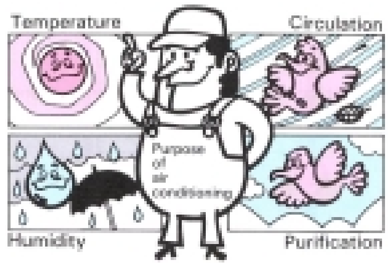
TECHNICAL SECTION – VEHICLE AIR CONDITIONING

WHAT IS AN AIR CONDITIONER?

An air conditioner is used for the following purposes.

a. Temperature Control
b. Air Circulation Control
c. Humidity Control
d. Air Purification

The Four Factors of Air Conditioners



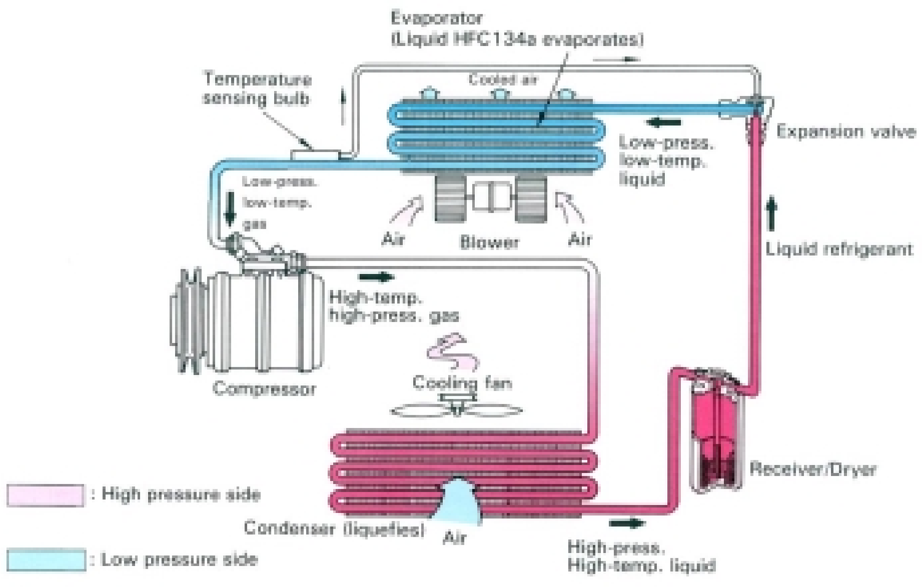
An air conditioner maintains the air in the room at comfortable temperature and humidity as follows:

a. When the room temperature is high, the heat is taken away to lower the temperature by the air conditioner and conversely, when the room temperature is low, heat is supplied to raise the temperature.

b. In addition, moisture in the room is removed to maintain a comfortable humidity level.

To perform these operations, the air conditioner for a vehicle generally consists of a heater, cooler (or evaporator), ventilation system such as a blower and ducts, and air purifier.

Refrigeration Cycle (Cooler System)



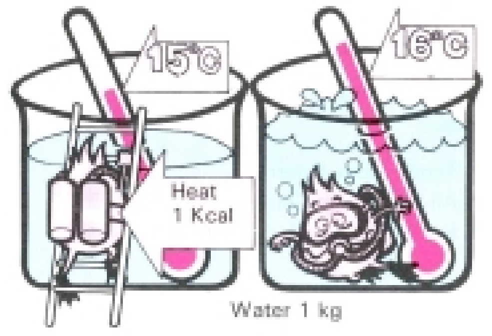
TECHNICAL TERMS AND CHANGE OF STATE

HEAT

Heat is one form of energy.

1 Kcal heat quantity changes the temperature of 1 kg of liquid water by 1°C

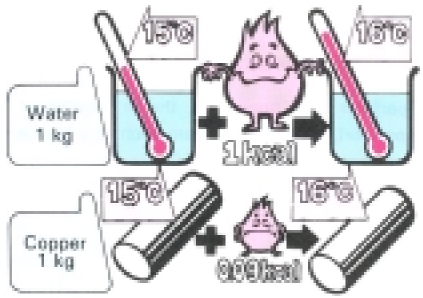
Heat Quantity



SPECIFIC HEAT

Specific heat is heat quantity required to CHANGE THE TEMPERATURE of an object by 1°C

Specific Heat



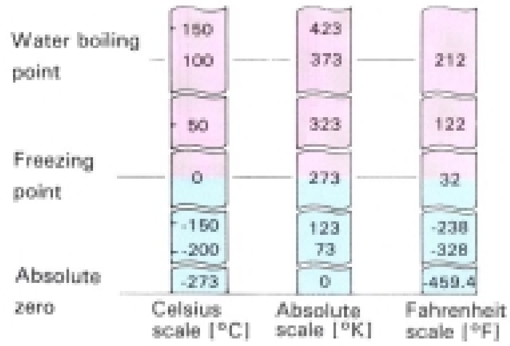
TEMPERATURE

a. Temperature Scales

Temperature is the degree of heat or coldness of an object. The unit generally used to express it is ’Centigrade degree (°C)” or “Fahrenheit degree (°F)”. In the Centigrade scale, the freezing point (solid point) of pure water is taken as 0°C, and the distance between the freezing point and boiling point divided into 100 parts and each part designated as 1°C. In the Fahrenheit scale, the freezing point of pure water is taken as 32°F, and the distance between the freezing point and boiling point divided into 180 parts, and each part designated as 1°F.

