STUDY GUIDE

About Kate the Chemist

Dr. Kate Biberdorf is a chemist, science entertainer, and professor at The University of Texas. Through her theatrical and hands-on approach to teaching, Dr. Biberdorf is breaking down the image of the stereotypical scientist, while reaching students who might otherwise be intimidated by science. Students' emotional responses, rather than rote memorization of facts, are key to Biberdorf's dynamic approach to her program, as well as science in general. Her exciting and engaging program leaves audiences with a positive, memorable impression of science—all while diminishing the stigma around women in science. She has appeared on *The Today Show*, *The Kelly Clarkson Show*, *NBC Nightly News*, the *Wendy Williams Show*, the *Rachael Ray Show*, the *Nick Cannon Show* and *Late Night with Stephen Colbert*.

She is the author of the bestseller *The Big Book of Experiments*, a full-color non-fiction book featuring 25 fun, kid-friendly experiments kids can do in their own kitchens. Readers learn how to make slime, fake tattoos, edible snot, glitter volcanoes and more! It was such a hit with kids across the country that Amazon selected it as one of their Best Books of 2020! Dr. Biberdorf's much anticipated follow-up book, *The Awesome Book of Edible Experiments*, is packed with 25 edible science experiment recipes kids can do in their own kitchen. Kids can make their own chocolate-covered pretzels, ice cream, and pretzel bites, all while learning the science behind their cooking.

The fun doesn't stop there! She is also the author of the *Kate the Chemist* fiction series that features a 10-year-old Kate the Chemist who, along with her friends and little brother Liam, solves problems in her community with the help of science! This five-book series shows kids that science truly is everywhere. The School Library Journal commented that the series "proves that science and fun go together like molecules in a polymer."

In addition to the fiction series, Dr. Biberdorf released her first nonfiction book for adults: *It's Elemental; The Hidden Chemistry in Everything.* This page-turner is about the ways we experience chemistry in our everyday life. In It's Elemental, Kate demystifies the fundamental principles of the science that may have eluded you in high school and shows how chemistry comes alive in everything we do. In a glowing starred review, Publishers Weekly raves "Readers will come away with an appreciation of how crucial—and how cool—chemistry actually is."

Dr. Biberdorf lives in Austin Texas with her husband, two dogs, and one very grumpy cat.

Dr. Biberdorf's website: https://www.katethechemist.com/

Included materials from Kate the Chemist that can be adapted for 5th-12th grades:

1. Physical vs chemical change worksheet & answer key (for teachers eyes only!)
2. Show format & experiment guide

Physical vs. Chemical Change

PART I
Physical Change

1. What is the definition of a physical change?

2. Name the physical change that occurs when a solid transitions into a liquid.

3. Name the physical change that occurs when a liquid transitions into a gas.

4. Name the physical change that occurs when a solid transitions into a gas.

5. Name the physical change that occurs when a gas transitions into a liquid.

6. Name the physical change that occurs when a liquid transitions into a solid.

7. Name the physical change that occurs when a gas transitions into a solid.

8. Does the chemical composition change during a physical change? Please be specific.

9. Is a physical change reversible? Please be specific.

10. Provide three examples of a physical change.

PART II
Chemical Change

1. What is the definition of a chemical change?

2. Does the chemical composition change during a chemical change? Please be specific.

3. Is a chemical change reversible? Please be specific.

4. Provide three examples of a chemical change.

Physical vs. Chemical Change

PART I
Physical Change

1. What is the definition of a physical change?
   A reversible change in the physical properties of a substance (e.g. size, shape, phase)

2. Name the physical change that occurs when a solid transitions into a liquid.
   Fusion

3. Name the physical change that occurs when a liquid transitions into a gas.
   Vaporization

4. Name the physical change that occurs when a solid transitions into a gas.
   Sublimation

5. Name the physical change that occurs when a gas transitions into a liquid.
   Condensation

6. Name the physical change that occurs when a liquid transitions into a solid.
   Freezing

7. Name the physical change that occurs when a gas transitions into a solid.
   Deposition

8. Does the chemical composition change during a physical change? Please be specific.
   No. The intermolecular bonds are broken during the physical change, but the intramolecular bonds will remain intact.

9. Is a physical change reversible? Please be specific.
   Yes. Ice can melt, and then we can freeze the water.

10. Provide three examples of a physical change.
    Sugar dissolving into water, crushing a can, breaking a glass, mixing sand and water

PART II
Chemical Change

1. What is the definition of a chemical change?
   An irreversible change involving the rearrangement of the atoms of one or more substances (e.g. cooking, fire, etc.)

