REFRIGERATION AND AIR CONDITIONING

Refrigeration:

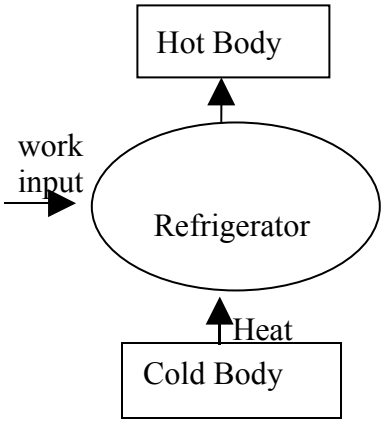
It can be defined as the process of transferring heat from a low temperature region to a high temperature region. In other words it is the process of cooling a substance. This can be achieved only if the heat is removed from that substance.

Principle of refrigeration:

The principle of refrigeration is based on second law of thermodynamics. It sates that heat does not flow from a low temperature body to a high temperature body without the help of an external work.

In refrigeration process, since the heat has to be transferred from a low temperature body to a high temperature body some external work has to be done according to the second law of thermodynamics as shown. This external work is done by means of compressor, condenser etc.

The machine, which works under this principle and serves the purpose of refrigeration is called a Refrigerator



Terms in refrigeration:

1. Refrigerator:

It is a machine used to extract heat from a body at low temperature and reject this heat to a body at high temperature. Thus it cools the body.

2. Refrigerant:

It is substance, which is used as a working fluid in refrigerators. The refrigerant has low boiling point, which means that it vaporizes at low temperature and takes away the heat from a substance.

Examples: Freon 12 used in Domestic refrigerators. Freon 22 used in Air Conditioners.

Properties of good refrigerant:

1. Have low freezing and boiling point
2. Have high COP
3. Be non toxic and non corrosive to metal
4. Be non explosive
5. Easily be liquefied

3. Capacity of Refrigerator:

It is defined as the rate at which heat can be removed from the cold body. Simply it is the rate at which refrigeration can be produced. Its unit is expressed in terms of Ton of Refrigeration. One ton of refrigeration is defined as the quantity of heat removed to freeze one ton of water into ice at $0^{o}C$ in 24 hours. Its value is 3.5 KW.

4. Refrigeration Effect:

It is defined as the ratio of the quantity of heat removed to the time taken.

Refrigeration Effect = Heat removed / Time taken

5. Coefficient of Performance (COP):

It is defined as the ratio of heat absorbed in a given time (Refrigeration Effect) to the work done

$$COP = \frac{\text{Refrigeration Effect}}{\text{Work done}}$$

Types of Refrigerators:

1. Vapor Compression Refrigerators
2. Vapor Absorption Refrigerators

Vapor Compression Refrigeration System:

This type of refrigeration system is the most commonly used system in domestic refrigerators. In VCRS the vapor alternatively undergoes a change of phase from vapor to liquid and vice versa during a cycle.

Construction:

Vapor compression refrigeration system has the following components at its basic parts.

1. **Compressor:** The function of the compressor is to compress the input refrigerant of low pressure and low temperature. As a result the pressure and the temperature of the refrigerant increases. Generally reciprocating compressors are used in a refrigeration system. An external motor is used to drive the compressor.
2. **Condenser:** The condenser is a coil of tubes, which are made of copper. This is used to condense the refrigerant which is in the form of vapor. And convert into liquid.
3. **Expansion Valve:** this is otherwise called throttle valve. This valve is used to control the flow rate of refrigerant and also to reduce the pressure of the refrigerant.
4. **Evaporator:** This is the part in which the cooling takes place. This is kept in the space where cooling is required. It is a coil of tubes made up of copper.