[°C] = 5/9 ([°F] – 32)
[°F] = 9/5 [°C] + 32

Temperature Scales



b. Wet Bulb and Dry Bulb Thermometers

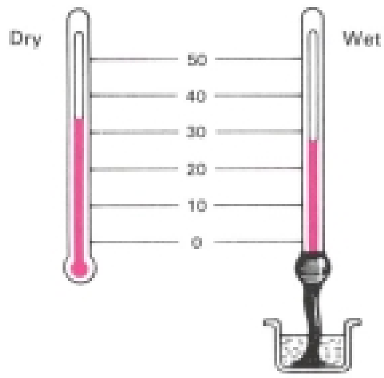
WET BULB THERMOMETER

The bulb (heat sensitising part) of a glass tube thermometer is wrapped with a gauze or other rough mesh cloth. One end of the cloth is immersed in a water container to allow the water to be drawn up by a capillary action and to moisten the heat sensitising part.

The water in the cloth surface near the heat sensitising part evaporates and robs the latent heat of evaporation from surrounding air, causing the air temperature around the heat sensitising parts to drop. The temperature registered by the thermometer at this time is called the wet bulb temperature.

This is used to find out humidity in combination with the dry bulb temperature.

Thermometer



c. Dew Point Temperature

When the air surrounding us is cooled, the air temperature drops, and when the humidity becomes 100%, that is, when the dry bulb and wet bulb temperature become the same, the water vapour contained in the air will be in a saturated state.

On further cooling, the water vapour reaches a condition where it cannot remain in a vapour state so that a part condenses and becomes dew. The temperature at which the humidity becomes 100% and dew is formed is called dew point temperature.

HUMIDITY

Humidity

When you pour water and ice into a glass, you notice that drops of water are generated on the glass. Do you sometimes wonder where these drops of water come from? The drops of water come from the surrounding air. This means humidity is water vapour contained in the air.

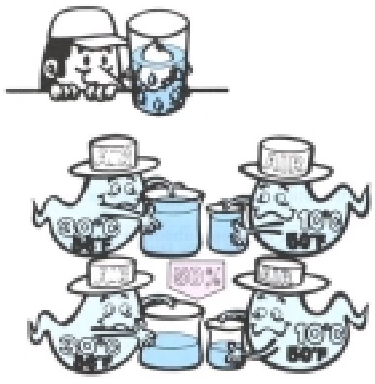
Relative Humidity

The relative humidity is used to measure the humidity. The relative humidity is the amount of water vapour the air contains in comparison with the amount the air could contain at a given temperature. Thus, if the relative humidity is 50%, the air contains 50% of the water vapour amount the air could contain at a given temperature.

Absolute Humidity

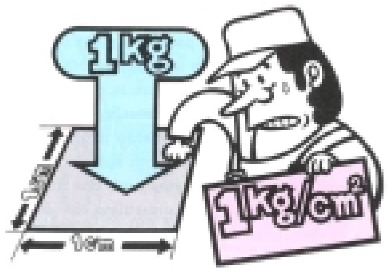
Absolute humidity is the amount of water the air contains, compared with the dry air.

Relative humidity



PRESSURE

Pressure



Pressure is defined as the vertical force applied on a unit area of a solid, liquid or gas. The unit of measurement generally used to indicate pressure is ‘kg/cm^2’.

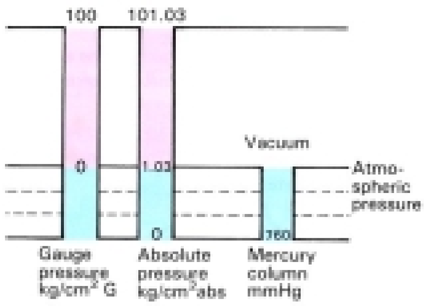
However, instead of ‘kg/cm^2’, Pascal is used as an international unit of measurement.

1 kPA (Pascall) = 1.01972 x 10^{-2} kg/cm^2
1 kg/cm^2 = 98.06 kPA

For blower performance, mmAq (Water Column) is generally used.

For pressure below atmospheric (Vacuum) mmHG (Mercury Column) is used.

