## UNIT STORYLINE

How can we make something new that was not there before?

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<th>Lesson Question</th>
<th>Phenomena or Design Problem</th>
<th>What we do and figure out</th>
<th>How we represent it</th>
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<tbody>
<tr>
<td><strong>LESSON 1</strong></td>
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<td>4 days</td>
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<tr>
<td>What happens when a bath bomb is added to water (and what causes it to happen)?</td>
<td>When solid bath bombs are added to water, they start breaking apart, and gas bubbles appear on and around them for a few minutes, until no solid is left.</td>
<td>We observe different bath bombs and what they do when added to water and then develop individual models and explanations to show what is happening at a scale smaller than we can see. We develop an initial class consensus model, brainstorm related phenomena, develop a DBQ and ideas for investigations to pursue. We figure out that: - We had competing ideas for whether the matter in the solid that we started with is still there after it is added to water. Some thought that it was all still there, while others thought not all of it was still there. - We had competing ideas for where the gas came from that was in the bubbles that appeared. One was that it was there to start with (trapped inside the solid). The other was that it formed from some of the stuff we started with (e.g., in the solid and/or water).</td>
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**Our Initial Consensus Model**

for what we saw happening to the solid bath bomb in water.

![Our Initial Consensus Model](image)

**Navigation to Next Lesson:** We want to collect some data to see whether we can find evidence for the gas being in the solid before it is added to water.

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<tr>
<th><strong>LESSON 2</strong></th>
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<tbody>
<tr>
<td>2 days</td>
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<tr>
<td>Where is the gas coming from?</td>
<td>The mass of a bath bomb put in water in an airtight container does not change, but the mass decreases after the cap on the bottle is opened and gas is heard escaping.</td>
<td>We investigate bath bombs, measuring their mass in a closed and open system before and after crushing them and before and after we add the bath bomb to water. We argue from evidence about where the gas came from. We figure out that: - The gas we observed from the bath bomb does not come from any gas that was originally trapped in the bath bomb itself. - Instead, the gas we observed when the bath bomb was placed in water comes from some change to the matter that is already there.</td>
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**Arguing for (or against) a claim:**

1. Make a claim that answers a question about a phenomenon.
2. Support your claim with both evidence and reasoning:
   a. Evidence: referencing data that support (or refute) the claim.
   b. Reasoning: explaining what these data mean and when applicable using the key model ideas.

**Navigation to Next Lesson:** Students agree to investigate common ingredients in bath bombs next and to test each ingredient one at a time in water.
LESSON 3
2 days
What's in a bath bomb that is producing the gas?
Investigation

Bath bombs have different ingredients and recipes. The ingredients in them interact with water in different ways, but none cause bubbles to appear when added to water on their own.

In this lesson, we make observations and collect data on each of the main ingredients in a bath bomb, recording the properties of each. We also investigate each ingredient as it mixes with water and record our observations. However, we see that the ingredients interact with water in different ways. We figure out that:

- Substances in the bath bomb have properties that can help us identify them (e.g., solubility, odor, state of matter at room temperature, melting point, density, and color).
- Mixing only one substance from a bath bomb with water does not cause gas bubbles to appear.

Navigation to Next Lesson: We figured out that a bath bomb has several ingredients, and these are called substances. These substances all have different properties. We figured out that mixing one substance with water does not make gas bubbles. We wonder if mixing two substances in water will produce gas bubbles, and if so, can we figure out which substances produce gas bubbles?

LESSON 4
2 days
Which combinations of the substances in a bath bomb produce a gas?
Putting Pieces Together, Investigation

Combining citric acid, baking soda, and water causes bubbles to appear. Lemonade mixes (which are made of specific substances, including citric acid) also caused bubbles when combined with water and baking soda.

We will discuss and record what we’ve figured out so far in the unit. We will plan and carry out an investigation to test different combinations of substances from a bath bomb, and we will use the results to argue that the gas produced must be a new substance. We figure out that:

- Citric acid and baking soda combined are the only substances from the bath bomb that, when combined with water, cause gas bubbles to form.
- The gas(es) in the bubbles are substance(s) that are different from any of the substances we started with.

