Constant volume Hydrogen Thermometer:

Principle: The volume of the gas is kept constant and measuring the change in pressure of the gas with temperature the temperature can be calculated.

Theory: Let P_o, P_{100} & P_t be the pressure of the gas at 0^0 C,100^0 C & t^0 C respectively at constant volume . Using Charles law

$$P_t = P_0\left(1+\gamma_p t\right) \rightarrow (1)$$

Since t and γ_p are unknown hence we need two equation to find values

$$P_{100} = P_0\left(1+\gamma_p 100\right) \rightarrow (2)$$

From equation (1)

$$\frac{P_t}{P_0} = 1+\gamma_p t$$

$$\frac{P_t}{P_0} - 1 = \gamma_p t$$

$$\frac{P_t - P_0}{P_0} = \gamma_p t \rightarrow (3)$$

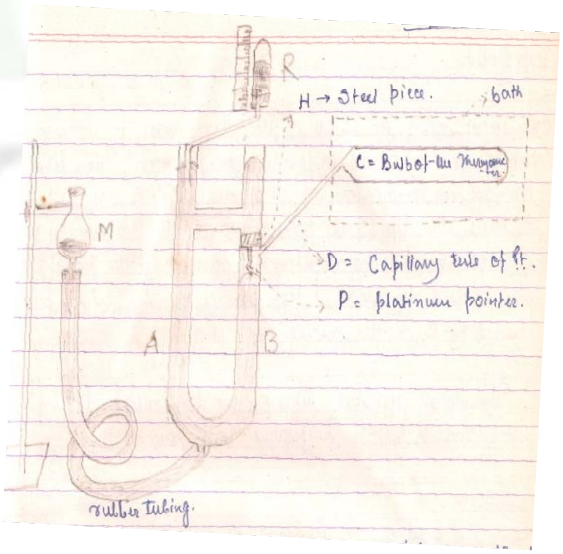
Similarly

$$\frac{P_{100} - P_0}{P_0} = \gamma_p \times 100 \rightarrow (4)$$

Dividing equation (3) by (4)

$$\frac{P_t - P_0 \big/ P_0}{P_{100} - P_0 \big/ P_0} = \frac{\gamma_p t}{\gamma_p \times 100}$$

$$t = \frac{P_t - P_0}{P_{100} - P_0} \times 100 \rightarrow (5)$$



Description: The bulb of the thermometer C consists of platinum- iridium tube of about one meter in length, 36 mm in diameter and one liter in capacity. The bulb C is connected with the limb B of a U tube by a capillary tube of platinum D of about one meter in length. The mercury column in limb B is separated into two parts by using a steel piece and both these parts communicate with the mercury column in limb A. M is the reservoir of mercury and is connected to the U tube by rubber tubing. R is a barometer for measuring the atmospheric pressure which is kept above the limb B and the stem of the barometer dips into the Hg column in limb A. P is a platinum pointer attached with the steel piece H. By raising or lowering the mercury reservoir M the level of Hg in the lower part of the limb B is always made to touch the tip of the pointer P, thereby keeping the volume of the gas constant during the experiment.

Experiment:

(1) The bulb of the thermometer is immersed in melting ice. By raising or lowering the reservoir the level of Hg column in the lower part of the limb B is just made to touch the tip of the pointer, making the volume of the gas constant. A cathetometer is focused at the tip of the pointer and the level of Hg column in the upper part of the limb B and the readings are noted.

(2) The same is repeated by keeping the bulb in boiling water and unknown temperature bath successively.

Calculation:

x_t , x_{100} & x_0 = Readings of the cathetometer when focused on the level of Hg column in the upper part of the limb B.

x = reading of the cathetometer when focused at the tip of the pointer P

P_A = atmospheric pressure

ρ = density of mercury

$$P_0 = P_A + h_0\rho g = P_A + (x_0 - x)\rho g$$
$$P_{100} = P_A + h_{100}\rho g = P_A + (x_{100} - x)\rho g$$
$$P_t = P_A + h_t\rho g = P_A + (x_t - x)\rho g$$
$$\therefore P_t - P_0 = (x_t - x_0)\rho g$$
$$P_{100} - P_0 = (x_{100} - x_0)\rho g$$

Using equation (5)

$$t = \frac{(x_t - x_0)}{(x_{100} - x_0)} \times 100$$

Advantage and disadvantage:

Using a constant volume hydrogen thermometer temperature from -200^0 C to 600^0 C can be accurately measured. Above 600^0 C accuracy slightly decreases up to 900^0 C Hydrogen diffused through platinum – iridium bulb and hence above 900^0 C a bulb of hard glass is used. Above 1200^0 C hydrogen diffuse through hard glass also. Hence nitrogen is used up to 1500^0 C above which nitrogen also diffuse through the bulb. Below -200^0 C helium is used instead of hydrogen.