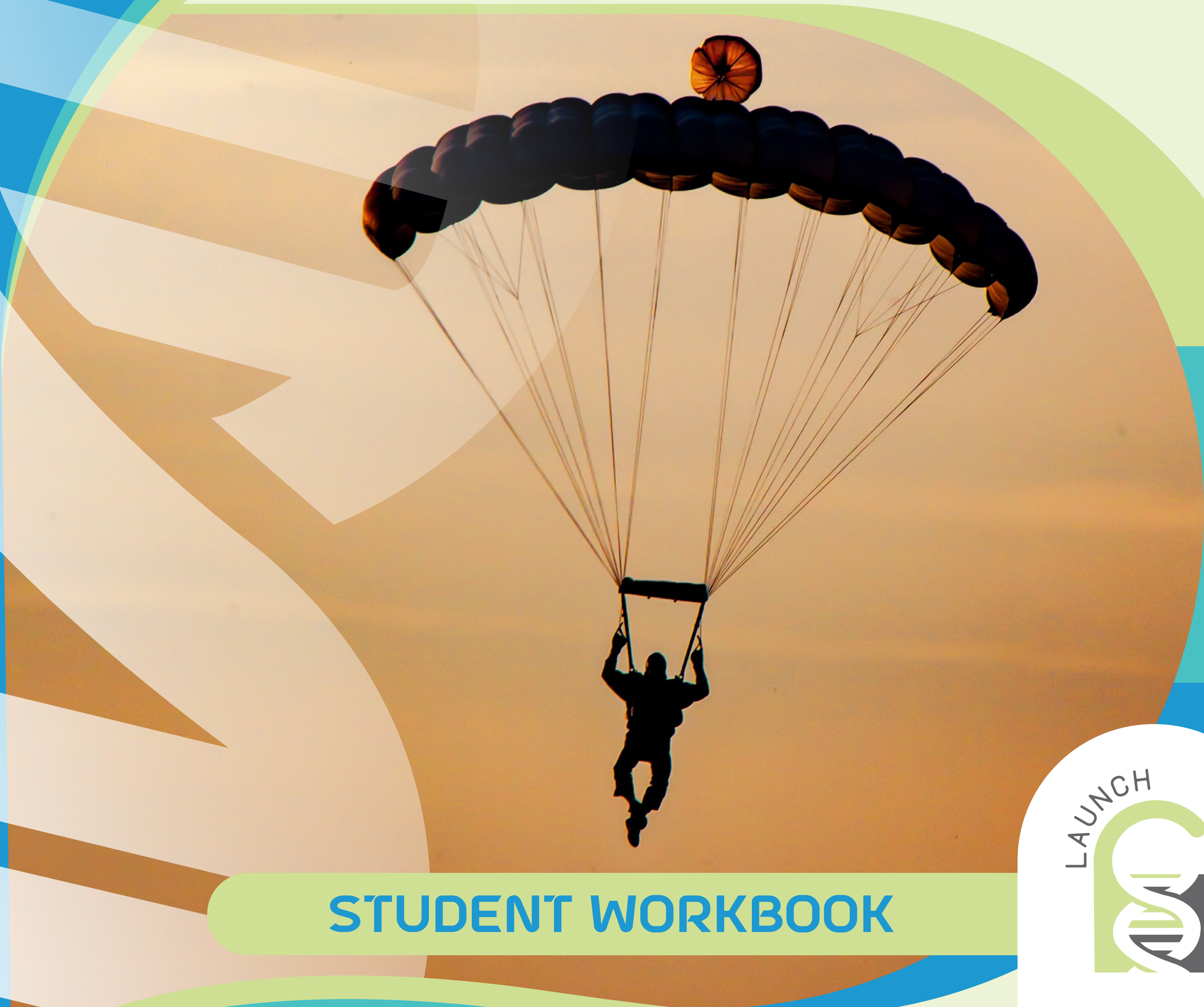
THE MIGHTY MOLE



STUDENT WORKBOOK

ACTIVITY 1

INCREASE IN INFLATION

Investigate what happens when you change the amount of reactants in a reaction that blows up balloons.

I

BOTTLES AND BALLOONS

A note before starting: the chemical reaction in this experiment is between vinegar (dilute acetic acid) and baking soda (sodium bicarbonate). Here is the equation for that reaction in both symbols and words:

$NaHCO_3$	+	CH_3COOH	→	CO_2	+	H_2O	+	$NaCH_3COO$
sodium bicarbonate (baking soda)	plus	acetic acid (vinegar)	yields (makes)	carbon dioxide	plus	water	plus	sodium acetate

WHAT YOU NEED:

FROM THE KIT:

- 6 balloons
- 6 plastic bottles
- Baking soda (sodium bicarbonate)
- Digital scale
- Plastic graduated cup
- Tape measure
- Vinegar
- Wooden splint

WARNING! CHOKING HAZARD - Small parts. Not for children under 3 years.
WARNING! CHOKING HAZARD - Children under 8 years can choke or suffocate on underinflated or broken balloons. Adult supervision required. Keep uninflated balloons from children. Discard broken balloons at once.
WARNING! DO NOT EAT OR DRINK anything in this kit.

