Announcements

1. Course schedule

   11/8-25: Chapters 19-22 – heat, thermodynamics

   11/25: 4^{th} hour exam

   11/27-29: Thanksgiving break

   12/2-6: Wave motion and review

   12/14: Final exam

2. Change in office hours for Fridays – 11-12/1-2

The notions of temperature and heat & the ideal gas law

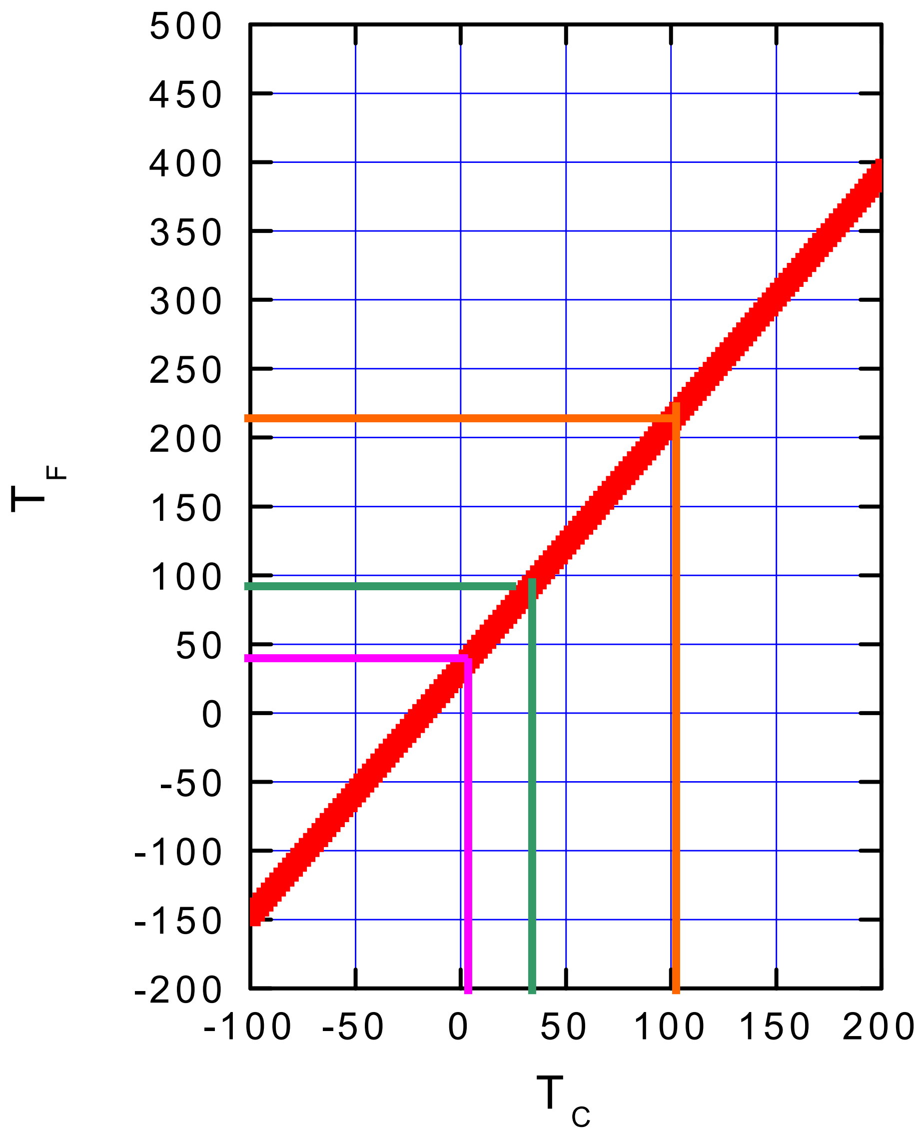
Random house dictionary definition:

temperature – a measure of the the warmth or coldness of an object or substance with reference to some standard value. The temperature of two systems is the same when the systems are in thermal equilibrium.

