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Question Bank

Engineering Thermodynamics

Department of Mechanical Engineering

UNIT-I
BASIC CONCEPT AND FIRST LAW

1. What do you understand by pure substance?

A pure substance is defined as one that is homogeneous and invariable in chemical composition throughout its mass.

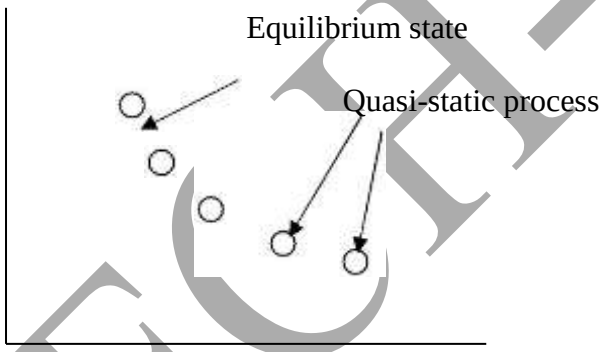
2. Define thermodynamic system.

A Thermodynamic system is defined as a quantity of matter or a region in space, on which the analysis of the problem is concentrated.

3. Name the different types of system.

1. Closed system (only energy transfer and no mass transfer Ex: piston and cylinder arrangement)
2. Open system (Both energy and mass transfer Ex. Air compressor)
3. Isolated system (No mass and energy transfer Ex: entire universe)

4. What do you mean by quasi-static process?



Infinite slowness is the characteristic feature of a quasi-static process. A quasi-static process is that a succession of equilibrium states. A quasi-static process is also called as reversible process.

5. Define Path function.

The work done by a process does not depend upon the end of the process. It depends on the path of the system follows from state 1 to state 2. Hence work is called a path function.

6. Define point function.

Thermodynamic properties are point functions. The change in a thermodynamic property of a system is a change of state is independent of the path and depends only on the initial and final states of the system.

7. Explain homogeneous and heterogeneous system.

The system consist of single phase is called homogeneous system and the system consist of more than one phase is called heterogeneous system.

8. Prove that for an isolated system, there is no change in internal energy.

In isolated system there is no interaction between the system and the surroundings. There is no mass transfer and energy transfer. According to first law of thermodynamics as dQ = dU

+ dW; dU = dQ – dW; dQ = 0, dW = 0, Therefore dU = 0 by integrating the above equation
U = constant, therefore the internal energy is constant for isolated system.

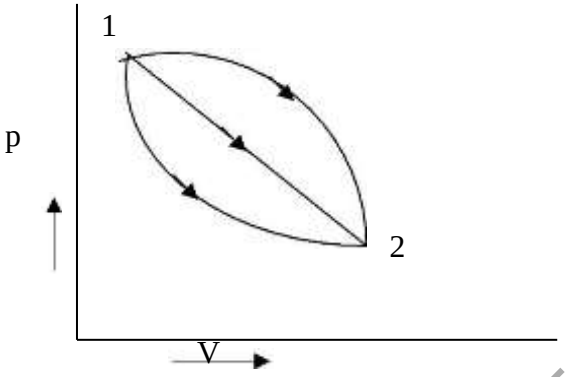
9. Indicate the practical application of steady flow energy equation.

1. Turbine, 2. Nozzle, 3. Condenser, 4. Compressor.

10. Define cycle.

It is defined as a series of state changes such that the final state is identical with the initial state.

11. Show that work is a path function and not a property.



With reference to the above figure, it is possible to take the system from 1 to 2 along many quasi-static paths such as A, B or C. Since the area under each curve represents the work for each process, the amount of work involved in each case is not a function of the end states of the process and it depends on the path of the system, follows in going from state 1 to state 2. For this reason, work is a path function and not a property.

12. Explain Mechanical equilibrium.

If the forces are balanced between the system and surroundings are called Mechanical equilibrium

13. Explain Chemical equilibrium.

If there is no chemical reaction or transfer of matter form one part of the system to another is called Chemical equilibrium

14. Explain Thermal equilibrium.

If the temperature difference between the system and surroundings is zero then it is in Thermal equilibrium.

15. Define Zeroth law of Thermodynamics.

When two systems are separately in thermal equilibrium with a third system then they themselves is in thermal equilibrium with each other.

16. What are the limitations of first law of thermodynamics?

a. According to first law of thermodynamics heat and work are mutually convertible during any cycle of a closed system. But this law does not specify the possible conditions under which the heat is converted into work.

b. According to the first law of thermodynamics it is impossible to transfer heat from lower temperature to higher temperature.

c. It does not give any information regarding change of state or whether the process is possible or not.

d. The law does not specify the direction of heat and work.

17. What is perpetual motion machine of first kind?

It is defined as a machine, which produces work energy without consuming an equivalent of energy from other source. It is impossible to obtain in actual practice, because no machine can produce energy of its own without consuming any other form of energy.

18. Define the term thermal engineering.

Thermal engineering is the science that deals with the energy transfer to practical applications such as energy transfer power generation, refraction, gas compression and its effect on the properties of working substance.

19. What is meant by surrounding?

Any other matter outside of the system boundary is called as surroundings.

20. What is boundary?

System and surrounding are separated by a real or imaginary line is called boundary.

21. State first law of thermodynamics and any two of its corollaries.

First law of thermodynamics states that when system undergoes a cyclic process, net heat transfer is equal to work transfer

COROLLARY I: there exists a property of a closed system such that a change in its value is equal to the difference between the heat supplied and the work done during any change of state.

COROLLARYII: the internal energy of a closed system remains unchanged if the system is isolated from its surroundings.

22. What is meant by reversible and irreversible process?

A process is said to the reversible, it should trace the same path in the reverse direction when the process is reversed, and it is possible only when the system passes through a continuous series of equilibrium state. If a system does not pass through continuous equilibrium state, when the processes is said to be irreversible.

23. Define the term enthalpy.

The combination of internal energy and flow energy is known as enthalpy of the system.

Mathematically, enthalpy $H = U + pV$ KJ

Where U= Internal energy, P = Pressure, V = Volume, In terms of C_p & $T = m\ C_p\ (T_2-T_1)$

24. What is meant by thermodynamics work?

It is the work done by the system when the energy transferred across the boundary of the system .It is mainly due to intensive property difference between system and surrounding.

25. Distinguish between the terms “state”, “change of state”, “path“”, “process”.

State: The properties of the system have definite values, the system is said to exist at a definite state.

Change of state: Any operation in which one or more of the properties of a system changes is called a change of state.

Path: The succession of states passed through during a change of state is called the path of change of state.

Process: When path is completely specified, the change of state is called a process Ex; constant pressure process.

26. Distinguish between heat and temperature.

The temperature is a thermal state of body which distinguishes a hot body from cold body. The

temperature of a body is proportional to the stored molecular energy.
Heat is something which appears at the body when a system changes its state due to a difference in temperature between the system and surroundings.

27. Define a thermodynamic system Classify the following system as open/closed/isolated (a) Mixture of ice and water in a metal container (b) A wind mill

A Thermodynamic system is defined as a quantity of matter or a region in space, on which the analysis of the problem is concentrated

(a) Mixture of ice and water in a metal container – open system

(b) A wind mill- closed system.

28. Differentiate closed and open system. (MU – Apr‟98, MKU – Nov‟95)

Closed System	Open System
1. There is no mass transfer. Only heat and work will transfer.	1. Mass transfer will take place, in addition to the heat and work transfer.
2. System boundary is fixed one	2. System boundary may or may not change.
3. Ex: Piston & cylinder arrangement, Thermal power plant	3. Air compressor, boiler

29. What is the difference between steady flow and non – flow process?

During the steady flow process the rate of flow of mass and energy across the boundary remains constant. In case of non – flow across the system and boundary.

30. Differentiate Intensive and Extensive properties (MU – Apr‟99, Apr‟2001; MSU – Nov‟96)

Intensive Properties	Extensive Properties
1. Independent on the mass of the system	Dependent on the mass of the system.
2. If we consider part of the system these properties remain same. e.g. pressure, Temperature specific volume etc.,	If we consider part of the system it will have a lesser value. e.g., Total energy, Total volume, weight etc.,
3. Extensive property/mass is known as intensive property	--

31. Define: Specific heat capacity at constant pressure. (MU – Oct‟99)

It is defined as the amount of heat energy required to raise or lower the temperature of unit mass of the substance through one degree when the pressure kept constant. It is denoted by C_p.

32. Define: Specific heat capacity at constant volume.

It is defined as the amount of heat energy required to raise or lower the temperature of unit mass of the substance through one degree when volume kept constant.

33. Define entropy of a pure substance. (MU – Oct‟2000; MKU – Nov‟96; BRU – Nov‟95)

Entropy is an important thermodynamic property, which increases with addition of heat and decreases with its removal. Entropy is a function of temperature only. It is an unavailability of energy during energy transfer.

34. Define an isentropic process. (MU – Oct‟99)

Isentropic process is also called as reversible adiabatic process. It is a process which follows the law of $pV^y = C$ is known as isentropic process. During this process entropy remains constant and no heat enters or leaves the gas.

35. Explain the throttling process.

When a gas or vapour expands and flows through an aperture of small size, the process is called as throttling process.

36. Define free expansion process.

When a gas expands suddenly into a vacuum through a large orifice is known as free expansion process.

37. What is meant by steady flow process? (BNU – Nov‟96)

During the process the rate of flow of mass and energy across the boundary remains constant, is known as steady flow process.

UNIT-II
SECOND LAW, ENTROPY AND AVAILABILITY

1. Define Clausius statement.

It is impossible for a self-acting machine working in a cyclic process, to transfer heat from a body at lower temperature to a body at a higher temperature without the aid of an external agency.