WHAT TO DO:

1. Use the black permanent marker to label the plastic bottles from 1–6.

2. Use a plastic graduated cup to measure 40 mL of vinegar and pour it into Bottle 1.

3. Repeat Step 2 for Bottles 2–6.

4. Place a balloon next to each bottle and label each one with a number 1–6 for which bottle it goes with.

5. Use the scale to find the mass of each balloon.

HOW TO USE THE DIGITAL SCALE

1. Take the cover off the scale and turn it on.

2. Check that the mass is being displayed in units of grams (g).

3. Place the empty balloon on the scale.

4. Use the tare button to “zero out” the scale. This is helpful because you won’t have to subtract the mass of the balloon to find the mass of the powder you’re about to place in it. The scale will just tell you the mass of the additional items (the powder).

5. Use a wooden splint to transfer sodium bicarbonate from its box to inside the balloon, a little bit at a time, until the scale displays the mass you want it to.

2. Predict the mass of just one of each item using only the data you have collected so far.

a. mass of one bead:

b. mass of one lead BB shot:

c. mass of one metal nut:

d. mass of one Skittle™

e. Explain how you determined a–d.

Part 2

WHAT TO DO:

1. Using the digital scale, find the mass of each green bead. Record your results in the Massive Molecules Part 2 Table.

2. Calculate the average mass of a green bead and write it in the table.

3. Repeat Steps 1–2 for the lead shot, metal nuts, and Skittles™.

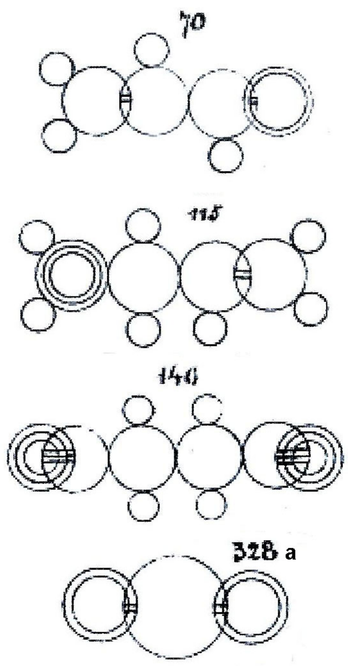
Massive Molecules Part 2 Table				
	Mass of a single green bead (g)	Mass of a single lead BB shot (g)	Mass of a single metal nut (g)	Mass of a single Skittle™ (g)
Item 1				
Item 2				
Item 3				
Item 4				
Item 5				
Item 6				
Item 7				
Item 8				
Item 9				
Item 10				
Average				

4 COUNTING MASS WITH MOLES

The Magic Number

Avogadro developed Avogadro's Law and proposed the idea of a molecule. While he was certain that the same volumes of two different gases would contain the same number of molecules, he wasn't able to determine what that number actually was.

Nearly a decade after his death in 1856, Johann Josef Loschmidt, an Austrian physicist was the first to estimate the number that would eventually be known as Avogadro's Constant. Loschmidt used kinetic molecular theory, or predictions of the behaviors of ideal gases, to estimate this number.

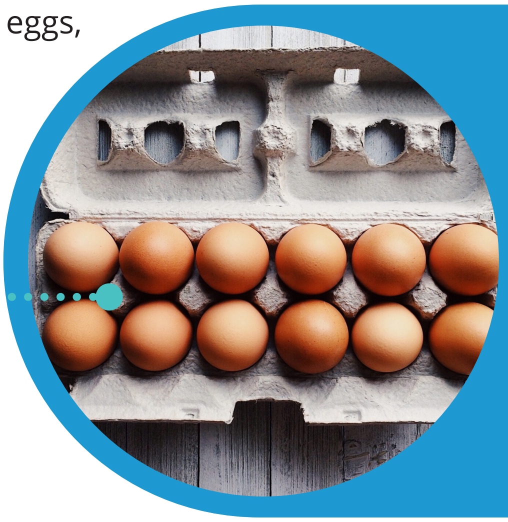


Johann Josef Loschmidt was active in the field of chemistry, even developing his own method for drawing particle-level structures.

Over the next several decades, methods for estimated Avogadro's constant improved. Once the charge of a single electron was established in 1910 as −1, particles could be counted using a change in electric charge, or a current. Researchers are now confident in their collective estimate that the number of molecules in 22.4 L of gas is approximately 602,214,199,000,000,000,000,000. This is usually rounded and shown in scientific notation because it is so large: 6.02×10^{23}.

The number 6.02×10^{23} is a unique unit of counting. Any group of 6.02×10^{23} things is called a **mole**, much like any group of 12 things is called a dozen or any group of 2 things is called a pair. While you could theoretically have a mole of any item, it usually refers to atoms or molecules. A mole is a set of 6.02×10^{23} particles of the same element or same compound.

The mole is important in chemistry because grouping atoms and molecules makes it easier to work with them in counting and calculations. Imagine if you wanted to buy 4 dozen eggs, but when you got to the store, all they had were single eggs. You would have to count out 48 eggs; that would be time-consuming. For atoms and molecules, it's even more difficult because the numbers of them are impossible to count individually.



A dozen eggs is 12 eggs. A mole of eggs would be 6.02×10^{23} eggs, and that number of eggs would cover the Earth's surface to a depth of 50 kilometers.[1]

LAUNCH

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Kit	SU-MIMOLE
Instructions	IN-MIMOLES
Revision Date	8/2021