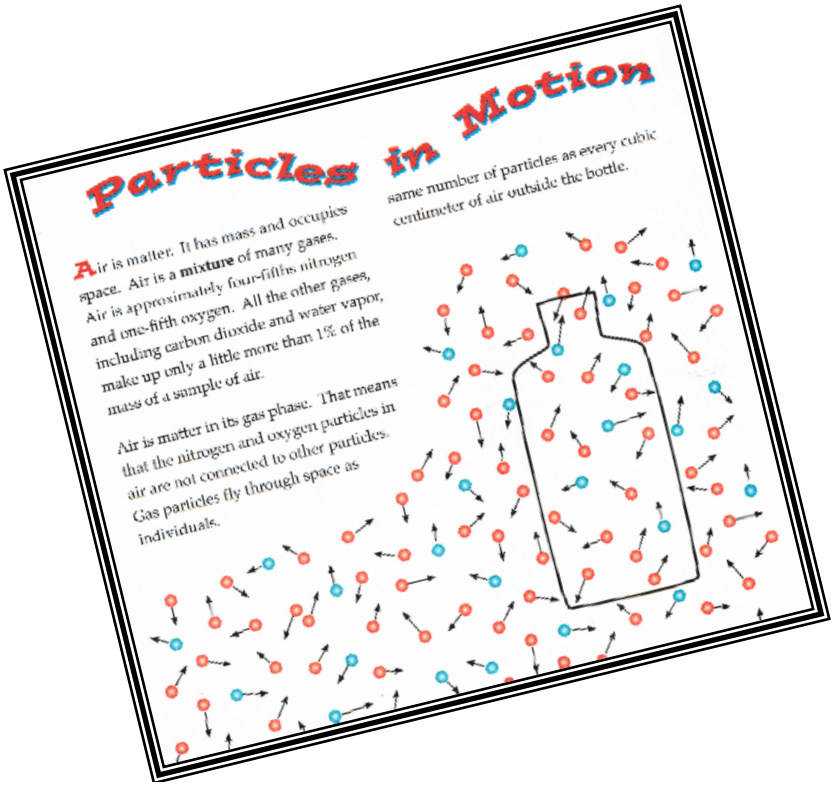
BOSTON Public Schools
Focus on Children
Office of Curriculum & Instruction
Department of Science

Close Reading and Text Dependent Questions in Science
Particles in Motion (Chemical Interactions—Grade 8)

The text selection, *Particles in Motion,* is found in
FOSS Student Resource Book, *Chemical Interactions,* pgs. 23-27.

