QUESTION BANK

SUBJECT :ENGINEERING THERMODYNAMICS
SEM/YEAR :III SEM/II YEAR

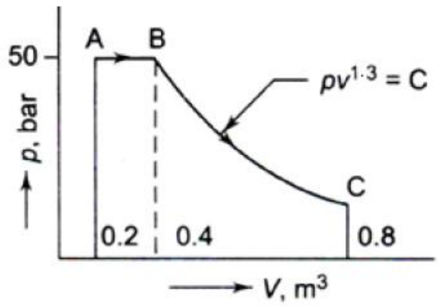
UNIT I BASICS, ZEROTH AND FIRST LAW 9
Review of Basics – Thermodynamic systems, Properties and processes Thermodynamic Equilibrium - Displacement work - P-V diagram. Thermal equilibrium - Zeroth law – Concept of temperature and Temperature Scales. First law – application to closed and open systems – steady and unsteady flow processes.

PART - A (2Marks)

S.No	QUESTIONS	LEVEL	COMPETENCE
1	Express flow Energy.	BT-2	Understanding
2	Give the conditions of steady flow process.	BT-2	Understanding
3	Summarize thermodynamic equilibrium.	BT-2	Understanding
4	Differentiate between point function and path function.	BT-3	Applying
5	Using Knudsen number define continuum.	BT-1	Remembering
6	What is meant by control volume and control surface?	BT-1	Remembering
7	Should the automobile radiator be analyzed as a closed system or as an open system?	BT-1	Remembering
8	Enlist the similarities between heat and work	BT-1	Remembering
9	What is microscopic approach in thermodynamics?	BT-1	Remembering
10	Generalize extensive property.	BT-6	Creating
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	Prove that the difference in specific heat capacities equal to C_p - C_v = R.	BT-5	Evaluating
14	Compare homogeneous and heterogeneous system.	BT-4	Analysing
15	Compare intensive and extensive properties.	BT-4	Analysing
16	Differentiate quasi static and non quasi static process.	BT-3	Applying
17	Generalize the term State and Process.	BT-6	
18	Prove that for an isolated system, there is no change in internal energy.	BT-5	Evaluating
19	Indicate the practical application of steady flow energy equation.	BT-6	Creating
20	Illustrate reversible and irreversible process.	BT-3	Applying

PART - B (13 Marks)

S.No	QUESTIONS	LEVEL	COMPETENCE
1	Determine the total work done by a gas system following an expansion process as shown in the figure.	BT-1	Remembering

	 . (13)		
2	(i) Derive the expression for the displacement work. (5) (ii) Determine the work transfer and heat transfer a system in which a perfect gas having molecular weight of 16Kg/Kmol i s compressed from 101.3KPa. 20˚C to a pressure of 600 KPa. following the law $PV^{1.3}$=constant. Take specific heat at constant pressure of gas as 1.7 kJ/kg K (8)	BT-1	Remembering
3	A mass of 8 kg gas expands within a flexible container so that the *p–v* relationship is of the from $pv^{1.2}$ = constant. The initial pressure is 1000 kPa and the initial volume is 1 m^3. The final pressure is 5 kPa. If specific internal energy of the gas decreases by 40 kJ/kg, find the heat transfer in magnitude and direction. (13)	BT-6	Creating
4	A stationary mass of gas is compressed without friction from an initial state of 0.3m^3 and 0.015MPa to the final state of 0.15m^3 and 0.105MPa, the pressure remaining constant during the process. There is a transfer of 37.6 kJ of heat from the gas during the process. How much does the internal energy of the gas change? (13)	BT-1	Remembering
5	A gas undergoes a thermodynamic cycle consisting of the following processes: (i) Process 1-2: constant pressure P_1=1.4 bar, V_1= 0.028m^3, W_{1-2}=10.5kJ (ii) Process 2-3: compression with PV=C, U_3=U_2 (iii) Process 3-1: constant volume, U_1-U_3 = -26.4kJ. There are no significant changes in the KE and PE. 1) Sketch the cycle on a PV diagram. (2) 2) Calculate the network for the cycle in kJ. (3)	BT-5	Evaluating

