SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF MECHANICAL ENGINEERING

QUESTION BANK

III - SEMESTER

1909302 ENGINEERING THERMODYNAMICS

Regulation – 2019

Academic Year 2022 – 2023

Prepared by

Mr. S. Sivasankar M.E., (Ph.D.)

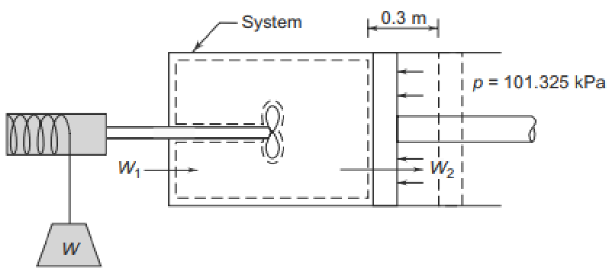
Assistant Professor (O.G)

UNIT 1 - BASIC CONCEPTS AND FIRST LAW

Basic concepts - concept of continuum, comparison of microscopic and macroscopic approach. Path and point functions. Intensive and extensive. System and their types. Thermodynamic Equilibrium State, path and process. Quasi-static, reversible and irreversible processes. Heat and work transfer-V diagram. Zeroth law of Thermodynamics – concept of temperature and thermal equilibrium– relationship between 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	Express flow Energy.	BT-2	Understanding
2	Interpret 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-2	Understanding
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 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	What is microscopic approach in thermodynamics?	BT-1	Remembering
10	Infer the extensive property.	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 $C_p - C_v = R$.	BT-1	Remembering
14	Compare homogeneous and heterogeneous system.	BT-2	Understanding
15	Compare intensive and extensive properties.	BT-2	Understanding
16	Differentiate quasi static and non 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	Illustrate the reversible and irreversible process.	BT-2	Understanding
21	Define an isolated system, there is no change in internal energy.	BT-1	Remembering
22	Show that work is a path function and not a property.	BT-1	Remembering
23	Relate the energy of an isolated system is always constant.	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 (13 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.	7	BT-4	Analysing
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).	6	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. 	13	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.	13	BT-5	Evaluating

4	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.	13	BT-5	Evaluating
5	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.	13	BT-4	Analysing
6	Explain in detail the following terms path functions, point functions, intensive, extensive properties of the system.	13	BT-2	Understanding
7	Explain the pdv-work in various Quasi - Static process with neat sketch.	13	BT-2	Understanding
8	Drive the Relationship Between Two Specific Heats.	13	BT-3	Applying
9	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 — — —	13	BT-4	Analysing

<table>
<tr><td>10</td><td>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 ;
(iv) The heat received or rejected by the gas during compression. Take γ = 1.4, R = 294.2 J/kg°C.</td><td>13</td><td>BT-5</td><td>Evaluating</td></tr>
<tr><td>11</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 transfers 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.

Process | Q (kJ/min) | W (kJ/min) | ΔE (kJ/min)
a-b | 0 | 2,170 | --
b-c | 21,000 | 0 | --
c-d | -2,100 | -- | -36,600
d-a | -- | -- | --</td><td>13</td><td>BT-5</td><td>Evaluating</td></tr>
<tr><td>12</td><td>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?</td><td>13</td><td>BT-5</td><td>Evaluating</td></tr>
<tr><td>13</td><td>With a help of PV diagram explain the following process Constant Volume, Constant pressure, Constant temperature, Polytropic process.</td><td>13</td><td>BT-2</td><td>Understanding</td></tr>
</table>

14	100 liter of an ideal gas at 300 K and 1 bar is compressed adiabatically to 10 bar. It is then cooled at constant volume and further, expanded isothermally so as to reach the condition from where it started. Draw the p-V diagram and calculate:(i) pressure at the end of constant volume cooling.(ii) change in internal energy during constant volume process.(iii) net work done and heat transferred during the cycle.Assume Cp = 14.3 kJ/kg K and Cv = 10.2 kJ/kg K	13	BT-5	Evaluating
15	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 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 (ii) The area of the inlet pipe given that the specific volume of the gases at the inlet is0.45 m^3/kg	13	BT-4	Analysing
16	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.	13	BT-4	Analysing
17	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.	13	BT-5	Evaluating

18	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	13	BT-6	Creating

PART - C (15 MARKS)

Sl.No	QUESTIONS	MARKS	BT LEVEL	COMPETENCE
1	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 Cp = 1 kJ/kg K, Cv = 0.714 kJ/kg K.	15	BT-5	Evaluating
2	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. (c) 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	15	BT-5	Evaluating