2. What is Perpetual motion machine of the second kind?

A Heat engine, which converts whole of the heat energy into mechanical work, is known as Perpetual motion machine of the second kind.

3. Define Kelvin Planck Statement.

It is impossible to construct a heat engine to produce network in a complete cycle if it exchanges heat from a single reservoir at single fixed temperature.

4. Define Heat pump.

A heat pump is a device, which is working in a cycle and transfers heat from lower temperature to higher temperature.

5. Define Heat engine.

Heat engine is a machine, which is used to convert the heat energy into mechanical work in a cyclic process.

6. What are the assumptions made on heat engine?

i. The source and sink are maintained at constant temperature.

ii. The source and sink has infinite heat capacity.

7. State Carnot theorem.

It states that no heat engine operating in a cycle between two constant temperature heat reservoir can

be more efficient than a reversible engine operating between the same reservoir.

8. What is meant by reversible process?

A Reversible process is one, which is performed in such a way that at the conclusion of process, both system and surroundings may be restored to their initial state, without producing any changes in rest of the universe.

9. What is meant by irreversible process?

The mixing of two substances and combustion also leads to irreversibility. All spontaneous process is irreversible.

10. Explain entropy?

It is an important thermodynamic property of the substance. It is the measure of molecular disorder. It is denoted by S. The measurement of change in entropy for reversible process is obtained by the quantity of heat received or rejected to absolute temperature.

11. What is absolute entropy?

The entropy measured for all perfect crystalline solids at absolute zero temperature is known as absolute entropy.

12. Define availability.

The maximum useful work obtained during a process in which the final condition of the system is the same as that of the surrounding is called availability of the system.

13. Define available energy and unavailable energy.

Available energy is the maximum thermal useful work under ideal condition. The remaining part, which cannot be converted into work, is known as unavailable energy.

14. Explain the term source and sink.

Source is a thermal reservoir, which supplies heat to the system and sink is a thermal reservoir, which takes the heat from the system.

15. What do you understand by the entropy principle?

The entropy of an isolated system can never decrease. It always increases and remains constant only when the process is reversible. This is known as principle of increase in entropy or entropy principle.

16. What is the difference between a heat pump and a refrigerator?

Heat pump is a device which operating in cyclic process, maintains the temperature of a hot body at a temperature higher than the temperature of surroundings.

A refrigerator is a device which operating in a cyclic process, maintains the temperature of a cold body at a temperature lower than the temperature of the surroundings.

17. What is meant by heat engine?

A heat engine is a device which is used to convert the thermal energy into mechanical energy.

18. Define the term COP?

Co-efficient of performance is defined as the ratio of heat extracted or rejected to work input.

$$COP = \frac{\text{Heat extracted or rejected}}{\text{Work input}}$$

19. Write the expression for COP of a heat pump and a refrigerator?

COP of heat pump

$$COP_{HP} = \frac{\text{Heat Supplied}}{\text{Work input}} = \frac{T_2}{T_2 - T_1}$$

COP of Refrigerator

$$COP_{HP} = \frac{\text{Heat extracted}}{\text{Work input}} = \frac{T_1}{T_2 - T_1}$$

20. What is the relation between COP_{HP} and COP_{ref}?

$COP_{HP} = COP_{ref} + 1$

21. Why Carnot cycle cannot be realized in practical?

(i) In a Carnot cycle all the four processes are reversible but in actual practice there is no process is reversible.

(ii) There are two processes to be carried out during compression and expansion. For isothermal process the piston moves very slowly and for adiabatic process the piston moves as fast as possible. This speed variation during the same stroke of the piston is not possible.

(iii) It is not possible to avoid friction moving parts completely.

22. Name two alternative methods by which the efficiency of a Carnot cycle can be increased.
(i) Efficiency can be increased as the higher temperature T_2 increases.
(ii) Efficiency can be increased as the lower temperature T_1 decreases.

23. Why a heat engine cannot have 100% efficiency?
For all the heat engines there will be a heat loss between system and surroundings. Therefore we can‟t convert all the heat input into useful work.

24. What are the processes involved in Carnot cycle.
Carnot cycle consist of Reversible isothermal compression isentropic compression, reversible isothermal expansion isentropic expansion

25. Write the expression for efficiency of the Carnot cycle.

$\eta = T2 - T1 / T2$

26. What are the important characteristics of entropy?

i. If the heat is supplied to the system then the entropy will increase.

ii. If the heat is rejected to the system then the entropy will decrease.

iii. The entropy is constant for all adiabatic frictionless process.

iv. The entropy increases if temperature of heat is lowered without work being done as in throttling process.

v. If the entropy is maximum, then there is a minimum availability for conversion in to work.

vi. If the entropy is minimum then there is a maximum availability for conversion into work.

27. Is the second law independent of first law? Explain.
Yes. The second law is independent of first law. The second law speaks about the quality of energy.

28. Why the performances of refrigerator and heat pump are given in terms of C.O.P and not in terms of efficiency?
The performance of any device is expressed in terms of efficiency for work developing machines. But heat pump and refrigerator are work absorbing machines. So, the performances of those devices based on C.O.P only.

29. Comment the statement "The entropy of universe tends to be maximum?
If the entropy of universe tends to be maximum, the irreversibility will be more due to friction between moving parts

30. What do you mean by "Clausius inequality"?
It is impossible for a self acting machine working in a cycle process unaided by an external agency to convey heat from a body at a lower temperature to a body at a higher temperature.

UNIT-III

PROPERTIES OF PURE SUBSTANCE AND STEAM POWER CYCLE

1. What is reversed Carnot heat engine? What are the limitations of Carnot cycle?

i. No friction is considered for moving parts of the engine
ii. There should not be any heat loss

2. Why Rankine cycle is modified?

The work obtained at the end of the expansion is very less. The work is to inadequate to overcome the friction. Therefore the adiabatic expansion is terminated at the point before the end of the expansion in the turbine and pressure decreases suddenly, while the volume remains constant.

3. Name the various vapour power cycle.
Carnot cycle and Rankine cycle.

4. Define efficiency ratio.
The ratio of actual cycle efficiency to that of the ideal cycle efficiency is termed as efficiency ratio.

5. Define overall efficiency.

It is the ratio of the mechanical work to the energy supplied in the fuel. It is also defined as the product of combustion efficiency and the cycle efficiency.

6. Define specific steam consumption of an ideal Rankine cycle.
It is defined as the mass flow of steam required per unit power output.

7. Name the different components in steam power plant working on Rankine cycle.
   Boiler, Turbine, Cooling Tower or Condenser and Pump.

8. What are the effects of condenser pressure on the Rankine Cycle?

By lowering the condenser pressure, we can increase the cycle efficiency. The main disadvantage is lowering the back pressure in release the wetness of steam. Isentropic compression of a very wet vapour is very difficult.

9. Mention the improvements made to increase the ideal efficiency of Rankine cycle.

1. Lowering the condenser pressure.
2. Superheated steam is supplied to the turbine.
3. Increasing the boiler pressure to certain limit.
4. Implementing reheat and regeneration in the cycle.

10. Why reheat cycle is not used for low boiler pressure?

At the low reheat pressure the heat cycle efficiency may be less than the Rankine cycle efficiency. Since the average temperature during heating will then be low.

11. What are the disadvantages of reheating?

Reheating increases the condenser capacity due to increased dryness fraction, increases the cost of the plant due to the reheats and its very long connections.

12. What are the advantages of reheat cycle?

i. It increases the turbine work.
ii. It increases the heat supply.
iii. It increases the efficiency of the plant.
iv. It reduces the wear on the blade because of low moisture content in LP state of the turbine.

13. Define latent heat of evaporation or Enthalpy of evaporation.

The amount of heat added during heating of water up to dry steam from boiling point is known as Latent heat of evaporation or enthalpy of evaporation.

14. Explain the term super heated steam and super heating.

The dry steam is further heated its temperature raises, this process is called as superheating and the steam obtained is known as superheated steam.

15. Explain heat of super heat or super heat enthalpy.

The heat added to dry steam at $100^{o}C$ to convert it into super heated steam at the temperature T_{sup} is called as heat of superheat or super heat enthalpy.

16. Explain the term critical point, critical temperature and critical pressure.

In the T-S diagram the region left of the waterline, the water exists as liquid. In right of the dry steam line, the water exists as a super heated steam. In between water and dry steam line the water exists as a wet steam.

At a particular point, the water is directly converted into dry steam without formation of wet steam. The point is called critical point.

The critical temperature is the temperature above which a substance cannot exist as a liquid, the critical temperature of water is $374.15^{o}C$. The corresponding pressure is called critical pressure.

16. Define dryness fraction (or) what is the quality of steam?

It is defined as the ratio of mass of the dry steam to the mass of the total steam.

17. Define enthalpy of steam.

It is the sum of heat added to water from freezing point to saturation temperature and the heat absorbed during evaporation.

18. How do you determine the state of steam?

If $V>v_g$ then super heated steam, $V= v_g$ then dry steam and $V< v_g$ then wet steam.

19. Define triple point.

The triple point is merely the point of intersection of sublimation and vaporization curves.

20. Define heat of vaporization.

The amount of heat required to convert the liquid water completely into vapour under this condition is called the heat of vaporization.

21. Explain the terms, Degree of super heat, degree of sub-cooling.

The difference between the temperature of the superheated vapour and saturation temperature at the same pressure.

The temperature between the saturation temperature and the temperature in the sub cooled region of liquid.

22. What is the purpose of reheating?

The purpose of reheating is to increase the dryness fraction of the steam passing out of the later stages of the turbine.

23. What is pure substance?

Pure substance is a substance which has a fixed chemical composition throughout its mass. Examples: Water, nitrogen, carbon dioxide, and helium. A pure substance does not have to be a single chemical element or compound. A mixture of various chemical elements or compounds is also called as pure substance as long as the mixture is homogeneous.