"Zeroth" law of thermodynamics:

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

Temperature scales $T_F = 9/5\ T_C + 32$



There is a lowest temperature:

$T_0 = -273.15^o\ C = 0\ K$

Kelvin ("absolute temperature") scale

$T_C = -273.15 + T_K$

Example –

Room temperature = 68^o F = 20^o C = 293.15 K

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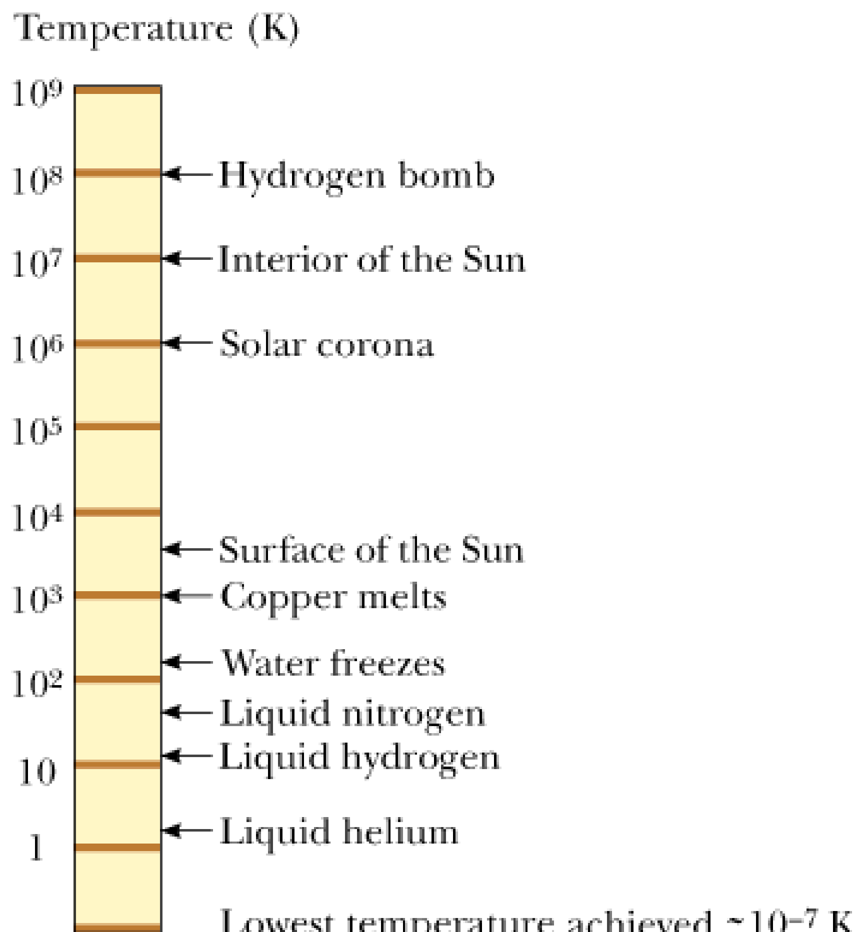
Figure 19.5



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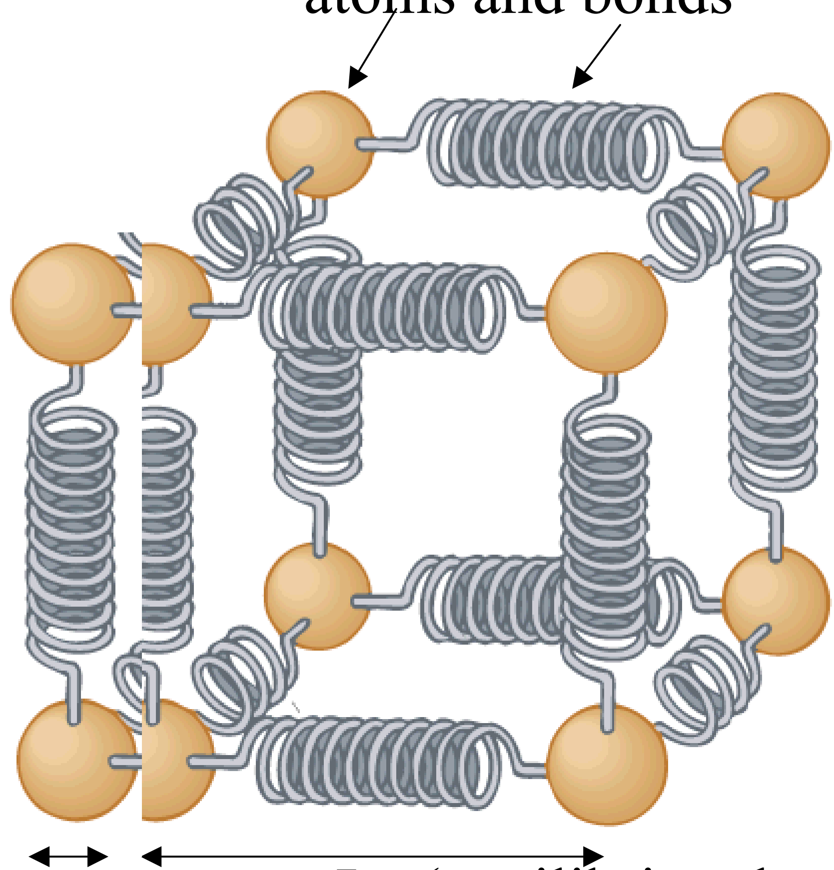
Effects of temperature on matter

