McGraw-Hill Ryerson

BC Science Connections 8

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UNIT 2

The behaviour of matter can be explained by the kinetic molecular theory and atomic theory

TOPIC 2.3

How can we describe and explain the states of matter?

Topic 2.3: How can we describe and explain the states of matter?

- The skier shown here is experiencing water in all of its forms:
  - Drinkable liquid (water)
  - Skiable solid (snow)
  - Invisible gas that he breathes in an out (air)

Why does water in its different states (solid, liquid, gas) have such different properties?

Concept 1: Matter can be solid, liquid, or gas.

- What are some examples of liquids, solids, and gases in your everyday life?

States of Matter: Solid

- Solid:
  - Holds its own shape
  - Has a constant volume
  - Examples: wood, silver, stone, plastic

States of Matter: Liquid

- Liquid:
  - Takes the shape of its container
  - Has a constant volume
  - Examples: oil, juice, antifreeze, gasoline

States of Matter: Gas

- Gas:
  - Takes the shape and volume of its container
  - Can be compressed
  - Examples: air, helium, hydrogen

The Fourth State: Plasma

- Plasma:
  - Does not have a defined shape and volume (similar to gas)
  - Have different electrical properties than gases
  - Examples: the Sun; visible fork of a lightening bolt; glowing gas of a neon sign

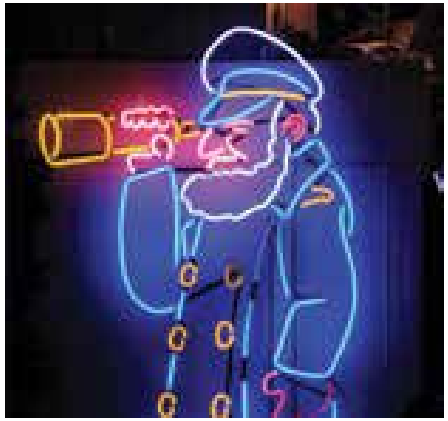


Figure 2.13 Examples of plasma.

Discussion Questions

- Gives two examples of solids, liquids, and gases.

- Which state of matter does plasma most resemble and why?

Concept 2: Matter is made of particles in constant motion.

- Scientists used a **model** to develop a **theory** about the behaviour of all states of matter.
- What is the difference between a model and a theory?

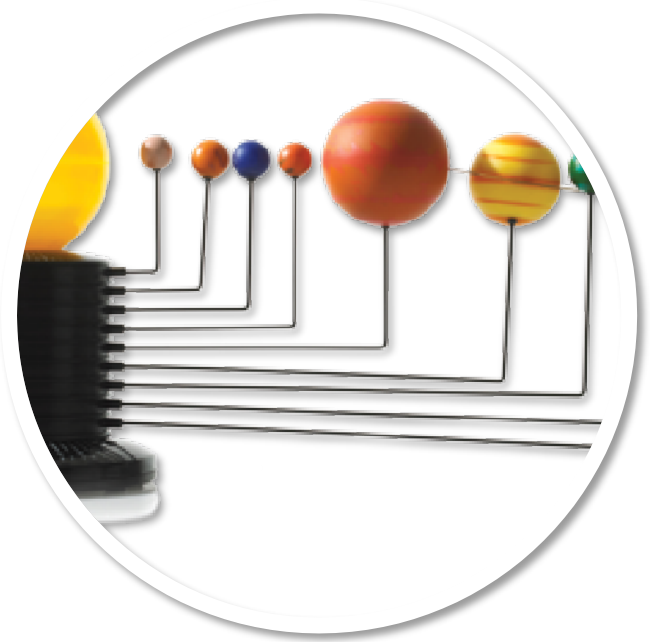


Figure 2.14: A model of the Sun and planets.

