

# Brominator: Problem Handouts



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# The Brominator

## Stage 1

Running a reaction that liberated copious amounts of  $\text{H}_2\text{S}$  just as the President and the Board of Trustees were touring the new chemistry building was, in hindsight, not a good idea. As a result, Professor Zaney was promptly moving to a new employment situation in Manhattan. In his haste to depart he forgot to clean out a small chemical storeroom, so the chemistry department hired several undergraduates to pack up the remaining materials and prepare them for shipping to New York.

"What are we going to do about this bromine?" one of the students asked. "Doc Z wants to drive down this weekend and pick these things up, but I don't think you're allowed to carry hazardous stuff like this either through the tunnels or over the bridge. We don't have the time to go through the paperwork to get this packed properly for shipping."

"I've got an idea!" (Crazy Eddie always had an idea about everything.) "Maybe we can turn it into something that is safe. Let's see what else is here. Whoa--check it out! Magnesium, calcium...even some strontium! This'll be a snap--all we've got to do is to turn the  $\text{Br}_2$  into a bromide salt; Doc can carry that in his car. Then, when he gets back to his lab, he can turn it back into bromine and the metal again."

"Umm, well, sure, cool, I guess. Sounds like it'll work. Does it matter which metal we use?"

"There's about a kilogram of bromine here; it'd probably be better if Doc just has to deal with one product. Leave it to me!" said Eddie, heading off to the lab.

1. What products are predicted to result from the reaction of  $\text{Br}_2$  with each of these metals? Why? Extending your line of reasoning, predict the products you'd expect from a reaction between (1) Rb and S, and (2) Sc and  $\text{O}_2$ . Write balanced equations for each of the reactions considered in this question.
2. What suggestions would you give to Eddie? What do you think he will decide to do?

# The Brominator

## Stage 2

Some time later Eddie reappeared with a handful of papers. "I've just done some experiments to see how much bromide we could get from each metal, but there's something weird going on."

Eddie's data are plotted below. In each trial of his experiment he added (carefully!) a known amount of Mg, Ca, or Sr to a flask containing a fixed mass of bromine. After the reaction was finished, he isolated and weighed the metal bromide produced. He plotted the mass of product against the mass of metal used in the reaction. In his haste, though, he forgot to label the scale on the x-axis. (See Graph 1.)

3. What fixed mass of bromine must Eddie have used in each of these experiments? Show your reasoning.
4. Eddie expected to see the mass of each product increase with the mass of the metal used, but he doesn't understand why the plots level out at some point, and why that point is different for each metal. Can you explain this behavior to Eddie?
5. You have 100 g of magnesium, 300 g of calcium, and 500 g of strontium. If you only want to make one metal bromide, which of these will be the best choice for using up the kilogram of bromine? Show how you reached your conclusion.

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## Stage 3

The students picked a metal and prepared its bromide salt. In a note to Professor Zaney, they explained what they'd done, but forgot to tell him which metal they'd used. Once Doc Z got back to his new lab with the bromide, he submitted a sample of the material for analysis and learned that it contained 86.8% bromine.

6. Which metal had the students used?
7. How could Doc recover the  $\text{Br}_2$  from this sample?

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## The Graph