24. Define the term „Boiling point" and „Melting point".

Boiling point: It is the temperature at which the liquid starts to change its state from liquid to vapour.

Melting point: It is the temperature at which the solid starts to change its state from solid to liquid.

25. What is meant by super heated steam? And indicate its use.

If the dry steam is further heated, then the process is called superheating and steam obtained is known as super heated steam.

Uses: i. Superheated steam has more heat energy and more work can be obtained using it.
ii. Thermal efficiency increase as the temperature of superheated steam is high.
iii. Heat losses be to condensation of steam a cylinder wall is reduced.

26. Define: Sensible heat of water.

The amount of heat required to raise the temperature of unit mass of water from 0^0C to the saturation temperature under a constant pressure. It is denoted by $h_{f.}$

27. State phase rule of pure substance.

The number of independent variable associated with a multicomponent, multiphase system is given by the phase rule. It is also called as Cibbs phase rule. It is expressed by the equation as

$$n= C-\omega+2$$

Where, n = the number of independent variable.
C = the number of components.
ω = the number of phase present in equilibrium.

UNIT-IV
IDEAL & REAL GASES AND THERMO DYNAMIC RELATIONS

1. Define Real gas.

It is defined, as a gas having the forces of attraction between molecules tends to be very small at reduced pressures and elevated temperatures.

2. What is equation of state?

The relation between the independent properties such as pressure, specific volume and temperature for a

pure substance is known as the equation of state.

3. State Boyle‟s law

It states that volume of a given mass of a perfect gas varies inversely as the absolute pressure when temperature is constant

4. State Charle‟s law.

It states that if any gas is heated at constant pressure, its volume changes directly as its absolute temperature.

5. Explain the construction and give the use of generalized compressibility chart. The general compressibility chart is plotted with Z versus P_r for various values of T_r. This is constructed by plotting the known data of one of mole gases and can be used for any gas. This chart gives best results for the regions well removed from the critical state for all gases.

6. Explain law of corresponding states

If any two gases have equal values of reduced pressure and reduced temperature, then they have same values of reduced volume.

7. Explain Dalton‟s law of partial pressure.

The pressure of a mixture of gases is equal to the sum of the partial pressures of the constituents. The partial pressure of each constituent is that pressure which the gas would expect if it occupied alone that volume occupied by the mixtures at
the same temperatures. $m = m_A+m_B+m_C+\ldots\ldots = \sum m_i$
m_i = mass of the constituent.
$P=P_A+P_B+P_C+\ldots\ldots = \sum P_i$, P_i – the partial pressure of a constituent.

8. State Avogadro‟s Law.

The number of moles of any gas is proportional to the volume of gas at a given pressure and temperature.

9. What is Joule-Thomson coefficient?

The temperature behaviors of a fluid during a throttling (h=constant) process is described by the Joule-Thomson coefficient defined as $=[\delta T/\delta P]_n$

10. What is compressibility factor?

The gas equation for an ideal gas is given by (PV/RT) = 1, for real gas (PV/RT) is not equal to 1 (PV/RT) = Z for real gas is called the compressibility factor.

11. What is partial pressure?

The partial pressure of each constituent is that pressure which the gas would exert if it occupied alone that volume occupied by the mixtures at the same temperature.

12. Define Dalton‟s law of partial pressure

The total pressure exerted in a closed vessel containing a number of gases is equal to the sum of the pressures of each gas and the volume of each gas equal to the volume of the vessel.

13. How does the Vander Waal‟s equation differ from the ideal gas equation of state? The ideal gas equation pV=mRT has two important assumptions.

1. There is little or no attraction between the molecules of the gas.
That the volume occupied by the molecules themselves is negligibly small compared to the volume of the gas. This equation holds good for low pressure and high temperature ranges as the intermolecular attraction and the volume of the molecules are not of much significance

2. As the pressure increases, the inter molecular forces of attraction and repulsion increases and the

volume of the molecules are not negligible. The real gases deviate considerably from the ideal gas equation

$$[p+(a/V^2)](V-b) = RT.$$

14. What are Maxwell relations?

$(\delta T/ \delta v)_s = -(\delta P /\delta s)_v$, $(\delta T / \delta P)_s = (\delta v /\delta s)_P$

$(\delta s / \delta v)_T = (\delta P /\delta T)_v$, $(\delta s / \delta P)_T = (\delta v /\delta T)_P$.

15. How does Vander walls equation differ from the ideal gas equation of state?

1. Intermolecular attractive study is made.
2. Shape factor is considered.

These assumptions are not made in ideal gas equation of state.

16. What is meant by virtual expansions?

Viral or virtual expansions are only applicable to gases of low and medium densities. The equation of a substance is given by

$$P = \frac{RT}{v} + \frac{a(T)}{v^2} + \frac{b(T)}{v^3} + \frac{c(T)}{v^4} + \frac{d(T)}{v^5} + \cdots\cdots$$

The coefficient of a(T),b(T),c(T),d(T)…... are viral coefficients. The Viral coefficient will vanish when the pressure becomes zero. Finally, the equation of states reduces to the ideal –gas equation.

17. Distinguish between ideal and real gas.

An ideal gas is one which strictly follows the gas laws under all conditions of temperature and pressure.

In actual practice, there is no real gas which strictly follows the gas laws the entire range of temperature and pressure. However hydrogen .oxygen, nitrogen and air behave as an ideal gas under certain temperature and pressure limits.

18. Define the term Joule-Thomson Co-efficient.

Joule-Thomson Co-efficient is defined as the change in temperature with change in pressure, keeping the enthalpy remains constant. It is denoted by the $\mu = (\delta T/\delta P)_h$

19. Define the co-efficient of volume expansion and isothermal compressibility.

Co-efficient of volume expansions:

Co-efficient of volume expansion is defined as the change in volume with the change in temperature per unit volume keeping the pressure constant. It is denoted by β

$$\beta = 1/v\ (\delta v/\delta T)_p$$

Isothermal Compressibility:

It is defined as the change in volume with change in pressure per unit volume by keeping the temperature constant. It is denoted by K.

$$K = -1/v\ (\delta v/\delta T)_T.$$

20. What is compressibility factor? What does it signify? What is its value foe an ideal gas at critical point?

The gas equation for an ideal gas is given by (PV/RT) = 1, for real gas (PV/RT) is not equal to 1 (PV/RT) = Z for real gas is called the compressibility factor.

1. Intermolecular attractive study is made.
2. Shape factor is considered.

At critical point, the Vander Waal‟s equation.

$$p_c V_c / RT_c = 1 \text{ for ideal gases.}$$

21. What is Joule-Thomson Co-efficient? Why is it zero for an ideal gas?

Joule-Thomson Co-efficient is defined as the change in temperature with change in pressure, keeping the enthalpy remains constant. It is denoted by the

$$\mu = (\delta T/\delta P)_h = 1/C_p[T\ (\delta v/\delta T)_p - v]$$

We know that the equation of state as

$$pV = RT$$

Differentiating the above equation of state with respect to T by keeping pressure, p constant

$(\delta v/\delta T)_p = R/p = v/T$

$\mu = 1/C_p[T.\ v/T - v]$

$\mu = 0$

It implies that the Joule-Thomson Co-efficient is zero for ideal gas.

22. What is Clasius Clapeyron equation?

Clasius Clapeyron equation Which involves relationship between the saturation pressure,saturation temperature, the enthalpy of evaporation and the specific volume of the two phase involved.

$Dp/dT = h_{fg} / Tv_{fg}$.

23. State Tds Equations.

Tds equations are

$$Tds = C_p dT - T [\delta v/\delta T]_p \, dp$$

$$Tds = C_v dT + T [\delta p/\delta T]_T \, dv$$

24. State Helmholtz function.

Helmholtz function is property of a system and is given by subtracting the product of absolute temperature (T) and entropy (s) for the internal energy u

Helmholtz function = u-Ts

25. State Gibbs function.

Gibbs function is property of a system and is given by

$G = u - Ts + pv = h - Ts$ [h= u + pv]

Where

h- Enthalpy

T- Temperature

S – Entropy.

UNIT-V
PSYCHROMETRY

1. What is humidification and dehumidification?

The addition of water vapour into air is humidification and the removal of water vapour from air is dehumidification.

2. Differentiate absolute humidity and relative humidity.

Absolute humidity is the mass of water vapour present in one kg of dry air. Relative humidity is the ratio of the actual mass of water vapour present in one kg of dry air at the given temperature to the maximum mass of water vapour it can with hold at the same temperature. Absolute humidity is expressed in terms of kg/kg of dry air. Relative humidity is expressed in terms of percentage.

3. What is effective temperature?

The effective temperature is a measure of feeling warmth or cold to the human body in response to the air temperature, moisture content and air motion. If the air at different DBT and RH condition carries the same amount of heat as the heat carried by the air at temperature T and 100% RH, then the temperature T is known as effective temperature.

4. Define Relative humidity.

It is defined as the ratio of partial pressure of water vapour (p_w) in a mixture to the saturation pressure (p_s) of pure water at the same temperature of mixture.

5. Define specific humidity.

It is defined as the ratio of the mass of water vapour (m_s) in a given volume to the mass of dry air in a given volume (m_a).

6. Define degree of saturation.

It is the ratio of the actual specific humidity and the saturated specific humidity at the same temperature of the mixture.

7. What is dew point temperature?

The temperature at which the vapour starts condensing is called dew point temperature. It is also equal to the saturation temperature at the partial pressure of water vapour in the mixture. The dew point temperature is an indication of specific humidity.

8. What is meant by dry bulb temperature (DBT)?

The temperature recorded by the thermometer with a dry bulb. The dry bulb thermometer cannot affected by the moisture present in the air. It is the measure of sensible heat of the air.

