Logic behind Thermometers & Temperature Scales

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Thermometer…COVID times@IIT-K

How to design a Thermometer?

- Thermometer-1624 (*Recreaction Mathematique* by Leurechon)- Instrument to measure the degree of hotness/coldness…(Aristotle-original Bansal Sir of Kota Factory~300 BC, University of Bologna ~1088)
- Identify a material property that changes with temperature in a monotonous manner
- Material property should be easily measurable: *$l(T)$, $V(T)$*
- Nail down two "special temperatures": Melting & Boiling point
- Coexistence of ice-water: Melting/ice point → T_1
- Coexistence of water-steam (without air): Boiling/steam point → T_2
- "Triple point" is more special i.e. more reproducible

More to monotony

- Monotonous variation with temperature can be non-linear!
- Non-linear variation is due to "material properties"
- Problem with non-linear variation: One may agree with temperature measurement at the two distinct temperatures, but not in-between
- Fix: Monotonous Linear variation with temperature

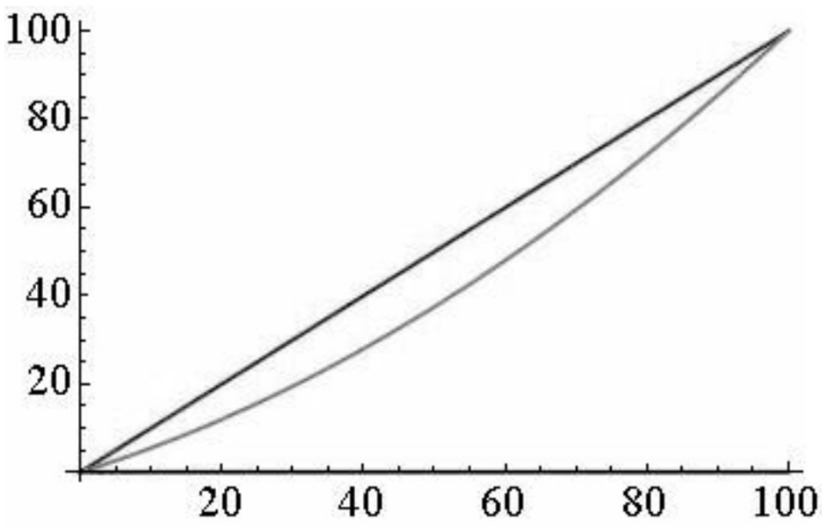
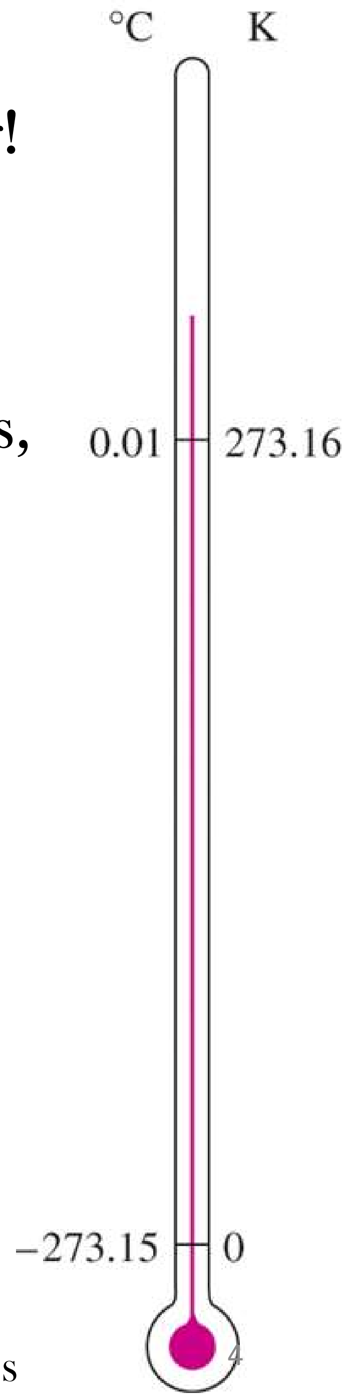


Fig: "Fundamentals of Physics" by R. Shankar



Figs: Cengel & Boles

Monotonous Linear variation of a property

- Gases have lesser interactions in general

- Ideally, the gases should be Ideal!

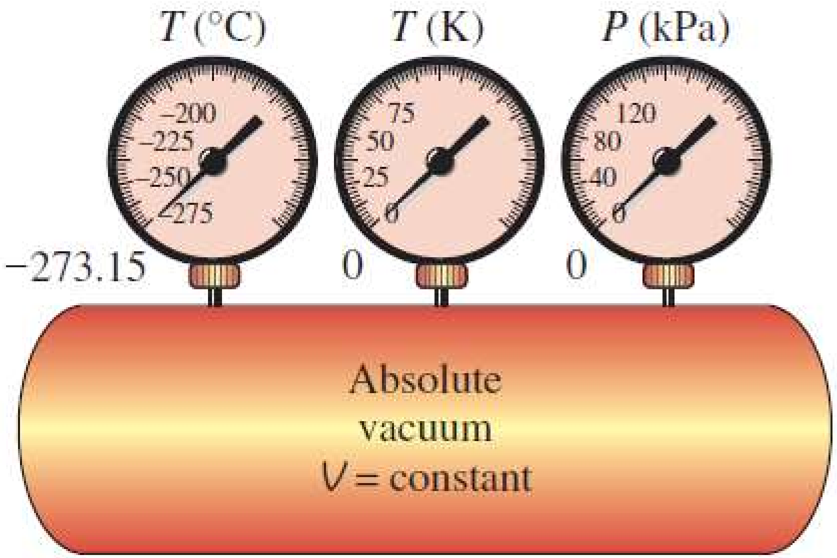


FIGURE 1–36
A constant-volume gas thermometer would read −273.15°C at absolute zero pressure.

