Session 8

Extending the Particle Model of Matter

In the previous seven sessions, we've evolved the particle model of matter by examining a variety of macroscopic behaviors. In this session, we'll extend the particle model even further to explain additional macroscopic phenomena, including electrical properties of matter. We will review the principles of the particle model of matter covered in the course, revisit macroscopic examples where they apply, and briefly survey recent developments in the understanding of matter. Can a refined model be applied to some exotic forms of matter like superconducting solids or Bose-Einstein condensate? What are other new frontiers in the scientific exploration of matter?

The Video

The final session begins by posing a question about whether we can explain the phenomena of "static cling" with the particle model we've been developing. Is there a principle of the model that accounts for this behavior?

We then review the four principles of our particle model through the lens of the Science Studio interviews and the content explorations from past sessions. Each principle is addressed with examples of the macroscopic behavior where it applies.

Next we follow some friends, Mark and Lauren, on a trip to the beach to look at the variety of phenomena they meet along the way. Is our model robust enough to explain the macroscopic behaviors they encounter? The story ends when our hosts point out potential places where the particle model may require extension, as in phenomena explained by the electrical properties of matter.

In Castro Valley, California, Linda Block prepares her fifth graders for a field trip to the Exploratorium in San Francisco by giving them hands-on experience with electrostatic forces between Styrofoam chips and rubbed plastic. We then follow the class on their field trip where we see a variety of examples of these forces at work in the exhibits at the Exploratorium. For a practical application of how electrical forces relate to the properties of materials, we visit Professor Christine Ortiz's lab at MIT, where we see how an atomic force microscope allows us to indirectly "image" molecular structures.

The rest of the program is devoted to further examples of how experiments from the early 1900s and beyond have led to an ever-increasing sophistication of our model of matter.

Learning Goals

During this session, we will:

- Review the particle/atomic model as expressed in previous programs
- Show limitations of the particle model and extend it to the subatomic scale
- Introduce exotic states of matter that require us to extend our conception of matter and its properties

On-Site Activities

Getting Ready (60 minutes)

Activity One—Problem Set and Concept Map Discussion (20 minutes)

1. With the whole group, discuss your concept maps and the answers to the problem set from Session 7.
2. With your partner, share and compare examples of properties and behavior of matter that you observed since last time that you were either able or not able to connect to the particle model of matter.

Activity Two—Idea Review (20 minutes)

Individually, write down the four principles of our particle model as you have come to understand them, including all the refinements we've made throughout the course. Then, in the whole group, compare your understandings.

Activity Three— Static Activity (20 minutes)

Working with a partner, try the following experiment:

a. Scatter some styrene (Styrofoam) chips or bits of paper on a table or desk.

b. Take a wool cloth and a styrene dinner plate and rub the bottom of the plate vigorously with the cloth.

c. Bring the plate as near to the chips or paper bits as you can without touching them. Observe what happens.

d. Now try the same thing with an aluminum pie plate.

e. Discuss what happened in both instances with your partner. Are there properties of matter that account for the differences or similarities in behavior in the two cases? Talk about what you think is happening on a particle level. Conduct similar experiments with other materials in the room.

Watch the Video (60 minutes)

As you watch the video, think about the following focus questions:

1. What are your thoughts about the Science Studio segments as you watch them for the second time?
2. Does Mark and Lauren's day at the beach make you think about any questions you've had about matter in your everyday activities?
3. How does static electricity relate to the forces between particles that were introduced in previous sessions?
4. How does Linda Block use "inquiry" to make her students more observant of the phenomena they are investigating?

Going Further (60 minutes)

1. A can of soda is placed in the freezer because you'd like to drink it soon. However, you get absorbed in your work and forget about it until the next morning. When you open the refrigerator, you find the can has bulged out on both ends and has split down the middle, with "soda ice" coming out. Given your current understanding of the particle model of matter, use as many aspects of it as possible to explain this event.

On-Site Activities, cont'd.

