University of Mosul

College of Science

Department of Physics

Second Stage

Heat and Thermodynamic

2024 – 2025

Lecture 3: Kinds of thermometers: Gas & liquid thermometers

Preparation

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2. Gas thermometers: These are thermometers that depend on the principle of a change in gas pressure when the volume is fixed, or a change in the gas volume when the pressure is constant with the change in temperature.

2.1 Jolly's constant volume air thermometer

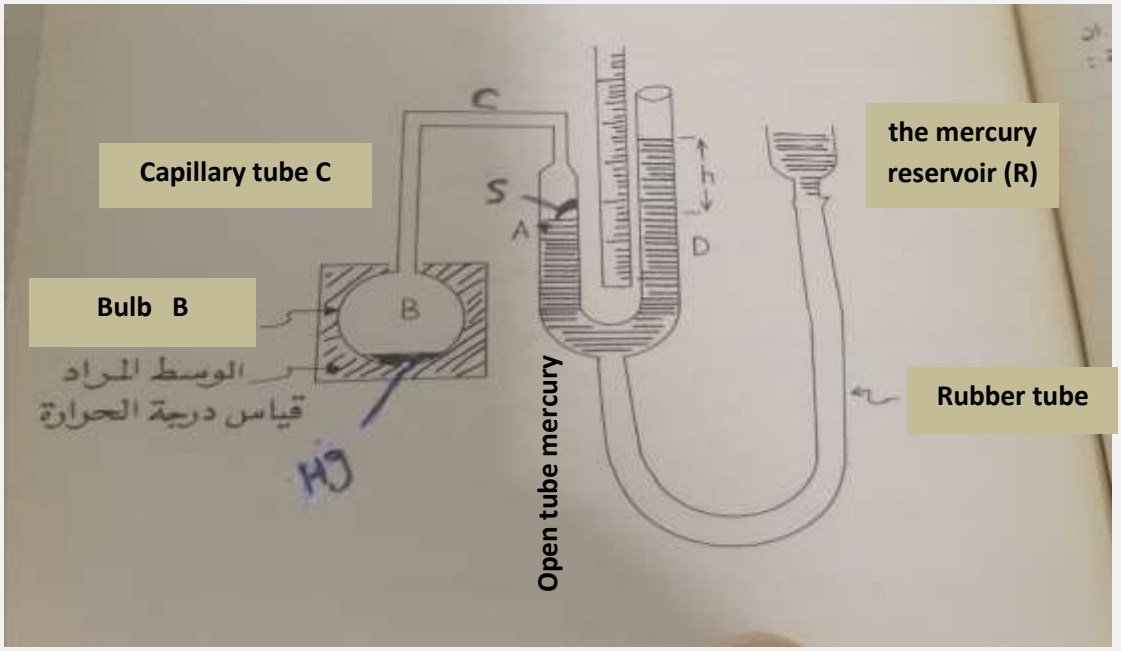
This thermometer is one of the most important and accurate thermometers, and its principle of operation is based on the basis that the gas pressure under a constant volume increases with the increase in temperature according to the following relationship:

$P_t = P_0(1+\gamma t)$

P_t : pressure of gas at temp. t

P_0 : pressure of gas at t_0

γ: coefficient of increasing pressure with temp.



Calibration the thermometer :To calibrate the thermometer with the Celsius scale, the bulb B is placed in crushed ice until the trapped gas becomes thermally balanced with the ice at 0C° and then the reservoir position is

modified, So that the surface of mercury becomes in contact with the sign S and then the gas pressure P_0 is set at zero degrees, which is equal to the atmospheric pressure P plus the difference between the two columns heights of mercury h_0,

$P_0=P+h_0$ ……..(2)

Then the bulb is placed in boiling water and the volume of gas is fixed and on it:

$P_{100}=P+h_{100}$ ……..(3)

Where h_{100} represents the difference between the two verticals of mercury at $100C$, then the bulb is placed in the liquid whose unknown temperature t is to be measured. The previous steps are repeated and we find that:

$P_t=P+h_t$ ……..(4)

As the volume of gas is constant, the pressure increases according to equation (1). We apply this equation at degrees t and $100C$, and we get:

