		UNIT-IV			
8	a)	Steam pressure is 10 bar, Calculate the Enthalpy and Entropy of the Steam. i) If the Steam is dry. ii) If the Steam is 90% dry.	L3	CO4	5 M
	b)	Briefly explain the P-V-T diagram.	L2	CO4	5 M
		OR			
9	a)	A substance undergoes a phase transformation from liquid to vapor at a constant pressure. At this pressure, the boiling point is 100°C. The critical temperature of the substance is 150°C. Calculate the heat.	L3	CO4	5 M
	b)	Using a Mollier chart, determine the following for steam at 4 bar: i. Specific enthalpy (h) ii. Specific entropy (s) iii. Quality (dryness fraction) if the steam is in the saturated state.	L3	CO4	5 M
		UNIT-V			
10		Compare and contrast the Otto, Diesel and Dual Combustion cycles in terms of their thermodynamic processes, P-V and T-S diagrams and thermal efficiency.	L2	CO5	10 M
		OR			
11		Explain the working of the Vapor Compression Refrigeration (VCR) system with the help of a labeled diagram. Discuss the factors affecting the Coefficient of Performance (COP) and how different refrigerants impact system performance.	L2	CO5	10 M

PVP 23

Code: 23ES1302

II B.Tech - I Semester – Regular Examinations - DECEMBER 2024

THERMODYNAMICS
(MECHANICAL ENGINEERING)

Duration: 3 hours Max. Marks: 70

Note: 1. This question paper contains two Parts A and B.
2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.
3. Part-B contains 5 essay questions with an internal choice from each unit. Each Question carries 10 marks.
4. All parts of Question paper must be answered in one place.

BL – Blooms Level CO – Course Outcome

PART – A

		BL	CO
1.a)	Define System and process.	L1	CO1
1.b)	State difference between macroscopic and microscopic viewpoints.	L1	CO1
1.c)	State the Zeroth Law of Thermodynamics.	L1	CO2
1.d)	Define enthalpy in thermodynamics.	L2	CO2
1.e)	State the Kelvin-Planck statement of the Second Law of Thermodynamics.	L1	CO3
1.f)	Define entropy in thermodynamics.	L2	CO3
1.g)	Give an example of a phase transformation process.	L2	CO4
1.h)	State the Clausius-Clapeyron equation.	L1	CO4
1.i)	What is the main difference between the Otto cycle and the Diesel cycle?	L2	CO5
1.j)	Define the Coefficient of Performance (COP) in refrigeration systems.	L1	CO5

PART – B

			BL	CO	Max. Marks
		UNIT-I			
2	a)	Explain about Quasi static process.	L2	CO1	5 M
	b)	A mass of 2.5 kg of air is compressed in a quasi-static process from 0.1 MPa to 0.7 MPa for which PV Constant. The initial volume is 0.8 m^3/kg. Find the work done by the piston to compress the air.	L2	CO1	5 M
		OR			
3	a)	Explain about thermodynamic equilibrium.	L2	CO1	5 M
	b)	The temperature t on a thermometric scale is defined in terms of a property K by the relation $t = a \ln K + b$ Where a and b are constants. The values of K are found to be 1.83 and 6.78 at the ice point and the steam point, the temperatures of which are assigned the numbers 0 and 100 respectively. Determine the temperature corresponding to a reading of K equal to 2.42 on the thermometer.	L3	CO1	5 M
		UNIT-II			
4		3Kg of air at a pressure of 150KPa and temperature 360K is compressed polytropically to 750KPa according to law $PV^{1.2}=C$. The gas is then cooled to initial temperature at constant pressure. The air is then expanded at constant temperature till it reaches original pressure of 150KPa. Draw the cycle on P-V diagram and determine the network and heat transfer.	L3	CO2	10 M
		OR			
5	a)	Explain the Steady Flow Energy Equation and its application in analyzing steady-state flow processes.	L2	CO2	5 M
	b)	A Centrifugal pump delivers 50kg of water per second. The inlet and outlet pressures are 1 bar and 4.2 bar respectively. The suction is 2.2m below the center of the pump and delivery is 8.5m above the center of the pump. The suction and delivery pipe diameters are 20cm and 10cm receptively. Determine the capacity of electric motor to run the pump.	L3	CO2	5 M
		UNIT-III			
6		A heat engine operates between two reservoirs at temperatures of 500 K and 300 K. The engine absorbs 600 kJ of heat from the hot reservoir. Calculate: a) The efficiency of the heat engine. b) The amount of heat rejected to the cold reservoir. Discuss how the efficiency relates to the Kelvin-Planck and Clausius statements.	L3	CO3	10 M
		OR			
7		Describe the Carnot cycle and explain its four distinct processes. Discuss the significance of the Carnot cycle in thermodynamics and why it is considered the most efficient cycle.	L2	CO3	10 M