	3) Calculate the heat transfer for the process 1-2. (3) 4) Show that the sum of heat transfer in the cycle is equal to the sum of work transfer in the cycle. (5)		
6	A turbine operating under steady flow conditions receives steam at the following state: pressure 13.8 bar, specific volume 0.143 m^3/kg, internal energy 2590 kJ/kg, velocity 30 m/s. The state of the stream leaving turbine is turbine is; pressure 0.35 bar, specific volume 4.37m^3/kg, internal energy 2360 kJ/kg, velocity 90 m/s. Heat is lost to the surroundings at the rate of 0.25 kJ/s. If the rate of steam flow is 0.38 kg/s, what is the power developed by the turbine? (13)	BT-1	Remembering
7	A thermodynamic system operates under steady flow conditions, the fluid entering at 2 bar and leaving at 10 bar. The entry velocity is 30 m/s and the exit velocity is 10m/s. During the process 25 MJ/hr of heat from an external source is supplied and the increase in enthalpy is 5kJ/kg. The exit point is 20m above the entry point. Estimate flow work from the system if the fluid flow rate is 15 kg/min. (13)	BT-2	Understanding
8	A vessel of constant volume 0.3m^3 contains air at 1.5 bar and is connected via a valve to a large main carrying air at a temperature of 38°C and high pressure. The valve is opened allowing air to enter the vessel and raising the pressure therein to 7.5 bar. Assuming the vessel and valve to be thermally insulated, predict the mass of the air entering the vessel. (13)	BT-2	Understanding
9	The gas expanding in the combustion space of a reciprocating engine has an initial pressure of 50 bar and an initial temperature of 1623˚C. The initial volume is 50000 mm^3 and the gas expands through a volume ratio of 20 according to the law $PV^{1.25}$ = constant. Calculate (i) the work transfer and (ii) heat transfer in the expansion process. Take R=270 J/kg.K and C_v= 800 J/kg.K (13)	BT-2	Understanding
10	(i) Write the steady flow energy equation of the boiler (6) (ii) Air flows steadily at the rate of 0.04 kg/s through an air compressor, entering at 6m/s with a pressure of 1 bar and specific volume of 0.85 m^3/Kg and leaving at 4.5 m/s with a pressure of 6.9 bar and a specific	BT-5	Evaluating

	volume of 0.16 m^3/Kg. The internal energy of the air leaving is 88 kJ/Kg greater than that of the entering air. Cooling water surrounding the cylinder absorbs heat from the air at the rate of 59 W. Calculate the power required to drive the compressor and the inlet and outlet cross sectional areas. (7)		
11	The power output of an adiabatic steam turbine is 5 MW and the state of steam entering the turbine is pressure 2 MPa; Temperature 400˚C; velocity 50 m/s; elevation 10 m. The state of the steam leaving the turbine is: pressure 15 kPa; dryness fraction 0.9; velocity 180 m/s; elevation 6m. Determine, 1. the change in enthalpy, kinetic energy and potential energy. 2. the work done per unit mass of the steam flowing through the turbine. the mass flow rate of the steam. (13)	BT-2	Understanding
12	(i) Write the steady flow energy equation and simplify it to be applicable for a gas turbine and a compressor. (5) (ii)In a gas turbine installation air is heated inside the heat exchanger up to 750°C from the ambient temperature of 27°C. hot air then enters into the gas turbine with a velocity of 50 m/s and leaves at 600°C. Air leaving the turbine enters a nozzle at 60m/s velocity and leaves the nozzle at the temperature of 500°C. for unit mass of the flow rate of air, Examine the following assuming the adiabatic expansion in the turbine and nozzle. (i) Heat transfer to air in heat exchanger (4) (ii) Power output from turbine (4) Velocity at the exit of the nozzle. Take C_p of air as 1.005kJ/kgK	BT-3	Applying
13	A three process cycle operating with nitrogen gas as the working substance has constant temperature compression at 34°Cwith the initial pressure 100 kPa. Then the gas undergoes a constant volume heating and then polytropic expansion with1.35 as index of compression. The isothermal compression requires -67 kJ/kg of work. Point out (i) P, V&T around the cycle. (3) (ii) Heat in and out (4)	BT-4	Analysing

