Lesson: “Why do some things explode?”

VIDEO TRANSCRIPT

EXPLORATION VIDEO 1

Hi, it's Doug! Explosions. Now, it used to be whenever I heard that word, I'd think of things like this, like special effects in a movie. But explosions aren't just something destructive that you see in movies or TV shows. Like, look at this. Here's a rock that has fallen on a road. Now, it's so heavy, it'd be hard for this construction crew to pick it up and carry it away, but there's something else they can do. Watch. They're using the power of an explosion to do something useful—in this case, to blast away rock. Here's another example. If you've ever driven through a tunnel, you can bet that explosions were involved in making it possible. Think about the tunnel as it was being made. In order to get all the way through a mountain, how are you going to do that? Well, here's what they do. Using the power of an explosion saves hours of time that would otherwise be spent trying to jackhammer through solid rock. Every time I drive through a tunnel, I think of the explosions that were needed. Here's another example of a useful explosion. This is a rocket called a Delta 2, blasting off from NASA's launch pad in Florida. It's headed to space. And you see the flames bursting out there. Without the power of an explosion, it would never be possible to travel fast enough to escape the Earth's gravity, and to get something in orbit around the Earth and space. Or here's a familiar kind of explosion, one you've surely seen in person. Now it may not be useful, but it's not destructive either. People make fireworks because we

enjoy watching them. What makes things explode? What is it that makes explosions possible? What do you think?

EXPLORATION VIDEO 2

In order to understand what's happening in an explosion, ideally, we'd be able to experiment with an explosion ourselves, but all of the examples we've seen use what scientists call high explosives. They involve substances like gunpowder or dynamite, which have to be handled by someone specially trained to use them safely. We won't be able to experiment with high explosives, but high explosives aren't the only thing that can create an explosion. There are smaller explosions that we can experiment with, and all explosions, whether they're big or small, work in similar ways. These smaller explosions were first discovered by, you can probably guess who: the alchemists. Now, you might have noticed that when certain substances are placed in acid, you can often see some kind of bubbles forming. That's what the alchemists noticed too. These bubbles got some of the alchemists really curious. What are they? Are they some kind of error? And why do they form? Why do they rise up? If only there were some way to capture and study the bubbles, but this turned out to be challenging. The bubbles easily rise up and escape from whatever container you have them in. Frustrated with this, one alchemist tried to capture the bubbles from an acid reaction so that they wouldn't rise up and escape. He put some acid in a flask, and then he added some baking soda so that bubbles started to form. Then he quickly put a stopper in the top of the flask so that the bubbles couldn't escape…but then the glass shattered. Other alchemists tried this as well. Sometimes the glass flask would shatter. Sometimes they wouldn't. Capturing the bubbles was frustrating. Always, whenever the flask was opened, it was as if the bubbles were trying to escape from the container, and it caused a lot of broken glass in the alchemists' laboratories. One alchemist decided on a name for the

bubbles, chaos, from an ancient Greek word describing things being messy or out of order. It's tempting to think maybe he was frustrated with the shattered glass in his laboratory. Why do you think the containers were shattering like this?

ACTIVITY INTRODUCTION VIDEO 1

In today's activity, you're going to experiment like an alchemist using acid to make bubbles, and then you'll try to capture those bubbles. Unlike the alchemists, though, you won't use a flask. You really don't want to be around shattering glass, but your experiment will give you clues that help you figure out why those glass flasks were shattering. In your experiment, you'll be using a more modern container, one that would have seemed like magic to an alchemist. This: a Ziploc plastic bag. It's a great container. Since it's clear, like glass, you can see what's going on inside it. And it's easy to seal up tight so that the bubbles can't escape, but since it's plastic, it won't hurt you if it does explode. The acid you'll be using is vinegar. You'll be adding baking soda to make the bubbles. Now you probably already know what will happen when you mix these two things together. But what will happen if you mix them together in a closed bag? You'll be finding out. I'll show you how to get started, step by step.

ACTIVITY PART 1 STEP 1

Find a partner. When you're done with this step, click the arrow on the right.

