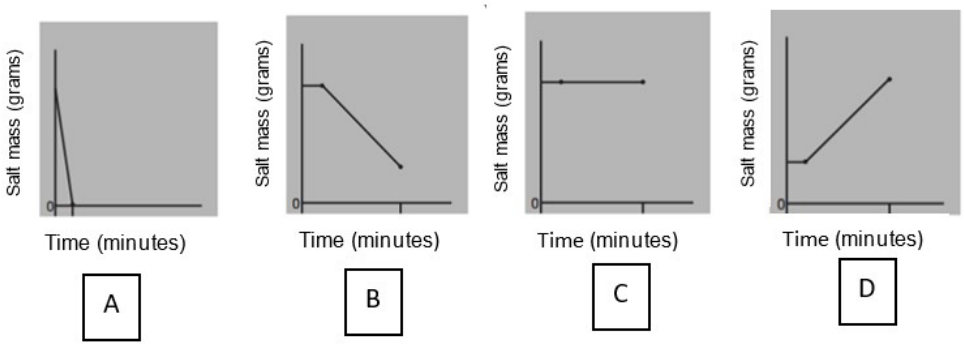
A1: Visual Perceptions of Structure of Matter Questionnaire – Pictorial format

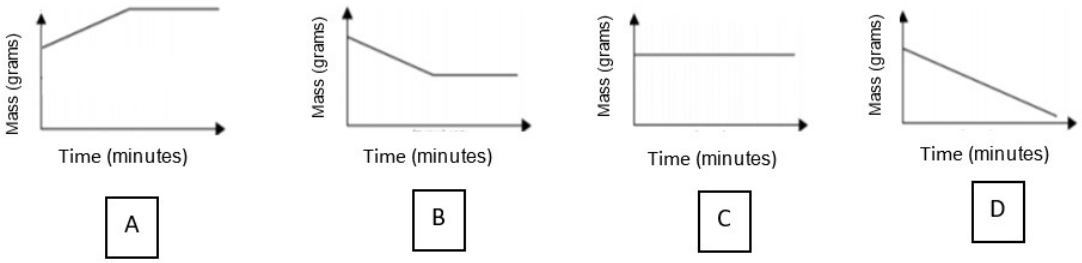
1. Students conducted an experiment to determine whether the mass of salt changes when it is dissolved in water. **Which of the following graphs best represents the mass of the salt (amount of salt) during the dissolving process?**



To what extent was the question clear to you? Please rate on a scale of 1 (very unclear) to 5 (very clear).

To what extent are the illustrations clear to you? Please rate on a scale of 1 (very unclear) to 5 (very clear).

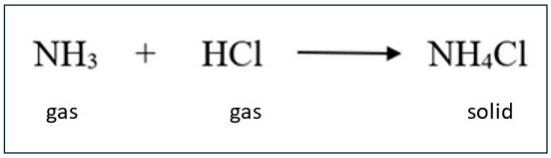
2. A metal sphere was heated and placed on an electronic scale.
Which graph best represents the scale reading as the metal sphere cools down?



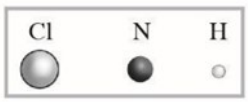
To what extent was the question clear to you? Please rate on a scale of 1 (very unclear) to 5 (very clear).

To what extent are the illustrations clear to you? Please rate on a scale of 1 (very unclear) to 5 (very clear).

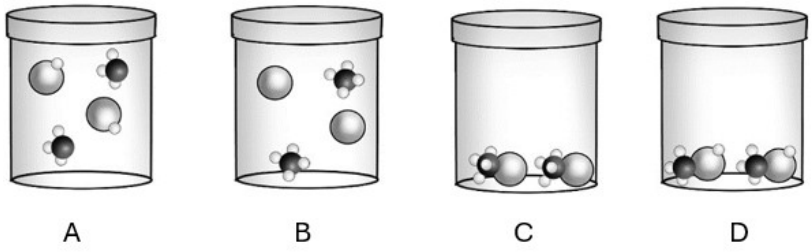
3. Here is a description of a chemical process occurring in a closed container:

