# UNIT-IV

- Basic concepts and definition
- Wet bulb, dry bulb & dew point
- Adiabatic saturation temperature
- Psychometric chart
- Measurement of humidity
- Humidification
- Dehumidification
- Principle, working & application of a.c
- Principle, working & application of refrigeration

**Definitions and concepts**

**Humidity**-Defined as the pound or kg of water vapor carried by 1 pound or kg of dry air under a specific set of conditions.

Humidity =Mass of vapor present in air(pound or kg)/mass of dry air (kg or pound)

OR

**Humidity**=Partial vapor pressure of water in air/ partial vapor pressure of dry air

**Saturated humidity-** It is the water vapor which is in equilibrium with liquid water at the given condition of temperature and pressure.

**Hs =MaPa / Mb(1-Pa)**

Where, **Ma**: molecular wt. of water vapor ,

**Mb**: molecular wt.of air

**Percentage humidity**-

**Percentage humidity=actual humidity/saturated humidityX100**

**Relative humidity**

RH = **actual partial pressure of water vapor in the air water mixture / partial pressure of water vapor at saturation X 100**

**Humid volume**- It is the volume occupied by a unit mass of dry gas and its associated vapor

**Saturated volume**- Humid volume of saturated vapor

**Humid heat**: It is the heat required to raise unit mass of dry gas and its associated vapor through one unit difference in temperature at constant pressure.

s= Ca + HCw ; where,, s: humid heat KJ/Kg.K

Ca: specific heat capacity of gases,

Cw: specific heat capacity of vapor,

H: humidity

Enthalpy : Enthalpy of air water vapor is the heat content of 1 kg of dry air and its associated moisture,expressed as kilojoule per kg of dry air

H = E + PV

**Heating,Ventilation & Air Conditioning system(HVAC):**

- HVAC system is a technology of automotive environment comforts which is design of a major sub-discipline of mechanical engineering,based on the principle of thermodynamics, fluid mechanic & heat transfer..

**Dew point:**

- It is the temperature to which a mixture of air-water vapor must be cooled(at constant humidity) to become saturated.

**Dry bulb temperature**:

- It is the temperature of moist air when it is measured at rest by an instrument, which is not affected by the moisture content of air or by radiation.

$$\mathbf{Ww-Wg = (hg \div KgMgP)(1/\lambda w)(tg-tw)}$$

where , hg÷KgMgP=constant

**Ww**= humidity of sample ; $\mathbf{t_g}$=dry bulb temp.

**Wg**=humidity of entering air ; $\mathbf{t_w}$=wet bulb temp.

**Wet bulb temperature:**

- It is a dynamic equilibrium temperature attained by a water surface when exposed to air under adiabatic conditions

**<u>Psychometric chart</u>**

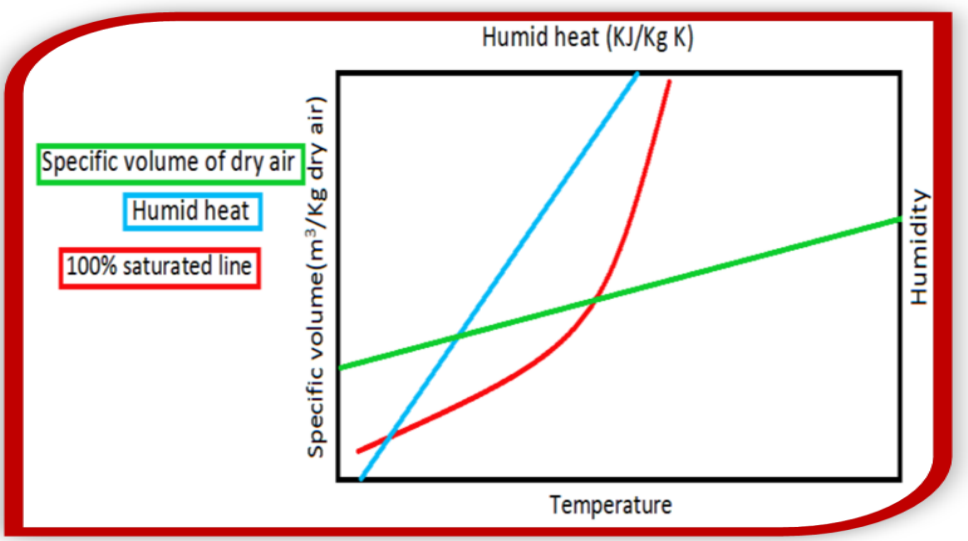
- ✓ The term derives from the Greek terms-'**psuchron'+'metron'**