2. Does the chemical composition change during a chemical change? Please be specific.
   Yes, you cannot "unburn" a log of wood.

   Fuel + Oxygen → Water + Carbon Dioxide

3. Is a chemical change reversible? Please be specific.
   No, water and carbon dioxide are not starting materials for a combustion reaction.

4. Provide three examples of a chemical change.
   Combustion, respiration, photosynthesis, oscillating clock reaction

Physical vs. Chemical Change

Presented by Kate the Chemist

The presentation will begin with a short introduction to Dr. Kate Biberdorf. She will share her story about becoming a chemistry professor + science entertainer and will explain how she has used her platform to build a STEM army. The students will be invited to join the STEM army by participating in a discussion on the difference between a chemical and physical change. After a brief lecture on these scientific principles, Dr. Biberdorf will invite students on stage (one at a time) to participate in the below demonstrations.

Each demonstration will have the following format:

1. student volunteer assists Dr. Biberdorf with the experiment
2. audience members discuss the experiment with their peers for 30-60 seconds
3. as a group, the audience votes on whether they believe the experiment was a physical or a chemical change
4. Dr. Biberdorf provides the audience with the answer, while providing a detailed explanation of the fundamental scientific principles

NOTE: All student volunteers MUST wear goggles and gloves, in order to participate in the experiment.

1. Colored Water over dry ice
    a. Materials
        i. 1 empty beaker
        ii. 2 beakers half full with water
        iii. dry ice
        iv. food coloring
    b. Procedure
        i. Add three handfuls of dry ice to the empty beaker
        ii. Add food coloring to the two beakers with water
        iii. Pour the beakers of water into the beaker of dry ice
    c. Type of Change
        i. Physical Change
            1. Sublimation
            2. Endothermic
    d. Explanation
        i. The dry ice absorbs the thermal energy from the water. This causes the solid carbon dioxide to sublime into gaseous carbon dioxide. This is an endothermic physical change.
2. Universal Indicator
    a. Materials
        i. 2 graduated cylinders
        ii. Water
        iii. NaOH
        iv. Universal indicator

v. Dry ice

b. Procedure
   i. Fill each graduated cylinder ¾ of the way full with water
   ii. Add 1mL of universal indicator for every 400 mL of water to each graduated cylinder
   iii. Add 1 mL of base for every 400 mL of water to one graduated cylinder
   iv. Add 2 mL of base for every 400 mL of water to the other graduated cylinder
   v. Stir the solutions
   vi. Add a small handful of dry ice to each graduated cylinder
c. Type of Change
   i. Physical Change (solid CO_2 to gas CO_2)
      1. Sublimation
      2. Endothermic
   ii. Chemical Change (color change)
      1. Acid/Base chemistry
      2. Exothermic
d. Explanation
   i. The dry ice absorbs the thermal energy from the water. This causes the solid carbon dioxide to sublime into gaseous carbon dioxide. This is an endothermic physical change.
   ii. The dry ice converts into carbonic acid in the presence of water. The acid and base perform a neutralization chemical reaction, resulting in an exothermic process.

3. Dry Ice Bubbles
   a. Materials
      i. 3L empty soda bottle
      ii. Tube-funnel apparatus
      iii. Water
      iv. NaOH
      v. Universal indicator
      vi. Dry ice
      vii. Bowl
      viii. Bubble Bath Solution
   b. Procedure
      i. Fill the soda bottle half full with water
      ii. Add 1mL of universal indicator to the soda bottle
      iii. Add 1 mL of base to the soda bottle
      iv. Pour the bubble bath solution into the bowl
      v. Add a small handful of dry ice to the soda bottle
      vi. Use the tube-funnel to route the gas to the bubble bath solution
      vii. Collect the dry ice bubbles on your hand
   c. Type of Change
      i. Physical Change (solid CO_2 to gas CO_2)
         1. Sublimation

        2. Endothermic
    ii. Chemical Change (color change)
        1. Acid/Base chemistry
        2. Exothermic
d. Explanation
    i. The dry ice absorbs the thermal energy from the water. This causes the solid carbon dioxide to sublime into gaseous carbon dioxide. This is an endothermic physical change.
    ii. The dry ice converts into carbonic acid in the presence of water. The acid and base perform a neutralization chemical reaction, resulting in an exothermic process (and the color changes).

