

The Chemical Adventures of Sherlock Holmes: The Case of Three

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The following story is a chemical mystery that emphasizes simple physical properties and chemical characterization of metals. It is the 13th in a series presenting a scientific problem in mystery format in the context of the popular and beloved characters Sherlock Holmes and Dr. Watson (1, 2). There is a break in the story where the reader (students and teachers) can ponder and solve the mystery. Sherlock Holmes provides his solution in the paragraphs following this break.

The Story

I felt my world shaking and heard a muffled sound, faint and far off. I felt a comfortable darkness slipping away as the shaking grew more intense. Finally, the confusion sharpened to something I could clearly recognize.

"Wake up, Watson."

I opened my eyes to the faint morning light of my bedroom on a cold winter morning and observed the angular face of the World's Greatest Consulting Detective peering down at me. His hand on my shoulder was removed and the shaking stopped at the instant I opened my eyes.

"What the devil is going on, Holmes? It's barely light."

"We have a prospective client, Watson, on her way to visit us even as we speak," said Holmes.

"At this time in the morning?" I asked.

"Time is urgent and I believe you will find this case of considerable interest. In addition, your medical knowledge could prove of some use. However, if you prefer to sleep the day away, I suppose you could make that choice."

Holmes's tone made it clear that a return to my deep slumber would be the wrong choice. I sat up in bed and swung my feet to the floor. "Give me a minute to pull myself together and I'll join you."

"Excellent, my good fellow!" Holmes declared as he turned and walked out of my room, pulling the door closed behind him.

I dressed quickly and joined him in the living area of our flat.

"Holmes, I don't know how you can rise so early," I said. "You were still out when I came in last night after midnight."

"London's criminal element prefers the darker hours to do their work, Watson. Fortunately, I do not always require the regular amounts of sleep you seem to crave. However, I do observe that you stayed up late enough to lose a significant amount of money at cards last night."

"And how do you conclude that?" I asked.

"Your pockets are turned inside out as if you were searching for a few additional coins and the nail on your right thumb is freshly chewed down to the quick. I have observed that you usually hold cards in your left hand, which would account for nail-biting the right preferentially. Indeed, I believe that if I could make a few careful measurements comparing your left and right thumb lengths and your tooth compression factor, I could estimate the amount of money you lost."

"Well, that will not be necessary," I said, a bit put off by

Holmes's causal analysis of my loss. "Suffice it to say I should have left the club three hours earlier than I did. My luck ran out too soon. But what is this case that has alerted us so early?"

Holmes looked down at his hands and with a roguish grin replied, "I was engaged in a bit of late-night surveillance when I saw our friend Sergeant Phelps and a couple of bobbies rush past. Of course, they didn't recognize me because I was in disguise. By the way, sometime I should tell you of how Sir Robert Peel reorganized the London police force more than fifty years ago. Our calling a policeman a bobby is in reference to his name Robert, as you may know. And I have developed some of my own thoughts on the optimal organizational structure of a modern police force."

"I am sure that would be quite fascinating," I said, "but what about the case?"

"Ah, yes," he said. "I followed Phelps and the bobbies to a nearby clock maker's house and shop on the corner of Wigmore and Welbeck Streets."

"Why, that's not more than four blocks from Baker Street!" I exclaimed.

"You know your London streets, Watson," said Holmes with a bit of sarcasm. "In any case, this clock maker had been struck on the head and knocked unconscious. They know that it was exactly at three o'clock in the morning because as he fell forward he knocked a clock off his bench and it broke, thus fixing the time of the evil act. His wife reported that particular clock was his most accurate. It always remained on the corner of his bench and was used to set other clocks to the correct time. I was hoping that later today you might go 'round to St. Bartholomew's Hospital where they have him and see if he has recovered enough to talk. He was going in and out of consciousness during the night. He was dizzy and disoriented. They don't know if he saw anything or not—or even if he'll remember anything, owing to the blow to his head. Perhaps there is some aspect of his medical treatment that could be improved."

"I'll certainly go there and see how he is and if there is anything I can do," I replied.