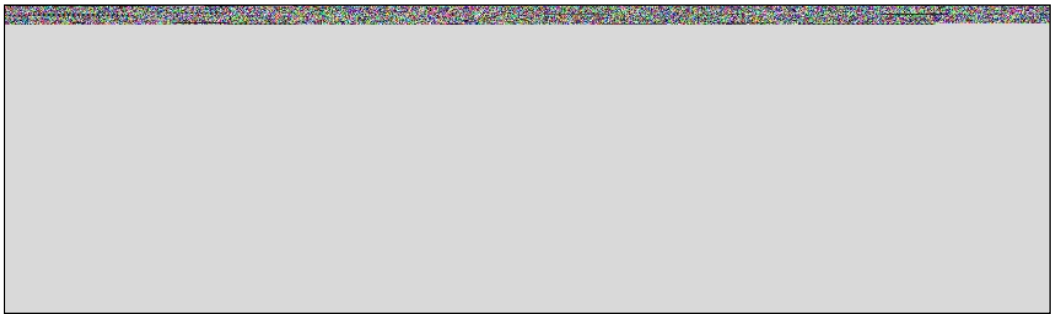


Based on the following legend:



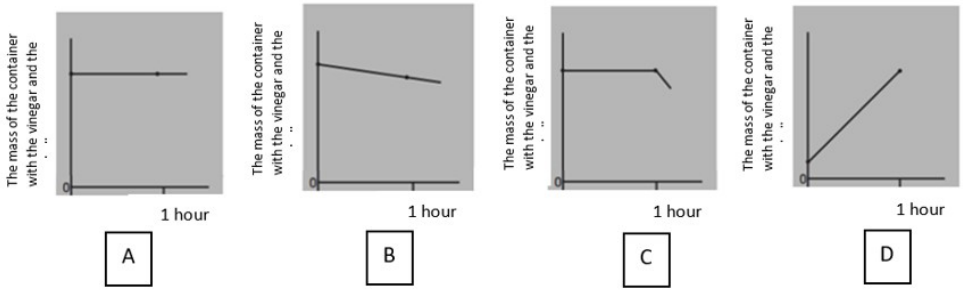
Which illustration depicts the reactants in this process?

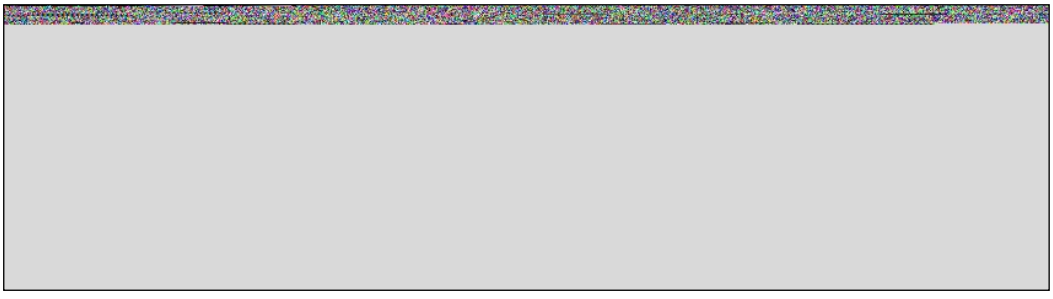




4. Dani placed an eggshell into an open container with vinegar, and bubbles immediately started rising from the shells. Dani measured the mass of the container with the eggshell and vinegar immediately after placing the shell in the container and then every ten minutes for an entire hour.

   a. **Which of the following graphs depicts the mass of the container with the vinegar and the eggshell after about an hour?**

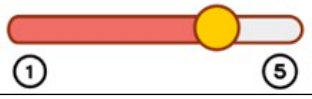




b. Choose the best explanation for your answer.

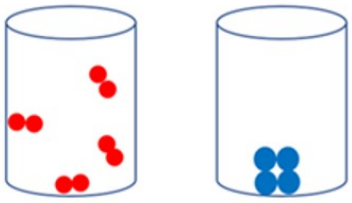
A. The mass increased because gas was produced, and gas has mass.
B. The mass decreased because bubbles began to rise, indicating that gas was released.
C. The mass did not change because no material was added or removed during the experiment.
D. The mass remained constant for an hour, and then a decrease occurred because it took a long time for the eggshell to react with the vinegar and release gas.

