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# REFRIGERATION

# Definition of Refrigeration

- Mechanical refrigeration is a process of lowering the temperature of a substance less than that of its surroundings.
- Capacity of refrigeration is expressed in tone.
- A tone of refrigeration is expressed in designed as the rate of heat removed from the surroundings equivalent to the heat required for melting one tone of ice in one day

# Application of Refrigeration

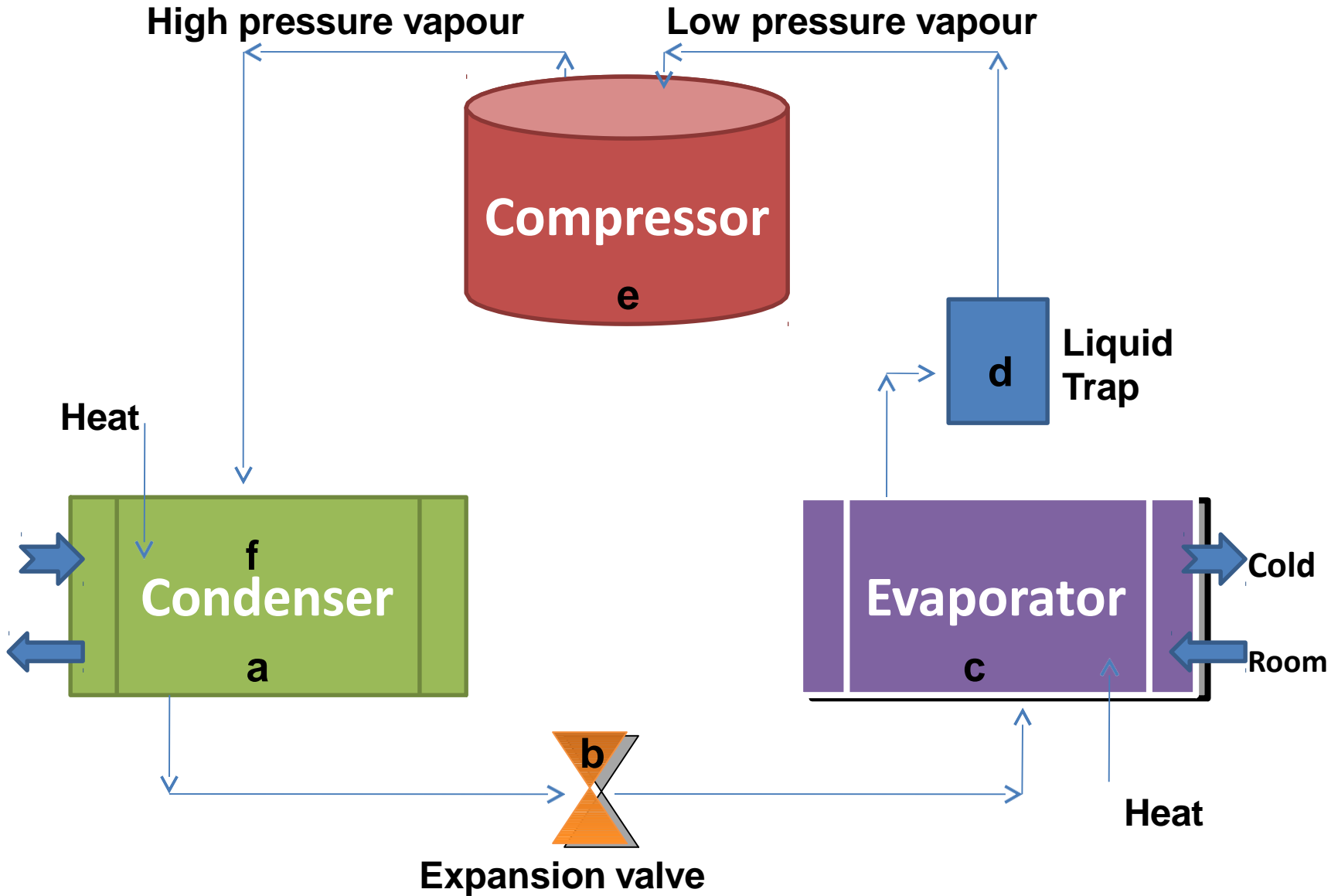
1. Removal of heat in chemical reactions.
2. Preservation of thermolabile substances (eg. Insulin, Hormones and vaccines)
3. Liquefy processing gas
4. Separation of vapours by distillation
5. Freeze drying (Lyophilization)

