5.8: In-Text References

1. Instead of talking about the temperature of an isolated atom or molecule, we talk about its kinetic energy. ↵
2. We can ignore gravitational effects because at the molecular level they are many orders of magnitude weaker than the forces between atoms and molecules. ↵
3. actually $v(\text{bar})$ is the root mean squared velocity of the gas particles,a measure that is similar to the mean, but makes the direction of the particles irrelevant. ↵
4. We can also, for all practical purposes, ignore the fact that $\mathrm{E} = mc^2$; the conversions between energy and matter are insignificant for chemical processes. ↵
5. Although this distribution of speeds of atoms was first derived mathematically, it is possible to observe experimentally that atoms in a gas are moving at different speeds. ↵
6. Interestingly, this is like our approach to the decay of unstable atoms. We cannot predict when a particular atom will decay, but in a large enough population, we can very accurately predict the number of atoms per second that will decay. ↵
7. We use average speed and velocity to describe the motion of the particles in a gas, but it is more accurate to use the root mean square (rms) of the velocity, that is, the square root of the average velocity. However, for our purposes average speed (or velocity) is good enough. ↵
8. Translational energies are also quantized but the quanta are so small that in practice we do not need to worry about that. ↵
9. There are a number of different energy units, including calories, but they are all measures of the same thing, so we will stick to joules here. ↵
10. Alternatively in microwave ovens, the water molecules gain energy by absorbing microwave radiation which makes them rotate. When they collide with other molecules this energy can also be transformed into vibrations and translations, and the temperature of the water heats up. ↵
11. The situation on planets like Venus and Jupiter is rather more complex. ↵
12. The boundary between a system and surroundings depends on how you define the system. It can be real (as in the beaker) or imaginary (as in some ecosystems). In biological systems, the boundary may be the cell wall, or the boundary between the organism and its surroundings (e.g., skin). ↵
13. The only exception would be cryptobiotic systems, like the tardigrads mentioned earlier. ↵
14. Remember that London dispersion forces fall off as $\frac{1}{r^6}$, where r is the distance between the molecules. ↵
15. In fact, we should say mass-energy here, but because most chemical and biological systems do not operate under the high-energy situations required for mass to be converted to energy we don't need to worry about that (for now). ↵
16. Or U if you are a physicist. This is an example of how different areas sometimes seem to conspire to make things difficult by using different symbols and sign conventions for the same thing. We will try to point out these instances when we can. ↵
17. One important point to note is that this relationship only works when the thermal energy is used to increase the kinetic energy of the molecules—that is, to raise the temperature. At the boiling point or freezing point of a liquid the energy is used to break the attractions between particles and the temperature does not rise. ↵
18. This is another example of the different ways that the same process is described. In chemistry we usually describe osmosis as movement from a solution of low concentration to high (where we are referring to the concentration of the solute). In biology osmosis is often described as movement from high concentration (of water) to low. These two statements mean exactly the same thing even though they appear to be saying the opposite of each other. ↵
19. One of many speculations about the relationship between the big bang and entropy; http://chronicle.uchicago.edu/041118/entropy.shtml ↵
20. http://www.schuhmacher.at/weblog/52cards.html ↵
21. A realistic understanding of the probability of something happening is a great asset (but would put the gambling and lottery industries, and perhaps part of the investment community, out of business). Listen to: http://www.wnyc.org/shows/radiolab/e...des/2009/09/11 ↵
22. or Ω in some texts. ↵
23. We multiply, rather than add W when we combine systems. ↵
24. A great lecture by Richard Feynmann on this topic: http://research.microsoft.com/apps/t...f62e4eca%7C%7C ↵
25. Many people use the term spontaneous, but this is misleading because it could make people think that the reaction happens right away. In fact, $\Delta\mathrm{G}$ tells us nothing about when the process will happen, only that it is thermodynamically favored. As we will see later, the rate at which a process occurs is governed by other factors. ↵
26. So why, you might ask, does water evaporate at temperatures lower than $100^\circ\mathrm{C}$? We will come to that soon. ↵

27. This is another rather counterintuitive idea, but remember that to freeze something you have to take heat away (for example, in a refrigerator). ↵