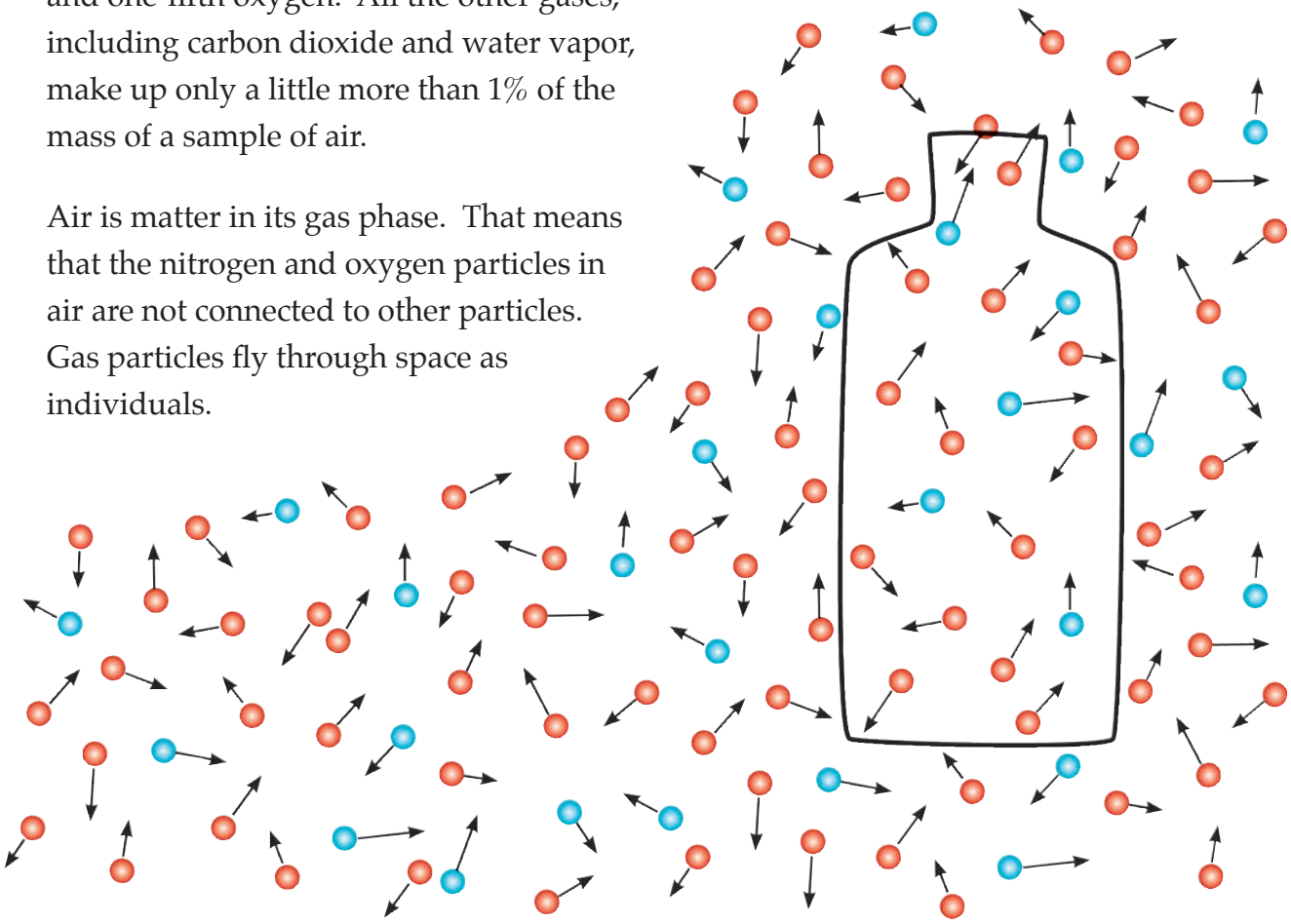


Look in the Student Learning Outcome Document for guidance on when this should be taught.
http://bpscurriculumandinstruction.weebly.com/student-learning-outcomes-by-grade.html

Particles in Motion

Air is matter. It has mass and occupies space. Air is a **mixture** of many gases. Air is approximately four-fifths nitrogen and one-fifth oxygen. All the other gases, including carbon dioxide and water vapor, make up only a little more than 1% of the mass of a sample of air.

Air is matter in its gas phase. That means that the nitrogen and oxygen particles in air are not connected to other particles. Gas particles fly through space as individuals.



Air particles fly through space as individual particles. Air particles fill an open bottle.

After you drink a bottle of spring water, you have an excellent container for an air investigation. The empty bottle, of course, isn't empty. It is full of air. Because air particles are flying all around, they are going into and out of the open bottle all the time. The **density** of air in the bottle is exactly the same as the density of the air outside the bottle. That means that every cubic centimeter of air in the bottle has the same number of particles as every cubic centimeter of air outside the bottle.

It is important to remember that air particles are really millions of times smaller than the representations in the illustrations. A cubic centimeter of air actually has about one quintillion air particles! A quintillion is a one followed by 18 zeroes (1,000,000,000,000,000,000). The illustrations are therefore not accurate, but they are good for thinking about what is going on at the particle level.