To what extent was the question clear to you? Please rate on a scale of 1 (very unclear) to 5 (very clear).



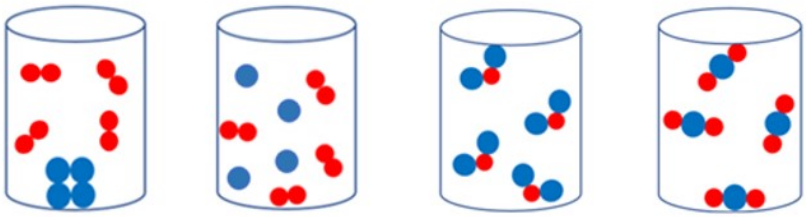
5. Ida wanted to illustrate a chemical reaction between carbon and oxygen.
He used a model of carbon C(s) and a model of oxygen (O2) as shown.

The circles represent the atoms of each substance.



Oxygen carbon

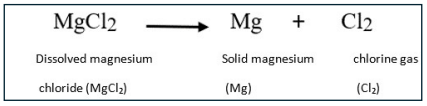
Which illustration depicts the product of reaction ? $C_{(S)} + O_{2(g)} \rightarrow CO_{2(g)}$



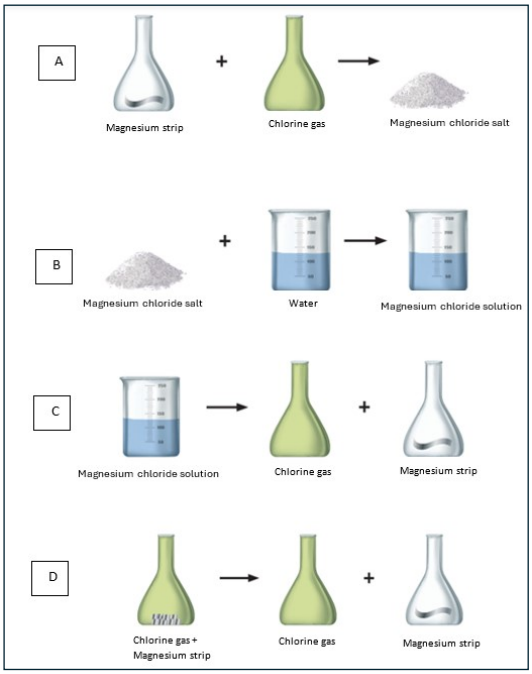
A B C D

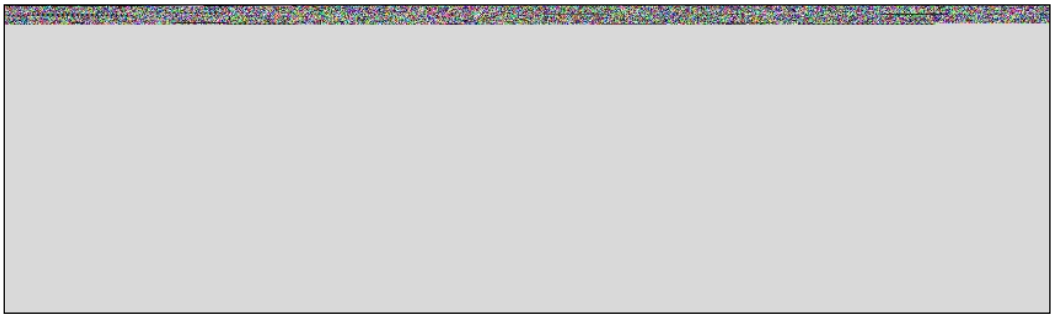
[redacted]

6. One of the dissolved substances sea water is magnesium chloride ($MgCl_2$). The metal magnesium (Mg) can be produced from this substance, in the following chemical process,



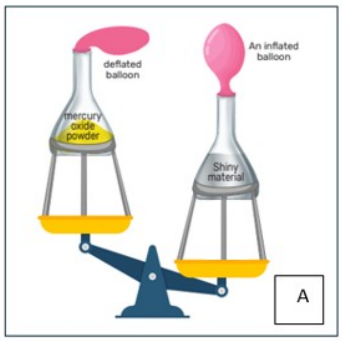
Which of the following illustrations depicts the chemical process?

