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?
- What are some key characteristics that distinguish liquids, solids, and gases from each other? (How would you ***define*** these words?)

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 lightning 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?

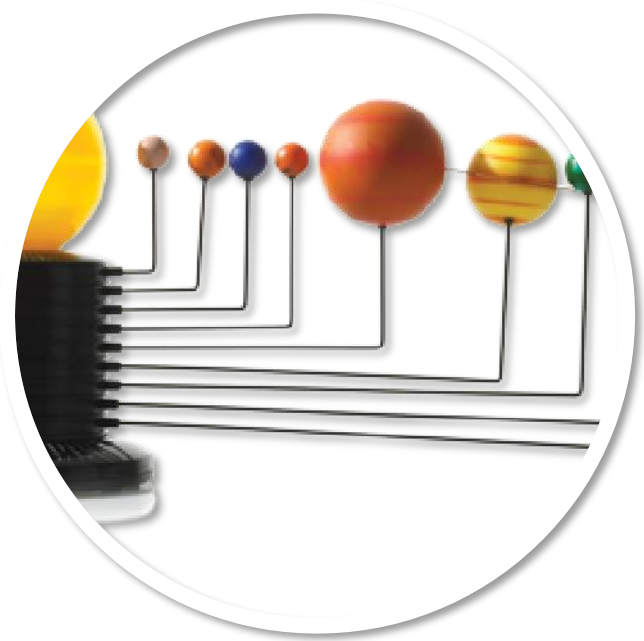


Figure 2.14: A model of the Sun and planets.

Models and Theories

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

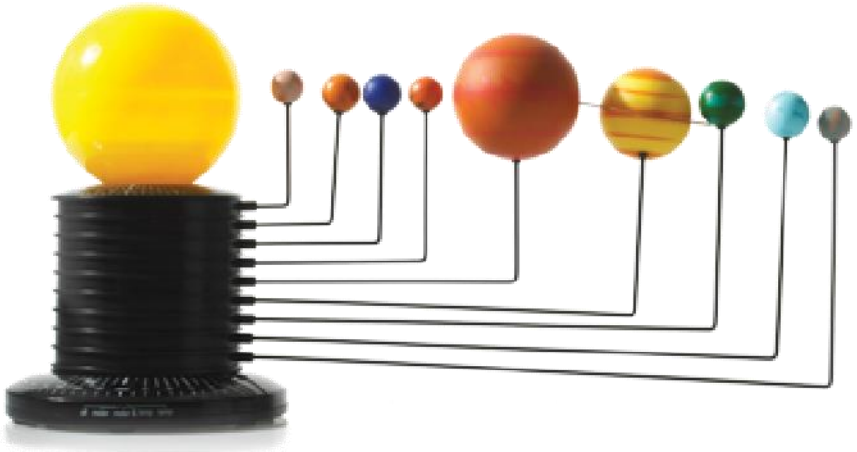
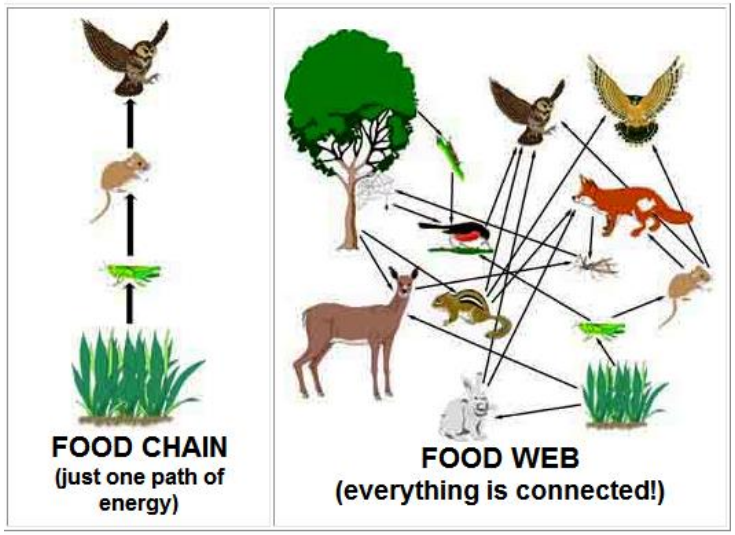
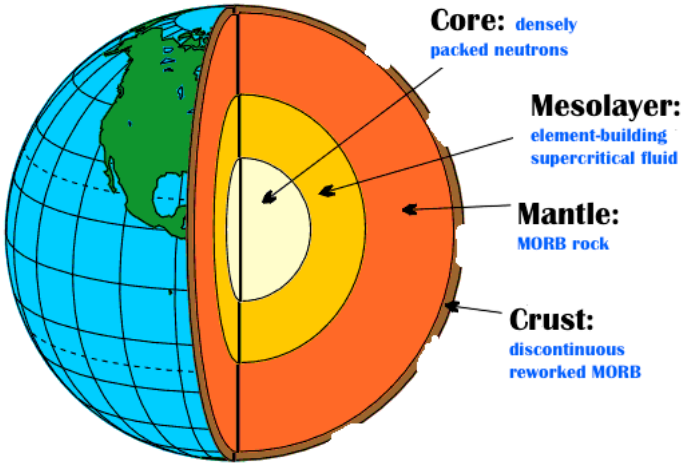
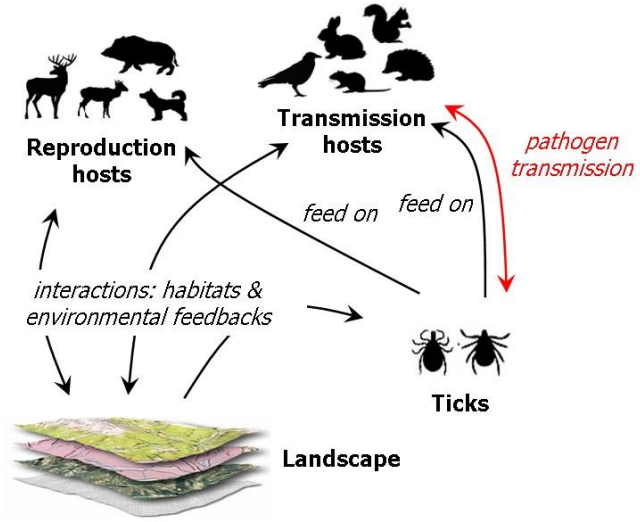
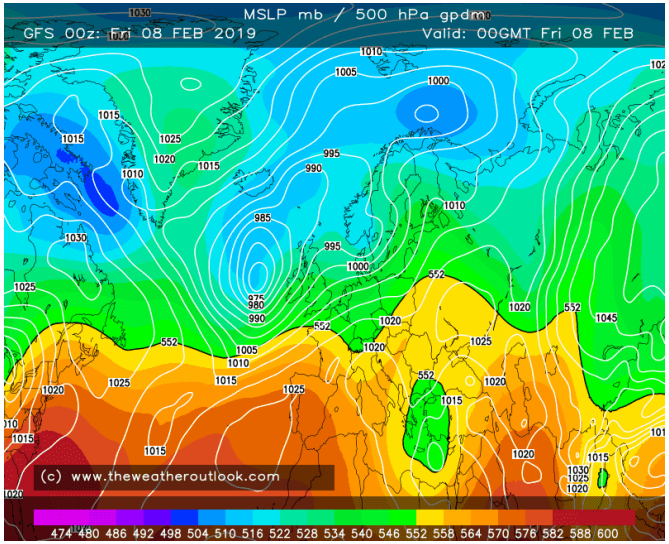


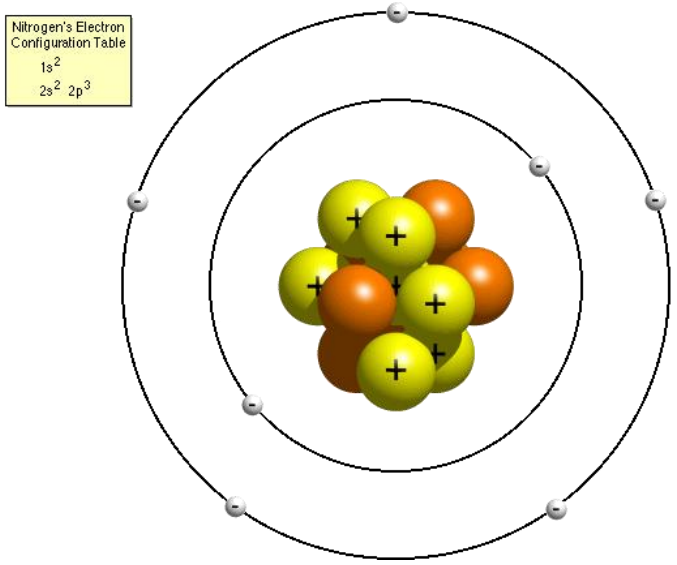
Figure 2.14: A model of the Sun and planets.

