Senior High School

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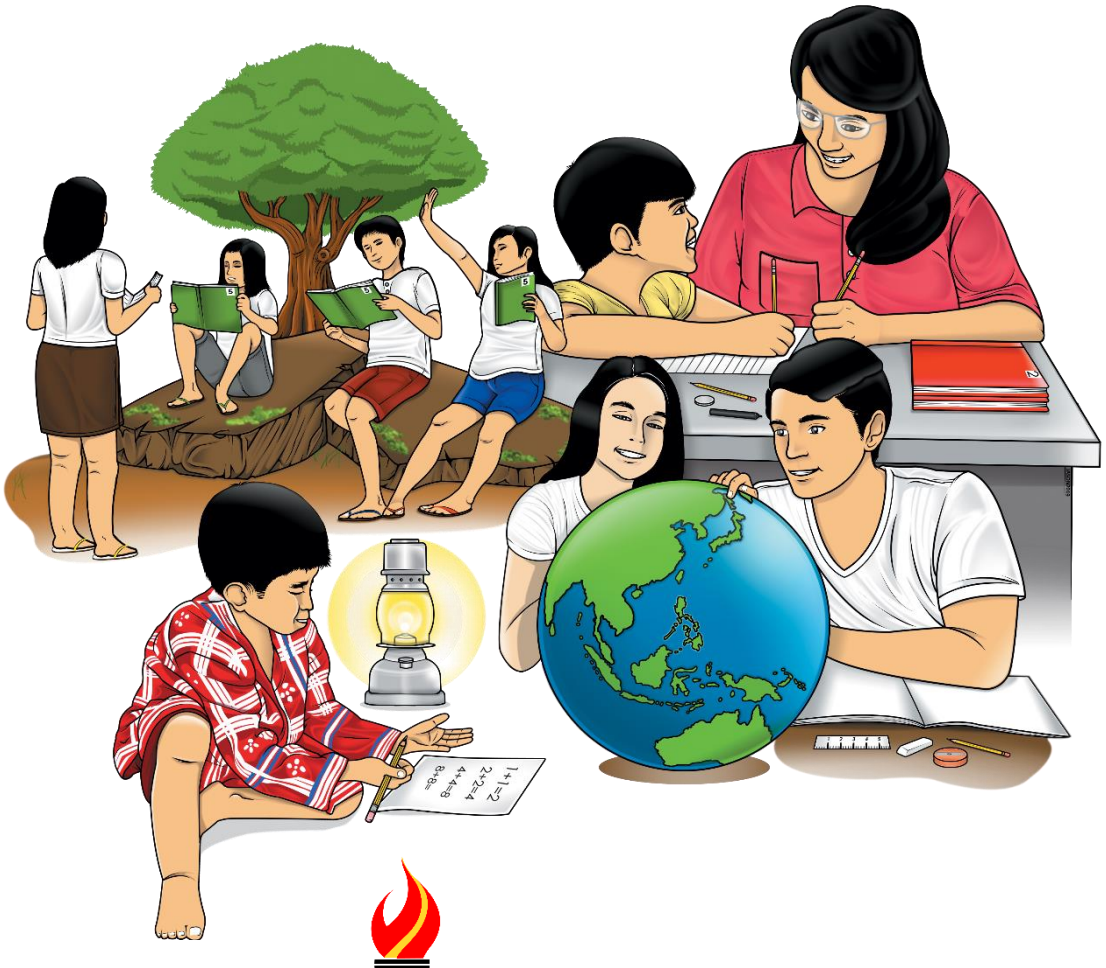
DEPARTMENT OF EDUCATION

Physical Science

Quarter 1 – Module 5: General Types of Intermolecular Forces



ALTERNATIVE DELIVERY MODE
ADM

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Alternative Delivery Mode
Quarter 1 – Module 5: General Types of Intermolecular Forces
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General Types of Intermolecular Forces

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Introductory Message

For the facilitator:

Welcome to the Physical Science 11/12 Alternative Delivery Mode (ADM) Module on General Types of Intermolecular Forces!