3	0.3 $m^3$of air at 4.5 bar and 140^{O}C is contained in a system. A reversible adiabatic expansion takes place until the pressure falls to 1.02 bar. The gas is then heated at constant pressure till enthalpy increases by 75 kJ. Solve (i) the work done and (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 Cp = 1 kJ/kg K, Cv = 0.714 kJ/kg K	15	BT-6	Creating
4	A frictionless piston is free to move in a closed cylinder. Initially there is 0.035 m^3 of oxygen at 4.5 bar, 60°C on one side of the piston and 0.07 m^3 of methane at 4.5 bar and –12°C on the other side. The cylinder walls and piston may be regarded as perfect thermal insulators but the oxygen may be heated electrically. Heating takes place so that the volume ofoxygen doubles. Examine :(i) Final state condition ; (ii) Work done by the piston ;(iii) Heat transferred to oxygen.Treat both gases as perfect and take :For oxygen Cp = 0.88 kJ/kg K, R = 0.24 kJ/kg KFor methane Cp = 1.92 kJ/kg K, R = 0.496 kJ/kg K.	15	BT-4	Analysing
5	Adapt the first law of thermodynamics in human bodies, I.C engines and also compare with them.	15	BT-6	Creating

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, ideal gases- different processes, principle of increase in entropy. Applications of II Law. High and low grade energy. Irreversibility. I and II law Efficiency.			
PART - A (2 MARKS)			
Sl.No	QUESTIONS	BT LEVEL	COMPETENCE
1	A reversible heat engine operates 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-1	Remembering
2	Define heat reservoir and source.	BT-1	Remembering
3	What is Helmholtz free enginery function?	BT-1	Remembering
4	State Clausius statement of II law of thermodynamics.	BT-2	Understanding
5	Choose a schematic diagram of a heat pump.	BT-1	Remembering
6	State kelvin Planck's second law statement.	BT-2	Understanding
7	Compare difference between adiabatic and isentropic process.	BT-2	Understanding
8	An inventor claims to develop an engine which absorbs 100KW of heat from a reservoir at 1000 K produces 60 kW of work and rejects heat to a reservoir at 500 K. Will you advise investment in its development?	BT-1	Remembering
9	What is thermal energy reservoir? Explain the term source and sink.	BT-1	Remembering
10	Label a reversed heat engine in practically.	BT-1	Remembering
11	How irreversibility in a process is define.	BT-1	Remembering
12	What is the difference between a refrigerator and an air conditioner?	BT-2	Understanding
13	What is meant by dead state?	BT-1	Remembering
14	A turbine gets a supply of 5kg /s of steam at 7 bar, 250◦C and discharges it at 1 bar. Infer the availability.	BT-2	Understanding
15	Point out the purpose of second law of thermodynamics.	BT-1	Remembering
16	What are the causes of irreversibility?	BT-1	Remembering
17	Sketch temperature entropy diagram.	BT-2	Understanding
18	Illustrate the principle of increase of entropy.	BT-1	Remembering
19	When a system is adiabatic, what changes will been happen in entropy of a substance in the system?	BT-2	Understanding

20	Summarize high grade and low grade energy.	BT-2	Understanding
21	What does the first law establish and what is its deficiency?	BT-1	Remembering
22	Tell the basic principle involved in the second law?	BT-1	Remembering
23	With a neat figure bring out the concept of source and sink.	BT-1	Remembering
24	What is meant by coefficient of performance?	BT-2	Remembering
25	What is meant by quality of energy?	BT-1	Remembering

PART - B (13 MARKS)

Sl.No	QUESTIONS	MARKS	BT LEVEL	COMPETENCE
1	Explain in detail about Carnot theorem and its corollary with a neat sketch	13	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.	13	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 ?	13	BT-4	Analysing
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.	13	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	13	BT-5	Evaluating

	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; (ii) Fuel consumed per hour. Take enthalpy of fusion of ice = 334.5 kJ/kg.			
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.	13	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?	7	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?	6	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.	13	BT-4	Analysing
9	Drive the equation for Clausius Inequality.	13	BT-3	Applying
10	Drive the equation for the entropy change of an ideal gas.	13	BT-3	Applying
11	A vessel of capacity 4 m3 contains air at pressure 2 bar and 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	13	BT-5	Evaluating

	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: (c) The pressure in the vessel (d) Quantity of heat transferred (e) The change of entropy of the gas during the cooling process			
12	0.04 m3 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.	13	BT-5	Evaluating
13	An insulated cylinder of volume capacity 4 m^3 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 : (i) Change in internal energy, (ii) Work done, (iii) Heat transferred, and (iv) Change in entropy. Take for nitrogen : c p = 1.04 kJ/kg K, and cv = 0.7432 kJ/kg K	13	BT-5	Evaluating
14	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. Analyse : (i) Change in enthalpy ; (ii) Change in internal energy ; (iii) Change in entropy ; (iv) Heat transfer ; (v) Work transfer	13	BT-4	Analysing