Particles Have Kinetic Energy

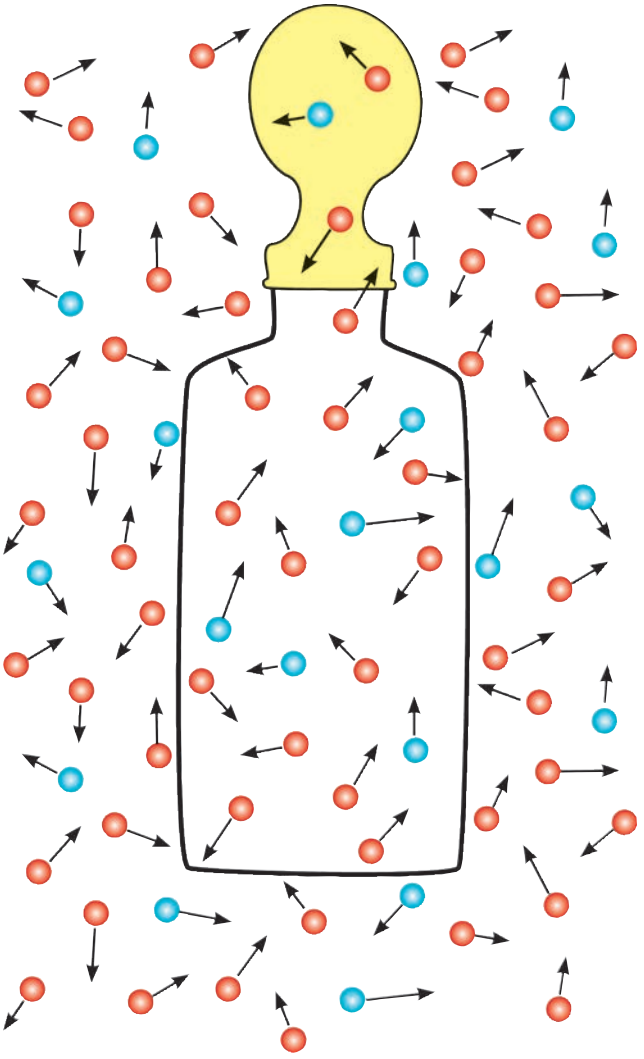
Not only are air particles incredibly small, they are always moving. And they move fast. At **room temperature**, they are going about 300 meters per second. That's equal to about 670 miles per hour.

Moving objects have energy. It's called **kinetic energy**. Anything that is in motion has kinetic energy, whether it is an ocean liner, a bicycle, a fly, a snail, you walking to class, water falling down a waterfall, or an oxygen particle in the air. They all have kinetic energy.

Kinetic energy, like all forms of energy, can do work. Air particles do work when they crash into things. Air particles push on each other, on you, on the walls of containers, and on everything else around them. Every air particle crashes into another particle about 10 billion times every second!

The amount of kinetic energy an object has depends on two things: the mass of the object and the speed at which it is moving. You can't change the mass of an air particle, but you can change its speed. By making a particle go faster, you increase its kinetic energy. Air particles can be made to move faster by heating a sample of air. Heat increases the kinetic energy of particles.