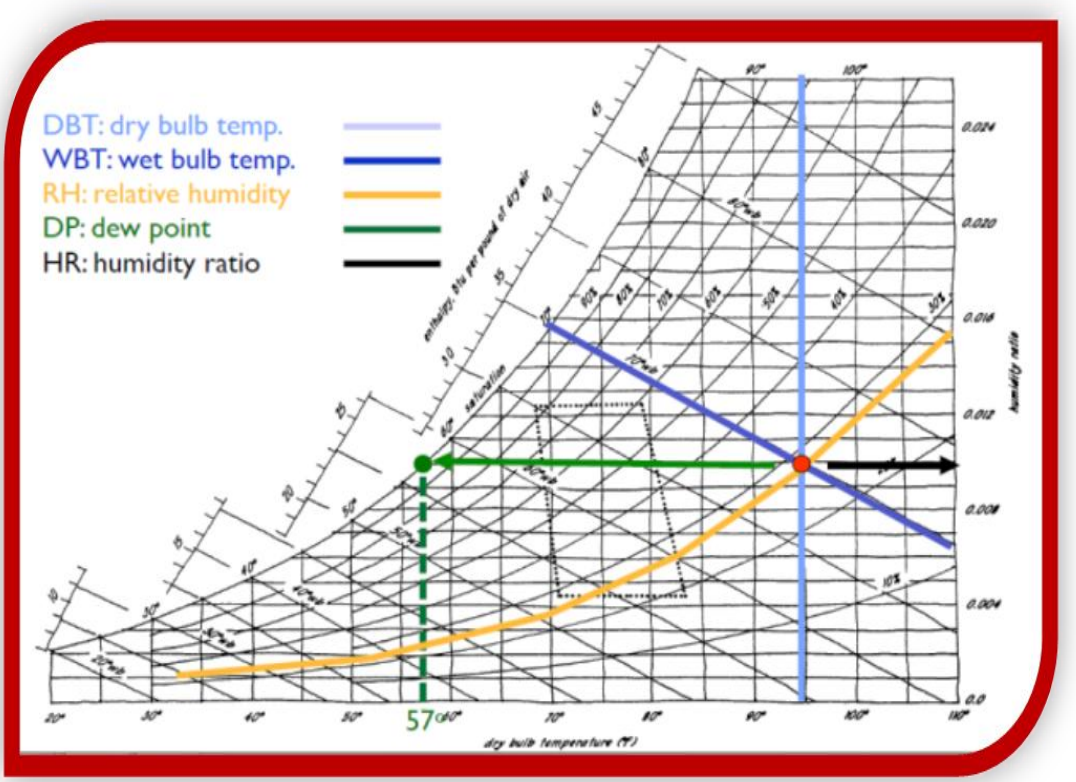
  means "**cold"+"measurement**"
- ✓ It is used for the determination of the vapor concentration and carrying capacity of the gas.'
- ✓ First pioneered by Willis H. Carrier in 1904

- It consists of-
  - Humid heat V/s humidity plot
  - Specific volume V/s temperature plot
  - Adiabatic cooling lines-
  - Humidity V/s temperature

