mystery science

Lesson: “Could you transform something worthless into gold?”

VIDEO TRANSCRIPT

ACTIVITY INTRODUCTION VIDEO 1

Hi, it's Doug! We're going to do something a little unusual today. You see, normally I present you with a story and then we do the activity later. But today we're going to start with the activity, because this activity takes some time in order for it to work. In today's activity, you're going to figure out what happened to the dull, brown stuff you cleaned off the pennies in the last Mystery. Remember, in the last Mystery we combined three things: salt, vinegar, and a bunch of dull pennies. By now, those pennies should have gotten shiny. In this Mystery you'll scoop some of that liquid into a bag, and then you'll put something in there, an object made of steel. You'll find out why later in this Mystery. It's a surprise. Okay, I'll show you how to get started, step by step.

ACTIVITY PART 1 STEP 1

If you're in a class, form a team of four. If you're not in a class, you'll need a helper for some steps. But otherwise, you can work alone. When you're done with this step, click the arrow on the right.

ACTIVITY PART 1 STEP 2

Get these supplies. You'll get more supplies later.

ACTIVITY PART 1 STEP 3

Choose a team name. Write it on the label. This shouldn't take too long. Just take about 20 seconds or so to do this. I'll start a timer if that's helpful. Okay, time's up—go to the next step.

ACTIVITY PART 1 STEP 4

Choose a job for each member of the team. You can be the Potion Pro, the Penny Pro, the Steel Master, or the Bag Boss.

ACTIVITY PART 1 STEP 5

Get your supplies. Each person will get a different thing and bring it back to the table. Put it all on the plate if you have one. Potion Pro and Penny Pro, go to the salt and vinegar container where the pennies have been soaking since the last Mystery. Potion Pro, scoop up half a cup of liquid. And Penny Pro, put five pennies in the cup using the spoon. Now, if you're in a class, you might have to take turns with other groups. Steel Master, you'll be getting a nail. And Bag Boss, you'll be getting a zip lock bag.

ACTIVITY PART 1 STEP 6

Watch this whole step before you do anything. Bag Boss, add the label near the top of the bag, like this. Then hold the bag open over the plate if you have one. Steel Master, carefully put the nail at the bottom. Don't drop it in, that could rip the bag. Just place it gently. Potion Pro, pour in the liquid and pennies. Penny Pro, seal the bag tightly. Zip it twice to double-check that it's really sealed. Keep the bag on the plate when you're done.

ACTIVITY PART 1 STEP 7

All right, quickly write down the time in question 3a on your worksheet, so you know when you started the experiment. Then go to the next step. Remember, you already did questions one and two during the last Mystery.

ACTIVITY PART 1 STEP 8

Bag boss, make sure the bag is sealed. Then pass the bag around so that each person in your group can look at it. Put it back on the plate when everyone's done looking. Then everyone do questions 3a, 3b, 3c, and 3d on your worksheet.

ACTIVITY PART 1 STEP 9

Discuss. If you're in a class, discuss this question as a class.

ACTIVITY PART 1 STEP 10

Bag Boss, hang your bag from the edge of your table with masking tape or your extra label, like this. Make sure that the nail and the pennies are in the liquid. When you're done, advance the slide to watch the next video.

EXPLORATION VIDEO 1

Last time, we saw the salt and vinegar change a dull copper penny to a shiny one. But we never figured out how it happened. We ruled out the possibility that the liquid added a layer of shiny copper to the coin. But that left these other two possibilities: One, that the liquid removed the

dull layer, revealing shiny copper underneath. Or two, that nothing was added or removed, but instead the liquid changed the dull copper to shiny copper in place. In the last Mystery, you thought up some ideas to figure out which of these two ideas could be true. Now take a moment to reflect on what your ideas were. Discuss them again so that you remember. What could you do to figure out which of these two ideas is true?