# Types of Refrigerants

- 1. Primary refrigerants:** These are liquids that change from a liquid to a gas after absorbing heat. (eg. Trichlorofluoromethane- $\text{Cl}_3\text{F}_2\text{C}$ , Dichlorodifluoromethane- $\text{Cl}_2\text{F}_2\text{C}$ , Ethylene, Propylene, Ammonia etc.)
- 1. Secondary refrigerants:** These are the liquids which act only as heat carriers (eg. Brine and water)

# Principle of refrigeration

- The refrigeration cycle is also known as vapour compression cycle. The cycle operates at two pressures high and low, to produce a continuous cooling effect.



# Basic construction of refrigeration cycle

# Refrigeration Cycle

- a. Receiver or Condenser
- b. Expansion valve
- c. Evaporation
- d. Liquid trap
- e. Compressor
- f. Condenser

# Refrigeration Cycle

- a. **Receiver or condenser:** The liquid is kept in a container namely condenser. The refrigerant is under pressure.
- b. **Expansion:** It is a device, which controls the rate of flow of refrigerant into the evaporator. Now high pressure refrigerant enters low pressure zone.
- c. **Evaporator:** It consist of coils, here the refrigerant evaporates by absorbing heat from the space. The energy required for this process is taken from the surrounding (space which is to be cooled). In this step, liquid vapourises, but some liquid still remains.



# Refrigeration Cycle

- d. Liquid trap:** This is used to remove the traces of liquid refrigerant and then returned to receiver (condenser).
- e. **Compressor:** Saturated vapour is allowed to pass through the compressor. The compression is adiabatic and it produces supersaturated gas.
- f. **Condenser:** The supersaturated gas (vapour) flows to the condenser where the gas is liquefied. The condenser can be air cooled (or) water cooled. Thus one cycle is completed as shown above and process is continued.

# AIR CONDITIONING

- Air conditioning is the process of treating air so as to control its temperature, humidity, cleanliness.

## **Applications**

1. Promoting the human comfort.
2. In manufacturing areas such as for tablets, capsules and sterile products.
3. Testing chambers
4. Maintenance of animals and equipment

# **Air Conditioning in Manufacturing areas**

- a. Compression of tablets
- b. Manufacturing of soft gelatin capsules
- c. Manufacturing of sterile products
- d. Testing chambers
- e. Maintenance of animals and equipment

# Air Conditioning in Manufacturing areas

- a. Compression of tablets:** In granulation section 45% RH and 22°C are necessary. In the tableting section less than 20% RH and 22°C are necessary.

In the production of effervescent products, dry syrups, controlling humidity is a vital factor. The RH should not exceed 10 to 15 % and temperature is at 22°C

# Air Conditioning in Manufacturing areas

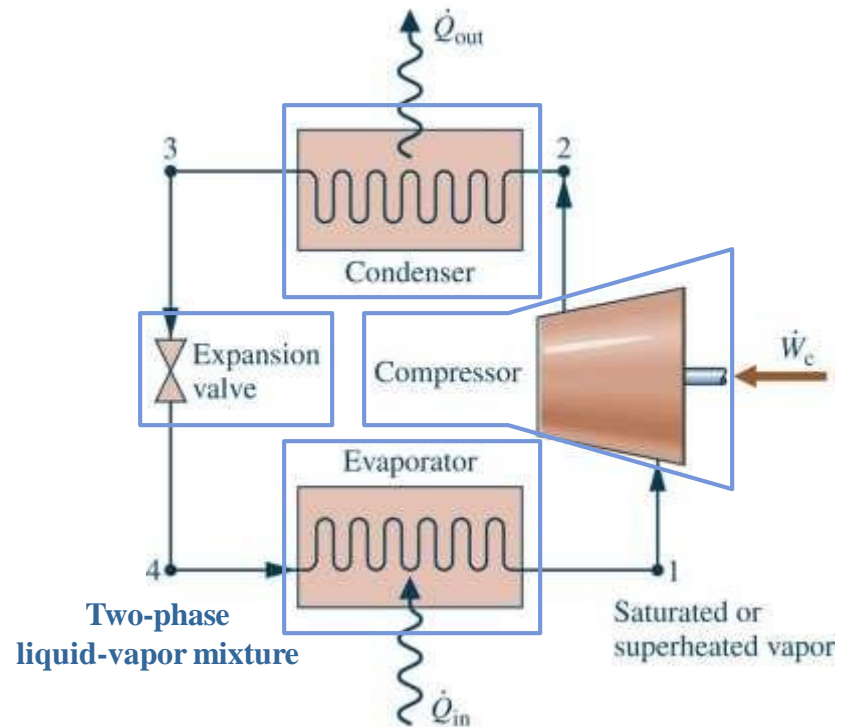
## **b. Manufacturing of soft gelatin capsules:**

