# REFRIGERATION

## Refrigeration:

It is a method of reducing the temperature of a system below that of the surroundings & maintaining it at that lower temperature by continuously extracting the heat from it by the aid of external work.

## Refrigerant:

The working fluid in a refrigeration system is called as refrigerant which continuously extracts the heat from the space within the refrigerator or any other system which is to be kept cool at temperatures less than the atmosphere and finally rejects to it to the surroundings.

# Principle of Refrigeration

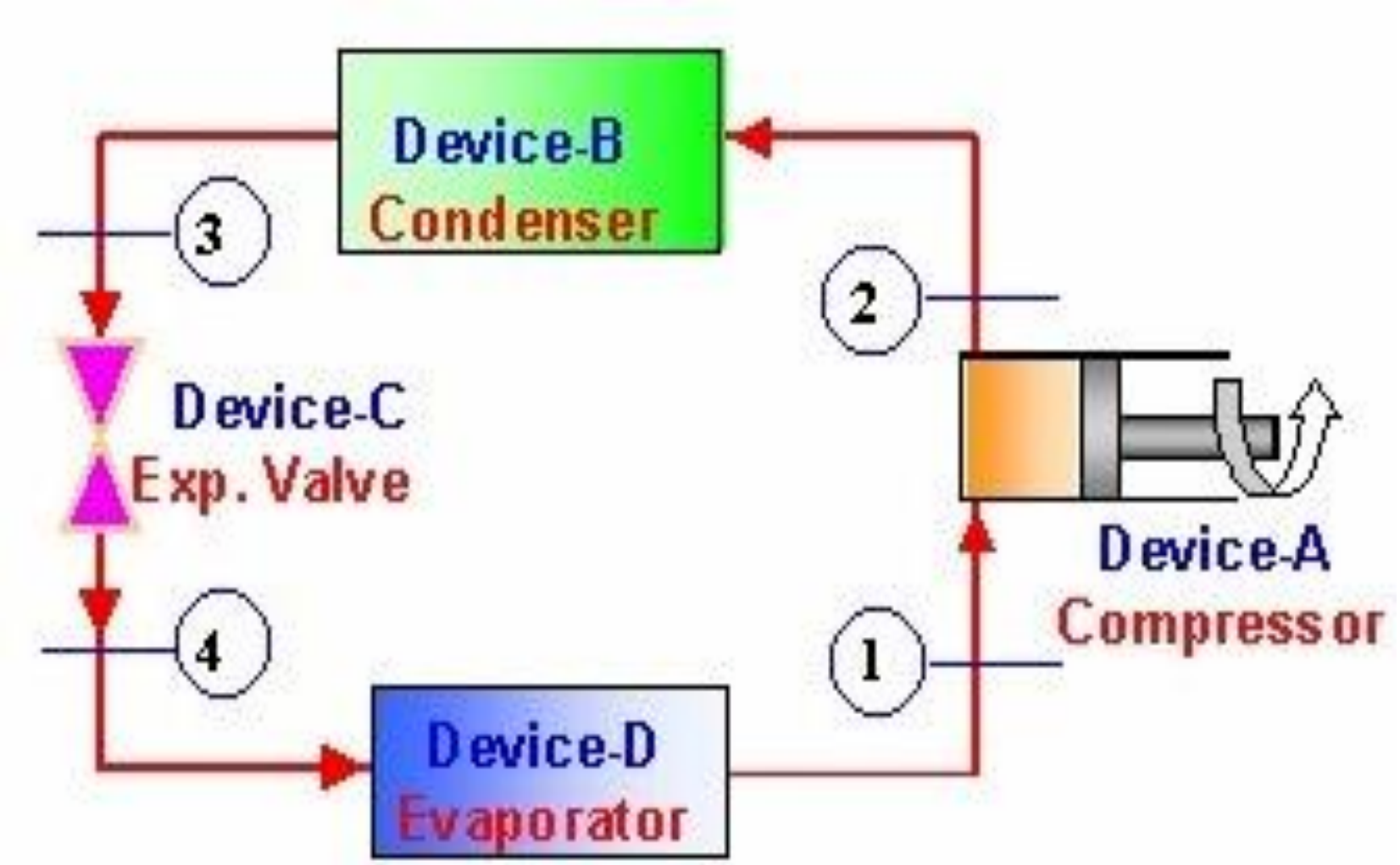
- Heat flows from a system at higher temperature to another at lower temperature.
- The boiling temperature of a fluid depend on its pressure.
- Fluids by absorbing the heat, change from liquid phase to vapour phase and subsequently condense to liquid phase by giving off the heat.
- Heat can flow from a system at low temperature to a system at higher temperature by the aid of external work as per the Second law of Thermodynamics.

# Parts of a Refrigeration system

***A refrigeration system consists of four main parts namely***

1. **Device A:** Compressor
2. **Device B:** Condenser
3. **Device C:** Expansion Valve
4. **Device D:** Evaporator

# Parts of a Refrigeration system



## *Evaporator:*

- The evaporator is the heart of the refrigerator where the liquid refrigerant is evaporated by the absorption of heat from the refrigerator cabinet in which the substances which have to be cooled are kept.

- The evaporator consists of a metal tubing known as Evaporator Coil which surrounds the freezing and cooling compartments of the refrigerator.

## *Compressor:*

- It is used to circulate the refrigerant in the refrigeration cycle
- It increases the pressure and therefore the temperature of the refrigerant.
- It is driven by the electrical motors.

