REFRIGERATION

Process of removing heat from a space to maintain it at a temperature lower than the surrounding temperature

Device used to obtain refrigeration effect is known as refrigerator

The working fluid used in refrigerator is called refrigerant.

Based on Claussius statement

Scope of Refrigeration

- Domestic
- Commercial
- Industrial
- Food processing and cold storage
- Air conditioning
- Transport

Applications

- Storage
- Dairy Products
- Beverages
- Processing and distribution

FOOD PROCESSING, PRESERVATION AND DISTRIBUTION

- Separation of gases
- Condensation of gases
- Dehumidification of air
- Solidification of solute
- Storage as liquid at low pressure

CHEMICAL AND PROCESS INDUSTRIES

- Removal of heat of reaction
- Cooling for preservation
- Recovery of solvents

VARIOUS TERMINOLOGIES

Sensible heating **: Heating with change in temperature**

Latent heating**: Heating with change in phase**

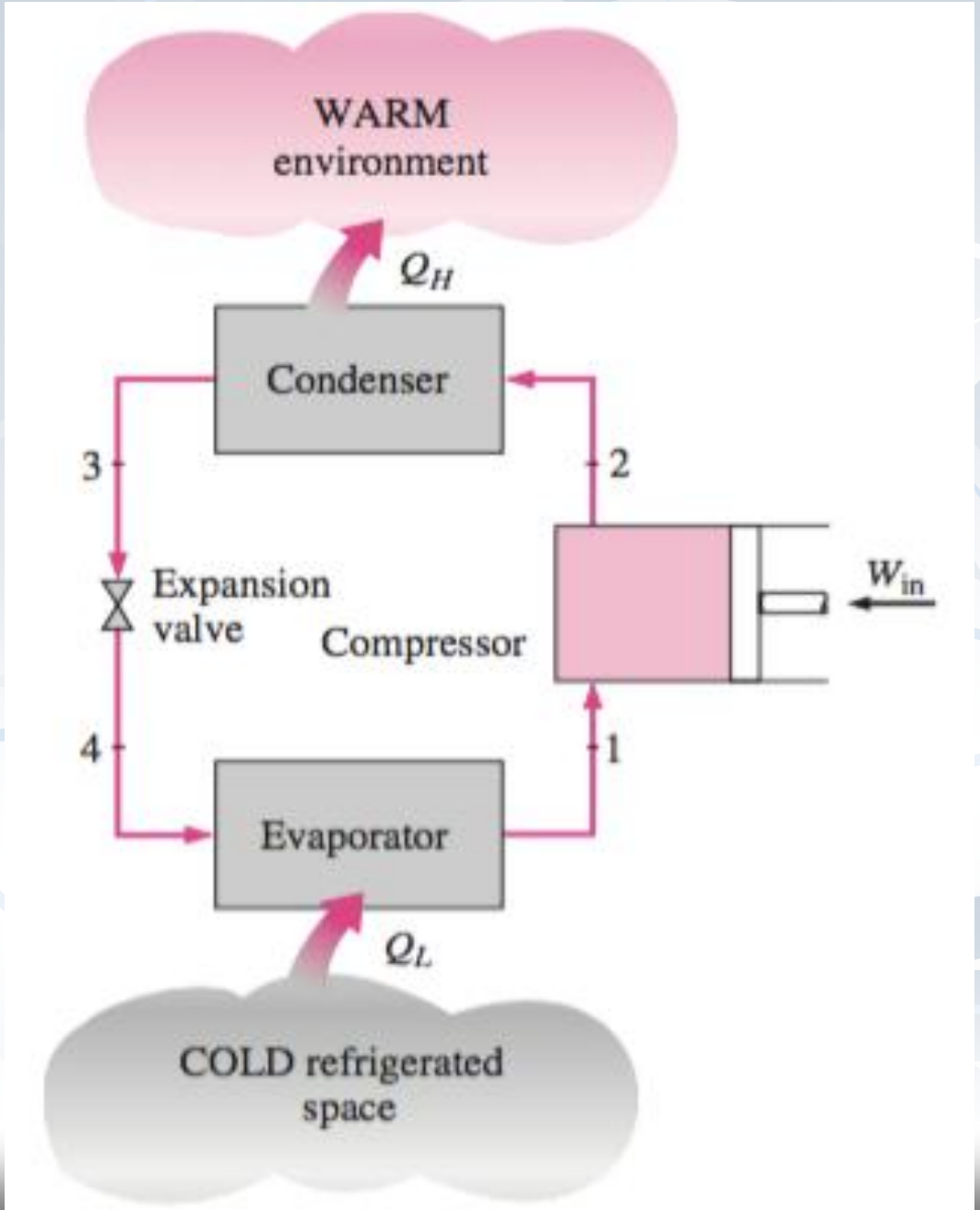
Enthalpy of vapourization**: Heat required to vaporize a unit mass of saturated liquid at given temperature and pressure**

Enthalpy of condensation**: Heat released during condensation of saturated vapour at given temp & press**