Navigation to Next Lesson: Since we know that the gas in those bubbles is a different substance(s) that wasn’t there to start with, we want to try and figure out what substance(s) the gas is. We want to try to capture that gas and test it to figure that out.
### LESSON 5
#### 2 days
**What gas(es) could be coming from the bath bomb?**

**Investigation**

A flame goes out when put into a container of pure helium gas, gas from a bath bomb, or air mixed with helium, but does not when put in air only.

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<tr>
<td><strong>LESSON 5</strong></td>
<td><strong>What gas(es) could be coming from the bath bomb?</strong></td>
<td>We brainstorm phenomena related to gases and identify some different properties. We analyze the data by taking into account common gases and their known densities and flammabilities. We test the flammability of air from the room, gas from the bath bomb, and helium gas. We carry out an investigation to see if gas from the bath bomb rises or sinks. We argue from evidence (density and flammability data) that the gas from the bath bomb can be narrowed down to three candidate substances. We figure out that:</td>
<td><img src="image" alt="Key Model Ideas" /></td>
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<td>- Density and flammability are properties.</td>
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<td>- In high concentrations, gases that are non-flammable will extinguish a flame.</td>
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<td>- Materials that are less dense float upward when surrounded by matter that is more dense; materials that are more dense sink downward when surrounded by matter that is less dense.</td>
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<td>- The gas from the bath bomb could be nitrogen, argon, or carbon dioxide.</td>
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</table>

![Navigation to Next Lesson: We want to see if we can explain a related phenomena using what we have figured out so far about property data.](image)

### LESSON 6
#### 1 day
**How can we explain another phenomenon where gas bubbles appear from combining different substances together?**

**Putting Pieces Together**

When different substances are combined (potassium chloride and hydrogen peroxide), they interact and produce a gas.

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<tr>
<td><strong>LESSON 6</strong></td>
<td><strong>How can we explain another phenomenon where gas bubbles appear from combining different substances together?</strong></td>
<td>We apply what we have figured out about properties to explain a related phenomena (elephant’s toothpaste). We revisit our DQB and reflect on what other related phenomena we might explain using the same key model ideas. We figure out that:</td>
<td><img src="image" alt="Key Model Ideas" /></td>
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<td>- The mass of a partially open system where potassium iodide and hydrogen peroxide are combined decreases because a gas is formed and some of it escapes the system.</td>
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<td>- The gas makes a glowing ember burst into flame and an already burning flame glow brighter.</td>
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<td>- Flammability data can help identify the types of gases that aren’t being produced.</td>
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<td>- Testing the melting/freezing point, density, and/or comparing the results of the flammability test to results from controls could help identify additional gases that aren’t being produced in this process.</td>
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![Navigation to Next Lesson: We know that the possible candidate substances that are in the gas from those bubbles are a different substance(s) that wasn’t there to start with. Therefore, we wanted to try to develop a model at a particle level to explain how it is possible that a new substance that wasn’t there before was produced from different substances we started with.](image)
### LESSON 7

**Lesson Question**

1 day

How can we revise our model to represent the differences in the matter that goes into and comes out of the bath bomb system?

**Putting Pieces Together**

No new phenomena are introduced in this lesson. We put the pieces together for all phenomena previously explored in Lessons 1 through 5.

1. We work as a class to summarize and review all of the science ideas we have figured out through the investigations we have done so far in order to put all the pieces together. We develop a new way to represent what we figured out, using an input/output table. We identify an unanswered question about where the particles that make up the substance(s) of the gas came from and individually develop a model to try to explain this. We figure out that:
   - The same substance is made of the same type of particles throughout.
   - Different substances are made of different materials throughout.
   - The particles that make up the substances in the gas bubbles from a bath bomb must be a different type of particle than any of those in the substances that were combined together to make it (water, baking soda, and citric acid).

### LESSON 8

**Lesson Question**

1 day

How can particles of a new substance be formed out of the particles of an old substance?

**Problematising**

Alternate models can help explain how to make new particles from old particles.

