

Molarity Lab – *Murder Investigation*

BACKGROUND: A crime has been committed and you, as the forensic detective, are going to use your knowledge of solution chemistry to solve the crime. Miss Scarlet was found dead on the floor of the *ballroom*. Beside her body police found a clear liquid, undoubtedly the murder weapon. Detectives were quick to ascertain that the murder weapon was one of two chemicals. They knew that Miss Scarlet has a violent allergic reaction to potassium iodide, and that there was widespread use of silver nitrate, which is toxic if ingested, by several members of the household. Police further discovered the following evidence.

Professor Plum, an eccentric chemistry teacher, was working in the *study* with silver nitrate solutions of molarities 0.20 to 0.30. Miss Scarlet was Plum's worst student, arriving to class late, being responsible for lots of broken glassware, and rarely cleaning up after her experiments. The policeman in charge, never having had a chemistry class, did not seriously consider this to be a motive for murder.

Mrs. White, an asthmatic, has a prescription for potassium iodide in the *bathroom*. Her pharmacist assures us that her potassium iodide solution has a molarity in the range of 0.05 M to 0.15 M. That Mrs. White was presently rooming with Miss Scarlet's ex-boyfriend led the police to suspect her. Neither she nor her boyfriend could be found in the *lounge* for comment.

Mr. Green, a photographer, had solutions of silver nitrate between 0.05 M and 0.15 M in the *darkroom*. Mr. Green apparently had been caught scarlet-handed at his own blackmail game. Pictures of him with Miss Scarlet were found hidden in Scarlet's *bedroom*. Mrs. Green should be spared seeing the pictures if at all possible.

Mrs. Peacock, wearing the same dress as Miss Scarlet, was found in the *stable*, administering potassium iodide solution to her horse. When questioned, she admitted that her horse had a severe case of bronchitis. Her veterinarian informed detectives that the strength of the solution was greater than 0.20 M. It is likely that she knew of Miss Scarlet's violent allergy to potassium iodide, since they had been lab partners in Professor Plum's chemistry class. Professor Plum recalled how angry Mrs. Peacock would get when Miss Scarlet came late to class, unprepared for the experiments, and how she invariably got sick a few days before the labs were due.

Colonel Mustard, had silver nitrate solutions in excess of 0.30 M, in the *conservatory*. The Colonel, who despised the left-wing politics of Miss Scarlet, enjoyed his leisure hours making explosives. Colonel Mustard had been the interim assistant principal at the high school and was largely responsible for closing the campus when Miss Scarlet, then president of the student body, overthrew the administration and took control of the school.

YOUR TASK: You can obtain a sample of the murder weapon found at Miss Scarlet's side by asking your teacher for it, in the *classroom*. If you can determine whether it is silver nitrate or potassium iodide, then you can narrow the list of suspects considerably. And if you can determine the molarity of the unknown solution, then you can solve the case.

Who was the murderer? What was the murder weapon? What was its molarity? Provide a short, formal lab report giving evidence and analysis useful for the prosecution of the murderer. Your evidence will be Exhibit A at the trial, and will be subjected to the scrutiny of the defense attorney. On the basis of your evidence, a murderer might be set free or an innocent person executed.

MATERIALS AVAILABLE: 100ml of unknown solution, 0.1 M NaCl (aq), 0.1M NaCO₃ (aq), beakers, flasks, graduated cylinders, filters, filter paper, balances

SUGGESTED PROCEDURE:

1. Use your knowledge of double replacement reactions and solubility rules to determine how each of the possible murderous solutions would react with the known solutions provided. Perform the reactions and assess the results.
2. Once you have figured out which of the possible solutions the unknown is, use your knowledge of separation of mixtures, and the definition of molarity to determine the approximate molarity of the solution.
3. After you have determined the identity of the murderous solution and its molarity you should be able to conclude which of the suspects is the murderer and where the murder was committed in order to write up your report for the court trial.

FINAL REPORT: The final report that you will hand in must contain the following sections:

Purpose: In one or two sentences, state what the problem is that you are trying to solve.

Materials: List the materials that you used in the lab

Procedure: List the steps that you used to determine the identity of the solution and its molarity. Be very specific so that someone could repeat what you did and get the same results. Include amounts used and types of glassware.

Data: This section should include tables with all observations made and any measurements recorded.

Calculations: Show all reaction predictions and calculations here.

Conclusions: In a short paragraph, summarize the conclusions that you have made as to the identity of the solution and its molarity, citing the lab techniques that you used to arrive at those conclusions. Finally, state who you suspect the murderer is and where the murder was committed, based on the police evidence.

Solution to the *Molarity Lab Mystery*

For all those who asked, here are some more details about the molarity murder mystery lab:

The murder weapon is ~0.1M silver nitrate. First the students should figure out the 4 possible double replacement reactions between the two possible murder weapons, KI or AgNO_3 , and the two available test solutions, NaCl and NaCO_3 . They should then realize that neither KI reaction would form a precipitate, but $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl}$. Once they've told you that they've figured out that part you can give them a few drops of the "murder solution" and the test solutions and they can mix them and make observations. From that they can determine the identity of the murder weapon, but not the molarity, which they need to figure out who the murderer is. That seems to take 1 class period.

For the second class period they must figure out how to determine the molarity. Again, I make them tell me their plan before I give them more materials. They should figure out that they can take a known volume of the AgNO_3 and react it with an excess of either of the test solutions, and then filter out the precipitate. They let the precipitate dry until the next class period.

During that period they can weigh the precipitate + filter paper (having previously weighed just the filter paper.) They can then use their balanced double replacement reaction and stoichiometry to relate the mass of this product to the mass of the AgNO_3 they must have started out with. Since they know the volume they started out with they can compute the molarity using the calculated mass. Mr. Green was the murderer.

I had great results with this lab, even if their lab techniques weren't perfect since the given range for Mr. Green was 0.5 - 1.5M anyway. Let me know if you have any more questions.

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