"Good, Watson, I knew I could count on you," said Holmes. "His name is Mr. William Wickersham and his wife, Mary Wickersham, is on her way here. She is the prospective client, whom we expect shortly."

It was only a few minutes before Sherlock Holmes, peering out the window, observed Mrs. Wickersham's approach along Baker Street. He hurried down to the curb and led her up the stairs to our flat.

Mrs. Wickersham walked slowly into the room. Strands of gray hair seemed to want to fly loose from her head, and she had a fragile birdlike quality about her. She clutched a large cloth bag in her hands, close to her chest. Her eyes were red and she shifted her gaze constantly about the room.

"Mrs. Wickersham, this is my friend and colleague Doctor Watson," said Holmes. "You may speak freely before him, and he has agreed to go round and check on your husband later today."

"Thank you, sir," she said. "If there is anything else that can be done for him, I'd owe you a debt forever."

"Think nothing of it," I replied.

"When I leave you two gentlemen, I'm going straight there," she said.

"I shall talk to you after I've had a chance to consider his current care," I said.

"That's fine," interrupted Holmes, "but we must turn to other matters so Mrs. Wickersham can be on her way."

Turning to face the delicate and distraught lady, Holmes asked, "Did you bring the sack I sealed last night and the other items?"

"Yes," she said, nodding, "here they are." She reached into her bag, removed a sealed brown paper sack and three scraps of paper, and handed them all over to Holmes.

Holmes produced an official looking receipt and said, "Would you be so good as to sign this paper indicating that I have received the indicated items?" Holmes held out a pen, which she took hold of in her right hand, quickly scrawling her signature. She barely glanced down at the sheet of paper.

Holmes opened the sealed sack, glanced inside, and then closed it again. He then examined the pieces of paper that she had brought with her. "Now, Mrs. Wickersham, would you be so good as to tell Dr. Watson and me what you know about the events leading up to the vicious attack on your husband."

"Well, sir," she said, as her eyes nervously scanned the flat, "my husband designs and makes wooden clocks. He has been doing so for many years. He is quite a skilled artisan and master craftsman. Each clock is made by hand and takes a considerable time. He usually works on several at a time and then starts a new batch. They are miniature grandfather clocks and his work is highly prized in certain circles."

"And most recently," said Holmes, hoping to hurry her along.

"Most recently—two days ago, actually—he completed three clocks and he was paid for each. But then the next day, night before last, he began raving like a madman about how he had been cheated. 'I've been robbed of my time,' he said, 'but they'll not get away with it.' Then the next day, yesterday, he was gone all afternoon from his shop. When he came home after supper, he told me he would be working later that night, and he immediately went to bed. He often slept in the early evening and then worked in the middle of the night in his shop, so that alone was not unusual."

"And then," said Holmes.

"And then, later that night I went to bed just as he was getting up to work. We spoke briefly and I fell asleep. During the night, I was sleeping poorly, heard a thud, and a few seconds later heard one of the doors of our shop slam shut. Then I went downstairs to his shop. He was slumped over his workbench and bleeding from where he'd been hit on the

back side of the head. It was just after three o'clock. I fetched a bobby and then Sergeant Phelps and some other officers showed up. Then you presented yourself and you know the rest."

"You will confirm for Dr. Watson that your husband was struck but once on the back, left side of his head with a thick wooden stick picked up inside the shop."

"That's true enough," she said.

"And I observed that night when the police were searching about the shop that the wooden floor has many rather bad creaks in it."

"That's true enough, it sounds some squeaks when my husband walks upon it, but rarely bothers when I tread about. However, I don't see I should be worrying about my floors with all my other problems."

"Indeed, I should say not," I said, trying to comfort the poor lady. "Shouldn't she go on to St. Bartholomew's Hospital now to check on Mr. Wickersham?" I asked Holmes.

"Yes, but there is one last question. Was your husband often in the habit of taking payment other than paper money for his work?" asked Holmes.

"My husband is a great one for trading. He'll take anything he thinks he can use—a load of coal, a supply of meat, bottles of wine. He loves to strike a deal."

