Day 1 Lesson Plan: Kinetic Molecular Theory

**Aim:** What is Kinetic Molecular Theory?

**Concepts in Kinetic Molecular Theory:**

- Review: Three states of matter
- Kinetic Molecular Theory is an important theory for explaining the behavior of molecules in matter.
- All matter is made up of moving particles too small to be seen even with the strongest microscope.
- Kinetic means "motion," so the theory is all about particles moving.
- Kinetic Molecular Theory helps explain the physical properties and behavior of gases.
- Kinetic Molecular Theory makes the following 5 assumptions:
  - Gases consist of large numbers of tiny particles that are far apart relative to their size.
  - Gas particles are always in random motion, so they possess kinetic energy, which is energy of motion.
  - Gas particles move in straight lines. Sometimes they collide with each other, or with a container. When they collide, there is no loss of energy.
  - Gas particles neither attract nor repel each other.
  - The average kinetic energy of gas particles depends on the temperature of the gas.
- The motion of particles can also be affected by variables such as number of particles in a container, particle size, and pressure. The relationships between these variables are an important part of Kinetic Theory.

**Measuring variables:**

- Pressure is measured in atmospheres (atm)
- Temperature is measured in Kelvins (K). Room temperature is approximately 300 K.
- When temperature INCREASES, the speed of particles goes up.
- When temperature DECREASES, the speed of particles goes down.
- The equation for the kinetic energy of a moving object is \( KE = \frac{1}{2}mv^2 \) where m is the mass of the particle and v is its speed.

**Real-life Examples:**

- The round shape of an inflated balloon is due to the motion of the gas particles inside. Ask students to explain.

**Discussion**

- How could Kinetic Theory help you explain why you can smell a cake that is baking in the kitchen when you are in your bedroom?
- Would it make any difference if it were a hot or cold day? Why or why not?
DAY 1 STUDENT WORKSHEET

On a separate sheet of paper, answer the following questions. Use your textbook as a reference if you need to.

1. What are the three states of matter?
2. What does ‘kinetic’ mean?
3. What are the 5 main points of the kinetic-molecular theory?
4. What is an ideal gas?
5. List 2 variables that affect gas particle motion:
6. Give a real life example of a gas that is affected by the kinetic theory.
7. Use diagrams to illustrate how an inflated balloon stays stretched. (What are the gas particles inside doing to keep it inflated?)
8. Explain why both gases and liquids can be described as fluids.
9. What are the units of each property we are studying?
   - Temperature?
   - Internal pressure?
10. Conversion exercises: Convert the following to Celsius and to Kelvins:

<table>
<thead>
<tr>
<th>Fahrenheit</th>
<th>Celsius</th>
<th>Kelvin</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
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<tr>
<td>212</td>
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</tbody>
</table>

To convert between Fahrenheit and Kelvin, first convert degrees Fahrenheit into degrees Celsius by using the following formula:

\[ C = \left(\frac{5}{9}\right) \times (F-32) \]

\( (C = \text{temperature in degrees Celsius}, F = \text{temperature in degrees Fahrenheit}) \)

Then convert Celsius to Kelvins using this formula:

\[ K = C + 273 \]
Thought questions:

11. If we have a closed rigid gas container and we inject more gas into the container, what will happen to the internal pressure of the container? Explain your answer.

12. If we have a closed rigid gas container and we raise the temperature of the container, what will happen to the internal pressure of the container? Explain your answer.

*Extra credit:

How can a small propane tank hold enough to cook with all summer?

Vocabulary list:

Theory: an accepted statement about science that has been tested and peer reviewed many times and can be used to make predictions.

Kinetic: this word means movement. Kinetic energy is energy that has to do with things moving.

To examine: means to look at or study.

Rigid: Solid, difficult to bend, not flexible.

Pressure: The amount of force per area. If you are pushing against a wall, you are putting pressure on the wall.

Internal Pressure: The amount of pressure inside a container. Gas molecules can push against the walls of a container.

External Pressure: The amount of pressure put on the outside of a container. If you sit on a box, you put pressure on the box.

Particles: All matter is made up of tiny particles. Think of them as tiny, round, hard balls.

Variable: Something that varies or changes.

