Exploring the World of Science

University of Michigan Science Olympiad
2021 Invitational Tournament

Forensics C

Test length: 50 Minutes

Team name: _____

Team number: _____

Student names: _____

Forensics C

University of Michigan Science Olympiad Invitational
February 20, 2021

Hi everyone and welcome to Forensics! Please make sure to read through the crime scene scenario and case notes before attempting any questions. Please also make sure to read the questions to completion as there may be additional information within the questions. Lastly, in order to maintain testing integrity, we ask that you please do NOT google any questions or use the Internet in any way. Thank you and have fun!

A Few Reminders:

1. DISCLAIMER: You do not need any prior knowledge of the characters or the scenario; it will not help you in any way. Instead, use only the information provided to answer the questions :)
2. The first tiebreaker is the subscore for Section E (Crime Scene Analysis). Subsequent tiebreakers will be the subscores for Section A (Qualitative Analysis), D (Physical Evidence), B (Polymers), and C (Chromatography), in that order.
3. Time is **not a tiebreaker!!**

Following the competition, this test will be posted publicly on the scioly.org Test Exchange. If it has not been posted within two weeks, I have probably just forgotten, and you can remind me at shamis@umich.edu.

Scenario:

In the year 2120, ten astronauts are sent to space and dropped into the roles of crew members aboard a spaceship, completing various maintenance tasks for the organization they're working for, MIRA. While this space travel adventure seems simple enough, the crew members are quickly met with dismay, as they learn of a shape-shifting impostor among them, crawling through the vents of the ship (something only the impostor is capable of) and killing innocent crew members.

Once Cyan stumbles upon Yellow's mutilated body in the security area (in front of the television cameras) of the ship, she hears the vent open but immediately reports the body to the others, holding a meeting before anyone else dies. After five deaths and with five crew members remaining, they all reason the impostor is one of them, and to ensure the safety of all, one must be voted out.

However, they still don't know who the impostor is! We need you to help to put together all the pieces of evidence, because one wrong vote can lead to the death of all. So, can you figure out who's sus?

1. **Black**: A mysterious member of the ship who seems to always be alone. When he first was chosen as one of the crew members, he was visibly distant from the others, possibly due to his nervousness. Moreover, during the emergency meetings in the past, Black has said to be by themself, completing their tasks without a care about who the impostor is. While he has been 'sussed' (accused) in the past, White has said they believe Black is clear. But, who knows? It's possible that Black is simply just trying to gain the trust of the fellow crew members.

    a. Blood Type: AB+
    b. Pet(s): While working in the deep, dark areas of the ship, Black has made friends with some of the bats (that happened to live there to no one's knowledge); he even named one of them!
    c. Outfit: Black cotton sweater with red fleece beanie
    d. Location: He has struggled to finish his tasks, as all of his have been labor-intensive. Black has insisted that he started this journey by refurbishing the old, broken parts of the ship using paint and adhesives. After, he went to refuel the ship with the motor oil bottles at two separate locations (Upper Engine and Lower Engine); but, before he can finish this task, he has needed to convert the motor oil to gasoline using pyrolytic techniques in Storage.

2. **Red:** Possibly one of the interrogative members on the ship. Red has constantly deflected the attention off of himself and accused others. To make matters worse, up until this round, Red was seen completing tasks with Yellow. While he does seem the most guilty at the moment, he exclaims “he would never kill the person who trusts him the most!” Or would he?

    a. Blood Type: A-
    b. Pet(s): Before being recruited by MIRA, Red was an avid equestrian, spending almost all his free time horseback riding. His clothes, as such, have been covered with horse hair, which is a bit of a concern to some of the members (like Cyan) as she has a severe allergy.
    c. Outfit: Red polyester jumpsuit with a plunger as a hat
    d. Location: After splitting off from Yellow this round, he started by heading down to the Electrical area of the ship to fix the wiring and divert the power elsewhere. Once complete, Red went to the left side of the ship to finish the time-consuming Reactor task, where he needed to start up the reactor by slowing down the nuclear fission reactions.

3. **White:** Although she gives off an intimidating look with her scary mask, White has been described as the “kindest and most loyal member of the ship.” She has stated countless times that she “finished her tasks ages ago and has nothing left to do.” Now, as she goes around trying to find the impostor, others are starting to question if she ever did complete her tasks and if her personality is two-faced.

    a. Blood Type: O+
    b. Pet(s): While White sat in the Cafeteria eating her snacks, she noticed some hungry squirrels that wandered onto the ship. As a result, she decided to share some of her trail-mix with them.
    c. Outfit: White linen dress with cream colored sun hat
    d. Location: Because she finished her tasks so quickly, White has not done much lately. Since she has finally gotten a break, she decided to head to the Cafeteria (after making one quick trip around the left side of the map) to eat a snack—a sweet and salty trail mix packaged in a sandwich bag along with a slice of cake she baked the night before. As she is hypoglycemic, White also kept track to make sure her blood-sugar levels did not drop, taking glucose pills along with her snacks to keep her in check.

