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Sherlock Holmes and the Yellow Prisms

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The following story provides a problem in qualitative chemical analysis, both organic and inorganic. The problem is presented in mystery form in the context of the popular and beloved characters Sherlock Holmes and Dr. Watson. There is a break in the story where the reader (students and teachers) can ponder and solve the chemistry and hence the crime. Sherlock Holmes provides his solution in the paragraphs following this break.

"...It is the essential difference, Watson, between the technician and the truly educated professional."

From a deep sleep, I drew up with a start, my pipe falling to the floor scattering burning ash around my feet. Holmes had apparently said something to me. Outside, February sleet glazed the window and I could hear the wind howling down Baker Street. In front of the glowing hearth, I looked up to see Holmes staring into the fire, his head surrounded as usual with acrid pipe smoke.

"You know my ways, Watson. Consider my chemical researches which have taken up no little time over the years. I have not published one trifle of my discoveries. Do you therefore consider them a waste?"

"Well, Holmes, surely...," I stammered. It was a rhetorical question. Holmes well knew that chemistry was my weakest subject during my premedical days at the University of London.

"Only in a few notable adventures," he continued, "have I actually used my chemistry. I'm far ahead of my time, good fellow, far ahead. We should compose some manuscripts and both be famous. At last, Watson, I will be called upon as a chemist. Had I not performed those cranial and laborious experiments on the coal-tar substances, LeStrade would have caught me helpless this time. But he shan't, Watson. Always have knowledge pounds and pounds beyond what you expect to use today. It is the essential difference."

"How does this apply, Holmes? Is the game afoot?" I was still in the stupor of sleep. He was making less sense to me than usual.

"LeStrade and I have been in contact. He will arrive in a few moments. There has been a murder on Kennington Road, a poisoning of the most evil and diabolical sort." As he said this, Holmes glared at me through narrow, burning eyes. The game *was* afoot. He was transformed into a higher gear of existence unique among the populace of London.

As I bent to retrieve my pipe and extinguish the fallen ashes, the heavy door to our flat swung open and LeStrade strode in arrogantly and unannounced.

"My messenger reached you, Holmes? Yes? No matter," he rambled without a glance in my direction. "This should be a simple case, but there are fathoms here that are beyond me."

"Proceed, LeStrade," Holmes said, leading us toward chairs near the fire and delivering a secret wink to me through the ever-billowing pipe smoke.

"The victim is an elderly man. He had been in declining health for months, I'm told, and taking on a hideous yellow tint to his skin. Indeed, the body was in a ghastly dehydrated state when we arrived yesterday. The man has three sons, Holmes, and needless to say, they are all prime suspects."

"What is the relationship between father and sons?" Holmes inquired.

"Well, all appearances suggest a close family. Several times a week, the sons gather at the Kennington house and serve tea to the father in his room. It has been the habit then for the four to engage in a game of whist or family discussion. However, on this occasion, perhaps due to the father's poor health, the three sons after serving tea convened in the drawing room for discussion among themselves. Upon returning to the father's room about an hour later, they found him dead, his body in the condition I described. I've brought with me his cup, tea pot, sugar bowl, and tin of tea leaves. They may be of some use."

Surprisingly, the great detective ignored this obvious violation of the crime scene.

"I need to know about the sons, LeStrade. What have you found out?" Holmes was repacking his pipe from the supply of shag in the Persian slipper.

"We have searched them all, Holmes. On the oldest son we found a package clearly marked strychnine containing a white powder. On the middle son, we found a package labeled 'corrosive sublimate', also a white powder."

"Why that's bichloride of mercury?" I exclaimed, excited that I had remembered a triviality from college.

"Yes, Watson," Holmes said in a way that was both soothing and impatient. "And the youngest son?" he quickly inquired of LeStrade.

"Clean, Holmes. A normal gentleman in all ways. Well, nearly. On his right hand was a nasty scar down the palm as if the flesh had been eaten away. On his left hand his finger tips were stained a dark yellow. Also, confound it, he was annoyingly hard of hearing and this made it very difficult to question him."

"What about wounds or marks on the victim?" Holmes was closing in.

LeStrade sat up, alerted. "Yes. A cut on his foot, Holmes. His servant told us that he had swung an axe at a rat in his basement and injured himself. An unrelated event, I should say."

"What are the son's occupations?" I asked. It seemed relevant if not interesting.

"We know this, Doctor." LeStrade turned to face me for the first time. "One son is connected with the military, one lives in a house in London which his father gave to him when he, the son, graduated from medical school; and one has considerable lands upon which he farms. It's my understanding that the land belonged to the father, until now, of course."

Holmes had a faraway look in his eyes and was staring at the fatal tea pot. "The oldest son is the farmer and was found with the strychnine. The middle son is the physician and was found with the poisonous mercury bichloride. And the youngest son is a military man."

"I didn't tell you that, Holmes," LeStrade barked. "How did you...?"

"Elementary, LeStrade. Let's do some chemistry."

We arose simultaneously and followed Holmes to the corner of the room reserved for his research. It was dusty and cluttered with old solutions, retorts, and stained-glass bottles of every imaginable color. Holmes poured some of the tea from the victim's pot into a test tube and reached for a

bottle with "HCl" etched into the thick glass. He added several drops of the acid to the test tube followed by drops of stannous chloride solution. He held the test tube up for LeStrade and me to see.

"Watson! Do you see a white milky precipitate?"

"No, Holmes, I don't. What does it mean?"

"It means," he said, "that a certain man's life will be spared."

