**Gas Law Comments** PhL 6.26.12

The simple gas law is derived in several places in my experience.

1. Using stat mech, Baby Reif derives the law on page 172 as

$pV = NkT$ or $p = nkT$

where k is Boltzmann's constant, n is the number of molecules per volume, p is mean pressure. One then defines R as

$R = N_a k$ $N_a$ = Avagadro = number of molecules in a mole of gas

where a mole of gas weighs 28 grams for $N_2$, and ν = number of moles of gas in a container.

$N = \nu N_a$ $pV = \nu N_a kT = \nu RT$ // Boyle's Law, BR p 174 (93)

No doubt this was first an experimental observation and later computed from stat mech. Now

ν/V = moles per unit volume 1 mole weighs M grams where M is the molecular weight.

ρ = mass/volume = Mν/V ν = ρV/M

then we can write

$pV = \nu RT = (\rho V/M)RT$ => $p = (1/M)\,\rho RT = \rho R'T$ $R' = R/A$

and this last is the way things appear in Lai p 389, so he is using an adjusted gas constant.

Wiki http://en.wikipedia.org/wiki/Ideal_gas_law agrees with me, saying

$$P = \rho \frac{R}{M} T$$

M = the molar mass (grams per mole).

Wiki goes on to define $R_{specific} = R/M$ and then they write

$$P = \rho R_{\text{specific}} T$$

This then is what the R means in Lai p 389.

What about specific heats? Wiki http://en.wikipedia.org/wiki/Heat_capacity defines

$C = Q/\Delta T$ // for some object

It can be expressed per kg, or per mole. Later this page says

$$C_p - C_V = nR$$

R = "universal gas constant" = $N_a k$

$$C_{p,m} - C_{v,m} = R$$

Now I suppose these are heat capacities per mole. If you wanted them per mass, you would do

$C_{p,m} = M\ c_p$

Then you would have

$c_p - c_v = R/M = R_{specific}$ // and this agrees with Lai p 392.