating, assume that the pressure is proportional to the diameter of the balloon. Simplify the work done by the gas inside the balloon.	16	BT-4	Analyzing
10	A fluid system, contained in a piston and cylinder machine, passes through a complete cycle of four processes. The sum of all heat transferred during a cycle is – 340 kJ. The system completes 200 cycles per min.Complete the following table showing the method for each item, and compute the net rate of work output in kW. Process Q (kJ/min) W (kJ/min) ΔE (kJ/min) 1—2 0 4340 — 2—3 42000 0 — 3—4 –4200 — –73200 4—1 — — —	16	BT-4	Analyzing
11	A cylinder contains 0.45 m^3 of a gas at 1×10^5 N/m^2 and 80°C. The gas is compressed to a volume of 0.13 m^3, the final pressure being 5×10^5 N/m^2. Determine : (i) The mass of gas (ii) The value of index 'n' for compression ; (iii) The increase in internal energy of the gas ; The heat received or rejected by the gas during compression. Take $\gamma = 1.4$, R = 294.2 J/kg°C.	16	BT-5	Evaluating
12	In a steady flow apparatus, 135 kJ of work is done by each kg of fluid. The specific volume of the fluid, pressure, and velocity at the inlet are 0.37 m^3/kg, 600 kPa, and 16 m/s. The inlet is 32 m above the floor, and the discharge pipe is at floor level. The discharge conditions are 0.62 m^3/kg, 100 kPa, and 270 m/s. The total heat loss between the inlet and discharge is 9 kJ/kg of fluid. In flowing through this apparatus, does the specific internal energy increase or decrease, and by how much?	16	BT-5	Evaluating
13	In a gas turbine unit, the gases flow through the turbine is 15 kg/s and the power developed by the turbine is 12000 kW. The enthalpies of gases at the inlet and outlet are 1260 kJ/kg and	16	BT-4	Analyzing

	400 kJ/kg respectively, and the velocity of gases at the inlet and outlet are 50 m/s and 110 m/s respectively. Examine: (i) The rate at which heat is rejected to the turbine, and The area of the inlet pipe given that the specific volume of the gases at the inlet is0.45 m^3/kg			
14	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. Analyze (i) the velocity at the exit of the nozzle and the mass flow rate and (ii) if the inlet area is 0.12 m^2 and the specific volume of the fluid at the inlet 0.19 m^3/kg, find the exit area of the nozzle; if the specific volume of the fluid at the exit is 0.5 m^3/kg.	16	BT-4	Analyzing
15	A centrifugal pump delivers 60 kg of water per second. The inlet and outlet pressures are 10 kPa and 400 kPa, respectively. The suction is 2 m below and delivery is 8 m above the centre line of the pump. The suction and delivery pipe diameters are 20 cm and 10 cm, respectively. Determine the capacity of the electric motor to run the pump.	16	BT-5	Evaluating
16	An air compressor is used to supply air to a rigid tank that has a volume of 4m^3. Initially, the pressure and temperature of the air in the tank are 200 kPa and 40°C respectively. The supply pipe to the tank is 8 cm in diameter, and the velocity of the air in the inlet pipe remains constant at 12 m/s. The pressure and temperature of the air in the inlet pipe are constant at 600 kPa and 40°C, respectively. Estimate the following. (a) The mass flow rate of the change. (b) The mass of air added to the tank if the compressor stops operating when the tank reaches 400 kPa and 60°C. (c) The time that the compressor must be operated to produce a tank pressure of 400 kPa and at temperature of 60°C	16	BT-6	Creating

17	0.2 m^3 of air at 4 bar and 130°C is contained in a system. A reversible adiabatic expansion takes place till the pressure falls to 1.02 bar. The gas is then heated at constant pressure till enthalpy increases by 72.5 kJ. Calculate: (i) The work done; (ii) The index of expansion, if the above processes are replaced by a single reversible polytropic process giving the same work between the same initial and final states. Take C_p = 1 kJ/kg K, C_v = 0.714 kJ/kg K.	16	BT-5	Evaluating
18	Air at a temperature of 15°C passes through a heat exchanger at a velocity of 30 m/s where its temperature is raised to 800°C. It then enters a turbine with the same velocity of 30 m/s and expands until the temperature falls to 650°C. On leaving the turbine, the air is taken at a velocity of 60 m/s to a nozzle where it expands until the temperature has fallen to 500°C. If the air flow rate is 2 kg/s, calculate (a) the rate of heat transfer to the air in the heat exchanger, (b) the power output from the turbine assuming no heat loss. the velocity at exit from the nozzle, assuming no heat loss. Take the enthalpy of air as h = cpt, where Cp is the specific heat equal to 1.005 kJ/kg K and t is the temperature	16	BT-5	Evaluating