	(iii) Net work (6) For Nitrogen gas C_v = 0.7431kJ/kg K.		
14	In 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 m^3/kg, 600kPa and 16m/s. the inlet is 32m above the floor and the discharge pipe is floor level. The discharge conditions are 0.62m^3/kg, 100kPa and 270m/s. the total heat loss between the inlet and discharge is 9 kJ/kg of the fluid. In flowing through this apparatus, does the internal energy increase or decrease and how much? (13)	BT-3	Applying
	PART-C (15 Marks)		
1	Apply the first law of thermodynamics in human bodies, I.C engines and also compare with them.	BT6	Create
2	Apply and explain the steady flow energy equation concept for any two heat transfer devices.	BT6	Create
3	An imaginary engine receives heat and does work on a slowly moving piston at such rate that the cycle of operation of 1 kg of working fluid can be represented as a circle 10 cm in diameter on a p-v diagram on which 1 cm = 300 kPa and 1cm = 0.1 m^3/kg. 1. how much work is done by each kg of working fluid for each cycle of operation? 2. the thermal efficiency of an engine is defined as the ratio of work done and heat input in a cycle. If the heat rejected by the engine in a cycle is 1000kJ per kg of working fluid, what would be its thermal efficiency?	BT5	Evaluating
4	A gas of mass 1.5 kg undergoes a quasi-static expansion which follows a relationship $p = a + bV$, where *a* and *b* are constants. The initial and final pressures are 1000 kPa and 200 kPa respectively and the corresponding volumes are 0.20 m^3 and 1.20 m^3. The specific internal energy of the gas is given by the relation $u = 1.5\, pv - 85$ kJ/kg where *p* is the kPa and *v* is in m^3/kg. Calculate the net heat transfer and the maximum internal energy of the gas attained during expansion	BT5	Evaluating

UNIT II & III SECOND LAW AND ENTROPHY AVAILABILITY AND APPLICATIONS OF II LAW

Heat Engine – Refrigerator - Heat pump. Statements of second law and their equivalence & corollaries. Carnot cycle - Reversed Carnot cycle - Performance - Clausius inequality. Concept of entropy - T-s diagram - Tds Equations - Entropy change for a pure substance.

Ideal gases undergoing different processes - principle of increase in entropy. Applications of II Law. Highand low-grade energy. Availability and Irreversibility for open and closed system processes - I and II law Efficiency

PART - A (2Marks)

S.No	QUESTIONS	LEVEL	COMPETENCE
1	A reversible heat engine operate between a source at 800˚C and sink at 30˚C. What is the least rate of heat rejection per KW network output of the engine?	BT-3	Applying
2	Define heat reservoir and source.	BT-6	Creating
3	What is Helmholtz free enginery function?	BT-1	Remembering
4	State Clausius statement of II law of thermodynamics.	BT-2	Understanding
5	Draw a schematic of a heat pump.	BT-3	Applying
6	State kelvin Planck's second law statement.	BT-3	Applying
7	Compare difference between adiabatic and isentropic process.	BT-1	Remembering
8	An inventor claims to develop an engine which absorbs 100KW of heat from a reservoir at 1000K produces 60 kW of work and rejects heat to a reservoir at 500 K. Will u advise investment in its development?	BT-1	Remembering
9	What is thermal energy reservoir? Explain the term source and sink.	BT-3	Applying
10	What is reversed heat engine?		Applying
11	What is irreversibility of a process?	BT-5	Evaluating
12	Compared available energy and unavailable energy.	BT-1	Remembering
13	What is meant by dead state?	BT-6	Creating
14	A turbine gets a supply of 5kg /s of steam at 7 bar, 250°C and discharges it at 1 bar. Solve the availability.	BT-2	Understanding
15	Point out the purpose of second law of thermodynamics.	BT-5	Evaluating
16	What are the causes of irreversibility	BT-1	Remembering
17	What is temperature entropy diagram?	BT-2	Understanding
18	What is the principle of increase of entropy?	BT-1	Remembering
19	When s system is adiabatic what can be said about the entropy change of substance in the system?	BT-2	Understanding
20	What do understand by high grade and low grade energy?	BT-4	Analysing

PART - B (13 Marks)