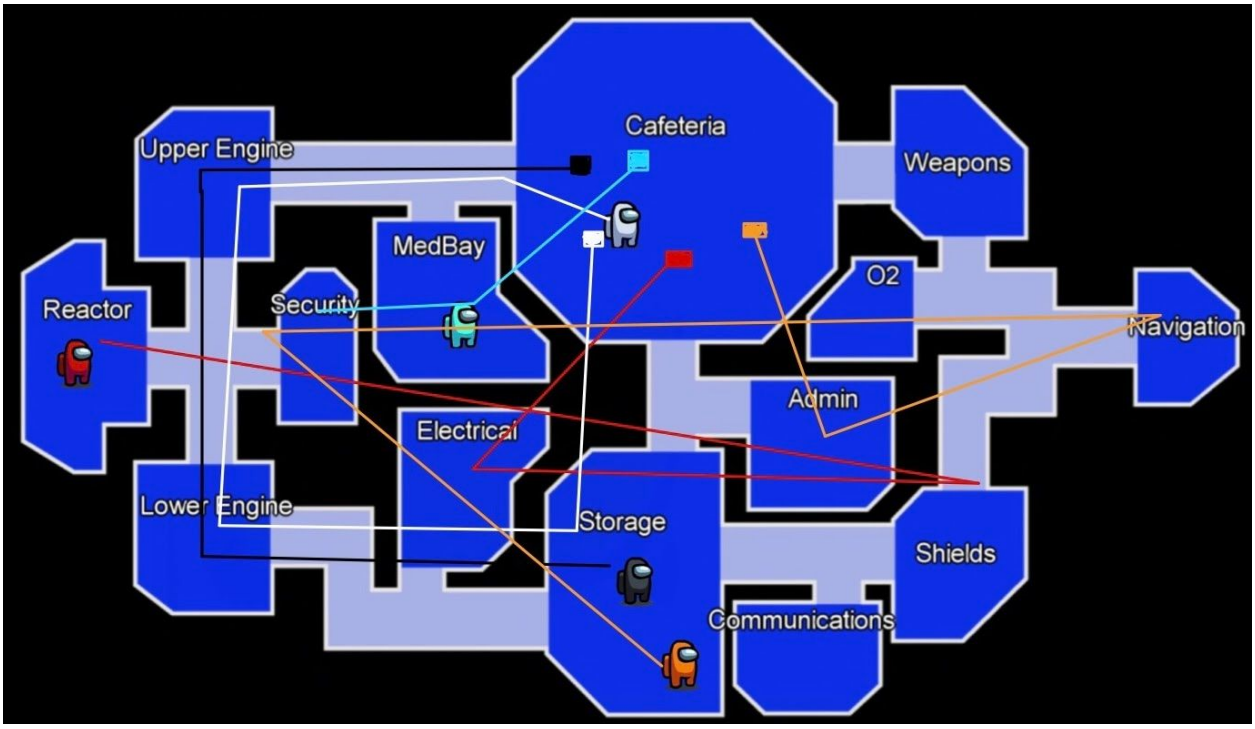
4. **Cyan:** Even though Cyan did report the murder, that doesn't mean she isn't a suspect. Frantic in nature and known to take medication for her bipolar disorder, Cyan has been seen to run around aimlessly by others, not completing a task. But, she insists she's "just trying to find bodies and catch the impostor." And, now, after discovering her third body in a row, the others are wondering if it's just a coincidence or a self-report.

    a. Blood Type: B+
    b. Pet(s): Out of all the crew members, Cyan is definitely not a pet-person (though she does have a gold-fish)! She is severely allergic to horses and was extremely afraid when she heard of the squirrel and bat friendships some of the members made around the ship.
    c. Outfit: Light blue spandex leggings with white coat and stethoscope
    d. Location: Cyan has spent most of her time waiting in the Medical Laboratory. She was required to sort the liquid samples, which were composed of a potassium chloride solution. After doing so, she went to the Security cameras, in hopes of catching the impostor red-handed but was horrified once seeing another crewmate lay dead there with a note on their forehead.

