

Professor Manual

Materials to prepare:

- Color printouts of the puzzles (1 copy of pages 4 through 6, 1 copy per group of 7 through 10)
- Different-colored prize boxes/envelopes (with prizes)
- Six bottles/beakers
- Lab equipment to perform the Luminol reaction
- Computer, preferably projected
- One envelope per team
- Required chemicals:
 - 3% Hydrogen Peroxide solution
 - Luminol
 - Na_2CO_3
 - CuSO_4
 - $(\text{NH}_3)_2\text{CO}_3$
 - VOSO_4
 - Table Salt (NaCl)
 - CaSO_4
 - food coloring

Optional Materials:

- Lab equipment to perform a flame test, decomposition test, and solubility in water
- Bins marked Aqueous, Organic, and Solid
- Cabinet with lock and 12 bottles/beakers *instead of six bottles/beakers*
- 9,10-bis(phenylethynyl)anthracene, rubene, 9,10-diphenylanthracene, and rhodamine B *instead of food coloring*

Preparation:

1. Cut out safety information puzzle, post-its puzzle, lab handout, safety diamonds, luminol structure puzzle, bond tracing puzzle, and procedure.
2. Put each set of luminol structure puzzle pieces into an envelope with the associated text attached.
3. Add chemicals to the bottles as listed on page 3, and attach the associated safety diamond.
4. Draw on a board three boxes labeled Aqueous, Organic, and Solid, in that order *OR* set out bins in the same order.

5. Open cabinet Powerpoint on computer *OR* place all 12 bottles into the cabinet in the locations listed on page 11, and set up lock to the code 362.
6. Open computer passcode Powerpoint on computer.
7. Set up all lab equipment being used.
8. Set up prizes of choice equal to the number of groups (we suggest small prizes of about equal value).
9. Split class into 4-6 groups randomly.

Procedure:

1. Introduce Research Rats:
“Beloved professor Dr. Simington has recently been found dead in her home. First and foremost, she was my beloved colleague. She was also an eccentric and believed that the government was spying on her to steal her work, and it looks like her research was intentionally obscure in an attempt to keep it safe. However, we have no clue what she was working on, and that’s where you guys come in. Help us finish her research, and you’ll certainly be rewarded.”
2. Waste puzzle:
Let students free to solve - you may need to let them know that they are allowed to research the chemicals. The code will go into the Powerpoint or cabinet, starting the next puzzle.
3. Post-its puzzle:
If using a cabinet, these should be inside, and if using the Powerpoint, hand them to the students to solve. You may want to print multiple copies so that different groups can work on the puzzle at the same time. If using the Powerpoint, have the students point to the right bottles.
4. Give one solution to each group, some will get two if there are less than six groups.
Assign each group a station to start and have them follow the guide to practice lab skills and gain information about their solution. After each group has finished with their station, have them move on to the next one. While the students are doing lab work, put up the computer passcode Powerpoint and the safety diamonds image.
5. Safety diamonds:
Once all groups have gone through all of the lab sections, they will have the information needed to solve the safety diamond puzzle. *“It seems like you all have figured out your unknowns - we don’t have a procedure or any information on her goals yet. Maybe she keeps some notes on her computer? We’re locked out of it, unfortunately, but maybe something in her lab can help you get in.”* You may need to specify that the correct passcode is all lowercase.
6. Reveal that the remainder of class will be competitive. Provide the groups with the luminol structure puzzle, email signature, and research paper. Groups are allowed to work

through the puzzles in any order. Assist with the process as needed without providing unnecessary guidance.

7. When a group is finished with the two puzzles, they may come up and receive the procedure, and choose a dye. At this point, the group has “won,” and you should inform them of this. Give the team a copy of the procedure. Either students can perform the reaction with your help, or on their own.
8. Finally, when a group has finished their research paper, check their work, and if they are correct, give them their prize.