9. What is meant by wet bulb temperature (WBT)?

It is the temperature recorded by a thermometer whose bulb is covered with cotton wick (wet) saturated with water. The wet bulb temperature may be the measure of enthalpy of air. WBT is the lowest temperature recorded by moistened bulb.

10. Define dew point depression.

It is the difference between dry bulb temperature and dew point temperature of air vapour mixture.

11. What is meant by adiabatic saturation temperature (or) thermodynamic wet bulb temperature?

It is the temperature at which the outlet air can be brought into saturation state by passing through the water in the long insulated duct (adiabatic) by the evaporation of water due to latent heat of vapourisation.

12. What is psychrometer?

Psychrometer is an instrument which measures both dry bulb temperature and wet bulb temperature.

13. What is psychometric chart?

It is the graphical plot with specific humidity and partial pressure of water vapour in y axis and dry bulb temperature along x axis. The specific volume of mixture, wet bulb temperature, relative humidity and enthalpy are the properties appeared in the psychometric chart.

14. Define sensible heat and latent heat.

Sensible heat is the heat that changes the temperature of the substance when added to it or when abstracted from it. Latent heat is the heat that does not affect the temperature but change of state occurred by adding the heat or by abstracting the heat.

15. What are the important psychometric processes?

    a. Sensible heating and sensible cooling, 2. Cooling and dehumidification, 3. Heating and humidification, 4. Mixing of air streams, 5. Chemical dehumidification, 6. Adiabatic evaporative cooling.

16. What is meant by adiabatic mixing?

The process of mixing two or more stream of air without any heat transfer to the surrounding is known as adiabatic mixing. It is happened in air conditioning system.

17. What are the assumptions made in Vanderwaal‟s equation of state?

i. There is no inter molecular forces between particles.

ii. The volume of molecules is negligible in comparison with the gas.

18. Define coefficient of volume expansion.

The coefficient of volume expansion is defined as the change in volume with the change in temperature per unit volume keeping the pressure constant. It is denoted by β.

19. State Helmholtz function.

Helmholtz function is the property of a system and is given by subtracting the product of absolute temperature (T) and entropy (S) from the internal energy (U).

i. Helmholtz function = U – TS

20. What are thermodynamic properties?

Thermodynamic properties are pressure (p), temperature (T), volume (V), internal energy (U), enthalpy (H), entropy (S), Helmholtz function (α) and Gibbs function

21. Define throttling process.

When a fluid expands through a minute orifice or slightly opened valve, the process is called as throttling process. During this process, pressure and velocity are reduced.

22. Define Molecular mass.

Molecular mass is defined as the ratio between total mass of the mixture to the total number of moles available in the mixture.

23. Define isothermal compressibility.

Isothermal compressibility is defined as the change in volume with change in pressure per unit volume keeping the temperature constant.

24. Define psychrometry.

The science which deals with the study of behavior of moist air (mixture of dry air and water vapour) is known as psychometric.

25. What is difference between air conditioning and refrigeration?

Refrigeration is the process of providing and maintaining the temperature in space below atmospheric temperature.

Air conditioning is the process of supplying sufficient volume of clean air conditioning a specific amount of water vapour maintaining the predetermined atmospheric condition with in a selected enclosure.

26. What is dew point temperature? How is it related to dry bulb and wet bulb temperature at the saturation condition?

It is the temperature at which the water vapour present in air begins to condense when the air is cooled.

For saturated air, the bulb, wet bulb and dew temperature are all same.

27. State Dalton‟s law of partial pressure.

The total pressure exerted by air and water vapour mixture is equal to the barometer pressure.

$P_b = p_a + p_v$

Where,

P_b= Barometric pressure.
P_a = partial pressure of dry air.
P_v= partial pressure of water vapour.

28. List down the psychometric processes.
    - Sensible heating process
    - Sensible cooling process
    - Humidification process
    - Dehumidification process
    - Heating and Humidification process
    - Cooling and Dehumidification process
    - Adiabatic mixing airstreams process
    - Evaporative cooling process.

29. Define bypass factor (BPF) of a coil.

    The ratio of the amount of air which does not contact the cooling coil to the amount of supply air is called BPF.

    BPF = Amount of air by passing the coil / Total amount of air passed.

30. State the effects of very high and a very low bypass factor.

    Very high by pass factor:
    - It requires lower ADP.Refrigerant plant should be or larger capacity.
    - It requires more air. Larger fan and motor required.
    - It requires less heat transfer area.
    - It requires more chilling water. Larger piping required.

    Very low by pass factor:
    - Higher ADP is to be employed.
    - It requires less air. Fan and motor size required.

31. What factor affect by pass factor?
    - Pitch of pins.
    - Number of coil tubes.
    - Air velocity over the coil.
    - Direction of air flow.

UNIT-I

BASIC CONCEPT AND FIRST LAW

1) Electric water with a resistance of 50 Ohms heater is connected across a power supply of 240 Volt for a period of 1 hour.

a) Determine the work done by the power source on the heater. b) How many units of electricity are consumed? **[5184 kJ; 1.44 k W hr**]

2) Air expands from 0.1 m3 to 0.23 m3 at a constant temperature of 50oC. Calculate the work done per kg of air. R_{air} 0.287 kJ /kg K**. [77.2 kJ]**

3) Oxygen contained in a cylinder fitted with a piston expands in a quasistatic process according to the law pV1.5 constant. The initial pressure, temperature and volume are 5 bar, 300 k and 0.05 m3. After expansion, the pressure is 2 bar. Find the following: a. Final volume b. Final temperature c. Work done **[0.0921 m^3 ; 221 K ; 13.16 kJ]**

4) Air is compressed adiabatically from 0.92 m3 to 0.29 m3 in a piston cylinder arrangement. Taking its initial pressure and temperature as 103 kPa and 300 k respectively, find the work done. Also find the final temperature**.[139.04 kJ ; 476 K]**

5). A spherical balloon has a diameter of 25 cm and contains air at a pressure of 150 kPa. The diameter of the balloon increases to 30 cm because of heating, and during this process, the pressure is proportional to the diameter. Calculate the work done on the gas assuming reversible work interaction**.[0.989 kJ]**

6). A bicycle pump has a total stroke of 25 cm and is used to pump air into a tyre against a pressure of 3.5 bar. Calculate the length stroke necessary before air enters the tyre when the piston is pushed in a) rapidly b) slowly Assume atmospheric pressure is 1 bar. **[17.0 cm ; 17.9 cm]**

7). A mass of air occupying 0.5 m3 at 2 bar and 200oC is compressed reversibly and adiabatically to 5 bar and then it undergoes isobaric expansion so that it gives out 45 kJ of work. If the system is to be brought back to its initial state what should be the polytrophic index? Calculate the network interaction of this cycle. Sketch the cycle on a p-V diagram. Also compute the power developed if the number of cycles executed per minute is 300**.[2.57 ; 17.8 kJ ; 88.9 kW]**

8) It is required to lift five people on an elevator through a height of 100 m. The work required is found to be 341.2 kJ and the gravitational acceleration is 9.75 m/s2. Determine the average mass per person**. [69.95 kg]**

9) What is the work required to accelerate a vehicle of mass 500 kg from rest to a velocity of 60 kmph**.[69.44 kJ]**

10) The indicator card of an 8 cm bore, 10 cm stroke water pump is in the shape of a rectangle of dimension 2 10 cm. The indicator spring constant is 22 MPa/m.a) Find the mean effective pressure. b) If the cycle is repeated once in every second, what is the power required by the pump? **[440 kPa ; 0.22 kW]**

11) A quantity of a substance in a closed vessel is undergoing a reversible process in such a way that the pressure is proportional to the square roof of volume from 1 m3 to 2m3. The initial pressure is 100 KPa. Compute the work done**.[2.33 kJ]**

12) A cylinder of 8 cm internal diameter is fitted with a piston loaded by a coil spring of stiffness 140 N/cm of compression. The cylinder contains 0.0005m3 of air at 15C and 3 bar. Find the work done when the piston moves by 4 cm as the gas expands. **[7.11 J]**

13) Carbondioxide is taken in a piston cylinder arrangement such that it occupies a volume of 1m3 at 1 bar and 27C. It has to be compressed to 0.2 m3 such that the temperature remains constant during compression. Compute the workdone and final pressure. **[-160.94 kJ; 500 kPa]**

14) 5 kg of oxygen initially at 10 bar, 370 K is undergoing expansion to 1 bar. If the final temperature is 300K. Determine the following:a) Initial volume b) Final volume c) Polytropic index d) Work done Take the molecular weight of oxygen as 32. **[0.48m3 ; 3.897m3 ; 1.1 ; 903 kJ]**

15) A rigid container of volume 0.4 m3 is filled with oxygen until the pressure reaches 1200 kPa. It is then cooled so that the pressure reduces to 900 kPa. How much work is performed? Draw a p-V diagram for the process**. [0 kJ]**

16) A paddle wheel supplies work to a system at the rate of 80 W. During a period of 1 minute the system expands from 0.03 m3 to 0.08 m3 against a constant pressure of 500 kPa. Find the net work interaction during this period of 1 minute. Ans : **[20.2 kJ]**

17) 1 Kg of air undergoes expansion from 800 kPa, 300 K to 120 kPa in such a way that p(v + 0.2) = Constant, where p is the pressure in kPa and v is the specific volume in m3/Kg. Find the work done in the process. **Ans : [466.88 kJ]**

ANNA UNIVERSITY QUESTIONS

1. Define a new thermodynamic scale say degree N, in which the freezing point and boiling point of water are 100ºN and 300ºN respectively. Correlate this temperature scale with centigrade scale. **[Nov/Dec-2008]**