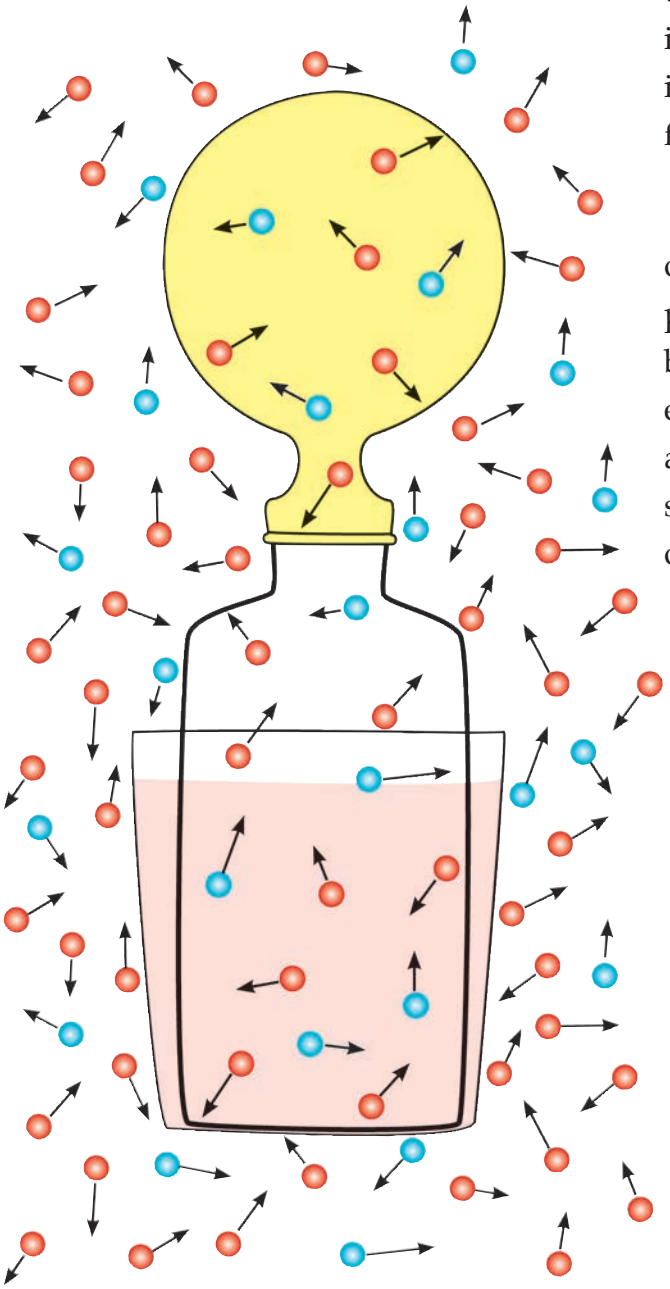
Back to the air investigation. Stretch a balloon over the top of the bottle full of air. Now the air is trapped inside the bottle-and-balloon system. No particles can get in or out.



A balloon can trap the air inside a bottle.

The density of air particles is the same in the bottle, in the balloon, and in the air surrounding the bottle-and-balloon system.

Now place the bottle-and-balloon system in a cup of hot water. The hot water warms the air inside the bottle. Particles in the warm air start to move faster. After a few minutes, the bottle-and-balloon system looks like this.



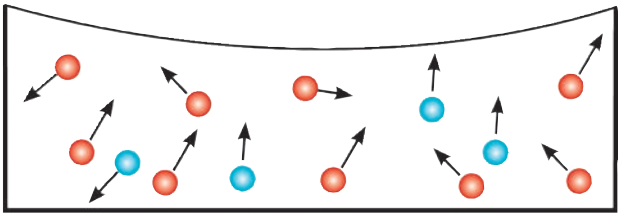
Hot water increases the kinetic energy of the air particles inside the bottle-and-balloon system. The particles fly faster and hit each other harder. The particles push farther apart, causing the gas to expand.

Why did the balloon inflate? The hot water heated the air in the bottle. As a result, the air particles began moving faster. Faster-moving particles have more kinetic energy. Faster-moving particles hit each other harder, which pushes them farther apart. You can see in the illustration that the particles of warm air inside the bottle-and-balloon system are farther apart.

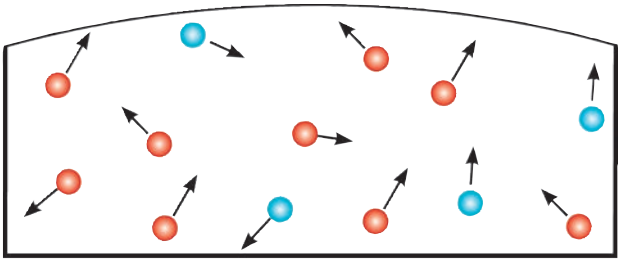
The faster-moving particles also push on the balloon membrane harder. The particles push hard enough to stretch the balloon membrane. The increased kinetic energy of the particles pushes them farther apart (air **expansion**), and the membrane stretches to hold the increased volume of air.