Atmosphere: This is a unit of pressure represented by ‘atm’.

Kelvin: This is a unit of temperature that scientist use represented by ‘K’. 298 K is about room temperature (= 25 degrees C).
Day 2 Lesson Plan: Kinetic Molecular Theory

Aim: What is the Kinetic Molecular Theory?

Agenda:

- Do Now – 7 min
- Gases – KMT – lecture/notes – 15 min
- What is pressure? – 10 min
- Demos – balloon and temp / can and water – 10 minutes
- What’s next?? (diffusion) – 5 minutes

Kinetic Molecular Theory: Describes the behavior of gases.
The variables involved are pressure, volume, temperature, and # of particles, size of particles.

Gases contain particles that are in straight, random motion
Gases particles collide with each other and the wall…these collisions are elastic (not like a tennis ball)
Gas particles are spread out, so they don’t take up space.
Gas particles are not attracted to each other

Demonstration: Balloon and flask on hot plate

What is pressure?
Pressure is the amount of force applied over a surface.
Gas molecules can apply pressure on the walls of a container.

Real-life examples:
To apply pressure on a wound; to apply pressure on a wall; water pressure;
Shake up a coke bottle…the bottle becomes harder because you’ve increased the pressure inside the bottle. How?

Internal vs. External Pressure (see diagram, next page)
Pressure is measured in atmospheres (atm)

If you increase the temperature of the flask, what do you predict will happen to the pressure in the balloon?
If the pressure of the gas increases, would it push harder or softer against the walls?

Balloon ➔ increase temperature, # of particles is constant, what happens to the pressure inside the balloon?
If you could increase the number of particles, what would happen to the pressure in the balloon?

Diffusion has to do with injecting a gas into a container and seeing how long it takes to spread out.
DAY 2 STUDENT WORKSHEET

Name: ___________________ Date: _________________ Class: ____________

Do Now: Kinetic Theory

When you increase the temperature of a gas, what happens to the pressure?
________________________________

When you increase the number of particles of a gas, what happens to the pressure?
________________________________

When there is more pressure inside a container, do you think the gas particles want to escape more or less from the container?
___________________________________________________________________

When you increase the temperature, do the particles move faster or slower? ______________________

When the particles are moving are they moving in a pattern or randomly?
____________________________________________________________________________________

Image of Balloon Demonstration Set-up

control group
Day 3 Lesson Plan: Diffusion

Aim: What is diffusion?

Review: What is the Kinetic Molecular Theory?

Diffusion of a Gas within a Gas:

- General principles: Molecules of gas are in constant random motion.
- Diffusion is from a region of higher concentration to a region of lower concentration.
- Avogadro’s hypothesis: Equal volumes of gases at the same temperature and pressure contain equal numbers of particles. [Particles in a gas are very far apart, with nothing but space in between. Thus a collection of relatively large particles does not require much more space then the same number of relatively small particles.]
- Rate of diffusion related to density of gas
- Graham’s Law: The relative diffusion of a gas within a gas is inversely proportional to the square root of its molecular weight.

\[
\frac{\text{Rate}_1}{\text{Rate}_2} = \sqrt{\frac{M_2}{M_1}}
\]

where:
Rate\(_1\) is the rate of diffusion of the first gas.
Rate\(_2\) is the rate of diffusion for the second gas.
\(M_1\) is the molar mass of gas 1
\(M_2\) is the molar mass of gas 2.

Atomic mass units (amu) is the term we use to describe the mass of molecules like CO\(_2\) and O\(_2\).

For CO\(_2\) and O\(_2\) (with P and T constant), which gas diffuses more quickly?

CO\(_2\) = 44 amu; O\(_2\) = 32 amu
Analyse: atomic mass unit and molar mass are same in number.

\[ \text{molar mass ratio} \rightarrow \text{ratio of rates of diffusion} \]

Compute:

\[
\frac{\text{rate of diffusion of } O_2}{\text{rate of diffusion of } CO_2} = \frac{\sqrt{M_{CO_2}}}{\sqrt{M_{O_2}}} = \frac{\sqrt{44.00 \text{ g/mol}}}{\sqrt{32.00 \text{ g/mol}}} = \frac{44.00 \text{ g/mol}}{32.00 \text{ g/mol}} = 1.17
\]

Conclusion: Lighter molecules travel faster, have more frequent collisions and thus diffuse more rapidly. Therefore, oxygen would diffuse about 1.17 times more rapidly than carbon dioxide.