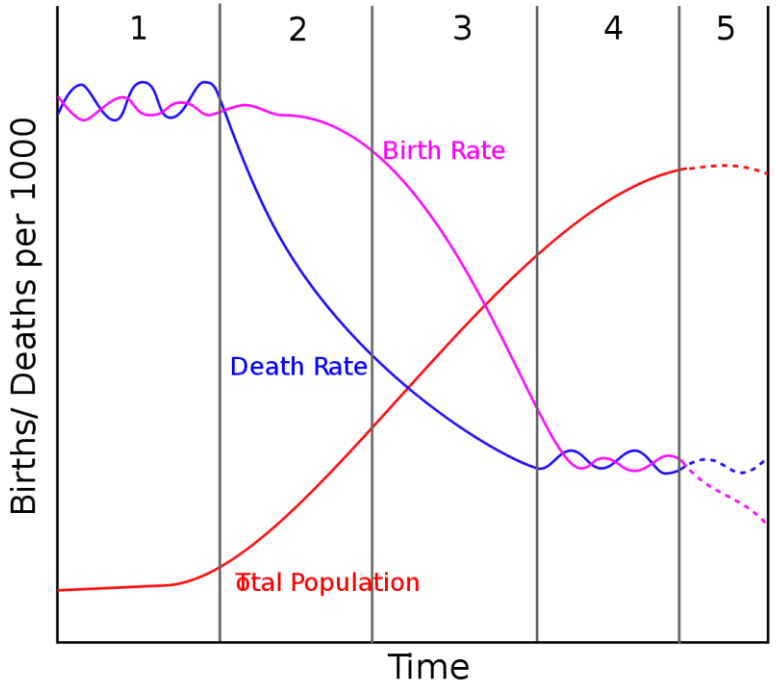

FOOD CHAIN
(just one path of energy)
FOOD WEB
(everything is connected!)


Core: densely packed neutrons
Mesolayer: element-building supercritical fluid
Mantle: MORB rock
Crust: discontinuous reworked MORB


Reproduction hosts
Transmission hosts
pathogen transmission
feed on
feed on
interactions: habitats & environmental feedbacks
Ticks
Landscape


MSLP mb / 500 hPa gpdm
GFS 00z: Fri 08 FEB 2019
Valid: 00GMT Fri 08 FEB
(c) www.theweatheroutlook.com
474 480 486 492 498 504 510 516 522 528 534 540 546 552 558 564 570 576 582 588 600


Nitrogen's Electron Configuration Table
$1s^2$
$2s^2\ 2p^3$


1
2
3
4
5
Births/ Deaths per 1000
Birth Rate
Death Rate
Total Population
Time

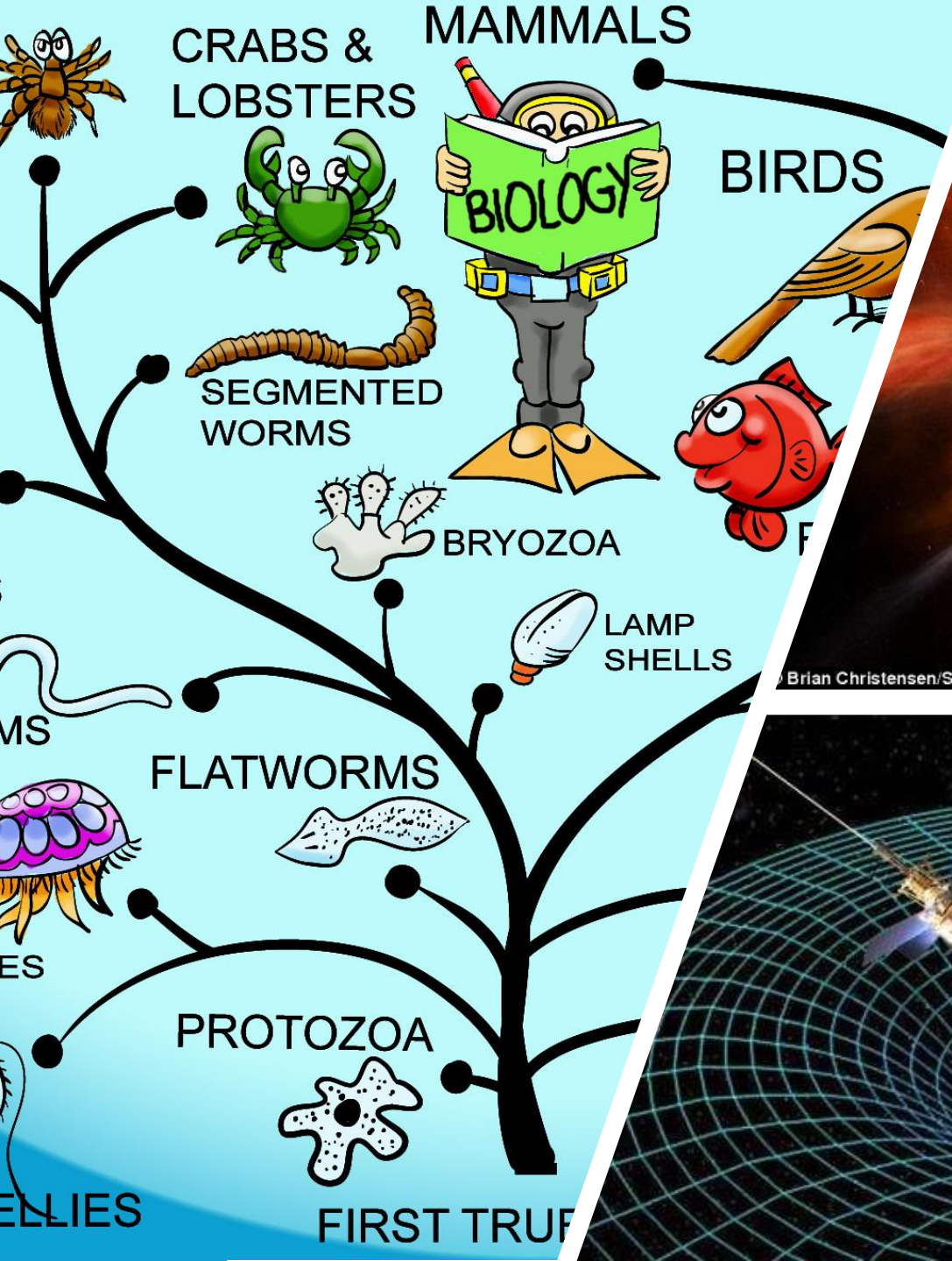
Models and Theories

- **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

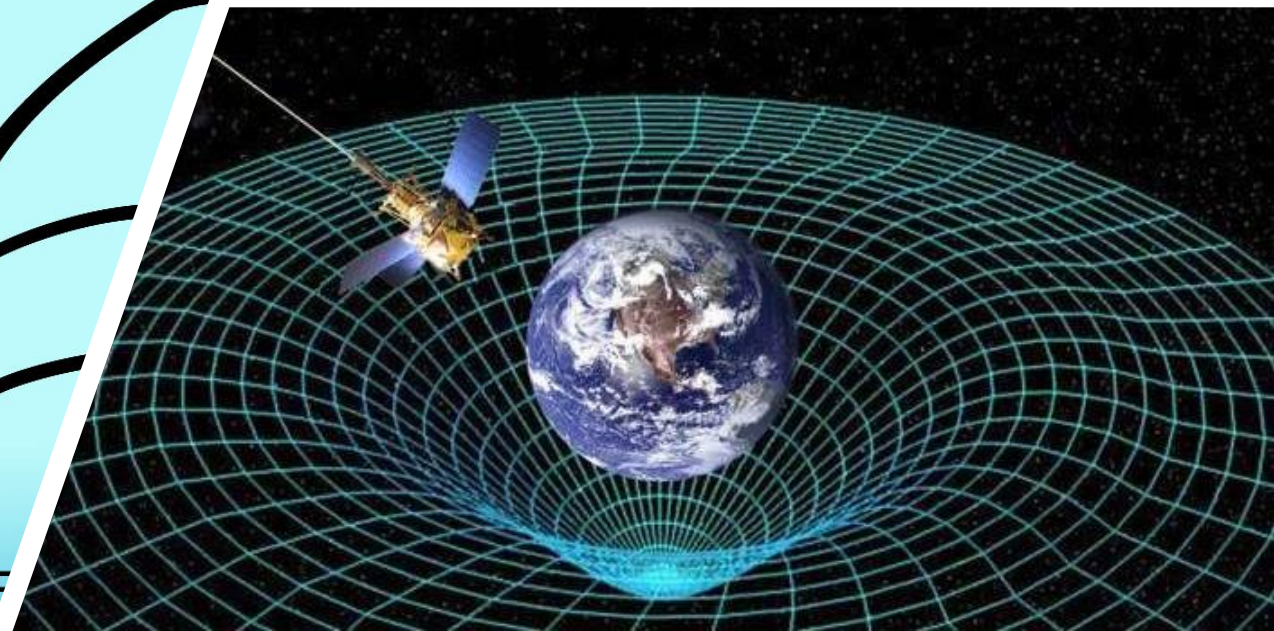
EVOLUTION IS JUST A THEORY!

