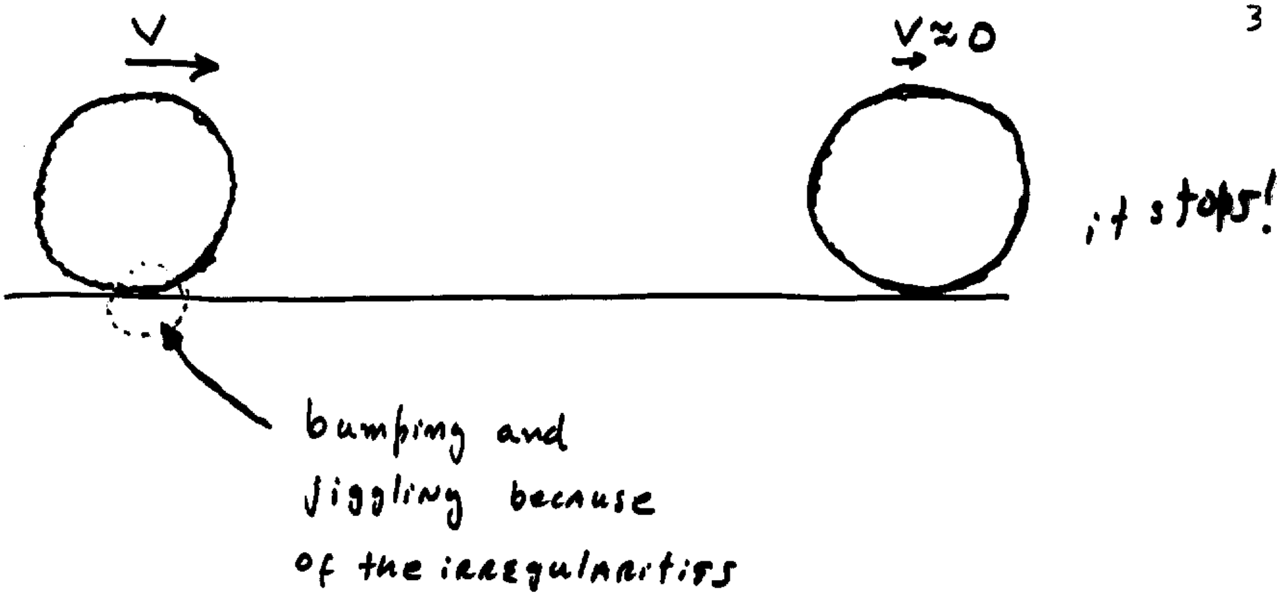
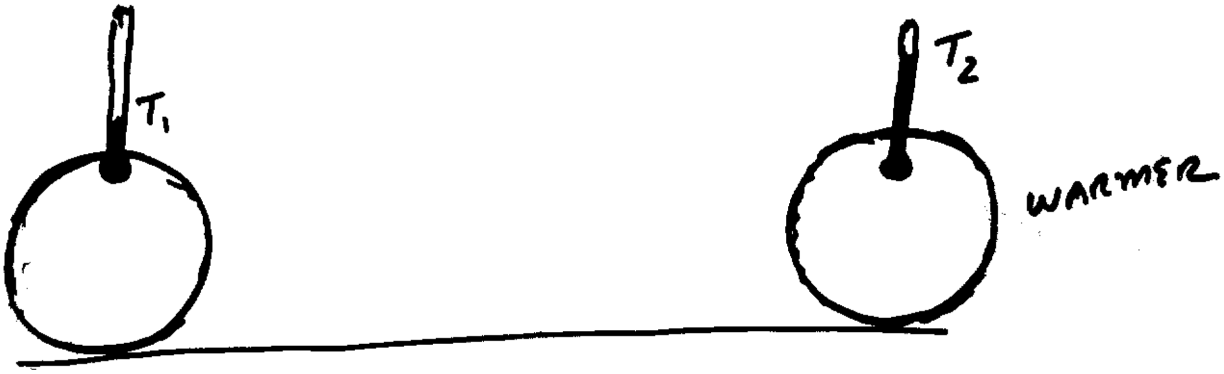
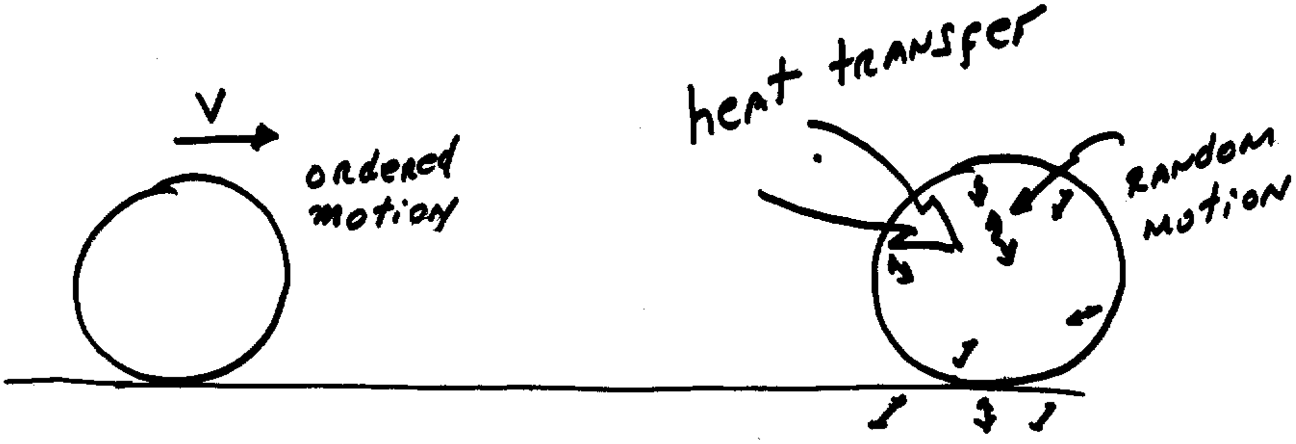
CONSERVATION of ENERGY.