This module was collaboratively designed, developed and reviewed by educators both from public and private institutions to assist you, the teacher or facilitator 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 into 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 and circumstances.

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 own 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 the Physical Science 11/12 Alternative Delivery Mode (ADM) Module on General Types of Intermolecular Forces !

The hand is one of the most symbolic parts of the human body. It is often used to depict skill, action and purpose. Through our hands we may learn, create and accomplish. Hence, the hand in this learning resource signifies that as a learner, you are capable and empowered to learn by yourself. Relevant competencies and skills can be successfully achieved 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 enabled 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 an activity that aims to check what you already know about the lesson to take. If you get all the answers correctly (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 sentence/paragraph to be filled in to process what you learned from the lesson.

 ***What I Can Do***	This section provides an activity which will help you apply your new knowledge or skill into real life situations or concerns.
 ***Assessment***	This is a task which 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. This also tends retention of learned concepts.
 ***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.
6. Return this module to your teacher/facilitator once you are through with it.

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 deep understanding of the relevant competencies. You can do it!

What I Need to Know

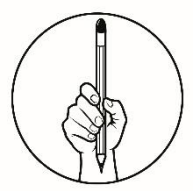
This module was designed and written with you in mind. It is here to help you master the *General Types of Intermolecular Forces*. The scope of this module permits it to be used in different learning situations. The language used recognizes the varied vocabulary level of students. The lessons are arranged to follow the standard sequence of the course. But the order in which you read them can be changed to correspond with the textbook you are now using.

The module is divided into two lessons, namely:

- Lesson 1 – How the general types of intermolecular forces are described
- Lesson 2 – Intermolecular forces present between and among substances

After going through this module, you are expected to:

1. describe the types of intermolecular forces present in substances, and
2. identify the types of intermolecular forces present between and among substances.



What I Know

Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. Forces that are present between and among molecules
    a. ionic
    b. covalent
        intermolecular
    c. intramolecular

    a. Forces that are present between an ion and a polar molecule
    b. ion-dipole
    c. dipole-dipole
    d. dispersion forces
    e. hydrogen bonding

2. The ease with which the electron distribution in the atom or molecule can be distorted
    a. diffusion
    b. polarizability
    c. dipole moment
    d. induced dipole

Attractive forces that arise as a result of temporary dipoles induced in atoms or molecules

    a. dipole forces
    b. induced dipole
    c. dispersion forces
    d. instantaneous dipole

5. An interaction between the H-atom in a polar bond and an electronegative atom such as O, N, or F
    a. h-bonding
    b. dipole-dipole
    c. london forces
6. ion-induced dipole

7. The strongest among the intermolecular forces
    a. ion-dipole
    b. h-bonding
    c. dipole-dipole
    d. dipole-induced dipole

8. Attractive forces between polar molecules where the positive end of one molecule aligns to the negative end of another molecule
    a. ion-dipole
    b. dipole-dipole
    c. dispersion forces
    d. ion-induced dipole

9. Results when an ion or polar molecule is placed near an atom or a nonpolar molecule such that the electron distribution is distorted by the force exerted by the said substances
10. h-bonding
11.
    a. ion-dipole forces
    b. dispersion forces
    c. dipole-dipole interaction

12. London dispersion forces are a function of the molar mass of substances. As the molar mass increases the dispersion forces of the molecules
    a. increase
    b. decrease
    c. remain the same
13. cannot be measured

14. A heat of hydration is the result of favourable interaction between the cations and anions of an ionic compound with water. The nature of this attraction is
    a. h-bonding
    b. ion-dipole forces
    c. dispersion forces
    d. dipole-dipole interaction

15. The measure of the shift of electron density from one atom to the more electronegative atom in a molecule
    a. Polarity
    b. Polarizability
    c. Dipole moment
    d. Forces of interaction

16. The strength of ion-dipole interaction depends on the ions present. with ions of the same magnitude, which is true about this interaction?
    a. Cations interact more strongly that anions because their charges are less concentrated.
    b. Cations interact more strongly that anions because their charges are more concentrated.
    c. Anions interact more strongly that anions because their charges are less concentrated.
    d. Anions interact more strongly that anions because their charges are more concentrated.