Working Principle:

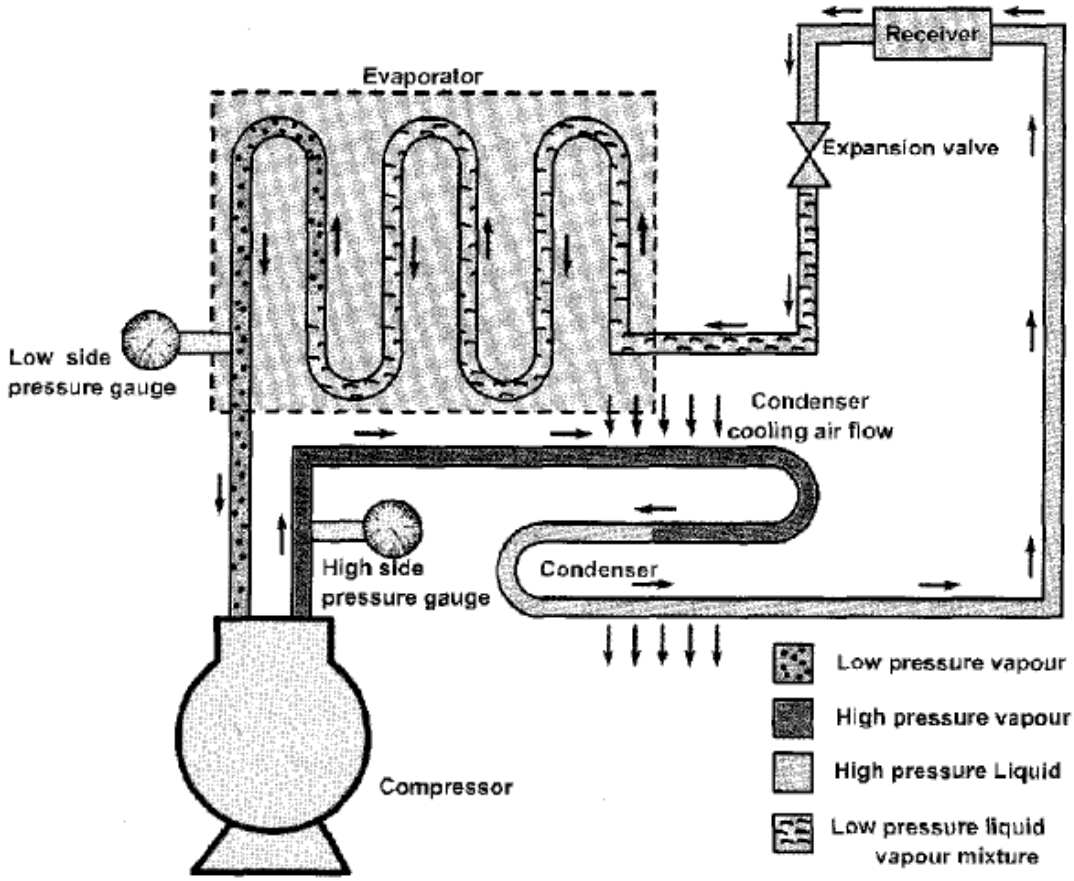
The refrigerant, which is at low pressure and low temperature flows into the compressor. In the compressor the refrigerant is compressed and converted into a high pressure and high temperature refrigerant.

This high pressure and high temperature refrigerant in vapor form then passes through the condenser where it is condensed into high pressure liquid refrigerant.

The high pressure liquid refrigerant thus produced passes through the expansion valve. In the expansion valve the pressure and temperature of the refrigerant drops and it partly evaporates. It is the allowed to flow into the evaporator at a controlled rate.

In the evaporator, the partly liquid and vapor refrigerant is mostly evaporated and converted into a low pressure vapor. During this process, the refrigerant absorbs its latent

heat of vaporization from the material that is to be cooled. Thus the body is cooled in the evaporator .



Then the low pressure vapor refrigerant enters the compressor and the cycle is repeated. Thus a material is cooled in vapor compression system.

Vapor Absorption Refrigeration System:

The compressor in the vapor compression refrigeration system consumes lot of energy. To avoid this, the vapor absorption refrigeration system has been developed. In this system, the compression process of vapor compression cycle is eliminated. Instead of that the three following process are introduced.

- Ammonia vapor is absorbed into water
- This mixture is pumped into a high pressure cycle
- This solution is heated to produce ammonia vapor.

Construction:

The vapor absorption refrigeration system has the following components.

Generator: the generator receives the strong solution of aqua-ammonia from the absorber and heats it. Because of this heating, the aqua-ammonia solution gets separated into ammonia vapor at high pressure and hot weak ammonia solution which contains mostly water.