S.No	QUESTIONS	LEVEL	COMPETENCE
1	A carnot heat engine draws heat from a reservoir at temperature 600K and reject heat to another reservoir at temperature T_3. The carnot forward cycle engine drives a carnot reversed cycle engine or carnot refrigerator which absorbs heat from reservoir at temperature 300K and reject heat to a reservoir at temperature T_3, determine: i. the temperature T_3 such that heat supplied to engine Q_1 is equal to the heat absorbed by refrigerator Q_2. ii. the efficiency of carnot engine and COP of carnot refrigerator. (13)	BT-1	Remembering
2	i. Show that the efficiency of the reversible heat engine depends only on the maximum and minimum absolute temperature in the cycle. (8) ii. State and prove carnot theorem. (5)	BT-1	Remembering
3	(i) A reversible heat pump is used to maintain a temperature of 0°C in a refrigerator when it rejects the heat to the surroundings at 25°C. if the heat removal rate from the refrigerator is 1440kJ/min, determine the COP of the machine and the work input required. (6) (ii) If the required input to run the pump is developed by a reversible engine which receives heat at 380°C and rejects heat to the atmosphere and then determines the overall COP of the system. (7)	BT-4	Analysing
4	Three Carnot engines A, B and C working between the temperature of 1000K and 300K are in a series combination. The works produced by these engines are in the ratios 5:4:3. Make calculations of temperature for the intermediate reservoirs. (13)	BT-5	Evaluating
5	A reversible heat engine operates between two reservoirs a temperature of 600°C and 40°C. the engine drives a reversible refrigerator which operates between the reservoirs at temperatures of 40°C and -20°C. the heat transfer to the heat engine is 2000 KJ and the network output for the combined engine refrigerator is 30 KJ. Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C. (13)	BT-5	Evaluating

6	(i) Describe the Carnot cycle and examine the Carnot principles, idealized Carnot heat engine, refrigerators and heat pumps. (8) (ii) Determine the expression for the thermal efficiencies and coefficient of performance for reversible heat engines, heat pump and refrigerators. (5)	BT-3	Applying
7	Two Carnot engines A and B are operated in series. The first one receives heat at 870°C and rejects to a reservoir at T. B receives heat rejected by the first engine and in turn rejects to a sink 300 K. calculate the temperature T for (i) Equal work output of both engines (4) (ii) Same efficiencies (4) (iii) Mention Clausius inequality for open, closed and isolated systems. (5)	BT-3	Applying
8	Air expands through a turbine from 500KPa, 520˚C to 100KPa, 300˚C. During expansion 10KJ/Kg of heat is lost to the surroundings which is at 98KPa, 20˚C. Neglecting the kinetic and potential energy changes, determine per kg of air, i. the decrease in availability ii. the maximum work and iii. the irreversibility. for air C_p =1.005 kJ/kgK and H=C_pT (13)	BT-4	Analysing
9	A fluid undergoes a reversible adiabatic compression from 4 bar, 0.3m^3 to 0.08 m^3 according to the law pv$^{1.25}$ = C. Determine the change in enthalpy the change in internal energy and change in entropy. (13)	BT-1	Remembering
10	Air flows through an adiabatic compressor at 2Kg/s. The inlet condition are 100KPa and 310 K, and the exit conditions are 700 kPa and 560K. Consider T0 to be 298K. Determine the change of availability and irreversibility. (13)	BT-1	Remembering
11	Two kg of air at 500 kPa, 80°C expands adiabatically in a closed system until its volume is doubled and its temperature becomes equal to that of the surroundings which is at 100 kPa, 5°C. for this process determine: (i) The maximum work (ii)The change in availability (iii)The irreversibility (13)	BT-4	Analysing

12	5 kg of air at 550 K and 4 bar is enclosed in a closed vessel. Examine the availability of the system if the surrounding pressure and temperature are 1 bar and 290°C If the air is cooled at constant pressure to the atmospheric temperature, determine the availability and effectiveness. (13)	BT-3	Applying
13	(i) 3 kg of air at 500 kPa, 90°C expands adiabatically in a closed system until its volume is doubled and its temperature becomes equal to that of the surroundings at 100kPa and 10°C. calculate the maximum work, change in availability and irreversibility (8) (ii) Briefly discuss about the concept of entropy (5)	BT-3	Applying
14	5 m^3 of air at 2 bar, 27°C is compressed up to 6 bar pressure following $PV^{1.3}$=C. it is subsequently expanded adiabatically to 2 bar. Considering the two processes to be reversible determine the network, net heat transfer, and change in entropy. Also plot the process on PV and TS diagram. (13)	BT-1	Remembering
	PART-C (15 Marks)		
1	A household refrigerator that has a power input of 450W and a COP of 1.5 is to cool 5 large watermelons, 10 kg each to 8˚C. If the watermelons are initially at 28˚C, determine how long it will take for the refrigerator to cool them. The watermelons can be treated as water whose specific heat is 4.2kJ/kg. Is your answer realistic or optimistic? Explain.	BT-6	Creating
2	(i) How do you minimize the energy consumed by your domestic refrigerator?. (ii) The interior lighting of refrigerators is provided by incandescent lamps whose switches are actuated by the opening of the refrigerator door. Consider a refrigerator whose 40W light bulb remains on continuously as a result of malfunction of the switch. If the refrigerator has a coefficient of performance of 1.3 and the cost of electricity is Rs. 5 per kWh, determine the increase in the energy consumption of the refrigerator and its cost per year if the switch is not fixed. Assume the refrigerator is opened 20 times a day for an avenge of 30 s.	BT-6	Creating
3	An air preheater is used to cool the products of combustion from a furnace while heating the air to be used for combustion. The rate of flow of products is 12.5kg/s and the products are cooled from 300°C and 200°C and for the products at this temperature C_p=1.09kJ/kg K. The rate of air	BT-6	Creating