## *Condenser:*

- It is a device in which the heat from the refrigerant which is at higher temperature is rejected to another medium usually atmospheric air.
- In a condenser the refrigerant vapour gives off its latent heat to the cooling medium and condenses into liquid so that it can be expanded in the expansion device.
- The heat given off in the condenser includes the heat absorbed in the evaporator as well as the heat developed during compression.

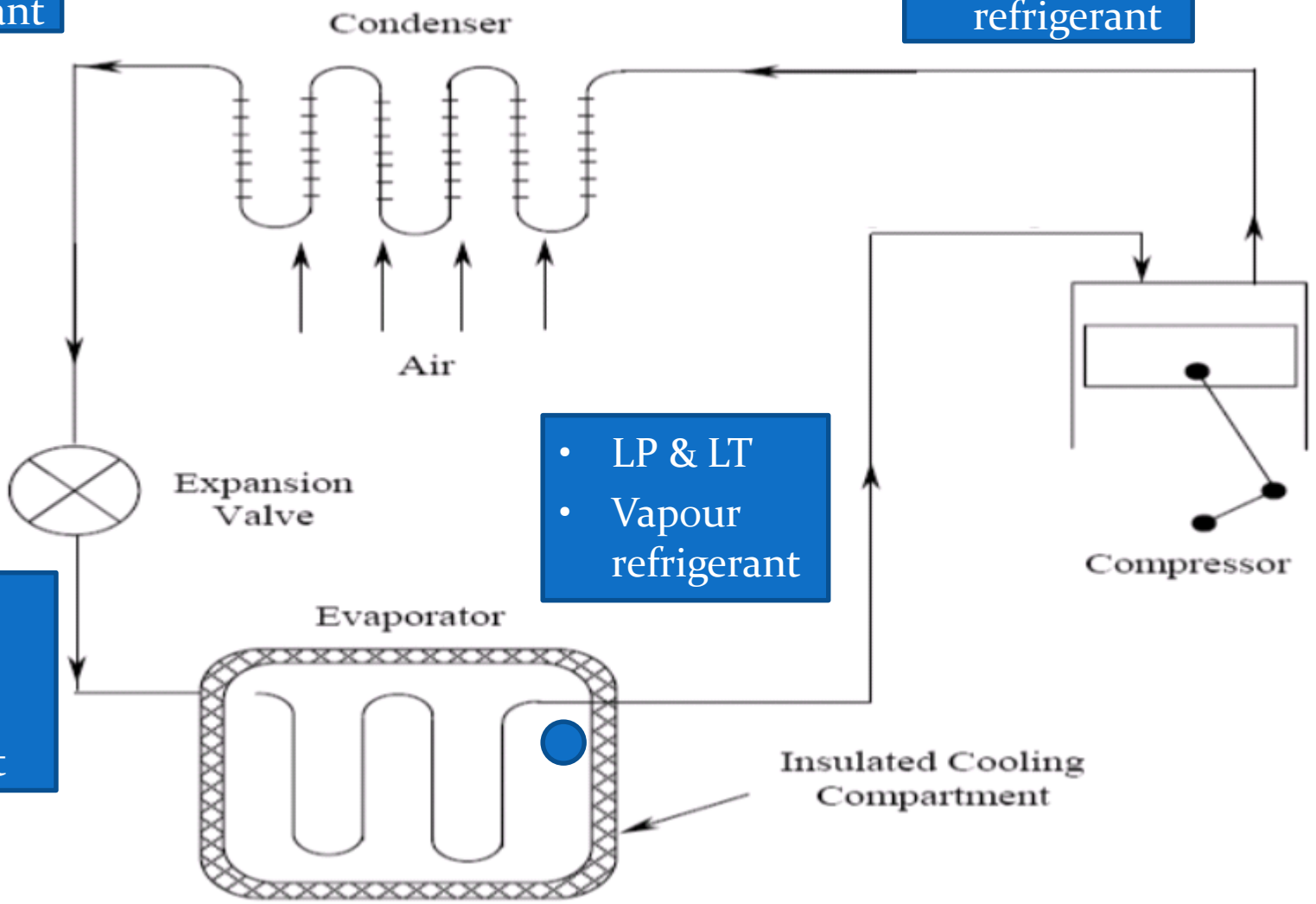
## *Expansion Valve or Throttle valve:*

- An expansion valve serves as a device to reduce the pressure of the refrigerant coming from the condenser suddenly and hence its temperature before it passes to the, evaporator.