Condenser: The condenser converts the high pressure ammonia vapor received from the generator into high pressure ammonia liquid. This condensation is done by means of circulating cool water.

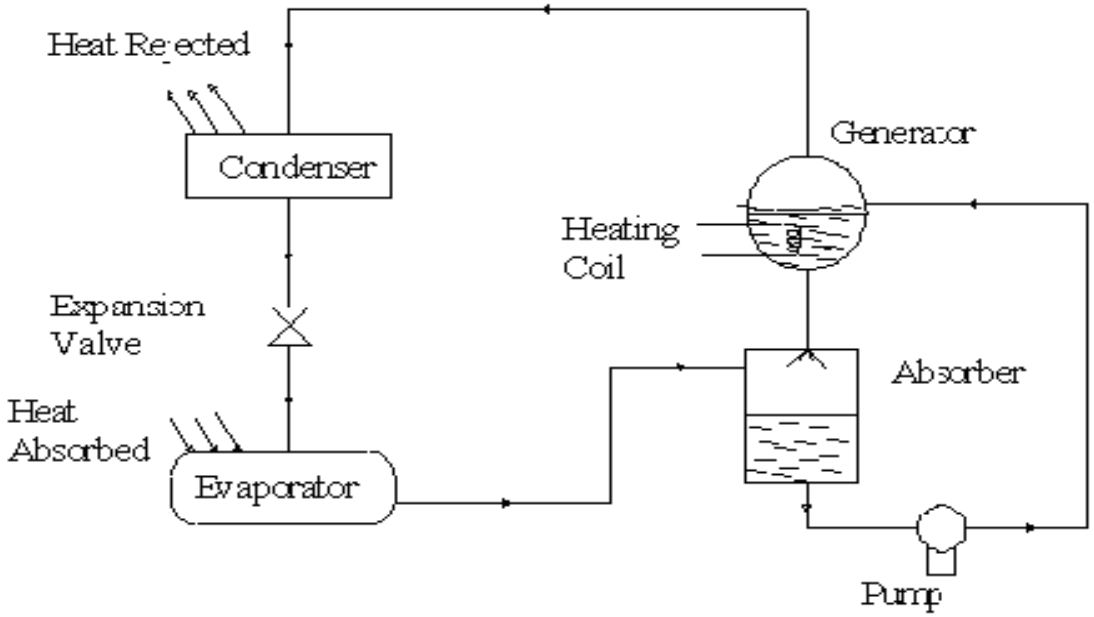
Expansion valve: This valve is otherwise called the throttling valve since the expansion, which takes place here, is throttling. While passing through this valve, the liquid ammonia gets expanded and gets converted into low pressure and low temperature ammonia.

Evaporator: The evaporator is otherwise known as cold chamber. Here the refrigerant absorbs the heat from the material which is to be cooled and gets evaporated. It has many coils made of copper.

Absorber: The absorber receives the low pressure ammonia vapor from the evaporator and the weak ammonia solution from the generator and mixes them well to form a strong solution of aqua-ammonia.

Working Principle:

The working fluid in vapor absorption refrigeration system is normally ammonia. The ammonia vapor and water are mixed to form a strong solution of aqua-ammonia in the absorber. This aqua-ammonia solution is then pumped into the generator. In the generator, this solution is heated. Because of heating, ammonia gets evaporated at high pressure and leaves behind the weak ammonia solution, which mostly contains water.



The high pressure ammonia vapor produced by the generator is condensed in the condenser and it becomes ammonia liquid, which is at high pressure. This high pressure liquid ammonia is allowed to pass through the expansion valve or throttling valve where it expands and becomes a low pressure and low temperature ammonia which mostly contains liquid ammonia and a little vapor ammonia.

Ammonia at low pressure and low temperature then passes through the evaporator where it absorbs the heat from the material which is to be cooled and gets evaporated. The evaporator is where the real cooling takes place. Because of the heat absorbed by ammonia, it gets evaporated and becomes low pressure ammonia vapor. The low pressure ammonia vapor is then sent into the absorber and the cycle is repeated.