Models and Theories

- **Model:**
  - A verbal, mathematical, or visual representation of a scientific structure or process

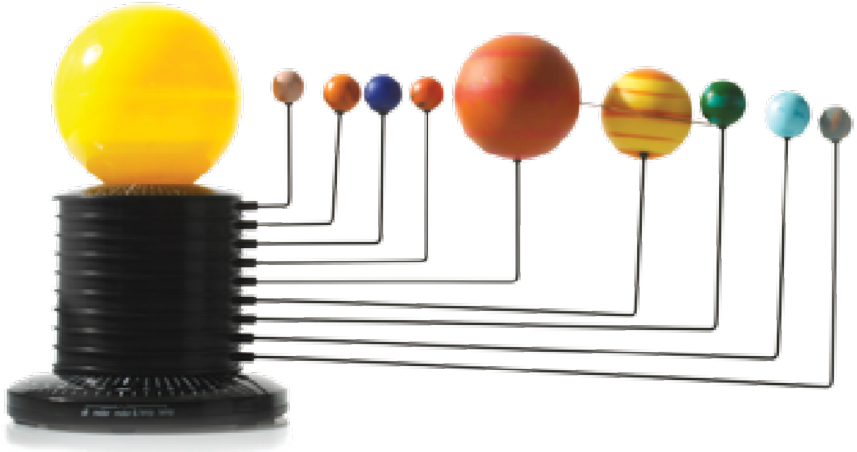


Figure 2.14: A model of the Sun and planets.

Models and Theories

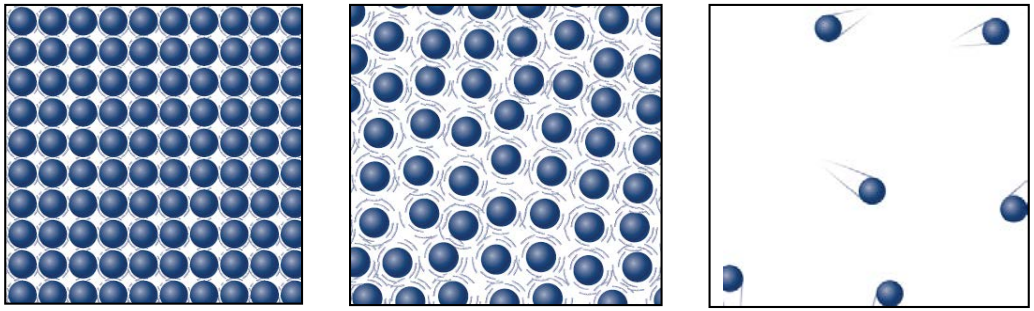
- **Theory**:
  - A scientific explanation that has been supported by consistent, repeated experimental results
  - Can be modified if new experimental data arise
  - Never considered to be proven

Explaining Properties of the States of Matter

- **Particle Model of Matter:**
  - All matter is made up of very small particles
  - Particles are so small, they cannot be seen even with the help of a light microscope
  - Scientists used this model develop a theory of the behaviour of all states of matter: **kinetic molecular theory of matter (KMT)**

The Kinetic Molecular Theory of Matter (KMT)

- All matter is made up of very small particles.
- The particles exist in empty space.
- Particles are constantly moving.
- Energy makes particles move.
  - More energy → faster movement → move farther apart



States of Matter and the Kinetic Molecular Theory

- The KMT explains the properties of solids, liquids, and gases.

- **Particles in a Solid**:
  - Very close together
  - Vibrate but do not move around
  - Attract one another strongly in a rigid structure

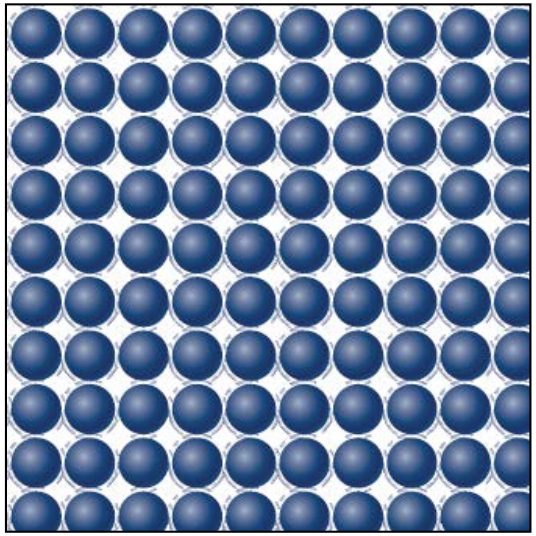


Figure 2.15: Particles in a Solid

States of Matter and the Kinetic Molecular Theory

- **Particles in a Liquid**:
  - Very close together
  - Slip and slide past an revolve around one another
  - Attract one another less strongly than in solids