$P_t=P_0(1+\gamma t)$

$P_{100}= P_0 (1+\gamma 100)$

We arrange these two equations and we get:

$Pt - P_0 = P_0 \gamma t$

$P_{100} - P_0 = P_0 \gamma 100$

$$t = \frac{P_t - P_0}{P_{100} - P_0} * 100 \dots\dots(5)$$

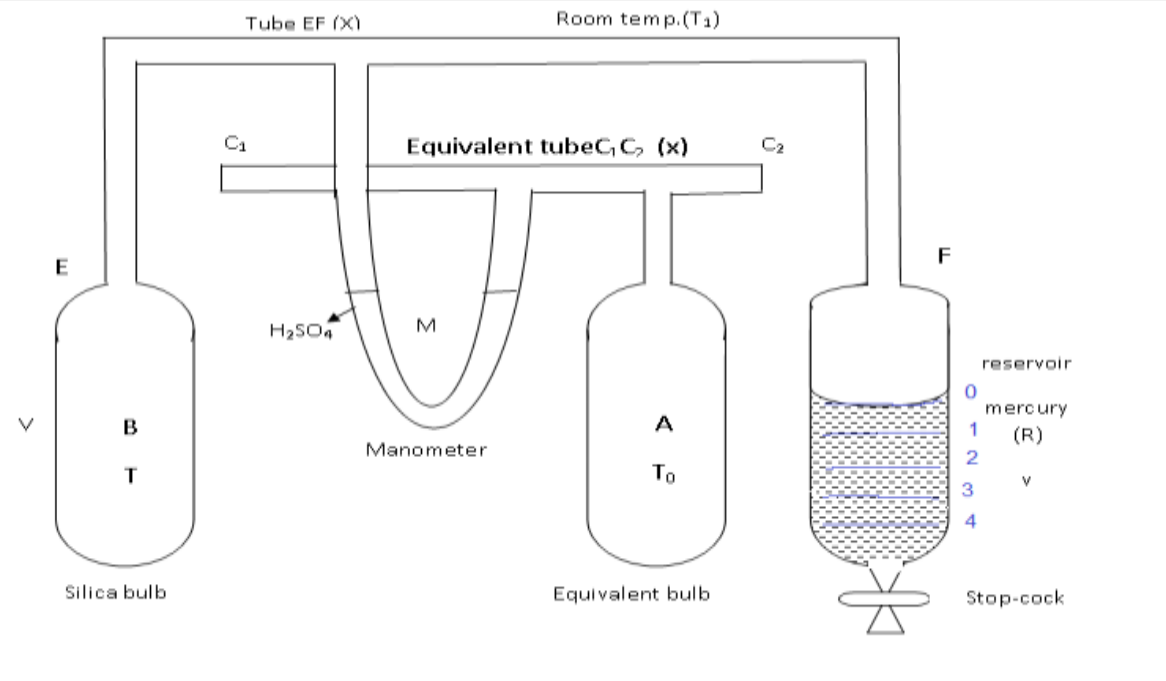
After substituting equations (2,3,4) into equation (5), we get:

$$t = \frac{(P + h\,t) - (P + h0)}{(P + h100) - (P + h0)} * 100$$

$$t = \frac{h_t - h_0}{h_{100} - h_0} * 100 \ldots \ldots (6)$$

Eq.(6) The temperature can be calculated in Celsius scale

2.2 Calender's Constant pressure air thermometer



The thermometer work

Bulbs A, B and reservoir R are placed in crushed ice and the ends of tube C_1C_2 are closed when the pressure on both sides of the manometer M is equal. So the air pressure in the bulb B is equal to the air pressure in the bulb A, Then we put the bulb B in the liquid whose temperature is to be measured, the pressure in the bulb B will increase and the levels of mercury in the manometer will vary, so open the tap slightly so that the mercury flows until the mercury is equal to the height of the two ends of the M manometer.

volume of the bulb A = volume of the bulb B = V

volume of tube EF= volume of equivalent tube C_1C_2=X

volume of air at the end of the reservoir R = v

Air pressure at each side = P.

