MIKE GIESELSKI

SCIENCE AT HOGWARTS

CHEMISTRY IN HARRY POTTER'S WORLD

By Jane Snell Copes

What do you like best about J.K. Rowling's *Harry Potter* series of books? Is it the joy of falling head-over-tail into this magnificently crafted tale of good and evil full of charms and enchantments? Or the five fabulous films with more to come? Or maybe it's your pride at slogging through all 4,100 pages of the adventures and getting to read them again a little more slowly once you know what happened?

As for me, I appreciate Rowling's incredible grasp of fable and myth, her wonderful character development, and her ability to tie all of the threads together into a great story. But I really love finding the science in the flash and bang of Harry's school world. My seven *Harry Potter* books bristle with sticky-notes reminding me where to find recipes for making green fire or an envelope that bursts into flames spontaneously.

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It's not "just magic" that Rowling writes about, although she does that brilliantly. There is also serious science that isn't totally mysterious. Below are excerpts from the *Harry Potter* series of books and some of the science inspired from those excerpts.

Flames, fireworks, stars, and elements

Here are three colorful excerpts taken from the *Harry Potter* book series:

"Harry took the wand. He felt a sudden warmth in his fingers. He raised the wand above his head, brought it swishing down through the dusty air and a stream of red and gold sparks shot from the end like a firework, throwing dancing spots of light onto the walls."

Rowling, J. K. *Harry Potter and the Sorcerer's Stone*; Scholastic Inc.: New York, 1997, p 85

"They stepped over the threshold, and immediately a fire sprang up behind them in the doorway. It wasn't an ordinary fire either; it was purple. At the same instant, black flames shot up in the doorway leading onward. They were trapped."

Rowling, J. K. *Harry Potter and the Sorcerer's Stone*; Scholastic Inc.: New York, 1997, pp 284–285

"He took a pinch of glittering powder out of the flowerpot, stepped up to the fire, and threw the powder into the flames. With a roar, the fire turned emerald green and rose higher than Fred, who stepped right into it, shouted 'Diagon Alley!' and vanished."

Rowling, J. K. *Harry Potter and the Chamber of Secrets*; Scholastic Inc.: New York, 1998, p 47

Have you ever done an experiment or seen a demonstration of how metal salt solutions give a Bunsen burner flame distinctive colors? If not, ask your teacher to gather the materials and directions for showing colored flames. We often use these flame tests to identify metal ions in solutions. For example, a blue-to-green flame usually indicates the presence of copper, a yellow flame reveals the presence of sodium, and a red flame shows the presence of lithium (Fig. 1).

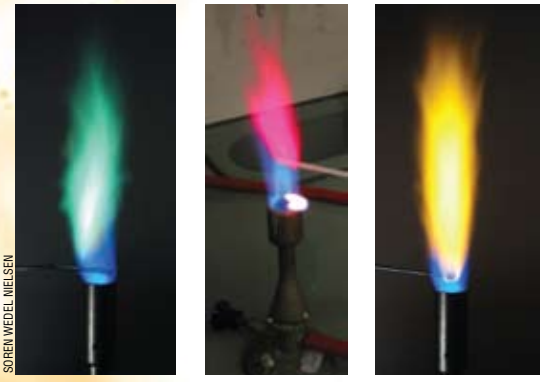

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Figure 1. Flame tests are used to identify chemical elements in a compound. These flame tests show the presence of (a) copper, (b) lithium, and (c) sodium.

You might also have seen red highway flares, which contain strontium salts. And colors in fireworks are due to metal salts heated by a mixture of chemicals that explode the shell.

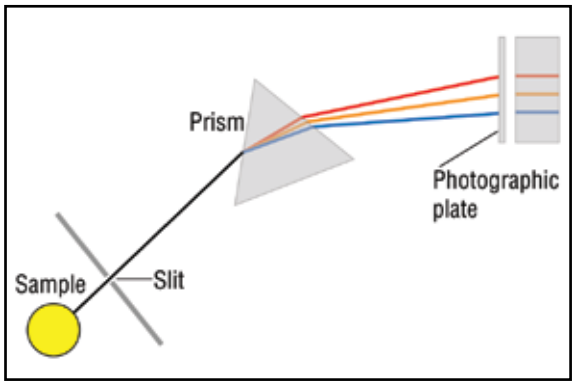

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Figure 2. Light from a heated chemical substance passes through a spectroscope's narrow slit. The beam of light then passes through a prism, which bends and spreads the light into a spectrum. Colored bright lines then appear on a dark background.