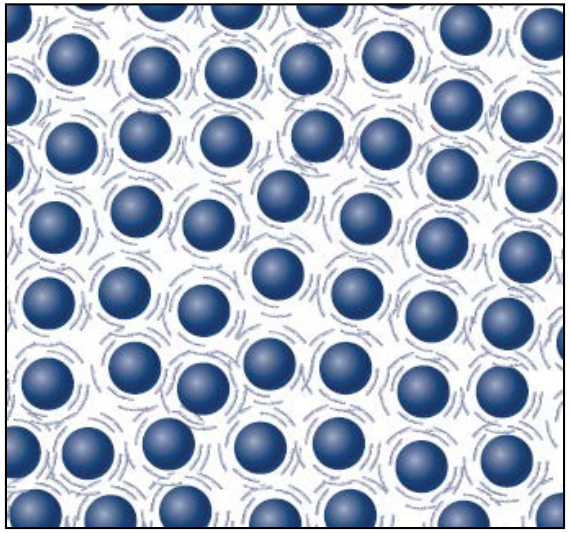


Figure 2.15: Particles in a Liquid

States of Matter and the Kinetic Molecular Theory

- **Particles in a Gas**:
  - Very far apart compared to their size
  - Move randomly and quickly in straight lines
  - Attraction to one another is effectively zero

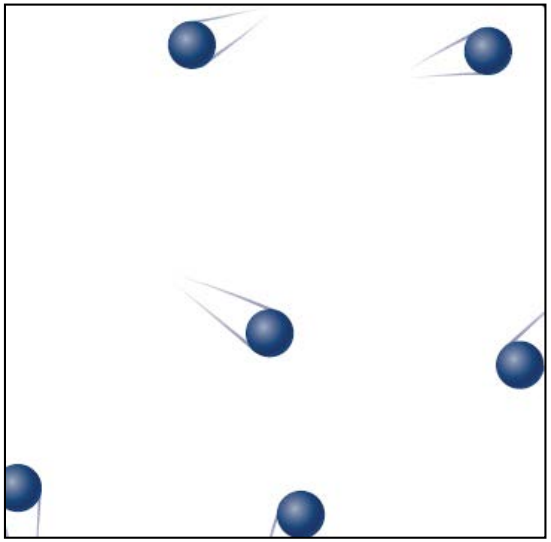
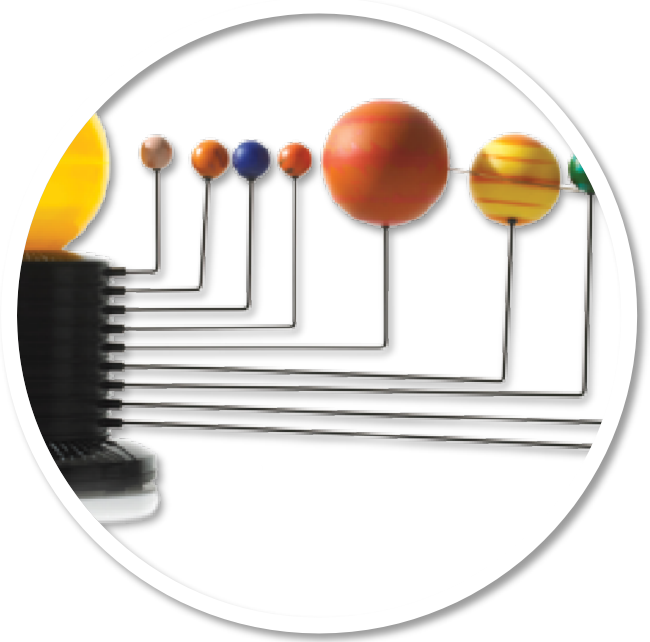


