Senior High School

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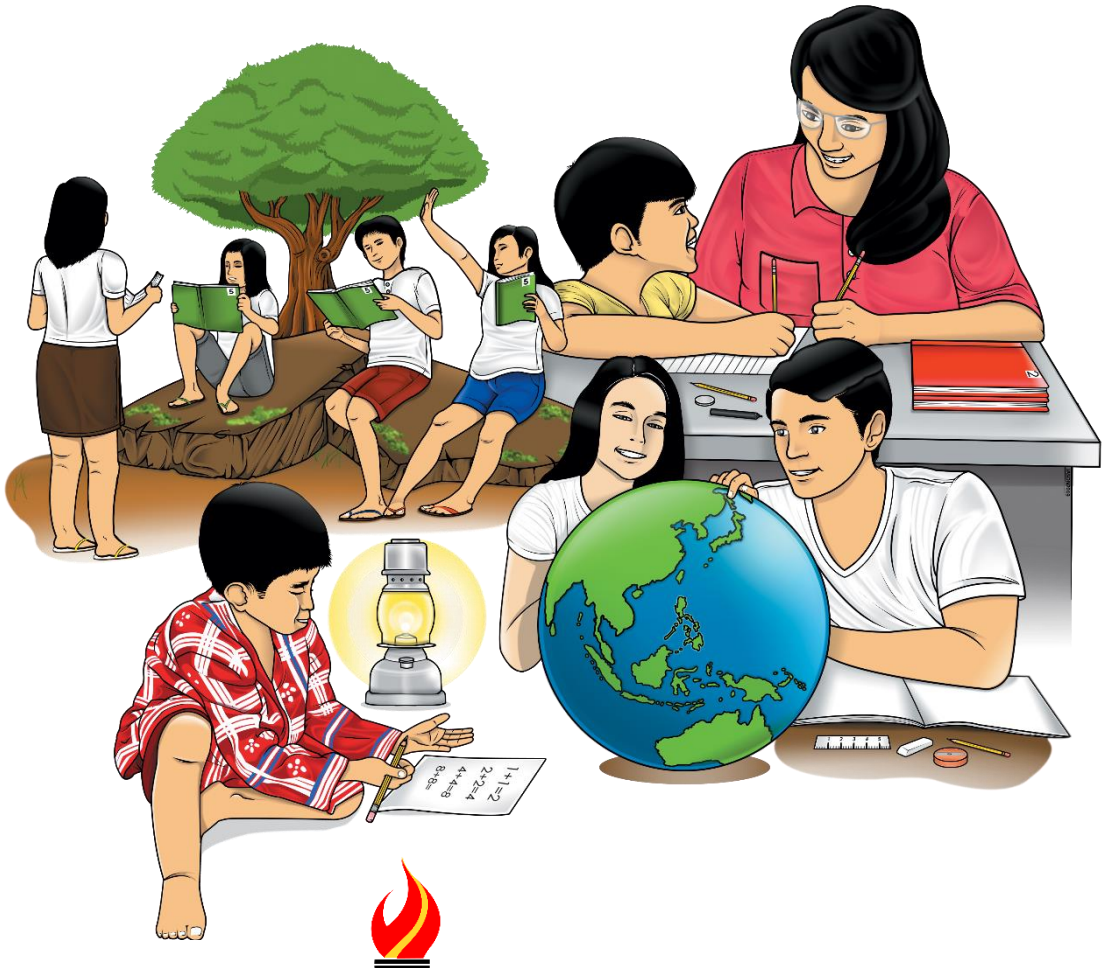
Physical Science

Quarter 1 – Module 3: Intermolecular Forces of Attraction



ALTERNATIVE DELIVERY MODE
ADM

Personal Development
Alternative Delivery Mode
Quarter 1 – Module 3: Intermolecular Forces of Attraction
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Introductory Message

For the facilitator:

Welcome to Physical Science Grade 11/12 Alternative Delivery Mode (ADM) Module on Intermolecular Forces of Attraction!

This module was collaboratively designed, developed, and reviewed to assist the teachers/facilitators in helping the learners meet the standards set by the K to 12 Curriculum while overcoming their personal, social, and economic constraints in schooling.

This learning resource hopes to engage the learners in guided and independent learning activities at their own pace and time. Furthermore, this also aims to help learners acquire the needed 21st - century skills while taking into consideration their needs.