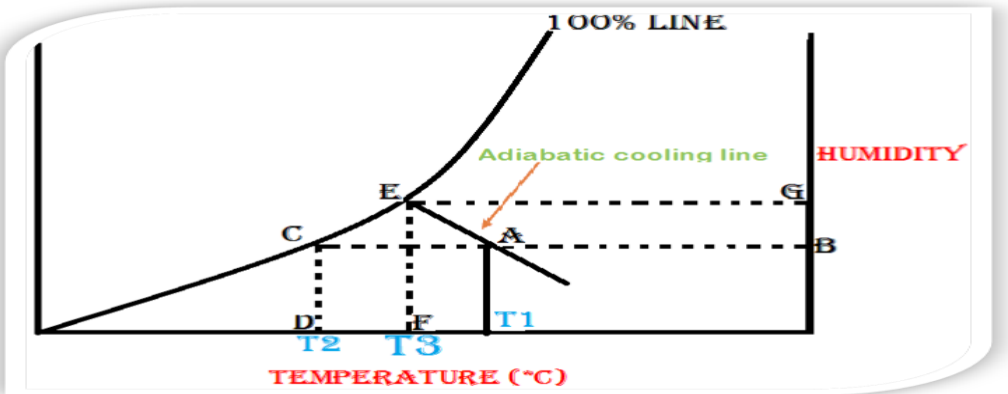
**Used to determine-**

- ✓ Humidity -by the help of wet bulb & dry bulb temperature.
- ✓ These show changes in humidity during drying under adiabatic condition
- ✓ Dew point
- ✓ Wet bulb temperature
- ✓ Dry bulb temperature



## Use of humidity chart




**HUMIDITY-** From A moving horizontally towards humidity axis gives an intercept at B on y axis,i.e humidity of the sample.

**Dew point-** From A moving horizontally towards 100% line give an intersection at C. Moving vertically from C downward to temp. axis gives an intercept at D , which is the dew pt. temp 'T2'.

**Adiabatic saturation temp/ Wet bulb temp-** From A, moving towards 100% line gives an intersection at E, moving vertically from E downwards to temp axis gives an intercept at F, i.e. adiabatic saturation temp.'T3'.

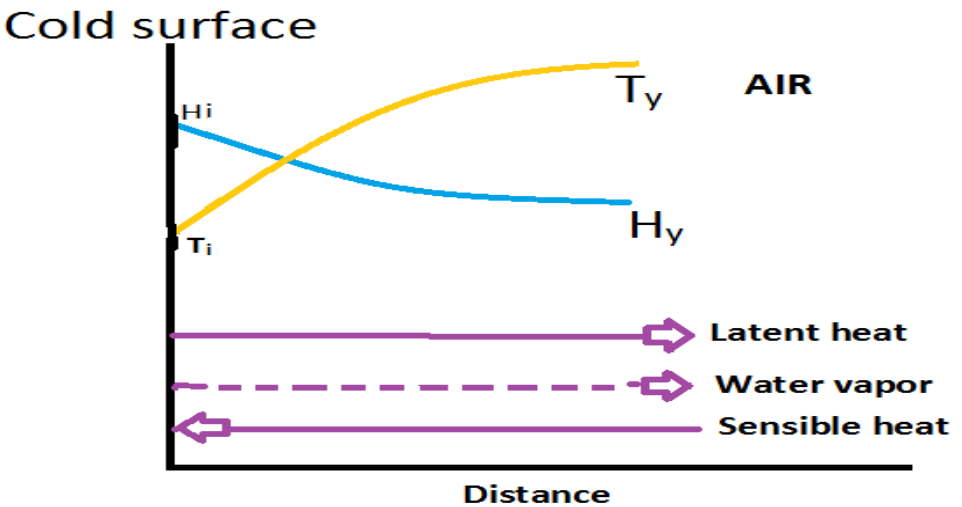
**Humidity at adiabatic saturation temp.-** From E moving horizontally towards humidity axis at G gives humidity at adiabatic saturation line.

## HUMIDIFICATION

**Definition**: Humidification is the process of increasing the moisture in the air.

**Mechanism:**

- In adiabatic humidification the air is in contact with liquid at constant temperature.The humidity at the interface (Hi) must be greater than humidity (Hy) of the gas ,so that air gets humidified. Since water is vaporized, the latent heat is transferred from liquid to gas.
- Hi and Ti represent equilibrium conditions of interface.
- Latent heat flow from liquid to gas & sensible heat flows from gas to liquid get balanced.




**Applications**

- In pharmaceutical industry, required humidity for various operation is from 20-30% RH & temperature within the range of 20-27 centigrade. Hence dry weather humidification is necessary.
- Used in the refrigeration system.

## DEHUMIDIFICATION

**Definition:** Process in which the moisture is decreased in the air, known as dehumidification.

Humidity is controlled using thermocouple regarding of the difference between wet & dry bulb temperature.

**Mechanism:**

- In this case humidity of air "Hy" is greater than the humidity at interface "hi" and therefore, the water vapor diffuse to interface.
- Since water vapor is condensed to water, latent heat is transfer to water so the temperature of the surface tends to rise & that of the air decreases.