Figure 2.15: Particles in a Gas

Discussion Questions

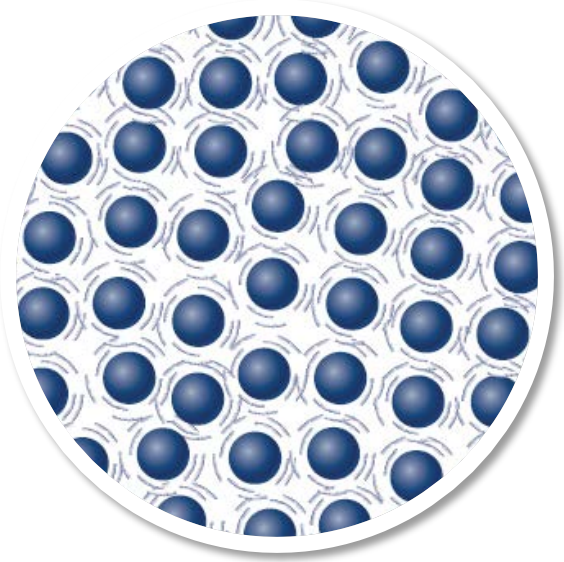
- In what ways does a model differ from a theory?
- Summarize the kinetic molecular theory of matter.



Discussion Questions

- Describe the particles of the three states of matter in terms of how they move and the spaces between them.

- It is easy to compress (reduce the volume of) a gas, but solids and liquids cannot be compressed very much. Use the KMT to explain why.