# Vapour Compression Refrigeration System

- HP & LT
- Liquid refrigerant

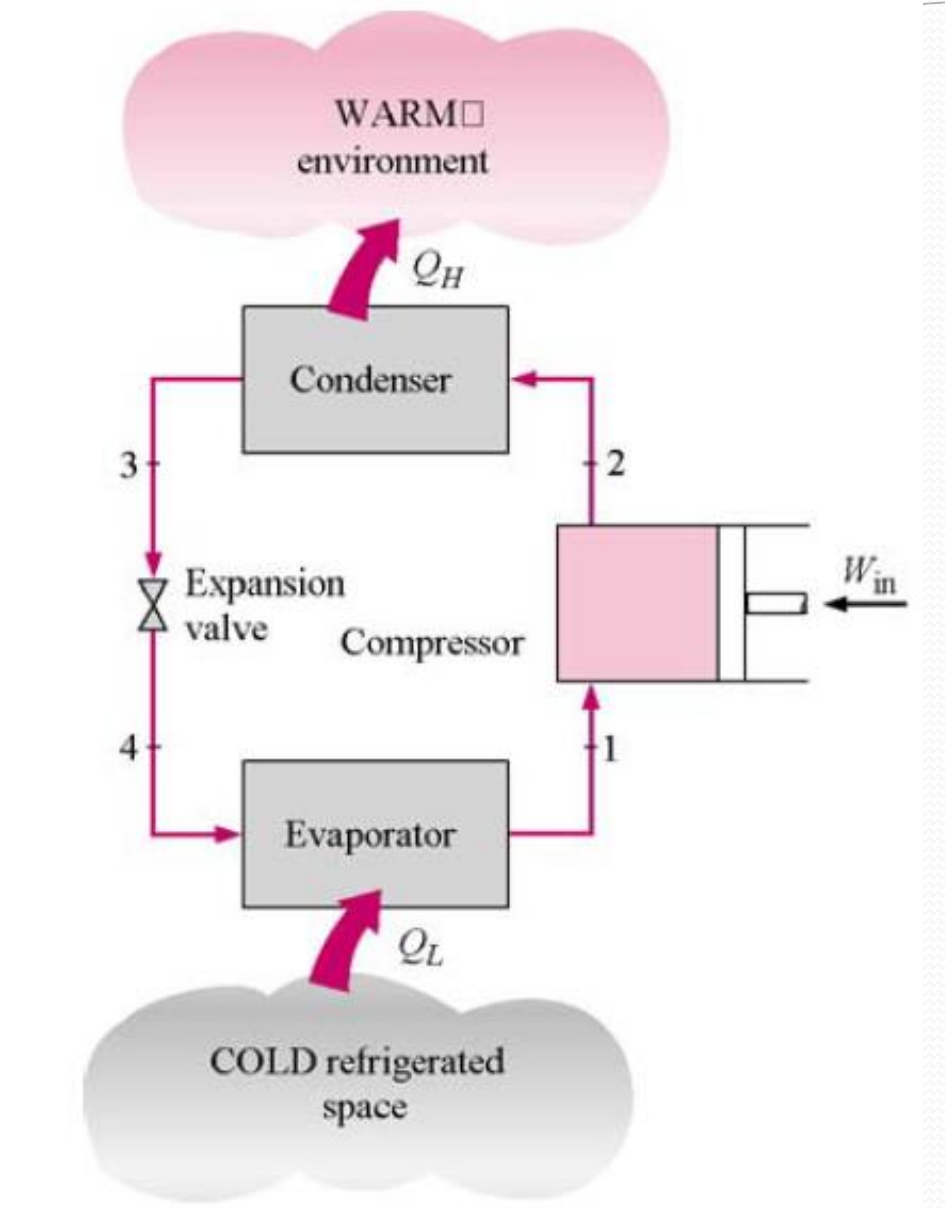
- HP & HT
- Vapour refrigerant