	flow is 1.15kg/s. the initial temperature is 40°C and the air C_p=1.005kJ/kg K. (i) Estimate the initial and final availability of the products. (ii) What is the irreversibility for the products? If the heat transfer from the product occurs reversibly through heat engine, what is the power developed by the heat engine? Take T_o=300K and neglect pressure drop both the fluids and heat transfer to the surroundings.		
4	A pressure vessel has a volume of 1 m^3 and contains air at 1.4 MPa, 175°C. The air is cooled to 25°C by heat transfer to the surroundings at 25°C. Calculate the availability in the initial and final states and the irreversibility of this process. Take P_0 = 100 kPa.	BT-5	Evaluating

PROPERTIES OF PURE SUBSTANCES 9

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

PART - A (2Marks)

S.No	QUESTIONS	LEVEL	COMPETENCE
1	Write a short note on Mollier Chart.	BT-1	Remembering
2	What are compressed solid and compressed liquid?	BT-1	Remembering
3	What is critical condition of steam?	BT-6	Creating
4	What is meant by dead state?	BT-2	Understanding
5	Superheated steam at 30 bar and 300°C enters a turbine and expanded to 5 bar and quality 0.974 dryness, compute the loss in availability for the adiabatic process if the atmospheric temperature is 270°C.	BT-3	Applying
6	Define pure substance.	BT-1	Remembering
7	Give triple point represented in P-V diagram.	BT-1	Remembering
8	Explain the terms, Degree of super heat, degree of sub-cooling.	BT-6	Creating
9	Discuss latent heat of vaporization.	BT-6	Creating
10	Draw P-T (Pressure-Temperature) diagram of a pure substance.	BT-5	Evaluating
11	Give the possible ways to increase thermal efficiency of Rankine cycle.	BT-1	Remembering
12	Summarize the advantages of using superheated steam in turbines.	BT-2	Understanding
13	Name the different components in steam power plant working on Rankine cycle.	BT-1	Remembering
14	Why is excessive moisture in steam undesirable in steam turbines?	BT-4	Analyzing
15	Draw the standard Rankine cycle on P-V and T-S coordinates	BT-3	Applying
16	Analysis the effects of condenser pressure on the Rankine Cycle.	BT-4	Analyzing
17	Show Carnot cycle cannot be realized in practice for vapour power cycles.	BT-3	Applying
18	State the advantages of regenerative cycle.	BT-2	Understanding
19	Describe the different operations of Rankine cycle	BT-1	Remembering
20	Explain various operation of a carnot cycle	BT-4	Analyzing

PART - B (13 Marks)			
S.No	**QUESTIONS**	**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. Calculate the pressure, mass, specific volume, specific enthalpy, specific entropy, and specific internal energy. (13)	BT-2	Understanding
2	A pressure cooker contains 1.5kg 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. (13)	BT-1	Remembering
3	A large insulated vessel is divided into two chambers, one containing 5Kg of dry saturated steam at 0.2 MPa and other 10kg of steam 0.8 quality at 0.5MPa. If the partition between the chambers is removed and the steam is mixed thoroughly and allowed to settle, find the final pressure, steam quality and entropy change in the process. (13)	BT-4	Analysing
4	(i) Explain the process of formation of steam with T-s diagram. (5) (ii) 3 kg of steam at 18 bar occupy a volume of 0.2550 m^3. During a constant volume process, the heat rejected is 1320 kJ. Determine final internal energy also find initial dryness and work done. (8)	BT-3	Applying
5	Draw the schematic diagram of Rankine cycle and explain its working with the help of h-s diagram. Also discuss Rankine cycle improvements. (13)	BT-3	Applying
6	The steam conditions at inlet to the turbine are 42 bar and 500˚C, and the condenser pressure is 0.035bar. Assume that the steam is just dry saturated on leaving the first turbine, and is reheated to its initial temperature. Calculated the Rankine cycle efficiency and specific steam consumption with reheating by neglecting the pump work using Mollier chart. (13)	BT-1	Remembering
7	(i) Why is Carnot cycle not practicable for a steam power plant? (5) (ii) In a steam power plant the condition of steam at inlet to the steam turbine is 20 bar and 300˚C and the condenser pressure is 0.1 bar. Two feed water heaters operate at optimum temperatures. Determine (1) The	BT-2	Understanding