Solubility Station:

- Students will determine the solubility of the unknown in water, as well as the color of the final solution


Flame/Decomposition Station:

- Students will determine the fire color when the unknown burns, and whether residue is left behind


Unknowns Master List:

- Unknown 1: Na_2CO_3
- Unknown 2: VOSO_4
- Unknown 3: NaCl
- Unknown 4: CuSO_4
- Unknown 5: CaSO_4
- Unknown 6: $(\text{NH}_4)_2\text{CO}_3$

Chemical Name	Precautions	
acetic anhydride	Flammable liquid and vapor. Harmful if swallowed or inhaled. Causes skin burns and eye damage. Handle carefully and inform instructor if there are any complications	
sodium bicarbonate	May be harmful or cause irritation if inhaled or ingested. Can cause irritation, redness, and pain in case of eye and skin contact	Solid
MTBE	Very hazardous if inhaled or ingested. Can cause irritation, redness, and pain in case of eye and skin contact	Organic
ethyl acetate	May cause respiratory irritation and allergic skin reaction. Harmful if swallowed	Organic
	May cause dizziness, nausea, and headaches if inhaled. Causes skin and eye irritation	Organic
	Causes skin and eye irritation. Can also cause nose and throat irritation if inhaled	Organic
potassium permanganate	Inhalation can cause lung, nose, and throat irritation. Can cause skin and eye irritation	Aqueous
sodium chloride (brine)	Contact with skin and eyes may cause irritation. Ingestion and inhalation cause irritation and dehydration	



sulfuric acid	Causes severe skin burns and eye damage, may cause respiratory irritation	
	Causes serious eye irritation	Organic Solid