17. At any certain time the shift in the position of the electrons in an atom will likely create a temporary positive and negative poles. This is known as
    a. dipole forces
    b. dipole moment
    c. dispersion forces
    d. instantaneous dipole

18. The force/s of attraction present between the species I_2 and NO_3^-
    a. London dispersion forces
    b. H-bonding and ion-induced dipole interaction
    c. Van der Waals interaction and dipole-dipole interaction
    d. London dispersion forces and ion-induced dipole interaction

19. Which of the following species is capable of hydrogen-bonding among themselves?
    a. ethane (C_2H_6)
    b. acetic acid (CH_3COOH)
    c. beryllium hydride (BeH_2)
    d. potassium fluoride (KF)

Lesson 1 Types of Intermolecular Forces

Atoms in molecules and ionic substances are attracted to each other either by sharing or complete transfer of electrons. These attractions keep the molecules and their identities intact.

But, say, how do molecules or substances stay together and exhibit properties that are unique to them? This is known as bulk properties.

In this lesson, you will learn how the different forces of attraction known as intermolecular forces keep substances together. You will also be able to identify the intermolecular forces present between and among substances, thus their bulk properties can be predicted.

What's In

This simple activity will help you recall what you understood about Lewis electron dot structure and polarity of molecules. The polarity of substances will guide you in identifying the intermolecular forces present between and among molecules.

Notes to the Teacher

1. This module will help the students understand the concepts of intermolecular forces (IMF).
2. Allow the students to answer each part thoroughly, either individually or in pairs.
3. Let the students check the answers to each part. Have a short discussion of the concepts involved after checking.
4. The students will then move to the next part of the module. They will have the feedback and discussion after every part.
5. Inputs can be given in addition to the discussion in this module.
6. Kindly entertain questions for further discussions.

Directions:

1. Use a clean sheet of paper to answer this part.
2. Copy the table and fill up with the correct information.
3. Show the direction of the dipole moment for each molecule.

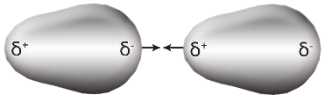
Substance	LEDS	Shape	Polarity
1. CCl_2F_2			
2. N_2			
3. CH_4			
4. H_2O			
5. CO			

Polarity of molecules based on the LEDS

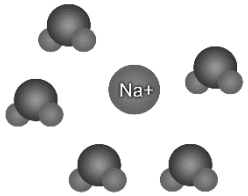
What's New

Activity 1:

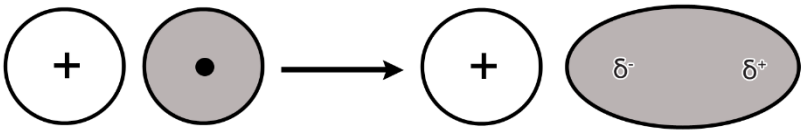
Using the illustrations below, describe what happens in each of the attractions between substances by completing each sentence with the correct words. Tell what kind of attractive forces keep the substances together.

1. 

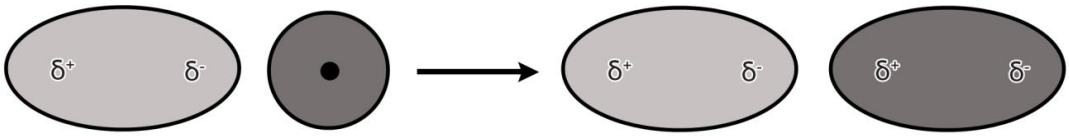
This attraction happens between polar molecules. The charges align so that the _____ pole of one molecule is attracted to the _____ end of the other molecule. Kind of interaction: _____

2. 

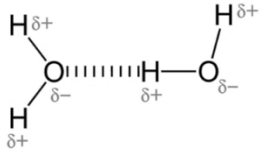
The _____ sodium ion is attracted to the partially _____ end of water molecules. Kind of attraction: _____

3. 