what is energy?



where did the energy go?

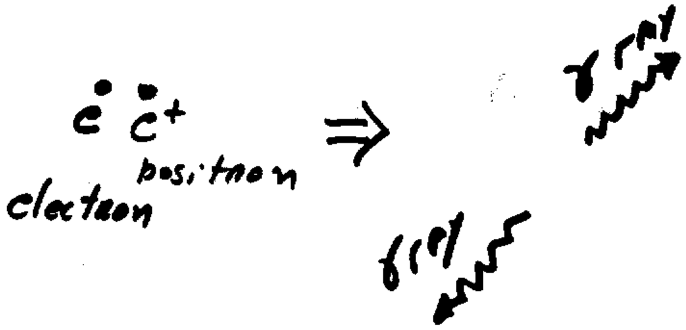




- ELECTRICAL ENERGY → pushing of electrical charges
- RADIANT ENERGY (light) → A form of electrical energy
- chemical energy → kinetic energy of electrons + interaction of e^-s and protons

  So. it is electrical

- NUCLEAR ENERGY → involved with the rearrangement of particles inside the nucleus.
- MASS ENERGY $E=mc^2$ → An object has energy from just its sheer existence



Knowing "m" we can find the frequency of the γ rays if we apply conservation of energy

So, the concept of energy conservation is useful.

What other <u>conservation laws</u> there are in Physics?

- SYMMETRY

ENERGY (time symmetry)

LINEAR MOMENTUM (translational symmetry)

ANGULAR MOMENTUM (rotational symmetry)