Comparison between VCRS and VARS:

	Vapor Compression Refrigeration System	**Vapor Absorption Refrigeration System**
1	It is more noise and wear and tear because of more moving parts	The system is comparatively quieter.
2	Mechanical energy is utilized by means of compressor	Heat energy is utilized
3	Refilling of refrigerant is easy	Refilling of refrigerant is difficult
4	During partial loading conditions the performance is poor	The performance is not affected even at the partial loading
5	The liquid refrigerant accumulated in the cylinder may damage the cylinder. So preventive measures are needed.	Liquid refrigerants do not affect the performance of the system. They do not produce any bad effect.

Applications of Refrigeration:

- In manufacturing ice
- For Preserving perishable food materials
- For Cooling water
- For preserving of blood, tissues and medicines

Domestic Refrigerators:

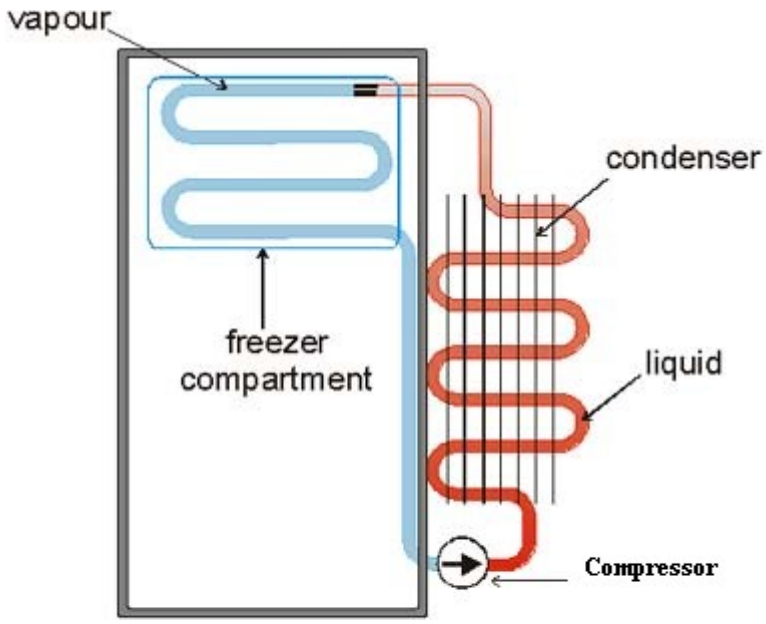
Most domestic refrigerators are of two types—either a single door fresh food refrigerator or a two-door refrigerator-freezer combination, with the freezer compartment on the top portion of the cabinet, or a vertically split cabinet (side-by-side), with the freezer compartment on the left side of the cabinet. They are completely self-contained units and are easy to install. Most refrigerators use R-22 refrigerant, normally maintaining temperatures of 0°F in the freezer compartment and about 35°F to 45°F in the refrigerator compartment. The technician must be able to perform various duties in the maintenance and repair of domestic refrigerators, water coolers, and ice machines. This section provides information to aid you in handling some of the more common types of troubles. But let us remind you that the information given here is intended as a general guide and should, therefore, be used with the manufacturer's detailed instructions.

Single Door Fresh Food Refrigerator

A single door fresh food refrigerator consists of an evaporator placed either across the top or in one of the upper corners of the cabinet. The condenser is on the back of the cabinet or in the bottom of the cabinet below the hermetic compressor. During operation, the cold air from the evaporator flows by natural circulation through the refrigerated space. The shelves inside the cabinet are constructed so air can circulate freely past the ends and sides, eliminating the need for a fan. This refrigerator has a manual defrost, which requires that the refrigerator be turned off periodically (usually overnight) to enable the buildup of frost on the evaporator to melt. Both the outside and inside finish is usually baked-on enamel. Porcelain enamel is found on steel cabinet liners. The interior of the unit contains the shelves, lights, thermostats, and temperature controls.