4. Balloon animal in liquid nitrogen
    a. Materials
        i. 2 balloon animals
        ii. Liquid nitrogen
        iii. Container for liquid nitrogen
    b. Procedure
        i. Put liquid nitrogen in container
        ii. Put balloon animals in container
    c. Type of Change
        i. Physical Change
            1. Exothermic (big to small balloon)
            2. Endothermic (small to big balloon)
    d. Explanation
        i. The liquid nitrogen absorbs the thermal energy from the balloon, resulting in the compression of the air molecules in the balloon.
        ii. This is a physical, exothermic process. When the balloon animal begins to warm up, the gasses decompress, resulting in a physical, endothermic process. (NOTE: In this example, the balloon is the system).
5. Helium balloon animal
    a. Materials
        i. Balloon animal with large helium balloon attached
        ii. Container for liquid nitrogen
        iii. Liquid nitrogen
    b. Procedure
        i. Put balloon animal in liquid nitrogen
        ii. Let go of balloon animal as it warms up
    c. Type of Change
        i. Physical Change
            1. Exothermic (big to small balloon)
            2. Endothermic (small to big balloon)
    d. Explanation
        i. The liquid nitrogen absorbs the thermal energy from the balloon, resulting in the compression of the air molecules in the balloon. This is a physical,

exothermic process. When the balloon animal begins to warm up, the gasses decompress, resulting in a physical, endothermic process. Helium is less dense than air; the balloon floats to the ceiling

6. Marshmallows
    a. Materials
        i. 10 marshmallows
        ii. Styrofoam cup
        iii. Spoon
        iv. Liquid nitrogen
    b. Procedure
        i. Put marshmallows into Styrofoam cup
        ii. Add liquid nitrogen to cup
        iii. Let sit for a few minutes
        iv. Have the student put their hands out
        v. Put 1-2 marshmallows in the students' hand
        vi. TWO BLOWS on the marshmallows
        vii. Put the marshmallow into your mouth
    c. Type of Change
        i. Marshmallows in liquid nitrogen
            1. Physical change
            2. Exothermic
        ii. Marshmallows in body
            1. Chemical Change
            2. Exothermic
    d. Explanation
        i. The liquid nitrogen absorbs the thermal energy from the marshmallows. This is a physical, exothermic process.
        ii. The stomach acid reacts with the marshmallow. This is an exothermic chemical change.
7. Bubble Snake
    a. Materials
        i. Precut plastic water bottle
        ii. Rubber band
        iii. Towel/rag
        iv. Food coloring
        v. ½ cup water
        vi. ¼ cup dish soap
        vii. Bowl
    b. Procedure
        i. Use the rubber band to secure the towel to the precut water bottle
        ii. Add the water and dish soap to the bowl, and stir
        iii. Use the food coloring to design a pattern on the towel
        iv. Dip the bottle-towel apparatus into the soapy water
        v. Blow into the water bottle mouthpiece to create a buttle snake

c. Type of Change
    i. Physical Change
        1. Exothermic
d. Explanation
    i. The gas molecules in a person's exhale are pushed into the soap solution that is caught within the towel fibers. The gas molecules are trapped, and form a bubble inside of the soap's interior.

8. Fire Breathing Dragon
    a. Materials
        i. Propane torch
        ii. Corn starch
        iii. Cup
        iv. Spoon
        v. Bottled Water
    b. Procedure
        i. Put scoop of corn starch into mouth
        ii. Blow corn starch over propane torch
        iii. Use water to wash out mouth
    c. Type of Change
        i. Chemical Change (Combustion Reaction)
            1. Exothermic
    d. Explanation
        i. This is a simple combustion reaction. It is an exothermic chemical reaction.
9. Alcohol Cannons
    a. Materials
        i. 3 giant empty, dry, plastic water jugs
        ii. 20 mL of methanol, ethanol, propanol
        iii. Propane Torch
    b. Procedure
        i. Add each alcohol to a separate container
        ii. Quickly cover the top of the jug with the palm of your gloved hand
        iii. Shake the jug for at least 30 seconds
        iv. Use the torch to ignite the flame
    c. Type of Change
        i. Chemical Change (combustion reaction)
            1. Exothermic
    d. Explanation
        i. We use alcohol as a fuel source for the exothermic chemical reaction.
10. Thundercloud
    a. Materials
        i. Liquid nitrogen
        ii. Hot water
        iii. Bucket
        iv. Tarps for floor

b. Procedure
    i. Put liquid nitrogen in bucket
    ii. Add hot water to the bucket
    iii. Observe giant nitrogen cloud
c. Type of Change
    i. Physical
        1. Endothermic
d. Explanation
    i. The liquid nitrogen absorbs the thermal energy from the hot water. The liquid nitrogen vaporizes into gaseous nitrogen in an endothermic physical change.