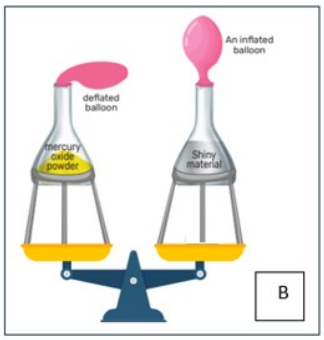


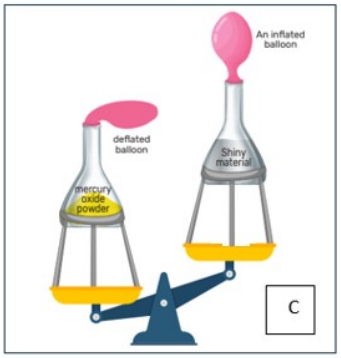


7. Students conducted an experiment in which they decomposed mercury oxide by heating it. They placed mercury oxide powder into a flask and sealed the flask with a balloon. Then, they heated the bottom of the flask. After five minutes, the balloon inflated, and a shiny substance appeared on the wall of the flask (see illustration).

Which of the following illustrations correctly depicts the total mass of the products obtained at the end of the experiment?

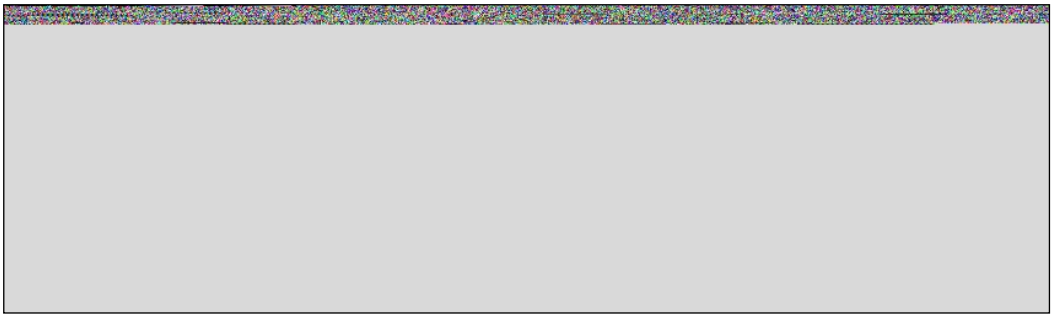




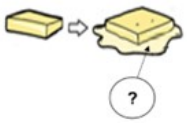


There is no suitable illustration

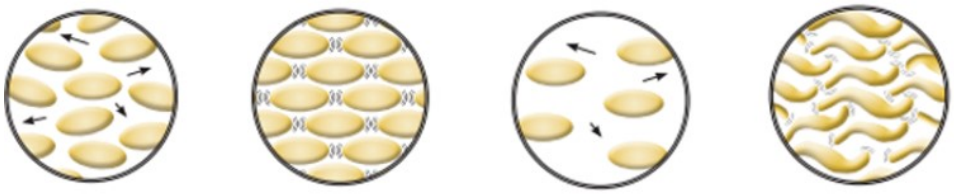
D



8. A package of butter was left outside the refrigerator, and after about two hours, it melted and became liquid.

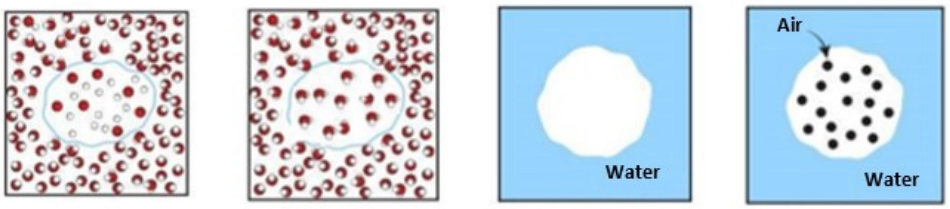


Which of the following depicts the particles in the butter at the end of the process?