Pressure Scales



1. Atmospheric Pressure

This is the pressure acting on all objects on earth. This pressure is the weight of air surrounding everyone and is equal to 1.03kg/cm^2 (1 atmosphere). At this pressure, the mercury column will be 760 mmHg.

1 atm = 1.03 kg/cm^2 = 760 mmHg

Practically all pressure gauges are made to indicate atmospheric pressure as 0.

2. Absolute Pressure

Absolute pressure is when perfect vacuum is taken as 0 kg/cm^2. Therefore, the atmospheric pressure is 1.03 kg/cm^2 in terms of absolute pressure.

To distinguish from absolute pressure, the pressure measured with a gauge is called a gauge pressure. For identification, absolute pressure is indicated by kg/cm^{2}abs and gauge pressure by kg/cm^{2}G.

The relationship between absolute pressure and gauge pressure is as follows:
Absolute press. [kg/cm^{2}abs] = Gauge press. [kg/cm^{2}G] + 1.03 kg/cm^2

CHANGE OF STATE

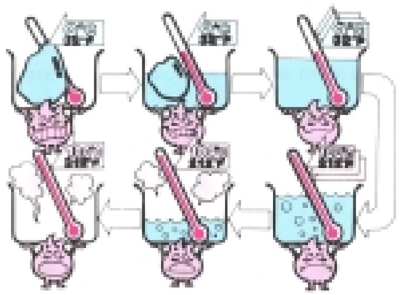
a. State Change of Water

Now, we will consider how ice changes its state when we add heat to it. We will use water as an example as it is the easiest matter to understand heat and state change.

If we add heat to ice until the temperature of ice reaches 0 degree Centigrade (32^0F), ice melts into water, and while the ice is melting, the temperature of ice and water remains at 0 degree Centigrade. After the ice has melted, the temperature of water begins to rise.

When the temperature of water reaches 100^0C, water begins to become steam. Until all the water becomes steam, the temperature of water remains 100^0C.

State Change of Water



b. Sensible Heat and Latent Heat

Fig. 1-11 shows the relation between heat and temperature. There are two kinds of heat called sensible heat and latent heat.

Sensible Heat

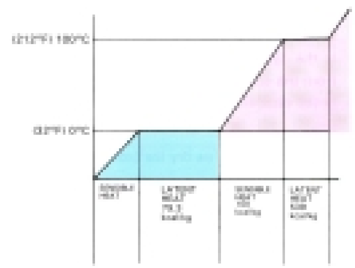
can change the temperature of water but cannot change the state of water. Therefore, the sensible heat raises or lowers the temperature of water.

In the case of water, 1kg of water at 0^0C must absorb 100 Kcal of sensible heat to change to 1 kg of water at 100^0C.

The Latent Heat

can change the state of water, but cannot change the temperature of water. Ice melts into water by adding latent heat and water evaporates into steam by adding latent heat. In the case of water, 1 kg of ice at 0 degree must absorb 80Kcal of latent heat to change to 1 kg of water at 0 degree, and 1 kg of water at 100 degrees must absorb 539 Kcal of latent heat to change to 1 kg of steam.

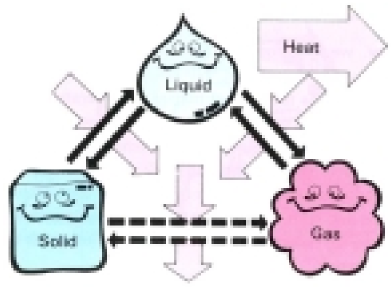
Sensible Heat and Latent Heat



Three States of Matter

As you know, matter exists in thee states; solid, liquid and gas. In the case of water, the solid state is ice, the liquid state is water, and the gas state steam.

Three States of Matter



① Fusion

When solid melts into liquid, heat is absorbed from the surrounding matter.

② Solidification

In the opposite situation, when liquid changes into a solid, heat is released to the surrounding. In the case of water, when 1 kg of ice melts into 1 kg of water, under atmospheric pressure, 80 kcal of heat is absorbed from the surrounding.

③ Evaporation

When liquid evaporates into gas, heat is absorbed from the surrounding.

④ Condensation

In the opposite situation, heat is released to the surrounding.
In the case of water, when 1 kg of water evaporates into 1 kg of steam 539 kcal of heat is absorbed from the surrounding.
In the opposite situation, 539 Kcal of heat is released to the surrounding matter.

⑤ Sublimation

In rare case such as dry ice (solid carbon dioxide) and naphthalene, heating causes the solid to directly turn into gas.