A _____ ion or _____ approaches a neutral nonpolar substance. This results to a distortion of the substance and leads to the development of positive and negative poles. Kind of attraction: _____

4. 

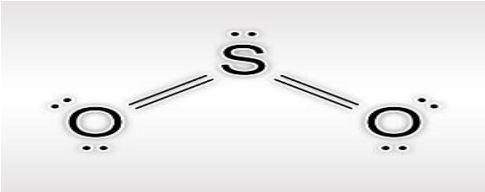
A permanent _____ approaches a neutral nonpolar substance resulting to a _____ dipole. Kind of attraction: _____

5. 

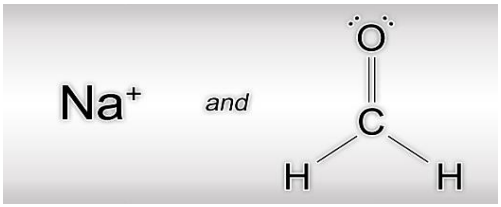
The partially- _____ oxygen of one water molecule is _____ to the partially- _____ hydrogen of the other water molecule. Kind of attraction: _____

Activity 2: Identify the intermolecular forces present among the following species.

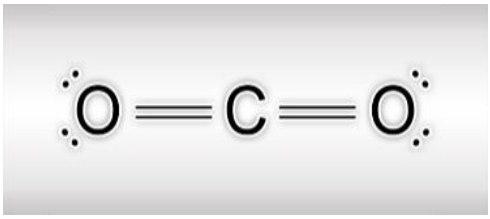
a. Sulfur dioxide (SO_2) and another SO_2



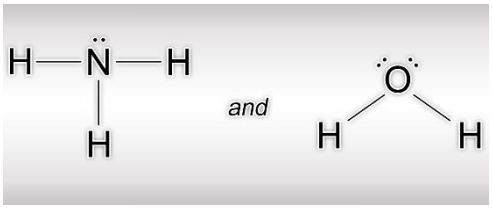
b. Sodium ion (Na^+) and Formaldehyde (CH_2O)



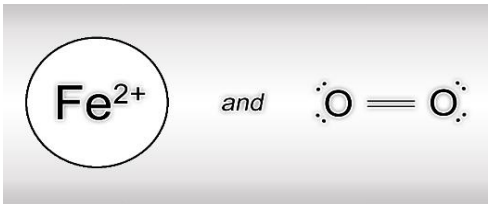
c. Carbon dioxide (CO_2)with another CO_2

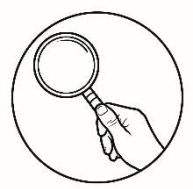


d. Ammonia ($NH_3$and H_2O)



e. Fe^{2+} and O_2





What is It

This section gives brief and thorough discussion of the concepts of intermolecular forces. The different types of intermolecular forces are described to be congruent with the first objective of this module. The second discussion is about the strategies to identify the intermolecular forces present between and among molecules.

Activity 1:

Atoms are held together in molecules by strong intramolecular forces, like covalent and ionic bonds. On the other hand, other forms of attractive forces are present to keep these molecules together giving rise to the different states of matter, which, then exhibit their own bulk properties such as boiling, melting, and freezing points, and viscosity among others.

There are three general types of intermolecular forces (IMF), namely, van der Waals forces, ion-dipole interaction, and H-bonding.

Van der Waals forces, after the Dutch chemist Johannes van der Waals (1837-1923) consist of dipole-dipole interaction, dipole-induced dipole interaction, and dispersion forces. Dipole-dipole attraction is present among polar molecules. Through constant movement, the charges of the molecules align in such a way that the positive (+) end of one molecule is attracted to the negative (-) end of the other molecule. This happens due to the shift of electron density towards the more electronegative element in the molecule resulting to (+) and (-) ends. The measure of this electron shift is known as dipole moment, represented by crossed arrow, $\overset{+}{\longrightarrow}$.