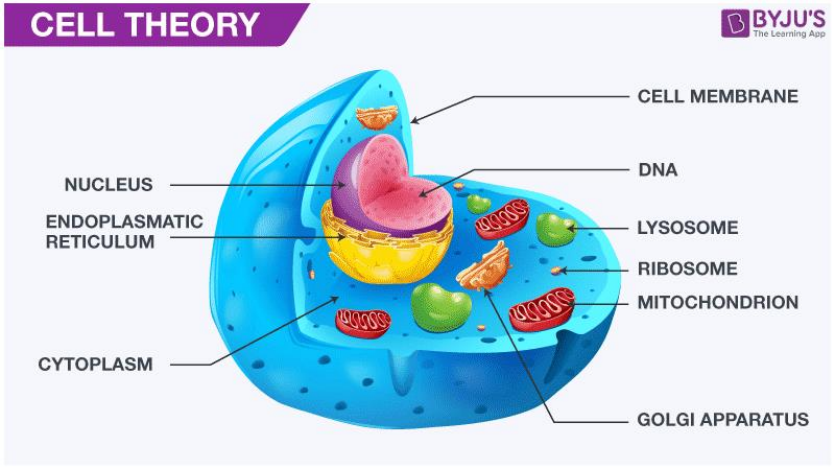
Actually, dear, evolution itself is an observed scientific *fact*. The "theory" of evolution is just the current best *explanation* for that observed fact. You know — just like the theory of gravity explains the observed fact of gravity and is not just some wild guess that gravity exists.

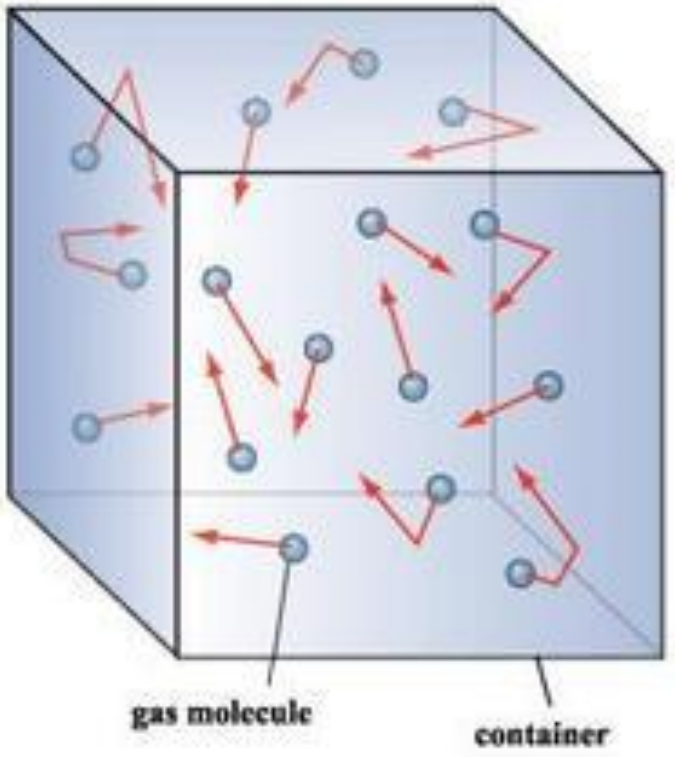
And remember, Dad — a scientific theory is a coherent group of tested general propositions, commonly regarded as correct, that can be used as principles of explanation and prediction for a class of phenomena. It's not just some wild guess or baseless assertion


MAMMALS
CRABS &
LOBSTERS
BIRDS
BIOLOGY
SEGMENTED
WORMS
BRYOZOA
LAMP
SHELLS
FLATWORMS
PROTOZOA
FIRST TRU


Brian Christensen/Stocktrek Images/Corbis




CELL THEORY
BYJU'S
The Learning App
CELL MEMBRANE
NUCLEUS
DNA
ENDOPLASMATIC
RETICULUM
LYSOSOME
RIBOSOME
MITOCHONDRION
CYTOPLASM
GOLGI APPARATUS