"Thank you, Mrs. Wickersham for coming by this morning so early, and Dr. Watson will call on you this afternoon," said Holmes as he led her to the door of our flat and down the stairs to Baker Street.

At the next moment, I heard him running back up the stairs and he burst into our flat.

"We must begin, right away, Watson," said Holmes.

"Begin what?" I asked.

"Why, our physical and chemical analysis to solve the case, of course," he said.

"Shouldn't we have a bit of breakfast before we get started on whatever this analysis is that we are about to begin?"

"I fear we have no time," said Holmes, as he leaned toward me and spoke quietly. "The criminal who did this deed did not complete the task. We must anticipate that he will strike again. It was not the intent of the blow to merely injure Mr. Wickersham, but to kill him. We must act quickly and efficiently. I need your help, Watson."

"Of course, I'll do whatever I can," I said.

"Good. Read aloud, if you will, Watson, from these pieces of paper while I set up the lab equipment. These were the contracts of Mr. Wickersham with each of his recent customers."

I examined the scraps of paper that Holmes offered me and read the contents of each one to Holmes while he bustled about in the corner of the room.

"The first note says, Mrs. Nellie Sigler employed on the line at the Royal Arms electroplating factory. One clock in exchange for standard price equivalent in copper."

"The second note says, Dr. Harold McGinness, Professor of Geology at the University. One clock in exchange for standard price equivalent in gold."

"I learned last night that the Professor's nickname is Rock, owing to his large bulk and developed muscles as well as his profession," interjected Holmes.

"The third note says, Mr. Gilmore Gilreath, accounting clerk at the Norris Firm," I said. "One clock in exchange for standard price equivalent in silver."

"Do any of the notes bear the signatures of the customers?" asked Holmes.

"Each note bears the signatures of Mr. Wickersham and the person who engaged his work," I replied.

"Excellent," said Holmes, "I will examine them in detail as soon as we have completed our measurements. Spread open your hands."

I opened my hands with my palms facing up and looked at Holmes for some guidance as to what I was doing. As if to answer me, he turned the paper bag that Mrs. Wickersham had brought upside down and emptied the contents into my hands. Pieces of metal reflected in the room's morning light. Indeed, as I looked down into my cupped hands I saw what I could easily identify as pieces of gold, silver, and copper.

On the table before him, Holmes had arranged bottles labeled *acidum hydrochloricum*, *acidum sulphuricum*, and *acidum nitricum* (3) and had placed on the table nine small beakers—three in a row in front of each of the three bottles. "You no doubt recognize the names of hydrochloric, sulfuric, and nitric acids. All extremely interesting and useful substances," said Holmes.

He proceeded to pour acid from the hydrochloric acid bottle into each of the three beakers in front of it. He repeated this process for the sulfuric acid and the nitric acid bottles until each of the nine beakers contained a small amount of colorless liquid.

"Observe, Watson," said Holmes, as he plucked three small pieces of silver from my hand. He dropped one piece into a beaker containing hydrochloric acid. At once I observed an incredible sight. An extremely vigorous bubbling began at once, the colorless liquid turned white and a white smoke issued forth from the liquid. This continued for about twenty seconds and then just as suddenly it stopped. The smoking stopped and the liquid cleared except that I noticed it had a very slight greenish tint to it. However, most amazing to me was the fact that the metal was completely gone. It had vanished, as if by some magician's trick or sleight of hand.

I looked to Holmes and he smiled, but before I could ask him what had happened, he dropped the second piece of the silver metal into the beaker of sulfuric acid. At first, it seemed as if nothing had occurred, but then I bent down to take a closer look. I observed an extremely slow, almost imperceptible, bubbling at the surface of the metal. I would classify this occurrence as a very lazy reaction, if indeed one would call it that at all.

Holmes grabbed a beaker containing nitric acid and moved to the front of our fireplace where a small blaze burned and smoke drifted up the chimney. "Of course in a proper lab we should have the protection of a fume cupboard (ventilation hood), and though I don't usually bother with my safety as I should, here we must at least take some caution." He set the beaker in front of the fireplace and dropped in the third piece of silvery metal.