15	A rigid cylinder containing 0.004 m^3 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.	13	BT-5	Evaluating
16	5 kg of air is heated from 300 K to 800 K. While the pressure changes from 80 kPa to 500 kPa. Analyse the change in entropy.	13	BT-4	Analysing
17	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, Cp = 1.004 kJ/kg K and Cv = 0.716 kJ/kg K	13	BT-5	Evaluating
18	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.	13	BT-3	Applying

PART - C (15 MARKS)				
Sl.No	QUESTIONS	MARKS	BT LEVEL	COMPETENCE
1	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 (v) The efficiencies of engines A and B.	15	BT-6	Creating
2	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.	15	BT-5	Evaluating
3	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.	15	BT-6	Creating
4	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	15	BT-5	Evaluating

	Process 2–3 ..... Constant pressure cooling Process 3–1 ..... Isothermal heating to initial state			
5	1 kg of air initially at 8 bar pressure and 380 K expands polytropically (Pv1-2 = 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.	15	BT-6	Creating

UNIT III - PROPERTIES OF PURE SUBSTANCE AND STEAM POWER CYCLE			
Formation of steam and its thermodynamic properties, p-v, p-T, T-v, T-s, h-s diagrams. p-v-T surface. Use of Steam Table and Mollier Chart. Determination of dryness fraction. Application of I and II law for pure substances. Ideal and actual Rankine cycles, Cycle Improvement Methods - Reheat and Regenerative cycles, Economizer, preheater, Binary and Combined cycles.			
PART - A (2 MARKS)			
Sl.No	QUESTIONS	BT 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	Discuss the critical condition of steam.	BT1	Remembering
4	Illustrate meant by dead state.	BT-1	Understanding
5	Superheated steam at 30 bar and 300◦C enters a turbine and expanded to 5 bar and quality 0.974 dryness, Infer the loss in availability for the adiabatic process if the atmospheric temperature is 270◦C.	BT-2	Understanding
6	Define pure substance.	BT-1	Remembering
7	Recite triple point represented in P-V diagram.	BT-1	Remembering
8	Infer the terms, Degree of super heat, degree of sub-cooling.	BT-2	Understanding
9	Discuss latent heat of vaporization.	BT-1	Remembering
10	Draw P-T (Pressure-Temperature) diagram of a pure substance.	BT-2	Understanding
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-2	Understanding
15	Draw the standard Rankine cycle on P-V and T-S coordinates	BT-2	Understanding
16	Classify the effects of condenser pressure on the Rankine Cycle.	BT-2	Understanding
17	Show Carnot cycle cannot be realized in practice for vapour power cycles.	BT-2	Understanding
18	State the advantages of regenerative cycle.	BT-2	Understanding
19	Describe the different operations of Rankine cycle.	BT-1	Remembering

20	Outline the various operation of a Carnot cycle.	BT-2	Understanding
21	Define saturation pressure and saturation temperature.	BT-1	Remembering
22	What do you understand by triple point and critical point?	BT-1	Remembering
23	Outline the p-T diagram? What is its use?	BT-2	Understanding
24	What do you mean by the entropy of superheated steam	BT-1	Remembering
25	What do you understand by the degree of superheat and the degree of subcooling?	BT-1	Remembering

PART - B (13 MARKS)

Sl.No	QUESTIONS	MARKS	BT LEVEL	COMPETENCE
1	A vessel having a capacity of 0.05 m3 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.	13	BT-4	Analysing
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	13	BT-5	Evaluating
3.i	Find the dryness fraction, specific volume and internal energy of steam at 7 bar and enthalpy 2550 kJ/kg.	7	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.	6	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	13	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.	13	BT-5	Evaluating
6	A processing plant requires wet steam at 10 bar, 0.9 dry and 3000 m^3/h. Analyse (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	13	BT-4	Analysing
7	With a neat sketch explain the working process of Rankine cycle with its pv diagram.	13	BT-1	Remembering
8	With a neat sketch explain the efficiency improvement methods in Rankine cycle with its pv diagram.	13	BT-2	Understanding
9	With a neat sketch explain the working process of Binary combined cycle with its pv diagram.	13	BT-2	Understanding
10	In a steam power cycle, the steam supply is at 15 bar and dry and saturated. The condenser pressure is 0.4 bar. Calculate the Carnot and Rankine efficiencies of the cycle. Neglect pump work.	13	BT-4	Analysing
11	A Rankine cycle operates between pressures of 80 bar and 0.1 bar. The maximum cycle temperature is 600°C. If the steam turbine and condensate pump efficiencies are 0.9 and 0.8 respectively, Analyze the specific work and thermal efficiency.	13	BT-4	Analysing
12	A steam power plant operates on a theoretical reheat cycle. Steam at boiler at 150 bar, 550°C expands through the high pressure turbine. It is reheated at a constant pressure of 40 bar to 550°C and expands through the low pressure turbine to a condenser at 0.1 bar. Draw T-s and h-s diagrams. Evaluate: (i) Quality of steam at turbine exhaust ; (ii) Cycle efficiency (iii) Steam rate in kg/kWh	13	BT-5	Evaluating
13	A simple Rankine cycle works between pressures 28 bar and 0.06 bar, the initial condition of steam being	13	BT-5	Evaluating