Two-Door Refrigerator-Freezer Combination

The two-door refrigerator-freezer combination is the most popular type of refrigerator. It is similar to the fresh food refrigerators in construction and the location of components except it sometimes has an evaporator for both the freezer compartment and the refrigerator compartment. Also, if it is a frost-free unit, the evaporators are on the outside of the cabinet. Because of the two separate compartments (refrigerator-freezer) and the larger capacity, these types of refrigerators use forced air (fans) to circulate the air through the inside of both compartments. The two-door refrigerator also has one of the following three types of evaporator defrost systems: manual defrost, automatic defrost, or frost-free. There are two types of automatic defrosting: the hot gas system or the electric heater system. The hot gas system, through the use of solenoid valves, uses the heat in the vapor from the compressor discharge line and the condenser to defrost the evaporator. The other system uses electric heaters to melt the ice on the evaporator surface. A frost-free refrigerator-freezer has the evaporator located outside the refrigerated compartment. On the running part of the cycle, air is drawn over the evaporator and is forced into the freezer and refrigerator compartments by a fan. On the off part of the cycle, the evaporators automatically defrost.



Refrigerator-freezer cabinets are made of pressed steel with a vinyl or plastic lining on the interior wall surfaces and a lacquer exterior finish. Most domestic refrigerators have urethane foam or fiber glass insulation in the cabinet walls. The side-by-side refrigerator-freezer arrangement has a number of features not found in other refrigerators. In addition to the automatic icemaker in the freezer compartment, it has an option for a cold water dispenser, a cube or crushed ice dispenser, and a liquid dispenser built into the door.

Air Conditioning: It is the process of controlling and maintaining the properties of air like temperature, humidity, purity, direction of flow etc in a closed space. One can have the desired condition around him using air conditioning.

Terms in Air Conditioning:

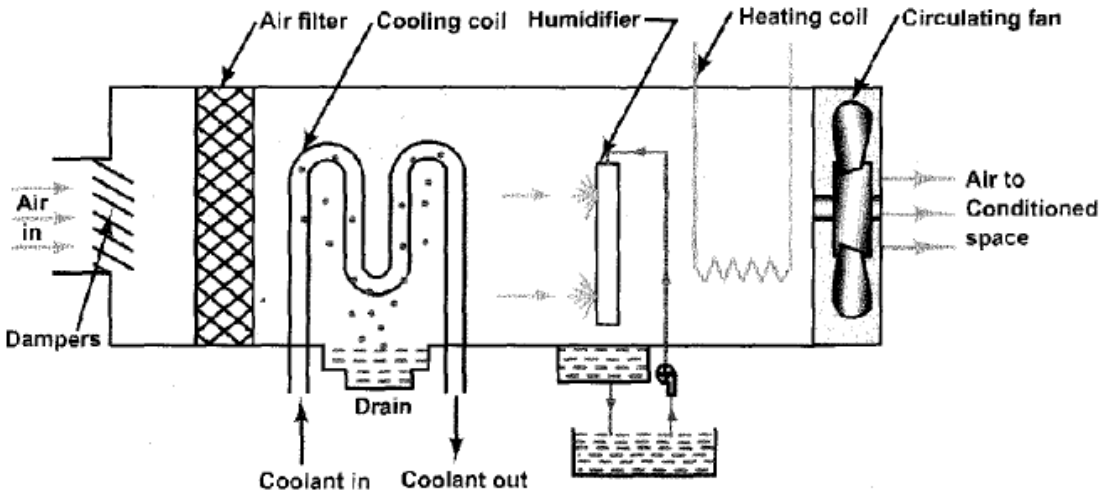
- **Psychrometry:** It is the study of the properties of moist air. The properties of the air and water vapor mixture are called psychometric properties.
- **Dry Air:** Atmospheric air without presence of water vapor is called dry air. It is combination of 79% of nitrogen and 21% of oxygen by weight.
- **Moist Air:** It is the mixture of dry air and water vapor. The amount of water vapor present varies according to the temperature.
- **Dry Bulb Temperature (DBT):** It is the temperature of the air measured using an ordinary thermometer. This temperature is not affected by the water vapor present in the air.
- **Wet Bulb Temperature (WBT):** It is the temperature measured by ordinary thermometer when its bulb is covered with wet cloth and exposed to air. It is always less than DBT.