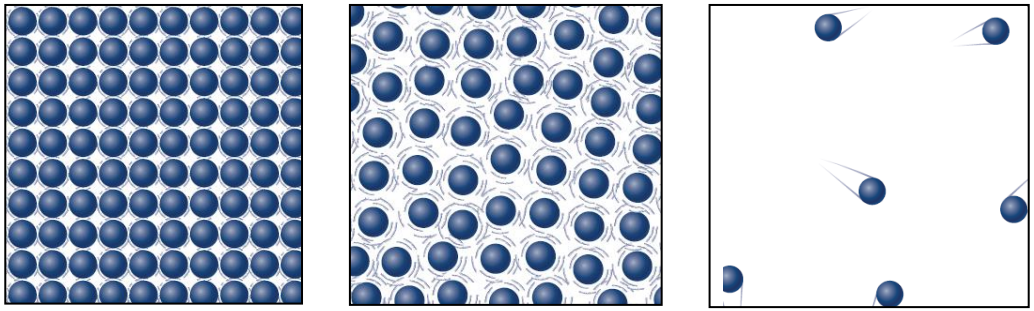

gas molecule
container

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

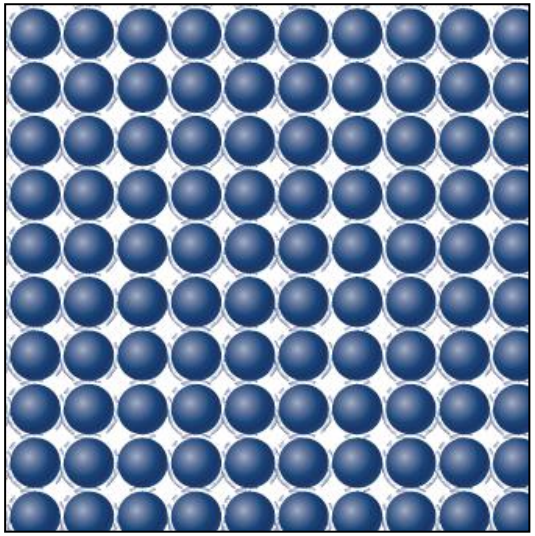


Figure 2.15: Particles in a Solid

States of Matter and the Kinetic Molecular Theory

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

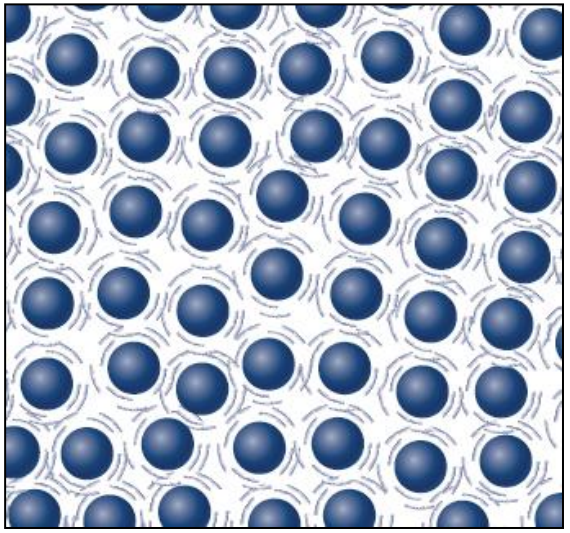


Figure 2.15: Particles in a Liquid

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

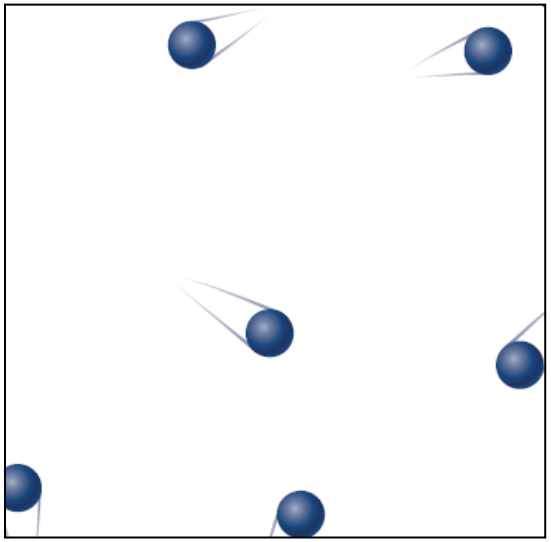
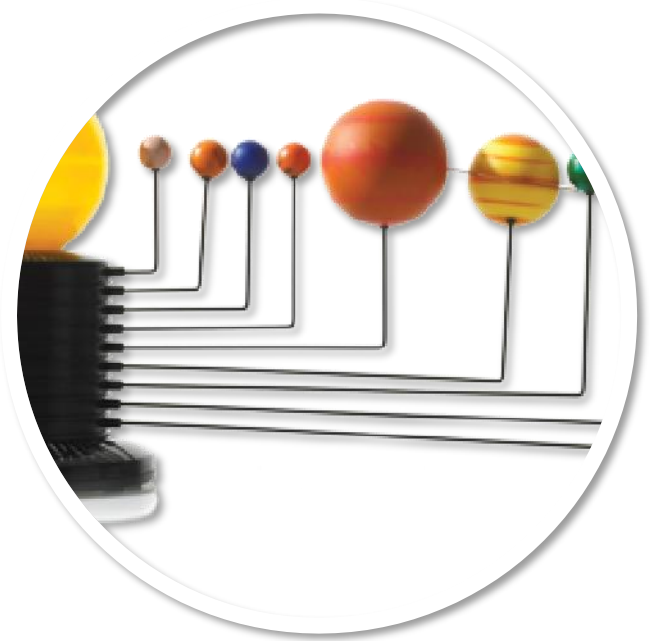


Figure 2.15: Particles in a Gas

Discussion Questions

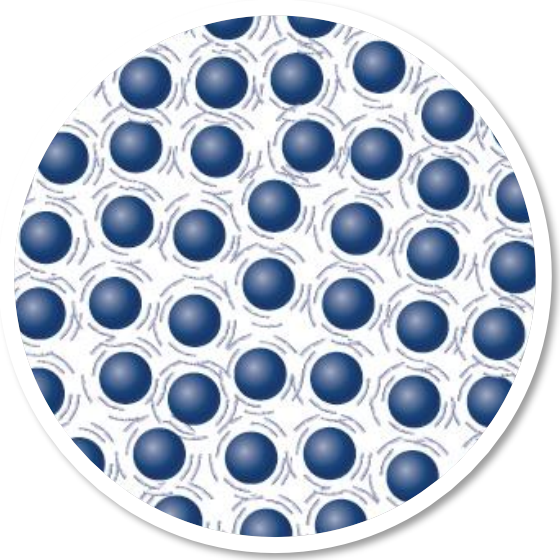
- In what ways does a model differ from a theory?
- Summarize the kinetic molecular theory of matter.



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.

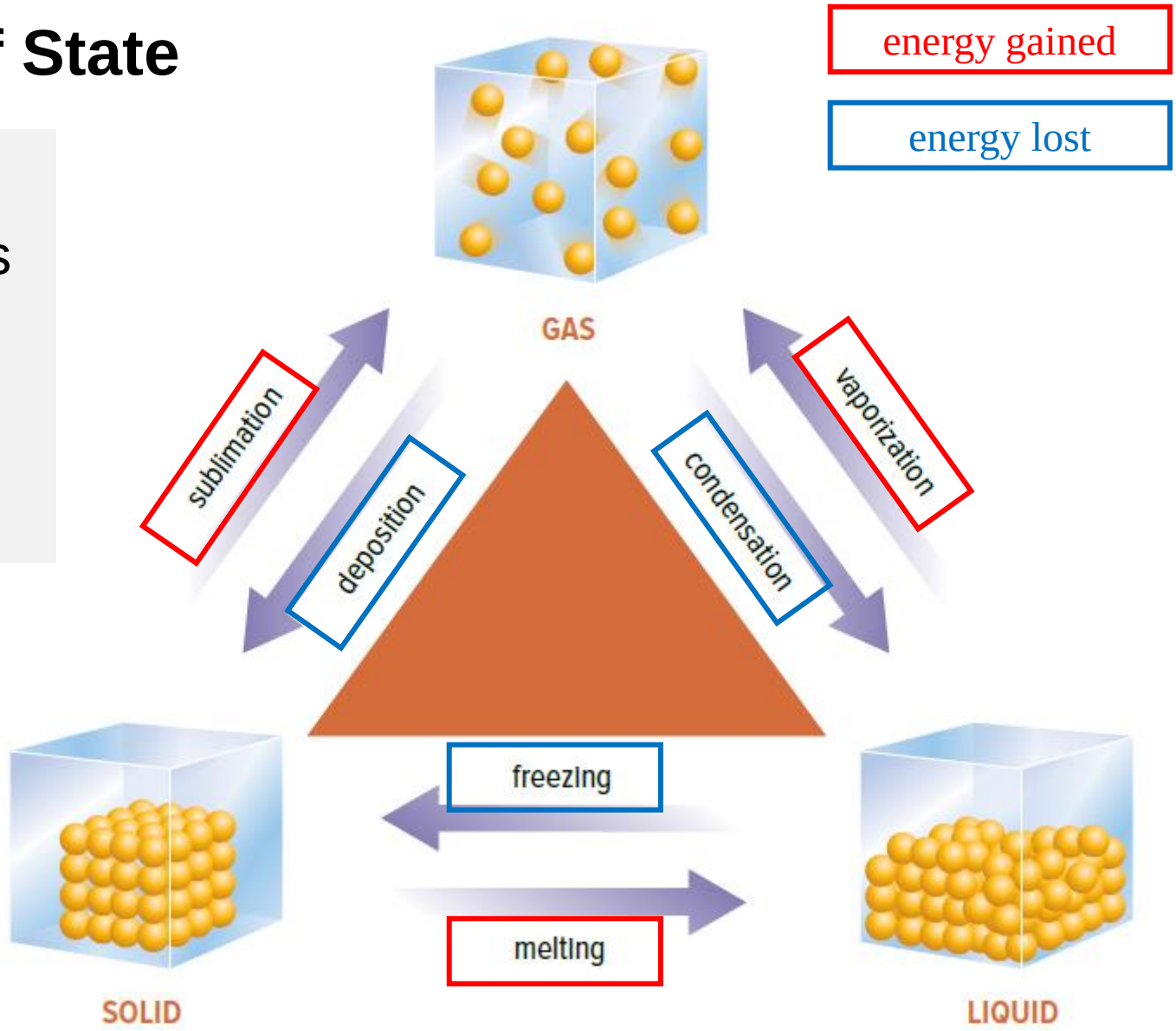


Concept 3: Changes in state result from changes in particle motion.

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

Changes of State

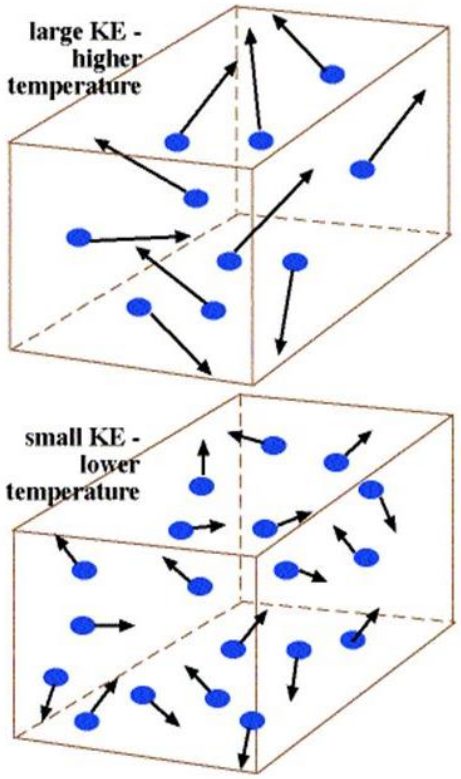
Figure 2.16: Specific terms are used to describe changes of state.