	quality of steam at turbine exhaust (2) Network per kg of steam (3) Cycle efficiency (4) The steam rate. Neglect pump work. (8)		
8	Steam at 480°C, 90 bar is supplied to a Rankine cycle. It is reheated to 12 bar and 480°C. the minimum pressure is 0.07 bar. Calculate the work output and the cycle efficiency using steam tables with and without considering the pump work. (13)	BT-2	Understanding
9	In a Rankine Cycle, the steam at inlet to the turbine is saturated at a pressure of 35 bar and the exhaust pressure is 0.2 bar. Determine i. The pump work (3) ii. The turbine work (3) iii. The condenser heat flow (3) iv. The dryness at the end of expansion. Assume flow rate of 9.5kg/s. (4)	BT-2	Understanding
10	A steam power plant operates on a theoretical reheat cycle. Steam at 25 bar pressure and 400°C is supplied to a high pressure turbine. After its expansion to dry state the steam is reheated to a constant pressure to its original temperature. Subsequent expansion occurs in the low pressure turbine to a condenser pressure of 0.04 bar. Considering feed pump work, make calculation to determine (i) quality of steam at the entry to the condenser (ii) thermal efficiency (iii) specific steam consumption. (13)	BT-5	Evaluating
11	A steam power plant operates on theoretical reheat cycle. Steam in boiler at 150 bar, 550°C expands through the high pressure turbine. It is reheated to a constant pressure of 40 bar to 550°C and expands through the low pressure turbine to a condenser at 0.1 bat. Draw T-s and h-s diagram. Find: i. Quality of the steam at the turbine exhaust.(4) ii. Cycle efficiency (4) iii Steam rate in kg/kW-hr (5)	BT-2	Understanding
12	(i) Steam at 30 bar and 350°C is expanded in a non-flow isothermal process to a pressure of 1 bar. The temperature and the pressure of the surroundings are 25°C and 100kPa respectively. Determine the maximum work that can be obtained from this process per kg of steam. Also find the maximum useful work. (8)	BT-6	Creating

	(ii) Write the aid of T-v diagram explain various phases of conversion of ice at -20°C to steam at 125°C. (5)		
13	(i) With the help of the schematic diagram, explain the regenerative Rankine cycle and derive the expression for its efficiency. Also represent the process in p-v and T-s diagrams.(7) (ii) Steam at 50 bar and 400°C expands in a Rankine cycle to 0.34 bar. For a mass flow rate of 150 kg/s of steam, determine Power developed (2) Thermal efficiency (2) Specific steam consumption (2)	BT-1	Remembering
14	Consider a steam power plant that operates on a reheat Rankine cycle and has a net power output of 80MW. Steam enters the high pressure turbine at 10 MPa and 500˚C and the low pressure turbine at 1 MPa and 500˚C. Steam leaves the condenser as a saturated liquid at a pressure of 10 kPa. The isentropic efficiency of the turbine is 80 percent, and that of the pump is 95 percent. Show the cycle on a T-s diagram with respect to saturation lines, and determine, (i) The quality (or temperature, if superheated) of the steam at the turbine exit, (ii) The thermal efficiency of the cycle, and (iii) The mass flow rate of the steam. (13)	BT-5	Evaluating
	PART-C (15 Marks)		
1	A steam power plant running on Rankine cycle has steam entering HP turbine at 20 MPa 500˚C and leaving LP turbine at 90% dryness. Consider condenser pressure of 0.005 MPa and reheating occurring up leaves HP turbine, the thermal efficiency and work done.	BT-5	Evaluating
2	A rigid closed tank of volume 3 m^3 contains 5kg of wet steam at a pressure of 200 KPa. The tank is heated until the steam become dry saturated. Determine the final pressure and the heat transfer to the tank.	BT-6	Creating
3	A simple steam power cycle uses solar energy for the heat input. Water in the cycle enters the pump as a saturated liquid at 40°C, and is pumped to 2 bar. It then evaporates in the boiler at this pressure, and enters the turbine	BT-6	Creating

	as saturated vapour. At the turbine exhaust the conditions are 40°C and 10% moisture. The flow rate is 150 kg/h. Determine (a) the turbine isentropic efficiency, (b) the net work output (c) the cycle efficiency, and (d) the area of solar collector needed if the collectors pick up 0.58 kW/m^2 .		
4	A textile factory requires 10,000 kg/h of steam for process heating at 3 bar saturated and 1000 kW of power, for which a back pressure turbine of 70% internal efficiency is to be used. Find the steam condition required at the inlet to the turbine.	BT-6	Creating