ACTIVITY INTRODUCTION VIDEO 2

So, did you think of any ideas for how a scale might help figure out what's going on? Here's an idea we had. If the vinegar and salt made the pennies shiny by removing a dull layer, then you should be able to weigh a penny before being dipped in vinegar and salt and after, and find out that it has lost weight. Well, we tried this out. I'll show you what happened. Here are some dull pennies that we put on a scale with tweezers. Now, let's see how much they weigh. Okay, you can see here they weigh 18.615 grams. Now, let's put them in salt and vinegar until they become shiny, and then we'll weigh them again. Okay now remember, when they were dull, they weighed 18.615 grams. Let's see how much they weigh now that they're shiny. Now, remember, if the dull layer was removed, then it should mean they weigh less. And we can see here. There's our final. They weigh 18.394 grams. They *do* weigh less. So, dull pennies lose weight when they become shiny. Now we know the salt and vinegar definitely worked by removing something from the penny. It would seem like the evidence is pretty convincing for this idea. The reason the salt and vinegar worked is that they removed a dull layer of copper that was surrounding the outer part of the penny. And that revealed shiny copper underneath. The penny didn't just change. We might even say that we've now solved the mystery from that last activity. But let's be good scientists here. Let's see if there's any more evidence we can find. It's time to go check your bags. You might even find that you have a new mystery on your hands.

ACTIVITY PART 2 STEP 1

Bag Boss, take the bag off the table. Hold it by the zipper side and look through it. Pass it around so that each person on the team can look inside. Check carefully for small changes, then discuss.

ACTIVITY PART 2 STEP 2

If you notice something happening in the bag, draw a picture on the back of your worksheet, and write down the time.

ACTIVITY PART 2 STEP 3

Bag Boss, hang your bag from the edge of your table again with the same masking tape, like this. Then advance the slide to watch the next video.

EXPLORATION VIDEO 2

Remember when I told you about the alchemists? The alchemists were convinced that it should be possible to create a potion that transforms ordinary metal into gold. If you could figure out how to make a potion like that, you would become incredibly rich. Last time, you saw that there definitely are substances that can transform things. Salt and vinegar transformed a dull penny into a shiny, new-looking one. How is that possible? And is this actually a step closer towards a potion that can transform ordinary metal into gold? Well, let me tell you a story. A legend. The legend goes than an alchemist went to a king to make him an offer. He told the king, "I cannot yet turn ordinary metal into gold, but I have discovered a way to transform ordinary steel into copper, which is more valuable than steel. If you give me your steel sword, I can show you." The

king was intrigued and he handed over his sword. The alchemist pulled out some kind of clear liquid. He called it a magic potion. The alchemist soaked the sword in the liquid and left it there overnight. In the morning, it looked like this. It looked like the steel sword had become copper. The king exclaimed, "I'm so impressed! I insist, tell me, how did you make this liquid? Is it magic? What is it?" But, the alchemist wouldn't tell. "I cannot reveal my secrets," he said, "but you can see that I'm a great wizard. I transformed steel into copper. I am confident that I can figure out a way to transform steel into gold next, if only you give me some money for my research." The king agreed and he handed the alchemist a bag of money. The alchemist thanked the king and left, promising to come back after he did more experiments. But, the alchemist never returned. He was never heard from again. Why do you think the alchemist left, never to be heard from again? Was there something he didn't want the king to figure out?

ACTIVITY INTRODUCTION VIDEO 3

This is just a story, a legend, but part of it is true. There really is a liquid that can do this. In fact, you have this liquid right there in the room with you. It's salt and vinegar, the same thing that you poured into your experiment bag today and made all those dull pennies shiny. You're going to take a look at it now. See if you can figure out how this liquid managed to change a king's steel sword to copper.

ACTIVITY PART 3 STEP 1

Your experiment has been going for about half an hour now. It's time to check and see what's happening. Bag Boss, take the bag off the table. Hold it by the zipper side and look through it. Pass it around so that each person on the team can look, and then discuss.

ACTIVITY PART 3 STEP 2

If you're in a class, compare your experiment to the experiments of other teams.