What is Temperature Really?

Changes of State and Temperature

- **Temperature**:
  - A measure of the average kinetic energy of particles in a substance
    - *Kinetic energy: energy of movement*



Predict what will happen:
a) To temperature if you increase or decrease energy?
b) To energy if you increase or decrease temperature?

Changes of State and Temperature

- **Temperature**:
  - Adding or removing energy from matter increases or decreases its temperature
  - Increasing temperature of matter means that particles are gaining energy

$$E_k = \frac{3}{2}kT$$

E_k = kinetic energy of atom or molecule in Joules

$k = 1.38 \times 10^{-23}\ J/K$

T = Temperature of gas in Kelvin

(Do not memorize (or panic)! FYI only.

r/NoStupidQuestions
Posted by u/MrWaterplant • 13h

If kinetic energy is converted into thermal energy, how hard to I have to slap a chicken to cook it?

Learning Discussion

1.6k 111 Share

(Do not memorize (or panic)! FYI only.

Parker Ormonde

As your friendly neighborhood physics major, I decided to calculate this with a few assumptions.

The formula for converting between kinetic energy and thermal energy is $1/2mv^2=mcT$

The average human hand weighs about 0.4kg, the average slap has a velocity of 11m/s (25mph), an average rotisserie chicken weighs 1kg (2lbs), has a specific heat capacity of 2720 J/kg*c, and let's assume the chicken has to reach a temperature of 205C (400F) for us to consider it cooked. The chicken will start off frozen, so 0C (32F)

1 average slap would generate a temperature increase of 0.0089 degrees Celsius. It would take 23,034 average slaps to cook the chicken.

To cook the chicken in one slap, you would have to slap it with a velocity of 1665.65 m/s or 3725.95 mph.

Just now Like Reply

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

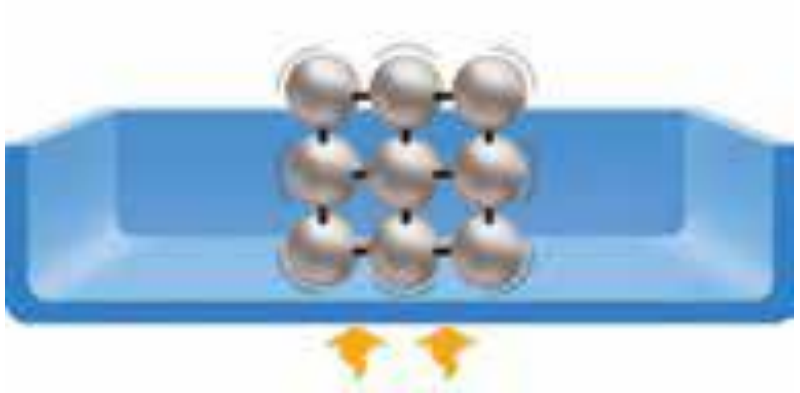
The Kinetic Molecular Theory and Changes of State

- 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

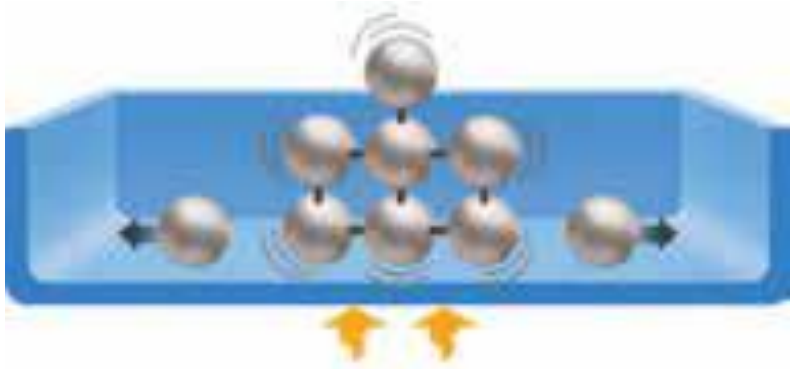
- **Solid mercury**
  - Particles are very close to one another and vibrate
  - Particles strongly attract one another



A sample of mercury absorbs energy (orange arrows)

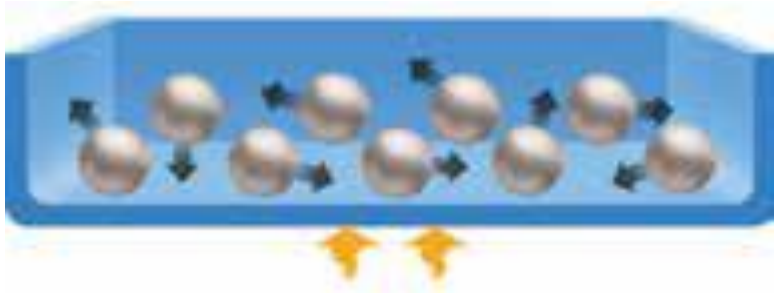
Changes of State: Mercury

- **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

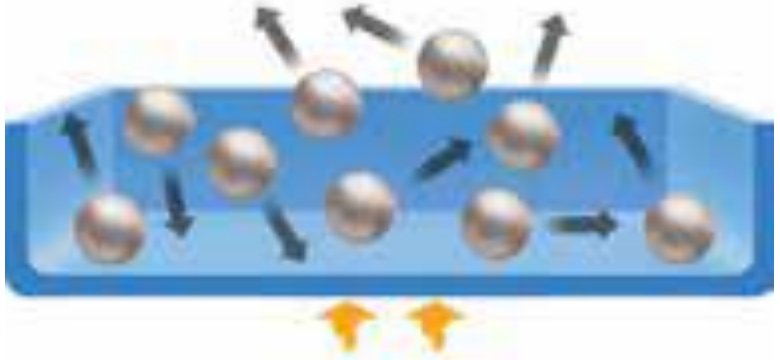
- **Liquid mercury**
  - Particles move freely around one another
  - Particles are still close together and strongly attracted
  - Take shape of their container



A sample of liquid mercury absorbs energy (orange arrows)

Changes of State: Mercury

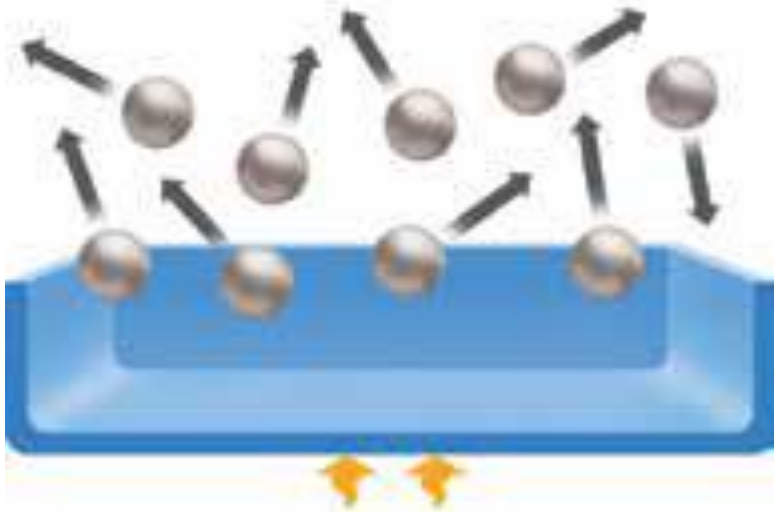
- **Boiling mercury**
  - As temperature increases, kinetic energy increases
  - Particles move more vigorously
  - Some particles gain enough energy to overcome attractive forces and escape into the air



A sample of mercury absorbs energy (orange arrows)