Temperature controlled is 20°C to 22°C. Humidity is controlled to a maximum of 40% in operating areas and between 20 and 30% in the drying areas.

**c. Manufacturing of sterile products:** In parenteral and ophthalmic products. The environmental conditions are much more stringent in filling and sealing rooms. Therefore, standards of clean air quality are of greater importance. The production of biological products (Schedule C & C1) air conditioning is essential.

# VAPOR-COMPRESSION REFRIGERATION CYCLE

- ▶ Most common refrigeration cycle in use today
- ▶ There are **four principal control volumes** involving these components:
  - ▶ Evaporator
  - ▶ Compressor
  - ▶ Condenser
  - ▶ Expansion valve



All energy transfers by work and heat are taken as positive in the directions of the arrows on the schematic and energy balances are written accordingly.



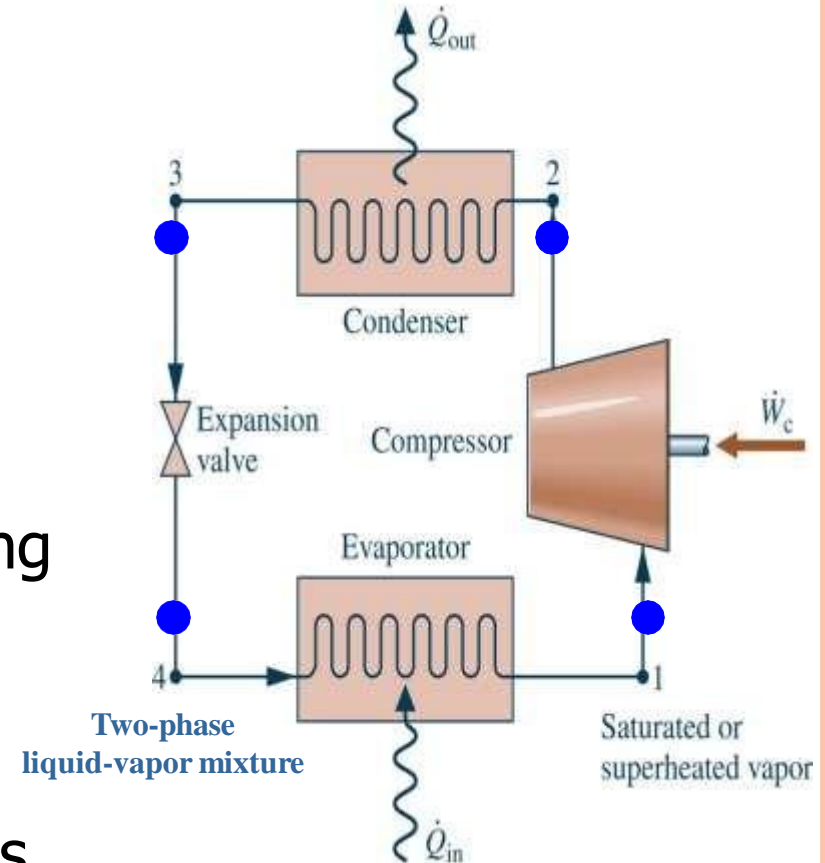
► The processes of this cycle are

**Process 4-1:** two-phase liquid-vapor mixture of refrigerant is evaporated through heat transfer from the refrigerated space.