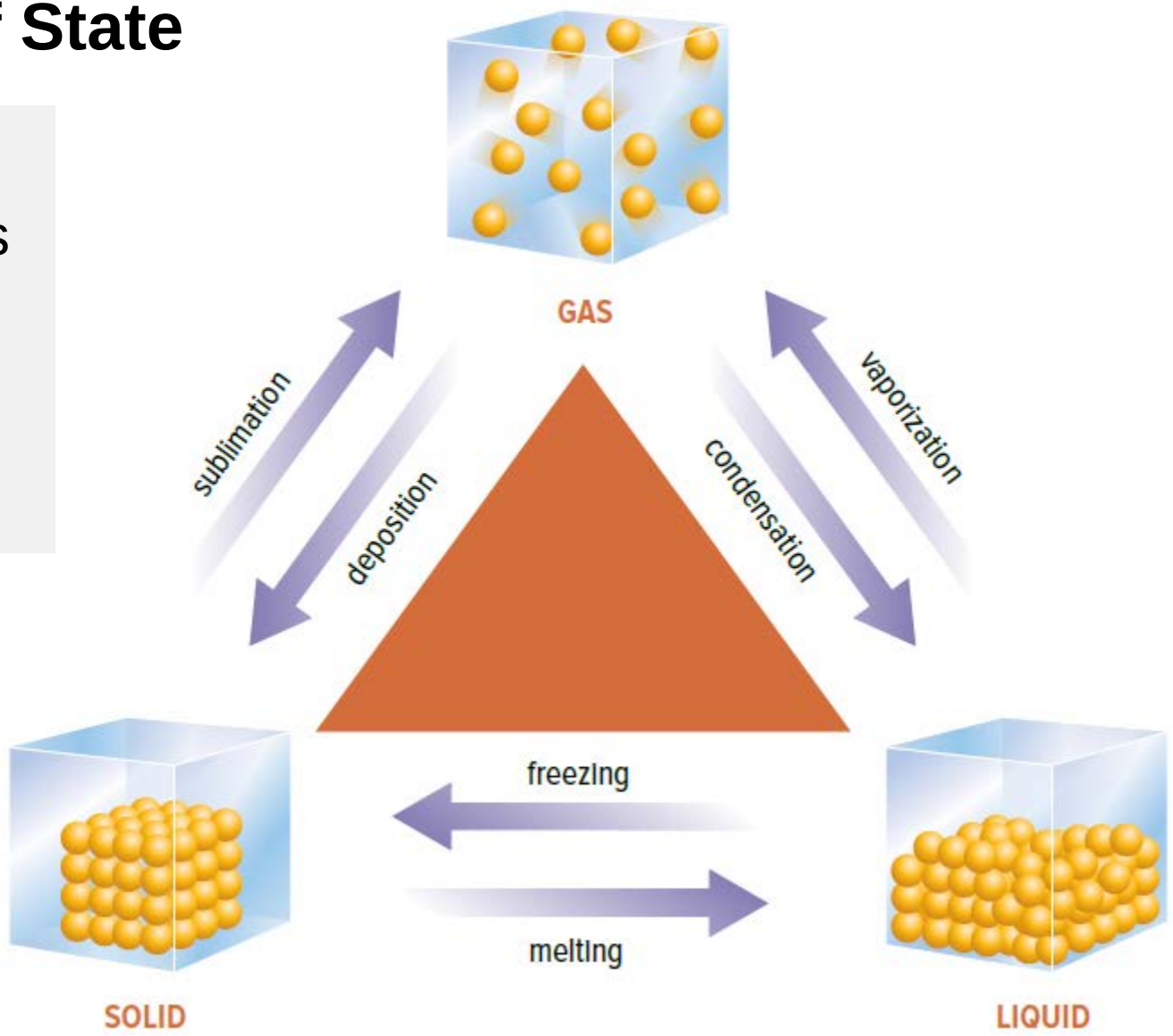


Concept 3: Changes in state result from changes in particle motion.

- Changes of state:
  - Occur when matter transforms from one state to another
  - Example: liquid (water) to solid (ice)

Changes of State

Figure 2.16: Specific terms are used to describe changes of state.



Changes of State and Temperature

- Temperature:
  - A measure of the average kinetic energy of particles in a substance
  - Adding or removing energy from matter changes the temperature of the matter
  - Increasing temperature of matter means that particles are gaining energy

Changes of State and Temperature

- Once matter reaches a certain temperature, the particles have gained enough energy to change state.
  - Example: Melting point is the temperature at which substance melts
    - Melting point of water: 0°C
    - When ice (water in a solid state) reaches 0°C, it melts and changes to a liquid state

The Kinetic Molecular Theory and Changes of State

- Why do substances change from one state to another when they are heated or cooled?
- Why does a heated solid melt instead of just becoming a very hot solid?

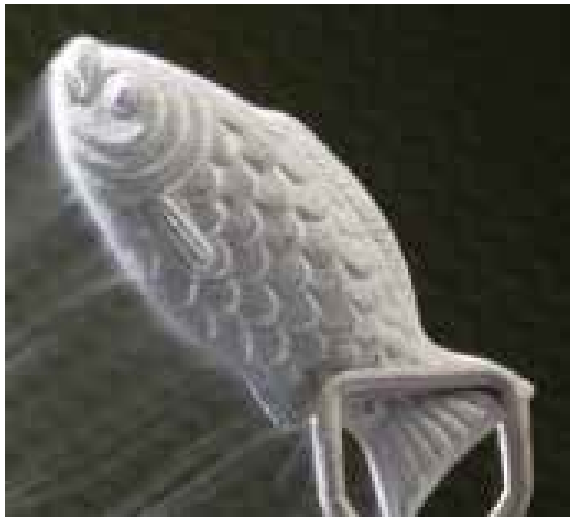


Figure 2.17 Solid mercury is formed by cooling it to below -38.8°C, the melting point of mercury.

Changes of State: Mercury

- **Solid mercury**
  - Particles are very close to one another and vibrate
  - Particles strongly attract one another

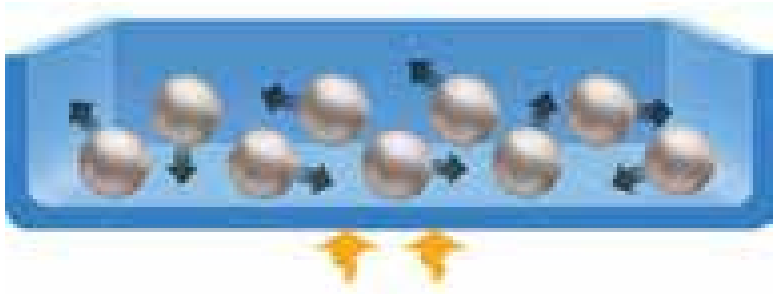
A sample of mercury absorbs energy (orange arrows)