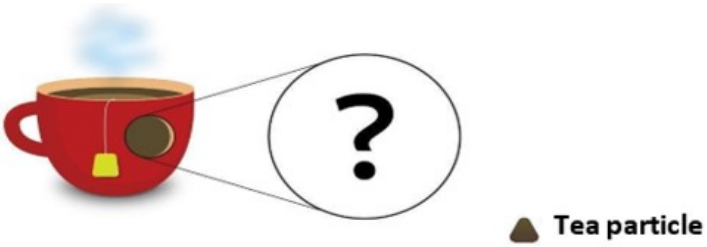
A B C D

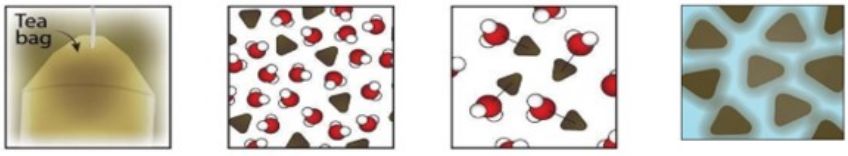
9. When water boils in a pot, bubbles form within the water. **Which of the following illustrations shows what these bubbles are made of?**



A B C D

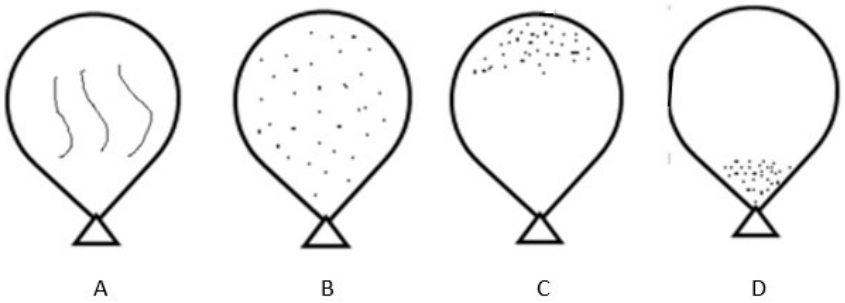
10. After placing a tea bag into a cup of hot water, it turns into a reddish-brown liquid. **Which of the following illustrations explains why the tea is reddish-brown and not clear like water?**



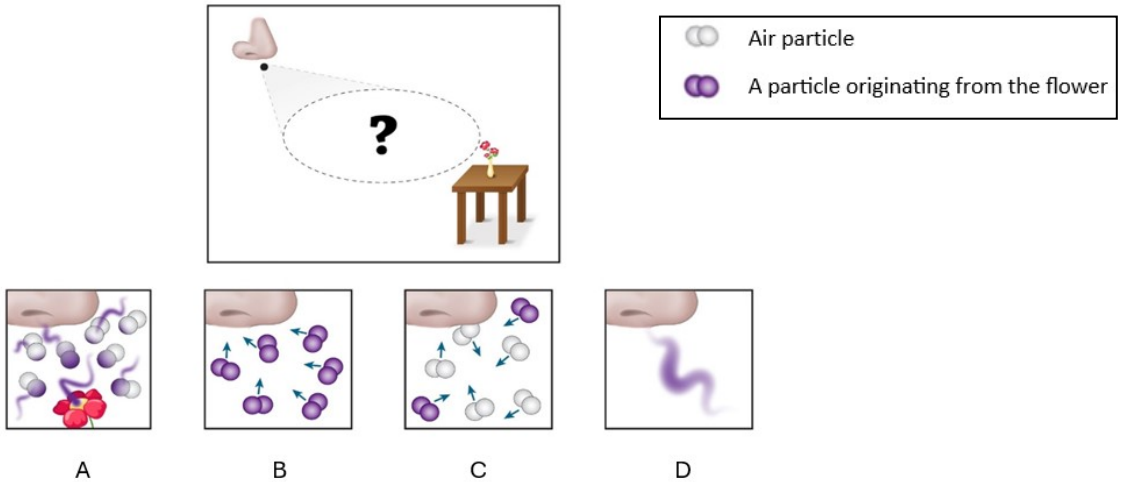


A B C D

11. When a small amount of air is released from an inflated balloon, and then the balloon is tied so that no more air can escape. **Which of the following illustrations shows how the remaining air particles inside the balloon are arranged?**



12. Danny was playing in his room and smelled the flowers from the other room. **Which of the following illustrations shows how the scent from the flowers reached Dani's nose?**



A2: Visual Perceptions of Structure of Matter Questionnaire – Verbal format

1.Students conducted an experiment to determine whether the mass of a substance changes when it is dissolved in water. The students dissolved salt in water, resulting in a salt solution.