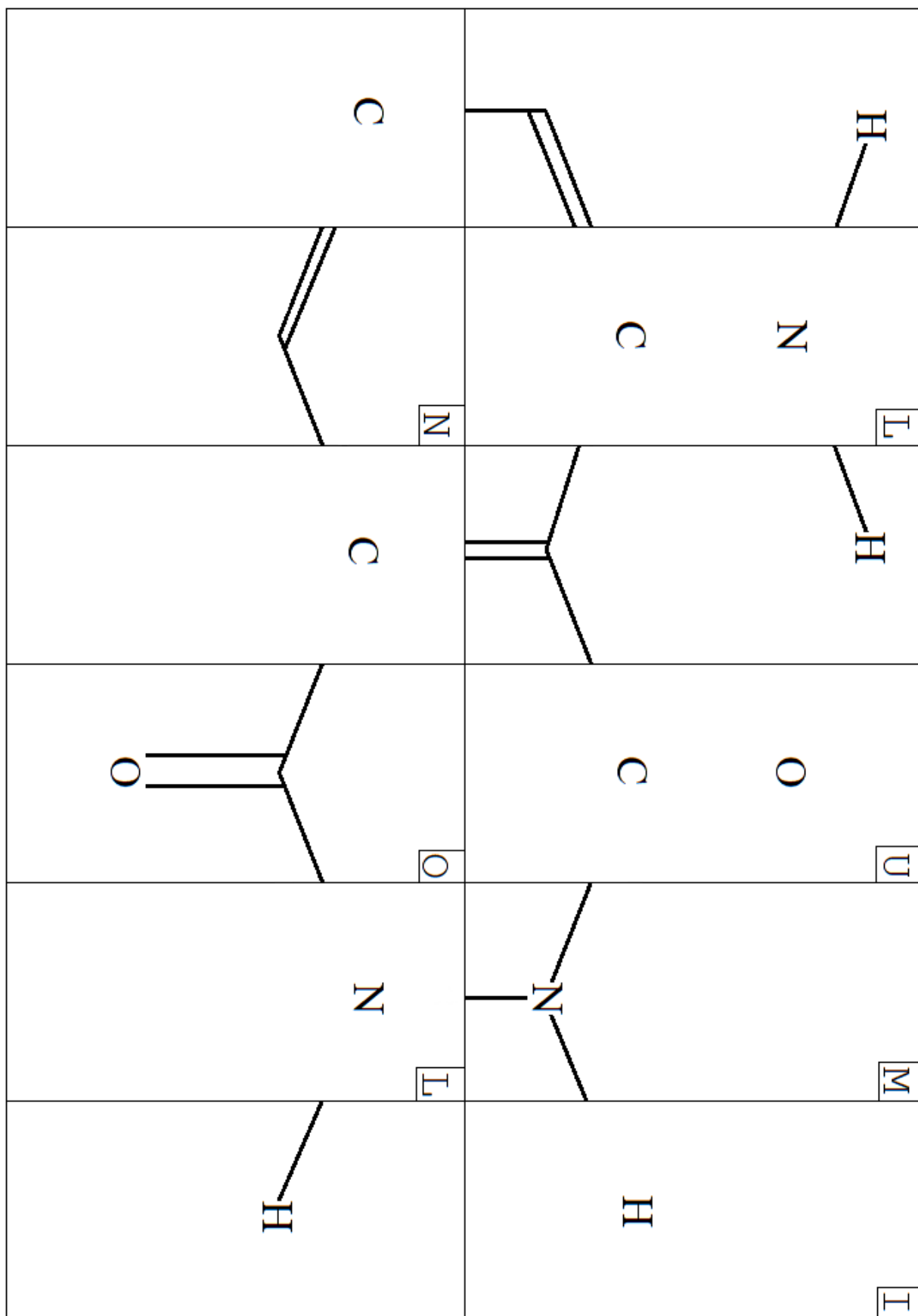


6



Answer: C





On her desktop she has a bunch of small images labeled “struc_1” to “struc_12”. I’ve printed them out for you to take a look out - hopefully you’ll be able to make sense of them.

Formula	Flame	Decomposition	Solubility
NaCO ₃	Yellow	Residue	Great, Bubbles
VO ₄	Yellow	Residue	Great
NaCl	Yellow	Residue	Poor
CuSO ₄	Green	Residue	Great
CaSO ₄	Red	Residue	Bad
(NH ₄) ₂ CO ₃	Red	Completely	Great

While you’ve been working with those images, I’ve been snooping around her computer a bit more. She’s been emailing frequently with someone who she refers to by first name - John. Unfortunately none of her emails have a last name and the name that comes up on the email also doesn’t have a last name. He always signs his emails with a strange signature though. Once again, it’s your job to figure out who this “John” is in hopes that he might know something.