2. The resistance of windings in a certain motor ids found to be 75 ohms at room temperature (25ºC) when operating at full load under steady state conditions. The motor is switched off and the resistance of the winding is immediately measures again and found to be 90ohms. The windings are made of copper whose resistance at temperature at tºC is given by Rt=R0 [1+0.00393 t] where R0 is the resistance at 0ºC. Find the temperature of the coil during full load. **[April/May 2010]**

3. A fluid having a temperature of 150ºC and a specific volume of 0.96 m^3/kg its initial state expands at constant pressure. Without friction, until the volume is 1.55 m3/kg. Find, for 1kg of fluid, the work, the heat transferred, and the final temperature if the fluid is air**.[Nov/Dec. 2009]**

4. 1 kg of gas at1.1bar, 27˚C is compressed to 6.6 bar as per the law pv1.3 = const. Calculate work and heat transfer, if i. When the gas is ethane (C2H6) with molar mass of 30kg/k mol and Cp of 2.1KJ/kgK **ii.** When the gas is argon (Ar) with molar mass of 40 kg/k mol and Cp of 0.52KJ/kgK **[Nov/Dec 2005]**

5. In an isentropic flow through nozzle, air flows at the rate of 600 kg/hr. at inlet to the nozzle,

pressure is 20mpa and temperature is 127˚C. The exit pressure is 0.5 MPa. Inlet air velocity is 300m/s determine (i). Exit velocity of air (ii). Inlet and exit area of nozzle**.[Nov/Dec 2006]**

6. A centrifugal pump delivers 2750kg of water per minute from initial pressure of 0.8 bar absolute to a final pressure of 2.08 bar absolute. The suction is 2cm below a d the delivery is 5cm above the center of pump. If the suction and delivery pipes are of 15cm and 10cm diameter respectively, make calculation for power required to run the pump**.[Nov/Dec 2006]**

7. A blower handles 1kg/sec of air at 293K and consumes a power of 15kW. The inlet and outlet velocities of air are 100m/s and 150m/s respectively. Find the exit air temperature, assuming adiabatic conditions. Take Cp of air as1.005KJ/kgK. **[Nov/Dec 2007]**

8. A room for four persons has two fans, each consuming 0.18kW power and three 100W lamps. Ventilation air at the rate of 0.0222kg/sec enters with an enthalpy of 84kJ/kg and leaves with an enthalpy of 59kJ/kg. If each person puts out heat is to be removed by a 0.175kJ/s, determine the rate at which heat is to be removed by a room cooler, so that a steady state is maintained in the room. **[Nov/Dec 2007]**

9. One litre of hydrogen at 273K is adiabatically compressed to one- half of its initial volume. Find the change in temperature of the gas, if the ratio of two specific heats for hydrogen is1.4. **[Nov/Dec 2007]**

10. A work done by substance in a reversible non –flow manner is in accordance with V= (15/p)m3, where p is in bar. Evaluate the work done on or by the system as pressure increase from 10 to 100 bar . Indicates whether it is a compression process or expansion process. If the change in internal energy is 500kJ, calculate the direction and magnitude of heat transfer. **[April/May 2008]**

11. In a gas turbine installation, the gases enters the turbine at the rate of 5kg/sec with a velocity of 50m/sec and enthalpy of 900kJ/kg and leave the turbine with 150m/sec and enthalpy of 400kJ/kg. The loss of heat from the gases to the surrounding is 25kJ/kg. Assume R = 0.285 kJ/kg˚K Cp = 1.004 kJ/kg˚K and inlet conditions to be at 100kPa and 27˚C. Determine the workdone and diameter of the inlet pipe. **[April/May 2008]**

12. Define a new thermodynamic scale say degree No, in which the freezing point and boiling point of water are 100˚N and 300˚N respectively. Correlate this temperature scale with centigrade scale. **[Nov/Dec 2008]**

13. A gas occupies 0.3m3 at 2bar. It executes a cycle consisting of processes: (1) 1-2; constant pressure with work interaction of 15kJ. (2) 2-3; compression process which follows the law pV = constant, and U3 =U3. (3) 3-3; constant volume process, and change in internal energy is 40kJ. Neglect change in KE and PE. Draw pV diagram for the process and determine network transfer for the cycle. Also show that first law is obeyed by the cycle. **[Nov/Dec 2008]**

14. A reciprocating air compressor takes in 2m3/min air at 0.11 MPa, 298K which it delivers at 1.5MPa, 384K to an after cooler where the air is cooled at constant pressure to 298K. The power absorbed by the compressor is 4.15kW. Determine the heat transfer in (i) the compressor (ii) the cooler. State your assumptions. **[AU Nov/Dec 2009]**

15. In a turbo machine handling an incompressible fluid with a density of 100kg/m3 the conditions of fluid at the rotor entry and exit are as given below;Inlet Exit a. Pressure 1.15MPa 0.05 MPa b. Velocity 30m/sec 15.5m/sec c. Height above datum 10m 2m If the volume flow rate of the fluid is 40m3/sec, estime the net energy transfer from the fluid as work. **.[AU Nov/Dec 2009]**

16. A rigid tank containing 0.4m3 of air at 400kPa and 30˚C is connected by a valve to a piston

cylinder device with zero clearance. The mass of the piston is such that a pressure of 200kPa is required to raise the piston. The valve is opened slightly and air is allowed to flow into the cylinder until the pressure of the tank drops to 200kPa. During this process, heat is exchanged with the

surrounding such that the entire air remains at 50˚C At all times. Determine the heat transfer for this process. **[AU Nov/Dec 2010]**

17. The electric heating system used in many houses consists of a simple duct with resistance wire. Air is heated as it flows over resistance wires. Consider a 15kW electric heating system. Air enters the heating section at 100kPa and 17˚C with a volume flow rate of 150m3/min. if heat is lost from the air in the duct to the surrounding at a rate of 100W, determine the exit diameter of air. **[AU Nov/Dec 2010]**

18. A frictionless piston-cylinder device contains 2kg of nitrogen at 100kPa and 300K. Nitrogen is now compressed slowly according to the relation pV1.4 = C until it reaches a final temperature of 360K. Calculate the work input during this process.[**AU Tiruchirapalli Nov/Dec 2009]**

19. A fluid is confined in a cylinder by a spring – loaded, friction less piston so the pressure in the fluid is a linear function of the volume (p = a+bv). The internal energy of the fluid is given by the following equation. U = 34.315pV **[AU Nov/Dec 2010]**

20. Where U is in kJ, p in kPa; and V in m3. If the fluid changes from an internal state of 170kPa, 0.03m3 to a final state of 4000kPa, 0.06m3, with no work other than that done on the piston, find the direction and magnitude of the work and heat transfer**.[AU Coimbatore Nov/Dec 2009]**

UNIT II

SECOND LAW, ENTROPY AND AVAILABILITY

1). A quantity of gas has an initial pressure, volume and temperature of 140 kPa, 0.14 m3 and 25ºC respectively. It is compressed to a pressure of 1.4 MPa according to the law pV1.25 = C. Determine the change in entropy Take cp =1.041 kJ/ kgK, cv = 0.743 kJ/kgK. **(Ans: □ 0.207 kJ/kgK)**

2). 1 kg of air has a volume of 56 litres and a temperature of 190oC. The air then receives heat at constant pressure until its temperature becomes 500oC. From this state the air rejects heat at constant volume until its pressure is reduced to 700 kPa. Determine the change of entropy during each process, stating whether it is an increase or decrease. **(Ans: 0.516 kJ/kgK, an increase □ 0.88 kJ/kgK, an decrease)**

3). A block of copper with a mass of 1.5 kg is initially at 700 K. It is allowed to cool by means of heat transfer to the surrounding air at 300 K. Determine the change in entropy of the copper and change in entropy of the universe after copper reaches thermal equilibrium. Assume specific heat of copper is 0.39 kJ/kgK. **(Ans : □ 0.4967 kJ/K, □0.2843 kJ/K)**

4). A vessel is divided into two temperatures by means of a membrane as shown in the figure given below. What will be the final state of air and change in entropy of the universe if the membrane is removed**. (Ans: Pf = 750.14 kPa, Tf = 65.11^{o}C)**

5). Air at 5 bar,100^{o}C, expands reversibly in a piston-cylinder arrangement. It expands to 2 bar in an isothermal process. Calculate (a) Heat transfer per unit mass of air (b) Change in specific internal energy (c) Change in specific entropy

6). One kg of air at 1 bar, 20oC, is compressed according to the law pv1.3 = constant until the pressure is 5 bar. Calculate the change in entropy and sketch the process on a T-S diagram indicating the area representing the heat flow.

7). 1 kg of air at 1bar, 25oC, changes its state to 6 bar and a volume of 1 m3. Calculate the change of entropy and sketch the initial and final state points on the p-v and T-S fields.

8). 0.5 m3 ethane (C2H4) at 7 bar, 260oC expand isentropically in a cylinder behind a piston to 1bar, 100oC. Calculate the work done in expansion assuming ethane as perfect gas. The same mass is now recompressed back to 7 bar according to the law pv1.35= constant. Calculate the final temperature and the heat transfer. Calculate also the change in entropy and sketch both process on the p-v and T-S fields. Take CP = for ethane.

9). The weight placed on the piston is such that the air occupies a volume of 1.5 litre when there exist thermodynamic equilibrium between the system and its surroundings. The corresponding pressure and temperature are 2 bar, 30oC. Heat is added until the pressure increases to 5 bar. Volume of air when the piston touches the stop is 3 litres. Find the following a) Final temperature b) Work done c) Heat transformed d) Change in entropy

10) .An ideal vapour absorption refrigeration system may be considered as the combination of the reversible heat engine operating a reversible refrigerator as given in the following diagram. Obtain the COP of the refrigeration system which is defined as the ratio of Qe to Qg.