UNIT - II SECOND LAW AND ENTROPY			
Heat Reservoir, source and sink. Heat Engine, Refrigerator, and Heat pump. Statements of second law and its corollaries. Carnot cycle Reversed Carnot cycle, Performance. Clausius inequality. Concept of entropy, T-s diagram, Tds Equations, entropy change for - pure substance.			
PART - A (2 MARKS)			
Sl.No	QUESTIONS	BT LEVEL	COMPETENCE
1	A cyclic heat engine operates between a source at 800˚C and sink at 30˚C. What is the least rate of heat rejection per KW net output of the engine?	BT-1	Remembering
2	Define heat reservoir and source.	BT-1	Remembering
3	State Carnot theorem.	BT-1	Remembering
4	State Clausius statement of II law of thermodynamics.	BT-2	Understanding
5	Draw a schematic diagram of a heat pump.	BT-1	Remembering
6	State kelvin Planck's second law statement.	BT-2	Understanding
7	What are the Corollaries of Carnot theorem?	BT-1	Remembering
8	A heat engine with a thermal efficiency of 45 percent rejects 500 kJ/kg of heat. How much heat does it receive?	BT-1	Remembering
9	What is thermal energy reservoir? Explain the term source and sink.	BT-1	Remembering
10	Define PMM of second kind.	BT-1	Remembering
11	Explain the throttling process.	BT-1	Remembering
12	What is the difference between a heat pump and a refrigerator?	BT-2	Understanding
13	What is meant by heat engine?	BT-1	Remembering
14	Name two alternative methods by which the efficiency of a Carnot cycle can be increased.	BT-1	Remembering
15	When will the Carnot cycle efficiency be maximum?	BT-2	Understanding
16	Define the term compression ratio.	BT-1	Remembering
17	What is the relation between COP_{HP} and COP_{ref}?	BT-2	Understanding
18	Write the expression for COP of a heat pump and a refrigerator?	BT-2	Understanding
19	Define thermal efficiency.	BT-1	Remembering
20	Why carnot cycle cannot be realized in practical?	BT-2	Understanding
21	What are the processes involved in Carnot cycle?	BT-1	Remembering
22	What are the conditions for reversible processes?	BT-2	Understanding
23	Why the performance of refrigerator and heat pump given in terms of C.O.P and not in terms of efficiency?	BT-1	Remembering
24	Define COP.	BT-2	Remembering
25	Why a heat engine cannot have 100% efficiency?	BT-1	Remembering
PART - B (16 MARKS)			
Sl.No	QUESTIONS	MARKS	BT LEVEL	COMPETENCE
1	Explain in detail about Carnot theorem and its corollary with a neat sketch.	16	BT-5	Evaluating

2	A reversible heat engine operates between two reservoirs at temperatures of 600°C and 40°C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40°C and -20°C. The heat transfer to the heat engine is 2000 kJ and the net work output of the combined engine refrigerator plant is 360 kJ. (a) Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C. (b) Reconsider (a) given that the efficiency of the heat engine and the COP of the refrigerator are each 40% of their maximum possible values.	16	BT-5	Evaluating
3	A cyclic heat engine operates between a source temperature of 1000°C and a sink temperature of 40°C. Examine the least rate of heat rejection per kW net output of the engine ?	16	BT-4	Analyzing
4	A reversible heat engine rejects heat at the rate of 1200 kJ/min at 30°C to a river. The efficiency of this engine is 45%. Conclude (a) temperature of the source and (b) power output of the engine.	16	BT-5	Evaluating
5	An ice plant working on a reversed Carnot cycle heat pump produces 15 tonnes of ice per day. The ice is formed from water at 0°C and the formed ice is maintained at 0°C. The heat is rejected to the atmosphere at 25°C. The heat pump used to run the ice plant is coupled to a Carnot engine which absorbs heat from a source which is maintained at 220°C by burning liquid fuel of 44500 kJ/kg calorific value and rejects the heat to the atmosphere. Determine: (i) Power developed by the engine; Fuel consumed per hour. Take enthalpy of fusion of ice = 334.5 kJ/kg.	16	BT-5	Evaluating
6	A series combination of two Carnot engines operate between the temperature of 180°C and 20°C. Calculate the intermediate temperature of the engines producing equal amount of work.	16	BT-6	Creating