“To solve my signature, you must connect all the highlighted hydrogen atoms together.”

N **H** N H H O O **H** H **H** O N O **H** H **H** H O O O **H**
H O H O H O H O H O H **H** H O H O H O H H H
H O N C H N O **H** H O H O H O H O H O O O H
N O H H H O H O H O H O H O O H H O N
H N O **H** H N O **H** H N O N O O H O H O O O H
H O H H H O H H H O H H H H H O H O H H N
H N O O O N O O O N O O O O O N O O N O O

1. Mix 50 mL H_2O_2 (3% sol.) in 1 L water.
2. Mix .2 g of the main unknown, 4.0 g Unknown 1, .4 g Unknown 4, and .5 g Unknown 6 in 1 L water.
3. Combine the two solutions.

Dr. Simington was experimenting with _____ (chemical formula: _____).

The first solution used was a _____ M solution of _____ in water. The

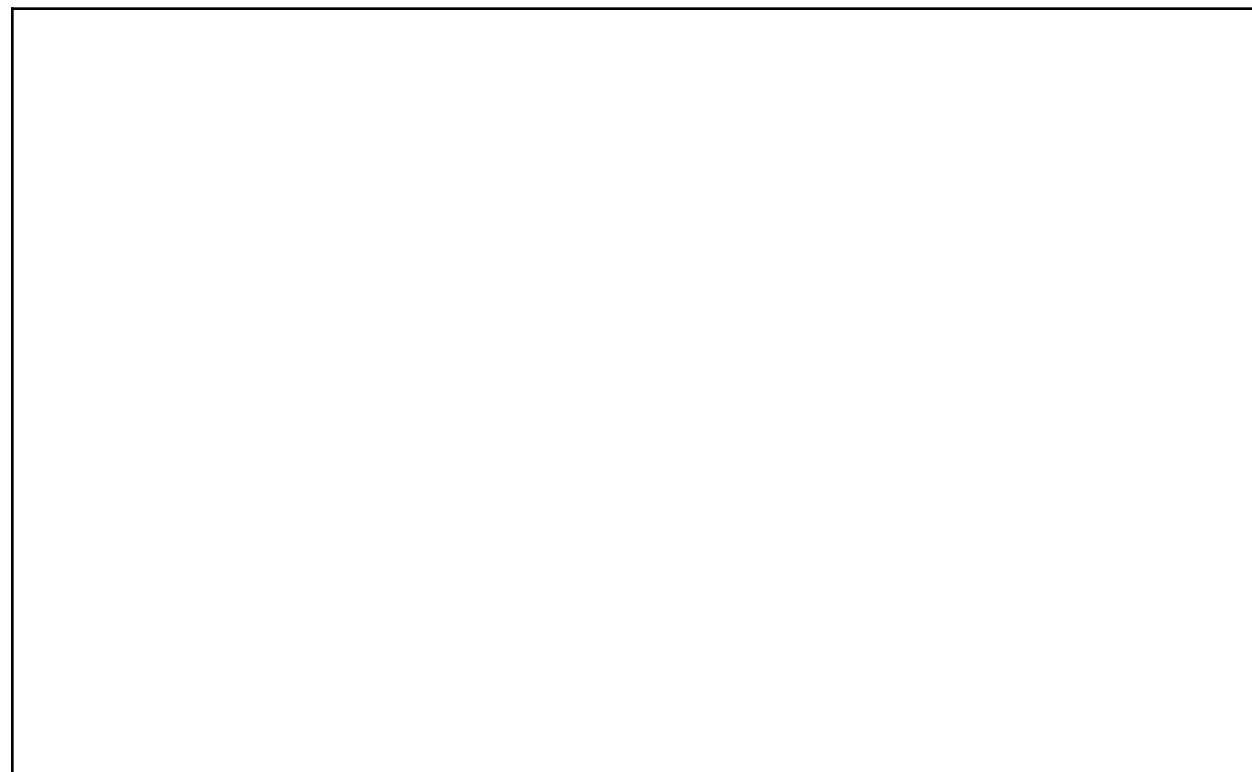
second solution was _____ mol _____, _____ mol