5. **Orange:** Last but not least, Orange has been the quietest of the group thus far. He has attributed his lack of speaking to his fear of being accused as the impostor. But, some believe that makes him even more guilty and that he has reason to kill Yellow. In the past, Orange was found hanging out with his best-friend Pink (a fallen crewmate); however, after Yellow falsely accused Pink of venting (something only an impostor is capable of) and she was voted off, he lost his only friend and now has spent the rest of the time by himself. So, was Yellow's death merely driven by revenge and hatred or simply a smart play by the impostor?

    a. Blood Type: B-
    b. Pet(s): In addition to Cyan, Orange has no pets, but that is probably due to his grief over Pink's death still. One thing to note is that Orange kept a few locks of her hair, possibly to remember her but still odd nonetheless.
    c. Outfit: Orange polyester coat with pumpkin hat
    d. Location: He has spent the last round finishing his download/upload task at, travelling all around the ship (from Cafeteria to Admin) to do so. As such, he has needed to extract the data from CD discs in order for the ship to function. After, he decided to take the garbage out by releasing it into space at Storage.

However, still hung-over Pink's death and his extreme work-load, Orange ended his day by taking medication for an intense migraine.



*Note: The boxes represent starting points of all the crewmembers

A. Qualitative Analysis

The crew members were able to recover 9 powders found on the left-side of the ship, the side where the body was located. As such, you are required to find the identity of these powders and state if they implicate any suspects.

There are nine powder analysis videos embedded in Scilympiad for you to analyze. In these videos, we will perform all the needed tests (Solubility, HCl, Flame, Benedicts, Iodine, NaOH, etc.) for you to examine as if you were in the lab performing the tests.

Powder	**Location**
A	Found at the cafeteria tables right outside the hallway to go to MedBay
B	Found on top of the scanner in MedBay

C	Found in the hallway outside of Reactor
D	Found on top of the vents that connect Electrical to Security
E	Found right in front of the cameras in Security
F	Found on top of the vents in Upper Engine
G	Found by the boxes and canisters in Storage
H	Found by the lab equipment in MedBay

1. Identify the powders [5 pt each]. Provide the full name of the compound (no chemical formula!):
    a. Powder A:
    b. Powder B:
    c. Powder C:
    d. Powder D:
    e. Powder E:
    f. Powder F:
    g. Powder G:
    h. Powder H:

2. Relate each of the powders to their suspect(s), if there are any. [5 pt each]:
    a. Powder A:
    b. Powder B:
    c. Powder C:
    d. Powder D:
    e. Powder E:
    f. Powder F:
    g. Powder G:
    h. Powder H:

Supplemental Questions:

1. What element has a tendency to contaminate flame tests? [4 pt]
    a. Sodium

b. Potassium
c. Carbon
d. Lithium

2. Write the balanced chemical equation for the reaction between sodium bicarbonate and hydrochloric acid. [6 pt]

3. Describe the relationship between electrical conductivity and pH. [4 pt]

4. Of the powders that were identified at the crime scene, which is the most acidic? [5 pt]

B. Polymers: Fibers, Plastics, and Hairs

The crew members found a variety of polymers scattered around the left side of the ship, ranging from fibers to plastics to hair. Some plastics, fibers, and hairs may implicate no one; in that case, write no one in the blank; conversely, they may implicate multiple crew members.

Plastics

The plastics found around the body were most likely used in the various tasks crew members had to complete. But, as small pieces, it's difficult to determine the identity by mere inspection. So, you decide to run water displacement and flame tests to find what type of plastic each might be.

Plastic	Location
Sample A	Found by the download/upload task outside of Security
Sample B	Found before the hallway between Lower Engine and Electrical, specifically by the vents
Sample C	Found by the hallway leading down from Upper Engine
Sample D	Found by the vents in Reactor
Sample E	Found by the lights in Electrical

Sample	**Corn Oil**	**46% IPA**	**Distilled H_2O**	**10% NaCl**	**25% NaCl**	**Saturated NaCl**	**Flame Test**
Plastic A	Sink	Sink	Float	Float	Float	Float	Burns rapidly and drips; gives off little smoke
Plastic B	Sink	Float	Float	Float	Float	Float	Becomes translucent when burnt and gives off small amount of smoke
Plastic C	Sink	Sink	Sink	Sink	Sink	Sink	Bubbles first then drips and gives off yellowish flame
Plastic D	Sink	Sink	Sink	Sink	Float	Float	Melts slightly and gives off orange flame with black smoke
Plastic E	Sink	Sink	Sink	Sink	Sink	Sink	Self-extinguishes and green flame

1. Identify the 5 plastics (give abbreviation ONLY) [2 pt each]:
    a. Plastic A:
    b. Plastic B:
    c. Plastic C:
    d. Plastic D:
    e. Plastic E:

2. For each of the following plastics, fill in the blank [2 pt each]:
    a. Plastic A likely implicates ____.
    b. Plastic B likely implicates ____.
    c. Plastic C likely implicates ____.
    d. Plastic D likely implicates ____.
    e. Plastic E likely implicates ____.