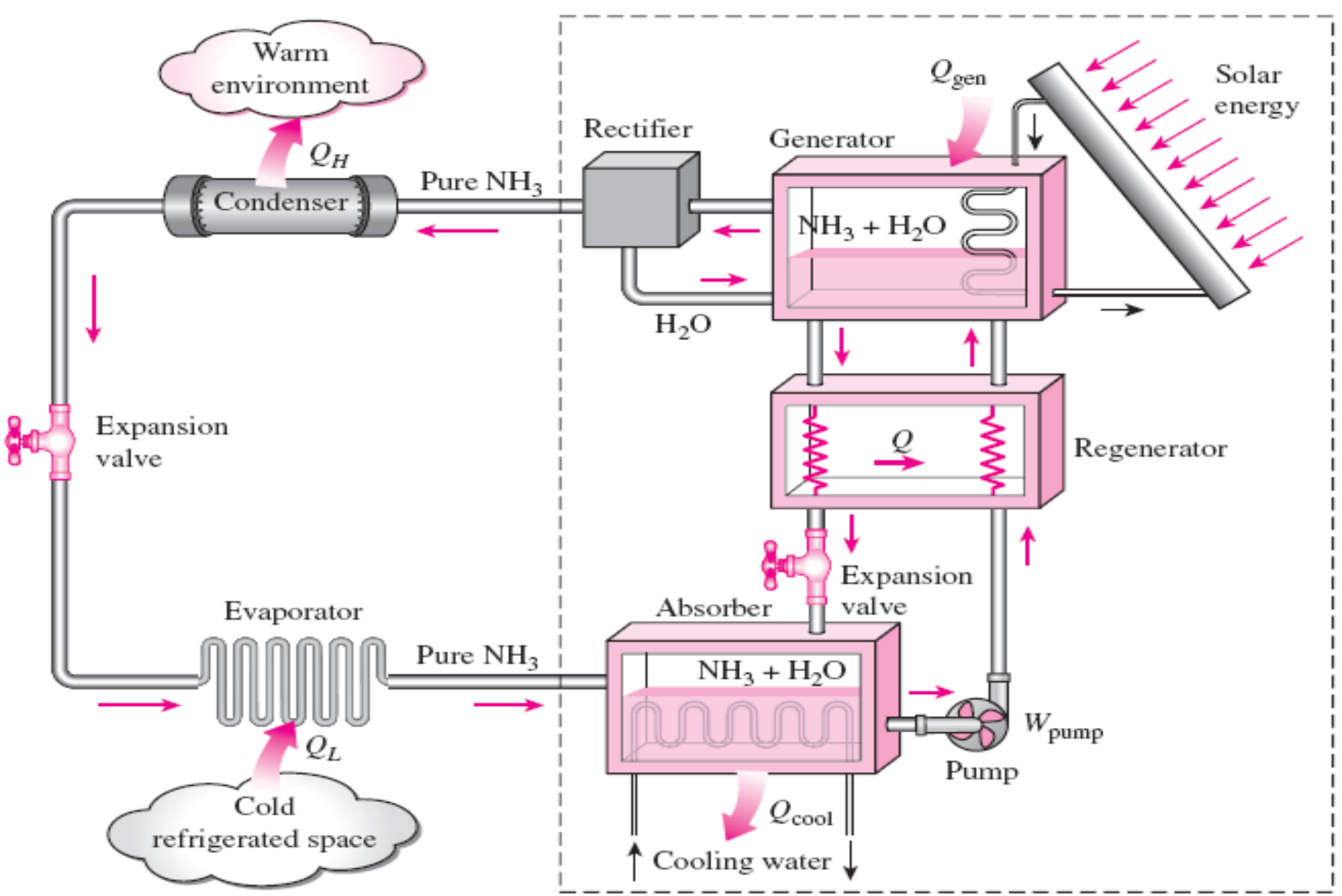
Boiling point **: Temperature at which vapour pressure equals surrounding fluid pressure**

Critical temperature**: Temperature above which gas cannot be liquefied, irrespective of pressure.**