Does the mass of the salt (amount of salt) change during the dissolving process?

A. Yes, the mass of salt decreases rapidly until no salt remains in the solution.

B. Yes, the mass of salt decreases after dissolution, leaving less salt in the solution.

C. No, the mass of salt remains constant.

D. Yes, the mass of salt increases after dissolution.

2. A metal sphere was heated and placed on an electronic scale. **What do you think happened to the mass of the sphere as it cooled down?**

A. The mass of the sphere initially increased as it cooled down, but after a certain period, the mass remained constant.

B. The mass of the sphere initially decreased as it cooled down, but after a certain period, the mass remained constant.

C. The mass of the sphere remained constant over time as it cooled.

D. The mass of the sphere decreased over time as it cooled down.

3. Here is a description of a chemical process occurring in a closed container:

Which of the following statements describes the reactants in this process?

A. The reactants are two types of molecules. One consists of nitrogen bonded to three hydrogen atoms, and the other molecule consists of a chlorine atom bonded to a hydrogen atom.

B. The reactants are molecules composed of a nitrogen atom bonded to four hydrogen atoms, along with individual chlorine atoms.

C. The reactants are identical molecules, each consisting of a nitrogen atom bonded to four hydrogen atoms and a chlorine atom.

D. The reactants are identical molecules, each consisting of a chlorine atom bonded to a hydrogen atom and a nitrogen atom bonded to three additional hydrogen atoms.

4. Danny placed an eggshell into an open container with vinegar. Bubbles immediately started rising from the shell. Dani measured the mass of the container with the eggshell and vinegar immediately after placing the shell in the container, and then every ten minutes for an entire hour.

a. What happened to the mass of the container with the vinegar and the eggshell during the hour?

A. The mass of the container with vinegar and the eggshell did not change throughout the entire process.

B. The mass of the container with vinegar and the eggshell decreased when the gas started to form

C. The mass of the container with vinegar and the eggshell remained constant for an hour, and then decreased

D. When the chemical reaction started, the mass of the container with vinegar and the eggshell increased.

b. Choose the most accurate explanation for your answer.

A. The mass increased because gas was produced, and gas has mass.

B. The mass decreased because the eggshell reacted with the vinegar, and bubbles formed, indicating that gas was released.

C. The mass did not change because no material was added or removed during the experiment.

D. The mass remained constant for an hour, and then a decrease occurred because it took a long time for the eggshell to react with the vinegar and release gas.

5. Here is a description of a chemical process occurring in a closed container:

Which of the following statements is correct:

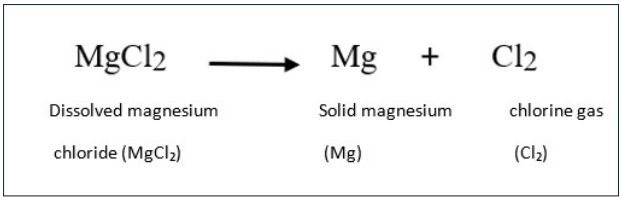
A. The product of the reaction is a mixture of solid carbon atoms and gaseous oxygen molecules.

B. The product of the reaction is a gaseous mixture of diatomic oxygen molecules and individual carbon atoms .

C. The product of the reaction is a gaseous compound, consisting of two carbon atoms and one oxygen atom.

D. The product of the reaction is a gaseous compound, consisting of two oxygen atoms and one carbon atom.

6. One of the dissolved substances in the Dead Sea is magnesium chloride ($MgCl_2$). The metal magnesium (Mg) can be produced from this substance, in the following chemical process:



Which statement about the process is correct?

A. The process describes the formation of the compound magnesium chloride ($MgCl_2$) from the metal magnesium and the gas chlorine.

B. The process describes the dissolution of the salt magnesium chloride ($MgCl_2$).

C. The process describes the decomposition of the salt magnesium chloride ($MgCl_2$) into its constituent elements.

D. The process describes the separation of a mixture of magnesium and chlorine.

7. Students conducted an experiment in which they placed mercury oxide powder into a flask and sealed it with a balloon. Then, they heated the bottom of the flask.