temperature of the body whose temperature is to be measured = T

Room temperature = T_1

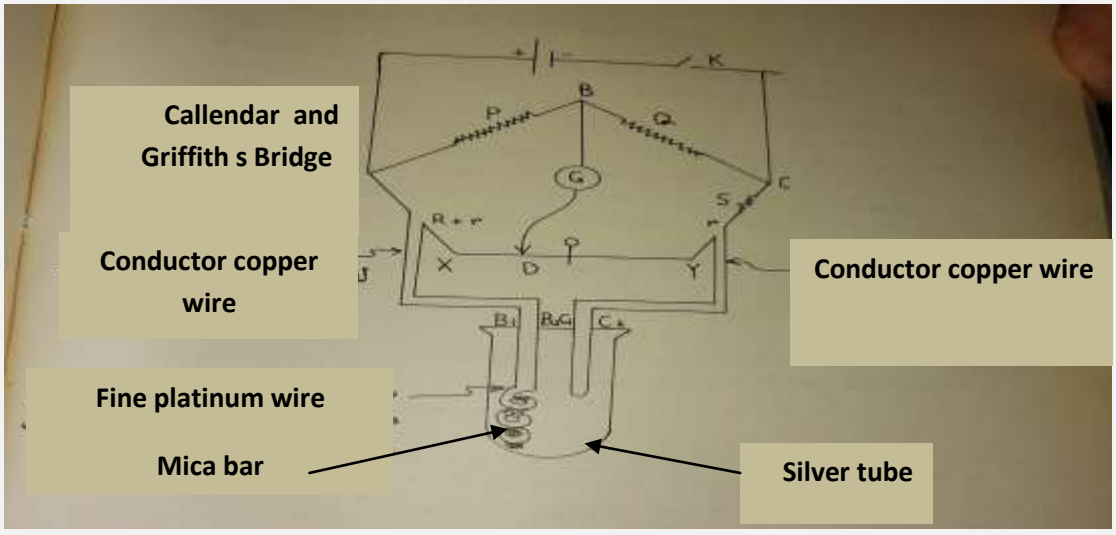
ice temperature =T_0

$$\therefore T = 273\left(\frac{V}{V-v}\right) \qquad K.\ldots(3)$$

https://www.youtube.com/watch?v=QfricLpCtccvhf رابط المحاضرة الخامسة

3. Electrical resistance thermometers (Platinum resistance thermometer) :

They are thermometers that work on the principle of change in electrical resistance with a change in temperature, for example: the platinum resistance thermometer.



To calibrate this thermometer, the tube containing the platinum wire is placed at known standard temperatures, then its resistance is measured at these degrees. Then the thermometer is placed in the medium with the unknown temperature and its resistance is determined in the same previous way, and from that the unknown temperature can be calculated. If it is:

R_t : resistance of the platinum wire at a temp. t

R_0 : resistance of the platinum wire at 0C °

$R_t=R_0(1+\alpha t+ \beta t^2)$ ……(1)

Where α and β are Constants dependent on the nature of the wire material. To find the values of these constants, we find the resistance value of the platinum wire in there standard known points:

1. ice point
2. steam point.
3. steam sulfur point 444.6C (In the case of measuring high temperatures)
4. In the case of measuring low temperatures, we use instead of the last point(the oxygen boiling point –182.5C°), and at these points the equation is

$R_{100}=R_0(1+\alpha 100+\beta(100)^2)$ ……..(2)

$R_{444.6}=R_0(1+\alpha 444.6+\beta(444.6)^2)$……(3)

By solving these two equations simultaneously, we obtain the values of the constants (α and β) from the last equation. We can neglect βt^2 because the value of is very small, and thus the equation becomes as follows:

$R_t=R_0(1+\alpha t)$……....(4)

$R_{100}=R_0(1+ \alpha\ 100)$…..(5)

from eq.(4)we get

$R_t-R_0=R_0\alpha t$…… (6)

$R_{100}-R_0=R_0\alpha 100$…… (7)

From the last two equations it results:

$$t = \frac{R_t - R_0}{R_{100} - R_0} * 100 \ldots\ldots (8)$$