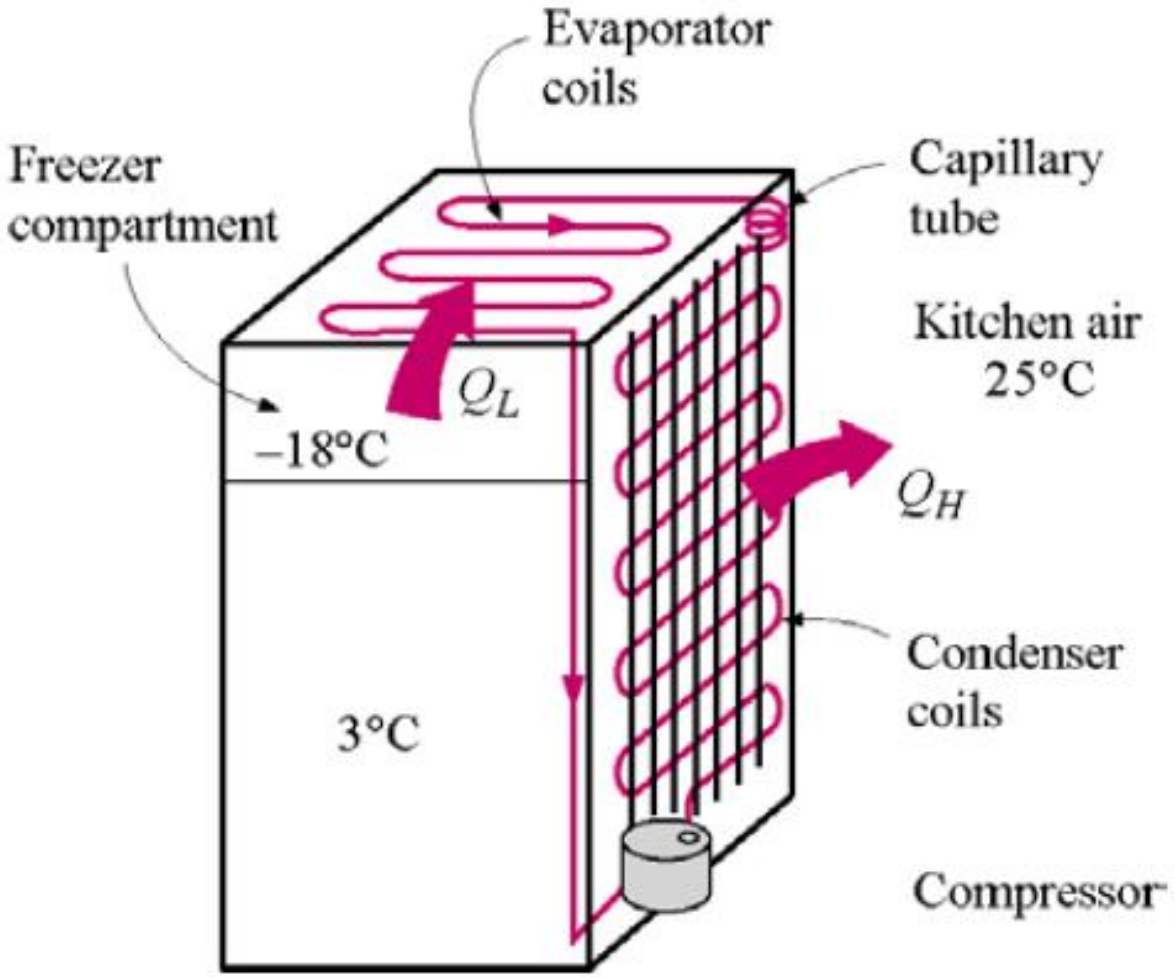

- LP & LT
- Vapour refrigerant

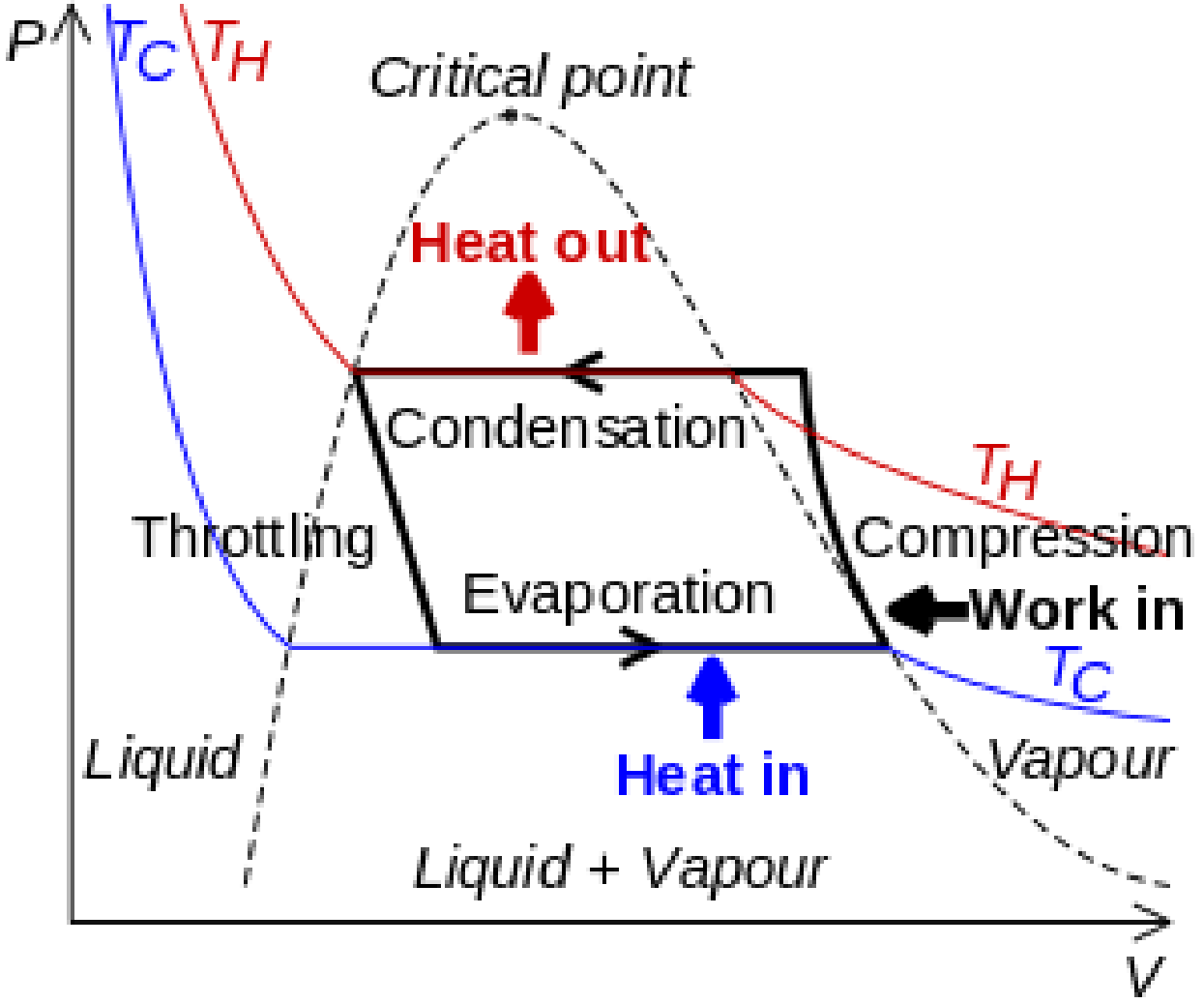
- LP &LT
- Liquid+ vapour refrigerant