In addition to the material in the main text, you will also see this box in the body of the module:

Notes to the Teacher

This contains helpful tips or strategies that will help you in guiding the learners.

As a facilitator, you are expected to orient the learners on how to use this module. You also need to keep track of the learners' progress while allowing them to manage their learning. Furthermore, you are expected to encourage and assist the learners as they do the tasks included in the module.

For the learner:

Welcome to Physical Science 11/12 Alternative Delivery Mode (ADM) Module on Intermolecular Forces of Attraction.

Our hand is one of the most represented parts of the human body. It is often used to depict skill, action, and purpose. With our hands, we create, accomplish and learn. Hence, you are capable and empowered to successfully achieve the relevant competencies and skills at your own pace and time. Your academic success lies in your own hands!

This module was designed to provide you with fun and meaningful opportunities for guided and independent learning at your own pace and time. You will be able to process the contents of the learning resource while being an active learner.

This module has the following parts and corresponding icons:

 ***What I Need to Know***	This will give you an idea of the skills or competencies you are expected to learn in the module.
 ***What I Know***	This part includes activity that will check what you already know about the lesson. If you get all the correct answers (100%), you may decide to skip this module.
 ***What's In***	This is a brief drill or review to help you link the current lesson with the previous one.
 ***What's New***	In this portion, the new lesson will be introduced to you in various ways such as a story, a song, a poem, a problem opener, an activity, or a situation.
 ***What is It***	This section provides a brief discussion of the lesson. This aims to help you discover and understand new concepts and skills.
 ***What's More***	This comprises activities for independent practice to solidify your understanding and skills of the topic. You may check the answers to the exercises using the Answer Key at the end of the module.
 ***What I Have Learned***	This includes questions or blank sentences/paragraphs to be filled in to process what you learned from the lesson.

 ***What I Can Do***	This section provides an activity that will help you transfer your new knowledge or skills into real-life situations.
 ***Assessment***	This is a task that aims to evaluate your level of mastery in achieving the learning competency.
 ***Additional Activities***	In this portion, another activity will be given to you to enrich your knowledge or skill of the lesson learned.
 ***Answer Key***	This contains answers to all activities in the module.

At the end of this module you will also find:

References	This is a list of all sources used in developing this module.

The following are some reminders in using this module:

1. Use the module with care. Do not put unnecessary mark/s on any part of the module. Use a separate sheet of paper in answering the exercises.
2. Don't forget to answer *What I Know* before moving on to the other activities included in the module.
3. Read the instruction carefully before doing each task.
4. Observe honesty and integrity in doing the tasks and checking your answers.
5. Finish the task at hand before proceeding to the next activity.
6. Return this module to your teacher/facilitator once done.

If you encounter any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator. Always bear in mind that you are not alone.

We hope that through this material, you will experience meaningful learning and gain a deep understanding of the relevant competencies. You can do it!

What I Need to Know

This module was designed to help you learn the intermolecular forces of attraction. It is composed of activities that will make your learning process a more productive one.

CONTENT STANDARD: The learners demonstrate an understanding of how the uses of different materials are related to their properties and structure

PERFORMANCE STANDARD: The learners should be able to make a creative representation of the atom or the chemical element in a timeline

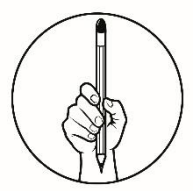
LEARNING COMPETENCIES: Describe the general types of intermolecular forces
CODE: S11/12PS-IIIc-d-17
Explain the effect of intermolecular forces on the properties of substances
CODE: S11/12PS-IIId-e-19

The module is divided into two lessons, namely:

- Lesson 1 – General Types of Intermolecular Forces
- Lesson 2 – Effect of Intermolecular Forces on the Properties of Substances

After going through this module, you are expected to:

1. describe the three major types of intermolecular forces of attraction;
2. explain the effect of intermolecular forces of attraction on the properties of substances; and
3. recognize the significance and/or implications of the types of intermolecular forces of attraction to real-world examples.



What I Know

Multiple Choice:

DIRECTIONS: Read each question carefully. Choose the letter of the best answer. Write your answer on a separate sheet of paper.