	dry saturated. Calculate the cycle efficiency, work ratio and specific steam consumption.			
14	A turbine is supplied with steam at a pressure of 32 bar and a temperature of 410°C. The steam then expands isentropically to a pressure of 0.08 bar. Find the dryness fraction at the end of expansion and thermal efficiency of the cycle. If the steam is reheated at 5.5 bar to a temperature of 395°C and then expanded isentropically to a pressure of 0.08 bar, what will be the dryness fraction and thermal efficiency of the cycle ?	13	BT-3	Applying
15	A binary-vapour cycle operates on mercury and steam. Saturated mercury vapour at 4.5 bar is supplied to the mercury turbine, from which it exhausts at 0.04 bar. The mercury condenser generates saturated steam at 15 bar which is expanded in a steam turbine to 0.04 bar. (a) Find the overall efficiency of the cycle.	13	BT-1	Remembering
16	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.	13	BT-4	Analysing
17	Steam at a pressure of 15 bar and 250°C is expanded through a turbine at first to a pressure of 4 bar. It is then reheated at constant pressure to the initial temperature of 250°C and is finally expanded to 0.1 bar. Using Mollier chart, estimate the work done per kg of steam flowing through the turbine and amount of heat supplied during the process of reheat. Compare the work output when the expansion is direct from 15 bar to 0.1 bar without any reheat. Assume all expansion processes to be isentropic.	13	BT-4	Analysing

18	A power plant generating electricity is working on a binary vapour cycle. Mercury is used in upper cycle and steam in the lower cycle. The ratio of mercury flow rate to steam flow rate is 10:1 on mass basis. At an evaporation of 106 kg/h for mercury, its specific enthalpy rises by 356 kJ/kg in passing through the boiler furnace adds 586 kJ to the steam specific enthalpy. The mercury gives up 251.2 kJ/kg during condensation, and the steam gives up 2003 kJ/kg in its condenser. The overall boiler efficiency is 85%. The combined turbine mechanical and generator efficiencies are each 95% for the mercury and steam units. The steam auxiliaries require 5% of the energy generated by the units. Estimate the overall efficiency of the plant.	13	BT-5	Evaluating
PART - C (15 MARKS)				
Sl.No	QUESTIONS	MARKS	BT LEVEL	COMPETENCE
1	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. Estimate the quality of the steam supplied from the boiler 2. Cp of superheat is 2.4 kJ/kg K.	15	BT-6	Creating
2	et 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.	15	BT-6	Creating
3	In a single-heater regenerative cycle the steam enters the turbine at 30 bar, 400°C and the exhaust pressure is 0.10 bar. The feed water heater is a direct contact type which operates at 5 bar. Solve : (i) The efficiency and the steam rate of the cycle. (ii) The increase in mean temperature of heat	15	BT-5	Evaluating

	addition, efficiency and steam rate as compared to the Rankine cycle (without regeneration). Pump work may be neglected.			
4	A certain chemical plant requires heat from process steam at 120°C at the rate of 5.83 MJ/s and power at the rate of 1000 kW from the generator terminals. Both the heat and power requirements are met by a back pressure turbine of 80% brake and 85% internal efficiency, which exhausts steam at 120°C dry saturated. All the latent heat released during condensation is utilized in the process heater. Predict the pressure and temperature of steam at the inlet to the turbine. Assume 90% efficiency for the generator.	15	BT-6	Creating
5	A steam power plant of 110 MW capacity is equipped with regenerative as well as reheat arrangement. The steam is supplied at 80 bar and 55°C of superheat. The steam is extracted at 7 bar for feed heating and remaining steam is reheated to 350°C, and then expanded to 0.4 bar in the L.P. stage. Assume indirect type of feed heaters. Solve : (i) The ratio of steam bled to steam generated, (ii) The boiler generating capacity in tonnes of steam/hour, and (iii) Thermal efficiency of the cycle. Assume no losses and ideal processes of expansion	15	BT-6	Creating