After five minutes, the balloon inflated, and a shiny substance appeared on the wall of the flask (see illustration).

What is correct to say about the total mass of the products obtained

at the end of the experiment?

A. The mass of the products is greater than the mass of the mercury oxide at the beginning of the experiment.

B. The mass of the products is equal to the mass of the mercury oxide at the beginning of the experiment.

C. The mass of the products is less than the mass of the mercury oxide at the beginning of the experiment.

D. There is no suitable answer

8. A piece of butter was left outside the refrigerator, and after about two hours, it melted and became liquid. **What happens to the particles of butter at the end of the process?**

A. The butter particles move more freely and are no longer vibrating in one place

B. The butter particles begin to move and vibrate from side to side.

C. The butter particles move and spread out, creating large spaces between them.

D. The butter particles become soft and jelly-like.

9. When water boils in a pot, bubbles form within the water.

What are these bubbles made of?

A. The bubbles are made of a mixture of gases made of oxygen atoms and hydrogen atoms surrounded by liquid water molecules.
B. The bubbles are made of water molecules in a gaseous state surrounded by water molecules in a liquid state.

C. There is nothing inside the bubbles; the bubbles are empty spaces surrounded by water.
D. The bubbles are made of air particles surrounded by water.

10. After placing a tea bag into a cup of hot water, a reddish-brown liquid is formed. **Why is the tea reddish-brown and not clear like water?**

A. The tea bag expands and colors the entire volume of water in the cup reddish-brown.
B. The reddish-brown color comes from particles in the tea that mix with the water particles

C. Particles in the tea bond with the water particles and create a new substance with a reddish-brown color.
D. There are particles in the tea bag that color the surrounding water reddish-brown.

11. When some air is released from an inflated balloon and then the balloon is tied so that no more air can escape. **How is the remaining air distributed inside the balloon?**

A. The air spreads throughout the balloon, but it is not made of particles.

B. The air particles are evenly distributed throughout the entire balloon.

C. The air particles gather at the top of the balloon.
D. The air particles gather around the knot at the bottom of the balloon.

12. Danny was playing in his room and smelled the flowers from the other room.

How did the scent from the flowers reach Dani's nose?

A. The air particles absorbed the scent of the flowers and carried it to Dani's nose.

B. Dani inhaled, which drew the scent particles from the flowers into his nose.

C. Air particles and scent particles collided with each other, causing some of the scent particles to reach Dani's nose.

D. The scent of the flowers moved through the air like a stream of smoke.

Appendix A3: **Interview Protocol**

Opening

Hello, I am …. Thank you very much for your willingness to assist me in my research and participate in this interview. During the interview, I will ask you questions. It is important to answer with everything you know. If a question is not clear enough, please let me know, and I will try to rephrase it in a clearer way. Thank you very much for your cooperation. This is not a test, and you are not required to answer everything.

Read the question again yourself, choose the distractor that seems right to you. Why did you choose this distractor in particular? Explain and detail all the reasons for your choice.

Butter Item

A piece of butter was left outside the refrigerator, and after about two hours, it melted and became liquid. **What happens to the particles of butter at the end of the process?**

A. The butter particles move more freely and are no longer vibrating in one place

B. The butter particles begin to move and vibrate from side to side.
C. The butter particles move and spread out, creating large spaces between them.
D. The butter particles become soft and jelly-like.
Read the question again yourself, choose the answer that seems right to you. Why did you choose this distractor in particular? Explain and detail all the reasons for your choice.

Hg Item

Students conducted an experiment in which they placed mercury oxide powder into a flask and sealed it with a balloon. Then, they heated the bottom of the flask.

After five minutes, the balloon inflated, and a shiny substance appeared on the wall of the flask (see illustration).

What is correct to say about the total mass of the products obtained

at the end of the experiment?

A. The mass of the products is greater than the mass of the mercury oxide at the beginning of the experiment.

B. The mass of the products is equal to the mass of the mercury oxide at the beginning of the experiment.

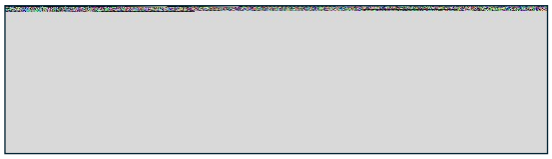
C. The mass of the products is less than the mass of the mercury oxide at the beginning of the experiment.