1. Which of the following is an intermolecular force of attraction that is present in non-polar molecules?

A. covalent bond
C. dipole-dipole forces
B. hydrogen bond
D. London dispersion forces

2. Which of the following is the strongest intermolecular force of attraction?

A. ionic bond
C. dipole-dipole forces
B. hydrogen bond
D. London dispersion forces

3. Which of the following molecules can exhibit hydrogen bonding?

A. HF
C. HCl
B. NaF
D. NaBr

4. What best explains the unusually high boiling point of water?

A. There is a strong dipole-dipole bond between water molecules.

B. Water is capable of hydrogen bonding.

C. Dispersion forces are present in all molecules.

D. The shape of the polar bonds is asymmetrical.

5. A substance with weak intermolecular forces of attraction will exhibit which of the following?

A. Low heat of vaporization

B. Slow evaporation

C. Low vapor pressure

D. High melting point

6. Which of the following pertains to London dispersion forces?

A. They are the weakest intermolecular force.

B. They operate only in polar molecules.

B. They operate only in ionic compounds.

D. They are an attractive force between hydrogen and an electronegative atom.

7. Which statement about dipole-dipole forces is correct?

A. They are present in polar molecules.

B. They are present in nonpolar molecules.

C. They are the weakest intermolecular force.

D. They are the strongest intermolecular force.

8. For a given substance, which of the following phase transitions shows an increase in the intermolecular forces of attraction?

A. solid to liquid

B. gas to liquid

C. Liquid to gas

D. Solid to gas

9. What type of intermolecular force is present in all substances, regardless of polarity?

A. ionic bond

B. hydrogen bond

C. dipole-dipole forces

D. London dispersion forces

10. Which of the following can exhibit hydrogen bonding among themselves?

A. H_2Te B. H_2Se C. H_2O D. H_2S

11-15. Which five properties below indicate strong intermolecular forces in a liquid?

A. a lower evaporation rate

B. a better capillary action

C. a higher boiling point

D. a higher melting point

E. a higher viscosity

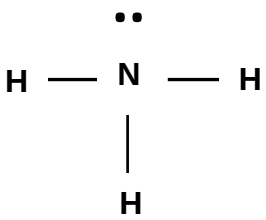
F. a greater surface tension

G. a lower boiling point

Lesson 1 General Types of Intermolecular Forces

What's In

To help you fully understand the intermolecular forces of attraction and their effect on the properties of substances, you must first understand the polarity of the molecules. Test your ability and apply the principles you have learned in the previous lesson by completing the table below. The first two items were already done for you as an example.

	Molecule	Lewis Structure	Shape of the Molecule/ Molecular Geometry	Net dipole moment	Polarity of the Molecule
1	NH_3		Trigonal Pyramidal	Yes	Polar
2	CS_2		Linear	No	Nonpolar
3	CH_4				
4	H_2O				

What's New

When you think of forces of attraction, you may think of humans. Like most of us, you will probably say that it is something that exists between people. In humans, there are forces of attraction that bring people together into friendship, marriage, and other types of relationships. Like people, molecules have this force of attraction that holds them together with the surrounding molecules. But just like any other force, there are stronger and weaker interactions.

What is It

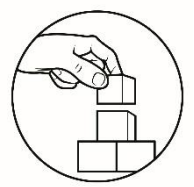
An **intermolecular force of attraction (IMFA)** is simply an attractive force between neighboring molecules. There are three common types, namely: London dispersion forces, Dipole-dipole, and Hydrogen bonds.

London dispersion forces are present in molecules, regardless of the polarity. This is the weakest among the intermolecular forces. They originate from the fluctuations of the electron distribution around the molecule over time. Since larger molecules have larger electron clouds, they exhibit stronger dispersion forces than smaller molecules. On the other hand, **dipole-dipole forces** are present only in polar molecules (i.e., those with a net dipole moment). This kind of force is stronger than London dispersion forces because polar molecules have a permanent uneven distribution of electrons. **Hydrogen bond** is a special type of dipole-dipole interaction that occurs in molecules having a hydrogen atom bonded to an electronegative atom such as fluorine, oxygen, or nitrogen. It is the strongest intermolecular force of attraction among the three.