PVP23

Code:23ES1302

II.B.Tech-I semester-Regular Examination-DEC-2024
THEROMODYNAMICS
`Scheme of evaluation

1.	Each question carries	-2 **Marks**
2.a)	Explanation	-5 **Marks**
2.b)	Given data& solution	-5 **Marks**
3.a)	Explanation	-5 **Marks**
3.b)	Solution	-5 **Marks**
4.	Given data& solution	-10 **Marks**
5.a)	Equation & Explanation	**-3Marks**
	Any two applications	**-2Marks**
5.b)	Given data &Equation	**-2 Marks**
	Solution	-3 **Marks**
6.	Efficiency & heat rejected	-7 **Marks**
	Discussion	**-3Marks**
7.	Diagram	**-3 Marks**
	Explanation	**-4Marks**
	Significance & Explanation	**-3 Marks**
8.a)	Enthalpy & Entropy of dry steam	**-2 Marks**
	Enthalpy & Entropy of wet steam	**-3Marks**
8.b)	Diagram&Explanation	-5 **Marks**
9.a)	Given data & Solution	**-5 Marks**
9.b)	Enthalpy, Entropy &dryness fraction	**-2+2+1 Marks**
10.	Thermodynamic process	**-3Marks**
	P-V and T-S diagrams &efficiency.	**-3+3+1 Marks**
11.	Diagram	**-3 Marks**
	Explanation	**-4Marks**
	Factors Affecting COP&Impact of Refrigerants	**--3 Marks**

Key

PART-A

1.a)

A **systemis** defined as specific region in space chosen for thermodynamic study.

Thetransformation of a thermodynamic system from one equilibrium state to another is called **process.**

1.b)

Macroscopic Viewpoint; The macroscopic viewpoint focuses on the overall behavior of a system.

Microscopic Viewpoint: The microscopic viewpoint, deals with the individual particles (atoms, molecules, or ions) that make up a system.

1.c)

If two systems are each in thermal equilibrium with a third, then they are in thermal equilibrium with each other.

1.d)

Enthalpy (H) is a thermodynamic property that represents the total energy content of a system. It is defined as the sum of the internal energy (U) of a system and the product of its pressure (P) and volume (V):

$H = U + PV$

1.e)

It is impossible for any device that operates on a cycle to receive heat from a single reservoir and produce only a net amount of work.

1.f)

Entropy is a thermodynamic property that measures the degree of disorder or randomness in a system. It is often interpreted as a measure of the energy in a system that is unavailable for doing useful work

1.g)

Melting of Ice (Solid to Liquid):

Ice melts to form water at 0°C when heat is added at constant pressure (at 1 atm).

Freezing of Water (Liquid to Solid):

Water freezes into ice at 0°C when heat is removed from the system at constant pressure.

Sublimation (Solid to Gas):

Dry ice (solid CO_2) directly changes into carbon dioxide gas when heated, without passing through the liquid phase.

Condensation (Gas to Liquid):

Water vapor in the air condenses to form liquid water when cooled to its dew point.

1.h)

The Clausius-Clapeyron equation relates the saturation pressure, saturation temperature, enthalpy of vaporization and specific volume of two phases of saturated fluid during phase change.

$$\left(\frac{dp}{dT}\right)_{sat} = \frac{p_{fg}}{RT^2}$$

The above equation is referred as Clausius-Clapeyron equation.

1.i)

The main difference between the Otto and Diesel cycles lies in the way heat is added to the working fluid.