- COUNTING

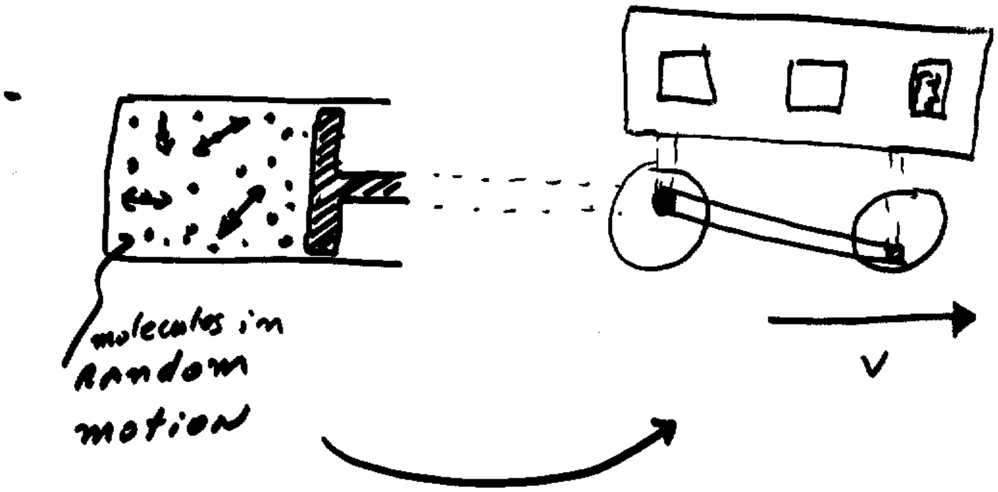
<u>CHARGE</u> CONSERVATION

CONSERVATION OF <u>BARYONS</u> neutron, proton, ...

CONSERVATION OF <u>LEPTONS</u> electron, neutrino

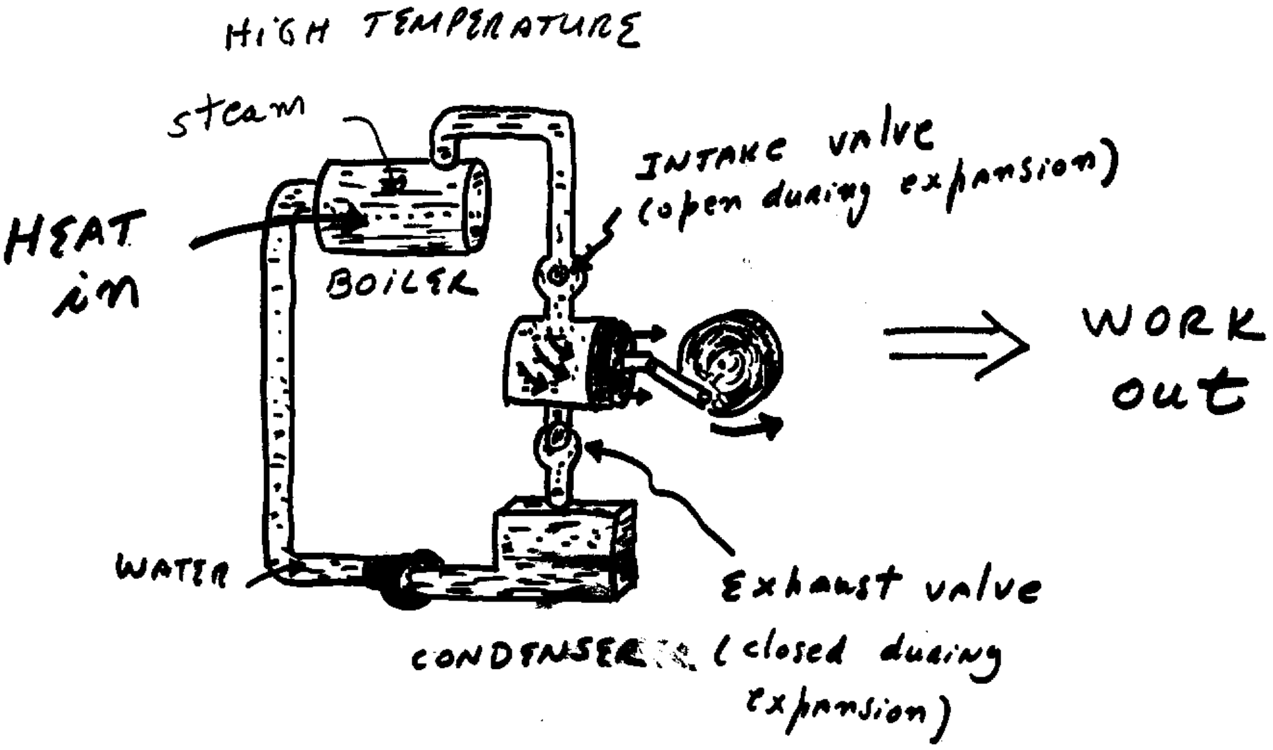
How much energy can be made available for human utility?