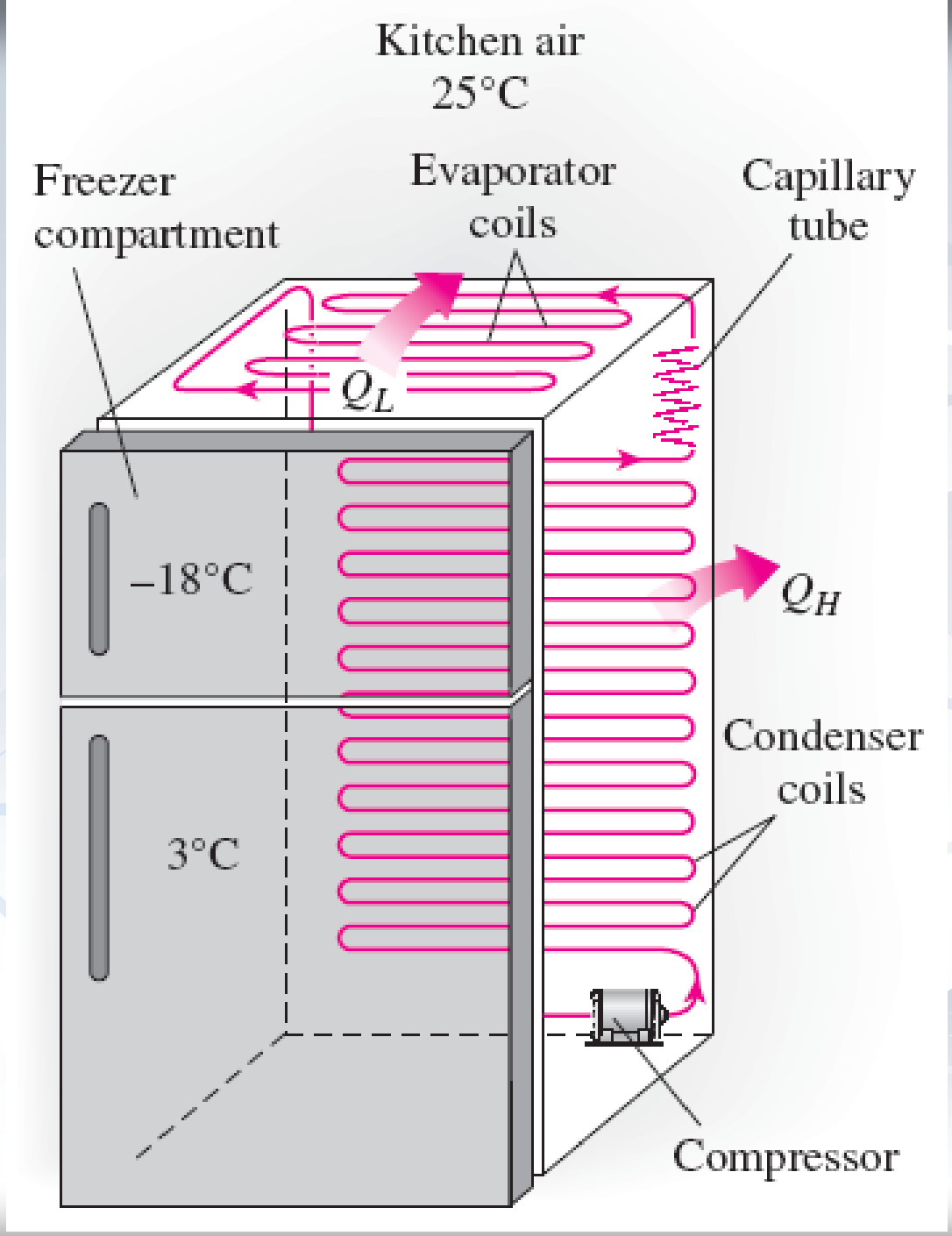
VAPOUR COMPRESSION REFRIGERATION



VAPOUR ABSORPTION REFRIGERATION



Vapour compression Refrigeration	Vapour Absorption Refrigeration
Uses mechanical work for operation	Uses heat for operation
Noisy operation	Comparatively less noisy
Smaller in size	Larger in size
Operating costs are high	Operating costs are less
Higher CoP	Low CoP
Presence of liquid traces causes damage to compressor	Liquid traces poses no such threats
Re filling of refrigerant is simple	Refilling is difficult
Maintenance cost is high	Maintenance cost is low


Kitchen air
25°C
Freezer
compartment
Evaporator
coils
Capillary
tube
Q_L
−18°C
3°C
Q_H
Condenser
coils
Compressor

TONNE OF REFRIGERATION

Amount of refrigeration effect produced by melting of one tonne of ice at 0 ^{0}C to water at 0 ^{0}C in 24 hours

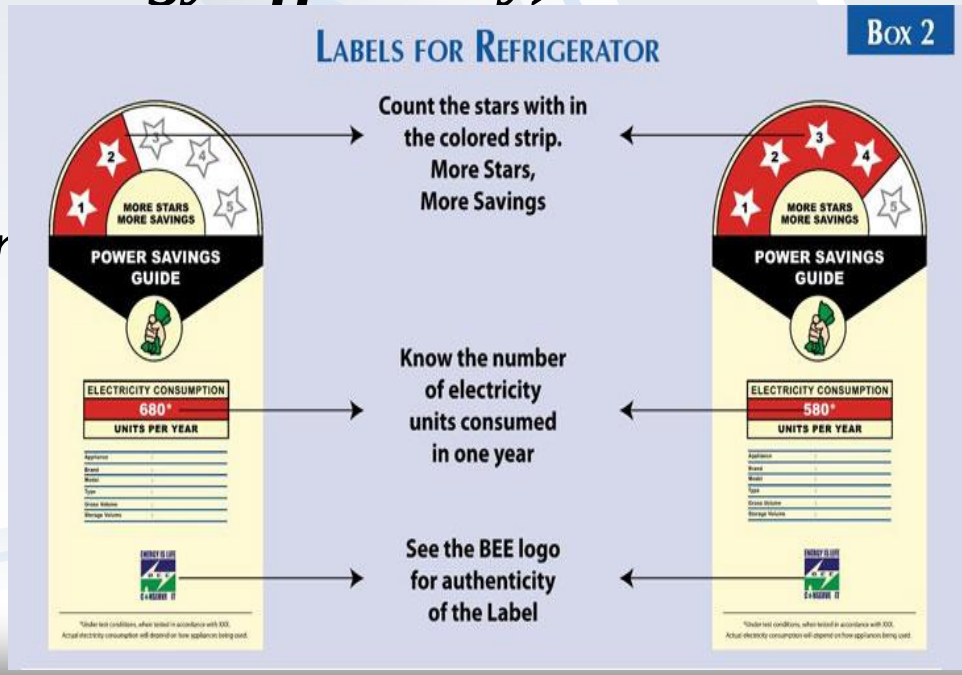
= 210KJ/min= 3.5 kW

Energy efficiency rating for Refrigerator

BEE (Bureau of Energy efficiency)

EER = heat removed

Electricity consumptior



REFRIGERANT

Working fluid used in a refrigerator

Eg: Ammonia, Carbon dioxide, Chloro-Fluro-Carbons

Desired properties:

1) Low boiling point

2) Low freezing point

3) Low Viscosity

4) High Thermal conductivity

5) Low specific volume

6) High latent heat

PSYCHROMETRICS

Study of properties of air-water vapour mixture

Dry air: **Air containing no water vapour.**

$$p = p_a + p_v$$

Where, p =Atmospheric pressure

p_a =Partial pressure of dry air

p_v =Partial pressure of water vapour

Dry Bulb Temperature (t_{db})**:Temperature measured by thermometer**

Wet Bulb Temperature (t_{wb})**:Temperature measure by thermometer when its wick is covered with cloth saturated with water.**