7.i	An inventor claims to have developed an engine which takes 100 MJ of heat at a temperature of 327°C, rejects 48 MJ at a temperature of 27°C and delivers 15 kWh of mechanical work. Is his claim valid?	8	BT-5	Evaluating
7.ii	A domestic food freezer maintains a temperature of –15°C. The ambient air temperature is 30°C. If heat leaks into the freezer at the continuous of 1.75 kJ/s, Identify the least power necessary to pump this out continuously?	8	BT-3	Applying
8	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, Examine (i) the intermediate temperature between A and B, (ii) the efficiency of each engine and (iii) heat rejected to the cold sink.	16	BT-4	Analyzing
9	Drive the equation for Clausius Inequality.	16	BT-3	Applying
10	Two Carnot engines A and B are connected in series between two thermal reservoirs maintained at T1 = 1000 K and T2 = 100 K, respectively. Engine A receives 1700 kJ of heat from the high-temperature reservoir and rejects heat to the Carnot engine B. Engine B takes in heat rejected by engine A and rejects heat to the low-temperature reservoir. If engines A and B have equal thermal efficiencies, Test the following, (i) The heat rejected by the engine B. (ii) The temperature at which heat is rejected by engine A and (iii) The work done during the process by engines, A and B, respectively. If the engines A and B deliver equal work, determine (iv) The amount of heat taken in by engine B and The efficiencies of engines A and B.	16	BT-4	Analyzing

11	A light is provided in the refrigerator. It is designed in such a way that light will be switched on when the door of the refrigerator is opened. Due to malfunction of the switch, bulb remains 'on' continuously. Calculate (a) the increase in energy consumption of the refrigerator and (b) its cost per month.	16	BT-5	Evaluating
12	Series combination of three Carnot engines A, B and C operate between temperatures of 1500 K and 300 K. If the amount of heat addition to each engine is in the ratio of 6:3:2, Solve the intermediate temperatures.	16	BT-6	Creating
13	A household refrigerator is maintained at a temperature of 2°C. Every time the door is opened, warm material is placed inside, introducing an average of 420 kJ, but making only small change in the temperature of the refrigerator. The door is opened 20 times a day and the refrigerator operates at 15% of the ideal COP. The cost of work is 32 paise per kWh. What is the monthly bill for this refrigerator? The atmosphere is at 30°C.	16	BT-4	Analyzing
14	A reversible refrigerator is used to produce 800 kg/hr of ice at 4°C from water at 20°C. The refrigerator operates between 20°C and –4°C. Take C_p ice = 2.0 kJ/kg K and latent heat of ice = 335 kJ/kg K. Calculate the power input to the engine.	16	BT-3	Applying
15	A house requires 2×10^5 kJ/h for heating in winter. Heat pump is used to absorb heat from cold air outside in winter and send heat to the house. Work required to operate the heat pump is 3 × 104 kJ/h. Determine : (i) Heat abstracted from outside ; (ii) Co-efficient of performance.	16	BT-4	Analyzing
16	A reversible heat engine operates between two reservoirs at temperatures 700°C and 50°C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 50°C and – 25°C. The heat transfer to the engine is 2500 kJ and the net work output of the combined engine refrigerator plant is 400 kJ. (i) Determine the heat transfer to the refrigerant and the net heat transfer to the reservoir at 50°C ; (ii) Reconsider (i) given that the efficiency of the heat engine and the C.O.P. of the refrigerator are each 45 per	15	BT-5	Evaluating

	cent of their maximum possible values.			
17	Two Carnot engines work in series between the source and sink temperatures of 550 K and 350 K. If both engines develop equal power determine the intermediate temperature.	16	BT-3	Applying
18	300 kJ/s of heat is supplied at a constant fixed temperature of 290°C to a heat engine. The heat rejection takes place at 8.5°C. The following results were obtained : (i) 215 kJ/s are rejected. (ii) 150 kJ/s are rejected. (iii) 75 kJ/s are rejected. Classify which of the result report a reversible cycle or irreversible cycle or impossible results.	16	BT-5	Evaluating