At once, a most remarkable and astonishing sight greeted me. Bubbles began again, but this time a brownish gas issued forth from the liquid, filling the beaker. Then, continuously drifting out of the beaker and pulled by the draft of the fireplace, the brown gas went toward and up the chimney. As the brown gas continued to form and bubbling could be seen and heard, the liquid slowly turned a slight brown color until it was the color of a weak whiskey.

"The brown gas is poisonous. I have placed the beaker here so the gas can be removed from our room and go up the chimney," said Holmes.

After a brief interval of time, perhaps a total of twenty or thirty seconds, the vigorous reaction stopped and no more brown gas was formed. However, the liquid retained its light brown color. And again, as in the hydrochloric acid test, the metal had vanished!

"Now, you have destroyed another portion of Mr. Wickersham's payment, Holmes," I cried out. "But what does all this mean?"

"It means, Watson, that things are not always what they seem."

Holmes took three small pieces of the shiny, reddish copper metal from my hand. He dropped one piece in the hydrochloric acid and a second piece in the sulfuric acid. I peered at the clear, colorless liquids in each beaker. There was no change—no reaction. Again Holmes moved before the fireplace with a small beaker of nitric acid and dropped in the third piece of copper. As before with the silvery metal, a vigorous reaction commenced at once, and that fascinating brown gas was released. Only this time, the liquid began to turn green, growing darker until the reaction stopped. Whereas the reaction of the silvery metal in nitric acid had turned the acid the color of some diluted Irish Whiskey, this reaction turned the liquid to the color of the green fields of Ireland.

And now Holmes took small pieces of the gold from my hand and dropped one of them in each of the three acids.

I glanced at the three beakers and remarked to Holmes, "Why, nothing has happened this time."

Holmes waited quietly for about a minute and then looked at each beaker closely. "Are you sure, Watson?" he replied.

I bent over and examined each carefully. I could see no change in the hydrochloric or the sulfuric acid beaker. However, in the beaker containing nitric acid, I thought I saw a tiny spot of green appearing in the liquid near the metal. Holmes took this nitric acid beaker, and after he heated it, the liquid darkened and produced the now familiar brown gas. Bubbles formed rapidly at the surface of the solid and continued until the metal had completely disappeared.

Holmes grabbed another piece of the gold and, after laying his hands on a nearby geologist's hammer, brought the hammer down on the gold, shattering it into pieces. I jumped back in surprise, but he made no comment. Instead he busied himself for several minutes scribbling in his notebook. He consulted several reference books, scribbled more notes, and then turned to me.

"Could you hand me those papers you read earlier?" Holmes asked.

I pulled out Mr. Wickersham's sales agreements and proffered them to Holmes. He took the pages from me, whipped out his magnifying lens, and began a close examination of each page. He spread the pages out on his chemical table and motioned for me to look over his shoulder.

"Handwriting can tell you a great deal about a person, Watson. Handwriting can reveal character—nervous or calm, extroverted or quiet, and much more. But here we look for the obvious. Note the angle and slope of each signature. It is quite obvious that Mrs. Nellie Sigler and Dr. Harold McGinness are both left handed, whereas Mr. Gilmore Gilreath is clearly right handed."

"Really, Holmes, shouldn't we go to the Hospital and see if Mr. Wickersham can tell us anything yet?" I asked.

"Metals have physical properties as well as chemical properties, so let us now turn our attention to that world for some answers," said Holmes.

I watched impatiently as Holmes arranged three small, finely marked graduated cylinders in a row and partially filled each with water. He then took care to read the exact levels of the liquid. He recorded these values in his notebook. I then assisted him in carefully determining the mass of a collection of pieces of the silvery metal. He recorded the mass in his notebook and then added the silvery pieces of metal to the first graduated cylinder. Together we observed the final volume of the water in the cylinder and calculated the change in the volume. Holmes recorded this value along with the metal's mass in his notebook. We then weighed pieces of the reddish metal and observed the volume displacement of these pieces in the second graduated cylinder. Finally, we repeated this process with pieces of the golden metal and the third cylinder.

"What do you make of that?" Holmes asked as he handed me his notebook.