- WE KNOW ENERGY CONSERVES



It is hard to convert this random motion into an ordered motion with 100% efficiency

The laws that govern how efficient can we convert "random energy" int "ordered enegy" are called the LAWS of THERMODYNAMICS



Heat in ⇒ STEAM ENGINE ⇒ WORK out

CARNOT

CLAUSIUS

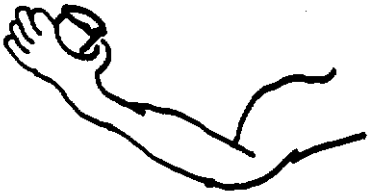
- SIMPLE THERMODYNAMIC SYSTEM:

macroscopic	unchnaged
homogeneous	chemically inert
isotropic	No electric fields
	No magnetic fields

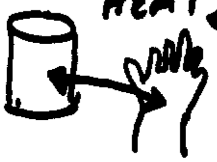
Example: cup of coffe, soda can

(gas in a laser discharge tube: maybe not)

- DISTINGUISHING WORK AND HEAT



$W = \frac{1}{2} m v^2 \leftarrow$ work you have done on the system

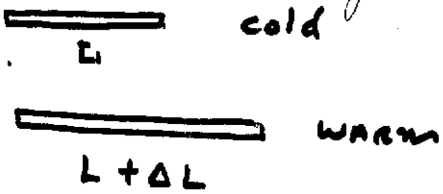


HEAT ← interchange of random motion energy

heat interchange will not stop until the temperatures of the can soda and your hand are equal.

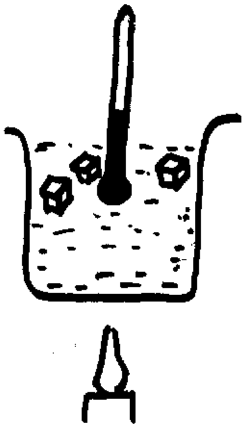
- HOW DO WE MEASURE TEMPERATURE ?

a) Firts, we notice that macroscopic material properties change upon applying heat



so, we build a thermoscope

b) Second, for calibration, we exploit the phase transformation water experience upon heating

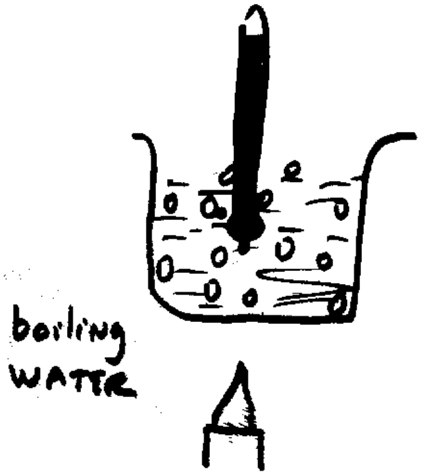


As we keep heating, we observe:

- the length of the Hg does not change (as far as there are ice cubes in coexistance with water)
- the solid ice cubes transform into liquid.

SO, we arbitrarily define this temperature as:

0° C (zero degrees celcius)