# Vapour Compression Refrigeration System

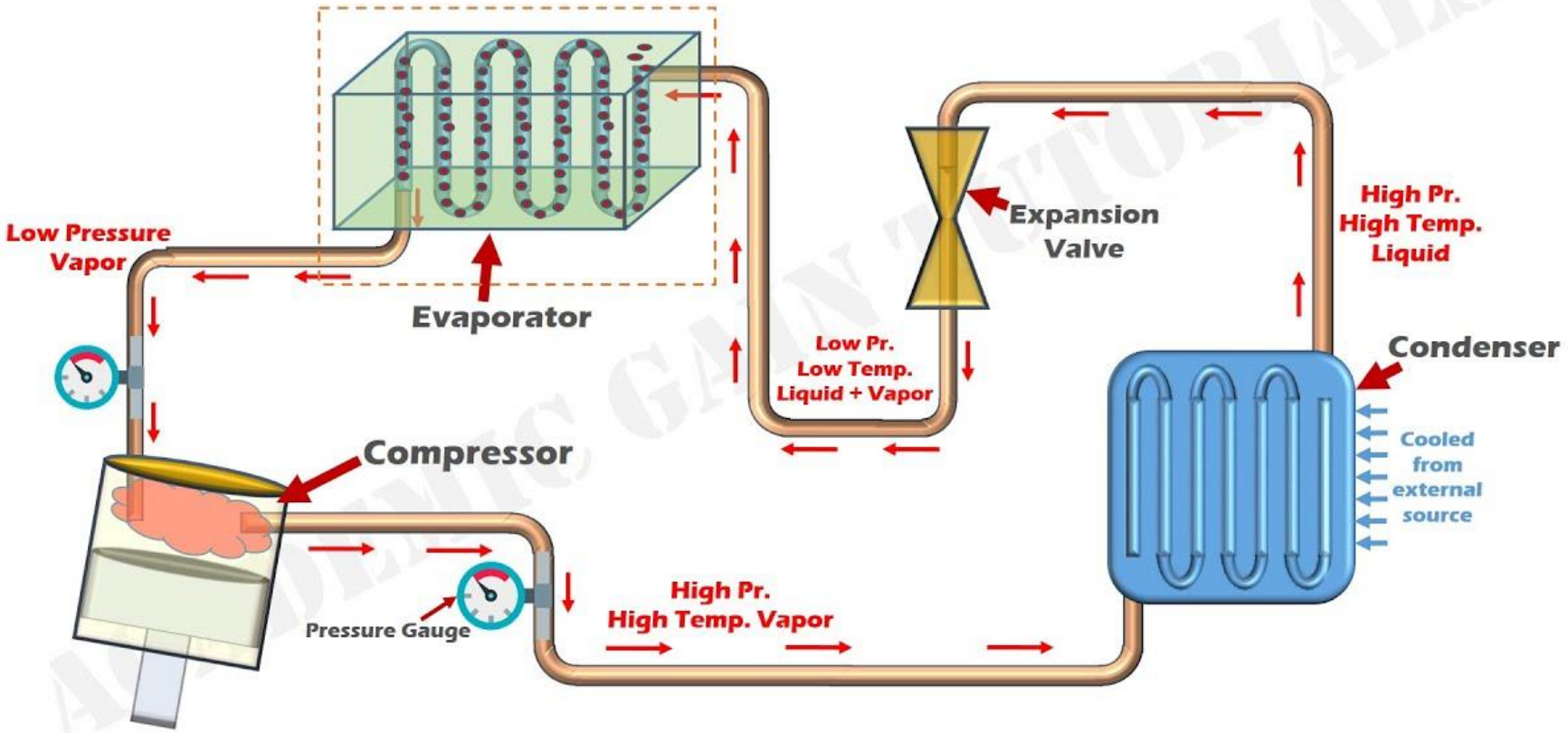


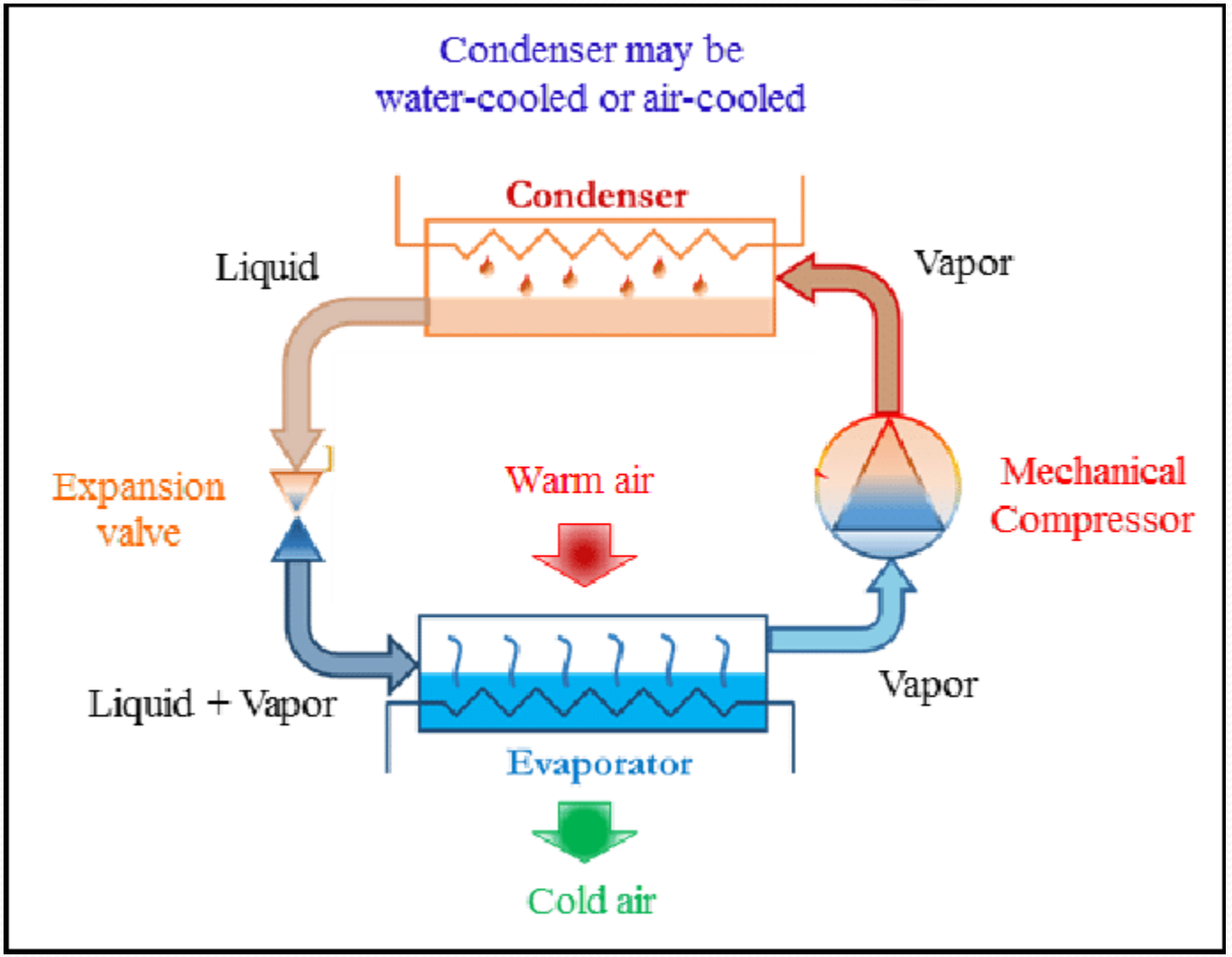
# Vapour Compression Refrigeration System