Changes of State: Mercury

- **Melting mercury**
  - As temperature of solid mercury increases, kinetic energy of particles increases
  - Increased kinetic energy allows them to overcome attractive forces and break free
  - Particles begin to revolve and slide past one another

Changes of State: Mercury

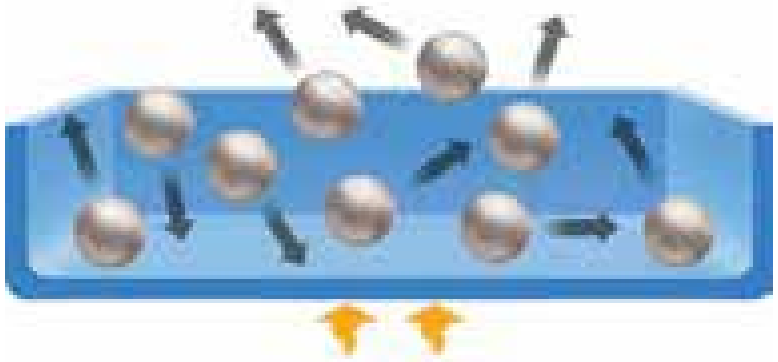
- **Liquid mercury**
  - Particles move freely around one another
  - Particles are still close together and strongly attracted
  - Take shape of their container



A sample of liquid mercury absorbs energy (orange arrows)

Changes of State: Mercury

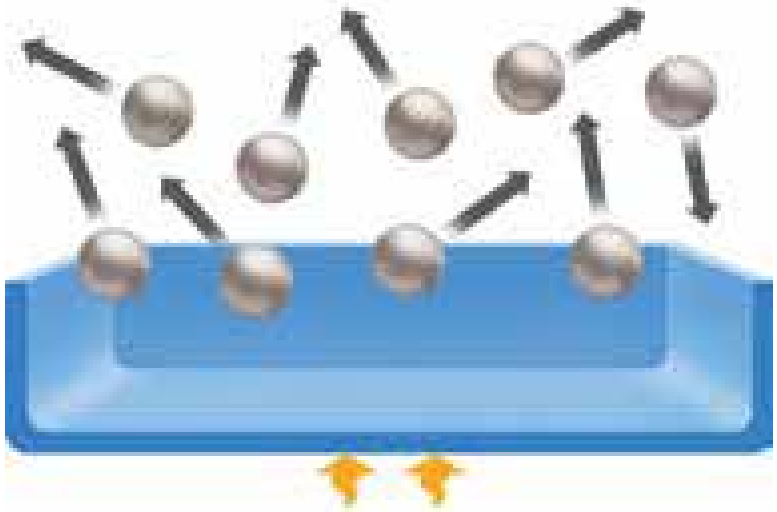
- **Boiling mercury**
  - As temperature increases, kinetic energy increases
  - Particles move more vigorously
  - Some particles gain enough energy to overcome attractive forces and escape into the air



A sample of mercury absorbs energy (orange arrows)

Changes of State: Mercury

- **Gaseous mercury**
  - Particles are highly energetic and move freely to fill container
  - Increasing temperature increases speed of gas particles
  - Sealed container: particles collide with each other and with container, increasing the pressure of the gas



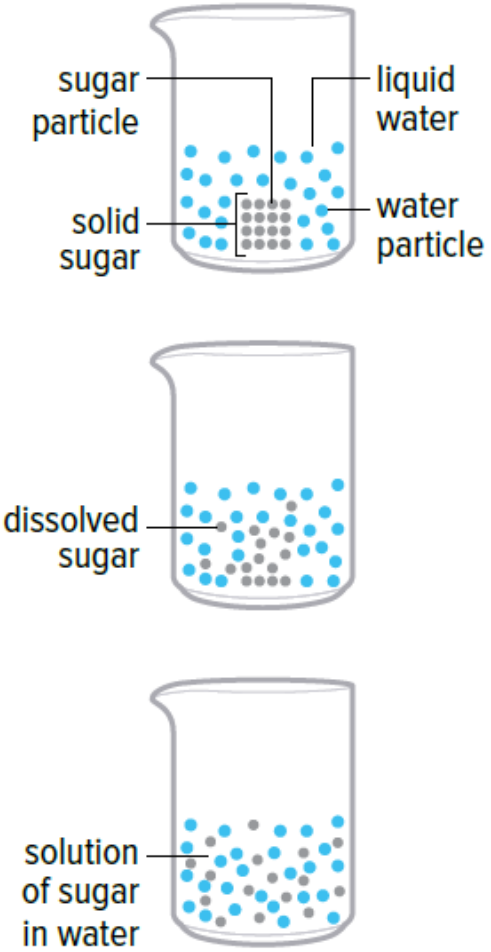
A sample of gaseous mercury absorbs energy (orange arrows)