11). Vapour absorption heat transformer is a novel device used for upgrading a portion of waste heat from low temperature to high temperature. An ideal vapour absorption heat transformer may be considered as the combination of the reversible heat engine operating a reversible heat pump as given in the following diagram. Obtain the COP of the vapour absorption heat transformer which is defined as the ratio of Qa to (Qg □ Qe).

ANNA UNIVERSITY QUESTIONS

1. The interior lighting of refrigerator 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 a malfunction of the switch. If the refrigerator has a coefficient of performance of 1.3 and the cost of electricity is Rs 8 per kWh. Determine the increase in the energy consumption of the refrigerator and its cost per year if the switch is not fixed. **[Nov/Dec -2009]**

2. A Carnot heat engine receives heat from a reservoir at 1173K at a rate of 800kJ/min and rejects the waste heat to the ambient air at 300K.The entire work output of the heat engine is used to drive a refrigerator that removes heat from the refrigerator space at 268K and transfers it to the same ambient air at 300K.Determine the maximum rate of heat removal from the refrigerator space and the total rate of heat rejection to the ambient air. **[Nov/Dec -2009]**

3. A heat pump working on the Carnot cycle takes from a reservoir at 5ºC and delivers heat to a reservoir at 60 ºC. The heat pump is driven by a reversible heat engine which takes heat from reservoir at 840 ºC and rejects heat to a reservoir at 60 ºC. The reversible heat engine also drives a machine that absorbs 80Kw. If the heat pump extracts 17kJ/s from the reservoir at 5 ºC, determine a) The rate of heat supplied from reservoir at 840 ºC source b) The rate of heat rejection to 60ºC sink **[April/May 2010]**

4. A cyclic heat engine operates between a source temperature 800 ºC and a sink temperature of 30 ºC. What is the least rate of heat rejection per kW net output of the engine? **[May/June 2010]**

5. A reversible heat engine operates between two reservoirs at temperatures of 600 ºC and 40 ºC. The engine drives a reversible refrigerator which operates between reservoirs at temperature of 40 ºC and -20 ºC. The heat transfer to the engine is 2000kJ and network output of the combined engine refrigerator plant is 360kJ.a) Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40 ºC.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. **[May/June 2010]**

6. A reversible heat engine operates between two reservoirs at 820 ºC and 27 º C engines drives a reversible refrigerator which operates between reservoirs at temperature of 27 ºC and -15 ºC. The heat transfer to the engine is 2000kJ and network available for the combined cycle is 300kJ.a) How much heat is transferred to the refrigerant and also determine the total that rejected to the reservoir at 27 ºC.b) If the efficiency of the heat engine and COP of the refrigerator is each 40% of their maximum values, determine heat transfer to the refrigerator and also heat rejected to the reservoir at 27 ºC **[Nov Dec -2008]**

7. A reversible heat engine in a satellite operates between a hot reservoir at T1 and radiating panel at T2. Radiation from the panel is proportional to its area and to T2. For a given work output and value of t1 show that the area of the panel will be minimum when T2/T1 =0.75. Determine the minimum area of the panel for an output of 1kW and constant of proportionality is 5.67W/m3K4 and T1IS 1000K **[May/June 2010]**

8. An inventor claims to have developed an engine which receives 1000kJ at a temperature of 160 ºC . It rejects heat at a temperature of 5ºC and delivers 0.12kWh of mechanical work. Is this valid claim, justify your answer through Clausius inequality**. [May/June 2009]**

9. Ten grams of water at 20ºC is converted into ice at -10 ºC at constant atmospheric pressure. Assuming the specific heat of liquid water to remain constant at 4.2J/gK and that of ice to be half of this value, and taking the latent heat of fusion of ice at 0 ºC to be 335J/g. Calculate the total entropy change of the system. **[May/June 2009]**

10. One kg of ice at -10 ºC is allowed to melt atmosphere at 30ºC. The ice melts and the water so formed rises in temperature to that of atmosphere. Determine the entropy change of ice, the entropy change of surrounding, and the entropy change of universe and write you comment based on principle of increase in entropy. The specific heat of ice is 2 kJ/kg-K and its latent heat is 335kJ/kg. **[April/May 2008]**

UNIT III

PROPERTIES OF PURE SUBSTANCE AND STEAM POWER CYCLE

1). Calculate the state of steam using steam tables. (a) Steam has a pressure of 15 bar and specific volume of 0.12 m3/kg. (b) Steam has a pressure of 10 bar and temperature of 200˚C (c) Steam has a pressure of 30 bar and enthalpy 2700 kJ/kg**. [Ans: (a) wet, (b) wet, (c) wet]**

2. A 0.25m3 vessel contains steam of 10bar at 200˚C. Find the pressure if the contents are cooled to dry saturated state at which temperature of 130˚C isentropically. **[Ans: p = 9.4 bar and x = 0.938dry]**

3. Find the volume, enthalpy and internal energy of steam (i) 500 kPa and 0.75dry (ii) 0.1 MPa and 425˚C**. [Ans: (i) v = 0.2812m3/kg, h= 2228.65 kJ/kg, u = 2080.95 kJ/kg. (ii) v = 0.3183 m/kg, h = 0.3317.85 kJ/kg, u = 2999.47 kJ/kg].**

4. Steam at 7bar and 0.9 dryness expands isothermally to 10.5bar. Calculate change in internal energy

and change in enthalpy**. [Ans: Δu =218.995 kJ/kg, Δh = 247.11 kJ/kg.]**

5. Find the internal energy and enthalpy of steam when steam conditions is 10 dry (i) 0.7dry (ii) 325˚C **[Ans: (i) h =2172.12 kJ/kg, u = 2036.11 kJ/kg. (ii) h =3105.3 kJ/kg, u = 2835.1 kJ/kg].**

6. Find the enthalpy and internal energy of unit mass of steam at temperature of 200˚C when (a) Dry and saturated (b) Steam delivered at 0.7 MPa and (c) quality of steam is 0.85. **[Ans: (i) h =2790.9 kJ/kg, u = 2593.18 kJ/kg (ii) h =28444.2 kJ/kg, u = 2634.27 kJ/kg (iii) h =2500.12 kJ/kg, u = 2332.06 kJ/kg].**

7. Steam is 10bar and 0.95dry from a boiler is sent to super heated to 400˚C at constant pressure. Using Mollier diagram, find heat supplied and change in internal energy**. [Ans: Q = 565kJ/kg, Δu = 465 kJ/kg]**

8. In a ranking cycle, the steam at inlet to turbine is saturated at a pressure of 32bar and the exhaust pressure is 0.04bar. Determine the following. Pump work ii. The turbine work iii. The Rankine efficiency iv. The condenser heat flow and v. The dryness fraction at the end of expansion.

9. In a regenerative steam cycle employing two feed water heaters the steam is supplied to the turbine at 30bar and 500˚C and is exhausted to the condenser at 0.025bar. The intermediate bleed pressures are obtained such that the saturation temperature intervals are approximately equal, giving pressure of 9bar and 1.2bar. Calculate the amount of steam bled at each stage the work output of the plant in kJ/kg of boiler steam and thermal efficiency of the plant.

10. A turbine is supplied with steam at 25bar and 350˚C, adiabatic expansion takes place to 10bar after which the steam is removed and reheated to the original temperature. It then expanded adiabatically in the turbine to 2bar at which a fraction of team bled to heat feed water, the remainder expanding in the turbine to a final pressure of 0.03bar. The condensate from the feeding water heater is pumped back into the feed water line. What is the efficiency of the cycle? Compare it with the Rankine efficiency.

ANNA UNIVERSITY QUESTIONS

1. If water is at 65ºC at 1 atm, what is the state of water? What is the specific enthalpy? [**April/May 2008]**

2. Find the enthalpy and entropy of steam when the pressure is 2MPa and the specific volume is 0.09m3/kg. **[May/June 2010]**

3. A vessel of volume 0.04m3 contains a mixture of saturated water and saturated steam at a temperature of 250ºC. The mass of liquid present is 9kg. Find the pressure, the mass and the specific volume, the enthalpy, the entropy and the internal energy. **[Nov/Dec.2009]**

4. Why do the isobars on Mollier diagram diverge from one another? **[May/June 2009]**

5. A large insulated vessel is divided into two chambers, one containing 5kg of dry saturated steam at 0.2MPa and the other 10 kg of steam, 0.8 qualities 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**.[May/June 2009]**

6. 2kg of water at 200 ºC are contained in a 20m3vessel. Determine the pressure, enthalpy, mass and volume of vapor within the vessel? **[May/June 2007]**

7. 3kg of steam at 18 bars occupies a volume of 0.2550m3.During a constant volume process, the heat rejected is 1320kJ. Determine final internal energy, find dryness fraction and pressure. Change in entropy and work done. **[April/May 2008]**

8. Steam at a pressure of 15bar and 250 ºC expands according to the law pV 1.25=C to a pressure of 1.5bar. Evaluate the final conditions, work done, heat transfer and change in entropy. The mass of the system is 0.8kg. **[Nov/Dec.2008]**

9. Steam in a pipeline with a pressure of 1000kPa flows through a throttling calorimeter when the pressure is 100kPa and temperature is 120 ºC. What is the initial quality of steam if enthalpy remains constant during throttling? **[May/June 2007]**

10. Steam floes through a turbine at the rate of 5000kg/h entering at 15bar, 300 ºC and leaving at 0.1bar with 4% moisture. The steam enters at 80 m/s at a point 2m above the discharge and leaves at 40m/s. compute the shaft power assuming that, the device is adiabatic but considering kinetic and potential energy changes. Calculate the diameters of the inlet and discharge tubes. **[April/May 2010]**