- **Wet Bulb Depression (WBD):** The difference between the dry bulb temperature and the wet bulb temperature. If the air is fully saturated then the wet bulb depression is zero.
- **Dew Point Temperature (DPT):** The temperature at which the water vapor in the air begins to condense when the temperature of the air is continuously reduced.
- **Humidity:** the quantity of water vapor present in the air is known as humidity. It depends on the temperature of the air and is independent of the pressure of the air.
- **Relative Humidity:** It is defined as the ratio of mass of water vapor present in a given volume of air at a given temperature to the mass of water vapor present in the same volume and temperature of the air when it is fully saturated.

Working of a Air conditioning system

It consists of dampers, air filter, cooling coil, spray type humidifier, heating coil and a fan. Atmospheric air flows through the dampers. The quantity of air depends upon the "load and the dampers control it. Air then passes through the Air filter. The filter removes dirt, dust and other impurities.

The air now passes over a cooling coil. So when air is cooled below its dew point temperature, the water vapour is removed from the air in the form of water droplets. The surface temperature of the cooling coil has to be maintained below the dew-point temperature of the atmospheric air to accomplish dehumidification. The quantity of water removed from air is collected in the sump and is drained. The temperature of air leaving the cooling coil is lower than the ambient temperature for comfort. During the dry weather the spray type humidifier is used to increase the humidity of the conditioned air. During wet weather condition the relative humidity of the air is high, is controlled by the heating coil. For the comfort condition required is DBT around 23^{o} C and relative humidity 60%. So the air is to be cooled and humidified to the comfort condition. Now the conditioned air is supplied to the conditioned space by a fan and ducts.



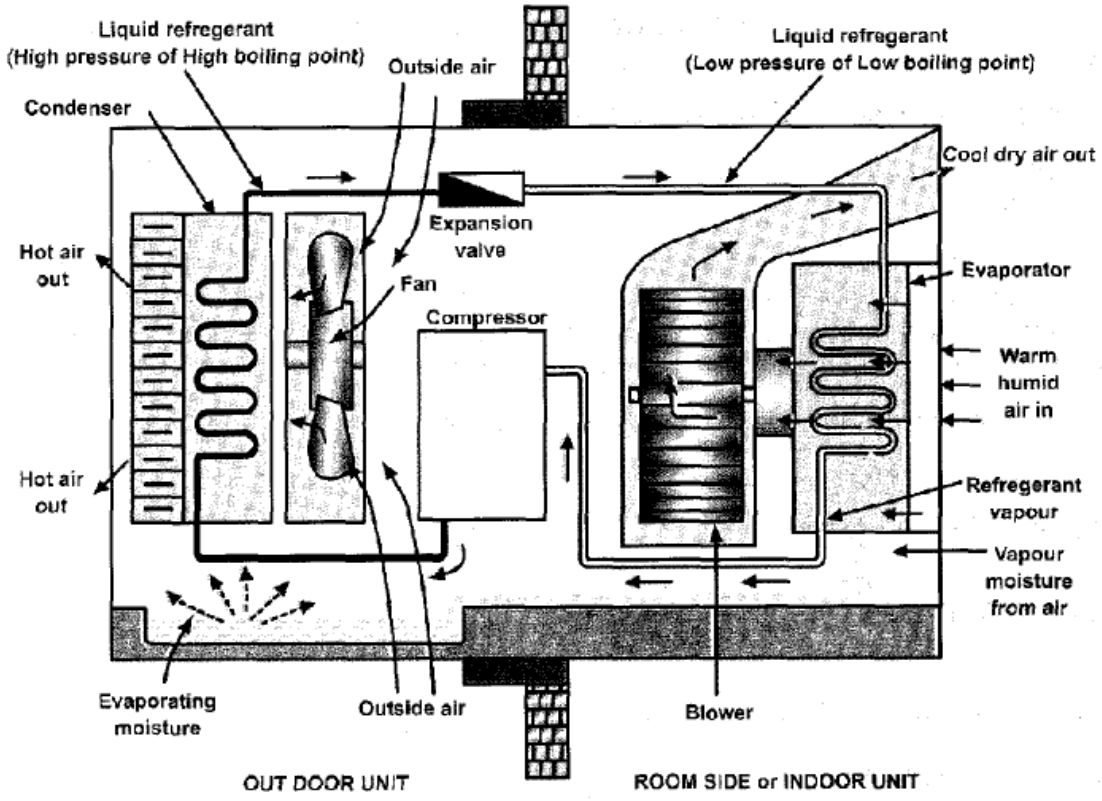
Layout of a Window Room Air Conditioner:

It is called a window air conditioner because it is usually fixed in a window. The Window or Room air conditioner is used to cool a single room or a large space. This window room air conditioner system has four main components. They are

- An entire cooling system, which includes a condenser, compressor and an evaporator.
- A fan and adjustable grills to ensure proper circulation of air.
- A filter, which is made of fiber, mesh or glass wool to remove the impurities in the air.
- Controlling equipments to regulate the properties of the air.