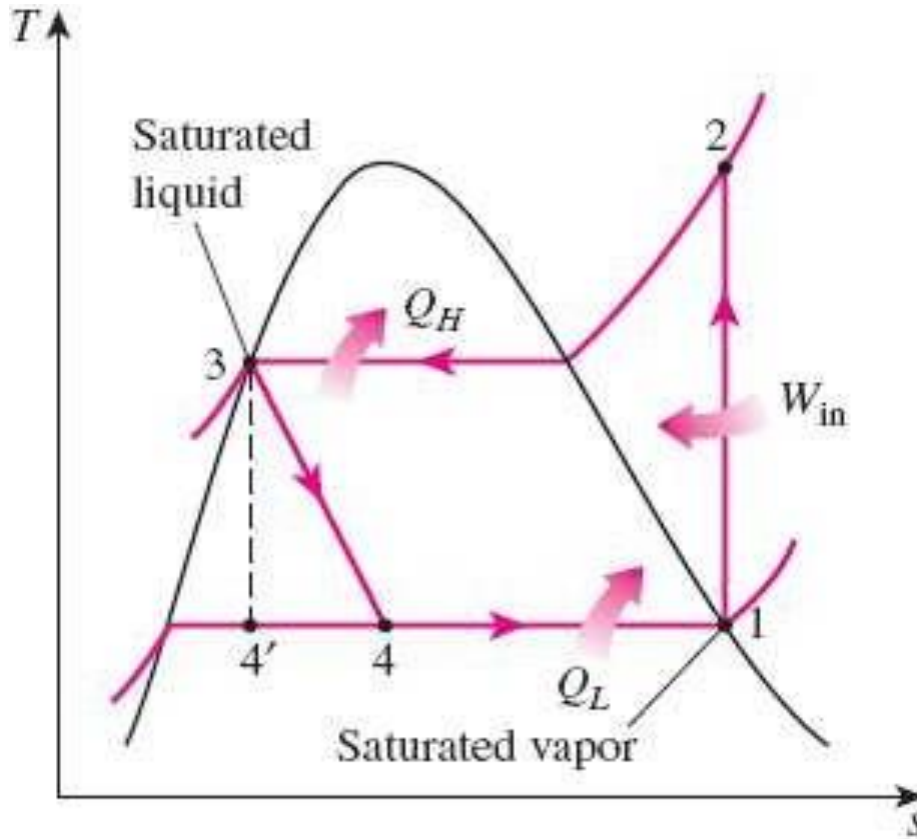
**Process 1-2:** vapor refrigerant is compressed to a relatively high temperature and pressure requiring work input.