UNIT III - AVAILABILITY AND APPLICATION OF II LAW			
Ideal gases undergoing different processes - principle of increase in entropy. Applications of II Law. High - grade and low - grade energy. Availability and Irreversibility for open and closed system processes - I and II law Efficiency.			
PART - A (2 MARKS)			
Sl.No	QUESTIONS	BT LEVEL	COMPETENCE
1	Define available energy.	BT-1	Remembering
2	What is meant by dead state?	BT-1	Remembering
3	What are the assumptions made on heat engine?	BT-2	Understanding
4	What is a reversed heat engine?	BT-1	Remembering
5	What are the causes of irreversibility?	BT-1	Remembering
6	What are the assumptions made on heat engine?	BT-2	Understanding
7	What do you understand by the entropy principle?	BT-1	Remembering
8	When a system is adiabatic, what changes will been happen in entropy of a substance in the system?	BT-2	Understanding
9	Compare difference between adiabatic and isentropic process.	BT-2	Understanding
10	How increment of entropy is denoted?	BT-2	Understanding
11	Define entropy.	BT-1	Remembering
12	What are the characteristics of entropy?	BT-1	Remembering
13	State the third law of thermodynamics.	BT-1	Remembering
14	Define unavailable energy.	BT-1	Remembering
15	What is law of the degradation of energy?	BT-2	Understanding
16	Write the equation for non-flow availability function.	BT-1	Remembering
17	Express the steady-flow availability function in equation form.	BT-1	Remembering
18	What is keenan function?	BT-1	Remembering
19	Write the equation of Helmholtz function.	BT-2	Understanding
20	What is free energy function?	BT-1	Remembering
21	What is irreversibility of the process?	BT-2	Understanding
22	Define effectiveness.	BT-1	Remembering
23	List the causes of entropy increase.	BT-1	Remembering
24	Can entropy of universe ever decreases? Why?	BT-2	Understanding
25	What is the value range for effectiveness of an actual process?	BT-2	Understanding
PART - B (16 MARKS)			
Sl.No	**QUESTIONS**	**MARKS**	**BT LEVEL**	**COMPETENCE**
1	Drive the equation for the entropy change of an ideal gas.	16	BT-3	Applying
2	A vessel of capacity 4 m3 contains air at pressure 2 bar and	16	BT-5	Evaluating

	temperature 30°C. Then, additional air is pumped into the system until the pressure rises to 30 bar and the temperature rises to 70°C. Calculate the following: (a) The mass of air pumped in (b) Equivalent volume of air pumped in expressed at 1 bar and 30°C. If the vessel is now allowed to cool until the temperature is again 30°C, calculate the following: (a) The pressure in the vessel Quantity of heat transferred (b) The change of entropy of the gas during the cooling process			
3	0.04 m^3 of nitrogen contained in a cylinder behind a piston is initially at 1.05 bar and 15°C. The gas is compressed isothermally and reversibly until the pressure is 4.8 bar. Calculate : (i) The change of entropy, (ii) The heat flow, and (iii) The work done. Sketch the process on a p-v and T-s diagram. Assume nitrogen to act as a perfect gas. Molecular weight of nitrogen = 28.	16	BT-3	Applying
4	An insulated cylinder of volume capacity 4 m3 contains 20 kg of nitrogen. Paddle work is done on the gas by stirring it till the pressure in the vessel gets increased from 4 bar to 8 bar. Determine : (a) Change in internal energy, (b) Work done, (c) Heat transferred, and (d) Change in entropy. Take for nitrogen : C_p = 1.04 kJ/kg K, and C_v = 0.7432 kJ/kg K	16	BT-5	Evaluating
5	A fluid undergoes a reversible adiabatic compression from 4 bar, 0.3 m^3 to 0.08 m^3 according to the law, $pv^{1.25}$ = constant. Analyze : (i) Change in enthalpy ; (ii) Change in internal energy ; (iii) Change in entropy ; (iv) Heat transfer ; (v) Work transfer	16	BT-4	Analyzing
6	A rigid cylinder containing 0.004 m3 of nitrogen at 1 bar and 300 K is heated reversibly until temperature becomes 400 K. Determine : (i) The heat supplied. (ii) The entropy change. Assume nitrogen to be perfect gas (molecular mass = 28) and take γ = 1.4.	16	BT-5	Evaluating
7	5 kg of air is heated from 300 K to 800 K. While the pressure changes from 80 kPa to 500 kPa. Analyze the change in entropy.	16	BT-4	Analyzing

