THERMAL PHYSICS

This is the branch of physics that deals with the study of heat and temperature.

Heat can be defined as the internal energy that flows from one body to another due to temperature difference. Heat energy is a scalar quantity. It is measured using a calorimeter.

Temperature can be defined as the physical property that determines the direction in which heat energy will flow when two bodies are in contact with each other. Heat energy will flow from a body of higher temperature to a body of lower temperature.

Temperature is also defined as the measure of the degree of hotness or coldness of the body. In molecular physics it is defined as the measure of the average kinetic energy of the molecules.

The instrument used to measure temperature is called a Thermometer.

NB:

The instrument used to measure very low temperature is the cryometer. The cryometer is a thermometer. The following devices can be used as cryometers

1. Thermocouples: They can measure temperature of about 1K
2. Vapor temperature thermometers: They can measure about 0.5K
3. Resistance thermometers: They can measure 0.01K
4. Melting curve thermometers: They can measure between 0.001 and 0.5K
5. Resistance noise Theremometers
6. Magnetic Thermometers
7. Nuclear-Resonance Thermometers: These can measure 0.000000K

NB:

The instrument used relatively high temperatures such as are encountered in furnaces. Most pyrometers work by measuring radiation from the body whose temperature is to be measured. Radiation devices have the advantage of not having to touch the material being measured

UNITS OF TEMPERATURE

Temperature is measured in three different units which are

1. Celsius or Centigrade
2. Fahrenheit
3. Kelvin (K)

A temperature in Kelvin is known as absolute temperature. The Kelvin scale has no negative values that means the minimum value in the Kelvin scale is

0K is also known as the absolute zero temperature. 0K is equals.

At 0K, the volume of any gas is theoretically at 0

These units can be converted from one form to another.

To convert between Celsius and Fahrenheit

To covert between Celsius and Kelvin

For the purpose of (Nigerian) exams, the following is used instead

From

But

If we want to multiply through by 5

THERMAL EQUILIBRIUM

Two bodies are said to be in thermal equilibrium if they have the same temperature

ZEROTH’S LAW OF THERMODYNAMIC EQUILIBRIUM

This states that;

If two thermodynamic systems are each in thermal equilibrium with a third system, then they are in thermal equilibrium with each other.

Two systems are said to be in the relation of thermal equilibrium if they are linked by a wall permeable only to heat and they do not change overtime.

THERMOMETERS

A thermometer is a device that is used to measure temperature

Before taking the types of thermometers we’re going to look at how thermometers are constructed.

A thermometer consists of a thermometric substance and this thermometric substance has a thermometric property.

THERMOMETRIC SUBSTANCES

These are substances that employed in the construction of thermometers

Mercury and Alcohol: These are thermometric substances that are usually used in liquid in glass thermometers. Mercury is used in clinical thermometer and are used in the maximum and minimum thermometers.

DIFFERENCES BETWEEN MERCURY AND ALCOHOL

|  |  |
| --- | --- |
| Mercury | Alcohol |
| Boils at a very high temperature | Boils at |
| Freezes at | Freezes at |
| Measures relatively high temperatures well | Measures relatively low temperatures well |
| Does not wet glass | Wets glass which is bad |
|  |  |

THERMOMETRIC PROPERTIES

These are the physical properties that vary with temperature. They are used to measure the temperature of a substance. Examples include

1. Expansion of a liquid ion terms of volume
2. Expansion of a liquid in terms of length
3. Increase in pressure at constant volume
4. Electrical Resistance
5. Electromotive Force
6. Change in color in an optical pyrometer
7. All thermometric substance should
8. Be good conductors of heat
9. Have uniform expansion
10. Have high coefficient of expansion
11. Have low melting points
12. High boiling points
13. Low specific heat capacity

NB: Water is not a suitable thermometric substance because

CONSTRUCTION AND CALIBRATION

Fixed points are usually employed in when constructing and calibrating thermometers. Fixed points are the unique temperatures at which physical events such as melting of ice or boiling of water take place.

1. Upper Fixed point (Steam point): This is the temperature of steam of boiling water at normal atmospheric pressure. It can also be defined as the temperature at which pure water and pure water vapor are in equilibrium. This temperature is or or. The instrument used to determine the upper fixed point of a thermometer is called a Hypsometer
2. Lower fixed point: This is the temperature of pure ice. It can be defined as the temperature at which pure ice and pure water are in equilibrium at normal atmospheric pressure. This temperature is and or.
3. Triple point of water: This is the unique temperature at which pure ice, pure water and pure water vapor are at equilibrium. The triple point of water is.