⑥ Adhesion

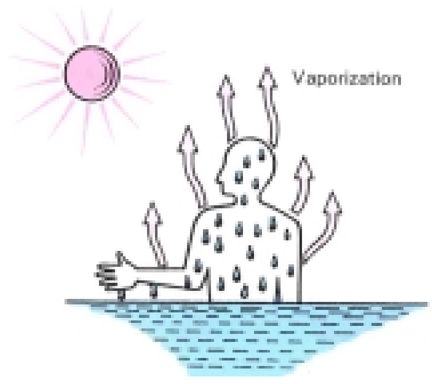
The reverse process is called adhesion.

PRINCIPLE OF COOLING

A cooler cools and dehumidifies the air inside the vehicle or fresh air from outside the car so as to produce comfortable cooling.

BASIC THEORY OF COOLING

Vaporisation

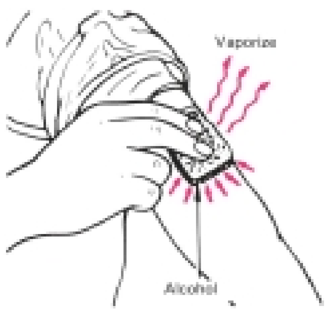


After swimming on a hot day we feel a little cold. This is because the water remaining on our body eventually vaporises. Whilst vaporising, this is drawing heat from our body.

For the same reason, we feel cool when we apply alcohol to our skin. The alcohol is placed as a liquid on our skin. After a short time the liquid starts to change into a gas (vaporise).

In this process heat is drawn from our skin (our skin feels cold). Using this principle we can apply it to an air conditioning system. ie: Heat being drawn when a liquid vaporises to a gas.

Basic Theory of Cooling



REFRIGERANT

Refrigerant is a substance that services as a moving fluid in a refrigerator and circulates through functional parts to produce the cooling effect by absorbing heat through the expansion valve and vaporising. The refrigerant used in new vehicle today is now HFC 134a, which has no-ozone-destroying properties (does not contain chlorine).

Characteristics of HFC134a

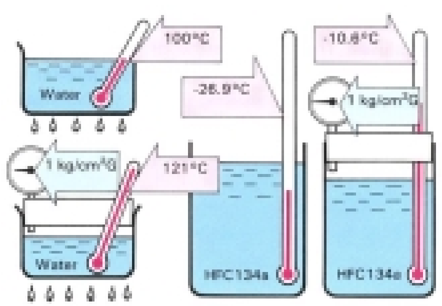
Water boils at 100^0C under atmospheric pressure, but HFC134a boils at -26.9^0C under atmospheric pressure.

Water boils at 121^0C under 1 kg/cm^{2}G (98kPa) of pressure, but HFC134a boils at -10.6^0C under 1kg/cm^{2}G (98 kPa) of pressure.

If HFC134a were released to the air under normal room temperature and atmospheric pressure, it will absorb the heat from the surrounding air and boil immediately, changing into a gas.

HFC134a is also easily condensed back into liquid under a pressurised conditions by removing the heat.

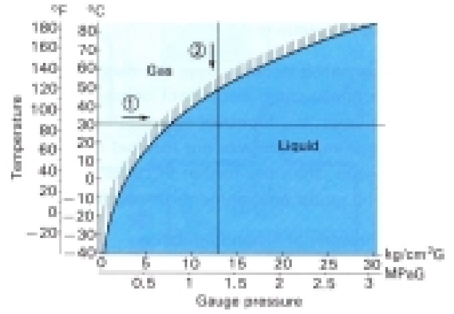
Characteristics of Refrigerant (HFC134a)



The graph shows the characteristic relationship between the temperature and pressure of HFC 134a.

The curve in the graph indicates the boiling point of HFC134a under different temperatures and pressures. The upper portion above the curve is gaseous HFC134a and the lower portion is liquid HFC134a.

Refrigerant Saturating Curve



Example-1

The gaseous refrigerant can be converted into the liquid refrigerant by increasing the pressure without changing the temperature.

Example-2

The gaseous refrigerant can also be converted into a liquid by decreasing the temperature without changing the pressure.

Conversely

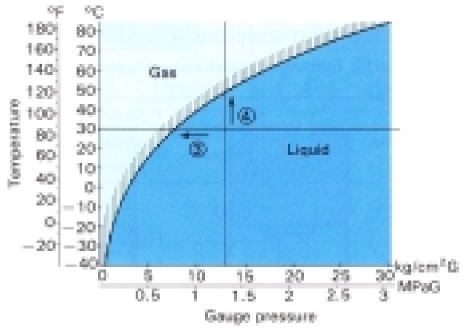
Example-3

The liquid refrigerant can be converted into gas by decreasing the pressure without changing the temperature.

Example-4

The liquid refrigerant can be converted into a gas by increasing the temperature without changing the pressure.

Refrigerant Saturating Curve



HFC134a has very good characteristics and properties to be used in automotive air conditioning systems. It is nonflammable, non-explosive, non-poisonous, non-corrosive, odourless and harmless to clothes and food.