8	One kg of air is compressed polytropically from 1 bar pressure and temperature of 300 K to a pressure of 6.8 bar and temperature of 370 K. Determine the irreversibility if the sink temperature is 293 K. Assume R = 0.287 kJ/kg K, C_p = 1.004 kJ/kg K and C_v = 0.716 kJ/kg K	16	BT-5	Evaluating
9	A liquid is heated at approximately constant pressure from 20°C to 80°C by passing it through tubes which are immersed in a furnace. The furnace temperature is constant at 1500°C. Solve the effectiveness of the heating process when the atmospheric temperature is 15°C. Take specific heat of liquid as 6.3 kJ/kg K.	16	BT-3	Applying
10	A closed system contains air at a pressure 2 bar, 300 K, and 0.05 m^3. The processes are given below. Calculate (a) the change in entropy for each process and (b) total change of entropy. Represent the cycle on PV and TS diagram. Process 1–2 Constant volume heat addition till the pressure becomes double Process 2–3 Constant pressure cooling Process 3–1 Isothermal heating to initial state	16	BT-5	Evaluating
11	1 kg of air initially at 8 bar pressure and 380 K expands polytropically ($pv^{1.2}$ = constant) until the pressure is reduced to one-fifth value. Predict the following : (i) Final specific volume and temperature. (ii) Change of internal energy, work done and heat interaction. (iii) Change in entropy.	16	BT-4	Analyzing
12	An iron cube at a temperature of 400°C is dropped into an insulated bath containing 10 kg water at 25°C. The water finally reaches a temperature of 50°C at steady state. Given that the specific heat of water is equal to 4186 J/kg K. Find the entropy changes for the iron cube and the water. Is the process reversible? If so why?	16	BT-3	Applying
13	Air at 20°C and 1.05 bar occupies 0.025 m^3. The air is heated at constant volume until the pressure is 4.5 bar, and then cooled at constant pressure back to original temperature. Calculate : (i) The net heat flow from the air. (ii) The net entropy change. Sketch the process on T-s diagram.	16	BT-4	Analyzing
14	0.04 kg of carbon dioxide (molecular weight = 44) is compressed from 1 bar, 20°C, until the pressure is 9 bar, and the volume is	16	BT-3	Applying

	then 0.003 m^3. Calculate the change of entropy. Take C_p for carbon dioxide as 0.88 kJ/kg K, and assume carbon dioxide to be a perfect gas.			
15	A system at 500 K receives 7200 kJ/min from a source at 1000 K. The temperature of atmosphere is 300 K. Assuming that the temperatures of system and source remain constant during heat transfer find out : (i) The entropy produced during heat transfer ; (ii) The decrease in available energy after heat transfer.	16	BT-4	Analyzing
16	8 kg of air at 650 K and 5.5 bar pressure is enclosed in a closed system. If the atmosphere temperature and pressure are 300 K and 1 bar respectively, determine : (i) The availability if the system goes through the ideal work producing process. (ii) The availability and effectiveness if the air is cooled at constant pressure to atmospheric temperature without bringing it to complete dead state. Take C_v = 0.718 kJ/kg K ; C_p = 1.005 kJ/kg K.	16	BT-3	Applying
17	15 kg of water is heated in an insulated tank by a churning process from 300 K to 340 K. If the surrounding temperature is 300 K, find the loss in availability for the process.	16	BT-4	Analyzing
18	Calculate the decrease in available energy when 20 kg of water at 90°C mixes with 30 kg of water at 30°C, the pressure being taken as constant and the temperature of the surroundings being 10°C. Take C_p of water as 4.18 kJ/kg K.	16	BT-3	Applying

UNIT IV - PROPERTIES OF PURE SUBSTANCE

Steam - formation of steam and its thermodynamic properties, p-v, p-T, T-v, T-s, h-s diagrams. p-v-T surface. Determination of dryness fraction. Calculation of work done and heat transfer in non-flow and flow processes using of Steam Table and Mollier Chart.

PART - A (2 MARKS)

Sl.No	QUESTIONS	BT LEVEL	COMPETENCE
1	Define latent heat of ice.	BT-1	Remembering
2	What is meant by super heated steam? And indicate its use.	BT-1	Remembering
3	Distinguish between flow process and non-flow process.	BT-1	Remembering
4	Is iced water a pure substance? Why?	BT-2	Understanding
5	How do you determine the state of steam?	BT-2	Understanding
6	Define pure substance.	BT-1	Remembering
7	State the phase rule of pure substances.	BT-1	Remembering
8	What is wet steam and dry steam?	BT-2	Understanding
9	Define dryness fraction of steam.	BT-1	Remembering
10	Draw P-T (Pressure-Temperature) diagram of a pure substance.	BT-2	Understanding
11	What is homogeneous in chemical aggregation?	BT-1	Remembering
12	Define critical pressure and temperature for water.	BT-2	Understanding
13	What is meant by boiling point and melting point?	BT-1	Remembering
14	What is Invariable in chemical aggregation?	BT-2	Understanding
15	Define saturation pressure and saturation temperature.	BT-1	Remembering
16	What do you understand by triple point and critical point?	BT-1	Remembering
17	Define latent heat of evaporation.	BT-2	Understanding
18	What is sub cooled liquid?	BT-2	Understanding
19	What is compressed liquid?	BT-1	Remembering
20	Define superheated vapour.	BT-1	Remembering
21	Write a short note on superheated temperature.	BT-2	Understanding
22	What is degree of superheat?	BT-2	Understanding
23	Define Saturated liquid.	BT-1	Remembering
24	Explain about hidden heat.	BT-2	Understanding
25	What is dryness fraction?	BT-1	Remembering