More than just the bright colors, there is actually a "fingerprint" specific to each element contained in the colored light. Your Bunsen burner was invented in 1855 by Robert Wilhelm Bunsen in Germany. He was studying the light from heated substances and needed a very hot, smokeless, nonluminous flame. Bunsen and his colleague Gustav Robert Kirchhoff used a prism and telescope lenses to look at the colored flames produced by many elements.

What you can see through the prism-and-lens combination—called a spectroscope—is a dark background with many bright lines. This pattern of lines is called the emission spectrum of the element.

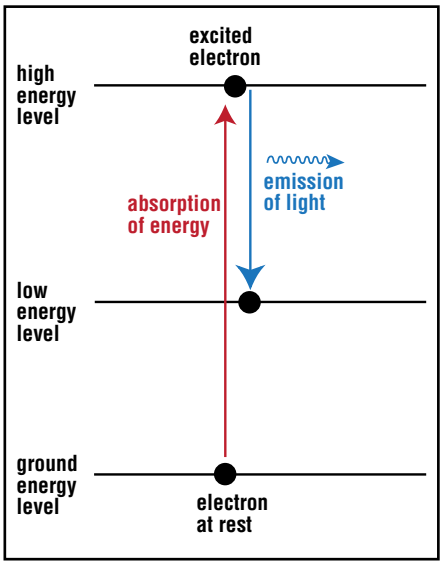

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Figure 3. Heating a chemical sample causes electrons to move from their ground energy level to a higher energy level (red). When these electrons move the high energy to a low energy level, they emit light (blue) with a color that is characteristic of their chemical nature.

When we heat a sample of an element hot enough, the heat kicks an electron from its original ground energy state to a higher energy level (Fig. 3). When the excited electron returns to a lower-energy state, light with a particular energy and characteristic color is released. Because many transitions between energy levels are possible, there can be many lines in an element's spectrum.

Incidentally, a number of elements were discovered because their "fingerprint spectra" were like no others yet observed. And the element helium was discovered in the spectrum of our Sun before it was found here on Earth. Since the sun is a star, you can think of it like a very large gas burner!

You can make your own spectroscope using an old CD and cardboard. The University of Wisconsin-Milwaukee provides simple directions to do so at http://www.uwm.edu/~awschwab/specweb_files/scopeinstruct.pdf

With your own spectroscope, first try looking at an incandescent light, which *won't* give you a line spectrum because its heated filament isn't hot enough to energize its electrons. Then take a look at fluorescent lights and street lights to see some interesting lines and try to identify chemical elements that are present in these lights. Note: Never look at the sun through your own spectroscope or with any other optical device.

You can also make your own version of "floo powder". With your teacher's assistance, try sprinkling dry boric acid powder into a burner flame. You will see a brilliant green flame, although I can't promise the unusual transportation effects so common in the wizard world!

In conclusion, although I don't want to totally demystify wizards' colored flames, we have some good scientific clues as to how they work in our world. But I just don't know how to make those black flames!

School Supplies at Hogwarts

Wouldn't you *love* to have these items?

"They stopped to buy parchment and quills. Harry cheered up a bit when he found a bottle of ink that changed color as you wrote."
Rowling, J. K. *Harry Potter and the Sorcerer's Stone*; Scholastic Inc.: New York, 1997, p 79

"He took out his wand, touched the parchment lightly, and said, '*I solemnly swear that I am up to no good.*' And at once, thin ink lines began to spread like a spider's web from the point that George's wand had touched. They joined each other, they crisscrossed, they fanned into every corner of the parchment; then words began to blossom across the top, great, curly green words . . . . The Marauder's Map."
Rowling, J. K. *Harry Potter and the Prisoner of Azkaban*; Scholastic Inc.: New York, 1999; pp 192-194

Writing with quills and magical ink on parchment sounds much more exciting than using our everyday pencils and paper. You can prepare invisible and disappearing inks, make ordinary paper look ancient, and conjure up color-changing effects with common grocery store items and a few chemicals from your teacher.

