Reading Guide for February 23

Chapter 15: Temperature, Heat, and Expansion

In our class, we will look at temperature and heat, but not so much at thermal expansion.

pp. 269–271. *Temperature*. This section first discusses measuring temperature, then systems in which temperature measurements are reported, then, in an almost hidden paragraph, gets around to explaining what temperature *is*. That paragraph is buried near the end of page 270.

The key sentence for our purposes is "temperature is proportional to ________________

____."
(Fill in the blank yourself.)

pp. 271–272. *Heat*. This section makes a semantic distinction between **internal energy** and **heat**. Knowing the distinction between them is useful for understanding what scientists are talking about when discussing thermal physics, and not so important for actually understanding the concepts of thermal physics. A more important distinction to be able to make is the distinction between heat (or internal energy) and **temperature**.

pp. 272–273. *"Measuring Heat."* Introduces the **calorie** as a heat-specific unit of energy. The joule works just fine, though.

Recommended workbook exercise: p. 73.

pp. 273–274. *Specific Heat Capacity*. Different materials require different amounts of energy (heat) to change their temperatures by the same amount. This difference is quantitatively described by the **specific heat capacity**, defined in the formula in footnote 4 at the bottom of p. 273. The key idea in this section is in boldface on page 273.

pp. 274–275. *The High Specific Heat Capacity of Water*. Water has many unique properties that make it important to us, and this section explains how its large specific heat capacity is one of them. Specifically, it greatly influences local weather and climate and global energy balance!

Chapter 17: Change of Phase

Temperature is a manifestation of molecular *kinetic* energy. Phase changes are a manifestation of molecular *potential* energy changes.

p. 301. *Phases of Matter*. There are four main types of phase. Things can get more complicated than that, as you'll learn if you study metallurgy or materials science. But that's beyond the scope of this course and this textbook.

pp. 301–302. *Evaporation*. This gives a molecular-level description of what happens when a liquid evaporates.

- What is **evaporation**?

- Some of the molecules at the surface of a liquid are more likely than others to break free of the liquid. What gives them this property?

- Why does evaporation cool the liquid that is left behind?

- What is **sublimation**?

Recommended workbook exercise: p. 79, questions 1–3.

pp. 302–303. "*Condensation*." **Condensation** is the reverse of evaporation. Why is it a warming process?

pp. 303–304. "*Condensation in the Atmosphere*." The important idea in this section is the concept of **saturation**. This is when the concentration of water molecules in the gas phase (vapor) is high enough, and their kinetic energies (temperature) are low enough that any additional water vapor will condense to form liquid. The passage explains why this can occur.

- How is **relative humidity** related to saturation?

p. 304. "*Fog and Clouds*." No new physics here, but it does explain how evaporation, condensation, and saturation dictate the creation of fog and clouds.

pp. 304–305. *Boiling*. You may have wondered, while reading the passage on evaporation, what made evaporation different from boiling. You may have also wondered, since water boils faster at elevation (such as in Laramie), why it takes longer to cook boiled food at elevation. This section answers all these questions. (Yaay!)

- What is **boiling**?

- Why does water in a pressure cooker boil at a higher temperature?

- Why does water boil at a lower temperature at high elevation (such as in Laramie) than at low elevation (such as sea level)?

- Why do boiled foods, such as boiled eggs and pasta, take more time to cook at high elevation than at low elevation?

p. 305. "*Geysers*." These are pressure cookers in which the pressure comes from the depth of the water.

p. 306. "*Boiling is a Cooling Process*." The reason is the same reason that evaporation is a cooling process.

p. 306. "*Boiling and Freezing at the Same Time*." I have tried to set up this demonstration here, but so far I haven't had any luck. I think our vacuum pumps aren't fast enough. If you ever go to San Francisco, by all means visit the Exploratorium. "Water Freezer" is a terrific exhibit, and there are many other terrific exhibits as well.

pp. 306–307. *Melting and Freezing*. Just as evaporation and condensation are reverse processes, so are melting and freezing. This reading explains what the molecules do in the processes, and also explains why having something dissolved in a liquid lowers the freezing point.

p. 307. "*Regelation*." Skip.

pp. 307–311. *Energy and Changes of Phase*. The first part of this chapter described how temperature changes and heat transfers during phase changes; this final part explains why.

The first part of the discussion explains how the liquid-vapor phase transitions are employed in refrigerators and heat pumps. The key idea here is not how these devices work, but how the phase transitions add heat to or withdraw heat from their surroundings. A refrigerator works because the refrigerant withdraws heat from the interior of the refrigerator and deposits the heat to the air outside the refrigerator.

Closely follow the description of heating water on pp. 308–309 (after the "Check Point" question), and the accompanying Figure 17.17.

- How much heat is absorbed by 1 g of ice as it melts at 0 °C?

- How much heat is absorbed by 1 g of water as it boils at 100 °C?

- Why doesn't the temperature change when the ice melts or the water boils?

- What is the **latent heat of fusion** of a substance?

- What is the **latent heat of vaporization** of a substance?

Try the "Check Point" questions on p. 310.

You don't need to worry about the rest of the material on p. 310, though it may do you some good to work the "Practicing Physics" problem at the bottom of the page.

Recommended workbook exercise: pp. 77–78, questions 1–10.

Reflection

The graph in Figure 17.17 (page 309) illustrates some key phenomena about phase transitions. In particular, there are two stretches in the graph in which heat is constantly put into a sample but its temperature does not increase! Does this make sense to you? If not, what sort of evidence would convince you?