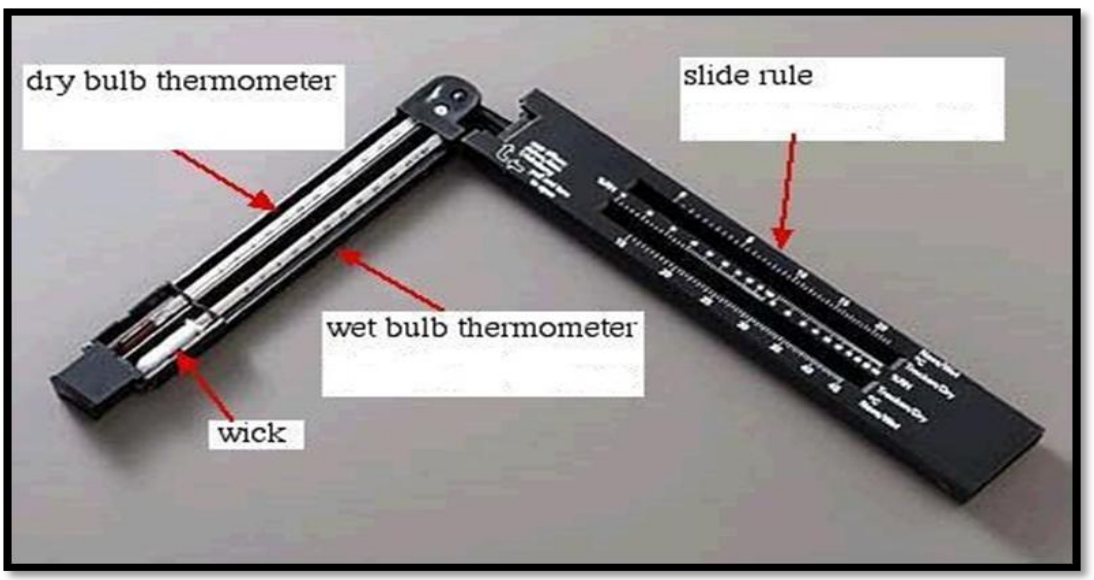
## APPROACHES TO DEHUMIDIFICATION

- Dehumidification occurs due to the lowering of water vapor pressure. If the temperature of surface is lower than the dew point of gas, condensation takes place & temperature of gas falls.
- Humidity can be reduced by compressing the air during compression the partial pressure of the vapor increase as soon as it reaches the saturation value, condensation takes place. The water gets liquefied & drained off.

**Measurement of humidity**:

**Dew point method**: Dew point is the temperature at which the sample of moist air at which air at constant pressure reach water vapor at saturation state.

**Psychometric method:** This method involves the simultaneous determination of wet bulb and dry bulb temperature. For this, sling psychometer is used




**Mechanical method**: Material such as human hair, wood fibers and some plastics have been used to measure humidity. These methods rely on a charge in dimension of the fiber with humidity.

**Electric hygrometer** : It measure the change in electrical resistance or a film of a moisture absorbing material exposed to the gas.

**Chemical or gravimetric method**: This method is based upon the difference in the weight of the moisture absorbing agent like:- Sulphuric acid, Phosphorus penta oxide.