PART - B (16 MARKS)

Sl.No	QUESTIONS	MARKS	BT LEVEL	COMPETENCE

1	A vessel having a capacity of 0.05 m^3 contains a mixture of saturated water and saturated steam at a temperature of 245°C. The mass of the liquid present is 10 kg. Examine the following : (i) The pressure, (ii) The mass, (iii) The specific volume, (iv) The specific enthalpy, (v) The specific entropy, and (vi) The specific internal energy.	16	BT-4	Analyzing
2	1000 kg of steam at a pressure of 16 bar and 0.9 dry is generated by a boiler per hour. The steam passes through a superheater via boiler stop valve where its temperature is raised to 380°C. If the temperature of feed water is 30°C, determine : (i) The total heat supplied to feed water per hour to produce wet steam. (ii) The total heat absorbed per hour in the superheater. Take specific heat for superheated steam as 2.2 kJ/kg K	16	BT-5	Evaluating
3 i	Find the dryness fraction, specific volume and internal energy of steam at 7 bar and enthalpy 2550 kJ/kg.	8	BT-1	Remembering
3 ii	Steam at 120 bar has a specific volume of 0.01721 m^3/kg, find the temperature, enthalpy and the internal energy.	8	BT-1	Remembering
4	Calculate the internal energy per kg of superheated steam at a pressure of 10 bar and a temperature of 300°C. Also find the change of internal energy if this steam is expanded to 1.4 bar and dryness fraction 0.8	16	BT-5	Evaluating
5	A rigid vessel of 10 m^3 volume contains steam at 4 MPa and 80% quality. Evaluate (a) the enthalpy (b) internal energy of the steam and (c) entropy of the steam.	16	BT-5	Evaluating
6	A processing plant requires wet steam at 10 bar, 0.9 dry and 3000 m^3/h. Analyze (a) The mass of steam supplied per hour (b) The quantity of fuel required Boiler efficiency = 0.35, Calorific value (C.V.) of fuel = 45000 kJ/kg	16	BT-4	Analyzing
7	Steam from boiler 1, at 20 bar and 300°C and from boiler 2, at 20 bar enter into a common main. The pressure in the main is 20 bar absolute and 250°C.	16	BT-3	Applying

	Estimate the quality of the steam supplied from the boiler 2. Cp of superheat is 2.4 kJ/kg K.			
8	Wet steam is contained in a closed vessel of capacity 2 m^3 at 5 bar and 0.8 dryness. Steam at 12 bar 0.95 dryness is supplied to the vessel untill the pressure inside the vessel becomes 8 bar. Calculate (a) the mass of the steam supplied to the vessel and (b) the final quality of the steam in the vessel. Neglect the volume of the moisture and thermal capacity of the vessel.	16	BT-3	Applying
9	A vessel having a volume of 0.6 m^3 contains 3.0 kg of liquid water and water vapour mixture in equilibrium at a pressure of 0.5 MPa. Calculate : (i) Mass and volume of liquid ; (ii) Mass and volume of vapour	16	BT-4	Analyzing
10	A pressure cooker contains 1.5 kg of saturated steam at 5 bar. Find the quantity of heat which must be rejected so as to reduce the quality to 60% dry. Determine the pressure and temperature of the steam at the new state.	16	BT-3	Applying
11	A spherical vessel of 0.9 m 3 capacity contains steam at 8 bar and 0.9 dryness fraction. Steam is blown off until the pressure drops to 4 bar. The valve is then closed and the steam is allowed to cool until the pressure falls to 3 bar. Assuming that the enthalpy of steam in the vessel remains constant during blowing off periods, determine : (i) The mass of steam blown off ; (ii) The dryness fraction of steam in the vessel after cooling ; (iii) The heat lost by steam per kg during cooling.	16	BT-3	Applying
12	Steam at 140 bar has an enthalpy of 3001.9 kJ/kg, find the temperature, the specific volume and the internal energy	16	BT-4	Analyzing
13	Calculate the internal energy per kg of superheated steam at a pressure of 10 bar and a temperature of 300°C. Also find the change of internal energy if this steam is expanded to 1.4 bar and dryness fraction 0.8.	16	BT-3	Applying
14	Two boilers one with superheater and other without superheater are delivering equal quantities of steam into a common main. The pressure in the boilers and main is 20 bar. The temperature of steam from a boiler with a superheater is 350°C and temperature of the steam in the main is 250°C. Determine the quality of steam supplied by the other boiler. Take cps = 2.25 kJ/kg.	16	BT-3	Applying