ACTIVITY PART 1 STEP 2

Get these supplies.

ACTIVITY PART 1 STEP 3

Discuss.

ACTIVITY PART 1 STEP 4

Decide who will be the Bag Boss and who will be the Cup Commander. You'll get a chance to switch roles later.

ACTIVITY PART 1 STEP 5

Cup Commander, squash your cup flat, like this, then cut across it, like this. Your cup is taller than what you need, so you’re modifying it just like a scientist or engineer. After you cut it, shape it into a cup again and put it onto the plate. Then, Bag Boss, put one spoonful of baking soda into the cup, like this.

ACTIVITY PART 1 STEP 6

Bag Boss, hold the bag open on the plate, like this. Cup Commander, spoon six spoonfuls of vinegar into the bag. Be careful. Don't spill the vinegar.

ACTIVITY PART 1 STEP 7

Bag Boss, keep holding the bag open. Cup Commander, carefully set the cup in the bag so that it's level. Bag Boss, hold the bag so the baking soda doesn't spill. And Cup Commander, zip the bag closed. Double-check, you want to make sure it's closed.

ACTIVITY PART 1 STEP 8

Now it's time to see what happens when the baking soda and vinegar mix. Bag Boss, check one more time that the bag is zipped. Then turn it over to dump out the baking soda and quickly set the bag on the plate.

ACTIVITY PART 1 STEP 9

Discuss what happened with your partner, then do question number one on your worksheet. You're going to describe what happened. Now, if something unexpected happened, like the bag wasn't really sealed, describe that. You sometimes learn useful things from unexpected results.

ACTIVITY PART 1 STEP 10

Here's what happened in our bag. And sometimes, this happened. Discuss these questions.

ACTIVITY PART 1 STEP 11

Draw a picture showing why the bag expanded on question number two of your worksheet. If it helps you think about it, you can draw the bag and the cup from the side, like this. Or, another thing you could do is you could draw a cartoon strip showing the steps involved, like this.

ACTIVITY PART 1 STEP 12

You have another bag so that you can modify your experiment and try it again. Do questions number three and four on your worksheet. You're going to decide how you'll change the experiment. If you have a partner, you can work together on these questions. Now, if your bag

exploded, I challenge you to make the bag expand until it almost explodes, but doesn't. If your bag didn't explode before, this time you could try to make it explode.

ACTIVITY PART 1 STEP 13

Try the experiment again. Describe your results on question number five of your worksheet.

EXPLORATION VIDEO 3

What is this stuff that's inside the bag? It's weird, when the reaction first happens, you can see lots of bubbles forming. They rise upwards to the top of the liquid and then they pop. That must be what's making the bag expand. But that space above the bubbles looks empty. The only reason we know there's something in there is because, well, you can feel pressure on the bag. So it must be that when the bubbles popped, they released something or things into the bag. It's a substance, but it's clear. You can't see anything. All you can see is that the bag is expanding. What would explain why you can feel it but you can't see anything in there? If you want to take a moment to figure this out yourself, now would be a good time to pause the video. What I'll do is point out a couple of examples we've seen in an earlier Mystery that might help you think about this. Are you ready? Okay, remember this: the outer layer of copper on a penny seemed to disappear. But then you realized it didn't disappear. You could make sense of it if you visualized the outer layer of copper as having been broken up into tiny pieces. Tiny particles too small to be seen that went into the liquid. Or remember this example? When you dissolve sugar in hot tea, it seems to disappear. But you know from tasting the tea that the sugar's still there. That made sense if you visualized the sugar getting broken up into tiny particles too small to be seen. What we're doing when we think of substances as being made of particles is we're creating a way to help us visualize something that we can't directly see. If we draw a picture of what we're

imagining, that can help us figure out whether what we're imagining makes sense. The picture acts like a model. It's a way to help us figure something out that we can't otherwise see or experiment with very easily. You already drew a picture on your worksheet of what you think made the bag explode. So does thinking about tiny particles give you any ideas on how you could improve your picture?