Aspect	**Otto cycle**	**Diesel cycle**
heat addition	Constant volume	Constant pressure
Compression Ratio	6:1 to 10:1	14:1 to 22:1
Efficiency	Lower thermal efficiency due to lower compression ratio.	Higher thermal efficiency due to higher compression ratio.
Operation	The fuel is ignited by spark plug.	The fuel auto-ignites.
Fuel Type	gasoline	diesel fuel

1.j)

It is defined as the ratio of the heat removed from the refrigerated space (the cooling effect) to the work input (energy consumed by the compressor).

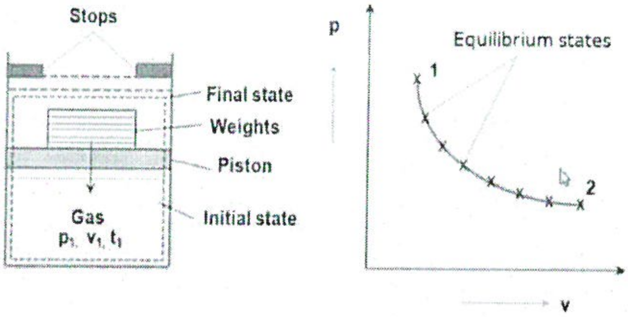
PART-B

2.a

Quasi-Static Process:

A quasi-static process is a thermodynamic process that occurs infinitely slowly, allowing the system to remain in equilibrium at every instant. This means that the system's properties (like pressure, temperature, and volume) change infinitesimally slowly, and the system can be considered to be in a series of equilibrium states.

Let us consider the assembly of cylinder and piston as shown in figure. Cylinder is contained with gas and system is in equilibrium condition initially. Let us see the state of the system initially is at state 1 and indicated by its thermodynamic properties P_1, V_1 and T_1. At this state pressure will be high and specific volume will be less at a temperature.



Let us remove very slowly infinitesimally small weights one by one from the piston, what will be happened? When we remove the first infinitesimally small weight from the piston, piston will move very slowly as well as with infinitesimally small amount and will secure its next equilibrium state. Due to removal of infinitesimally small weights, one by one and also quite slowly, system will process from one state to another state with succession of equilibrium states.

Hence, we can say here that system will arrive to final state from initial state with various equilibrium intermediate states and these intermediate states are displayed in above figure. Such a process, where system process in such a manner as studied above, will be termed as quasi static process or quasi equilibrium process in the field of thermal engineering.

2.b

Given data:

m=2.5 kg

P_1=0.1 MPa=$0.1 \times 10^6\ Pa$

P_2=0.7 MPa

v_1=0.8 m^3/kg

$V_1 = m.v = 2.5 \times 0.8 = 2$ m^3

$$W = P_1 V_1 ln\frac{P_2}{P_1}$$

$$= 0.1 \times 10^6 \times 2ln\frac{0.7}{0.1}$$

$$W = 389.18 \text{ kJ}$$

3.a)

Thermodynamic Equilibrium

In thermodynamics, a system is said to be in thermodynamic equilibrium, when the system is thermal, mechanical, and chemical equilibrium.

Thermal Equilibrium

A system is in thermal equilibrium if there is no temperature gradient within the system or between the system and its surroundings. Heat transfer stops because the temperature is uniform everywhere.

Mechanical Equilibrium

A system is in mechanical equilibrium if there are no unbalanced forces or pressure differences within the system or between the system and its surroundings. No changes occur in pressure at any point in the system over time.

Chemical Equilibrium

A system is in chemical equilibrium if there are no net chemical reactions occurring or no net transfer of matter due to diffusion. The composition of the system remains constant over time.

3.b

At the **ice point**$t = 0$ K=1.83

$$t = a \ln K + b \quad \Rightarrow 0 = a \ln 1.83 + b \quad \Rightarrow b = -a \ln 1.83$$

At the **steam point**$t = 100$ K=6.78

$$t = a \ln K + b \quad \Rightarrow 100 = a \ln 6.78 + b \quad \Rightarrow b = 100 - a \ln 6.78$$

Solve the above equations $a = 76.35 \quad b = -46.14$

$$t = 76.35 \ln K - 46.14$$

Temperature corresponding reading of K=2.42

$$t = 76.35 \ln 2.42 - 46.14$$

$$t = 21.33°\text{C}$$

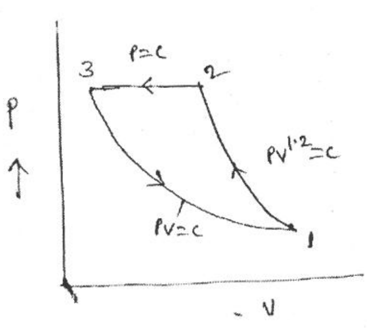
4.Given data:

$m = 3\,kg$

P_1=150 kPa

$T_1 = 360K$

P_2=750 kPa



$PV^{1.2} = c$
$R = 287\ kJ/kgK$
$T_3 = T_1 = 360K$

$$P_1V_1 = mRT_1$$

$$150 \times 10^3 \times V_1 = 3 \times 287 \times 360$$
$$V_1 = 2.07\ m^3$$
$$P_3V_3 = P_1V_1 \quad \Rightarrow 750 \times 10^3 \times V_3 = 150 \times 10^3 \times 2.07 \quad \Rightarrow V_3 = 0.414\ m^3$$

Process 1-2:
$P_1V_1^{1.2} = P_2V_2^{1.2}$
$150 \times 10^3 \times 2.07^{1.2} = 750 \times 10^3 \times V_2^{1.2}$
$V_2 = 0.541\ m^3$

$$W_{1-2} = \frac{P_2V_2 - P_1V_1}{1-n} = \frac{750 \times 10^3 \times 0.541 - 150 \times 10^3 \times 2.07}{1 - 1.2} = -477.64\ kJ$$

Constant pressure Process 2-3:
$$W_{2-3} = P_2(V_3 - V_2) = 750 \times 10^3(0.414 - 0.541) = -95.25\ kJ$$

Process 3-1:
$$W_{3-1} = P_1V_1 ln\frac{P_3}{P_1}$$
$$= 150 \times 10^3 \times 2.07 ln\frac{750 \times 10^3}{150 \times 10^3}$$
$$W = 500\ \text{kJ}$$

Net work done=$W_{1-2} + W_{2-3} + W_{3-1}$=-72.89 kJ

apply the First Law of Thermodynamics

Qnet = Wnet = −72.89 kJ

5. a)

The equation for steady flow can be written as:

$$m\left(h_1 + \frac{V_1{}^2}{2} + Z_1g\right) + Q = m\left(h_2 + \frac{V_2{}^2}{2} + Z_2g\right) + W$$

Where:

Q: Rate of heat transfer to the system(kW).
W: Rate of work done by the system(kW).
m: Mass flow rate (kg/s).
h_1, h_2: Specific enthalpy at inlet and outlet (kJ/kg).
V_1, V_2: Fluid velocity at inlet and outlet (m/s).
Z_1, Z_2: Height (elevation) of fluid at inlet and outlet (mmm).
g: Gravitational acceleration (9.81 m/s^2).

The Steady Flow Energy Equation is widely used in analyzing and designing steady-state flow processes in various engineering systems:

Turbines

Turbines convert enthalpy (thermal energy) into mechanical work.

Using SFEE, the work output of a turbine can be calculated: $W = m(h_1 - h_2)$.

Kinetic and potential energy terms are often negligible compared to the change in enthalpy.

Compressors and Pumps

Compressors and pumps consume work to increase the pressure of a fluid. SFEE calculates the required work input: $W = m(h_2 - h_1)$

Heat Exchangers

Heat exchangers transfer heat between two fluid streams without work interaction. SFEE helps in determining the heat transfer rate: $Q = m(h_2 - h_1)$

Nozzles and Diffusers

Nozzles increase the velocity of a fluid at the cost of pressure, while diffusers do the opposite.

SFEE for a nozzle: $\left(\frac{V_1^2}{2} - \frac{V_2^2}{2}\right) = (h_2 - h_1)$

Heat transfer and work terms are negligible in these cases.

Boilers and Condensers

Boilers add heat to a fluid to convert it into vapor, while condensers remove heat to convert vapor into liquid.