Properties of Ideal gas, real gas - comparison. Equations of state for ideal and real gases. vander Waal's relation - Reduced properties - Compressibility factor - Principle of Corresponding states - Generalized Compressibility Chart. Maxwell relations - TdS Equations - heat capacities relations - Energy equation, Joule-Thomson experiment - Clausius-Clapeyron equation.

PART - A (2Marks)

S.No	QUESTIONS	LEVEL	COMPETENCE
1	State the principle of corresponding states	BT-1	Remembering
2	Identify the application of Clasuius - Clapeyron equation	BT-1	Remembering
3	State the assumptions made in deriving ideal gas equation using the kinetic theory of gases.	BT-3	Applying
4	What is Joule-Thomson coefficient? Why is it zero for an ideal gas?	BT-1	Remembering
5	One Kg of ideal gas is heated from 18°C to 93°C. Taking R=269Nm/Kg - K and γ=1.2 for the gas. Calculate the change in internal energy	BT-1	Remembering
6	Using Clausius-Clapeyron equation, estimate the enthalpy of vaporization at 200°C. V_g=0.1274 m^3/Kg; V_f= 0.01157 m^3/Kg; dp/dt= 32KPa/K.	BT-1	Remembering
7	How does the Vander Waal's equation differ from the ideal gas equation of state?	BT-2	Understanding
8	Draw a generalized Compressibility Chart and its significance.	BT-2	Understanding
9	Write down two Tds relations.	BT-2	Understanding
10	Determine the molecular volume of any perfect gas at 600 N/m^2 and 30°C. Universal gas constant may be taken as 8314 J/Kg mole- K.	BT-2	Understanding
11	Write the Maxwell's equations and its significance.	BT-2	Understanding
12	What is compressibility factor?	BT-2	Understanding
13	Define isothermal Compressibility.	BT-1	Remembering
14	Define Avogadro's law.	BT-5	Evaluating
15	What is real gas? Give examples	BT-1	Remembering
16	What are known as thermodynamic gradients?	BT-1	Remembering
17	What is known as equation of state and when it can be used for engineering calculations?	BT-2	Understanding
18	What is the difference between an ideal and a perfect gas?	BT-6	Creating
19	State Boyle's and charle's laws and derive an equation of the state for a perfect gas.	BT-1	Remembering
20	What are semi-perfect or permanent gases?	BT-1	Remembering

PART - B (13 Marks)			
S.No	**QUESTIONS**	**LEVEL**	**COMPETENCE**
1	(i) One kg of CO_2 has a volume of 1 m^3 at 100˚C. Compute the pressure by a) Van der Waals' equation b) Perfect gas equation The Van der Waals' constants a = 362850 $Nm^4/(kg\text{-}mol)^2$ and b=0.0423 $m^3/(kg\text{-}mol)$. (10) (ii) Write the Berthelot and Dieterici equations (3)	BT-6	Creating
2	Derive an expression for Clausius Clapeyron equation applicable to fusion and Vaporization.	BT-5	Evaluating
3	A vessel of capacity 3 m^3 contain 1kg mole of N_2 at 90˚C, i. Calculate pressure and the specific volume of the gas. ii. If the ratio 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, then 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. (13)	BT-5	Evaluating
4	CO_2 flow at a pressure of 10 bar and 180˚C into a turbine, located in a chemical plant, and there it expands reversibly and adiabatically to a final pressure of 1.05 bar. Calculate the final specific volume, temperature and increase in entropy. Neglect changes in velocity and elevation. If the mass flow rate is 6.5 kg/min, evaluate the hat transfer rate from the gas and the power delivered by the turbine. Assume CO_2 to be a perfect gas and C_v -0.837kJ/kgK (13)	BT-1	Remembering
5	i. Deduce Van der Waals equation of state and explain its importance. (5) ii. Explain the principle of corresponding states and the use of compressibility chart. (8)	BT-2	Understanding
6	i. Derive Tds relation in terms of change in T and V (5) ii. Explain Joule-Thomson experiment and deduce the expression for Joule-Thomson coefficient. (8)	BT-2	Understanding