You can write a message that is initially invisible using a cotton swab, a wooden skewer, or a toothpick dipped in lemon juice, a sugar water solution, or a cream of tartar solution (Table 1 on next page). Then let the message dry completely before decoding it by using a light bulb or juice from a purple cabbage.

With help from your chemistry teacher, you can use some color-changing inks (Table 2 on next page). Write your message on white paper, let it dry, then spray or brush it with the developer solution.

Harry Potter and his friends write their homework on long parchment scrolls, with assignments made in "inches of parchment" rather than by number of pages or words. Traditional parchment is made from sheepskin, calfskin, or goatskin. But you can prepare some quickly "aged" paper, resembling parchment, by using a strong solution of ordinary black tea.


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Paint with this liquid and let dry	Develop message like this	What do you see?	Why does it work?
lemon or orange juice	heat carefully over 100 watt light bulb	message turns brown	charred sugars are brown
sugar water solution	heat carefully over 100 watt light bulb	message turns brown	heated sugar is brown
cream of tartar solution	spray or brush with purple cabbage juice	red text appears on pink paper	acid-base reaction of cabbage indicator

Table 1. Invisible inks.

Paint with this solution	Develop with this solution	What do you see?	Why does it work?
phenolphthalein solution, 1% in alcohol	dilute household ammonia or 0.1 M sodium hydroxide solution	red text appears, then disappears	paint is an acid-base indicator
thymolphthalein solution, .04% in alcohol	dilute ammonia or 0.1 M sodium hydroxide solution	blue characters appear, then disappear	paint is an acid-base indicator
vinegar, 5% acetic acid	purple cabbage juice	magenta text on pink background	developer is an acid-base indicator
sodium carbonate solution, 0.1 M	purple cabbage juice	green letters appear on pink background	developer is an acid-base indicator

Table 2. Color-changing inks.

Brew the tea at least five times its normal strength and let the solution cool. Then soak plain paper in the tea, drain it, and let the sheets dry overnight on newspapers. Any curling or crumpling of the paper adds to its appeal. You can also make an excellent color-changing paper by soaking plain paper in purple cabbage juice. Write with vinegar or baking soda solution when the paper is dry.

The language of spells

Latin is the language of many spells, jinxes, hexes, and curses used in the wizard world. Hogwarts students work hard in all their classes to get the words just right.

"'And saying the magic words properly is very important, too . . . .'

Hermione rolled up the sleeves of her gown, flicked her wand, and said, '*Wingardium Leviosa!*'"

Rowling, J. K. Harry Potter and the Sorcerer's Stone; Scholastic Inc.: New York, 1997, p 171

With hundreds of languages and dialects in our world, Latin is used for scientific names of plants, animals, and bacteria. Latin is the root language of many chemical element names as well.

See if you can figure out the element names derived from these Latin roots listed below:

Root	Meaning	Element
natrium	soda	sodium
alum	stringent taste	aluminum
carbo	charcoal	
cuprum	Cyprus	
fluere	to flow or a flux	
Gallia	France	
aurum	goddess of dawn	
germania	Germany	
ferrum	firmness	
lutetia	Paris	
magnes	magnet	
nitrum	native soda	
rhenus	Rhine River	
rubidus	deepest red	
Scandia	Scandinavia	
argentum	bright	

Scientists have recently made elements with atomic numbers 112, 113, 114, 115, 116, 118, and 122 in their laboratory, but these elements don't have permanent names yet because their synthesis has not been confirmed by other scientists. Their provisional names are Latinized forms of their atomic numbers. For example, element 112 is called "un un bium" (for "112-ium") and element 115 is called "un un pentium" (for "115-ium").

And in case you were wondering about how to make a Dark Mark, look for molybdenum or lead. Both names are derived from "a black material that leaves a mark on paper"!

Although Harry Potter and his friends are learning how to perform magic, they may be learning about chemistry and physics as well. And so did you (if you read this article).

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