What factors other than molecular mass could affect the speed of diffusion?

Real-life Examples:

- You can smell popcorn aroma in the room even after you finish eating it.
- Spray air freshener at one corner of the room. After a few minutes, you can smell it everywhere in the room.

Discussion

- How could diffusion help you explain why you can smell air freshener?
- If 10ml of household ammonia and 10ml of perfume oil were placed at each end of the classroom, which vapor would an observer standing midway between them smell first? Is there a way to make the observer smell the vapors faster?
DAY 3 STUDENT WORKSHEET

On a separate sheet of paper, answer the following questions. Use your textbook as a reference if you need to.

1. What 2 variables affect diffusion?
2. What is atomic mass measured in?
3. Which gas is heavier, helium or argon?
4. Give a real life example of diffusion
5. Use diagrams to illustrate how argon diffuses in a closed chamber of helium.
6. What is the connection between atomic mass unit and molar mass?
7. Estimate the molar mass of a gas that effuses at 1.6 times the effusion rate of carbon dioxide.
8. List the following gases in order of increasing average molecular velocity at 25°C: H₂O, He, HCl, BrF and NO₂.
9. Please fill out the following tables and graph to the worksheet.

**Gas: Helium**

<table>
<thead>
<tr>
<th>Temperature (K)</th>
<th>Time 1 (s)</th>
<th>Time 2 (s)</th>
<th>Time 3 (s)</th>
<th>Average Time (s)</th>
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**Gas: Argon**

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<tr>
<th>Temperature (K)</th>
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<th>Time 2 (s)</th>
<th>Time 3 (s)</th>
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</table>

control group

OVER
Use 2 different symbols for the helium and for the argon gas. You should have 2 dots for each Temperature.

Vocabulary list:

Molar mass: molar mass is the mass of one mole of a substance. It is normally expressed in units of g/mol, in which case its numerical value is identical with the molecular weight.

Helium: A type of gas. It is a very light gas and when you inhale it, your voice changes pitch.

Argon: A type of gas. It is a heavy gas.

amu: This stands for atomic mass unit. It is the unit for the mass of atoms.
Day 4 Lesson Plan: Diffusion

Aim: What is diffusion and what are some of the conditions where we can observe it?

Agenda:

• Do Now –10 min
• Diffusion: Definition, lecture/notes – 15 minutes
• Connection to calculation – 15 minutes
• Demo: Diffusion of food coloring in hot and cold water – 10 minutes
• Homework: Write me a story/comic

Diffusion: describes how one gas or liquid spreads through another gas or liquid. It depends on the mass (or size) of the particles and the temperature. If the particles are small, they travel fast. If the particles are big, they travel slowly. If the temperature is hot, they travel fast. If the temperature is cold, they travel slowly.

Question: How is the diffusion explained similar and different from the diffusion we learned about in biology?
   Similar: traveling through another solution
   Different: Energy requirements

Question:

Calculation: Graham’s law of diffusion
The heavier the particle, the slower it traveled
Graham worked out that the rate at which the particles spread out is inversely proportional to the square root of the molecular weight. We can write his law as a mathematical equation:

\[ \text{Rate}_A / \text{Rate}_B = \sqrt{\text{mass of } B} / \sqrt{\text{mass of } A} \]

So what might you predict about the rate of Gas A when compared with gas B if gas A was four times less massive than gas B? If you wanted to compare “real” gases, you have hydrogen with molar mass of 2, how would its rate of diffusion compared with oxygen with a molar mass of 36?

You can also examine diffusion in your everyday life. You see diffusion every day but perhaps what you observe does not involve gases. So here is a thought questions: We can describe a gas as a fluid. Are there any other fluids you use every day that also show diffusion?