We develop alternate models for how new particles might be made from old particles using manipulatives (printed colored circles). We formulate questions we have about how we could figure out what happens when new substances are made from old. We read about what Dalton and other scientists did to see if adding energy to water could form new particles. We figure out that:

- When new substances form from old substances, the particles of the old substances might break apart and/or stick together to form new combinations of particles.
- We have a new line of investigations to pursue to see if new substances are formed when energy is added to a single substance (water).

**Navigation to Next Lesson:** Since the only way there can be a new substance formed is if new particles were formed, we want to see if it is really possible to make new types of particles (and therefore new substances) out of something that we think is made of only one kind of particle.
### LESSON 9

**2 days**

**Lesson Question**

Does heating liquid water produce a new substance in the gas bubbles that appear?

**Phenomena or Design Problem**

Investigation

Gas from heated water extinguishes a flame. Clear liquid collected when gas cools has a mass to volume ratio of 1 for any size sample.

**What we do and figure out**

We carry out an investigation to test the flammability of the gas produced by heating water. We collect data on the mass and volume of different samples of the water we started with and two other clear liquids and compare the mass and volume of each to the substance we collected from the gas produced by heating the water. We analyze graphs of the data and determine that the ratio of mass to volume for a substance is constant and that this is a property (density). We argue that the property data indicates that the gas we collected is made of the same particles that were in the water we started with. We figure out that:

- Density is calculated as a ratio of mass to volume (a unit rate). It is constant (a property) for any sample of a substance, regardless of size.
- The gas produced by the heated water is made of the same type of particles as those in the water that we started with.

**How we represent it**

![Graph showing volume vs. mass data with a line of best fit.](Image)

&larr; **Navigation to Next Lesson:** Now that we know that adding energy to water by heating it to make a gas doesn't produce any new substances, and therefore no new types of particles, we want to see if adding energy to water using electricity might create new substances.

### LESSON 10

**1 day**

**Lesson Question**

When energy from a battery was added to water, were the gases produced made of the same particles as were produced from heating the water?

**Phenomena or Design Problem**

Investigation

When energy from a battery is added to water, two streams of gas bubbles are produced. When a lit match is put into trapped gas from these two sources, one pops and the other glows brighter.

**What we do and figure out**

We will carry out an investigation to test the flammability of gases produced by providing energy to water with electricity. We will construct an explanation for whether the gas(es) produced from water using energy from a battery were made of the same particles as those produced from heating the water. We figure out that:

- Two different gases with different properties are produced from adding energy from a battery to water.
- The particles that make up these different gases must be different from each other; they must also be different than the ones that were produced from heating water.
- The matter that makes up all of the substances must come from matter that made up some of the original water particles.

**How we represent it**

![Graph showing volume vs. mass data with a line of best fit.](Image)

&larr; **Navigation to Next Lesson:** We want to return to our poster “What is happening with particles when new substances are made?” and evaluate those ideas in light of the explanations we developed.
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<td><strong>LESSON 11</strong></td>
<td>2 days</td>
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</table>
| How do Dalton’s models of the particles that change in a reaction compare to the ones we developed? | ![Diagram](image) 1 atom of hydrogen, 1 atom of oxygen, 1 compound particle of water | We gather and summarize information from a reading on investigations that Dalton and other scientists did and molecular models they developed for atoms, compound particles, chemical reactions, and substances. We will individually use those models to predict and explain what gas is produced in the bath bomb reaction and what is happening to the particles in the system. We figure out that:  
- Molecules are made of atoms and all the substances in our world are made of very few types of atoms.  
- A substance is made of the same type of molecules (or atoms throughout). The number, type, and arrangement of atoms in the molecules that make up a substance are unique to that substance.  
- In a chemical reaction, the particles that make up old substances can be broken apart and the atoms that make them up can be rearranged to form new molecules to make new substances. | Key Model Ideas  
- Gases, liquids, and solids are all made of matter.  
- All matter is made of particles.  
- In a closed system, no matter can get in or out, so the mass stays the same.  
- Bohr model: electrons orbiting an atom.  
- In an open system, matter can get in or out, so the mass can change.  
- Properties don’t change for a substance.  
- Less dense gases (and liquids) tend to float when surrounded by denser gases (and liquids).  
- Hazard gases (and liquids) sink downstream when surrounded by less dense gases (and liquids).  

