Re: Simple(?) Thermodynamics Problem

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- *From*: The_Man <me_so_horneeeee@xxxxxxxxx>
- *Date*: Sat, 09 Jun 2007 18:02:55 −0700

On Jun 9, 5:42 pm, KMyers1 <KMye...@xxxxxxxxxxxxx> wrote:

> On Jun 9, 3:43 pm, KMyers1 <KMye...@xxxxxxxxxxxxx> wrote:
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> > On Jun 8, 10:50 pm,The_Man<me_so_hornee...@xxxxxxxxx> wrote:
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> > > On Jun 8, 8:58 pm, KMyers1 <KMye...@xxxxxxxxxxxxx> wrote:
> > >
> > > > My 25 year old college thermo is a little rusty (well ok, more than a little). Here are a couple of related problems that I want to solve.
> > > > Can anyone tell me how to do it:
> > > >
> > > > 1. Have an ideal gas with initial pressure P1, temperature T1, and volume V1. Now I add a certain amount of heat (measured in kJ or BTU) without changing the volume (V2=V1). What are the new pressure P2 and temperature T2?
> > > > From the initial conditions and the Ideal gas law, you find the number
> > >
> > > of moles of gas (n). The addition of heat will depend on the

heat
capacity at constant volume (Cv) for the gas (this will depend on the
number of degrees of freedom from the gas). From Cv/n you will get the
temperature increase dT, so the new temp T2 = T1 + dt.. Then
recalculate the pressure P2 from T2, V, and n

> 2. Same ideal gas and same initial conditions, but this time I
> compress the gas to a new volume V2 in an insulated container. What
> are the new pressure P2 and temperature T2?

Use the formula for adiabatic expansion/contration.

P1V1^(gamma)= P2V2^(gamma), where gamma = Cp/Cv.
For an ideal gas, Cp=Cv +R.

> I know that I need to use the ideal gas law as part of the solution to
> these problems, but that only gives me one equation with two
> unknowns. What am I missing for the second equation?

I hope that helps. Simply specficying "ideal gas" isn't enough; you
need to know the number of degrees of freedom for the gas.

> Thanks,
> Kevin M.− Hide quoted text −

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Very helpful, thanks!

Now a related question. In the problems mentioned above, I am actually working with real gases rather than ideal. Gases that I am working with include hydrogen, oxygen, nitrogen, carbon dioxide, and water vapor. Now I would think that tables giving values for the Cp and Cv factors that you mentioned would be available online and/or in reference books. I would also assume (possibly incorrectly) that Cp and Cv vary with changes in temperature and/or pressure, so that it isn't accurate to simply assume constant values for Cp and Cv over wide ranges of temperature and pressure. Therefore, I really need to find tabular listings of these values over a reasonably wide range of temperatures and pressures (roughly 0 to 3000 deg F and 0 to 3000 psig), or some way to compute them (possibly from the degrees of freedom that you mention).

I am not familiar with the concept of degrees of freedom as it relates to gases, but I would assume from your statement that different gases have different degrees of freedom, that it is probably somehow related to their molecular structure, and that Cp and/or Cv can be computed from that value. So, if you could help me out with some additional information on where to find Cp and Cv values or how to compute them, I would certainly appreciate it.

By the way, I already did some searching for Cp and Cv values on the internet, but all of the values that I am finding so far seem to cover very limited pressure and temperature ranges. So, either I am searching wrong, or there must be some kind of assumption or computation that is generally used which I am missing. Again, I am guessing that may be related to the degrees of freedom concept that you mentioned, or possibly these values really don't vary greatly (or at all?) over large ranges of temperature and pressure?

Thanks again,
Kevin M.

Found a Wikipedia article that pretty well straightens me out regarding Cv and its dependency on degrees of freedom, etc. Based on that article, it looks like I should be able to reasonably approximate Cv as a constant value over the range of temperatures that I'm looking at for my ballpark purposes. However, I'm still unclear whether Cp can also be assumed to have a relatively constant value?

For an ideal gas, you can simply assume that Cp = Cv +R.
It is also possible to calculate these values to a very high degree of accuracy through quantum chemical calculations. Since the gases you are interested in are only 3 or 4 atoms tops, the thermodynamic properties can be coimputed on a desktop computer in minutes. DFT works well, and for even higher accuracy,something like CCSD (Coupled Clusters Singles and Doubles) would definitely do the trick.

If you don;t have access to the software, someone who does could do the calculation for you − it takes only minutes.

Kevin M.− Hide quoted text −

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