ACTIVITY PART 3 STEP 3

Here's what happened to our nail after about an hour. You can see it looks like copper, just like the king's sword. Now if nothing has happened yet in your bag, that means you'll need to give it more time. But that's okay, you can do the next few steps, and then leave it soaking overnight. Teachers, if you have a nail that you prepared for class, now would be a good time to pass it around.

ACTIVITY PART 3 STEP 4

Answer the remaining questions on your worksheet.

ACTIVITY PART 3 STEP 5

Discuss.

ACTIVITY PART 3 STEP 6

And discuss these questions, too.

ACTIVITY PART 3 STEP 7

If your nail hasn't changed yet, then Bag Boss, give your bag to your teacher to store for you. It might take as long as overnight. Advance the slide to watch the next video.

EXPLORATION VIDEO 3

The king was happy with his copper sword, but one day he started wondering, was it really copper all the way through? So he scratched the sword and discovered that underneath, the sword was still steel. It had only been coated with a layer of copper. Now, you could test this yourself on your nail. If you use some sandpaper to scratch it, watch what happens. You see that silver color? That's steel. So you haven't really transformed the nail into copper. You've just coated it with copper. The liquid didn't create copper. Instead, it removed dull copper from the pennies you put into it. So you see we can finally solve the mystery of how the salt and vinegar changed a dull penny into a shiny one. You've seen lots of evidence now. We've seen that the penny weighs less after being soaked in salt and vinegar. That's what you'd expect if the dull copper layer was removed. But even if you weren't certain, then we saw that when a steel object is placed in the liquid, the steel started to look like copper. That copper must have been coming from somewhere. Where was it coming from? The pennies. The vinegar and salt removed the layer of dull copper, and so what happened was that dull copper went into the liquid. You then put that same liquid in your bag today. And then, once you'd done that, you placed a steel nail into the liquid. The copper that was in the liquid went onto the nail, coating the steel in copper. Now, all of this still leaves a big question: If the salt and vinegar removed dull copper from the pennies, then why couldn't we see the dull copper in the liquid? What do you think?

WRAP-UP VIDEO

Think about when you put sugar in tea or lemonade. You can see the little grains of sugar as you pour it in. But watch what happens as the grains are placed into the liquid. Look, it's as if the sugar disappears. But it's not gone, is it? For example, you can definitely still taste it. The tea

would be sweet now. We can make sense of this if we think of substances as being made of tiny particles. Particles so small that we can't see them, like a single grain of sugar in tea. We can imagine that each grain of sugar is breaking up into smaller and smaller pieces. We call this *dissolving*. The sugar dissolves into tiny particles that are too small to see. Now, let's bring this all back to the experiment that you did today. Why couldn't we see any dull copper in the liquid? The reason we may not have seen it is because it was breaking up into smaller and smaller particles of copper, so incredibly small that we couldn't see it with our eyes. But we know it's there because when we put steel in the liquid, the copper particles all start building up a layer on top of the steel, and so they become visible again. The copper on your nail came from the original dull pennies. Would it surprise you to learn that the alchemist did the same thing as you? The alchemist secretly put dull copper coins in the liquid before going to the king, letting that outer layer of dull copper dissolve. So you see, when the alchemist put the sword into the liquid, copper wasn't being created, it was there the whole time in the liquid, just as tiny particles too small to see. That's why the alchemist left town. Sure, he could coat a king's sword in copper, but he couldn't create copper. In that sense, the alchemist's liquid isn't a potion. It's not magic—it's not creating something from nothing. Copper can't just appear from nowhere. Neither can gold nor anything else. But still, the alchemists were on to something. No one in history had thought so much about mixing different substances in order to make something useful happen. Even if your liquid didn't create copper, it's still a really clever and easy way to coat something in copper. In fact, we still use a method similar to this in the modern day whenever we want to coat something in a layer of metal. Watch. The alchemists weren't scientists, but they discovered so many of the substances and processes that we use today, and they discovered some things even more amazing than what you saw today. Stay curious, and find out more in the next Mystery!