"Why, I make nothing of it," I said. "First there was that series of strange reactions and now you sink various metals in water. I say it is a strange way to conduct a criminal investigation. We should be out questioning the suspects."

"Do you think so?" asked Holmes.

"Indeed I do," I replied.

"Well, we are no longer conducting an investigation," stated Holmes in a quick but matter-of-fact manner.

"But why not?" I sputtered. "I have never known you to give up on a case before."

"I have not given up on this case, Watson. I am no longer conducting an investigation because the investigation is over. I have the perpetrator. However, I fear the situation is more

grave than I at first imagined. We must get to the hospital at once. You see the numbers in my table." He handed me his open notebook.

Metal Color	Volume Change (cc)	mass (g)
silvery	4.0	28.4
reddish copper	5.2	38.5
gold	3.1	15.5

Suddenly, Holmes took back his notebook, grabbed his hat and coat from a chair near the fire place, and moved toward the door of our flat. I followed him as he ran down the stairs of 221B toward Baker Street. As he pushed onto the street, I continued behind him as he hailed a hansom cab.

"But who is it, Holmes?" I cried as I reached his side. "What have you deduced?"

"I'll explain on the way," he said. "There is no time to waste." As he spoke, he climbed into the carriage and I jumped in behind him. At a word from Holmes, the driver shook the reins he held tightly in his hands and snapped his whip. I fell back against the seat as we took off. We clattered down Baker Street and rushed through the streets of London toward St. Bartholomew's Hospital.

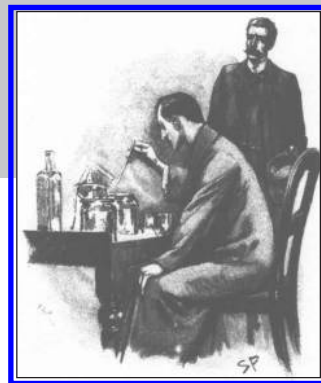


Can You Solve the Mystery?

The mystery can be solved with a knowledge of the physical and chemical properties of metals. However, like Holmes, you may need to consult a reference book for additional information.

1. What did the chemical tests tell Holmes about the metals?
2. What did the physical tests tell Holmes about the identity of each metal?
3. Who tried to kill Mr. Wickersham and how did Holmes reach this conclusion?
4. Why does Holmes consider the situation to be more serious than he first imagined?

Sherlock Holmes reveals his solution in the paragraphs that follow.



The Solution

As we crossed Marylebone Road, Holmes tossed his lab notebook on my lap. I looked down at the open page and saw again the table he had prepared from the masses and water level changes of the three metals.

"What would you do with those numbers?" Holmes asked.

"Hmmm," I said, giving myself some time to think, "you have determined the volume change in cubic centimeters from the water rise when the metal was placed in the cylinder."

"Yes," said Holmes, staring at me, "and?"

"And you have recorded the mass in grams of each of the metal samples," I replied slowly. Holmes had a way of making you feel that even a simple question was a major examination.

"You state the obvious," said Holmes. "But what would you do with the numbers?"

"Well, I'm not sure that I should do anything with them," I sputtered.

"Density," said Holmes, "is a physical property characteristic of each metal or solid substance."

"So different metals have different densities," I said. "You could divide the mass by the volume to determine the unique density of each metal sample."

"Excellent," said Holmes. "Why don't you do so?"

I took a pen and jotted the results in his notebook as I spoke aloud, "Let's see ... the silver is 7.1, the copper is 7.4, and the gold is 5.0. And all are in units of grams per cubic centimeter."

"Your math is correct, and while we were working in our flat, I consulted a reference manual on the properties of metals, minerals, and solids," said Holmes. "Would it surprise you to learn that the density of silver is known to be 10.5 while that of zinc is 7.14 grams per cubic centimeter?" (4).

"Why, that means that Gilmore Gilreath substituted cheap zinc metal pieces in place of the far more valuable silver he had promised!" I shouted. "He is guilty. We must have him arrested at once for his attempt on the life of poor Mr. Wickersham."

"Perhaps we should consider all the facts," said Holmes.