UNIT IV - IDEAL AND REAL GASES			
Properties of Ideal gas- Ideal and real gas comparison- Equations of state for ideal and real gases Reduced properties. Compressibility factor-.Principle of Corresponding states. -Generalized Compressibility Chart and its use.			
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	State the assumptions made in deriving ideal gas equation using the kinetic theory of gases.	BT-2	Understanding
4	What is meant by partial volume?	BT-1	Remembering
5	One Kg of ideal gas is heated from 18^0C to 93^0C. Taking R=269 N-m / Kg -K and $^{\gamma}$=1.2 for the gas. Calculate the change in internal energy.	BT-1	Remembering
6	Define the Boyle temperature. How is it Computed?	BT-1	Remembering
7	Using Clausius-Clapeyron equation, estimate the enthalpy of vaporization at 200°C. Vg=0.1274 m^3/Kg; Vf= 0.01157 m^3/Kg; dp/dt = 32KPa/K.	BT-2	Understanding
8	Draw a generalized Compressibility Chart and its significance.	BT-2	Understanding
9	What are virial coefficients? When do they become zero?	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	Show that for an ideal gas Cp - Cv = R.	BT-2	Understanding
12	List the effect of compressibility factor.	BT-2	Understanding
13	Define isothermal Compressibility.	BT-1	Remembering
14	Distinguish between the characteristic gas constant and the universal gas constant.	BT-1	Remembering
15	Summarize the examples of real gases.	BT-2	Understanding
16	Recite 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	Difference between an ideal and a perfect gas.	BT-2	Understanding

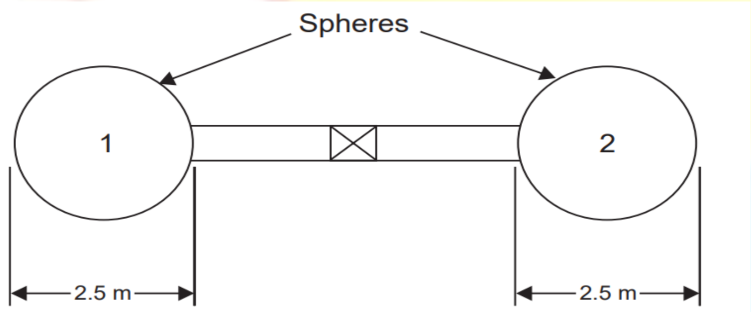
19	State Boyle's and charle's laws and derive an equation of the state for a perfect gas.	BT-1	Remembering
20	What is meant by semi-perfect or permanent gases?	BT-1	Remembering
21	How gases are classified?	BT-1	Remembering
22	What are the two basic properties of an ideal gas?	BT-1	Remembering
23	Infer solid, liquid and gas are recognised through their key characteristics.	BT-2	Understanding
24	What is a real gas?	BT-1	Remembering
25	Define Compressibility factor.	BT-1	Remembering

PART - B (13 MARKS)

Sl.No	QUESTIONS	MARKS	BT LEVEL	COMPETENCE
1.i	Heat is added at constant pressure to a gas at 50°C, 0.2 m^3. The final temperature of the gas is 250°C. Examine the final volume and increase in volume during the supply of heat.	7	BT-4	Analysing
1.ii	The density of a gas at NTP is 1.5 kg/m^3. Find (a) Characteristic gas constant (b) Molecular weight (c) Specific volume of the gas at 15 bar and 40°C	6	BT-1	Remembering
2	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.	13	BT-5	Evaluating
3.i	An ideal gas is heated from 20°C to 100°C. Assume 1 kg of mass, R = 0.2 kJ/kg K, g = 1.2. Find, (a) Specific heats (b) Change in internal energy (c) Change in enthalpy.	7	BT-5	Evaluating
3.ii	A gas undergoes polytropic process from 100 N/m^2 and 120°C to 20 N/m^2, –20°C. Calculate polytropic index n.	6	BT-5	Evaluating
4	2 m^3 of gas is heated at constant pressure from 30°C to 200°C. Estimate, (a) Characteristic gas constant	13	BT-5	Evaluating

	(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 Cv = 0.714 kJ/kg K m = 1 kg			
5	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.	13	BT-5	Evaluating
6	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.	13	BT-5	Evaluating
7	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?	13	BT-1	Remembering

8	A container is having air at a pressure of 2 bar and temperature 30°C. The volume of the container is 3 m^3. Now additional air is pumped into the container until the pressure rises to 40 bar abs and the temperature rises to 65°C. Determine, (a) The mass of air pumped in (b) Express this mass as a volume at a pressure of 1 bar and 25°C. If the vessel is allowed to cool until the temperature is again 30°C, find, (c) the pressure in the vessel (d) the heat transferred during cooling process (e) the change of entropy during cooling process Neglect the heat capacity of the vessel. Assume air as ideal gas.	13	BT-5	Evaluating
9	A steel flask of 0.04 m^3 capacity is to be used to store nitrogen at 120 bar, 20°C. The flask is to be protected against excessive pressure by a fusible plug which will melt and allow the gas to escape if the temperature rises too high. (i) How many kg of nitrogen will the flask hold at the designed conditions ? (ii) At what temperature must the fusible plug melt in order to limit the pressure of a full flask to a maximum of 150 bar ?	13	BT-5	Evaluating
10	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 cp and cv. (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.	13	BT-4	Analysing

