# General Physics

## Radiology Techniques Department

## 1st Class

## Al-Mustaqbal University college

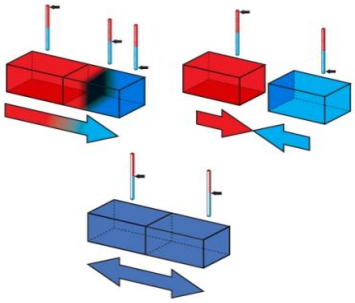


**Lecture 4: Thermodynamic**

**(Temperature and Heat)**

**2020/2021**

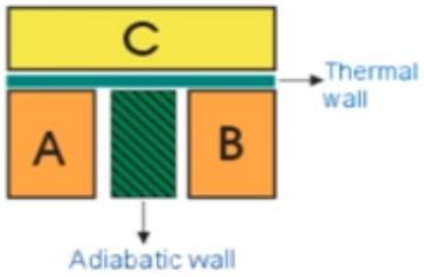
## Thermal Contact and Thermal Equilibrium



- Two objects are in **thermal contact** with each other if energy can be exchanged between them.
- **Thermal equilibrium** is a situation in which two objects would not exchange energy by heat or electromagnetic radiation if they were placed in thermal contact.

### Zeroth Law of Thermodynamics

If objects A and B are separately in thermal equilibrium with a third object C, then A and B are in thermal equilibrium with each other.




## Temperature and Thermometer Scale

- **Temperature** is the measure of hotness and coldness of the body.
- **Thermometer** is a device that is used to measure the temperature of a system.
- Thermometers are based on the principle that some physical property of a system changes as the system's temperature changes.

| Type of thermometer<br>نوع الثيرمومتر | Material<br>المادة | Physical property<br>الكمية الفيزيائية |
|---|---|---|
| Liquid thermometer | Mercury or Alcohol | Change in length |
| Gas Thermometer | Hydrogen | Change in pressure |
| Resistance thermometer | Platinum | Change in resistance |
| Thermocouple thermometer | Chromel and Alumel | Change in electric potential |
| Radiation Thermometer | Pyrometer | Change in radiation colour |
| Magnetic thermometer | | Change in susceptibility |

- Change of temperature may alter the electrical resistance, conductivity, viscosity….

**The three scales that have been developed to measure temperature are….**
Celsius (°C), Fahrenheit (°F) and Kelvin (K)

## 1-Celsius Scale

In this scale, the freezing point of water is zero (0°C) and temperature of the boiling water is 100°C.

## 2-Fahrenheit Scale

In this scale, the freezing point of water at 32°F and boiling water is at 212°F.

## 3-Kelvin Scale

In this scale, The freezing 273.15 K and the temperature of boiling water is 373.15 K. The 0 K temperatures is equal to –273°C in Celsius scale. At 0 K, the atomic particles are at rest and hence, it is called absolute zero

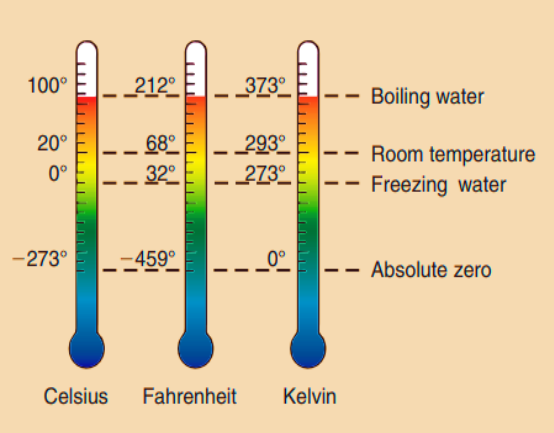
Temperature Scales

$$T_C = \frac{5}{9}(T_F - 32)$$

$$T_F = \frac{9}{5}T_C + 32$$

$$T_K = T_C + 273$$

C, F, and K refer to Celsius, Fahrenheit, and Kelvin, respectively.