SFEE is used to determine the heat transfer: $Q = m(h_2 - h_1)$

5. b)

Given data:

$m = 50\ kg/s$

$d_1 = 0.2\ m$

$d_2 = 0.1\ m$

$P_1 = 1\ bar = 1 \times 10^5 Pa$

$P_2 = 4.2\ bar = 4.2 \times 10^5 Pa$

$Z_1 = 8.5\ m$

$Z_2 = 2.2\ m$

assumption: $v_1 = v_2 = 0.001 m^3/kg\ \ for\ water$

$$a_1 = \frac{\pi}{4}d_1^2 = \frac{\pi}{4}(0.2)^2 = 0.03141\ m^2$$

$$a_2 = \frac{\pi}{4}d_2^2 = \frac{\pi}{4}(0.1)^2 = 0.00785\ m^2$$

$$m = \rho a_1 V_1 \Rightarrow V_1 = 1.59\ m^3/s$$

$$m = \rho a_2 V_2 \Rightarrow V_2 = 6.37\ m^3/s$$

$$m\left(u_1 + P_1 v_1 + \frac{V_1^2}{2} + Z_1 g\right) + Q_{12} = m\left(u_2 + P_2 v_2 + \frac{V_2^2}{2} + Z_2 g\right) + W_{12}$$

$$\Delta u = 0$$

$$Q_{12} = 0$$

$$m\left(P_1 v_1 + \frac{V_1^2}{2} + Z_1 g\right) = m\left(P_2 v_2 + \frac{V_2^2}{2} + Z_2 g\right) + W_{12}$$

$$50\left(1 \times 10^5 \times 0.001 + \frac{1.59^2}{2} + 8.5 \times 9.81\right)$$

$$= 50\left(4.2 \times 10^5 \times 0.001 + \frac{6.37^2}{2} + 2.2 \times 9.81\right) + W_{12}$$

$$W_{12} = -22.2kW$$

6.

Given data:

$T_c = 300\ K$

$T_H = 500K$

$Q_H = 600\ kJ$

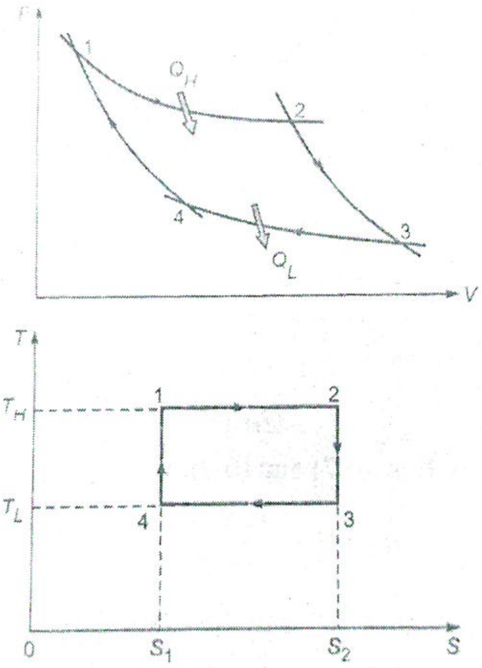
$$\eta = 1 - \frac{T_c}{T_H}$$
$$= 1 - \frac{300}{500}$$
$$\eta = 0.4 = 40\%$$
$$\eta = 1 - \frac{Q_c}{Q_H}$$
$$0.4 = 1 - \frac{Q_c}{600}$$
$$Q_c = 360\ kJ$$

Kelvin-Planck Statement: This statement states that it is impossible for a heat engine to operate in a cycle and produce network while exchanging heat with a single reservoir. In our case, the heat engine operates between two reservoirs, so it doesn't violate the Kelvin-Planck statement.

Clausius Statement: This statement states that it is impossible for a process to occur whose sole result is the transfer of heat from a cooler body to a hotter body. The heat engine in our case transfers heat from a hotter reservoir to a cooler reservoir while producing work, which doesn't violate the Clausius statement.

7.

The Carnot cycle is a theoretical thermodynamic cycle proposed by Sadi Carnot in 1824. It is considered the most efficient cycle possible for a heat engine operating between two temperature reservoirs. The cycle consists of four reversible processes: two isothermal (constant temperature) processes and two adiabatic (isentropic, no heat transfer) processes. The Carnot cycle operates between a hot reservoir at temperature T_H and a cold reservoir at temperature T_c.



Carnot Cycle on p–V and T–S diagram

Process 1-2: Isothermal Expansion: The working substance (gas) absorbs heat from a high-temperature reservoir. The gas expands isothermally, doing work on the surroundings. The temperature of the gas remains constant during this process.

Process 2-3: Adiabatic Expansion: The gas continues to expand, but without any heat exchange with the surroundings. The gas cools as it does work on the surroundings.