Discussion Questions

- Define temperature.
- What is the melting point of a substance?
- Use the KMT to explain how a liquid changes into a solid.

Concept 4: The kinetic molecular theory explains physical changes and properties.

- The KMT can explain:
  - Dissolving a solid in a liquid
  - Diffusion
  - Thermal expansion



KMT: Dissolving a Solid in a Liquid

- Dissolving: a solid completely mixes with a liquid to form a solution
  - Particles in a solid are in constant random motion due to their kinetic energy
    - Particles move randomly and constantly into the empty areas between the liquid particles

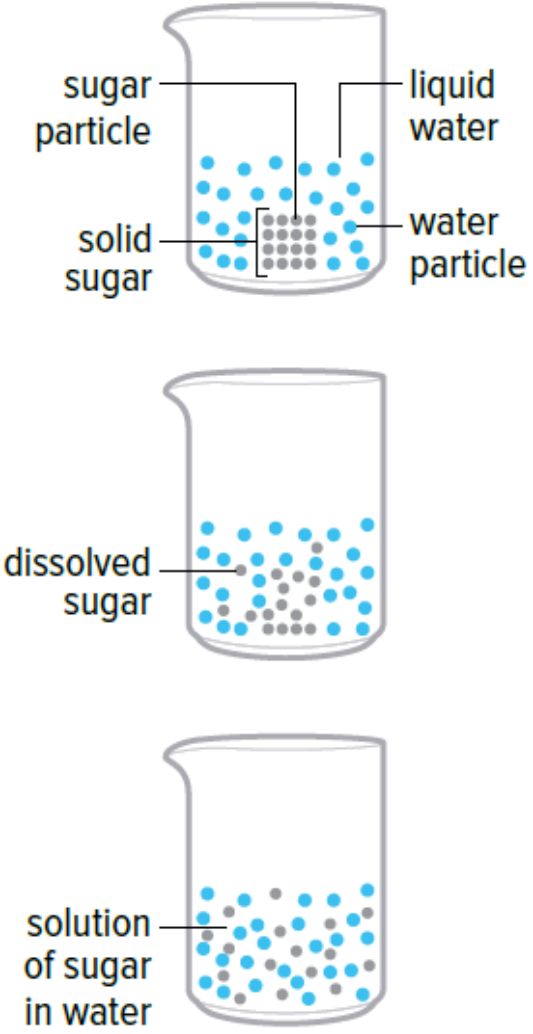


Figure 2.18 Why does sugar dissolve faster in hot water?

KMT: Explaining Diffusion

- Diffusion: the movement of one material through another
- How does the smell of toasted bread travel through a room to your nose?
  - Odours come from gases that have specific smells
  - During cooking, gases are released
  - Gas particles move freely and spread throughout the room

KMT: Explaining Thermal Expansion

- Solids, liquids and gases: expand when heated, and contract when cooled
- Thermal expansion: the expansion of heated materials
- Heating increases kinetic energy of particles
  - Causes particles to vibrate faster and move slightly apart
  - Material as a whole expands