Chemical reactions  
- When new substances are produced from old substances, some of the substances that make up the original substances break apart and/or join to make new types of substances.  |

**Navigation to Next Lesson:** We are ready to take stock of all that we have learned, revise our final model, and use it to explain the chemical reaction that takes place when a bath bomb is placed in water.

| **LESSON 12**  | 2 days          |                          |                     |
| How can a new substance (a gas) be produced and the total mass of the closed system not change? | ![Image](image)  

The mass of water captured in a container after a bath bomb reacts in it is greater than was initially in the container before the bath bomb was put in it. A white substance, with a different density and different solubility than any of the substances in the bath bomb is found in this container after the water is boiled off.  

We revise our consensus model with the molecules of the reactants and the gas produced from the bath bomb. We explain why it could be possible that water is also a product in this chemical reaction. Using property data and molecular models, we argue whether one of the solids found in the container after the water has been boiled off is a new substance. We develop a model to represent what is happening to particles in three different chemical processes. We revisit the DQB and identify which questions we have made progress on. We figure out that:  
- In a chemical reaction, the amount of matter at the beginning (in the reactants) is the same amount of matter at the end of the reaction (in the products). This is because all of the atoms we started with are still there. No new atoms can appear that weren’t there to start with.  
- Chemical reactions, phase changes, and dissolving are all chemical processes that involve rearrangement of the particles that make up the matter in the system.  |

**Navigation to Next Lesson:** We identified one line of questions that we made only a small bit of progress on related to odors. We have some ideas about how we might investigate this line of questions further.
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<tr>
<td>LESSON 13</td>
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<tr>
<td>1 day</td>
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<tr>
<td>Why do different substances have different odors and how do we detect them?</td>
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<td>We carry out an investigation about the scents of different substances to see if we can identify these substances by their odors. We gather information from a reading about how sensory receptors in our nose work. We use what we figure out from the odor lab and the reading to write an explanation about why different substances have different odors and how we detect them. We figure out that:</td>
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<tr>
<td>Putting Pieces Together</td>
<td></td>
<td>- Odor is a property of a substance that is determined by the number, type, and arrangement of atoms that make up that substance.</td>
<td>[Image of sensory receptors]</td>
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<td>- Molecules of substances must travel into our nose for us to detect an odor.</td>
<td>[Image of sensory receptors]</td>
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<td>- Our nose has many different cells that each have different structures (sensory receptors for odor) that different shaped molecules can fit into, which will cause that cell to send a signal to other nerve cells that relay that signal to our brain.</td>
<td>[Image of sensory receptors]</td>
</tr>
<tr>
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<td>- The perception of different scents is the result of a combination of signals that the brain receives from different nerve cells.</td>
<td>[Image of sensory receptors]</td>
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</tbody>
</table>

Some substances can be identified by their odor and each substance has a unique molecular structure. These odors are received by the receptors in our nose and signals are sent to our brain so we can recognize what the substance is.

Navigation to Next Lesson: We want to apply everything we figure out to another phenomenon in the world.

| LESSON 14       |                             |                          |                    |
| 2 days          |                             |                          |                    |
| What is happening to the Taj Mahal? | | We apply what we have figured out about properties to explain a related phenomena (pollution and erosion on marble). We carry out an investigation to collect data about what happens when different substances in the air interact with marble. We identify what other evidence we would want to collect in terms of property data to be able to argue whether a chemical reaction occurs. We figure out: | |
| Putting Pieces Together | | - Two pollutants in the air around the Taj Mahal are interacting with the surface causing a chemical reaction to occur and change the surface to a new substance. | [Image of Taj Mahal crumbling] |
|                  |                            | - Algae that is on the surface of the Taj Mahal secretes different acids that cause a chemical reaction to occur with the (calcium carbonate) marble surface. | [Image of Taj Mahal crumbling] |
|                  |                            | - The algae and pollutants in the air around the Taj Mahal are causing it to crumble due to chemical reactions that are occurring. | [Image of Taj Mahal crumbling] |

The marble of the Taj Mahal is crumbling and falling apart.

LESSONS 1-14
25 days total