Process 3-4: Isothermal Compression: The gas is compressed isothermally, releasing heat to a low-temperature reservoir. Work is done on the gas by the surroundings.

Process 4-1: Adiabatic Compression: The gas is further compressed without any heat exchange with the surroundings. The temperature of the gas increases.

Significance of the Carnot Cycle in Thermodynamics

Theoretical Maximum Efficiency: The Carnot cycle provides the upper limit for the efficiency of any heat engine operating between two reservoirs. No real engine can exceed the Carnot efficiency due to practical limitations like irreversibilities and non-ideal behavior.

Reversible and Ideal: All processes in the Carnot cycle are reversible, meaning there is no entropy generation or energy loss. Real systems, however, involve irreversibilities, making them less efficient.

Benchmark for Real Engines: The Carnot cycle sets the standard for comparing the performance of real-world heat engines. The closer a real engine operates to the Carnot cycle, the more efficient it is.

Foundation of the Second Law of Thermodynamics: The Carnot cycle supports the second law, which states that no heat engine can be more efficient than a Carnot engine operating between the same two reservoirs.

Why the Carnot Cycle is Considered the Most Efficient Cycle

Reversible Nature: All processes in the Carnot cycle are reversible, which minimizes entropy generation and energy losses.

Optimal Heat Transfer: Heat transfer occurs isothermally, ensuring maximum heat absorption and rejection with minimal temperature gradients.

Maximizes Work Output: The cycle maximizes the net work done for a given amount of heat absorbed, making it the most efficient use of energy.

Dependence Only on Reservoir Temperatures: The efficiency depends solely on T_H andT_c independent of the working substance.

8.a)

Given Data:

i) $\boldsymbol{P = 10\ bar\&}$ steam is dry

Read the Properties at $P = 10\ bar\&$ saturated liquid-vapor mixture condition from steam tables

$h_g = 2776.2 KJ/kg$

$s_g = 6.583\ KJ/kg\ K$

ii) $P = 10\ bar$&steam is 90% dry

Read the Properties at $P = 10\ bar\&$ saturated liquid-vapor mixture condition from steam tables

$h_f = 762.6\ KJ/kg$ $\quad h_g = 2776.2 KJ/kg \quad h_{fg} = 2013.6 KJ/kg$

$s_f = 2.138\ KJ/kg\ K$ $\quad s_g = 6.583\ KJ/kg\ K\ s_{fg} = 4.445\ KJ/kg\ K$

$\Rightarrow s = s_f + xs_{fg} = 2.138 + 0.9 \times 4.445 = 6.1385\ KJ/kg\ K$

$h = h_f + xh_{fg} \quad \Rightarrow h = 762.6 + 0.9 \times 2013.6 = 2574.44\ KJ/kg$

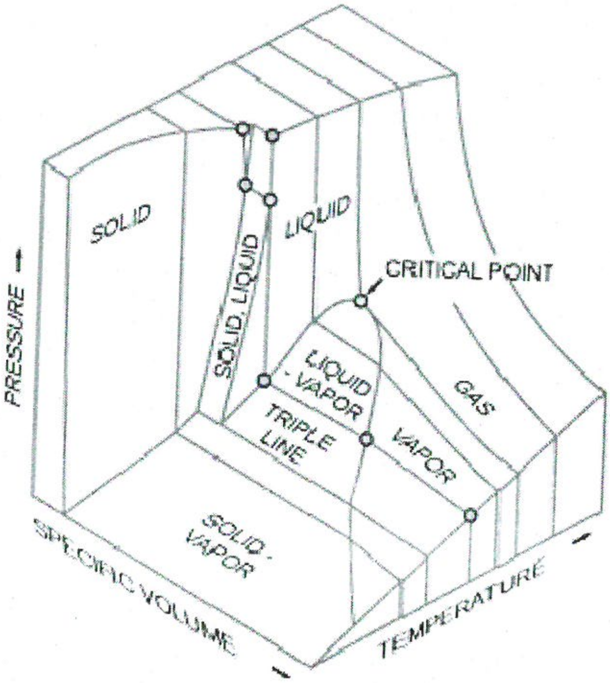
8.b)

P-V-T diagram: The three axes correspond to Pressure (P), Volume (V), and Temperature (T).Each point on the diagram represents a specific state of the substance, defined by its pressure, volume, and temperature.