- **Indicates amount of moisture that can be added by evaporation**
- **A psychrometer is a device used to measuring dbt & wbt**

Saturated air: **Air saturated with moisture**

- **it contains maximum vapour content it can hold.**
- **Further addition of moisture will result in condensation**

Dew point temperature: **It is the temperature at which condensation begins when cooled at constant pressure.**

- **saturation temperature of water vapour corresponding to p_v**
- **When air temperature equals dpt air is said to be saturated**
- **dpt is always less than or equal to air temperature, as a result when air temperature decreases moisture content is removed by condensation.**

$$T_{dp} = T_{saturation\ at\ p_v}$$

For saturated air : $t_{db} = t_{wb} = t_{dp}$

Relative Humidity (RH or ϕ): **Ratio of partial pressure of water vapour to the saturation pressure at same temperature**

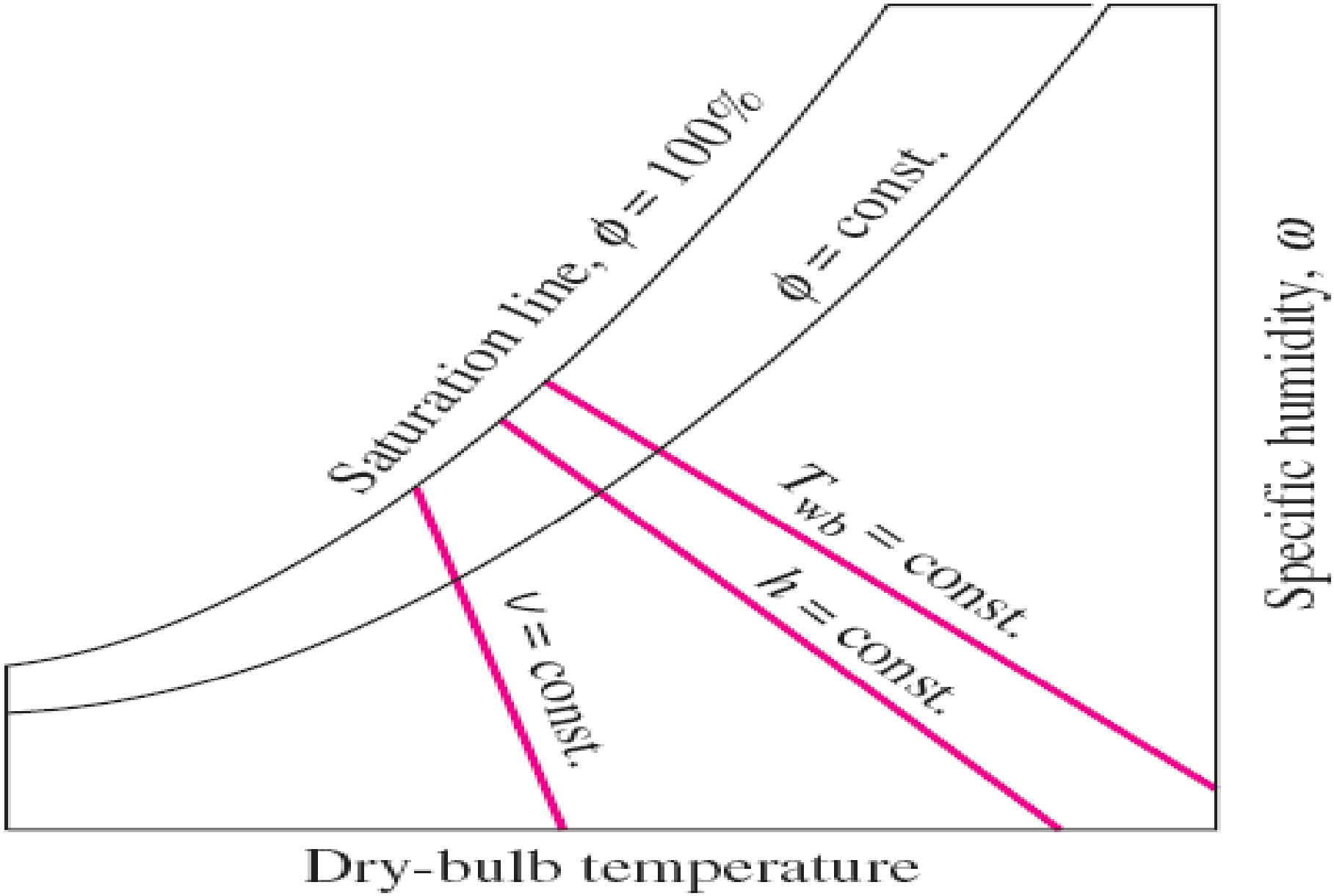
$$\phi = \frac{p_v}{p_{sat}}$$

- **Saturated air relative humidity is 100%.**
- **Ratio of mass of water vapour at given temperature to the mass of water vapour when air is at saturation temperature for same volume of air.**