Student feedback about where they might observe diffusion e.g. tea, coffee, cocoa, sugar.
Demonstration/Teacher Guide: *Diffusion in liquid (another fluid) and the effect of temperature*

1. Heat beaker of water on hotplate
2. Also get the same amount of cold water in another beaker of the same size
3. Have a couple of student volunteers (one for hot and one for cold) with stopwatches to record the rate of diffusion
4. Have a couple of students (one for the hot water and one for the cold) add one drop of food coloring
5. The student recorders should record how long it takes for the food coloring to diffuse throughout the water. (When this was done the first time the hot beaker was left on the hot plate and was boiling and one of the students suggested that it was the boiling which was helping the color to diffuse in the hot water. So then I took a second beaker of boiling water off the hot plate and repeated the test in hot water that was still rather than moving [*A teachable moment!*])
6. Discussion about gases and liquids and diffusion and the effect of temperature and mass on the rate, perhaps using some examples from everyday life such as the smell of a trash can on a cold day and a hot day
7. Have students: 1) write their observations of the demonstration; 2) explain using their understanding of diffusion what happened in the two containers
DAY 4 STUDENT WORKSHEET

Name: ____________________  Date: _______________  Class: __________

Do Now: Diffusion

Name three gases that will diffuse ____________ __________ ______________

What would you need to know about the gases to predict which one would move the furthest and why?

_____________________________________________________________________________

Diagram of Diffusion Demonstration Set-up

Food coloring

Hot water  Cold water
**Homework: Diffusion**

Write me a story or a comic book

You are going to pretend that you are a gas particle that has been injected into a closed box. I want you to describe your thoughts as a particle inside this box. To complete this task you need the following terms:

Straight, random motion
Elastic collisions
Attraction toward other gas particles
Your speed compared to other particles
Your mass/size
What happens when the temperature increases.

Your story needs to be at least 1 page long; if you choose to do a comic book it needs to be 15-20 frames long.
Day 5: Gas Laws

Aim: What are the Gas Laws and how do they help us understand the world?

Concepts about the Gas Laws:

- Historically, one of the earliest phenomena that chemists studied was the properties of gases.
- The gas laws bring together temperature, volume, and pressure and help us see how those factors are related.
- If temperature is constant, when pressure goes up, volume goes down (Boyle’s Law).
  - $P_1 \times V_1 = P_2 \times V_2$
  - This is an INVERSE RELATIONSHIP. What does this mean?
  - The graph of an inverse relationship is a curve
- If pressure is constant, when temperature goes up, volume goes up (Charles’s Law).
  - $V_1 / T_1 = V_2 / T_2$
  - This is a DIRECT RELATIONSHIP
  - The graph of a direct proportion is a straight line.
  - Absolute zero is the temperature at which the average kinetic energy of gas particles would theoretically be zero.
  - Absolute zero $= 0 \text{ K} = -273.15^\circ \text{ C}$
  - Scientists are working to reach temperatures below absolute 0.
- If volume is constant, when temperature goes up, pressure goes up (Gay-Lussac’s Law).
  - $P_1 / T_1 = P_2 / T_2$
  - This is a DIRECT RELATIONSHIP
  - The graph of a direct proportion is a straight line.

Measuring variables:

- Pressure is measured in atmospheres (atm)
- Temperature is measured in Kelvins (K). Room temperature is approximately 300 K.
- Volume is measured in liters (L).

Real-life Examples of Gas Laws:

- On a hot summer’s day, the pressure in a car tire increases.
- The pilot of a hot-air balloon heats the air inside the balloon to make it rise.

Discussion

- What do the gas laws have to do with
  - Tennis balls?
  - Carburetors?
  - Aerosol cans?
DAY 5 STUDENT WORKSHEET

On a separate sheet of paper, answer the following questions. Use your textbook as a reference if you need to.

1. In your own words, describe Boyle’s Law.
2. Express Boyle’s Law as a mathematical equation.
3. List 2 variables that affect gas particle motion:
4. What are the units used to measure the following variables:
   a. Temperature?
   b. Internal pressure?
   c. Volume?
5. Which variable must be held constant for Boyle’s Law to work?
6. In your own words, describe Charles’s Law.
7. Express Charles’s Law as a mathematical equation.
8. Which variable must be held constant for Charles’s Law to work?
9. What is absolute zero?
10. In your own words, describe Gay-Lussac’s Law.
11. Express Gay-Lussac’s Law as a mathematical equation.
12. Which variable must be held constant for Gay-Lussac’s Law to work?