Regions for Different Phases: The diagram is divided into regions corresponding to the **solid**, **liquid**, and **vapor (gas)** phases.The boundaries between these regions represent **phase transitions**:

- **Solid-liquid boundary:** Melting/freezing line.
- **Liquid-vapor boundary:** Boiling/condensation line.
- **Solid-vapor boundary:** Sublimation line.

Critical Point: At the **critical temperature** and **critical pressure**, the liquid and vapor phases become indistinguishable.Beyond the critical point, the substance exists as a **supercritical fluid**.



Triple Point: The point where the **solid**, **liquid**, and **vapor** phases coexist in equilibrium.This unique condition occurs at a specific temperature and pressure.

Isotherms, Isobars, and Isochores:

- **Isotherms:** Curves showing constant temperature behavior on the P–V plane.
- **Isobars:** Curves showing constant pressure behavior.
- **Isochores:** Curves showing constant volume behavior

9.a)

Boiling Point: 100 °C = 373 K

Critical Temperature: 150 °C = 423 K

Approximate latent heat: L=32.824 kJ/mol

The heat required for phase transformation depends on themass (m) ornumber of moles (n) of the substance. If the substance's molar mass (M) is given or assumed, the number of moles can be calculated as by assuming 1 kg water

$$Q = \frac{m}{M}L = \frac{1000}{18}32.824 = 1824.67 \text{ kJ}$$

9.b)using a Mollier chart, determine the following for stream at 4 bar: i) specific enthalpy ii) specific entropy iii) quality (dryness fraction) if the steam is in the saturated state.

Read the Properties at $P = 4\ bar\&$ saturated vapor condition from chart

$h_g = 2737.6\ KJ/kg$

$s_g = 6.894\ KJ/kg\ K$

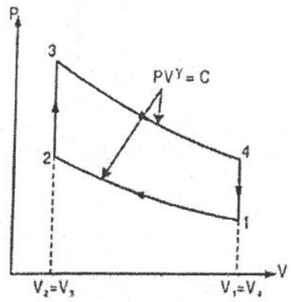
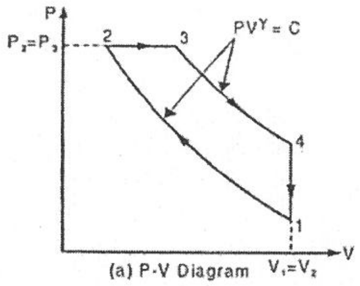
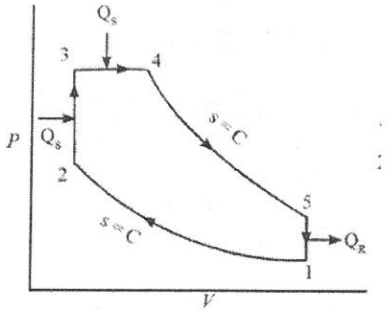
$x = 1$

10.

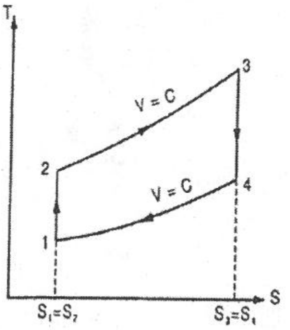
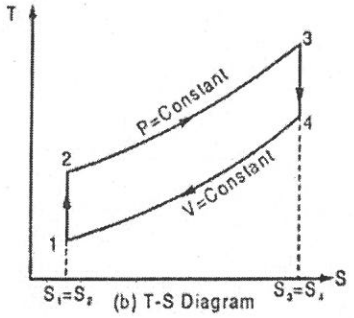
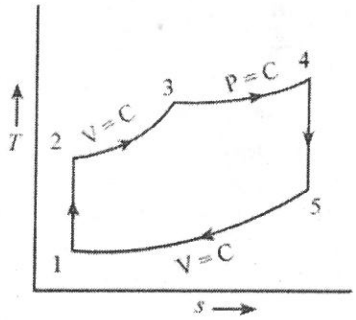
Thermodynamic Processes