Dipole-induced dipole interaction, just like the dipole-dipole forces, depends on the presence of polar molecules. The other molecule needs not be a polar one. The partial charges present in the dipole cause the polarization or distortion of the electron distribution of the other molecule. This gives rise to regions of partial (+) and (-) poles. This induced dipole will then be attracted to the original polar molecules, resulting to dipole-induced dipole attraction.

Dispersion forces (London dispersion forces), were named after the German physicist Fritz London (1900-1954). The electron cloud of a neutral substance can be normally distributed around the nucleus. At any given time, the electron distribution may be uneven resulting to an instantaneous dipole. This temporary dipole will then influence the neighbouring atoms through attractive and repulsive forces. Eventually, the substances will gain instantaneous dipoles, too. Attraction between opposite charges will happen among the species present. These are true for ion-induced dipole and induced dipole-induced dipole interactions.

Ion-dipole interaction results from the attraction between either a cation (+) or an anion (-) with permanent polar molecules. The ions will be attracted to the opposite charges present in the dipole resulting to this type of attraction.

H-bonding is a special type of dipole-dipole interaction between the H-atoms in a polar bond. It requires that the H-atoms in the molecules be bonded with more electronegative atoms such as O, N, or F to form H-bonds with other molecules.

All interacting substances exhibit the presence of London dispersion forces in addition to other forces of attraction among them.

Activity 2: Intermolecular forces (IMF) present among species

Polar substances exhibit *dipole-dipole* interaction due to the presence of (+) and (-) ends of the molecules. In the exercise above, sulphur dioxide (SO_2) has polar ends that will participate in the dipole-dipole forces of attraction.

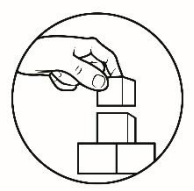
With the presence of an ion (cation or anion), the charged ends of polar molecules will be attracted to the dipole. This is true in the case of Na+ and formaldehyde. The positive (+) sodium ion will be attracted to the partially-negative oxygen in formaldehyde, resulting to an *ion-dipole* interaction.

For the third example, CO_2 is a nonpolar substance. It is a linear molecule and the electron shift at the right of C is balanced by the electron shift to the left. This produces no net shift in electron density so no net charged is produced. For nonpolar molecules, only *dispersion forces* are present.

In both NH_3 and H_2O, the hydrogen atoms are bonded to more electronegative atoms, nitrogen and oxygen, respectively. This permits them to form H-bonds with other molecules with the same condition. Thus, H-bond is present between NH_3 and H_2O.

Ion-induced dipole forces of attraction are present among Fe^{2+} ions together with oxygen molecules. The charge in iron will distort the electron distribution in O_2 resulting to temporary poles in oxygen. The oppositely-charged particles, Fe^{2+} and partially-negative end of O_2 will then be attracted to form the above-mentioned force of attraction.

In all of the examples above, London dispersion forces are also present.



What's More

Activity 1.1 Description of Intermolecular Forces

Match Column A with column B. Choose the letters of the correct answer and write it on your answer sheet.

Column A	Column B
1. Attractive forces between polar molecule	a. hydration
2. Electrostatic attraction between an ion and a polar molecule	b. ion-induced dipole
3. Favorable interaction between the ions of an ionic compound and water	c. H-bonding
4. Distortion of the electron distribution of an atom or molecule brought about by an ion or a polar molecule	d. polarizability e. dipole-dipole
5. Dispersion of charges when an ion approaches a molecule	f. dipole-induced dipole
6. Happens when a H-atom bonded to electronegative atoms, such as O, N, F approaches a nearby electronegative atom	g. ion-dipole
7. Dispersion of charges when a dipole approaches a nonpolar molecule	h. dipole i. cations
8. The ease with which electron distribution is distorted	j. dispersion forces k. anions
9. Substance with positive and negative ends	
10. Positively-charged ions	

Activity 2.1 Intermolecular Forces present among species

Identify the intermolecular forces present in the following species.