ACTIVITY INTRODUCTION VIDEO 2

Your drawing is a model of how particles might explain why the bag inflates. Now we're going to do a bonus activity. In this activity, you're going to make a physical model, where you and some classmates act out what's going on with the particles in the bag. Both of these models, drawing something or acting it out, are different ways to think about what's going on. The physical model uses paper to represent the sides of the plastic bag, and it uses fingers to represent particles being added to the bag. The first thing we're going to do is cut the bag out of paper, then we'll act it out. I'll show you how to get started, step by step.

ACTIVITY PART 2 STEP 1

Form a team of four people. If you're working alone, you'll need some friends to help.

ACTIVITY PART 2 STEP 2

Choose who will be Team Leader and who will be Particles One, Particles Two, and Particles Three. Team Leader, you are also Particles Four. Now, this shouldn't take too long. I'll give you 10 seconds to choose jobs. Are you ready? Go. Okay, time's up. Go to the next slide.

ACTIVITY PART 2 STEP 3

Get your supplies.

ACTIVITY PART 2 STEP 4

There are four stretchy bags on the worksheet. Team Leader, cut the sheet into four pieces.

Each member of the team takes one piece.

ACTIVITY PART 2 STEP 5

Cut on the thick black line to cut out the rectangle.

ACTIVITY PART 2 STEP 6

Fold your stretchy bag like this. Cut on the center line. Stop when you reach the stop sign.

ACTIVITY PART 2 STEP 7

Fold your paper lengthwise, like this. Cut on all the other lines, like this.

ACTIVITY PART 2 STEP 8

Team Leader, check to make sure all the cuts are made by stretching one of the stretchy bags just a little bit, like this.

ACTIVITY PART 2 STEP 9

Team Leader, hold one of the bags like this. Particles One, put both your hands inside the bag. Other Particles, add your hands one by one. Team Leader, add your hands last. How many particles did you add before the bag broke? You can try this a few times with your extra bags if you like.

ACTIVITY PART 2 STEP 10

Discuss.

WRAP-UP VIDEO

The chaos or bubbles are some kind of stuff. Even though as the bag puffs up, we can't actually see what's making it expand. The alchemists weren't sure what this stuff was. They just knew that it was difficult to capture. It would escape the container, or worse, it would make the container burst. The name chaos was given to it by an alchemist from the country of the Netherlands. He spoke Dutch as his language. Now, the reason I'm telling you this is because it's important how the word chaos is pronounced in the Dutch language. That k-uh sound of chaos in Dutch is actually pronounced with a g-uh sound. We borrowed this word into English, but we wrote it the way that it sounded. So, not as chaos, but more like gas. That's where our word gas comes from. It's from the word chaos from the alchemists. Gas is the stuff you've been creating. When you put a substance in acid and you see bubbles form, you're seeing a gas. As you study more chemistry, you'll learn that there are lots of different kinds of gases. Some of them you've probably already heard of, gases like oxygen and helium and carbon dioxide. You've probably heard of that one. It's the same gas you exhale when you breathe out. It's also

the gas that bubbles in soda pop are made out of. By the way, the gas that you put in a car, that's a confusing word. It's not a gas. That word is just short for gasoline, which is a liquid. The gas that you produced today in your experiment was carbon dioxide. Most gases are invisible like this, but not always. When you put metal in nitric acid—you might remember this from an earlier Mystery—it creates brown fumes. Watch this. Those brown fumes you see there are a brown-colored gas called nitrogen dioxide. But whether it's an invisible kind of gas or a visible one, all gases are real things. They're substances. They're much lighter in weight than liquids and solids, but you can fill up a container with gases. You can even feel the pressure of the gas on the container. If we visualize a gas as being made of tiny particles, one way we can explain why a container fills up and explodes is to imagine that as the bubbles are being created by the baking soda and vinegar reaction, they're releasing more and more gas particles into the space above the liquid. As those particles move outwards, they press on the walls of the container and once there are too many of them, the container bursts. It explodes. All explosions have this in common. They all involve a build-up of gas. So much gas that the container they're in bursts. Stay curious, and see you next Mystery!