"Yes, well, what was the meaning of the chemical tests you performed?" I asked. "I saw the silvery metal disappear in the hydrochloric acid."

"You saw zinc dissolve in hydrochloric acid to produce zinc ions and liberate colorless hydrogen gas. Silver does not thus react, so I knew Mr. Gilreath substituted something in place of silver. The chemical test indicated deception and the physical test of density confirmed the exact nature of the subterfuge. Further, we observed that zinc reacts slowly in sulfuric acid and rapidly in nitric acid."

"So Gilreath is guilty," I said.

"Clearly guilty of fraud and receiving goods without proper payment," said Holmes. "As a clerk in an accounting firm, I am quite sure Mr. Gilreath knew the relative value of silver and zinc. But we must look further, Watson."

"What else is there to know?" I asked.

"Would you also be surprised to learn that the density of gold is well known to be 19.3 grams per cubic centimeter," replied Holmes (4). "Furthermore gold does not react with hydrochloric, sulfuric, or even nitric acid. You saw what happened to the other metals when they were placed in nitric

acid. A classic test for gold is its immunity to destruction by nitric acid. However, upon heating in the nitric acid, you observed how the gold solid seem to vanish."

I looked at the notebook before me and saw the density of what I had taken to be gold was only 5.0. "Why did you strike the gold?"

"Gold is extremely malleable," said Holmes. "It can be beaten into thin sheets. And upon consulting my reference, I found that the iron disulfide mineral, FeS_2 , more commonly known as pyrite, has a density of 5.0 grams per cubic centimeter. Pyrite is brittle and shatters just as you saw."

"But it looked like gold," I said.

"Perhaps you would be interested to know that the other common name of pyrite is fool's gold—owing to the very property you observed," Holmes said.

"Now the facts are muddling up my theory completely," I said.

"Facts often have a way of doing that," Holmes said. "But we must conclude that Dr. Harold McGinness, the geology professor, is also guilty of fraud. As an expert in minerals he would have had easy access to and certain knowledge of the properties of fool's gold."

"I may have been fooled by fool's gold for real gold and zinc for silver," I admitted, "but I know copper when I see it. I am sure that reddish metal was real copper. At least Mrs. Nellie Sigler is an honest person."

"Then, said Holmes, "you should know that the density of copper is 8.92 grams per cubic centimeter" (4).

"But you told me that zinc is 7.14 and I calculated Mrs. Sigler's metal to be 7.4 so it is not zinc or copper."

"Rather, a combination of the two," said Holmes. "I suggest you review the classic story of how the Greek mathematician and inventor Archimedes used the density of metals to determine that the king's crown had been made with some of the gold replaced with silver. Look here, Watson."

Holmes took his notebook and rapidly scribbled some equations. "Consider this formula and its solution," he said, as he handed me the notebook.

Let x = fraction of copper
 then $1-x$ = fraction of zinc
 If average is 7.4 $\frac{\text{g}}{\text{cm}^3}$ then,

$$7.4 = 7.14(1-x) + 8.92(x)$$

$$7.4 = 7.14 - 7.14x + 8.92x$$

$$0.26 = 1.78x$$

$$x = 0.15 \approx 15\% \text{ Cu and } 85\% \text{ Zn}$$

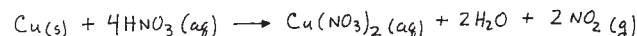
I examined his work and realized he was saying that 85% of the metal was the cheaper zinc and only 15% was the more expensive copper metal. So Nellie Sigler had also cheated the clock maker, although not nearly as severely as the other two.

I looked up at Holmes. He must have known the question on my mind because he immediately said, "As a worker in an electroplating factory, Mrs. Sigler would have had the means to use electrolysis to plate out copper from a solution of ions onto the surface of the zinc pieces. An examination of her factory's equipment and chemicals and a check of her whereabouts of late should strengthen this conclusion. What you saw was copper but only a thin layer of it. The outer

layer of copper did not react with the hydrochloric or sulfuric acid. However, it and the underlying zinc were quickly consumed with the nitric acid."

"Then what was that strange brown gas produced as the metal disappeared?" I asked.