TYPES OF THERMOMETERS

1. Liquid in glass thermometer: This is the thermometer used in our day to day lives. They are broadly classified into two
2. Clinical thermometer: This uses mercury as its thermometric substance. These are thermometers used in hospitals and at home to check the temperature of humans. Since the average temperature of the body is , This thermometer is constructed to have a short range (i.e. from to )

One of the main features in this thermometer is the constriction (kink) which prevents the mercury from running back to the bulb.

This thermometer can be sterilized in boiling water due to the rapid increase in the mercury level that can cause the thermometer to break.

1. Maximum and minimum thermometer: This thermometer is used to measure the maximum and minimum temperatures of the day. It makes use of mercury and volatile alcohol. Both components are arranged in the form

Alcohol (at one end of the tube) – Mercury (at the U-Tube) – Alcohol (At the other end)

1. Resistance Thermometer: The thermometric property of this thermometer is the electrical resistance of the wire in it. The thermometric substance (wire) is the Platinum wire. Platinum is used because it is pure and does not take part in chemical reactions easily.

This thermometer is used to measure the temperature of liquids accurately. It measures a wider range of temperatures than the liquid in glass thermometers.

The major disadvantage of this thermometer is that it can’t be used to measure varied temperatures.

1. Thermocouple: The thermometric property of this thermometer is the electromotive force (emf) of the cell involved or created.

A thermocouple consists of two different metal s joined at different ends. If one of the ends is heated and the other is cooed (frozen), an electric current will be created. The electric current can be used to measure a temperature that will be established between the junctions.

The magnitude of the current depends on:

The metals used

The temperature between the two junctions;

A thermocouple is used to measure a wider range of temperatures accurately. It is also used to measure varied temperatures such as the temperature of an airplane wing after flight.

1. Gas Thermometer: this is the thermometer that can be used to measure a very high temperature accurately. It is also known as a standard thermometer because of its high degree of accuracy and precision.
2. Constant Volume Gas Thermometer
3. Constant Pressure

The major disadvantage of this thermometer is that it does not attain thermal equilibrium easily. Also, it can’t be used in school because of its large size.

THERMAL EXPANSION

The size of a solid is altered when there is an increase in temperature. Solids expand when heated and contract when cooled. The amount of expansion depends on the nature of the solid and the temperature involved.

Actually when a solid is heated, so many effects can happen which include

1. Expansion
2. Change in state
3. Increase in temperature
4. Burning
5. Deformation
6. Change (i.e. increase or decrease) in resistance
7. Thermionic Emission

ADVANTAGES OF EXPANSION

The knowledge of expansion is used to constructing thermostats. A thermostat is a device used to maintain constant temperature

It is also used to construct bimetallic thermometers

They are used in the balance wheels of rails

The knowledge of expansion helps to remove tight rubbers from glasses without the glasses breaking or destroying the rubber.

DISADVANTAGES OF EXPANSION

1. Sagging of overhead cables
2. Gaining and/or losing of time as a result of the expansion and contraction of the balance wheel of a watch
3. It can cause the collapse of a bridge if it expands at a fixed point. That’s why they usually use rollers in the construction of bridges.
4. It can cause the bursting of water pipes in cold weathers since solids contract in cold weathers.
5. Expansion causes thick glasses to break or crack if hot water is poured into it due to uneven expansion of the class. It should be noted that thin glasses have uniform expansion while thick glass have differential or varying expansion

LINEAR EPANSION

This is defined as the increase in length per unit per degree rise in temperature

AREA EXPANSION

This is also called superficial expansivity

This is the increase in Area per unit area per degree rise in temperature

VOLUME EXPANSIVITY

This is also called cubic expansion

The instrument used to determine the cubic expansion of a substance is called a Dilatometer.

THERMAL STRESS

When a metal rod of length is heated and clamped rigidly to prevent expansion or contraction, tensile or compressive stresses called thermal stresses develop in the metal. The thermal stress is given as:

THERMAL EXPANSION OF LIQUIDS

When a liquid in a container is heated, the level of the liquid initially drops and then increases (like it normally should) later on. The initial drop in the level of the liquid is due to the expansion of the container in which it is placed.

Equal volumes of different liquids expand by different amounts for every degree rise in temperature.

The expansion of the liquid alone is called apparent cubic expansion

The expansion of the liquid and the container is called real cubic expansion

APPARENT CUBIC EXPANSION

This can be defined as the apparent increase in volume (mass) per unit volume (mass) per each degree rise in temperature when the volume of the container is taken as constant.

ANOMALOUS EXPANSION OF WATER

This explains the anomalous (strange) behavior of water when it is heated over a wide range of temperatures.

When ice below is heated, the ice increases in volume until it gets to. Between and, there is a decrease in the volume of water. At and above, the volume begins to increase as all other liquids.

It can therefore be said that the anomalous behavior of water is between and.

Since density varies inversely as volume, an increase in volume will correspond to a decrease in density and vice versa. Therefore the maximum density of water which is is at.