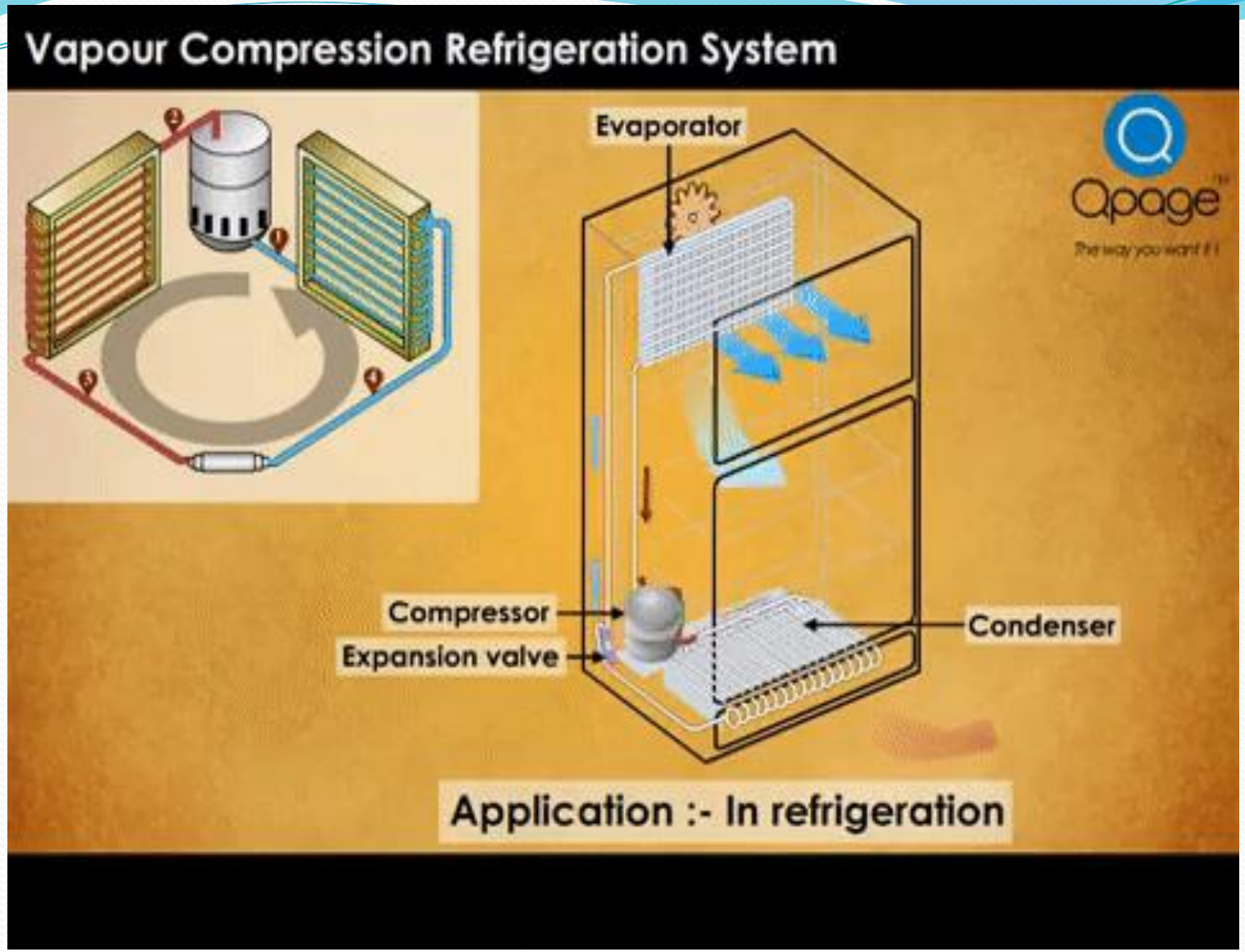



P
$T_C$
$T_H$
Critical point
Heat out
Condensation
$T_H$
Throttling
Compression
Evaporation
Work in
$T_C$
Liquid
Heat in
Vapour
Liquid + Vapour
V

# Vapour Compression Refrigeration System




Condenser may be
water-cooled or air-cooled
Condenser
Liquid
Vapor
Expansion
valve
Warm air
Mechanical
Compressor
Liquid + Vapor
Vapor
Evaporator
Cold air


Vapour Compression Refrigeration System
Evaporator
Compressor
Expansion valve
Condenser
Application :- In refrigeration

# Vapour Compression Refrigeration System

- In a vapour compression refrigeration system a ***refrigerant*** is circulated through the system in which it alternately evaporates and condenses, thus undergoing a change of phase from liquid to vapour and again from vapour to liquid.