Thought question:
Why might it be a bad idea to leave an aerosol can in your car on a summer day?

*Extra credit:
A helium-filled balloon has a volume of 2.75L at 20° C. The volume of the balloon decreases to 2.46 L after it is placed outside on a cold day. What is the outside temperature in K? In ° C?
Day 6 Lesson Plan: What can we learn from the gas laws?

Aim: How are pressure, volume, and temperature related?

Agenda:

- Do Now – 5 minutes
- Pressure: Internal vs. external – 10 minutes
- Gas Laws – Boyle’s and Charles’s Law – 15 minutes
- Demo: Balloon in hot water – 5 minutes
- Summary: Gases and how they behave – 15 minutes
- Homework: Question on gas laws

Pressure: Internal vs. external *(start boiling water)*

Draw a balloon…arrows going in and out. When something isn’t moving, like a balloon, the pressure from the air all around us is equal to the amount the gas inside the balloon is pushing out.

So let’s say I have a syringe. If I apply pressure to the plunger I can depress it to a certain point but no further. That means that the gas inside the syringe is putting the same pressure on the inside, making it difficult to depress the syringe any further.

So if you apply pressure on the plunger of the syringe, do you see why pressure is going up inside the syringe as well? Why can’t I depress the plunger until the volume inside is zero?

If you apply external pressure, why doesn't the volume go to zero? What is holding it up? [no longer conforming to the Ideal Gas Law]

Demonstration Analogy

Use 8 volunteers…put them in a square. (4 inside [they are the gas molecules], 4 make the walls, push them in) As the wall goes in what happens to the gas molecules? Do they like this?
The Gas Laws: Boyle’s and Charles’s Law

Boyle’s Law: Relates pressure and volume at constant temperature.  
Pressure – independent / Volume – dependent / Temperature – constant

Demonstration: Squeeze a balloon…as I apply pressure to the outside of the balloon, what is happening to the volume of the balloon? What happens to the pressure inside the balloon? Why? (the gas molecules are hitting the walls quicker and it increases the pressure inside).

Draw a graph similar to this:

Charles’s Law: Relates temperature and volume at constant pressure  
Temperature – independent / Volume – dependent / Pressure – constant

Draw a graph similar to this: (perhaps the students can suggest what the graph might look like?)

Demonstration: Take the water that you have been heating and put it in a large container and then add a balloon that you have partly inflated (perhaps using a student helper or two to feel the balloon at various stages) and tied off. What happens to the internal pressure of the balloon when I put it in the hot water? What happens to the volume? Why? Excitement of particles.

c control group
### Summary of Gas Laws (Notes)

<table>
<thead>
<tr>
<th>KINETIC MOLECULAR THEORY</th>
<th>DIFFUSION</th>
<th>GAS LAWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEMP and PRESSURE</td>
<td>SIZE/MASS and TIME OF DIFFUSION</td>
<td>PRESSURE and VOLUME</td>
</tr>
<tr>
<td>PARTICLE # and PRESSURE</td>
<td>TEMPERATURE and TIME OF DIFFUSION</td>
<td>TEMP and VOLUME</td>
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<tr>
<td>Examples: Boiling water and the lid popping off. Gas cylinder: chained down</td>
<td>Examples: tea in hot water, food coloring in hot water. Farting in a warm shower is smellier than one in a cold shower.</td>
<td>Examples: Balloon rising with temp. Cramming gases into a small container increases pressure.</td>
</tr>
<tr>
<td></td>
<td>Demos: Heating and cooling balloon on flask</td>
<td>Demos: Food coloring in water</td>
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<td></td>
<td>Demos: Food coloring in water</td>
<td>Demos: Balloon in hot and cold water</td>
</tr>
</tbody>
</table>
DAY 6 STUDENT WORKSHEET

Name: ____________________  Date: _________________  Class: ___________

Do Now: Gas Laws

1. Using what you know about the Gas Laws, label the axes on this graph. What does the graph tell you about the relationship between the variables on the graph?

____________________________________________________________________
____________________________________________________________________

Which property/factor is held constant? __________________________________

2. Using what you know about the Gas Laws, label the axes on this graph. What does the graph tell you about the relationship between the variables on the graph?