Specific humidity or Humidity ratio (W): **Mass of water vapour per unit mass of dry air in a given sample of air.**

$$W = \frac{m_v}{m_a} = 0.622 \frac{p_v}{p - p_v}$$

PSYCHROMETRIC CHART



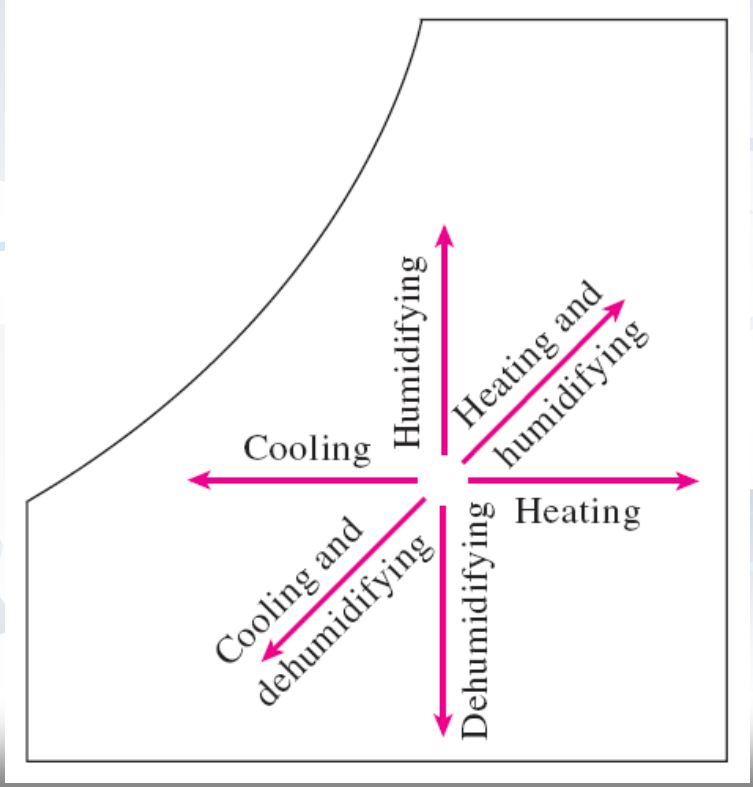
PSYCHROMETRIC PROCESSES

Sensible heating: **Raising the temperature**

Sensible cooling: **Lowering the temperature**

Humidification: **Increasing the moisture content**

Dehumidification: **Decreasing the moisture content**

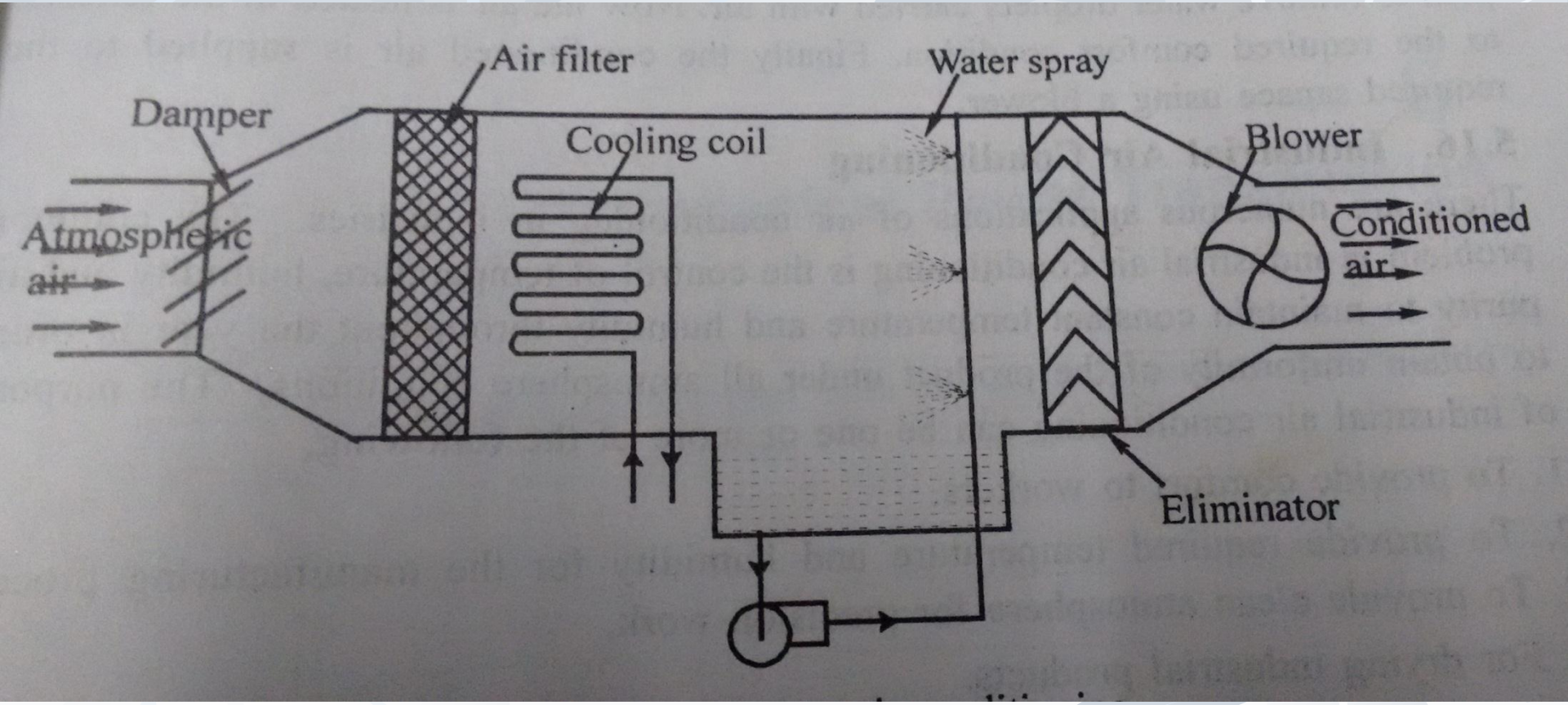


AIR CONDITIONING