**Process 2-3:** vapor refrigerant condenses to liquid through heat transfer to the cooler surroundings.

**Process 3-4:** liquid refrigerant expands to the evaporator pressure.

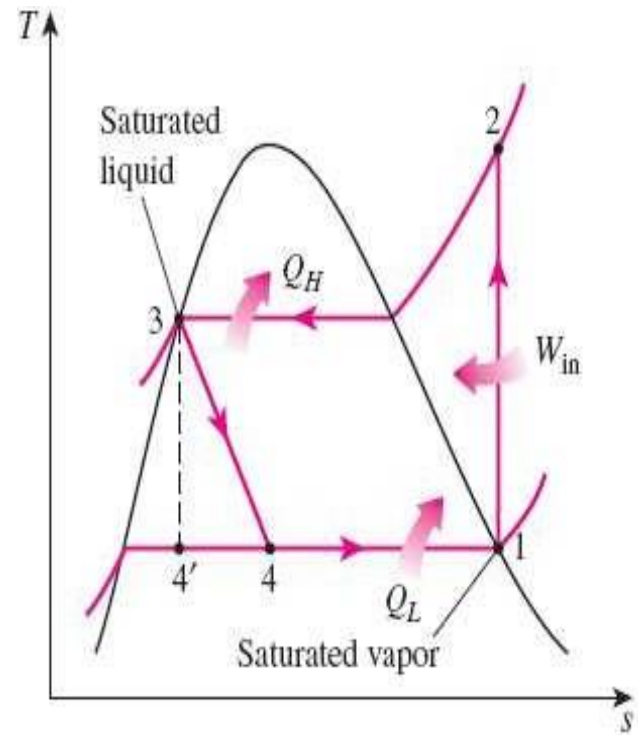


# *T-S* *DIAGRAM*



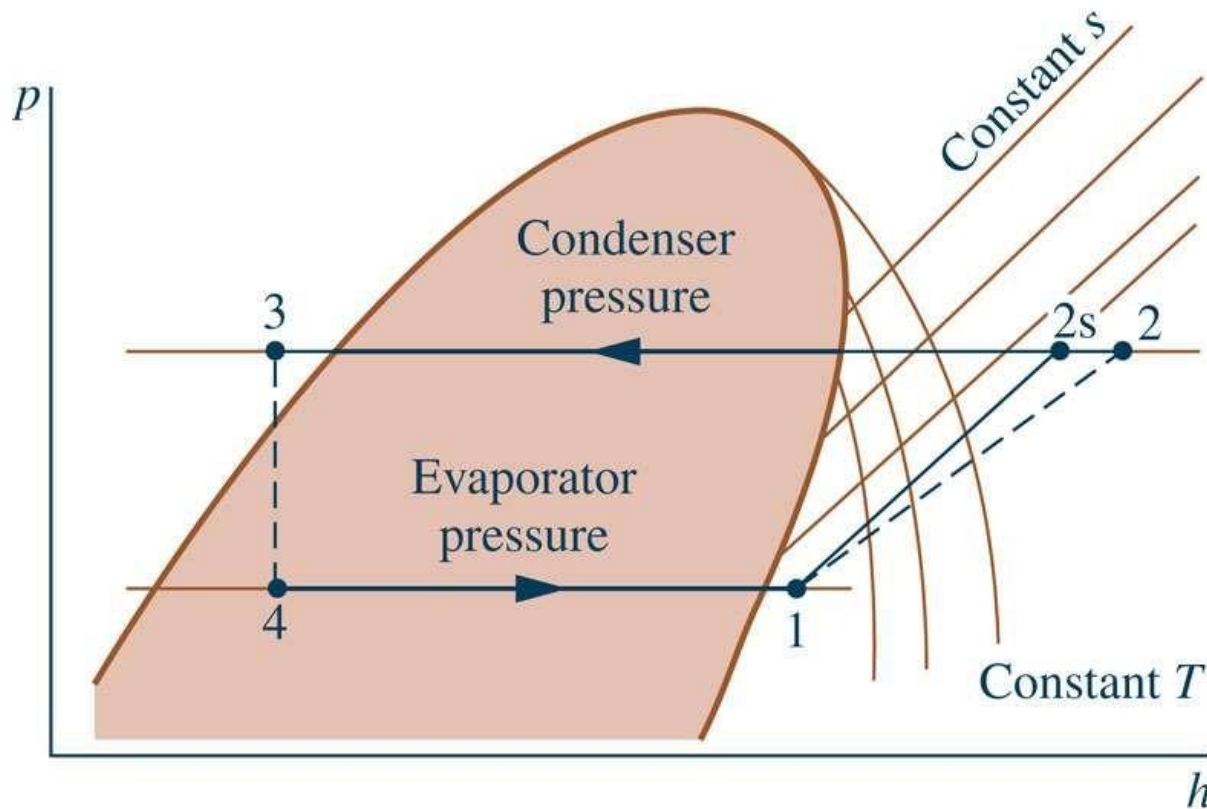


- The area under the curve for the process **4-1** represents the heat absorbed from the refrigeration space.
- Area under the curve **2-3** represented the heat rejected to the surrounding.
- **COP** improves by 2-4% for each compressor if the evaporating temperature is raised or the condensing temperature is lowered



# *P-H DIAGRAM*

- ▶ The **pressure-enthalpy (*p-h*) diagram** is a thermodynamic property diagram commonly used in the refrigeration field.



**THANK YOU**