KMT: Explaining Thermal Expansion

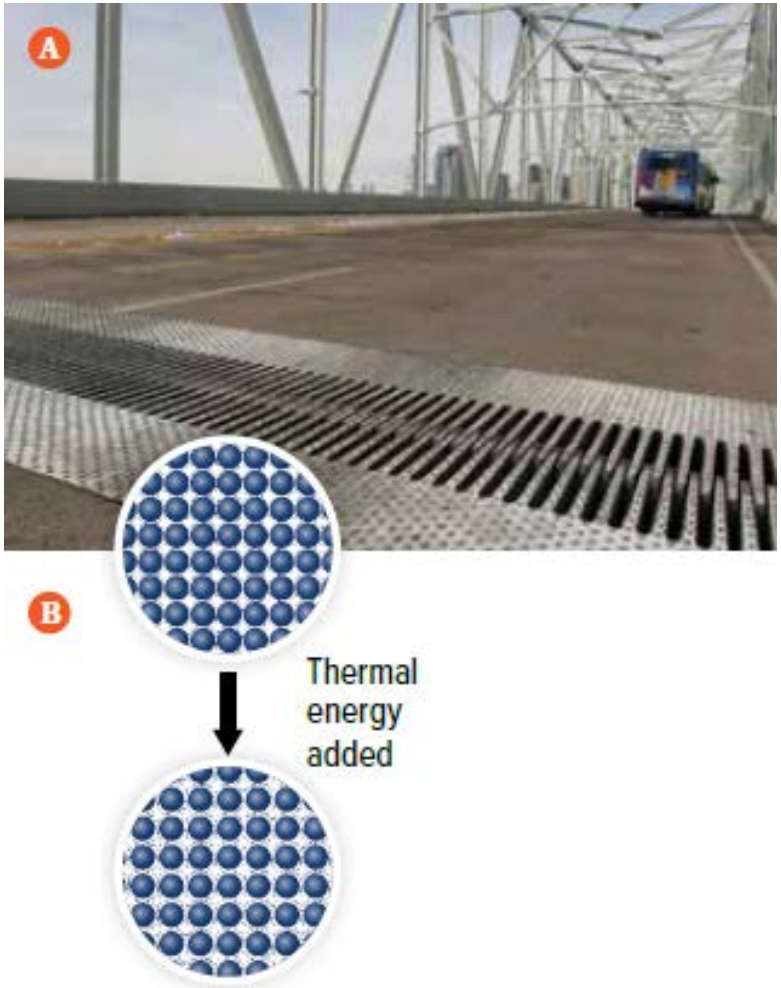


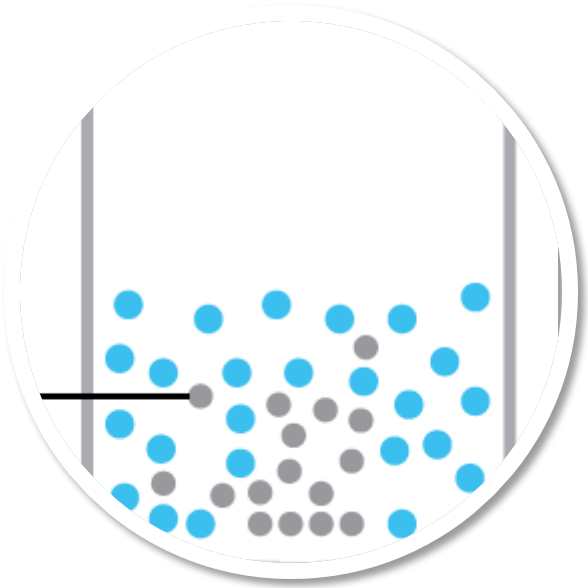
Figure 2.19 (A) Expansion joints prevent damage by allowing material to expand and contract with changes in temperature.

(B) When a solid is heated, its particles gain energy and vibrate faster. They move farther apart and the solid expands as a result.

Discussion Questions

- Use the KMT to explain why a balloon in a hot car will expand and may eventually pop.

- Use the KMT to explain what happens when salt dissolves in water.



Discussion Questions

- The thermometers you use in a lab likely contain a narrow column of red-dyed alcohol. Use the KMT to explain how this type of thermometer works.

- What might happen if a bridge were build in B.C. without an expansion joint? Explain.

Summary: How can we describe and explain the states of matter?

- Matter can be solid, liquid, or gas.
- Matter is made of particles in constant motion.
- Changes in state result from changes in particle motion.
- The kinetic molecular theory explains physical changes and properties.