A very good example of a molecule that contains only London dispersion forces is methane (CH_4), the simplest hydrocarbon. It is a non-polar molecule, and is not capable of any other type of intermolecular force of attraction. Another example of a hydrocarbon is octane (C_8H_{18}), a nonpolar molecule that exhibits only London dispersion forces as well. Since octane is a bigger molecule than methane,

the former is capable of stronger dispersion forces. An example of dipole-dipole attraction can be seen in hydrogen chloride (HCl). This is because the electronegativity difference between the H and the Cl atoms make the covalent bond between them polar. Lastly, hydrogen bonds can be seen in a water molecule (H_2O) because hydrogen is bonded to a highly electronegative atom which is oxygen.

Intermolecular forces are involved in phase changes. The IMFA in solids are very strong, thus the particles are compact. The IMFA in liquids are not strong enough to keep the particles remain in fixed positions so liquids generally tend to resemble the shape of their containers. The IMFA in gases are extremely weak or almost negligible thus, particles are free to move around.



What's More

ACTIVITY 1 IMFA – WHAT TYPE?

Objective: Identify the types of intermolecular forces of attraction.

Directions: Identify the type of IMFA for the following substances and answer the questions that follow.

Table 1 – Substances and IMFA Types

Substance	Type of IMFA
1. CO	
2. NH_3	
3. CCl_4	

Critical Thinking Questions:

1. How do you determine the type of IMFA that occurs in each of the given substances? _____

_____

2. Rank the strength of each compound based on IMFA.

(1 = strongest, 2 = in between, 3 = weakest)

Explain your answer. _____

_____

ACTIVITY 2

IMFA – INCREASE OR DECREASE?

Objective: Determine the increase or decrease in the intermolecular forces of attraction that takes place in phase change.

Directions: For each of the phase changes below, choose whether the intermolecular forces increased or decreased. Write a checkmark (/) under the column for your answer. Then, answer the critical thinking questions.

Table 2 – Phase Changes and Increase or decrease in IMFA

Phase Changes			***Intermolecular Forces***	
	Initial State	***Final State***	***Increase***	***Decrease***
	solid	liquid		/
1	liquid	solid		
2	liquid	gas		
3	gas	liquid		
4	solid	gas		
5	gas	solid		

Critical Thinking Questions:

1. Which of the phases of matter (solid, liquid, gas) has the strongest and weakest IMFA? _____

2. What do you think is the reason for the varying strengths of IMFA between the phases of matter?

_____

Lesson 2 Effect of Intermolecular Forces on the Properties of Substances

What's New

Intermolecular forces of attraction (IMFA) control how well molecules stick together. These affect many of the measurable physical properties of substances. Read the poem below to have a preview of these properties.

IMFA

Helen Grace L. Cabalag, 2020

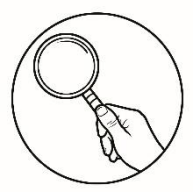
Intermolecular forces vary
In their effects on a substance's property
The magnitude of their intensity
Can be observed in a fluid's viscosity.

If IMFA is the topic of discussion,
These two properties are always in mention
In liquids, there is evaporation
in tubes, there is capillary action.

Oh before moving on to the lesson,
Another property caused by cohesion
Striders walk without hesitation,
Present in water, there is surface tension.

The rule "like dissolves like" in solution
Is the same in the forces of attraction
The very core of the explanation
To a table salt-water combination.

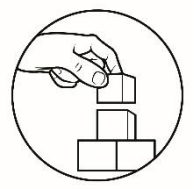
Whether it is high or low, it is ranging
Boiling and melting points are always changing
IMFA need a little bit of explaining
For extreme temperatures in H-bonding.



What is It

The intermolecular forces are associated with the observable properties of various substances. The physical properties of molecules depend upon the type and strength of their intermolecular forces of attraction. These properties are solubility, melting point, boiling point, surface tension, viscosity, capillary action, and evaporation rate.

When it comes to **solubility**, the solute and the solvent mix when they both exhibit the same intermolecular forces of attraction. The **melting and boiling points** of substances with stronger IMFA are higher compared to those with weaker IMFA. In the case of **surface tension**, molecules with stronger intermolecular forces of attraction will exert greater cohesive forces and acquire less surface area (higher surface tension) than those with weaker IMFA. **Viscosity** is also affected by intermolecular forces**.** Molecules with stronger intermolecular forces of attraction have greater resistance to flow, and thus higher viscosity compared to those with weaker IMFA. This is also true in **capillary action**. Capillary action is something that you observe when you dip a paper towel in water, and the water "magically" climbs up the towel. The water molecules climb up the towel and drag other water molecules along the way. A better capillary action indicates stronger intermolecular forces. This trend however is different in **evaporation**. The lower the evaporation rate, the weaker the intermolecular forces.