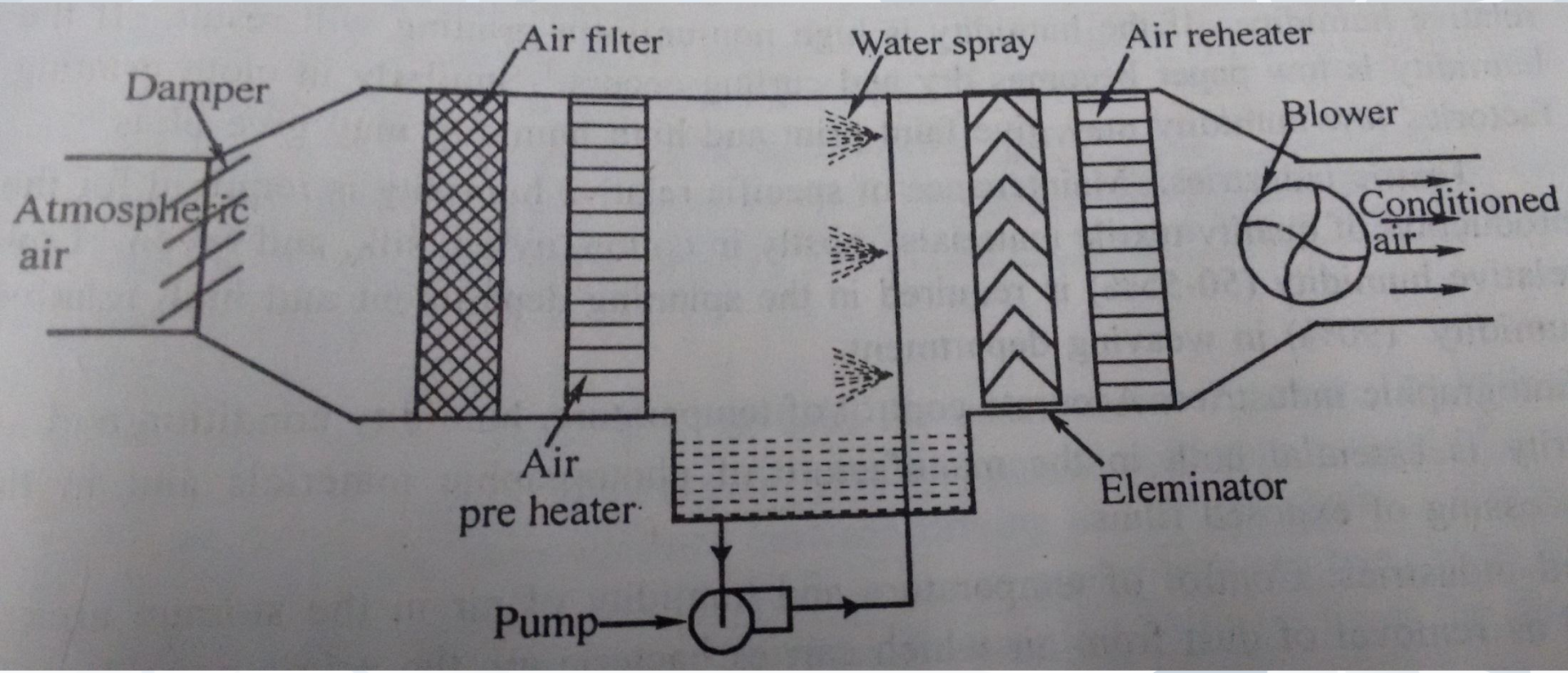
The Process of controlling the temperature and humidity of a living space

- ***This involves psychrometric processes***
- ***Combination of process are done in AC***
- ***In summer : Sensible cooling and dehumidification***
- ***In Winter : Sensible heating and humidification***
- ***Air conditioning is used for comfort and for industrial purposes***
- ***A/C of present technology can heat, cool, humidify, dehumidify, clean and deodorize the air i.e… condition it***