11. Steam expands isentropically in a nozzle from 1MPa, 250 ºC to 10kPa. The steam flow rate is 1 kg/s. Find the velocity of steam at exit from the nozzle and exit area of the nozzle. Neglect the velocity of steam at inlet to the nozzle. The exhaust steam from nozzle flows into the condenser and flows out as saturated water. The cooling water enters the condenser at 25 ºC and leaves at 35 ºC. Determine the mass flow rate of water**.[April/May 2010]**

12. In a thermal power plant operating on a Rankine cycle, superheated steam at 50 bar and 500 ºC enters the turbine, the isentropic efficiency of which is 0.8. The condenser pressure is 0.05 bar and it delivers the saturated liquid to a feed pump, the isentropic efficiency of which is 0.7. Determine the thermal efficiency of the power plant and the mass flow rate of steam required for 50MW net power generation**. [April/May 2010]**

13. In a reheat cycle, the initial steam pressure and the maximum temperature are 150 bar and 550 ºC respectively. If the condenser pressure is 0.1 bar and the moisture at the condenser inlet is 5% and assuming ideal processes, determine a. The reheat pressure b. The cycle efficiency c. The steam rate **[May/June 2009]**

14. In a single heater regenerative cycle, steam inlet to turbine is 30 bar , 400 ºC. Exhaust pressure is 0.1 bars. Feed water heater works at 5 bar. Find the cycle efficiency, steam rate and increase in mean temperature of heat addition. **[April/May 2008]**

15. In a steam power plant the condition of steam at inlet to the steam generator is 20bar and 300 ºC and the condenser pressure is 0.1bar. Two feed water heaters operate at optimum temperature. Determine a) The quality of steam at exhaust b) Net work per kg of steam c) Cycle efficiency and d) The steam rate. Neglect pump work **[Nov/Dec.2009]**

UNIT IV
IDEAL & REAL GASES AND THERMO DYNAMIC RELATIONS

1). A mixture of ideal gases consists of 10 kg nitrogen and 15kg of carbon dioxide at a pressure 300 kPa and a temperature of 28ºC. 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 volume and density of the mixture, and v. The CP and CV of the mixture If the mixture is heated at constant volume to 40ºC, find the changes in internal energy, enthalpy and entropy of the mixture. Find the same properties of the mixture, if the heating is carried at constant pressure to 50ºC. Take for N2 and CO2 1.4 and 1.286

2. Find the increase in entropy when 7.5 kg of oxygen at 70ºC are mixed with 8kg of nitrogen at the same temperature. The initial pressure of each constituent is 103kPa and is the same as that of mixture.

3. A vessel is divided into three compartments (a) (b) and (c) by two partitions. Part (a) contains oxygen and has a volume of 0.3m3, (b) has a volume of 0.5m3 and contains nitrogen, while (c) is 0.1m3 and holds CO2. All three parts are at a pressure of 2bar and a temperature of 13ºC. When the partitions are removed and the gases mix, determine the change in 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.

4. A closed rigid cylinder is divided by a diaphragm into two equal compartments, each of volume 0.5m3. Each compartment contains air at a temperature of 30ºC. The pressure in one compartment is 2.0MPa and in the other compartment is 1.5MPa. The diaphragm is ruptured so that the air in both the compartments mixes to bring the pressure to a uniform value throughout the cylinder which is insulated. Find the net change of entropy for the mixing process.

5. A mixture of gases contains 55% N2, 35% O2 by mass. 5kg of the mixture is compressed from200kPa and 298K to 450kPa polytropically which follows the Pv 1.2 = C determine the work done, heat transferred and change in entropy, take (CP) O2=0.918kJ/kgK (CP) CO2=0.918kJ/kgK

6. A mixture of 7.5kg of N2 and 8kg of CO2 at a pressure of 103kPa and 308K is compressed reversibly and adiabatically to a pressure of 550kPa. Determine (a) the initial and final pressure of each component (b) final temperature (c) change in internal energy, (d) entropy and work done on the mixture. Take (CP) N2=1.04 kJ/kg K, CP) CO2=0.914kJ/kgK.

7. Compute the specific volume of steam at 1 bar 550K using Vander Waals equation. Take critical temperature of steam is 647.3K and Critical pressure is 220.9bar.

8. A mixture of 5 kg oxygen and 7.5kg Argon is in insulated piston cylinder arrangement at 103kPa, 330K.The piston now compresses the mixture to half its initial volume .Molecular weight of oxygen is 32 and for argon is 40. Ratio of specific heats for oxygen is 1,39 an for argon is 1.667

9. 0.6kg of Co and 1.5kg of air is contained in a vessel of volume 0.5m3 at 15ºC. Air has 23.3% of O2 and 76.6% of N2 by mass. Calculate the partial pressure of each constituent and total pressure in the vessel. Molar masses of CO, CO2 and N2 are 28, 32 and 28kg/kmol.

10. Methane at 1.013 bar and 30ºc enters an insulated mixing chamber at a rate of 5 kg/sec. It is mixed with aur at 1 bar in an air/methane mass ratio of 18. The flow is stead and kinetic energy changes are negligible. Ambient pressure and temperature are 1.013 bar and 30ºC, determine (a) the temperature of

the mixture leaving the chamber and (b0 the irreversibility of the mixing per kilogram of methane. Take CV and CP of methane as 1.7354kJ/kgK and 2.2537kJ/kgK respectively.

ANNA UNIVERSITY QUESTIONS

1. Using the Calapeyron equation, estimate the value of the enthalpy of vaporization of refrigerant R-134a at 293K, and compare it with the tabulated value. **[Nov/Dec-2009]**

2. Over a certain range of pressures and temperatures, the equation of a certain substance is given by the relation V= - Where C is constant, derive an expression for a) The change in enthalpy and b) The change in entropy of the substance in an isothermal process**. [April/May 2009]**

3. A closed vessel has a capacity of 0.5m3. It contains 20% nitrogen and 20% oxygen 60% carbon dioxide by volume at 20 ºC and 1 MPa .Calculate the molecular mass, gas constant, mass percentage and the mass of mixture. **[April/May 2008]**

4. Show that for a vanderwaal‟s gas = 0 = R/ln **[Nov/Dec-2009]**

5. A mixture of ideal gases consists of 2.5kg of N2 and 4.5 kg of CO2 at a pressure of 4 bar and a temperature of 25 ºC. Determine i. Mole fraction of each constituent, ii. Equivalent molecular weight of the mixture, iii. Equivalent gas constant of the mixture, iv. The partial pressure and partial volumes, v. The volume and density of the mixture, **[Nov/Dec . 2008]**

6. 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 27ºC. Before mixing the following information is known about the gases in two vessels.

Vessel-A	**Vessel-B**
p=1.5MPa	p=0.6MPa
t=50ºC	t=20ºC
Constants=0.5 kg mol	Constants=2.5 kg mol

Calculate the final equilibrium process, and the amount of heat transferred to the surrounding .If the vessel has been perfectly insulated. Calculate the final temperature and pressure which would have been reached. Take =1.4. **[May/June 2009]**

7. A tank contains 0.2m3of gas mixture composed of 4 kg of nitrogen, I kg of oxygen and 0.5kg of carbon dioxide. If the temperature is 20ºC, determine the total pressure, gas constant and molar mass of the mixture? **[May/June 2007]**

8. Show that CP-CV=R for ideal gas. **[May/June 2009]**

9. Explain how real gases deviate from an ideal gas behavior. **[Nov/Dec. 2008]**

10. 45kg of CO and 1kg of air is contained in a vessel of volume 0.4m3 at 15˚C. Air has 23.3% of O2 and 76.7% of N2 by mass. Calculate the partial pressure of each constituent and total pressure in the vessel. Molar masses of CO2, O2 and N2 are 28, 32 and 28kg/Kmol. [**AU Nov/Dec 2005]**

11. A certain gas Cp = 0.913kJ/kgK and Cv = 0.653 kJ/kgK. Find the molecular weight and the specific gas constant R of the gas. **[AU Nov/Dec 2007]**

12. A closed system vessel has a capacity of 0.5m3. It contains 20% nitrogen and 20% carbon dioxide by volume at 20˚C and 1MPa. Calculate the molecular mass, gas constant, mass percentage and the mass of mixture**. [AU April/May 2008]**

13. A mixture of ideal gases consists of 2.5kg of N2 and 4.5 kg of CO2 at pressure of 4bar and a temperature of 25˚C.Determine i. Mole fraction of each consistent, ii. Equivalent molecular weight of the mixture, iii. Equivalent gas constant of the mixture, iv. The partial pressure and partial volumes, v. The volume and density of the mixture. **[AU Nov/Dec 2008]**

14. A rigid tank contains 2kmol of N2 and 6 kmol of CO2 gases at 300K and 15MPa. Estimate the volume of the tank on the basis of i. The ideal – gas equation of state ii. Compressibility factor and Amagat‟s law, and iii. Compressibility factor and Dalton‟s law**. [AU Nov/Dec 2010]**

15. An insulated right tank is divided into two compartments by a partition. One compartment contains 7kg of oxygen gas at 40˚C and 100kPa. And the other compartment contains 4kg of nitrogen gas at 20˚C and 150kPa. Now the partition is removed, and the two gases are allowed to mix. Determine i. The mixture temperature and ii. The mixture pressure after equilibrium has been established. **[AU Nov/Dec 2010]**

UNIT V
PSYCHROMETRY

1). Air has a dry bulb temperature of 25°C and wet bulb temperature of 15°C. if the barometer reads 1 bar, calculate a) Vapour pressure b) Specific humidity c) Saturation ratio d) Relative humidity e) Dew point temperature f) Vapour density g) Enthalpy of mixture.