Changes of State: Mercury

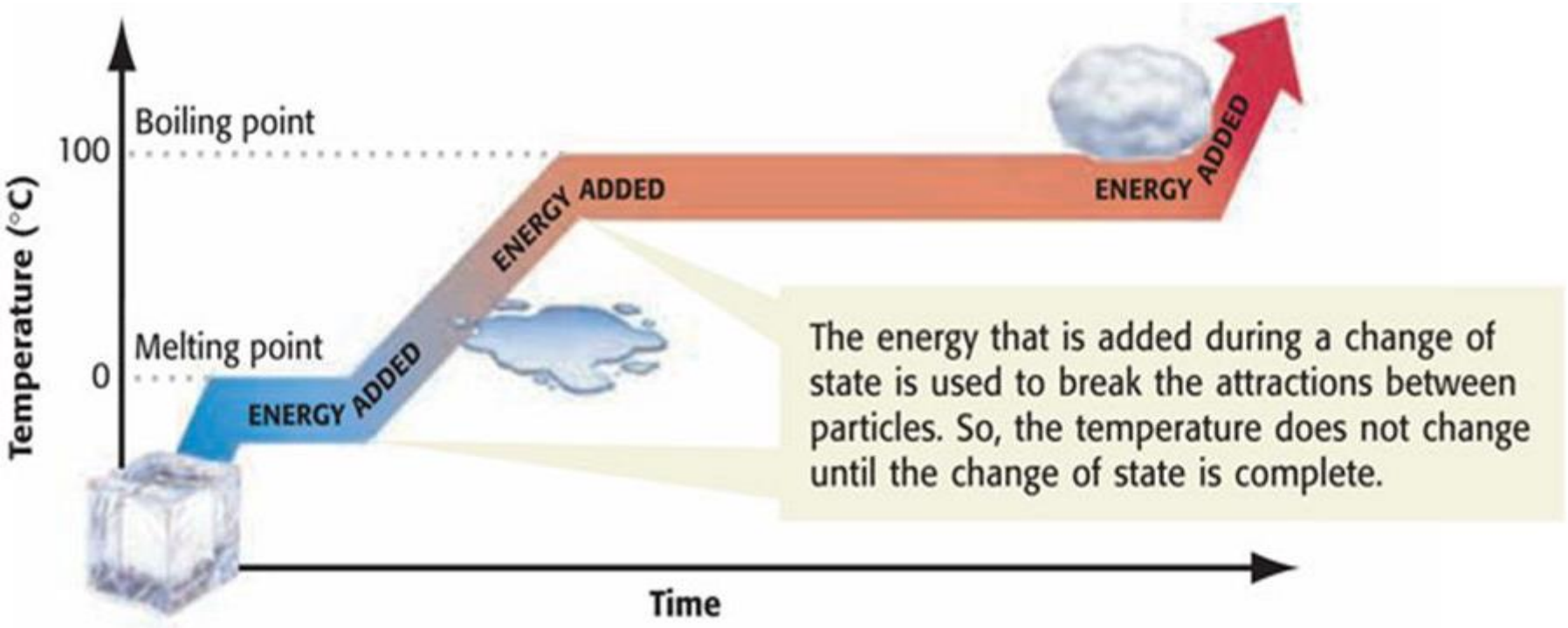
- **Gaseous mercury**
  - Particles are highly energetic and move freely to fill container
  - Increasing temperature increases speed of gas particles
  - Sealed container: particles collide with each other and with container, increasing the pressure of the gas



A sample of gaseous mercury absorbs energy (orange arrows)

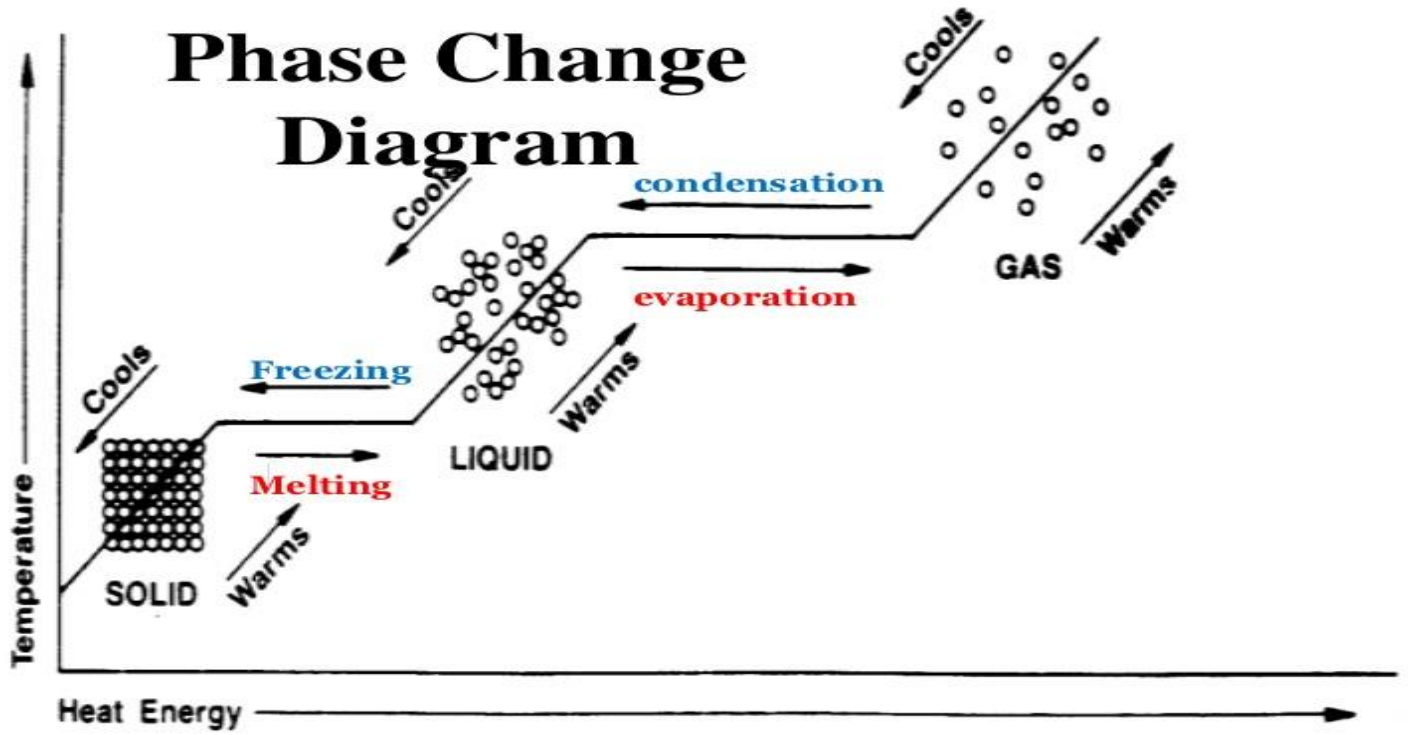
Changes of State and Temperature

- Once matter reaches a certain temperature, the particles have gained enough energy to change state.