11	1 kg of air at a pressure of 8 bar and a temperature of 100°C undergoes a reversible polytropic process following the law $pv^{1.2}$ = constant. If the final pressure is 1.8 bar determine : (i) The final specific volume, temperature and increase in entropy ; (ii) The work done and the heat transfer. Assume R = 0.287 kJ/kg K and γ = 1.4.	13	BT-5	Evaluating
12	Two spheres each 2.5 m in diameter are connected to each other by a pipe with a valve as shown in Fig. One sphere contains 16 kg of air and other 8 kg of air when the valve is closed. The temperature of air in both sphere is 25°C. The valve is opened and the whole system is allowed to come to equilibrium conditions. Assuming there is no loss or gain of energy, determine the pressure in the spheres when the system attains equilibrium. Neglect the volume of the pipe. 	13	BT-4	Analysing
13	One kg of CO_2 has a volume of 1 m^3 at 100°C. Compute the pressure by (i) Van der Waals' equation (ii) Perfect gas equation.	13	BT-5	Evaluating
14	A container of 3 m^3 capacity contains 10 kg of CO2 at 27°C. Estimate the pressure exerted by CO_2 by using : (i) Perfect gas equation (ii) Van der Waals' equation (iii) Beattie Bridgeman equation.	13	BT-5	Evaluating

15.i	If the values for reduced pressure and compressibility factor for ethylene are 20 and 1.25 respectively, compute the temperature.	7	BT-4	Analysing
15.ii	Calculate the density of N_2 at 260 bar and 15°C by using the compressibility chart.	6	BT-5	Evaluating
16.i	What should be the temperature of 1.3 kg of CO_2 gas in a container at a pressure of 200 bar to behave as an ideal ?	7	BT-1	Remembering
16.ii	A spherical shaped balloon of 12 m diameter contains H_2 at 30°C and 1.21 bar. Find the mass of H_2 in the balloon using real gas equation.	6	BT-1	Remembering
17	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.	13	BT-4	Analysing
18	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.	13	BT-5	Evaluating

PART - C (15 MARKS)

Sl.No	QUESTIONS	MARKS	BT LEVEL	COMPETENCE
1	An ideal gas initially at 80°C and 1 bar undergoes the following reversible processes. (a) The gas is compressed adiabatically to 120°C (1–2). (b) It is then cooled at constant pressure from 120°C to 80°C (2–3). (c) Finally the gas is expanded at constant temperature to a final pressure of 1 bar (3–1). Assume: Cv = 5/3 R kJ/kg mole K Determine, (a) deltah, (b) deltau, (c) W and (d) q for the entire cycle on per kg mole basis.	15	BT-4	Analysing

2	Air at a pressure of 10 bar occupies a volume of 0.3 m^3 and contains 2 kg. This air is then expanded to a volume of 1.4 m^3. Determine, (a) The final temperature (b) The work done (c) The heat absorbed or rejected by the air (d) The change in enthalpy for each of the following processes 1. Constant pressure 2. Isothermal 3. Adiabatic 4. Polytropic PV1.2 = C	15	BT-5	Evaluating
3	A vessel of 0.05 m^3 capacity is filled with air. The pressure at the end of the pumping operation is 80 bar and temperature 50°C. The air is then cooled to the atmospheric temperature of 20°C. Then leakage occurred to 20 bar. When the leakage was stopped, the temperature of air being 5°C. Examine, (a) How much heat was lost by the air in the vessel before the leakage began? (b) How much heat was transferred during leakage by the air remaining in the vessel? Assume index of expansion during leakage to be constant. R = 0.287 kJ/kg K Cv = 0.714 kJ/kg K	15	BT-5	Evaluating
4	A balloon is filled with H_2 at 20°C and atmospheric pressure. The surrounding air is at 15°C and barometer reads 75 cm of Hg. The diameter of the balloon is 20 m. Examine what load the balloon will lift.	15	BT-4	Analysing
5	CO_2 flows at a pressure of 10 bar and 180°C into a turbine, located in a chemical plant, and there it expands reversibly and adibatically 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 heat transfer rate from the gas and the power delivered by the turbine. Assume CO_2 to be a perfect gas and cv = 0.837 kJ/kg K.	15	BT-5	Evaluating