**Three scales used to represent temperature.**

**Question:** Convert 77°F to degrees Celsius.

**Solution:** $T_c = 5/9\ (T_f - 32) = 5/9\ (77 - 32) = 25°C$

## Internal Energy (Thermal Energy)

Internal energy which is the sum of the mechanical energies of its molecules

**Internal energy does include kinetic energies due to:**

- Random translational motion
- Rotational motion
- Vibrational motion Internal energy also includes potential energy between molecules

## Heat

Heat is a form of energy that is very important to radiologic technologists. Excessive heat, a deadly enemy of an x-ray tube, can cause permanent damage. **Heat** is a type of energy transfer that is caused by a temperature difference

- The unit of heat, the calorie, is defined as the heat necessary to raise the temperature of 1 g of water by 1°C.
- more precise, measurements determined the amount of mechanical energy needed to raise the temperature of water from 14.5°C to 15.5°C.

1 cal = 4.186 J This is known as the mechanical equivalent of heat.

## Heat Capacity and Specific Heat

The **heat capacity** of a material is the amount of heat required to raise its temperature 1 g by 1°C.

$$Q = C\,\Delta T$$

The amount of heat required to raise temperature of a 1 kg material by 1°C is called **specific heat capacity**, and it is expressed in J/kg °C

$$c = \frac{C}{m} \qquad then \qquad C = mc$$

where c is called the specific heat capacity or specific heat.

**Table 1: specific heat of some substance at 25 °C and 1 Atmospheric pressure**

| Substance | specific heat J/kg °C |
|---|---|
| Al | 900 |
| Cu | 387 |
| Glass | 873 |
| Wood | 1700 |
| Water | 4186 |
| Ice | 2090 |

- Water has the highest specific heat of common materials (**God's Wisdom)**.

The equation is often written in terms of Q :

$$Q = m\, c\, \Delta T$$

Example: A 0.500-kg aluminum pan on a stove and 0.250 kg of water in it are heated from 20.0 °C to 80.0 °C . (a) How much heat is required? What percentage of the heat is used to raise the temperature of (b) the pan and (c) the water?

Answer :

$\Delta T = T_f - T_i = 60.0$ °C.

$Q_w = m_w\, c_w\, \Delta T$

$= (0.250\ kg)\ (4186\ J/kg\ °C)\ (60.0\ °C) = 62.8\ kJ.$

$Q_{Al} = m_{Al}\, c_{Al}\, \Delta T$

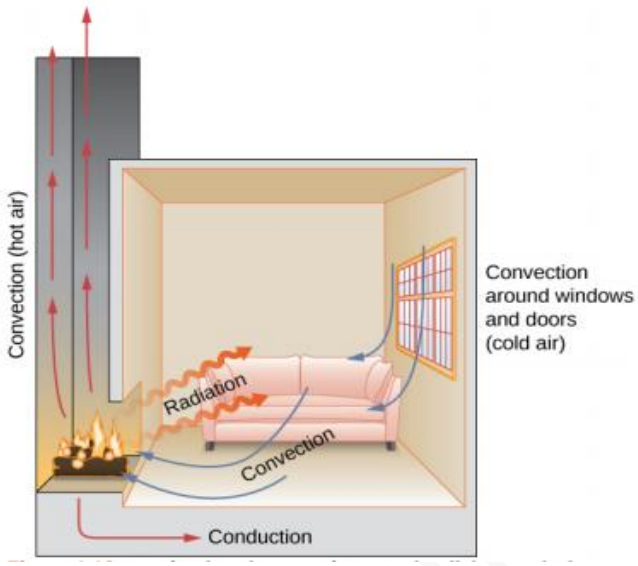
$= (0.500\ kg)\ \ (900\ J/kg\ °C)\ (60.0\ °C) = 27.0\ kJ$

Find the total transferred heat:

$Q_{Total} = Q_w + Q_{Al} = 89.8\ kJ$

## Methods of Heat Transfer

- Heat is transferred by **conduction**, **convection**, and **radiation**.




**Conduction** is the transfer of heat through a material or by touching. Heat is conducted from an x-ray tube anode through the rotor to the insulating oil.

**Convection** is the mechanical transfer of "hot" molecules in a gas or liquid from one place to another.

**Radiation** is the transfer of heat by the emission of infrared radiation. An x-ray tube cools primarily by radiation.

**1-(H.W)** "Room temperature" is generally defined in physics to be 25 °C . (a) What is room temperature in °F? (b) What is it in K?

**2-(H.W)** A 0.250-kg block of a pure material is heated from 20.0 °C to 65.0 °C by the addition of 4.35 kJ of energy. Calculate its specific heat and identify the substance of which it is most likely composed.