2. In Session 5, we introduced the idea of intensive and extensive properties. What is your understanding of what makes a property intensive to the substance? Working in small groups, decide which of the following (if any) properties are intensive or extensive for a given substance:

   a. Color
   b. Density
   c. Speed of dissolving in water
   d. Mass of one particle
   e. Electron arrangement
   f. Boiling point
   g. Volume
   h. Force between particles of the same substance

Track Your Understanding

Facilitators: Hand out the Track Your Understanding answers from Session 1.

At the first session, you answered a set of questions that were meant to help you assess your initial understandings of some of the big ideas in physical science. Now that you have participated in eight *Physical Science* sessions, we hope you will find it useful to assess how your understandings have changed. Your facilitator will pass out your original answers to the following questions. Please take some time to revisit your answers and to revise and/or add to them.

Physical Science Questions

1. What distinguishes something that is matter from something that is not matter?
2. What criteria would you use to distinguish between a solid, liquid, and gas? Are these the only states of matter? Explain your answer.
3. Is it possible to subdivide a piece of solid matter infinitely (e.g., a piece of aluminum foil)? Why or why not?
4. On a particle level, what are the differences between the states of matter?
5. What is the difference between a physical change and a chemical change? Give some examples of each.
6. Where does water go when it evaporates?
7. What is the difference between melting and dissolving?
8. What is meant by the statement "Matter cannot be created or destroyed"?
9. Explain the difference between boiling and burning.
10. Complete the following: Atom is to element as molecule is to ___________________.
11. Distinguish between the concepts of volume, weight, and density.
12. What does matter of different densities look like on the particle level?
13. What factors determine whether an object rises or sinks in water? In other liquids?
14. Explain the concept of "buoyancy."
15. What effect does heat have on solids, liquids, and gases? Explain your answer.
16. Describe the relationship between heat and temperature.

Wrapping Up

This is the last session of the *Essential Science for Teachers: Physical Science* course. You might want to wrap up with a final journal entry, and sign-off in Channel-TalkPhysicalSci with a final posting to your colleagues.

* Ongoing Concept Mapping

Try to draw all the big ideas about the particle model of matter into one concept map. Feel free to take sections from your previous concept maps, but make sure to include the following big ideas:

- Particles
- Pressure
- Physical change
- Heat
- Archimedes's principle
- Solid/liquid/gas
- Forces between particles
- Force
- Chemical change
- Temperature
- Density
- Continuous model of matter
- Electric charge
- Buoyant force
- Motion
- Rising/sinking
- Phase change
- Shapes of particles

Guided Journal Entry

Throughout this course, we've introduced many refinements to our particle model but, in this last session, we've introduced other aspects of macroscopic behavior that would require further refinements. Reflect on why our ideas, as we've developed them, constitute a good scientific model as defined in Session 2, and also why they don't. You could refer to the recent advances in physical science, briefly described in program 8, as examples of how our scientific models have been revised and changed.

Guided Channel-TalkPhysicalSci Posting

We've looked at many "pairs" of concepts, some similar, some opposites. From the list below, choose the pair you still find most confusing:

- Force/weight
- Force/pressure
- Chemical change/physical change
- Density/volume
- Continuous model of matter/particle model of matter
- Heat/cold
- Immersed object/watery ghost
- Mass/weight
- Intensive/extensive
- Rising/sinking
- Atoms/molecules
- Heat/temperature
- Buoyant force/weight

Take this opportunity to clarify your confusion about this pair, and then design an activity based around the pair that, if presented to other teachers of your grade level, would help them to understand the fundamental relationship between the two.

Wrapping Up, cont'd.

Textbook Reading Suggestions

The following are suggestions for several reading topics that may provide additional background and enrichment information. These topics are likely to be addressed in any college-level physics or chemistry textbook.

- Electrostatic force
- Electron orbitals
- Absolute zero
- Dark matter
- Valence Shell Electron Pair Repulsion (VSEPR) Theory
- Kinetic molecular theory of matter
- Particle physics

Graduate Credit Activities

Complete your work on the annotated bibliography and action research project.

Notes