The working of the window air conditioner shown in Figure 6.4, is described as under:

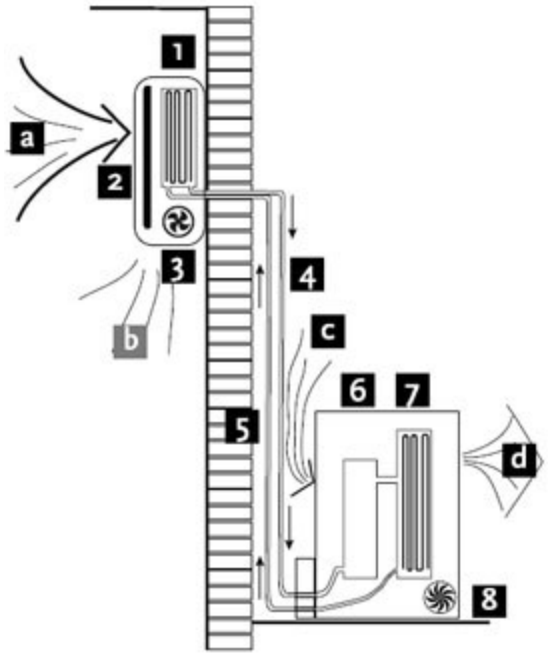
The refrigerant vapour leaving the compressor is at high pressure and temperature. It then passes through the condenser. Outside air is drawn in by the fan and it cools the refrigerant in the condenser, the refrigerant then becomes liquid. The high pressure, low temperature liquid refrigerant enters the expansion valve. The pressure and temperature of the refrigerant falls when it leaves the valve. The cold refrigerant from the valve passes through the evaporator (the evaporator side of the air conditioner faces the room to be cooled). The warm air from the room is drawn in by blower. The evaporator cools this air and the liquid inside the evaporator tube gets vaporized by absorbing the heat from the warm air. The cool air is again sent to the room through the opening at the top of the air conditioning unit. The liquid and vapour refrigerant from the evaporator passes to the compressor and is compressed to high-pressure, high temperature liquid. The operation hereafter is carried out in cycle as the same manner as explained.



The amount of air circulated into the room can be controlled by the dampers provided. When air flows over the cooling coil or the evaporator coil, the moisture in the air gets condensed and they are made to drip into the trays provided below the coils. This water evaporates to some extend and thus helps in cooling the compressor and condenser. For every cycle, the temperature of the air keeps on reducing. The unit automatically stops with the help of thermostat and control panel, when the required temperature is reached inside the room.

Split Air Conditioner:

A Streamlined and light-weight air handler is mounted on the inside wall. Refrigerant and condensate lines run through a small hole in the wall to the outside unit. Initial power is to the outside unit and then relayed to the air handler. Extremely quiet as the compressor and condenser coil are outside. Full electronic and remote control. The compressor (6) in the exterior unit compresses the refrigerant into a high-temperature, high-pressure gas. When this gas flows along the cooling fins of the condenser (7), heat is exuded and the gas is led to the evaporator (1) in the interior unit. The liquid expands into a gas at a low temperature and low pressure. This gas absorbs the warmth of the air in the room, the cooled air is blown back into the room and the heat is led to the compressor along with the gas.



1. Evaporator
2. Filter
3. Fan
4. Gas line
5. Liquid line
6. Compressor
7. Condenser
8. Fan

A fan (3) draws the air (a) over the filter (2) and blows the cooled air (b) back into the room. A fan (8) draws air over the condenser and blows warm air (d) away. As with cooling, the moisture in the air condenses on the cold evaporator at room temperature.