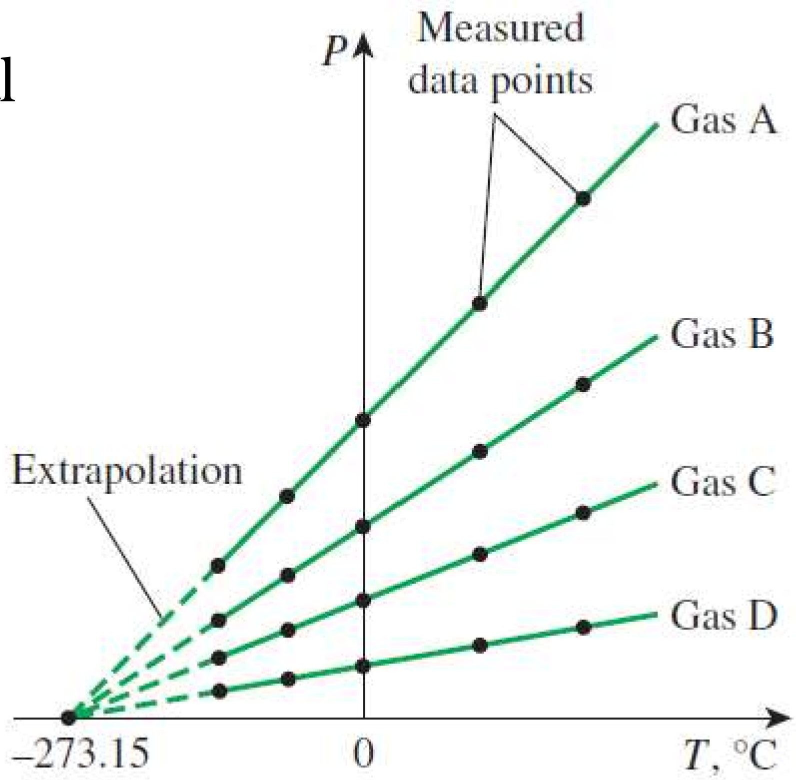


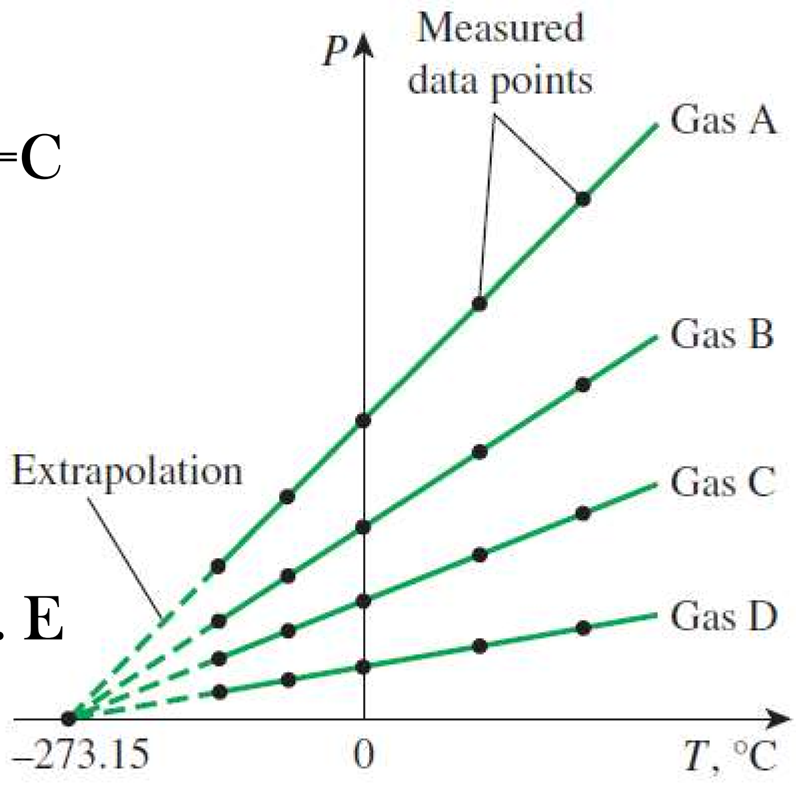
FIGURE 1–35
P versus T plots of the experimental data obtained from a constant-volume gas thermometer using four different gases at different (but low) pressures.

$$T(\text{K}) = T(^\circ\text{C}) + 273.15$$

Figs: Cengel & Boles

Kelvin scale is intuitive & natural!

- All gases at low pressure: PV=Constant=C
- Possible to keep reducing P & T
- Pressure cannot fall below zero!
- T (in Kelvin) is a measure of average K. E
- Hence, both T(**K**) $\geq$ **0** & P $\geq$ **0**
- $T = \lim_{p \to 0} \left(\frac{pV}{R}\right)$



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Temperature & 2^{nd} TD law: Advertisement

- Ideal gas: PV=Monotonous Fxn(T); Real gas: P(V-b)=Mono.Fxn(T)…this Fxn(T) cannot have maxima/minima/stationary point

- Defining Temperature without referring to properties of materials/gases is possible via 2^{nd} law of TD…