Solids and liquids

Model of a solid composed of atoms and bonds



ΔL

L_i (equilibrium bond length at T_i)

Thermal exansion:

$$\Delta L = \alpha\, L_i\, \Delta T$$

Typical expansion coefficients at $T_C = 20^o$ C:

Linear expansion: $\Delta L = \alpha L_i \Delta T$

Steel: $\alpha = 11 \times 10^{-6} / {}^oC$

Concrete: $\alpha = 12 \times 10^{-6} / {}^oC$

Volume expansion:

$V=L^3 \quad \Rightarrow \Delta V = 3\alpha V_i \Delta T = \beta V_i \Delta T$

Alcohol: $\beta = 1.12 \times 10^{-4} / {}^oC$

Air: $\beta = 3.41 \times 10^{-3} / {}^oC$

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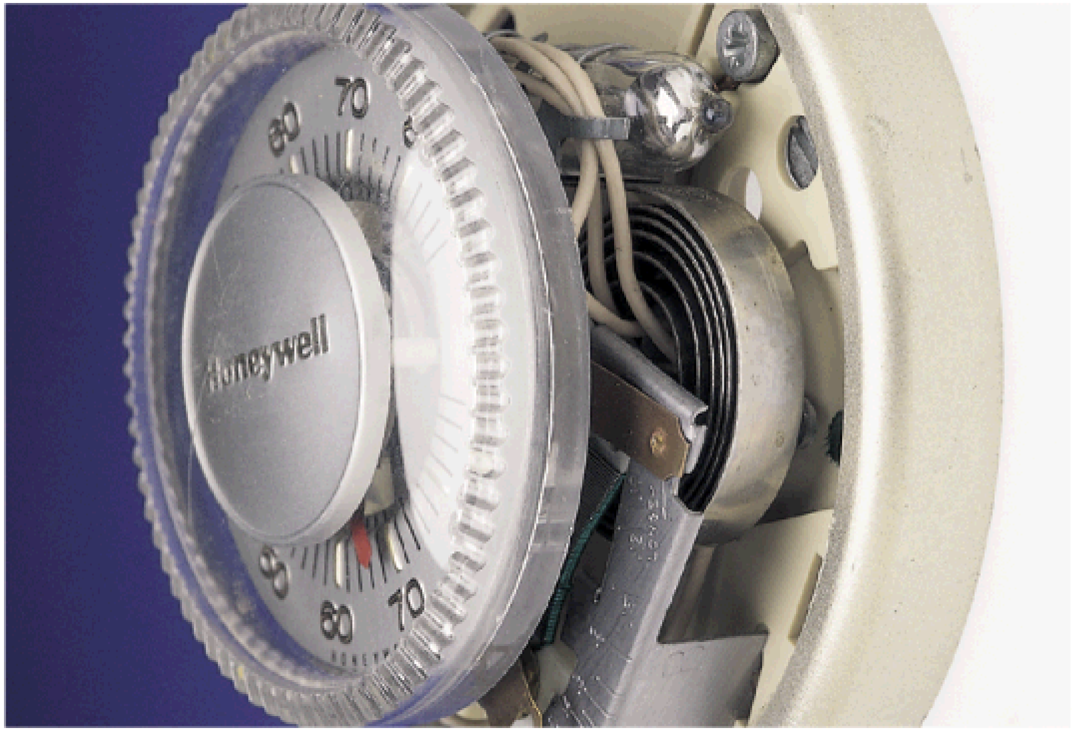
Figure 19.9c



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Gases

Ideal gas law

Temperature in K

$$PV=nRT$$

Pressure in Pa

Volume in m^3

#moles

1 mol = 6.02×10^{22} molecules

(corresponds to amount in "molecular mass" in grams)

Universal gas constant:

$R = 8.315\ \mathrm{J/mol \cdot K}$

$= 0.08214\ \mathrm{L \cdot atm/mol \cdot K}$

Example:

Volume expansion at constant P

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Figure 19.11

$$V = \frac{nR}{P} T$$

$$\Rightarrow \Delta V = \frac{nR}{P} \Delta T = \frac{nR}{PV_i} V_i \Delta T$$

$$= \frac{1}{T_i} V_i \Delta T = \beta V_i \Delta T$$

$\beta = 1/T_i = 1/293\text{K} = 0.0034/\text{K}$

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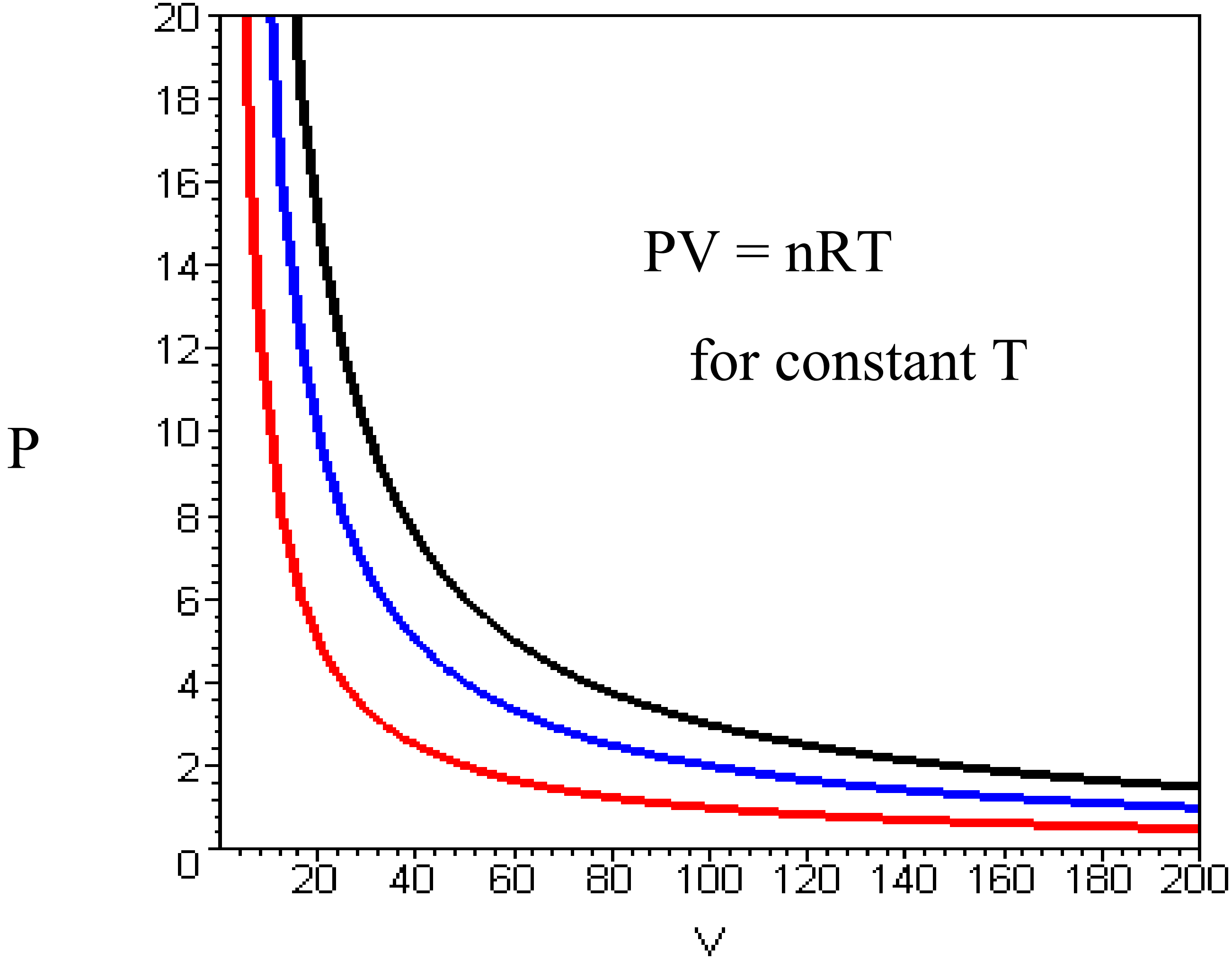
PV = nRT
for constant T
P
V
20
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
120
140
160
180
200