What Happens When Gases, Liquids, and Solids Heat Up?

Gas. If a sample of matter is gas, its particles are not bonded (attached) to other particles. Each particle moves freely through space. When a sample of air



The particles in gases fly through space in all directions as individuals.

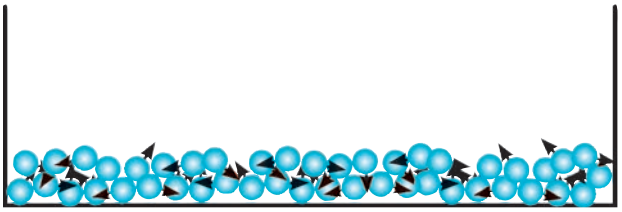


When gases get hot, the particles fly faster. Faster particles hit other particles harder, pushing the particles farther apart. This causes the gas to expand.

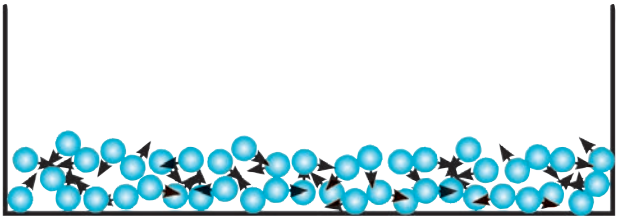
heats up, the particles move faster and hit each other harder. The result is that the particles push each other farther apart.

In the illustrations above, a container of gas has a flexible membrane across the top. When the gas gets warm, the kinetic energy of the particles increases, particles hit each other harder, and the gas expands. As the gas expands, it pushes the membrane upward.

Liquid. Particles in liquids are in close contact with one another. Attractions between the particles keep them from flying freely through space. The particles in liquids can, however, move over, around, and past one another. Individual particles in liquids are able to move all through the mass of liquid.



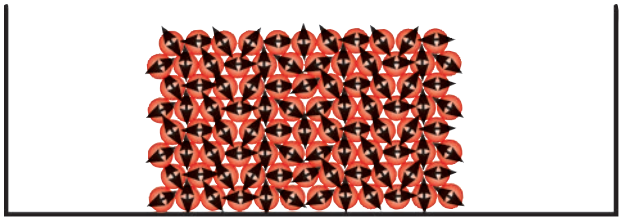
The particles in liquids are held close to each other. Particles bump and slide around and past each other.



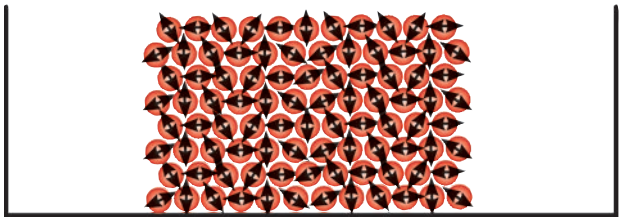
When liquids get hot, the particles bump and push each other more. Increased bumping pushes the particles farther apart. This causes the liquid to expand.

The motion of particles in a liquid is kinetic energy. When a liquid gets warm, the particles move faster. The particles have more kinetic energy. As a result, they hit other particles more often and hit harder. This pushes the particles farther apart. When particles are pushed farther apart, the liquid expands.

Solid. Particles in solids have bonds holding them tightly together. The particles cannot move around at all. The particles are, however, still in motion. Particles in solids are always **vibrating** (moving back and forth) in place.



The particles in solids are bonded. Particles move by vibrating, but do not change positions.



When solids get hot, the particles vibrate more. Increased vibration pushes the particles farther apart, causing the solid to expand.