2. Air water at 20°C and 1 bar has relative humidity 80%. Calculate a) Partial pressure of the vapour and the air b) Specific humidity c) Saturation raio d) Dew point temperature e) Density of the air f) If the mixture is cooled at constant pressure to a temperature of 10°C, find the amount of water-vapour condensed per kg of dry air.

3. The atmospheric air has a dry bulb temperature of 20°C and specific humidity of 0.0095kg/kg of dry air. If the barometer reads 760mm of Hg. Determine a) Partial pressure of vapour b) Relative humidity c) Dew point temperature

4. A mixture of air and water-vapour possesses a volume of 700m3 at 1 bar pressure and temperature 35°C.Its relative humidity is 75%. Find the specific humidity , dew point temperature, mass of air and mass of vapour in the mixture.

5. The sliding psychrometer in a laboratory test recorded the following reading a) Dry bulb temperature=25°C b) Wet bulb temperature=15°C c) Barometer reading=760 mm of Hg d) Partial pressure of the vapour=10mm of Hg. Determine specific humidity and saturation ratio.

6. The sliding psychrometer reads 40 °C DBT and 30°C WBT. Calculate specific humidity, relative humidity, dew point temperature, enthalpy, and specific volume of air mixture. Assume atmospheric air pressure as 1.0132bar 1. Atmospheric air at a pressure of1 bar and 25 °C has a relative humidity 0f 75%, find a) Partial pressure of the water vapour and the air b) Specific volume c) Dew point temperature d) Specific humidity e) Degree of saturation f) Density of the mixtures g) Water vapour condensed per kg of dry air when the mixture is cooled a constant pressure to a temperature of 10°C.

7. An air –water vapour mixture enters an adiabatic saturation at 30°C and leaves at 20°C, which is the adiabatic saturation temperature. The pressure remains constant at 100kPa. Determine the relative

humidity and humidity ratio of the inlet mixture. 8. A sling psychrometer reads 40°C DBT and 36°C WBT. find the humidity ratio, relative humidity, dew point temperature, specific volume of air density, density of water vapour and enthalpy.

9. The atmospheric air has a dry bulb temperature of 25°C and specific humidity of 0.0098kg/kg of dry air. If the barometer reads 760mm of Hg, Determine a) Partial pressure of vapour b) Relative humidity c) Dew point temperature.

10. An air mixture at 25°C and 1 bar has relative humidity 75% calculate i. Partial pressure of the vapour and the air ii. Specific humidity iii. Saturation ratio iv. Dew point temperature v. Density of the air vi. If the mixture is cooled at constant pressure to a temperature of 10°C, find the amount of water-vapour condensed per kg of dry air.

11. A mixture of air and water vapour possesses a volume of 750 m3at I bar pressure and temperature 40°C. Its relative humidity is 70%. Find the specific humidity, dew point temperature, mass of air and mass oof vapour in the mixture.

ANNA UNIVERSITY QUESTIONS

1. Atmospheric air at 1.0312 bar has a DBT of 32ºC and a WET of 26 ºC. Compute i. The partial pressure of water vapour ii. The specific humidity iii. The dew point temperature iv. The relative humidity v. The degree of saturation vi. The density of air in the mixture. Use thermodynamic table only. **[Nov/Dec-2008]**

2. A sample of moist air 1 atm and 25 ºC has a moisture content of 0.01 by volume. Determine the humidity ratio, the partial pressure of water vapour, the degree of saturation , the relative humidity and the dew point temperature **[May/June 2007]**

3. Atmospheric air at 1.0132 bar has a DBT of 32 ºC and WET at 26 ºC compute i. the partial pressure of water vapour ii. The specific humidity iii. The dew point temperature iv. The relative humidity v. The degree of saturation vi. The density of the air in the mixture vii. The density of vapour in the mixture and viii. The enthalpy of the mixture**. [Nov/Dec-2009]**

4. What is the lowest temperature that air can attain in an evaporative cooler if it enters at 1 atm, 302 K and 40% relative humidity? **[Nov/Dec-2009]**

5. Air at 20 ºC, 40% RH is mixed adiabatically with air at 40 ºC, 40% RH in the ratio of 1 kg of the former with 2 kg of the latter (on dry basis). Find the final condition of air**.[May/June 2007]**

6. 30 m2/min of moist air at 15 ºC DBT and 13 ºC WBT are mixed with 12m3/min of moist air at 25 ºC and 18 ºC WBT. Determine DBT and WBT of the mixture assuming the barometric pressure is one atmospheric. **[Nov/Dec-2008]**

7. Air at 16˚C and 25% relative humidity passes through a heater and then through a humidifier to reach final dry bulb temperature of 30˚C and 50% relative humidity. Calculate the heat and moisture added to the air. What is the sensible heat factor? **[AU Nov/Dec 2005]**

8. Saturated air at 20˚C at a rate of 1.167m3/sec is mixed adiabatically with the outside air at 30˚C and 50% relative humidity at a rate of 0.5m3/sec. Assuming adiabatic mixing condition at 1 atm,

determine specific humidity, relative humidity , dry bulb temperature and volume flow rate of the mixture**. [AU Nov/Dec 2005]**

9. A room 7m × 4m × 4m is occupied by an air water vapour mixture at 38˚C. The atmospheric pressure is 1bar and the relative humidity is 70%. Determine humidity ratio, dew point temperature mass of dry and mass of water vapour. If the mixture of air-water vapour is further cooled at constant pressure until the temperature is 10˚C. Find the amount of water vapour condensed. **[AU Nov/Dec 2006]**

10. Air at 20˚C, 40%RH is mixed adiabatically with air at 40˚C 40%RH in the ratio of 1kg of the former with 2kg of later. Find the final condition of air. Draw the process in chart also as diagram. **[AU Nov/Dec 2006, April/May 2008 & Tiruchirapalli Nov/Dec 2009]**

11. In a laboratory test a sliding psychrometer recorded dry bulb and wet bulb temperature as 303K and 298K respectively. Calculate i. Vapour pressure ii. Relative humidity iii. Specific humidity iv. Degree of saturation v. Dew point temperature vi. Enthalpy of the mixture. **[AU Nov/Dec 2007]**

12. 1kg of air at 313K dry bulb temperature and 50% relative humidity is mixed with 2kg air at 293K dry bulb temperature and 203K dew point temperature. Calculate the temperature and specific humidity of the mixture. **(AU Nov/Dec 2007).**

13. A steam of air at 101.32kPa, and a relative humidity of 30% is flowing at the rate of 14.15 m2/min. a second stream at 101.32kPa, 30˚C and a relative humidity of 50% is flowing at the rate of 8.5m3/min. The two streams are mixed adiabatically to form a third stream at 101.31kPa. Determine the specific humidity, the relative humidity and the temperature of the third stream**.[AU April/May 2008]**

14. Atmospheric air at 1.0132 bar has a DBT of 32˚C and a WBT of 26˚C.compute a. The partial pressure of water vapour b. The specific humidity c. The dew point temperature d. The Relative humidity e. The Degree of saturation f. The density of air in the mixture g. The density of water in the mixture and the enthalpy of the mixture. Use thermodynamic table only. **[AU Nov/Dec 2008 &.Coimbatore Nov/Dec 2009]**

15. 30m3/min of moist air at 15˚C DBT and 13˚C WBT are mixed with 12m3/min of moist air at 25˚C DBT and 18˚C WBT. Determine DBT and WBT of the mixture assuming the barometric pressure is one atmosphere**. [AU Nov/Dec 2008]**

16. What is the lowest temperature that air can attain in an evaporated cooler, if it enters at 1 atm, 302K, and 40percent relative humidity? **[AU Nov/Dec 2009]**

17. An air-conditioning system is to take in outdoor air at 283K and 30% relative humidity at a steady rate of 45m3/min and to condition it to 298Kand 605 relative humidity. The outdoor air is first heated tom295K in the heating section and then humidified by the injection of hot steam in the humidifying section. Assuming the entire process takes place at a pressure of 100kPa, determine i. The rate of heat supply in the heating section and ii. The mass flow rate of the steam required in the humidifying section. **[AU Nov/Dec 2009]**

18. A 5m×5m×3m room contains air at 25˚C and 100kPa at a relative humidity of 75%. Determine i. The partial pressure of dry air ii. The specific humidity iii. The enthalpy per unit mass of the dry air, and iv. The mass of the dry air and water vapour in the room**. [AU Nov/Dec 2010]**

19. The dry and the wet-bulb temperatures of atmospheric air at 1atm (101.325kPa) pressure are measured with a sling psychrometer and determine to be 25˚C and 15˚C respectively. Determine i. The

specific humidity ii. The Relative humidity. iii. The enthalpy of the air using thermodynamic relations. **[AU Nov/Dec 2010]**

20. Saturated air leaving the cooling section of an air condition system at 14˚C at a rate 50m3/min is mixed adiabatically with the outside air at 32˚C and 60%relative humidity at rate of 20m3/min. Assuming that the mixing process occurs at a pressure of 1atm,determine i. The specific humidity ii. The Relative humidity iii. The dry bulb temperature and iv. The volume flow rate of mixture. **[AU Nov/Dec 2010]**

21. Consider a room that contains air at 1atm, 35˚C and 40% relative humidity. Using psychometric chart determine i. The specific humidity ii. The enthalpy iii. The wet- bulb temperature iv. The dry-bulb temperature v. Specific volume of air. **[AU Tiruchirapalli Nov/Dec 2009]**

22. Water at 30C˚flows into a cooling tower at the rate of 1.15kg per kg of air. Air enters at a dbt of 20˚C and a relative humidity of 60% and leaves it at a dbt of 28˚C and 90% relative humidity. Make-up water is supplied at 20˚C determine i. The temperature of water leaving the tower,ii. The fraction of water evaporated, and iii. Approach and range of the cooling tower. **[AU Tiruchirapalli Nov/Dec 2009)**