Sherlock Holmes took up the notebook and wrote this single chemical equation (5, 6):



"Nitrogen dioxide is a toxic gas and that's why I allowed it to flow up the chimney," said Holmes. "Nitric acid is a powerful oxidizing agent and so it converted the outer copper layer from a metal to copper ions in solution¹ and also the inner zinc from metal to ions. Both reactions liberate the brown NO₂ gas."

"But if all three cheated Mr. Wickersham, who struck him on the head?" I asked.

"Consider that the clock maker was slumped over his workbench and was struck on the back, left side of his head. Therefore whoever hit him must have been left handed to hit him on the left side of the head from behind."

"What about the wife?" I asked.

"You observed that Mrs. Wickersham is right handed, and if she had intended to kill her husband, I doubt she would have run out to alert the bobbies without making sure the job was done."

"But that leaves both Sigler and McGinness as possibilities, since your examination of their signatures indicated both are left handed," I said.

"However, since Mr. Wickersham did not turn around to face his assailant, he must not have heard her. Dr. McGinness, the geology professor who was nicknamed Rock because of his size, would surely have caused the old wooden floors to creak and make a warning sound. At three o'clock in the morning, you can be sure Mr. Wickersham would have noticed such a sound and turned around. As the assailant ran out, the door slammed shut, and Mrs. Wickersham came downstairs.

"So it was Mrs. Nellie Sigler," I exclaimed. "Since she was clearly not as strong as McGinness, the blow to Mr. Wickersham's head was not of sufficient force to kill him."

"And since all three cheated him of the money he was due, if one could try to kill him, then we have to consider the possibility of the others also. That is why we must get to the hospital. We must warn the staff of the possible danger of action by Mrs. Sigler, Dr. McGinness, or Mr. Gilreath. Then we must alert Sergeant Phelps to the need to arrest Mrs. Sigler for attempted murder and fraud and to arrest McGinness and Gilreath for fraud alone."

"What alerted you that all three were involved in this devious activity?" I asked.

"Mrs. Wickersham reported that her husband was gone all afternoon on the day after he claimed he was cheated," replied Holmes. "Apparently he knew as much about metals as he did about clocks. In any case, a visit to any one of the three would require at most two hours, but a visit to all three would consume a large part of the day. At that point, I was concerned we might be dealing with an extremely complex case. In addition, Mr. Wickersham's handmade clocks are quite expensive and a factory worker, a clerk, or a college professor would normally not have the resources to afford

one. But I see we are nearing St. Bartholomew's Hospital. Let's hope we have arrived in time."

Several months later I returned late one evening to our flat at 221B Baker Street to find that a lovely new clock had been placed upon our mantle. Holmes was hunched in a corner chair reviewing some chemical journals, but looked up as I entered.

"Where did you get this magnificent timepiece, Holmes?" I asked.

"Why, from Mr. Wickersham, of course," said Holmes. "I'm sure you recall his case. You know that his wife told us he loves to bargain. It was he who insisted a handcrafted clock should be made for us in place of any consulting fee. Naturally, I accepted."

"I've been reviewing my notes on that case," I said. "I've been trying to think of a suitable title to chronicle that chemical adventure. I briefly considered *The Night That Time Stopped*, because of the breakage of the clock, but it didn't have the right ring to it."

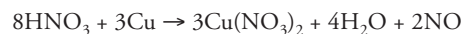
"Let's see," replied Holmes, "that was the case where the victim was struck at three o'clock in the morning, and we confronted three suspects who had made payments to Mr. Wickersham with three different false metals. I used three acids to do chemical tests and determined three densities of the three false solids."

"Yes, I know all that, but what should I call it?" I asked.

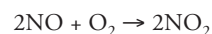
"I am confident that given time you will think of something suitably descriptive," stated Holmes with a smile. "Why don't you sleep on the matter?"

Note

1. Holmes's equation is a simplification of the chemistry that actually involves two steps (6). The reduction of nitric acid by copper yields nitrogen monoxide as shown below.



However, the nitrogen monoxide reacts instantly with oxygen in the air to yield nitrogen dioxide.



Literature Cited

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