____________________________________________________________________
____________________________________________________________________

Which property/factor is held constant? __________________________________

3. Why do car tires sometimes look flat on a COLD morning when they looked fine on the warm evening before?

____________________________________________________________________

Homework question:

How can we use the gas laws to understand how a carbon dioxide fire extinguisher works?
Day 7 Lesson Plan: Phase Change

**Aim: What is Phase Change?**

**Concepts about Phase Change:**
- Phase changes are changes of state such as the change from liquid to gas, or solid to liquid, or gas to liquid.
- Particles in a gas
  - are well separated with no regular arrangement.
  - vibrate and move freely at high speeds.
- Particles in a liquid
  - are close together with no regular arrangement.
  - vibrate, move about, and slide past each other.
- Particles in a solid
  - are tightly packed, usually in a regular pattern.
  - vibrate (jiggle) but generally do not move from place to place.
- Factors such as temperature, heat, pressure, and mass of molecules are related to phase changes.
- When we heat or cool substances, they are able to change their state. Why?
- As heat energy is added to a solid, the temperature rises. At some point temperature remains constant: this is where the phase change of MELTING is occurring.
  - When a liquid becomes a solid the process is called SOLIDIFICATION or FREEZING

![Melt_Solidification](image)

- As heat energy is added to a liquid, the temperature rises. At some point temperature remains constant: this is where the phase change of BOILING is occurring.
  - When a gas becomes a liquid the process is called CONDENSATION

![Boil_Condensation](image)

- Phase changes occur at different temperatures for different substances.
**Measuring variables:**
- Pressure is measured in atmospheres (atm)
- Temperature is measured in Kelvins (K). Room temperature is approximately 300 K.
- Heat is measured in kilojoules (kJ)

**Real-life Examples of Phase Change:**
- boiling water, freezing ice cubes
- read/write DVDS

**Discussion**
- What does phase change have to do with
  - Making ice cream?
  - Melting snow?
  - Jell-O?
DAY 7 STUDENT WORKSHEET

On a separate sheet of paper, answer the following questions. Use your textbook as a reference if you need to.

1. What are the three states of matter?
2. In your own words, describe phase change.
3. What are some of the properties of a gas?
4. What are some of the properties of a liquid?
5. What are some of the properties of a solid?
6. What change of phase is described by the term CONDENSATION?
7. What change of phase is represented by the term FREEZING?
8. What change of phase is represented by the term BOILING?
9. What term is used to label the change of a substance from the solid phase to the liquid phase?
10. As you keep adding heat to a substance, does it keep on getting hotter? Is there a limit?
11. Both gases and liquids have particles that move around. How are gases and liquids different?

Thought question:
Why might it be a bad idea to leave a pot of soup boiling on the stove?

*Extra credit:*
Why does it make sense to pump gas in the morning rather than in the evening?
DAY 8 LAB WORKSHEET

Lauric Acid Lab

*Aim: Can you see phase change in the real world?*

Your Name: ________________________   Date: ______________
Lab Partners: __________________________________

**Introduction:** You know that matter can exist in one of three physical states—solid, liquid, or gas. For a pure substance, changes in state occur at a definite temperature, which is a physical property of that substance. Water, for example, changes from a solid to a liquid at 0°C.

In a solid, the particles are arranged in an orderly, repeating, three-dimensional pattern. As the solid is heated, the energy of the particles increases. Eventually, at some temperature, which is called the melting point, the molecules overcome the forces of attraction holding the particles together, and the substance changes to a liquid. At another temperature, called the boiling point, molecules in the liquid state overcome the forces of attraction between them and the substance changes from a liquid to a gas.

When a liquid is cooled, the reverse process occurs. The temperature of the gas decreases until the condensation point is reached and the gas becomes a liquid. Only after the gas has completely changed to a liquid will the temperature decrease again. The temperature of the liquid decreases further until the freezing point is reached. Only after the liquid is completely changed to a solid will the temperature begin to decrease further.