7	From the basic principles, prove the following C_p-C_v = $-T\left(\frac{\partial v}{\partial T}\right)_p^2 \left(\frac{\partial p}{\partial v}\right)_T$ and verify the validity of Maxwell's relation $\left(\frac{\partial s}{\partial p}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_p$ for steam at 300°C and 500 KPa (13)	BT-2	Understanding
8	The gas neon has a molecular weight of 20.183 and its critical temperature pressure and volume are 44.5 K, 2.73 MPa and 0.0416 m^3/kg mol. Reading from a compressibility chart for a reduced pressure of 1.3, the compressibility factor Z is 0.7. What are the corresponding specific volume, pressure, temperature and reduced volume? (13)	BT-2	Understanding
9	Determine the pressure of nitrogen gas at T=175 K and v = 0.00375m^3/kg on the basis of a. The ideal gas equation of state. (7) b. The van der Walls equation of state.(6) The van der Walls constant for nitrogen areα=0.175m^6-kPa/kg; b=0.00138m^3/Kg	BT-6	Creating
10	The pressure and temperature of mixture of 4 kg of O_2 and 6 kg of N_2 and 4 bar and 27°C respectively. For the mixture determine the following; a) The mole fraction of each component b) The average molecular weight c) The specific gas constant d) The volume and density e) The partial pressure and partial volume. (13)	BT-6	Creating
11	(i) Explain Joule Kelvin effect. What is inversion temperature? (ii) A certain gas has C_p=1.968kJ/kg K and C_v=1.505kJ/kg K. Find its molecular weight and the gas constant. A constant volume chamber of 0.3m^3 capacity contains 2kg of this gas at 5°C. Heat is transferred to the gas until the temperature is 100°C. Find the work done, heat transferred and the changes in internal energy, enthalpy and entropy. (13)	BT-4	Analysing
12	Derive any three Maxwell relations. (13)	BT-2	Understanding
13	(i) Under what conditions, a real gas behaves like an ideal gas? why? (6) (ii) Can you use the relation $\Delta H = m\ C_p\ (T_2 - T_1)$ to calculate the change in total internal energy of an ideal and real gas? if yes, for which process?	BT-1	Remembering

	If no, why? (7)		
14	Consider an ideal gas at 303 K and 0.86m^3/Kg. As a result of some disturbance the state of gas changes to 304 K and 0.87m^3/Kg. Estimate the change in pressure of the gas as the result of this disturbance. (13)	BT-5	Evaluating
	<u>PART-C (15 Marks)</u>		
1	Two vessels A and B both containing nitrogen, are connected by a valve which is opened to allow the contents to mix and achieve an equilibrium temperature of 27˚C. Before mixing in vessel A has pressure 1.5 MPa, temperature 50˚C, contents 0.5 kg mole and vessel B has pressure 0.6 MPa, temperature 20˚C, contents 2.5kg mole. Compute the final equilibrium pressure, and the amount of heat transferred to the surroundings. If the vessel is perfectly insulated, calculate the final temperature and pressure which would have been reached. Take Y=1.4.	BT-6	Creating
2	A tank of capacity 0.45 m^3 is insulated and is divided into two sections through a partition. One section initially contains H_2 at 3bar and 130˚C and has a volume of 0.3 m^3 and the other section initially holds N_2 at 6 bar and 30˚C. The gases are then allowed to mix after removing the adiabatic partition. Determine: i. the temperature of the equilibrium mixture ii. the pressure of the mixture iii. the change in entropy for each component and total value.	BT-5	Evaluating
3	Show that slope of the sublimation curve at the triple point is greater than that of vaporization curve on P-T diagram, using (i) latent heat and (ii) entropy change	BT-3	Applying
4	A vessel is divided into three compartments (a), (b), and (c) by two partitions. Part (a) contains oxygen and has a volume of 0.1 m^3, (b) has a volume of 0.2 m^3 and contains nitrogen, while (c) is 0.05 m3 and holds CO_2. All three parts are at a pressure of 2 bar and a temperature of 13°C. When the partitions are removed and the gases mix, determine the change of entropy of each constituent, the final pressure in the vessel and the partial pressure of each gas. The vessel may be taken as being completely isolated from its surroundings.	BT-5	Evaluating