D. There is no suitable answer

Read the question again yourself, choose the answer that seems right to you. Why did you choose this distractor in particular? Explain and detail all the reasons for your choice.

NH_3 Item

Here is a description of a chemical process occurring in a closed container:



Which of the following statements describes the reactants in this process?

A. The reactants are two types of molecules. One consists of nitrogen bonded to three hydrogen atoms, and the other molecule consists of a chlorine atom bonded to a hydrogen atom.

B. The reactants are molecules composed of a nitrogen atom bonded to four hydrogen atoms, along with individual chlorine atoms.

C. The reactants are identical molecules, each consisting of a nitrogen atom bonded to four hydrogen atoms and a chlorine atom.

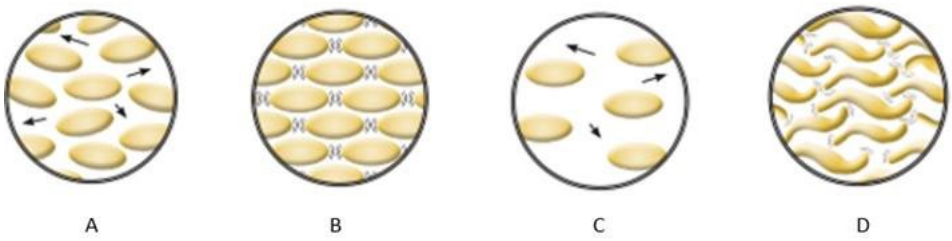
D. The reactants are identical molecules, each consisting of a chlorine atom bonded to a hydrogen atom and a nitrogen atom bonded to three additional hydrogen atoms.

Read the question again yourself, choose the distractor that seems right to you. Why did you choose this distractor in particular? Explain and detail all the reasons for your choice.

Butter Item vis

A package of butter was left outside the refrigerator, and after about two hours, it melted and became liquid.

Which of the following depicts the particles in the butter at the end of the process?



Read the question again yourself, choose the distractor that seems right to you. Why did you choose this distractor in particular? Explain and detail all the reasons for your choice.

Hg Item vis

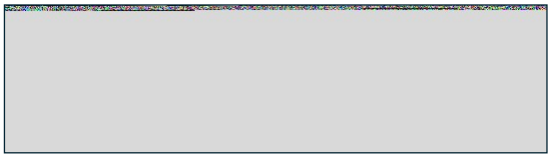
Students conducted an experiment in which they decomposed mercury oxide by heating it. They placed mercury oxide powder into a flask and sealed the flask with a balloon. Then, they heated the bottom of the flask. After five minutes, the balloon inflated, and a shiny substance appeared on the wall of the flask (see illustration).

Which of the following illustrations correctly depicts the total mass of the products obtained at the end of the experiment?

Read the question again yourself, choose the distractor that seems right to you. Why did you choose this distractor in particular? Explain and detail all the reasons for your choice.

NH_3 Item vis

1. Here is a description of a chemical process occurring in a closed container:



Based on the following legend: 

Which illustration depicts the reactants in this process?

Read the question again yourself, choose the distractor that seems right to you. Why did you choose this distractor in particular? Explain and detail all the reasons for your choice.

Appendix A4: Average ratings of teaching to compare instruction of classrooms that responded to the verbal format and to the visual format.

Description of the statements	Mean rating VERBAL (N=94)	Mean rating VISUAL (N=106)
My teacher uses computer simulations that show the movement of particles	2.33(0.43)	2.34(0.37)
My teacher uses illustrations of particles from a textbook	2.55(0.22)	2.55(0.39)
My teacher draws the particle model on the board	2.92(0.49)	2.73(0.57)
We do experiments in science classes	1.81(0.82)	1.88(0.48)
My science teacher gives class work (worksheets)	2.36(0.46)	2.62(0.27)
My science teacher gives homework	1.32(0.65)	1.66(0.53)
My science teacher explains the subjects well	3.32(0.39)	3.15(0.50)