1. Chlorine gas (Cl_2)
2. Carbon monoxide (CO)
3. Sulfur dioxide (SO_2)
4. Dichloromethane (CH_2Cl_2)
5. Dimethyl ether (CH_3-O-CH_3)

What Have I Learned

1. What are the general types of intermolecular forces?

2. Describe the following in your own words.
   a. van der Waals forces
      a.1 dipole-dipole interaction
      a.2 dipole-induced dipole interaction
      a.3 dispersion forces

   b. ion-dipole interaction

   c. H-bonding

3. List down the intermolecular forces present in each species.

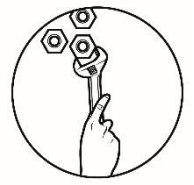
   a. HBr

   b. CS_2

   c. C_2H_6

   d. CH_3COOH

   e. Br_2



What I Can Do

Knowledge of concepts is not enough for a learning experience to be meaningful. We should also understand how the concepts we learned on intermolecular forces can be applied to real life situation to get the most out of what we learned. Let us look at this simple situation that will help us realize the advantage of fully understanding intermolecular concepts.

Situation:

Storage of different substances at home needs careful attention. Alcohol, acetone, and hair sprays, even gasoline should be taken care of to avoid fire. Where should these substances be stored? Why do we need extra precaution in keeping them at home? Relate your answer to intermolecular forces.

Assessment

Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. What is true about intermolecular forces?
   a. They are strong bonds that form between atoms of molecules.
   b. Substances can form more than one but one will predominate.
   c. They are stronger than the intramolecular forces between atoms.
   d. There is a vague relationship between intermolecular forces and bulk properties.

2. Ion-dipole interaction results from the
   a. Attraction between an ion and a polar molecule.
   b. Repulsion between a dipole and another dipole.
   c. Repulsion between a polar with a nonpolar molecule.
   d. Attraction between a polar with another polar molecule.

3. Why are dispersion forces high in molecules with great number of electrons?
   a. The electron distribution of big molecules is easily polarized.
   b. The nucleus in the molecules has greater effective shielding effect.
   c. The electrons move freely around the nucleus resulting to greater energy.
   d. The electrons in the molecules can easily jump from one orbital to another.

   a. 4. What are considered van der Waals forces of attraction?
   b. ion-induced dipole; dipole-dipole; London dispersion forces
   c. dipole-dipole; dipole-induced dipole; London dispersion forces
   d. London dispersion forces; ion-induced dipole; dipole-induced dipole
   e. dipole-induced dipole; ion-induced dipole; London dispersion forces

5. Distinguishing characteristic of London dispersion forces

   a. There is instantaneous dipole that influences neighboring substances to gain dipoles.
   b. There is permanent (-) and (+) ends that participate in electrostatic attractions.
   c. The electron cloud of the atoms are evenly distributed around the nucleus.

The atoms of two neighbouring molecules participate in give and take of electrons.

6. How does dipole-dipole interaction happen?
    a. Polar molecules shift electron density that gives rise to neutral substances.
    b. The electron distribution in the polar molecules is distorted that results to (-) and (+) poles.
    c. Polarization of big nonpolar molecules brings about the formation of permanent (+) and (-) charges.
    d. The (-) and (+) ends of one polar molecule align themselves to the (+)and (-) ends of another polar molecule and attract each other.

7. During ion-dipole interactions, the cation causes the
    a. repulsion of charges among the molecules.
    b. distortion of the electron distribution in the dipole.
    c. attraction of the (-) ion to the (+) end of a permanent dipole.
    d. formation of (+) ions that are attracted to the permanent dipole.

8. H-bonding forms when the substances involved are polar and have molecules with
    a. H-atoms attached to O, N, F.
    b. C-atoms attached to O, N, F.
    c. central atoms with O, N, F as attached atoms.
    d. unshared pair of electrons in the central atom.

9. Which ions will result to higher ion-dipole interactions?
    a. anions
    b. divalent
    c. cations
    d. monatomic

What Intermolecular forces are present in the following species?