What's More

IMFA – EFFECTS ON PROPERTIES

Objective: Determine the effects of intermolecular forces of attraction on the properties of substances.

ACTIVITY 1 – Boiling and Melting Point

Directions: The boiling and melting points of HCl and O_2 are shown below. Determine the type of intermolecular force of attraction exhibited by the molecules.

Molecule	Boiling Point	Melting Point	Type of IMFA
1. HF	20°C	-83 °C	_____
2. O_2	-182°C	-218 °C	_____

Table 3– Melting & Boiling Point and IMFA Types

Critical Thinking Questions:

1. What can you infer from the table above? _____

_____

2. How do you relate the melting and boiling point of a substance to its IMFA? Explain their relationship.

_____

_____

ACTIVITY 2 – Viscosity

Directions: Follow the procedures below and answer the critical thinking questions.
Materials: water, dishwashing liquid, mug/cup

Procedures:

1. Pour water and dishwashing liquid into the mug/cup.
2. Observe the flow of the substances upon pouring.

Critical Thinking Questions:

1. What did you observe? _____

2. What can you conclude about the link between the strength of the IMFA and the viscosity of a substance?

_____

_____

ACTIVITY 3 – Capillarity

Directions: Follow the procedures below and answer the critical thinking questions.

Materials:

water from the faucet, cooking oil, alcohol, large shallow container, narrow glass tube or clear plastic straw, ruler

Procedures:

1. Place about 20 ml (about 4 teaspoonfuls) of water in the shallow container.
2. Hold the narrow tube above the extent of the water within the container.
3. Observe how far the water travels in the tube.
4. Measure the distance traveled by the liquid using a ruler.
5. Repeat steps no. 1-4 for the remaining two substances, remember to wash and dry the dish and the tube/straw well.

Results:

Record your output in the table below. You do not need to measure the exact distance traveled by the substance. Describe whether it traveled a short /far distance.

Table 4– Substances and Distance Travelled

Substance	**Distance traveled in the tube**
water from the faucet	
cooking oil	
alcohol	

Critical Thinking Questions:

1. Which of the substances travelled farther up the tube? _____
2. What can you conclude about the link between the strength of the IMFA and capillarity? _____

_____

ACTIVITY 4 – Evaporation

Directions: Follow the procedures below and answer the critical thinking questions.
Materials:

water and nail polish remover (acetone), shallow bowls, teaspoon (the one being used for coffee or tea)

Procedures:

1. Measure 20 ml of the given substances by using a teaspoon. Each teaspoon is roughly estimated with 5mL capacity.
2. Place 20 ml of each of the substances in separate bowls.
3. Move carefully each bowl to a warm/sunny spot.
4. Mark the quantity of liquid in each bowl using a permanent marker.
5. Make several marks at different positions around the bowl.
6. Observe each bowl every minute and note which liquid evaporates quickly.

Results

Record your measurements in the table below. You do not need to measure the specific level of the liquid. Just write what extent or proportion the liquid evaporates.

Table 5– Substances and Level of Liquid

Substance	Level of liquid in different time intervals				
	5 min	10 min	15 min	20 min	25 min
Water					
Nail polish remover					

Critical Thinking Questions:

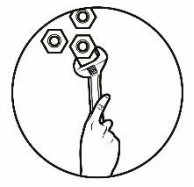
1. Which of the two substances takes the longest time to evaporate? _____
2. What can you conclude about the link between the strength of the IMFA and evaporation? _____

_____

What I Have Learned

Complete the following sentences to summarize the important concepts discussed in this module.

1. The types of intermolecular forces of attraction are _____, _____ and _____.
2. _____ is present in all molecules while _____ are exhibited only by polar ones. _____ on the other hand occurs when hydrogen is bonded to fluorine, chlorine, oxygen or nitrogen.
3. Intermolecular forces have effects on the physical properties of substances. The stronger the force, the more difficult it is to pull molecules off from each other. When comparing properties of substance, strong intermolecular forces lead in _____ boiling and melting points, _____ viscosity, _____ surface tension, _____ capillary action and _____ evaporation rate.