Changes of State and Temperature

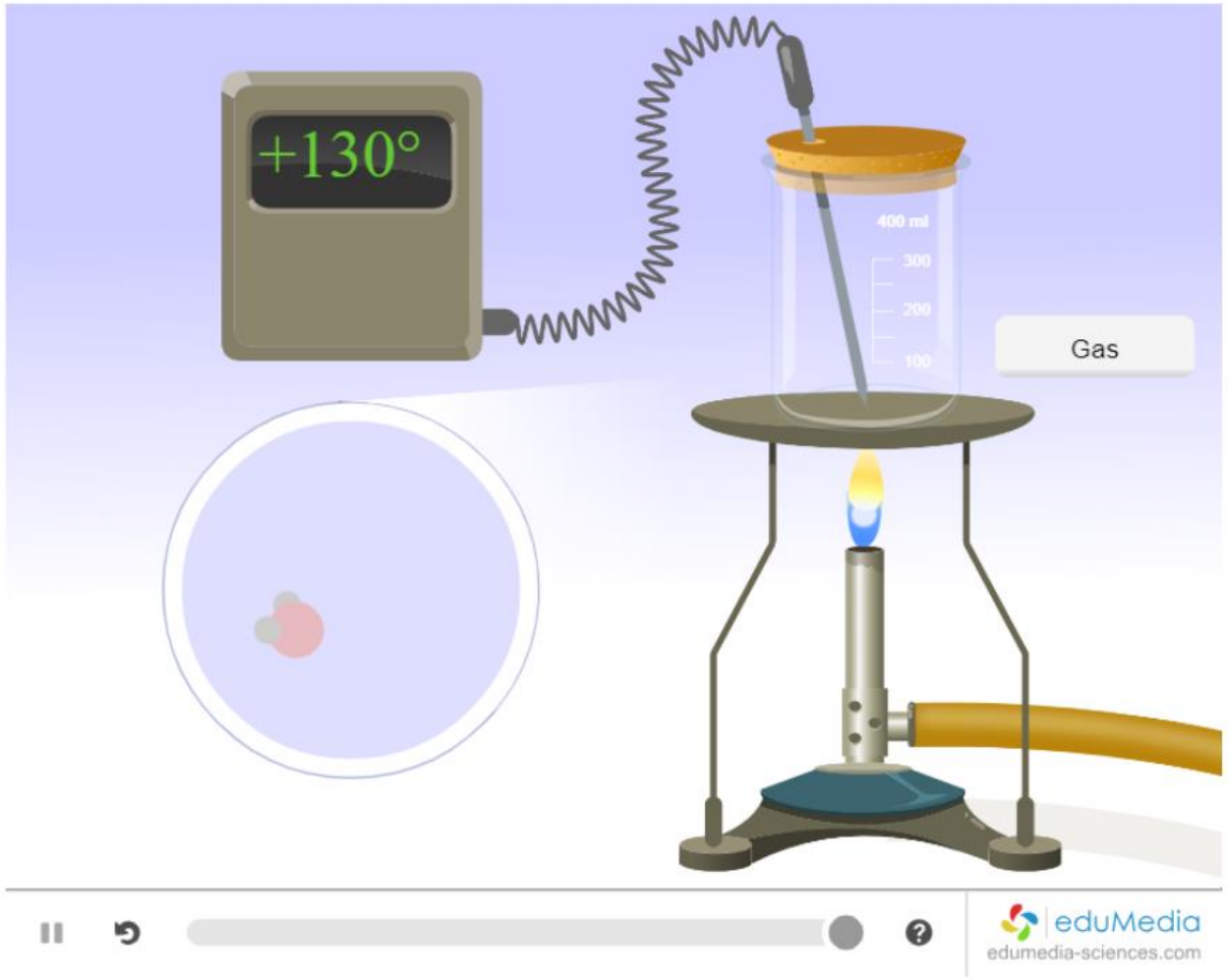
- Warming: heat energy converted to kinetic energy: makes particles move faster
- Phase change: heat energy used to overcome attraction forces



Discussion Questions

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

Simulation



Practice Questions (1)

1. **What is the name of the process where a liquid changes into a gas?**
   a) condensation
   b) vaporization
   c) transmission

2. **The molecules in a substance remain the same, no matter what state they are in.**
   a) True
   b) False

3. **Matter looks and behaves differently when it changes from one state to another.**
   a) True
   b) False

4. **What is the energy of motion?**
   a) potential energy
   b) matter energy
   c) kinetic energy

Practice Questions (2)

5. What does the Kinetic Theory of Matter state?

a) All particles of matter are in constant, random motion.
b) All particles of matter are motionless.
c) Energy can be transferred but not destroyed.

6. Which particles have the most kinetic energy?

a) water particles
b) ice particles
c) water vapour particles

7. Which particles have the least kinetic energy?

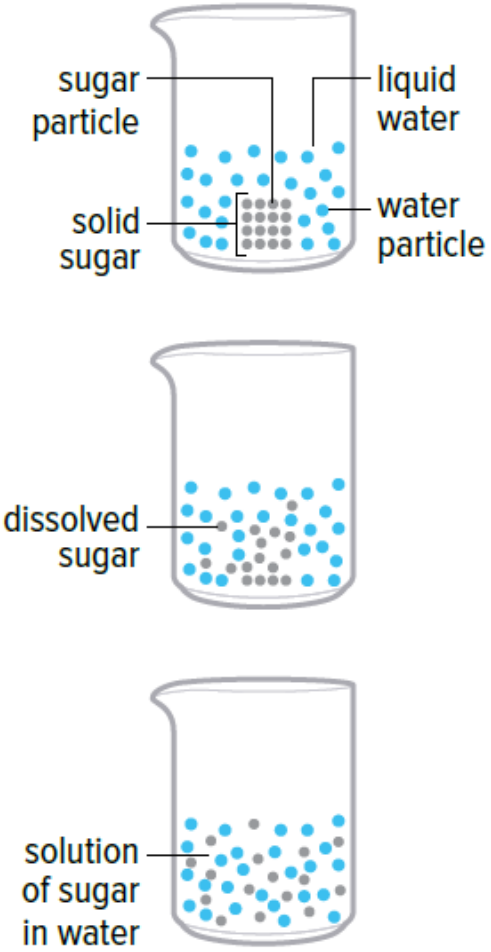
a) water particles
b) ice particles
c) water vapour particles

8. Particles in hot water have

a) more kinetic energy than cold water
b) the same kinetic energy as cold water
c) less kinetic energy than cold water

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

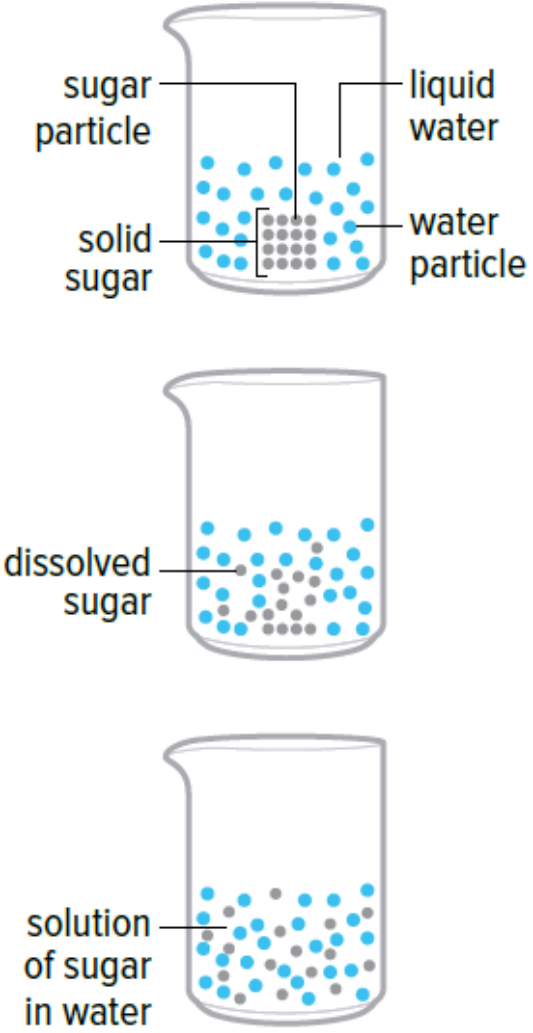


Figure 2.18 Why does sugar dissolve faster in hot water?