- Vapour compression system makes use of the ***mechanical energy*** supplied to the compressor to run the refrigerator.

- The Vapour Compression Cycle consists of an evaporator made of coiled tubes installed in the freezing compartment of the refrigerator and is connected to the ***suction side of the compressor*** and the ***exit of the throttle valve***.

- The delivery side of the compressor is connected to the condenser inlet.

- Condenser outlet is connected to the inlet of the throttle valve.

## *In the Evaporator:*

- Low-pressure low-temperature refrigerant in semi vapor semi liquid state enters the Evaporator coils.
- As it flows through the evaporator, it absorbs heat from the contents of the freezing compartment, gains its Latent heat and gets converted into vapour phase.

## *In the Compressor:*

- Low-pressure low-temperature refrigerant vapour from the evaporator is drawn by the compressor.
- In the compressor, it is compressed to higher pressures so that the saturation temperature of the refrigerant corresponding to the increased pressure is higher than that of the cooling medium in the condenser, so that high-pressure high-temperature refrigerant vapour can reject heat in the condenser.

## *In the Condenser:*

- High-pressure high-temperature refrigerant vapour from the compressor enters the condenser.
- In the condenser, refrigerant vapour gives off its Latent heat to the atmospheric air and gets condensed into liquid.

## *In the Expansion Valve:*

- High-pressure condensed liquid refrigerant approximately at room temperature flows through the expansion valve (throttle valve) where it expands to low pressure and low temperature.

# State & Condition of the Refrigerant

| | INLET | OUTLET |
|---|---|---|
| Compressor | Vapour<br>LP, LT | Vapour<br>HP, HT |
| Condenser | Vapour<br>HP, HT | Liquid<br>HP, LT |
| Throttle valve | Liquid<br>HP, LT | Liquid+ Vapour<br>LP, LT |
| Evaporator | Liquid+ Vapour<br>LP, LT | Vapour<br>LP, LT |

# Unit of Refrigeration

In a refrigeration system, the rate at which the heat is absorbed in a cycle from the interior space to be cooled is called ***Refrigerating Effect.***

The ***capacity of a refrigeration system*** is expressed in ***Tons of refrigeration*** which is the unit of refrigeration.

***A ton of refrigeration is defined as the quantity of heat absorbed to convert one ton of water at $0^0$C to one ton of ice at the same temperature in 24 hours.***

# Unit of Refrigeration – contd.

Here it should be noted that one American ton (2000 pounds) is taken as the standard in the refrigeration practice.

In S.I. System,

1 Ton of Refrigeration = 210 kJ/min = 3.5 kW

# Coefficient of Performance of a Refrigerator

The performance of a refrigeration system is expressed by a factor known as ***Coefficient of Performance* (COP).**

***The COP of a refrigeration system is defined as the ratio of amount of heat absorbed or extracted in a system to the amount of work supplied.***

$$COP = \frac{\text{Amount of heat absorbed}}{\text{Amount of work supplied}}$$

Therefore, the performance indicator of a refrigerator COP can be improved by increasing the amount of heat absorbed from a system and by minimizing the amount of work supplied.