UNIT V - GAS MIXTURES AND THERMODYNAMIC RELATIONS			
Mole and Mass fraction, Dalton's and Amagat's Law. Properties of gas mixture Molar mass, gas constant, density, and change in internal energy, enthalpy, entropy and Gibbs function. Maxwell relations, Tds Equations, Difference and ratio of heat capacities, Energy equation, Joule Thomson Coefficient, Clausius Clapeyron equation, Phase Change Processes. Simple Calculations			
PART - A (2 MARKS)			
Sl.No	QUESTIONS	BT LEVEL	COMPETENCE
1	State Amagat's Law.	BT-1	Remembering
2	Identify the application of Clausius - Clapeyron equation	BT-1	Remembering
3	Identify the relationship between the partial pressures of the constituents in gas mixtures.	BT-1	Remembering
4	What is Joule-Thomson coefficient? Why is it zero for an ideal gas?	BT-1	Remembering
5	What is metastable equilibrium?	BT-1	Remembering
6	Explain Joule Kelvin effect. What is inversion temperature?	BT-1	Remembering
7	Define Gibb's Theorem.	BT-2	Understanding
8	Write down two Tds relations.	BT-2	Understanding
9	Write the Maxwell's equations and its significance.	BT-1	Remembering
10	Why does the Gibbs function remain constant during phase transition?	BT-1	Remembering
11	What is the condition when Cp = Cv.	BT-1	Remembering
12	Using the definitions of mass and mole fractions, derive a relation between them.	BT-2	Understanding
13	Define Equation of state.	BT-1	Remembering
14	Prove that specific heat at constant volume (Cv) of a Van der Waals' gas is a function of temperature alone.	BT-1	Remembering
15	Define molar mass.	BT-1	Remembering
16	Using the cyclic equation, prove that; $(\delta p/\delta T)_v = \beta / KT$	BT-1	Remembering
17	For a perfect gas, show that the difference in specific heats is; cp-cv = R/T	BT-1	Remembering
18	Show that the internal energy and enthalpy of an ideal gas are functions of temperature only.	BT-2	Understanding
19	What is the energy equation? How does this equation lead to the derivation of the Stefan –Boltzman law of thermal radiation?	BT-1	Remembering
20	What do you understand by phase equilibrium?	BT-1	Remembering
21	What are the various properties of gas mixture?	BT-2	Understanding

22	Derive an expression for the internal energy of gas mixtures	BT-2	Understanding
23	How the gas constant for a mixture is evaluated?	BT-1	Remembering
24	Define the law of partial pressures.	BT-2	Understanding
25	Derive an expression for the enthalpy of gas mixtures.	BT-2	Understanding

PART - B (13 MARKS)

Sl.No	QUESTIONS	MARKS	BT LEVEL	COMPETENCE
1.i	A vessel of 0.35 m^3 capacity contains 0.4 kg of carbon monoxide (molecular weight = 28) and 1 kg of air at 20°C. Calculate : (i) The partial pressure of each constituent, (ii) The total pressure in the vessel, and The gravimetric analysis of air is to be taken as 23.3% oxygen (molecular weight = 32) and 76.7% nitrogen (molecular weight = 28).	7	BT-5	Evaluating
1.ii	The gravimetric analysis of air and other data are as follows : Constituent Percentage Molecular weight Oxygen 23.14 32 Nitrogen 75.53 28 Argon 1.28 40 Carbon dioxide 0.05 44 Calculate : (i) Gas constant for air ; (ii) Apparent molecular weight.	6	BT-5	Evaluating
2	A vessel contains at 1 bar and 20°C a mixture of 1 mole of CO^2 and 4 moles of air. Analyse for the mixture : (i) The masses of CO_2, O_2 and N_2, and the total mass ; (ii) The percentage carbon content by mass ; (iii) The apparent molecular weight and the gas constant for the mixture ; (iv) The specific volume of the mixture. The volumetric analysis of air can be taken as 21% oxygen and 79% nitrogen.	13	BT-4	Analysing
3	A mixture of hydrogen (H_2) and oxygen (O_2) is to be made so that the ratio of H_2 to O_2 is 2 : 1 by volume. If the pressure and temperature are 1 bar and 25°C respectively, calculate :	13	BT-4	Analysing