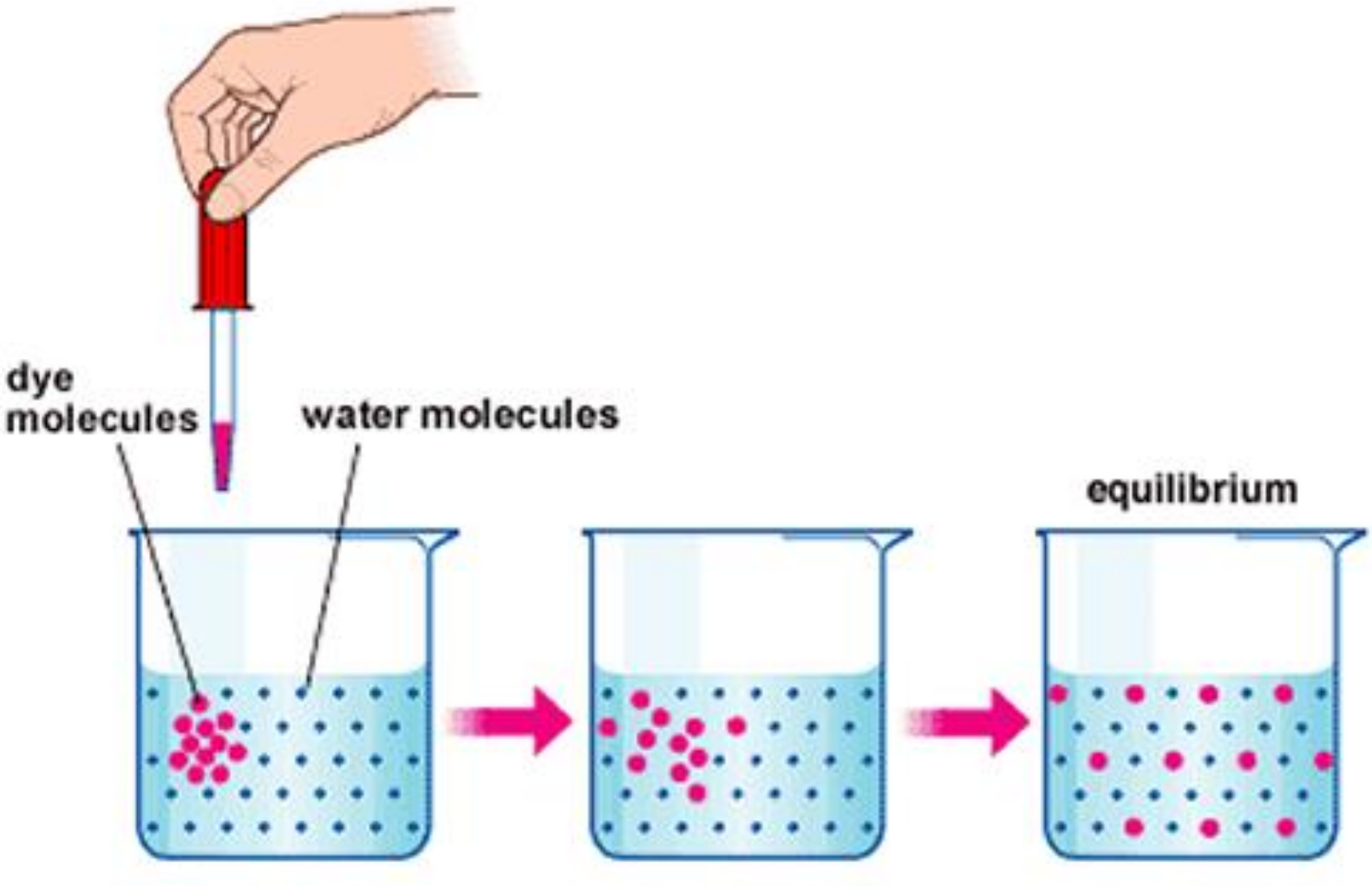
KMT: Explaining Diffusion

- 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 Diffusion

- **Diffusion**:
  - The movement of one material through another
  - (Most obvious when a concentrated substance diffuses outward)
    - High concentration = lots of particles in a small volume

KMT: Explaining Diffusion



https://socratic.org/questions/what-are-the-similarities-and-differences-between-diffusion-and-osmosis

KMT: Explaining Diffusion

- Examples:
  - Tea
  - Food colouring
  - Perfume
  - Smoke
  - Body Odour
  - Flatulence

KMT: Explaining Thermal Expansion

- What does the KMT tell us about the relationship between temperature and states of matter?
  - Increase temperature → change of state
- What does the KMT tell us about the relationship between states of matter and volume?
  - Change of state → change in volume
- What can we conclude?
  - Increasing temperature causes volume change!

KMT: Explaining Thermal Expansion

- What can we predict will happen to a slab of concrete on a warm day?
- Why do construction workers tend to lay smaller slabs of concrete together with gaps between them rather than single large pieces?

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

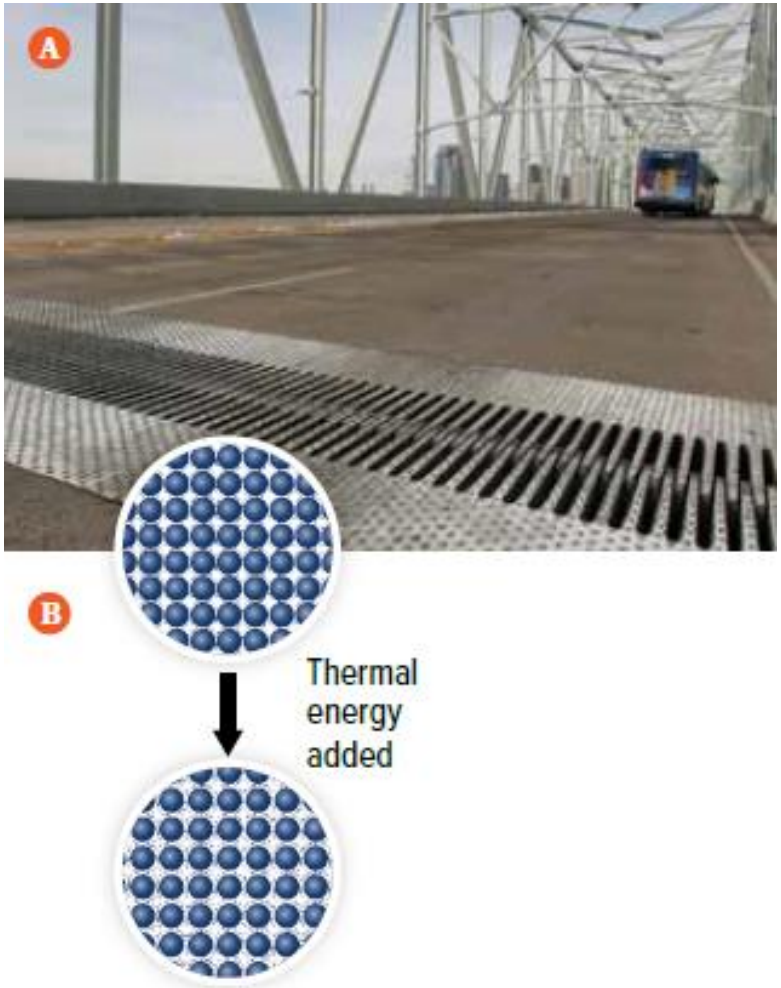


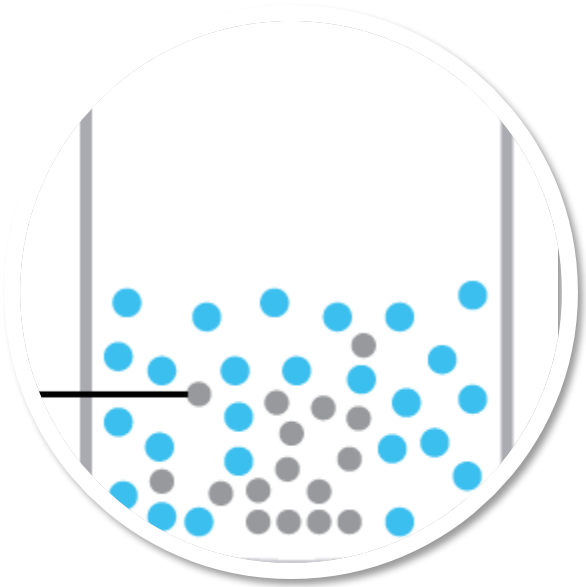
Figure 2.19 (A) Expansion joints prevent damage by allowing material to expand and contract with changes in temperature.

(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

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

In a hot car, the temperature is higher. According to the KMT, the particles in the balloon will have more kinetic energy and move faster at a higher temperature. Thermal expansion will occur, as more kinetic energy in the gas will cause it to expand and take up more space. If the gas expands too much, the balloon may pop.

Discussion Questions

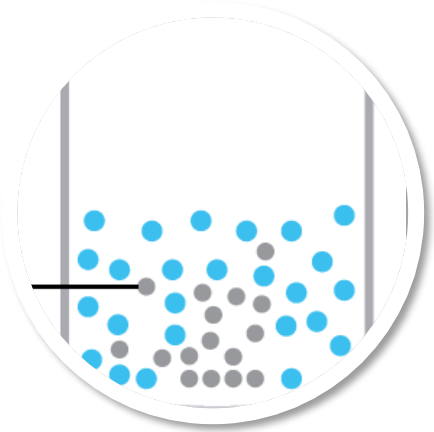
- Use the KMT to explain what happens when salt dissolves in water.

The KMT states that all particles exist in empty space, and that all particles are in constant motion. (In a solid such as undissolved salt, particles vibrate; in a liquid such as water, particles slip and slide past each other.) Dissolving occurs when random motion causes the salt particles on the outside to enter into the empty space between the water molecules. Random motion continues until all the salt particles have entered into, and spread themselves out between the water molecules.

Learning Check-in

Pick one of the following questions to write down and answer on your sheet of paper. Put your name, date, and block, for handing in.

1) Use the KMT to explain why salt will dissolve faster in hot water than in cold water.



2) Use the KMT to explain why dissolving is different than melting.

3) Use the KMT to explain why large chunks of rock sugar will dissolve slower than granulated sugar.

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.