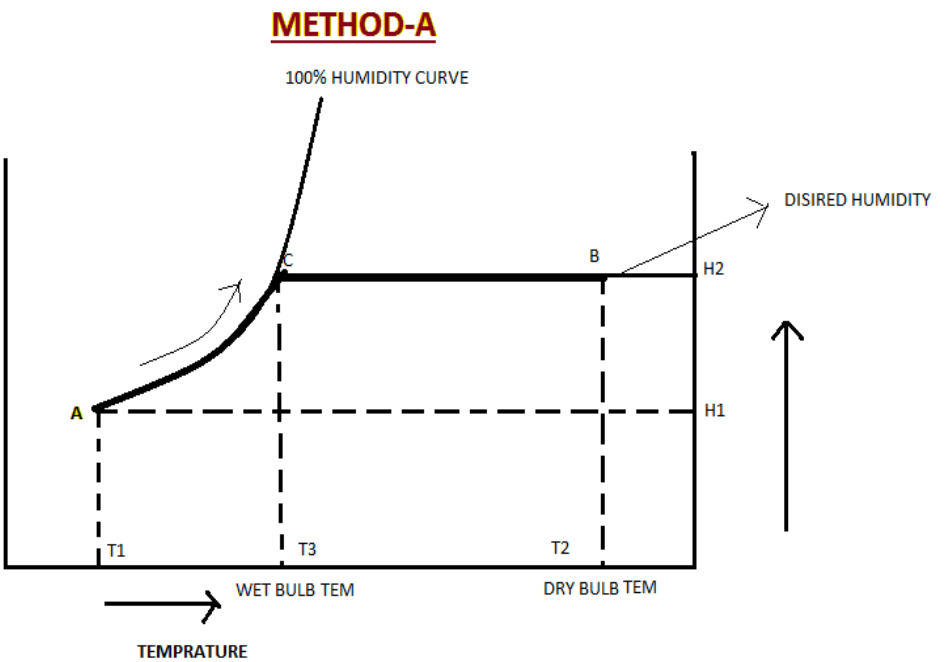
## Air conditioning

Air conditioning is a process of treating air so as to control its temperature, humidity, cleanliness and distribution simultaneously to meet the requirements of the condionized space.

***Principle:*** Normally the air is allowed to reach complete saturation by providing appropriate conditions, then humidity is fixed.

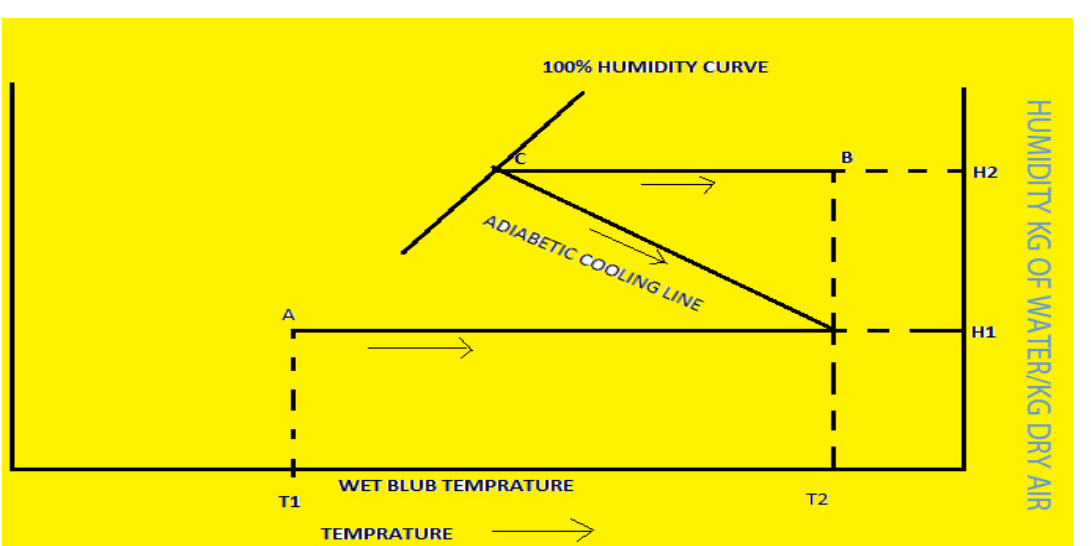
**Working**: Method 1-

- Air enters in the equipment(dry air) with temperature T1 and humidity H1
- Air is allowed to attain the desired humidity(H2) by treating with water(cold)
- Heated to attain the desired temperature(T2) at the same humidity(H2




**Method 2-**

- Air enters in the equipment(dry air) with temperature(T1) & humidity(H1)
- It is preheated to temperature(T4)
- Air is cooled along the adiabatic cooling line until it gain desired humidity(H2)
- It is reheated to reach to the desired temperature(T2) with humidity(H2



**Applications:**

- Promoting the human comfort.
- Maintenance of proper condition for the manufacture, processing and preserving material & equipment.
- Compression of tablets
- Manufacture of soft gelatin capsules
- Manufacture of sterile products
- Environmental test chambers

**Calculation of load of Air Conditioning System**

- The temperature condition are designed for winter and summer outdoor temperature.
- Space cooling load is calculated under following factors:
    - ✓ Direction and magnitude of wind velocity.
    - ✓ Outside humidity and temperature.
    - ✓ The nature of construction of materials.
    - ✓ Orientation of opening windows and doors.
    - ✓ Period of occupancy and the number of persons in the room and their activities.
    - ✓ Hence, a.c is provided under assumed conditions keeping variables fixed

