PH202 Reading Guide

Chapter 12: Thermal Properties of Matter

In this chapter we continue our discussion of thermal energy that we started in chapter 11. Chapters 10, 11, and 12 connect the discussion of energy and thermal energy starting initially with the particle model and concluding in this chapter with the macroscopic model. Chapters 11 and 12 introduce and explain the ideas of thermodynamics and thermal physics in the context of Chapter 10's discussion of conservation of energy.

Chapter 12 is the first of two chapters in Part III of our text book, Properties of Matter. These chapters stress a *macroscopic* view of matter. In Chapter 12, we characterize systems with macroscopic variables such as temperature and pressure. Indeed pressure or temperature are not defined for single particles. Nevertheless an understanding of the relationships among these different variables requires frequent reference to the atomic model, a *microscopic* view of what atoms and molecules are doing. In this chapter, the treatment moves back and forth between these two views. This "macro-micro" connection forms a theme that runs through the range of topics that the chapter covers, from the gas laws to thermal expansion, providing the "physics glue" to the treatment of these topics.

Student Learning Objectives

In covering the material of this chapter, students will learn to

- Use the atomic model of the ideal gas, and understand how the microscopic motion of atoms determines macroscopic quantities such as temperature and pressure.
- Apply the ideal gas law to solve problems involving gases undergoing changes in pressure, volume, and temperature.
- Understand and apply the equations of thermal expansion.
- Use concepts of specific heat and heat of transformation
- Solve basic calorimetry problems involving heat transfer between systems.
- Understand how heat is transferred between objects by the different means of conduction, convection, and radiation.

Physics Tools

- Ideal gas: Diagrams to characterize physical changes of gas, particularly pV - diagrams
- Phase diagram showing change from solid to liquid to gas. Important example is the phase diagram of water.

When reading the text

- Answer all "Stop To Think" questions (the answers are in the back of the chapter)
- Understand all examples
- Answer the following questions to ensure you understood the text

Some questions that successful students can answer after reading the text:

Section 12.1 (page 357-359):

What are the three phases of matter?

What is a typical simplification of the atomic model of the three phases of matter?

What is the mass of one carbon atom in units of u (atomic mass unit) and in units of kg?

What is one mole?

What is the mass of 1 mole carbon atoms? What is the mass of 1 mole of Oxygen molecules?

How many cubic centimeter (cm^3) are in one liter? How many mL are in 1 cm^3?

Section 12.2(page 359-366):

We said in chapter 11 that temperature is proportional to the average kinetic energy per atom of a material. What is the thermal energy of a gas with N atoms at a temperature T?

Does the temperature of matter double when the average kinetic energy doubles?

Does the temperature of matter double when the average velocity of atoms doubles?

What is the definition of pressure?

What are the standard units for pressure?

What is the standard atmospheric pressure in standard units?

What other pressure units are mentioned in the textbook? Give typical examples for each unit.

What is the gauge pressure?

What is the pressure in a vacuum?

What is the ideal gas law?

Section 12.3(page 366-372):

Which processes are called ideal gas processes?

How does a p-V diagram look like for an ideal gas sample with constant temperature?

What is the work done by an isobaric process?

How can you graphically determine the work done by a gas?

What is an adiabatic process?

Sections 12.4 (page 373-375):

How does the volume of matter expand as a function of temperature?

Why do you now see the volume of a glass of water double when you double the temperature from 20°C to 40°C?

How does the length of a 1m aluminum rod change when you increase the temperature by 10°C?

What are special properties of water and ice, when considering thermal expansion?

Sections 12.5 (page 375-379):

If you heat up a piece of matter by 10°C how much heat do you need to add? What physical quantities or properties do you need to know to make a good prediction?

Rank the specific heat capacity of Gold, Aluminum, and water.

How much heat do you need to add to a liter of water to heat the water up by 1°C?

How much heat do you need to add to a kg of ice to melt it?

How much heat to you need to add to a kg of water to evaporate it?

Sections 12.6 (page 379-381), we will not cover section 12.7:

If you add 10g of gold and 10g of aluminum both at a temperature of 100°C into a beaker with 100ml of water at a temperature of 20°C respectively, which beaker heats up more?

Sections 12.8 (page 383-388):

What 3 kinds of heat transfer are there described in the textbook?

Rank the thermal conductivity of silver, steel and wood.

How does the heat transfer by conduction depend on length and cross section of matter?

Would you rather use a thick or a thin stick to melt your marshmallows at a camp fire?

How does the heat transfer by radiation depend on the temperature?

Suggested Workbook Problems (best is answering all workbook questions)

There are quite a few good questions to practice proportional reasoning, and using graphs

Chapter 12: 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 21, 23, 25, 26, 30, 35, 36