Otto Cycle	Diesel Cycle	Dual Cycle
Process 1-2: Isentropic (adiabatic) compression. **Process 2-3:** constant-volume heat addition. **Process 3-4:** Isentropic (adiabatic) expansion (power stroke). **Process 4-1:** constant-volume heat rejection.	**Process 1-2:** Isentropic (adiabatic) compression. **Process 2-3:** constant-pressure heat addition. **Process 3-4:** Isentropic (adiabatic) expansion (power stroke). **Process 4-1:** constant-volume heat rejection.	**Process 1-2:** Isentropic (adiabatic) compression. **Process 2-3:** constant-volume heat addition (partial heat addition). **Process 3-4:** constant-pressure heat addition (remaining heat addition). **Process 4-5:** Isentropic (adiabatic) expansion (power stroke). **Process5-1:** constant-volume heat rejection.

P-V diagram

Otto Cycle	Diesel Cycle	Dual Cycle
	 (a) P-V Diagram	
heat additionat constant volume.	heat additionat constant pressure.	heat additionat constant volume and constant pressure.

T-S diagram

Otto Cycle	Diesel Cycle	Dual Cycle
	 (b) T-S Diagram	
heat rejectionat constant volume.	heat rejection at constant volume.	heat rejection at constant volume.

Thermal efficiency

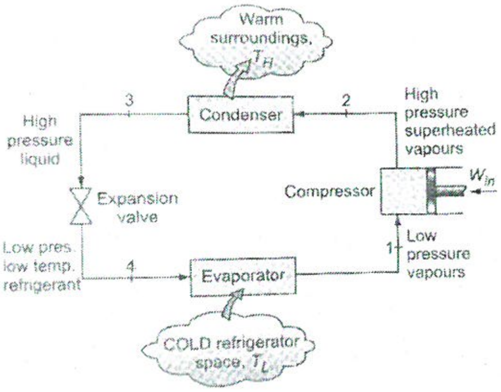
Otto Cycle	Diesel Cycle	Dual Cycle
High for same r	Lower for same r	Between Otto and Diesel for same r

11.

vaporcompression refrigeration systemconsists of the followingessentialparts:

Compressor

The low pressure and temperature vapor refrigerant fromevaporatorisdrawn into the compressor, where it iscompressed toa high pressureand temperature. This high pressure and temperature vaporrefrigerantisdischarged into thecondenser.



Condenser

Thecondenser (orcooler)consists ofcoils ofpipe in which the high pressure and temperature vapour refrigerant is cooled andcondensed. The refrigerant, whilepassing through thecondenser, rejectsheat to the surrounding cooling medium which is normally airor water.

Receiver

Thecondensed liquid refrigerant from the condenser isstored in a vessel known as receiver. From receiver it is supplied to the evaporator through the expansion valve or refrigerantcontrol valve.

Expansion Valve (or throttle valve or refrigerantcontrol valve)

The function of the expansion valve is to allow the liquid refrigerantunderhigh pressure and temperature to passata controlled rateafter reducing its pressure and temperature. Some of the liquid refrigerantevaporates as itpasses through theexpansion valve, but the greaterportion is vaporized in theevaporatorat the lowpressure and temperature

Evaporator

An evaporator consists of coils ofpipe in which the liquid-vaporrefrigerantat lowpressureand temperature is evaporated by absorbing heat from the space (air, wateror brine) which is to be cooled.

Factors Affecting the Coefficient of Performance (COP)

Temperature Difference: A larger temperature difference between the evaporator and condenser leads to a higher COP.

Compressor Efficiency: A more efficient compressor requires less work input to achieve the same refrigeration effect, leading to a higher COP.

Refrigerant Properties: The choice of refrigerant can significantly impact the COP. Refrigerants with suitable thermodynamic properties, such as high latent heat of vaporization and low specific heat capacity, can improve the COP.

Compressor Work: Compressor efficiency: Inefficient compressors increase power consumption.Pressure ratio: A larger pressure difference between condenser and evaporator increases compressor work.

Impact of Refrigerants on System Performance

Thermodynamic Properties:

Latent Heat of Vaporization: A higher h_{fg} improves refrigeration effect and COP.

Pressure Range: A refrigerant with moderate pressure requirements reduces compressor work and leakage issues.

Specific Volume of Vapor: A refrigerant with a smaller specific volume requires less work during compression, enhancing COP.

Critical Temperature: A refrigerant with a critical temperature much higher than the condenser temperature ensures efficient heat rejection.