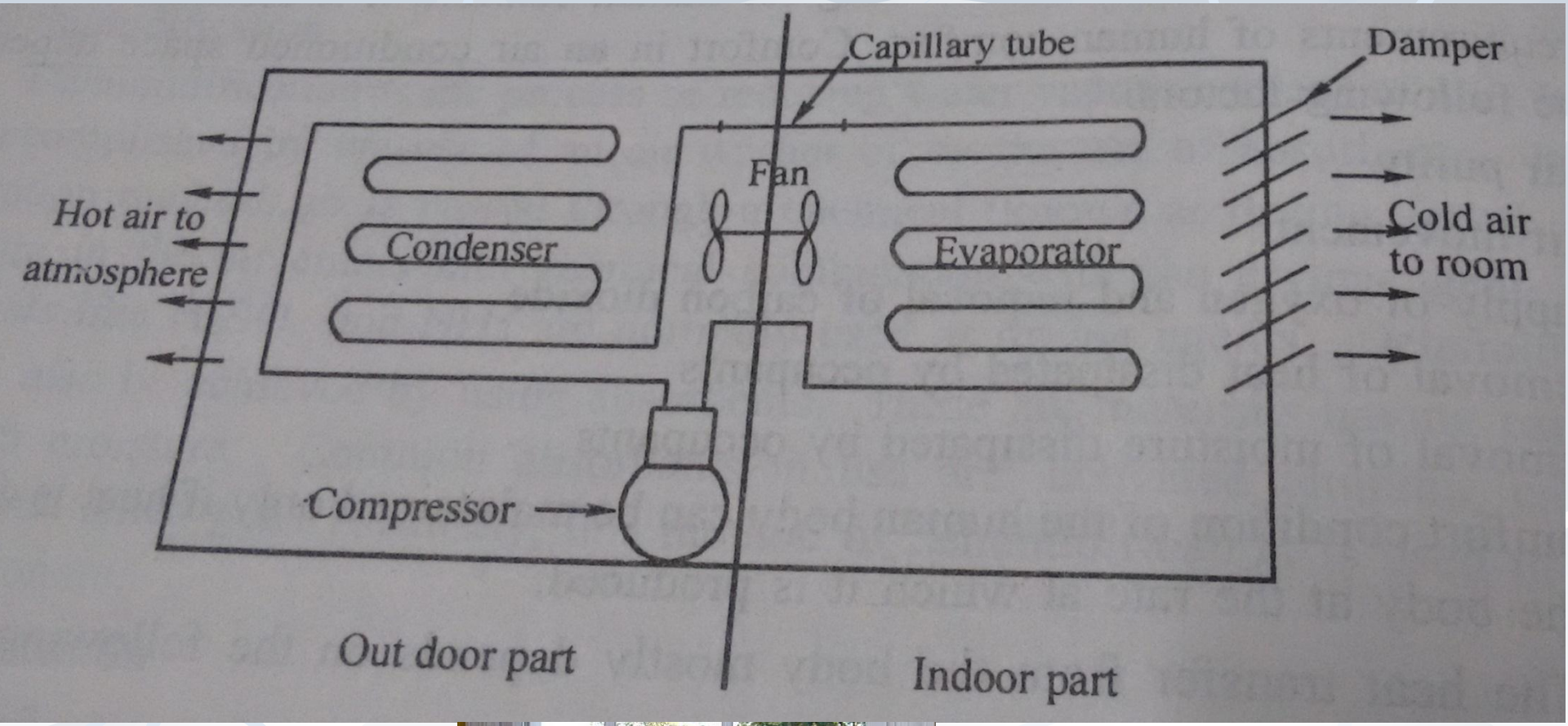
SUMMER AIR CONDITIONING



WINTER AIR CONDITIONING

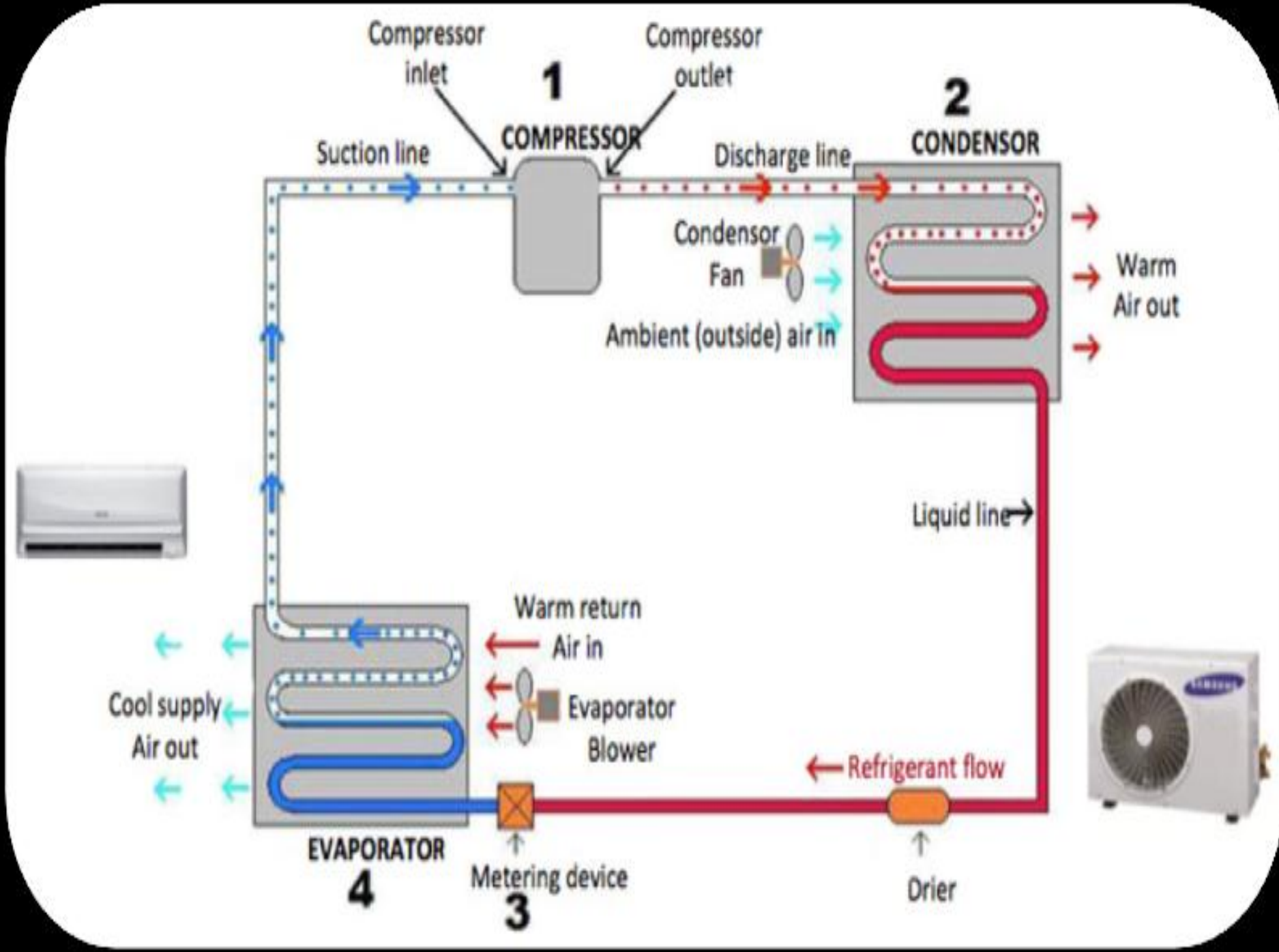


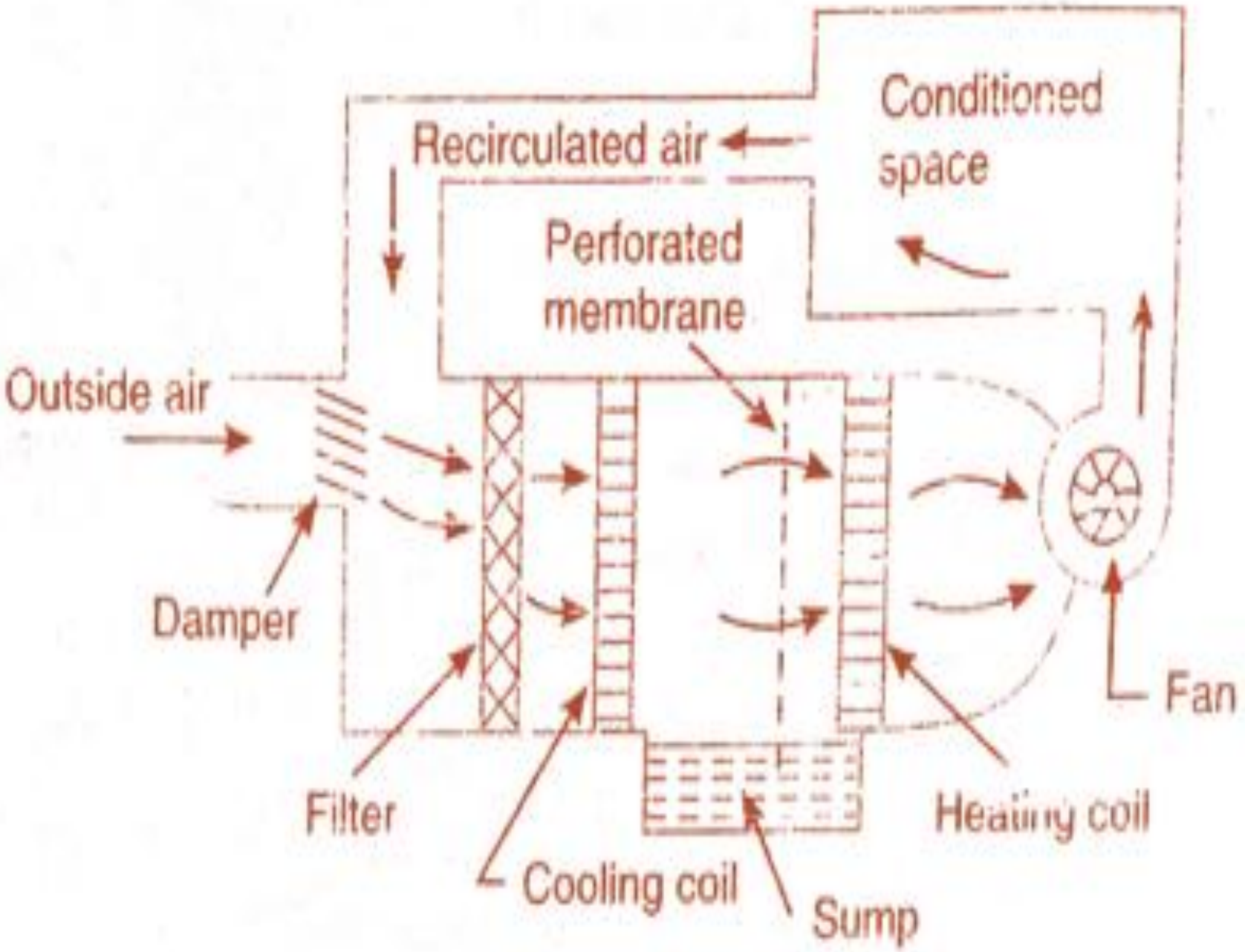
WINDOW AIR CONDITIONING



SPLIT AIR CONDITIONING

- ***The split air conditioner comprises of two parts: the outdoor unit and the indoor unit.***
- ***The outdoor unit, fitted outside the room, components like the compressor, condenser and expansion valve.***
- ***The indoor unit comprises the evaporator or cooling coil and the cooling fan. For this unit slot in the wall of the room is not required.***
- ***Split ACs are typically more effective than window air conditioners because of the inherent difference in insulation***
- ***Further, the present day split units have aesthetic looks and add to the beauty of the room. The split air conditioner can be used to cool one or two rooms.***


Compressor inlet
1
COMPRESSOR
Compressor outlet
2
CONDENSOR
Suction line
Discharge line
Condensor Fan
Ambient (outside) air in
Warm Air out
Liquid line
Warm return Air in
Cool supply Air out
Evaporator Blower
Refrigerant flow
EVAPORATOR
4
Metering device
3
Drier


Conditioned space
Recirculated air
Perforated membrane
Outside air
Damper
Filter
Cooling coil
Sump
Heating coil
Fan

HUMAN COMFORT

- *Depends on : Temperature, relative humidity, air motion*
- *Human body cools by : Perspiration (latent heat), radiation and convection (sensible heat)*
- *Lower humidity ⇨ High evaporation ⇨ High cooling*

- *Comfort standards :*

  Temperature = 25 ^0C

  Relative Humidity = 50%

  Air flow rate = 7.5 m/min (15 m/min max.)

  Air distribution =Temperature variation within room not to exceed 2 ^0C