**Purpose:** Changes of state (phase changes) occur in the change between solid and liquid and liquid and gas. In this activity, you will observe what happens as lauric acid (C₁₂H₂₄O₂) melts. You will measure the temperature at timed intervals as the lauric acid is heated to determine its melting point experimentally (What other strategies could you use to find out a temperature for the melting point of lauric acid? Why are both useful?)
Pre-Lab:

1. What phase is the lauric acid in at the beginning of the lab? ________________
2. What will be the next phase the acid changes to when you add heat? _________________
3. Predict the shape of its heating curve:

4. What are the independent and dependent variables?
   Independent: ________________  Dependent: ________________

5. What do you **always** need to wear while chemicals are on the lab tables? Why?

Materials:

- goggles
- lauric acid test tube
- 2 beakers, 400 mL
- thermometers
- hot plate
- tap water
- ice for ice bath

*Day 8 Lab Worksheet, Page 2*
**PHASE CHANGE: Lab**

**Procedure:**

1. Put on goggles.
2. Fill one 400 mL beaker ¾ full of tap water and heat it on the hot plate. Turn the hot plate all the way to 10. **Once you see tiny bubbles, turn it down to 6. CAUTION: Do not touch the hot plate or beaker.**
3. At the same time make an ice bath using a 400 mL beaker and ice from the front desk.
4. Get a large test tube of lauric acid and hold it with a test tube holder. Place it in the hot water bath. (You need to melt the lauric acid so you can insert the thermometer into the acid)
5. As the solid begins to melt, place a thermometer into the test tube, once you are able to insert the thermometer (see diagram on previous page), use the test tube holder to place the test tube in an ice water bath. Stop once the temperature reaches about 30°C.
6. Carefully place the test tube containing the lauric acid back into the hot water bath (it should NOT be boiling).
7. Immediately begin to take temperature readings every 30 seconds. Record your temperatures and time in the data table provided.
8. Begin stirring gently as soon as you are able to move the thermometer easily. Continue to measure and record the temperature until the lauric acid is at approximately 55°C.
9. Turn off the hot plate. Remove the thermometer from the lauric acid and return test tube to your teacher.
10. Clean up your work station and wash your hands.

**Observations:**

Approximate melting point of lauric acid ___________

Describe the changes you witnessed?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Could you see the actual molecules? Why or why not?

________________________________________________________________________

*Day 8 Lab Worksheet, Page 3*
**PHASE CHANGE: Lab**

**Data Table:**

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (right when you put the test tube in hot water)</td>
<td></td>
</tr>
<tr>
<td>0.5 (30 seconds)</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td></td>
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<tr>
<td>3.0</td>
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<td>3.5</td>
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<tr>
<td>4.0</td>
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<td>4.5</td>
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<td>5.0</td>
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<td>6.0</td>
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<tr>
<td>11.0</td>
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<tr>
<td>11.5</td>
<td></td>
</tr>
<tr>
<td>12.0</td>
<td></td>
</tr>
</tbody>
</table>

**Why do you need to record so many points?**

________________________________________________________________________________

________________________________________________________________________________

*Day 8 Lab Worksheet, Page 4*
Draw a graph representing the table on the previous page. You MUST label all axes, put in the scale, and write a title.

Title: _____________________________________________

Think About it:

1. Did you prediction match your actual data? ____________ Why do you think it was the same or different?

_____________________________________________________________________________

2. What was difficult about the procedure (measuring the temperature, keeping the time, etc.)?

_____________________________________________________________________________

_____________________________________________________________________________

Day 8 Lab Worksheet, Page 5
3. How can you explain the fact that at its melting point the temperature of the lauric acid did not change even though you were still adding heat? What is happening to the heat energy you are putting into the lauric acid:
   When it is a solid?
   ____________________________________________
   ____________________________________________
   When it is changing from solid to liquid? [What is happening to the forces of attraction between the lauric acid molecules?]
   ____________________________________________
   ____________________________________________
   When it is a liquid?
   ____________________________________________
   ____________________________________________

6. Yesterday we talked about the theory behind phase change, including the relationship between heat and temperature during a phase change. Why do you think scientists need to test things theoretically and also do actual experiments?

   ____________________________________________
   ____________________________________________

7. Draw particle diagrams of what you think the molecules will look like as a solid and as a liquid:

   Solid  During Melting  Liquid