15	Steam enters an engine at a pressure 10 bar absolute and 400°C. It is exhausted at 0.2 bar. The steam at exhaust is 0.9 dry. Find : (i) Drop in enthalpy ; (ii) Change in entropy.	16	BT-4	Analyzing
16	Find the entropy of 1 kg of superheated steam at a pressure of 12 bar and a temperature of 250°C. Take specific heat of superheated steam as 2.1 kJ/kg K.	16	BT-3	Applying
17	A piston-cylinder contains 3 kg of wet steam at 1.4 bar. The initial volume is 2.25 m3. The steam is heated until its temperature reaches 400°C . The piston is free to move up or down unless it reaches the stops at the top. When the piston is up against the stops the cylinder volume is 4.65 m 3. Determine the amount of work and heat transfer to or from steam.	16	BT-3	Applying
18	Find the internal energy of 1 kg of steam at 20 bar when (i) it is superheated, its temperature being 400°C ; (ii) it is wet, its dryness being 0.9. Assume superheated steam to behave as a perfect gas from the commencement of superheating and thus obeys Charle's law. Specific heat for steam = 2.3 kJ/kg K.	16	BT-4	Analyzing

UNIT V - GAS MIXTURES AND THERMODYNAMIC RELATIONS			
Properties of Ideal gas, real gas - comparison. Equations of state for ideal and real gases. VanderWaal's relation - Reduced properties - Compressibility factor – Principle of Corresponding states – Generalized Compressibility Chart. Maxwell relations, Tds Equations, Difference and ratio of heat capacities, Energy equation, Joule Thomson Coefficient, Clausius Clapeyron equation			
PART - A (2 MARKS)			
Sl. No	QUESTIONS	BT LEVEL	COMPETENCE
1	State the principle of corresponding states.	BT-1	Remembering
2	How does the Vander Waal's equation differ from the ideal gas equation of state?	BT-1	Remembering
3	What are the assumptions made to derive ideal gas equation analytically using the kinetic theory of gases.	BT-2	Understanding
4	What is equation of state?	BT-1	Remembering
5	Define isothermal Compressibility.	BT-1	Remembering
6	State Joule's law.	BT-1	Remembering
7	Define Regnault's law.	BT-1	Remembering
8	Explain the construction and give the use of generalized compressibility chart.	BT-2	Understanding
9	What are virial coefficients? When do they become zero?	BT-2	Understanding
10	Define Compressibility factor.	BT-1	Remembering
11	Have you ever encountered any ideal gas? If so, where?	BT-2	Understanding
12	What is the significance of compressibility factor?	BT-2	Understanding
13	Write the equation of state for ideal gas.	BT-2	Understanding
14	What is Joule-Thomson coefficient?	BT-1	Remembering
15	What is coefficient of volume expansion?	BT-1	Remembering
16	Explain Joule Kelvin effect. What is inversion temperature?	BT-1	Remembering
17	Define Gibb's function.	BT-2	Understanding
18	Write down two Tds relations.	BT-2	Understanding
19	Write the Maxwell's equations and its significance.	BT-1	Remembering
20	In what way the Clausius Clapeyron equations is useful?	BT-1	Remembering
21	State Helmholtz function.	BT-1	Remembering
22	In a gas mixture, which component will have the higher partial pressure, the one with the higher mole number or the one with the larger molar mass?	BT-2	Understanding
23	What is Clausius Clapeyron Equation?	BT-1	Remembering

24	Why is Joule-Thomson coefficient zero for an ideal gas?	BT-1	Remembering
25	What are Maxwell relations?	BT-1	Remembering

PART - B (16 MARKS)

Sl. No	QUESTIONS	MARKS	BT LEVEL	COMPETENCE
1	50°C air is contained in a spherical vessel of 2 m diameter. The vessel is evacuated till it becomes 70 cm of Hg. During the process, the temperature remains constant. Determine (a) The mass pumped out (b) The pressure in the tank in cm of Hg, if the tank is cooled to 5°C Assume atmospheric pressure of 760 mm Hg.	16	BT-5	Evaluating
2	2 m^3 of gas is heated at constant pressure from 30°C to 200°C. Estimate, (a) Characteristic gas constant (b) Ratio of specific heats (c) Heat added (d) Work done (e) Change in internal energy (f) Final volume (g) Initial pressure Assume C_p = 0.98 kJ/kg K, C_v = 0.714 kJ/kg K, m = 1 kg	16	BT-5	Evaluating
3	2 kg of O_2 from a pressure of 1 bar, 60°C is compressed to a final pressure of 5 bar along with a polytropic path for which $PV^{1.3}$ = C. Calculate, (a) The heat transferred (b) The change of entropy Assume: R = 0.280 kJ/kg K Cp = 0.98 kJ/kg K.	16	BT-5	Evaluating
4	A gas is raised from 30°C to 120°C. Calculate, (a) Molar specific heat at constant pressure (b) Cp (c) Cv (d) Change in specific enthalpy Assume molecular weight of the gas as 40(M) and the gas follows a relation of Cp = 5/3R.	16	BT-5	Evaluating