"Now my idea," LeStrade announced, "is that strychnine could have been added to the sugar. The victim's servant told us that he used a lot of sugar in his tea."

"Watch, then," was all Holmes replied as he put a spoonful of the sugar into a beaker and added a minimum of water. The sugar dissolved quickly to give a clear, colorless solution, into which he dropped more of the HCl and stannous chloride. I observed no change at all.

It seemed to me that Holmes was learning very little, but his eyes continued to burn with that creative intensity I had seen in him so many times before.

"Now," he said, "the tea leaves, LeStrade, hand me the tin of tea leaves."

Holmes poured the crushed tea leaves out onto a white sheet of stationery and whipped out a magnifying lens in his old manner. He crouched over the tea myopically for a minute or two. A short exclamation burst from his lips, and from a drawer beneath the countertop he produced narrow tweezers. With this implement in hand, he furiously went to work on the tea, picking and collecting some material seen only to him. After ten minutes, he led us back to the light of the fire and held up a vial of the substance from the tea.

The content of the vial, by firelight, seemed to glow with a brilliance of its own. Crystals, yellow crystals, flashing prisms of captured sunlight! I thought it impossible that such beauty and perfection could kill, but apparently it had.

Holmes was uncommunicative. After a long silence, he hurried back to the laboratory corner, muttering under his breath. LeStrade and I followed. I had the irrational notion that Holmes was going to quiz me on this later.

We watched him carefully as he carried out his operations. The yellow prisms were taken up in water and he placed a drop of the resulting solution upon a square of blue litmus. The spot of solution turned the litmus to red. He added a few drops of ammonium sulfide solution to the now-aqueous poison. After warming, the yellow liquid became a terrible blood red. I knew now that Holmes was on the scent.

We watched as he arranged three bottles before him on the bench; carbolic acid, aqua fortis, oil of vitriol!

"Watson. I must ask you to retire to the hearth. The next step is a bit dangerous." He waved his hand in the air and said, "LeStrade, you may stay if you wish."

LeStrade, however, backed slowly away from Holmes and joined me at the fireplace. We could not relax. As bottles clinked in the corner and Holmes continued to mutter to himself, we paced back and forth before the light of the fire, both smoking furiously at cigarettes.

Suddenly, behind us in the darkened lab corner, a loud explosion shook the apartment.

"Holmes!" I cried and rushed to find him. He emerged from a smoky cloud wearing a sinister smile. He ignored me and went straight to LeStrade. Holmes whispered a few words in his ear, whereupon LeStrade grabbed his coat and rushed out into the winter night.

"Holmes!" I cried, again. My concern for his safety had turned to hurt feelings.

"Come, my friend." He took me gently by the arm and we both settled into our chairs by the fireplace.

"Light up your pipe, Watson," he said, "and listen to the tale."

Stop Here

Although it may require a little investigation, this mystery can be solved using chemical knowledge. Can you answer these questions:

1. What did Holmes's chemical tests reveal?
2. What was the poison used?
3. Which son was the murderer?

The following paragraphs contain Holmes's chemical solution to the mystery. Compare your solution to his.

"The doctor, the middle son, is innocent, Watson," he said. "His possession of bichloride of mercury is expected in this situation as he was undoubtedly treating an infection in his father's cut foot. In any case, we saw, did we not, that neither the tea nor the sugar contained that poisonous substance."

He paused, but my puzzled look caused him to continue.

"The presence of tin in solution from stannous chloride will cause the soluble mercuric chloride to convert to the insoluble mercurous chloride. However, we observed that no white precipitate was formed upon addition of hydrochloric acid and stannous chloride."

"The farmer, Holmes!"

"No, Watson, not the farmer either. The oldest son brought strychnine to his father's house to poison the rats in the cellar. My solubility test on the sugar would have detected this insoluble and legendary alkaloid."

"But the youngest son, Holmes, how. . . ?"

"It had to be him, good fellow. I knew it as soon as I confirmed the identity of the poison by chemical synthesis."

"Carbolic acid, Holmes? Aqua fortis?" I was confused.

"Phenol, Watson!" he shouted. "Nitric acid! When they are mixed with sulfuric acid the product is formed!"

"Start at the beginning, Holmes. You lose me. My chemistry, well. . . ."

"The youngest son is a military man," he minded me, "hard of hearing we are told, with scarred and stained hands. He has been handling phenol, which is extremely corrosive, and nitric acid, which stains the skin. He must work in munitions, Watson, where loud explosions have affected his hearing, and where he would easily have acquired the knowledge and supplies to prepare *picric acid*, an explosive and, I might add, a toxic nitro compound. The ammonium sulfide test is a known method of detecting this ominous material."

"The condition of the body, Holmes, the hideous yellow skin. . . ?"

"Look it up, Watson. These are symptoms of chronic picric acid poisoning. The murderer was administering the substance to his father for months."

"But why, Holmes? There must be deep motives for this evil act."

"We can only speculate at this point. I suppose the father had a will that left something to all three sons. But, notice Watson, that the oldest brother had already acquired the farm and that the middle brother got the money to attend medical school and set up a practice in the city. Perhaps there was little left for the youngest brother. LeStrade will sort out these details."

"Depressing, Holmes. I think of my own father and how I miss him."

"Chin up, my friend. Study and work. The snakes will surely crawl into our souls if we let them. Remember the pounds and pounds of learning, Watson. It is the essential difference."

With a warm smile, he stood, tapped my shoulder affectionately with his fist, and relit his foul, beloved briar.