Lab #1

"error" will be % difference from reference values

"uncertainty" will be via propagation of errors

Example: density $= \rho = \frac{m}{V}$ $\quad m = 100\,kg \quad \varepsilon(m) = 1\,kg \quad V = 10\,m^3 \quad \varepsilon(V) = 2\,m^3$

$$\varepsilon^2(\rho) = \left[\frac{\partial \rho}{\partial m}\varepsilon(m)\right]^2 + \left[\frac{\partial \rho}{\partial V}\varepsilon(V)\right]^2$$

$$= \left[\frac{1}{V}\varepsilon(m)\right]^2 + \left[\frac{-m}{V^2}\varepsilon(m)\right]^2 = \left[\frac{1}{10}\cdot 1\right]^2 + \left[\frac{-100}{10^2}\cdot 2\right]^2 = \frac{1}{100} + 4 = 4.01$$

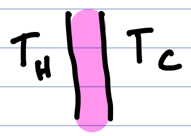
$\rightarrow \varepsilon(\rho) = \sqrt{4.01} \approx 2\,\frac{kg}{m^3}$ $\qquad \Rightarrow \rho = 10\,\frac{kg}{m^3} \pm 2\,\frac{kg}{m^3}$

Thermal Conductivity

Rate of heat flow

$$H = \frac{dQ}{dt} = kA\,\frac{T_H - T_C}{L}$$

L = distance between T_H and T_C



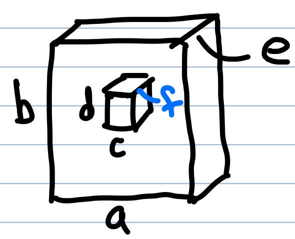
A = area ⊥ to heat flow
k = thermal conductivity

Demo with 6-pronged apparatus

	k
Cu	385
AL	205
Br	109
Ni	91
Fe	80
SS	14

higher k-values led to more quickly dropping off

Example heat flow through a door with a window



what is the heat loss per unit time?

we have $T_H, T_C, k_{window}, k_{door}$

$$H_{total} = H_{door} + H_{window} = \frac{(k_{door} A_{door})\Delta T}{e} + \frac{(k_{window} A_{window})\Delta T}{f}$$

where $A_{door} = ab - cd$

$A_{window} = cd$

thermodynamics of gasses

link macroscopic to the microscopic

macroscopic	microscopic
bulk pressure	molecular mass
volume	speeds
temperature	kinetic energies
mass	

State variables

P pressure

T temperature

V volume

m mass or n (# moles) or N (# molecules)

"Equation of State" $PV = NkT$ or nRT

k = Boltzmann constant $1.38 \cdot 10^{-23}\ J/k$

R = Gas constant $= 8.314\ J/mol \cdot k$

Application # air molecules in this room

$$N = \frac{PV}{kT} = \frac{(0.78\,atm)\left(\frac{1.01 \cdot 10^5\,Pa}{1\,atm}\right)(3m \cdot 12m \cdot 14m)}{\left(1.38 \cdot 10^{-23}\frac{J}{k}\right)(293\,k)} \sim 10^{28} \text{ molecules}$$

Ch 02 ConceptQs

s1.html $T = \frac{PV}{Nk} \Rightarrow 273k \rightarrow 546k$ $\boxed{E}$

s2.html #1 $P = \frac{NkT}{V} = nRT$ $\boxed{C}$ #2 $\boxed{C}$

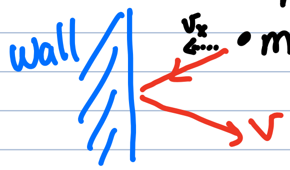
s3.html $P \propto \frac{T}{V}$ A 100 B 20 C 80 D 30 E 50 F 50 AC(EF)DB $\rightarrow \boxed{E}$

54.html $T = \frac{PV}{Nk}$ A $\frac{4}{10,000}$ B $\frac{4}{5,000}$ C $\frac{4}{20,000}$ D $\frac{6}{10,000}$ $\boxed{B}$ hot

E $\frac{2}{10,000}$ F $\frac{1}{10,000}$ G $\frac{2}{10,000}$ H $12/60,000$ $\boxed{F}$ cold

Why does an increase in T result in an increase in P?

→ think microscopically!



As a particle bounces off a wall, it undergoes an elastic collision, and hence a change in momentum p

$$\Delta p_x = m \Delta v_x = m 2 v_x$$

pressure due to one particle $F/A = \frac{\Delta p/\Delta t}{A}$ so P depends on velocity of particles (see §22)

since kinetic energy of a particle $= \frac{1}{2} m v_{avg}^2 = \frac{3}{2} nRT = 3kT$

→ typical speed is $v = \sqrt{\frac{3kT}{m}}$

This explains why there is hardly any H in the Earth's atmosphere: small $m \Rightarrow$ large v (greater than v_{escape})

Atmospheric content

N_2 78%

O_2 21%

Ar 1%

O_2 in this room $v_{O_2} = \sqrt{\frac{3\, k_B\,(293K)}{m_p \cdot 2 \cdot 16}}$

$= 476$ m/s

H_2 in this room

$$v_{H_2} = \sqrt{\frac{3 k_B (293k)}{m_p \cdot 2}} \simeq 1906 \text{ m/s}$$