10) CH_4

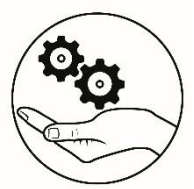
11) CH_3COOH

12) O_3

13) N_2

14) NH_3

15) PCl_5

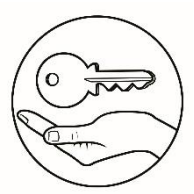


Additional Activities

This part will test whether you fully understand what intermolecular forces are present between and among species. You can answer this by recalling the strategies discussed earlier in this module. Remember also that there may be more than one IMF present in the given substances.

Identify the intermolecular forces present in the following substances.

1) Silicon tetrafluoride, SiF_4
2) Acetone, CH_2O
3) Methyl alcohol, CH_3OH
4) Methane, CH_4
5) Phosphorus trichloride, PCl_3



Answer Key

What I Know

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

What's More

Act. 1.1

1. E
2. G
3. A
4. J
5. B
6. C
7. F
8. D
9. H
10. I

Act. 2.1

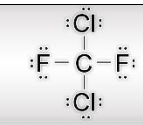
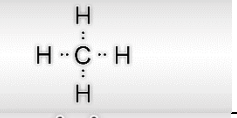
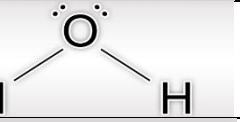
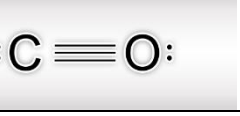
1. LDF
2. 2.LDF,
3. LDF,
4. 3. LDF,
5. dipole-dipole
6. 4.LDF,
7. dipole-dipole
8. 5. LDF,
9. dipole-dipole

Assessment

1. C
2. A
3. A
4. B
5. A
6. D
7. C
8. A
9. C
10. London Dispersion forces
11. London dispersion forces; dipole-dipole; H-bonding
12. London dispersion forces; dipole-dipole
13. London dispersion forces
14. London dispersion forces; dipole-dipole; H-bonding
15. London dispersion

What's In

Polarity of molecules based on the LEDS

Substance	LEDS	Shape	Polarity
1. CCl_2F_2 (Freon-12)		Tetrahedral	Polar
2. N_2 (Nitrogen gas)		Linear	Nonpolar
3. CH_4 (Methane)		Tetrahedral	Nonpolar
4. H_2O (Water)		Bent	Nonpolar
5. CO (Carbon monoxide)		Linear	Polar

What's New

Act.1

1. partially negative, positive ; Kind of interaction: dipole-dipole
2. positive, negative ; Kind of interaction : ion-dipole
3. positive, cation ; Kind of intersection; ion-induced dipole
4. dipole, temporary; Kind of interaction: dipole-induced dipole
5. negative, attracted, positive ; Kind of interaction: H-bonding

Act. 2

1. London dispersion forces, dipole-dipole
2. London dispersion forces, ion-dipole
3. London dispersion forces
4. London dispersion forces, dipole-dipole, H-bonding
5. London dispersion forces, ion-induced dipole

What Have I Learned

1. The general types of intermolecular forces are van der Waals forces, ion-dipole interaction, and H-bonding.

   2a) van der Waals forces are interactions between molecules that can be either repulsive or attractive depending on the distance of the molecules.

   a1) Dipole-dipole intraction depends on the presence of (+) and (-) charges that align themselves so that the (+) will be attracted to the (-) poles of the molecules.

   a2) Dipole-induced dipole interaction depends on the presence of a dipole that causes the polarization of the electron distribution resulting to temporary dipoles.

   a3) Dispersion forces result from the distortion of the electron distribution or polarization of the molecules.

2. a. London dispersion forces, dipole-dipole
   b. London dispersion forces
   c. London dispersion forces, dipole-dipole interaction, H-bonding
   d. London dispersion forces
   e. London dispersion forces

Additional Activities

1. London dispersion forces
2. London dispersion forces , dipole-dipole interaction
3. London dispersion forces , H-bonding, dipole-dipole interaction
4. London dispersion forces
5. London dispersion forces , dipole-dipole interaction

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