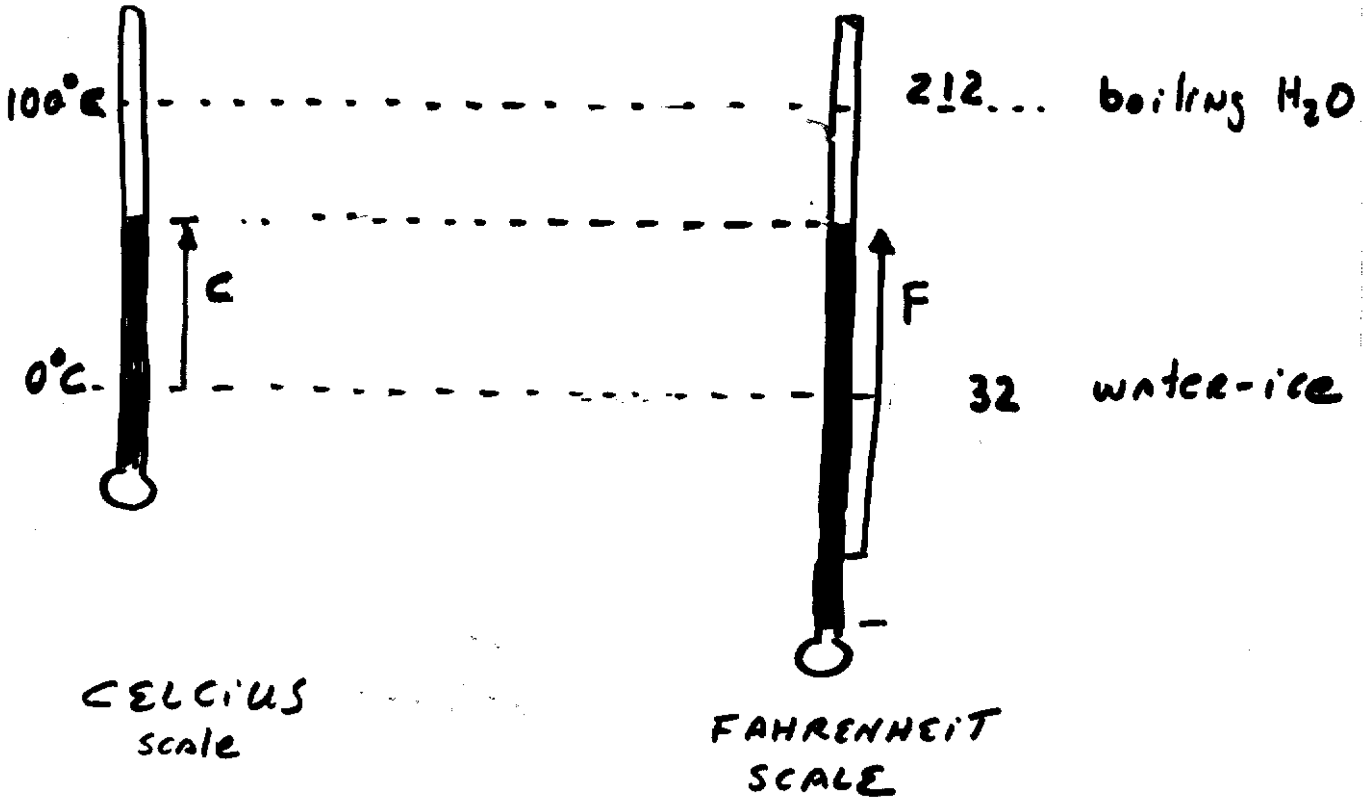


then we reach another point of phase transformation

- while the water keeps boiling, the temperaure or length of the Hg colum remains constant.

So we arbitrarily define this temperature as:

100°C (100 degrees celcius)



$$\frac{C}{100} = \frac{F-32}{180} \quad \Leftrightarrow \quad \boxed{C = \frac{5}{9}(F-32)}$$

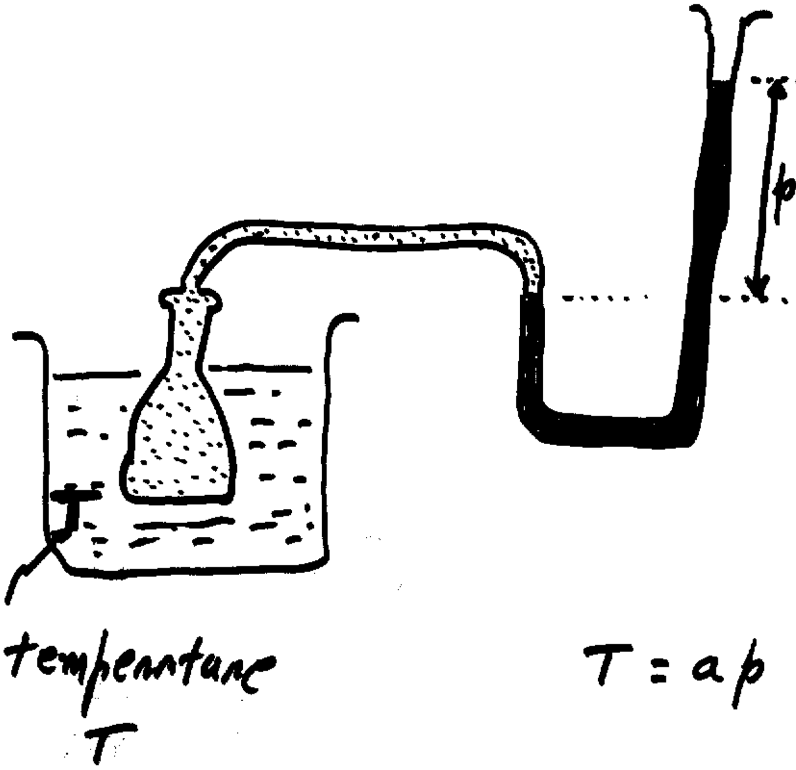
EXERCISE: At what temperature the readings of both thermoscopes above coincide?

or At what temperature both thermoscopes provide the same reading?