The vibrational motion of particles in solids is kinetic energy. Heat makes the particles in a solid vibrate faster, giving them more kinetic energy. Faster-vibrating particles bump into one another more often and hit each other harder. This pushes the particles farther apart. When particles are pushed farther apart, the solid expands.

Summary

General Rule 1. When a sample of solid, liquid, or gas matter heats up, it expands. When matter gets hot, its particles gain kinetic energy. The increased kinetic energy pushes the particles farther apart. This causes the matter to expand.

General Rule 2. When a sample of solid, liquid, or gas matter cools down, it contracts. When matter cools down, its particles lose kinetic energy. The decreased kinetic energy lets the particles come closer together. This causes the matter to contract.

Review Questions

1. **What is kinetic energy?**
2. **What are two ways to increase an object's kinetic energy?**
3. **Explain why a balloon inflates when a bottle-and-balloon system is placed in hot water.**
4. **What happens to a sample of matter when its particles lose kinetic energy?**
5. **How are particles in solids, liquids, and gases the same? How are they different?**

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Student Questions

1. According to the text, what combination of elements makes up air? Use the evidence from the text to create a pie chart showing the percentages of elements found in air.

2. As stated in the text, "the density of air in the bottle is exactly the same as the density of the air outside the bottle". Use the illustration to help infer what density means based on this statement.

3. Based on the context of the sentence, "Kinetic energy, like all forms of energy can do work". What is the meaning of the word work as it appears in the article?

4. In the text, the author states, “the amount of kinetic energy an object has depends on two things: the mass of the object and the speed at which it is moving”. Provide evidence to explain what is meant by the phrase from the same paragraph that states, “you can’t change the mass of an air particle, but you can change its speed”.

5. What explanation does the author provide to explain why a balloon inflates when a bottle-and-balloon system is placed in hot water?

6. Using illustrations from the text compare and contrast the movement of particles in gases, liquids, and solids.

7. Based on the information provided in the text, paraphrase the general rules about kinetic energy and the movement of particles.

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Sample Answers

1. **According to the text, what combination of elements makes up air? Use the evidence from the text to create a pie chart showing the percentages of elements found in air.**
   The text states that air is comprised of 4/5th nitrogen and 1/5th oxygen.

2. **As stated in the text, "the density of air in the bottle is exactly the same as the density of the air outside the bottle". Use the illustration to help infer what density means based on this statement.**
   As the illustration indicates, there are the same numbers of particles in a cubic centimeter of air in the bottle as outside of it. That is what is meant by density being the same.

3. **Based on the context of the sentence, "Kinetic energy, like all forms of energy can do work." What is the meaning of the word work as it appears in the article?**
   Work in the article is when an air particle crashes into another object and contributes to its movement.

4. **In the text, the author states, "the amount of kinetic energy an object has depends on two things: the mass of the object and the speed at which it is moving." Provide evidence to explain what is meant by the phrase from the same paragraph that states, "you can't change the mass of an air particle, but you can change its speed"?**
   What is meant is that particles retain their mass but can be sped up or slowed down, so their kinetic energy can vary.

5. **What explanation does the author provide to explain why a balloon inflates when a bottle-and-balloon system is placed in hot water?**
   The particles, as a result of being heated indirectly by the hot water, have sped up, thereby increasing the kinetic energy in the bottle.

6. **Using illustrations from the text compare and contrast the movement of particles in gases, liquids, and solids.**
In gasses, particles move freely throughout the space that the gas molecules take up. In liquids, the particles attract each other and are in close contact with each other so they do not move as freely as they do in gasses. In solids, particles are bonded or stuck together, so they do not move around at all. In solids the particles are vibrating, but do not move around each other.

7. **Based on the information provided in the text, paraphrase the general rules about kinetic energy and the movement of particles.**
As particles are heated, kinetic energy increases, expansion occurs and the particles move faster. When heat is taken away from particles, kinetic energy decreases, contraction occurs and particles move more slowly.