	(i) The mass of O_2 required ; (ii) The volume of the container.			
4	A gaseous mixture of composition by volume, 78% H_2 and 22% CO is contained in a vessel. It is desired that the mixture should be made in proportion 52% H_2 and 48% CO by removing some of the mixture and adding some CO. Calculate per mole of mixture the mass of mixture to be removed, and mass of CO to be added. Assume that the pressure and temperature in the vessel remain constant during the procedure.	13	BT-5	Evaluating
5	The analysis by weight of a perfect gas mixture at 20°C and 1.3 bar is 10% O_2, 70% N_2, 15% CO_2 and 5% CO. For a reference state of 0°C and 1 bar determine : (i) Partial pressures of the constituents ; (ii) Gas constant of mixture.	13	BT-5	Evaluating
6	2.5 kg of N_2 at 15 bar and 40°C is contained a rigid vessel. Adequate quantity of O_2 is added to increase the pressure to 20 bar while the temperature remains constant at 40°C. Analyse the mass of O_2 added.	13	BT-4	Analysing
7	Given that air consists of 21% oxygen and 79% nitrogen by volume. Determine : (i) The moles of nitrogen per mole of oxygen ; (ii) The partial pressure of oxygen and nitrogen if the total pressure is atmosphere ; (iii) The kg of nitrogen per kg of mixture.	13	BT-5	Evaluating
8	A vessel of 6 m^3 capacity contains two gases A and B in proportion of 45 per cent and 55 per cent respectively at 30°C. If the value of R for the gases is 0.288 kJ/kg K and 0.295 kJ/kg K and if the total weight of the mixture is 2 kg, calculate : (i) The partial pressure ; (ii) The total pressure ; (iii) The mean value of R for the mixture.	13	BT-5	Evaluating
9	One kilogram of air is at a pressure of 5 atm and at a temperature of 227°C. It expands reversibly to a pressure of 2 atm following the law, $pV^{1.3} = c$. Assuming air is an ideal gas calculate:(i) the work done and heat transferred. (ii) If the system does the same expansion in a steady flow process. What is the work done by the system?	13	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, pvn = 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.	13	BT-4	Analysing
11	Drive the Maxwell relations.	13	BT-2	Understanding
12	Explain the Joule – Thomson Co-efficient and express the relations.	13	BT-1	Remembering
13	Drive the entropy equations (Tds Equations)	13	BT-2	Understanding
14	Explain the Clausius – Claperyon equation and express the relations.	13	BT-1	Remembering
15	Drive the equation for internal energy and enthalpy.	13	BT-2	Understanding
16	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 ; $v_{liq.}$ = 1 × 10 m^3/kg ; v_{ice} = 1.01 × 10^3 m^3/kg.	13	BT-5	Evaluating
17	Find the value of co-efficient of volume expansion β and isothermal compressibility K for a Van der Waals' gas obeying (p + a/v2)(v-b) = RT	13	BT-1	Remembering
18	A cylinder-piston arrangement contains 2 kg of superheated steam at 10 bar and 573 K. It undergoes an adiabatic expansion to 1 bar pressure. Find the work that can be obtained during the expansion process.	13	BT-2	Understanding

PART - C (15 MARKS)				
Sl.No	QUESTIONS	MARKS	BT LEVEL	COMPETENCE
1	In an engine cylinder a gas has a volumetric analysis of 13% CO_2, 12.5% O_2, and 74.5% N_2. The temperature at the beginning of expansion is 950°C and the gas mixture expands reversibly through a volume ratio of 8 : 1, according to the law $pv^{1.2}$ = constant. Calculate per kg of gas : (i) The workdone ; (ii) The heat flow ; (iii) Change of entropy per kg of mixture. The values of cp for the constituents CO_2, O_2 and N_2 are 1.235 kJ/kg K, 1.088 kJ/kg K and 1.172 kJ/kg K respectively.	15	BT-6	Creating
2	A mixture of ideal gases consists of 4 kg of nitrogen and 6 kg of carbon dioxide at a pressure of 4 bar and a temperature of 20°C. Find : (i) The mole fraction of each constituent, (ii) The equivalent molecular weight of the mixture, (iii) The equivalent gas constant of the mixture, (iv) The partial pressures and partial volumes, (v) The volume and density of the mixture, and (vi) The cp and cv of the mixture. If the mixture is heated at constant volume to 50°C, find the changes in internal energy, enthalpy and entropy of the mixture. Find the changes in internal energy, enthalpy and entropy of the mixture if the heating is done at constant pressure. Take γ : for CO_2 = 1.286 and for N_2 = 1.4.	15	BT-5	Evaluating
3	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.	15	BT-5	Evaluating

4	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 v_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.	15	BT-5	Evaluating
5	The pressure on the block of copper of 1 kg is increased from 20 bar to 800 bar in a reversible process maintaining the temperature constant at 15°C. Determine the following : (i) Work done on the copper during the process, (ii) Change in entropy, (iii) The heat transfer, (iv) Change in internal energy, and (v) $(c_p - c_v)$ for this change of state. Given : β (Volume expansivity = 5×10^{-5}/K, K (thermal compressibility) = 8.6×10^{-12} m²/N and v (specific volume) = 0.114×10^{-3} m³/kg.	15	BT-5	Evaluating