What I Can Do

Directions: Answer the following.

1. Explain in terms of intermolecular forces why water has an extraordinarily high boiling point.
2. List down two problems that might be experienced by all life forms on earth if the evaporation rate is very low.
3. Make a concept map to show the classification of intermolecular forces and their relationship to the physical properties of substances

Assessment

Multiple Choice. Read each question carefully. Choose the letter of the best answer. Write your answer on a separate sheet of paper.

1. Which of the following is the intermolecular force that is present in all types of neighboring molecules?

A. ionic bond
B. hydrogen bond
C. dipole-dipole forces
D. London dispersion forces

2. Which is properly ordered from the weakest to strongest intermolecular attractions?

A. London dispersion forces, dipole-dipole, hydrogen bond
B. dipole-dipole, hydrogen bond, London dispersion forces
C. dipole-dipole, London dispersion forces, hydrogen bond
D. London dispersion forces, hydrogen bond, dipole-dipole

3. Which type of intermolecular force of attraction is the strongest in the molecule HF?

A. ionic bond
B. dispersion
C. dipole-dipole
D. hydrogen bond

4. Which one of the following properties decreases once the strength of its intermolecular forces increases?

A. viscosity
B. boiling point
C. melting point
D. evaporation rate

5. Which of the following trends is correct about substances with stronger intermolecular attractions?

A. higher melting and higher boiling points
B. lower melting points and higher boiling points
C. lower melting and boiling points
D. higher melting points and lower boiling points

6. Which of the following pertains to London dispersion force?

A. It is the weakest intermolecular force.
B. They operate only in polar molecules.
C. They operate only in ionic compounds.
D. It is an attractive force between hydrogen and fluorine.

7. Which statement about dipole-dipole forces is incorrect?

A. They are present in polar molecules.

B. They are present in nonpolar molecules.

C. They are the weakest intermolecular force.

D. They are the strongest intermolecular force.

8. Which of the following phase transitions shows a decrease in the intermolecular forces of attraction?

A. liquid to solid

B. liquid to gas

C. gas to liquid

D. gas to solid

9. What type of intermolecular force is present in all substances, regardless of polarity?

A. ionic bond

B. hydrogen bond

C. dipole-dipole forces

D. London dispersion forces

10. Which of the following can exhibit hydrogen bonding among themselves?

A. H_2Te B. H_2Se C. H_2O D. H_2S

11-15. Which five properties below indicate weaker intermolecular forces in a liquid?

A. a higher evaporation rate

B. a weak capillary action

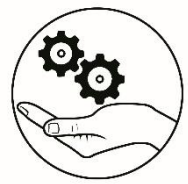
C. a higher boiling point

D. a lower melting point

E. a lower viscosity

F. a greater surface tension

G. a lower boiling point



Additional Activities

BE AN EXPERT ON IMFA

Directions: Choose one type of IMFA and answer these questions:

Critical Thinking Questions:

1. What type of attraction did you choose? _____
2. Is your IMFA weak or strong? Explain,

_____

3. What are the common substances that are used at home or industries that are held together by IMFA? Give one substance for each type.

_____

4. How does your IMFA influence or affect a substance's physical properties?

_____

_____

What I Know

1. D
2. B
3. A
4. B
5. A
6. A
7. A
8. B
9. D
10. C
11. A
12. C
13. D
14. E
15. F

What's More

Lesson 1 Activity 1
1. Dipole-dipole
2. Hydrogen bond
3. London dispersion

Activity 2
1, 3, 5 – increase
2,4 – decrease

Lesson 2 Activity 1
1. H-bond 2. London dispersion
CQ: 1. HF because of H-bond
2. higher IMFA, higher melting and boiling point

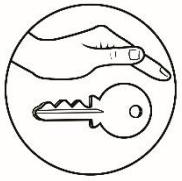
Activity 2 dishwashing liquid is slower than water

Activity 3
tap water>alcohol>cooking oil
CQ 1. Tap water
2. better capillary action, higher IMFA

Activity 4
Nail polish remover evaporates faster than water

Assessment

1. D
2. A
3. D
4. D
5. A
6. A
7. A
8. B
9. D
10. C
11. A
12. B
13. D
14. E
15. G



Answer Key

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