## REFRIGERATION

- Refrigeration is a mechanical process of lowering the temperature of a substance below of its surroundings.
- It is a process in which work is done to remove the heat from one location to another.
- During this process surrounding become cool.
- The term refrigeration expressed in tonn, as-

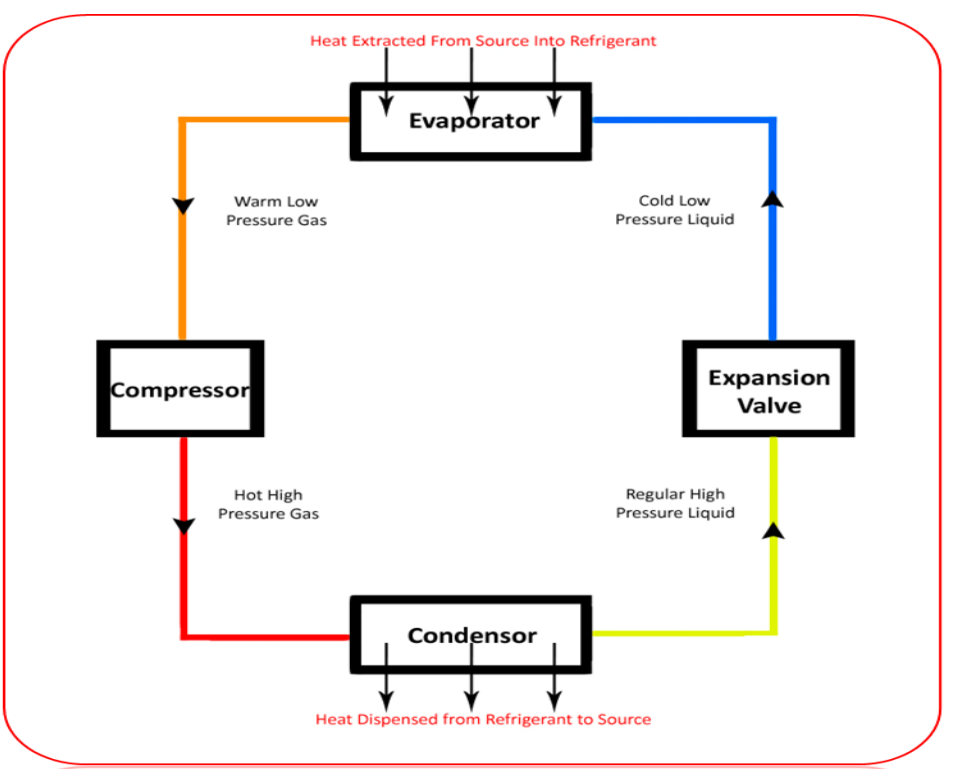
one tonn= Heat removal at rate of 14000kJ/hr.

**Principle**

- Refrigeration cycle is known as vapor compression cycle which is mostly used in many house hold and in large commercial industries.
- The cycle operates two pressure - high and low pressure.
- In this cycle a circulating refrigerants enter into the compressor as a vapor ,then the vapor is compressed at constant entropy

**Basic Component of Refrigeration**

1. Receiver or condenser
2. Expansion valve
3. Evaporator
4. Liquid trap
5. Compressor



**REFRIGERANTS**

**DEFINITION**: Liquid which readily absorbs heat when evaporated at a low temperature and pressure and gives out heat on condensing at a higher temperature and pressure.

**TYPE:**

**Primary refrigerants**: Liquids that change to a gas after absorbing heat eg: ethylene, ammonia

**Secondary refrigerants**: Liquid which act only as heat carriers. eg: air and water.

**Selection of Refrigerants**

- Latent heat of vaporization should be large to produce desired cooling effect.
- At normal temp and pressure, refrigerant must be in vapors phase and on compression and cooling, it should be liquefied easily.
- The pressure require to liquefy the vapors of the refrigerant in the condenser must be maintained easily at room temp.
- Evaporator section must be maintained at about -15 ˚ greater than the atm. pressure.
- The specific volume of the refrigerant vapors should be large.