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5	A rigid vessel is having two compartments. Both the compartments, A and B, are of a volume 0.25 m^3. The pressure in A is 2 bar and that in B is 4 bar. Both the compartments are at the same temperature. When 40 kJ of heat is added, the partition wall is damaged. What is the final pressure when equilibrium is attained?	16	BT-1	Remembering
6	A vessel of capacity 3 m^3 contains 1 kg mole of N^2 at 90°C. (i) Calculate pressure and the specific volume of the gas. (ii) If the ratio of specific heats is 1.4, evaluate the values of C_p and C_v. (iii) Subsequently, the gas cools to the atmospheric temperature of 20°C ; evaluate the final pressure of gas. (iv) Evaluate the increase in specific internal energy, the increase in specific enthalpy, increase in specific entropy and magnitude and sign of heat transfer.	16	BT-4	Analyzing
7	A container of 3 m^3 capacity contains 10 kg of CO_2 at 27°C. Estimate the pressure exerted by CO2 by using : (i) Perfect gas equation (ii) Van der Waals' equation (iii) Beattie Bridgeman equation.	16	BT-5	Evaluating
8	Air in closed station systems expands in a reversible adiabatic process from 0.5 MPa, 17˚C to 0.2 MPa. Find the final temperature and also for unit mass of air, calculate the change in enthalpy, the heat transferred and the work done.	16	BT-4	Analyzing
9	Two kilogram of air in a closed system, having initial volume and temperature of 0.5 m^3 and 7˚C, respectively, undergoes a constant pressure heating process to 100˚C. There is no work other than pdv work. Determine (i) the work done during the process, (ii) the heat transferred and (iii) the entropy change.	16	BT-5	Evaluating

10	Air is contained in a cylinder fitted with frictionless piston. Initially, the cylinder contains 0.5 m^3 of air at 2 bar and 27˚C. The air is then compressed reversibly according to the law, $pv^n = c$, until the final pressure is 8 bar at which point temperature is 137˚C. Examine (i) the polytropic index n; (ii) the final volume of air; (iii) the work done on air; (iv) the heat transfer; and (v) the change in entropy.	16	BT-4	Analyzing
11	Drive the Maxwell relations.	16	BT-3	Applying
12	Explain the Joule – Thomson Co-efficient and express the relations.	16	BT-4	Analyzing
13	Drive the entropy equations (Tds Equations)	16	BT-3	Applying
14	Explain the Clausius – Claperyon equation and express the relations.	16	BT-4	Analyzing
15	Drive the equation for internal energy and enthalpy.	16	BT-3	Applying
16	4 kg of carbon dioxide at 40°C and 1.4 bar are mixed with 8 kg of nitrogen at 160°C and 1.0 bar to form a mixture at a final pressure of 0.7 bar. The process occurs adiabatically in a steady flow apparatus. Calculate : (i) The final temperature of the mixture ; (ii) The change in entropy. Take value of Cp : for CO_2 = 0.85 kJ/kg K and N_2 = 1.04 kJ/kg K.	16	BT-4	Analyzing
17	An ice skate is able to glide over the ice because the skate blade exerts sufficient pressure on the ice that a thin layer of ice is melted. The skate blade then glides over this thin melted water layer. Determine the pressure an ice skate blade must exert to allow smooth ice skate at – 10°C. The following data is given for the range of temperatures and pressures involved : $h_{fg(ice)}$ = 334 kJ/kg ; $\upsilon_{liq.}$ = 1 × 10 m^3/kg ; υ_{ice} = 1.01 × 10^3 m^3/kg.	16	BT-3	Applying
18	For mercury, the following relation exists between saturation pressure (bar) and saturation temperature (K) : $\log_{10} p = 7.0323 - 3276.6/T - 0.652 \log_{10} T$ Calculate the specific volume υ_g of saturation mercury vapour at 0.1 bar. Given that the latent heat of vapourisation at 0.1 bar is 294.54 kJ/kg. Neglect the specific volume of saturated mercury liquid.		BT-4	Analyzing