EXERCISE: Practice reading "sample problem 19-2" on p. 458

The same procedure can be used to calibrate other thermoscopes.

CONSTANT-VOLUME GAS thermometer



The height of the column of liquids is a measure of the pressure of the gas and can be used to quantify the temperature

$$T = ap + b$$

a, b const determined after calibration

All thermoscopes calibrated using the freezing and boiling point of water will read 0°C and 100°C at those points respectively. But, we have a question: If a Hg thermoscope indicates that the temperature of a system is 37°C does a constant-volume thermoscope also indicates 37°C ?

the answer is: No,

the reading differ, although, slightly.

But, the farther from the calibration points, the greater difference.

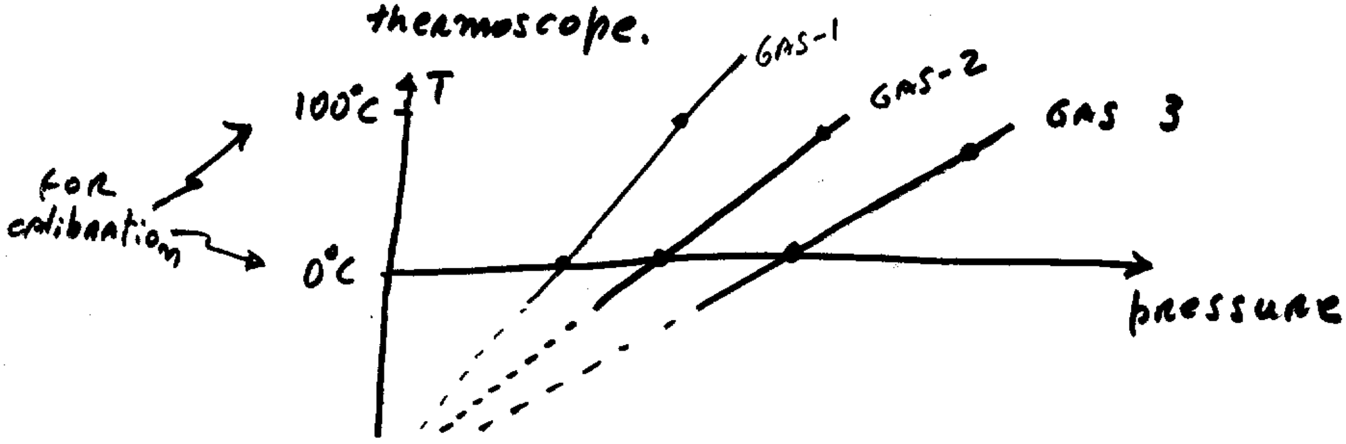
So, which thermoscope is correct?

Answer: NONE is 100% accurate

What to do?

Answer: Let's adopt a strategy such that the "actual" temperature of the system is independent of the particular means or substance used to determine the temperature.

Let's use the constant-volume gas thermoscope.



But precise calibration is difficult.

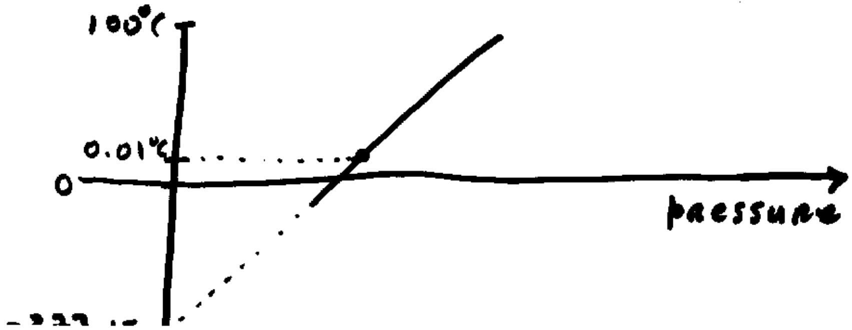
↳ Freezing and boiling point of water depend on the pressure on the water surface

($T_{boiling}$ increases with pressure)

To avoid these difficulties, a single-point calibration of a thermometer is made

Liquid water, ice and water vapor all coexist simultaneously at a unique temperature and pressure called the triple point of water