_____, _____ mol _____, _____ mol

_____, and several drops of _____ dye dissolved in 1 L water. Then, the two

solutions were combined and the result was that _____

_____.



The structure of her main chemical

We should be able to find out more about her research by contacting Dr. _____.

Cheat Sheet:

Waste Puzzle Solution:

AQUEOUS	ORGANIC	SOLIDS
Potassium Permanganate	MTBE	Sodium Bicarbonate
Sodium Chloride	Ethyl 6-acetoxyhexanoate	[mystery solid material]
Sulfuric Acid	Acetic anhydride	
	[mystery organic material]	
	[mystery organic material]	
	[mystery organic material]	
3	6	2

Post-its Solution

	unknown 4	unknown 3
	unknown 2	
	unknown 6	
unknown 5	unknown 1	







Note: Students may assemble this flipped 180.

Lab Puzzle Solution:

	Solubility	Flame	Decomposition	Chemical Formula
Unknown 1	Great, Bubbles	Yellow	Residue	NaCO ₃

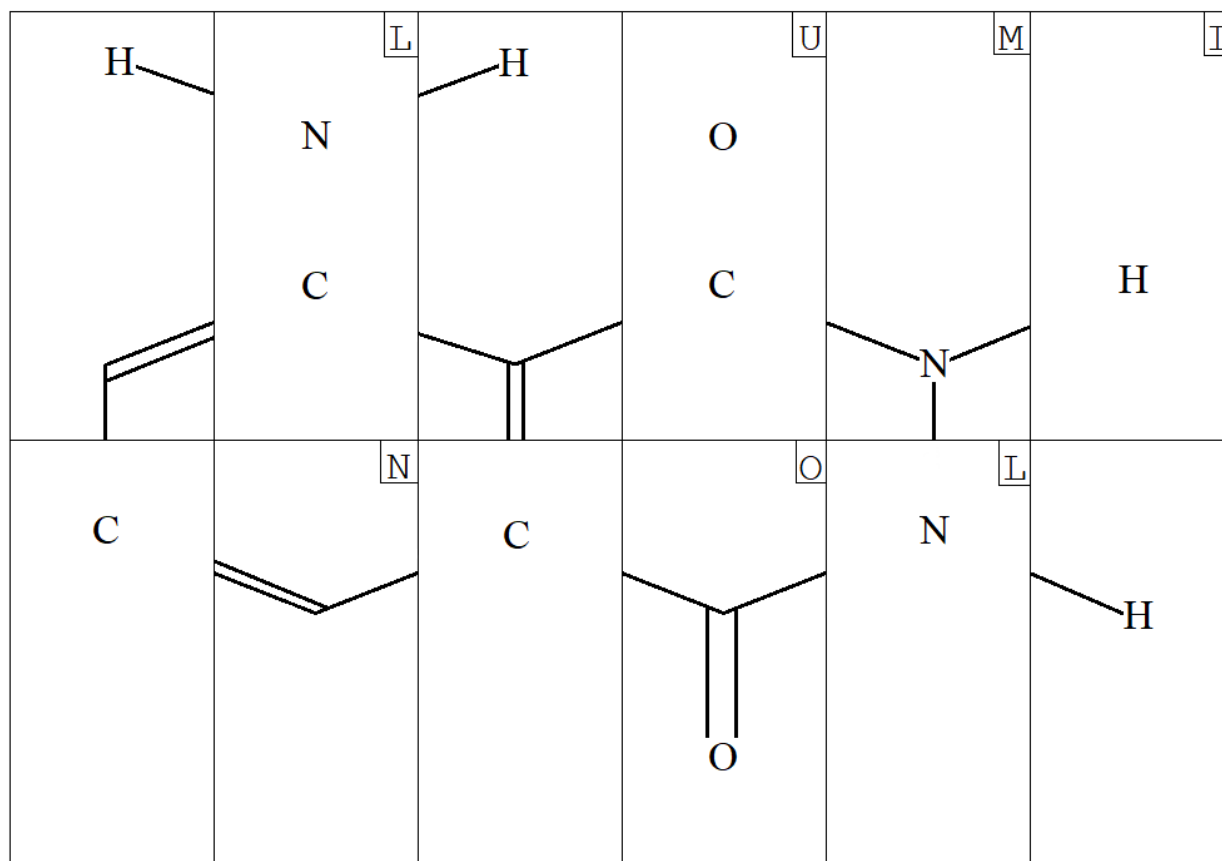
Unknown 2	Great	Yellow	Residue	VOSO_4
Unknown 3	Poor	Yellow	Residue	NaCl
Unknown 4	Great	Green	Residue	CuSO_4
Unknown 5	Bad	Red	Residue	CaSO_4
Unknown 6	Great	Red	Completely	$(\text{NH}_4)_2\text{CO}_3$

Safety Diamond Puzzle Solution:

Unknown 1	NaCO_3		Yellow Pages	9
Unknown 2	VOSO_4		Red Carpet	2
Unknown 3	NaCl		Yellowjacket	2
Unknown 4	CuSO_4		Blue Moon	6
Unknown 5	CaSO_4		Yellow Brick Road	9
Unknown 6	$(\text{NH}_4)_2\text{CO}_3$		Red Cross	8

6,79,22,8,92,16 → CAuTiOUS

Luminol Structure Puzzle Solution:



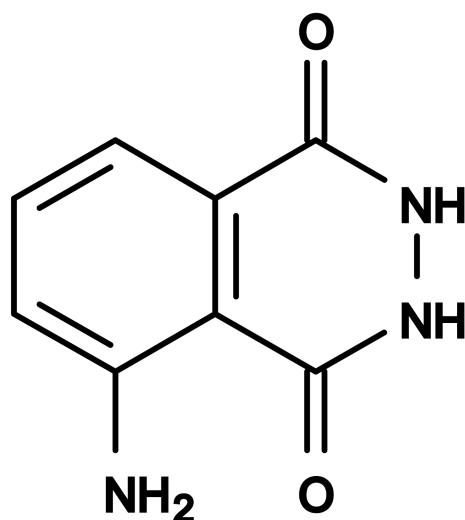
Atomic Structure Puzzle Solution:

To figure out the name of our collaborator, you must connect all the highlighted hydrogen atoms together. Keep in mind that Hydrogen can bond to only one other atom, Oxygen can bond to two, Nitrogen can bond to three, and Carbon can bond to four.

LEWIS

Mad Libs Research Paper Solution:

Dr. Simington was experimenting with **Luminol** (chemical formula: $C_8H_7N_3O_2$). The first solution used was a **.05 M** solution of H_2O_2 in water. The second solution was **.00113 mol Luminol**, **.0377 mol Na_2CO_3** , **.00251 mol $CuSO_4$** , **.00640 mol $(NH_3)_2CO_3$** , and several drops of **varies based on team** food coloring dissolved in 1 L water. Then, the two solutions were combined and the result was that **the solution glowed (in color determined by dye)**.



can be rotated/flipped

The structure of her main chemical

We should be able to find out more about her research by contacting Dr. **Lewis (or John Lewis)**.