# Desirable Properties of Refrigerant

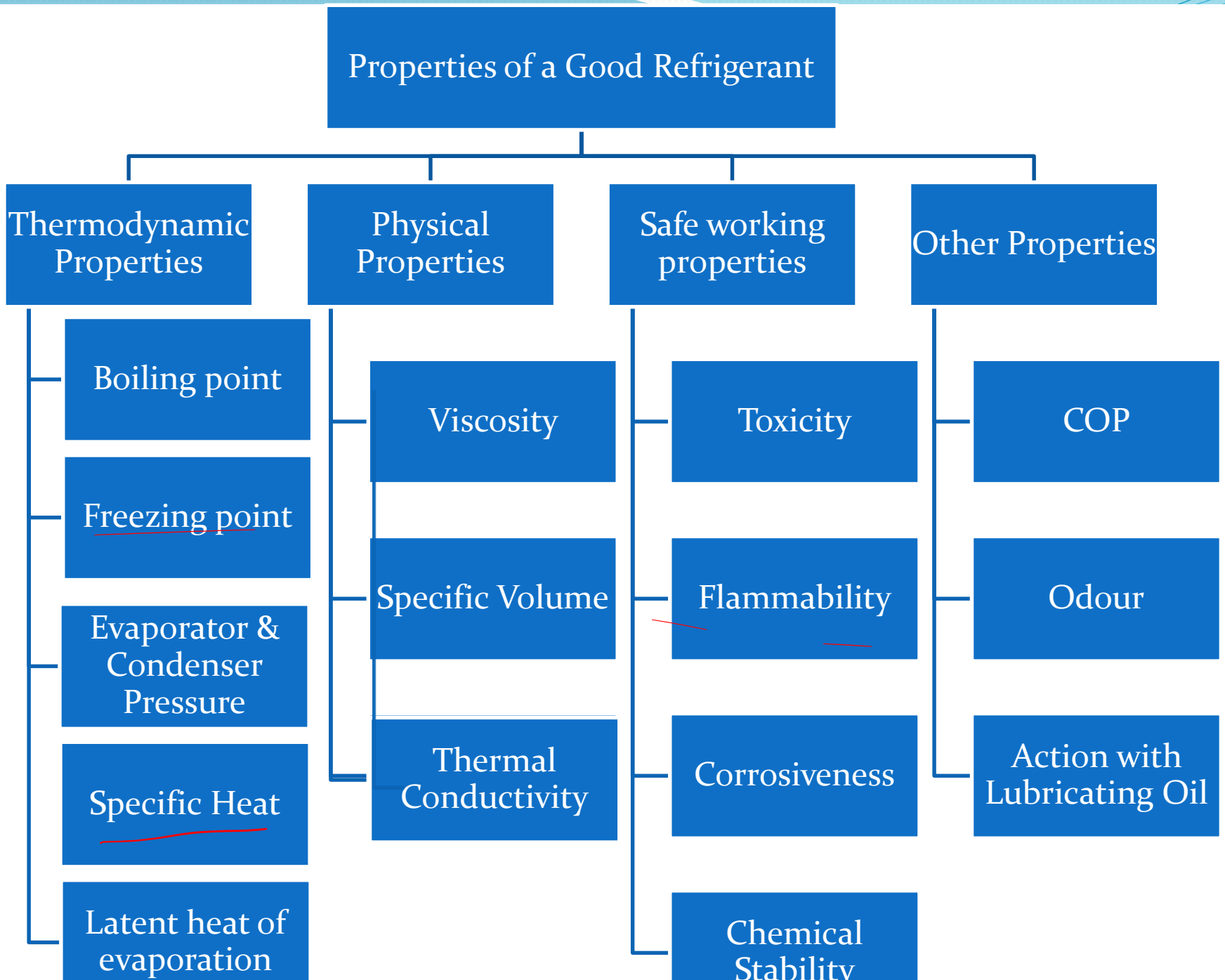
In order to produce a good refrigeration effect, an ideal refrigerant must possess certain desirable properties which are categorized as below:

**(A) Thermodynamic Properties**

**(B) Physical Properties**

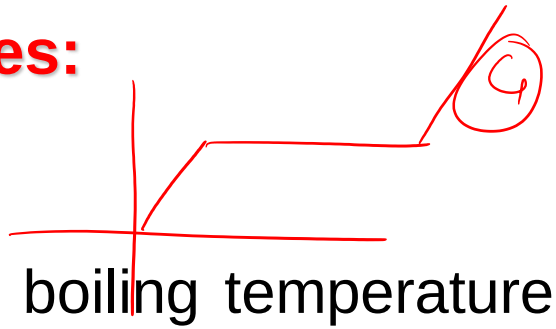
**(C) Safe Working Properties**

**(D) Other Properties**


Properties of a Good Refrigerant
Thermodynamic Properties
Physical Properties
Safe working properties
Other Properties
Boiling point
Freezing point
Evaporator & Condenser Pressure
Specific Heat
Latent heat of evaporation
Viscosity
Specific Volume
Thermal Conductivity
Toxicity
Flammability
Corrosiveness
Chemical Stability
COP
Odour
Action with Lubricating Oil

# Properties of an Ideal Refrigerant

## 1. Thermodynamic properties:



### a. Boiling point:

An ideal refrigerant should have low boiling temperature to give better refrigeration effect.

### b. Freezing point:

An ideal refrigerant should have low freezing point, because the refrigerant should not freeze at lower temperature.

### c. Evaporator & condenser pressure:

To detect the leakage of refrigerant, both the evaporator & condenser pressures should be above the atmospheric pressure.

## d. Specific Heat:

A good refrigerant must have high specific heat when it is vapourised and low specific heat when it is in liquid state. The high specific heat of the refrigerant helps in decreasing the super-heating of the vapour. The low specific heat of the refrigerant helps in sub-cooling of the liquid and easy drop in temperature after expansion. Both these desirable properties will increase the refrigerating effect.

## d. Latent heat of evaporation:

This must be very high so that a minimum amount of refrigerant will give the desired result. In other words, it increases the refrigeration effect.

## d. Physical properties:

### a. Viscosity:

The viscosity of a refrigerant in both the liquid and vapour states must be very low as it improves the heat transfer and reduces the pumping effort required.

### b. Specific volume:

It is the volume per unit mass. It must be very low, as it will reduce the size of the compressor

### c. Thermal conductivity:

Refrigerant should have high thermal conductivity for high heat transfer

## 3. Safe Working Properties:

### a. Toxicity:

A good refrigerant should be non toxic, because any leakage of the refrigerant results in poisoning the atmosphere in the refrigerator.

b. Flammability: A good refrigerant should have very low flammability and should be non explosive.

### c. Corrosiveness:

A good refrigerant should be non corrosive, to prevent the corrosion of metal parts of the refrigeration system.

d. Chemical Stability: An ideal refrigerant must not decompose under operating conditions.

## 4. Other Properties:

a. Coefficient of Performance (COP): The COP of a refrigerant must be high so that the energy spent in refrigeration will be less.

b. Odour: A good refrigerant must be odourless otherwise some food stuff such as meat, butter, etc. will lose their taste.

c. Action with Lubricating Oil: A good refrigerant must not react with the lubricating oil used in lubricating the parts of the compressor.

d. It should be easily available and economical