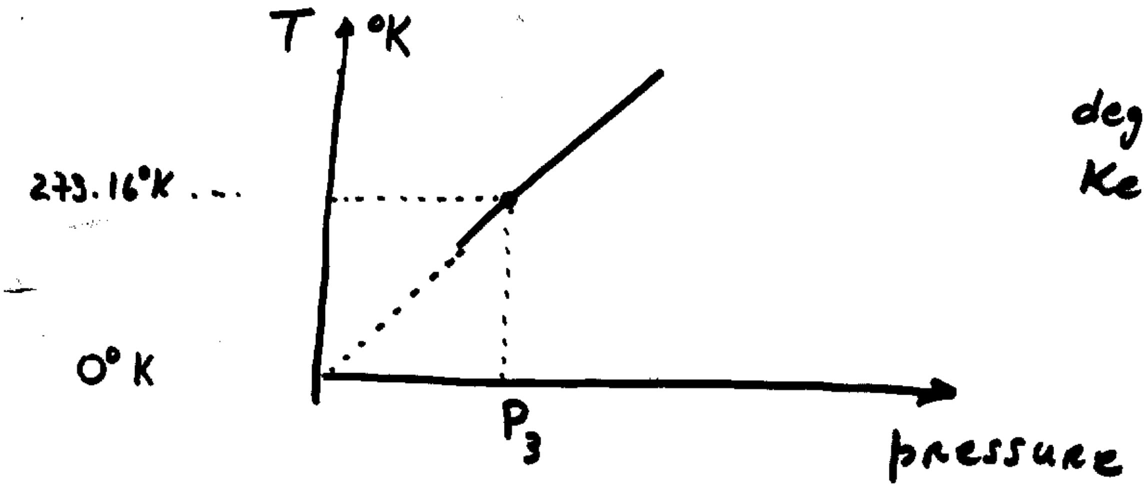
the temperature of the triple point of water is defined to be 0.01 °C;
the pressure of the mixture at the triple-point is experimentally found to be 611.73 Pa.



The ABSOLUTE-TEMPERATURE SCALE

The ideal-gas temperature scale is defined by setting the temperature of the triple point of water to be 273.16 °K

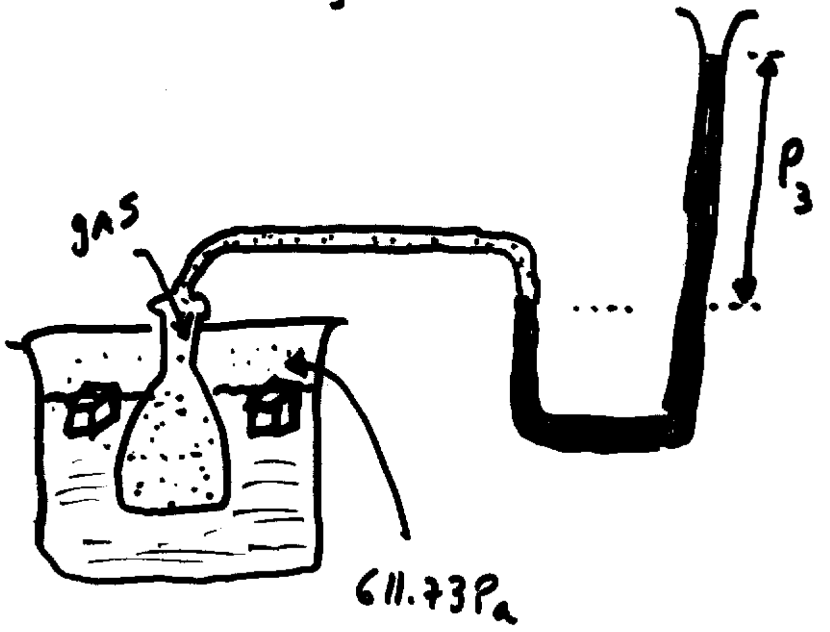
degrees Kelvin



$$\boxed{T = \frac{273.16}{P_3} P}$$

$$\boxed{T = t_{celcius} + 273.15\,K}$$

$$T = \frac{273.16}{P_3} P$$



The pressure P_3 in the formula above is <u>not</u> the pressure of the triple point of water 611.73 Pa, but the pressure of the gas in the constant-volume gas thermometer when it is in thermal equilibrium with a system of water, ice and water vapor at its triple point.

The pressure P_3 in the formula above depends on the specific amount in the constant-volume gas thermometer.