Supplemental Questions:

1. What is the difference between LDPE and HDPE and what are some of the uses for each of these two plastics? [2 pt]

2. Of the plastics identified at the crime scene, which one(s) can char? [2 pt; no partial credit]

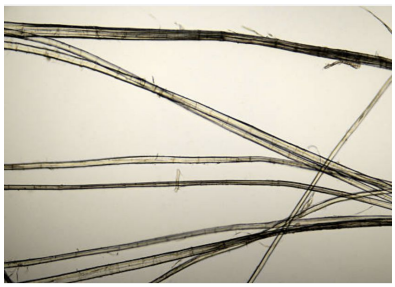
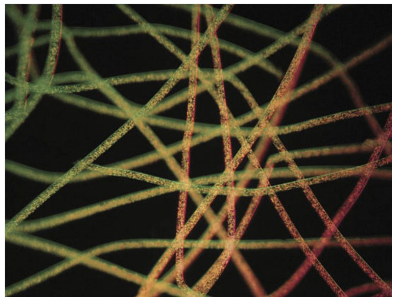
3. Of the plastics identified at the crime scene, are any of them considered condensation plastics? If so, which one(s)? [2 pt; no partial credit]

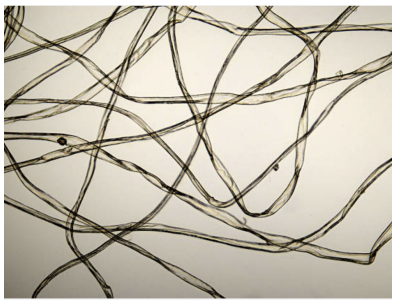
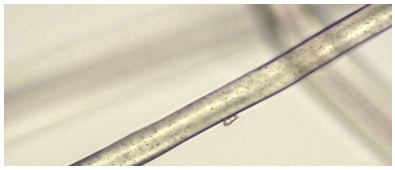
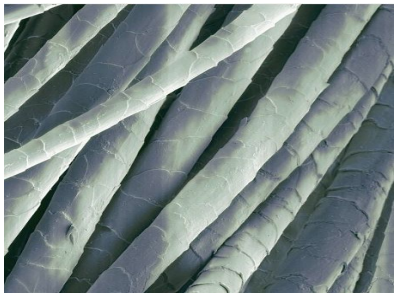
4. Which of the plastics identified above are polar molecules? [2 pt; no partial credit]

5. True or False: **All** of the Forensics plastics are thermoplastics [2 pt]

Fibers

In addition to the plastics, traces of random fibers were found by the crew members scattered around the left side of the ship. Using the table below, identify each fiber presented and who it implicates.

Sample	Location	Burn Test	Microscope
Fiber A	Found on top of the vents that connect MedBay to Security	Burn to ash quickly with a smell of burnt paper	
Fiber B	Found in the hallway leading from Storage	Melts into a hard sphere and gives off an unpleasant smell	

Fiber C	Found in front of the cameras in Security	All of the fiber burns out quickly and turns into ash with minimal smell	
Fiber D	Found on top of the vents in Security	Fiber burns rapidly and melts into a sphere giving off a dark smoke	
Fiber E	Found in the lower part of the Reactor area	Fiber curls and balls up into ash giving a burning hair smell	

1. Identify each of the fibers using the table above [3 pt each]
   a. Fiber A:
   b. Fiber B:
   c. Fiber C:
   d. Fiber D:
   e. Fiber E:

2. Based on the above information, which fibers appear to be implicating, and who does each one implicate? [3 pt each]
   a. Fiber A appears to implicate ____
   b. Fiber B appears to implicate ____
   c. Fiber C appears to implicate ____
   d. Fiber D appears to implicate ____
   e. Fiber E appears to implicate ____

Supplemental Questions:

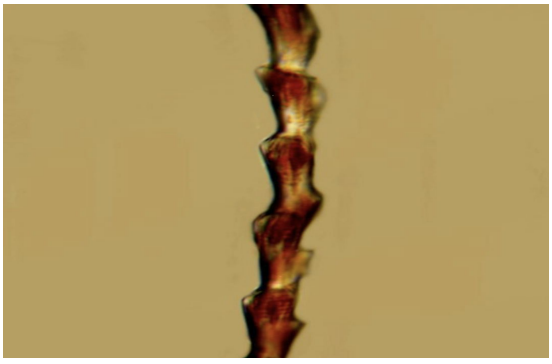
1. Of the fibers identified, which of them are synthetic fibers? [2 pt; no partial credit]
    A. Polyester
    B. Linen
    C. Cotton
    D. Nylon
    E. Spandex
    F. Wool

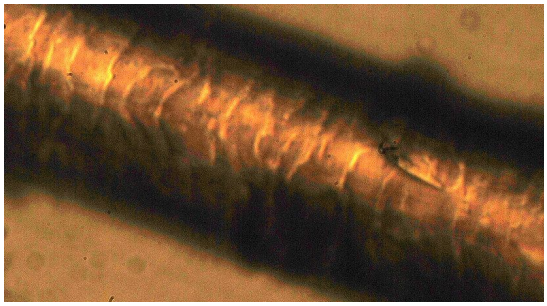
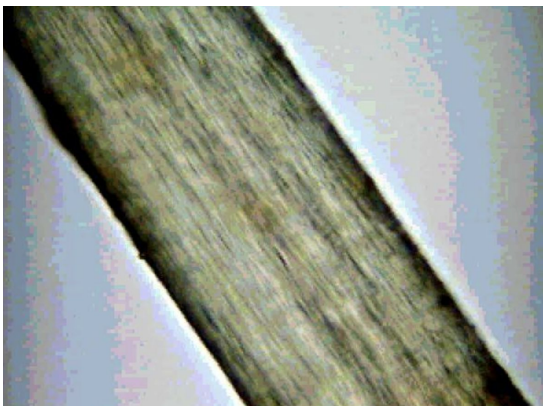
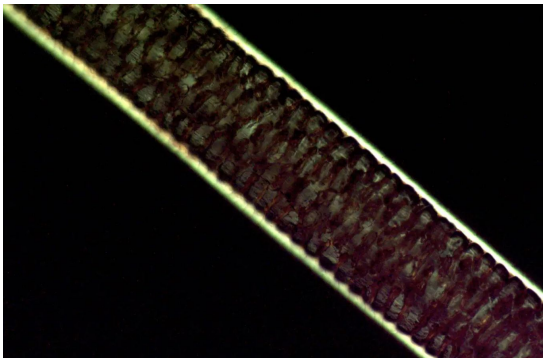
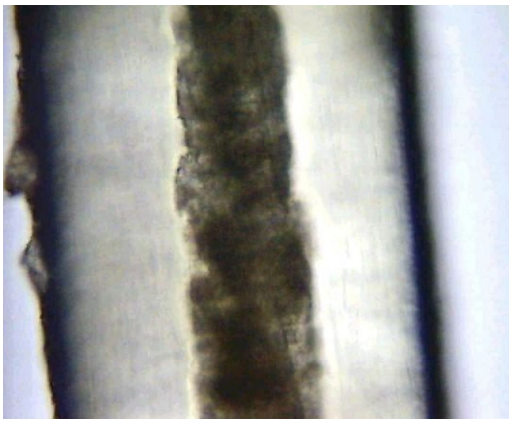
2. How do synthetic and animal fibers react to heat? [2 pt]

3. Why do animal fibers react strongly to bases in contrast to synthetic or plant fibers? [3 pt] *Include a description of the molecular composition of each of these fibers and an example of a base that could react with animal fibers

Hair

Lastly, crew members took images under a microscope of the five pieces of types of hair found from the left side of the ship. They seem to be of various types of animals, but they need you to match each accordingly and find if they implicate a suspect.

Hair	Location	Microscope
Hair A	Found by the refueling station in Upper Engine	

Hair B	Found by the empty bins in Storage	
Hair C	Found in front of the cameras in Security	
Hair D	Found scattered around the benches in Cafeteria	
Hair E	Found in the hallway between MedBay and Upper Engine	

1. Identify the hair presented in [2 pt each]
    a. Image A:
    b. Image B:
    c. Image C:
    d. Image D:
    e. Image E:

2. Based on the above information, which fibers appear to be implicating, and who does each one implicate? [2 pt each]
    a. Hair A appears to implicate ____
    b. Hair B appears to implicate ____
    c. Hair C appears to implicate ____
    d. Hair D appears to implicate ____
    e. Hair E appears to implicate ____

Supplemental Questions

1. How were you able to distinguish between the hair cross sections in Image C and Image E? [3 pt]

2. In most parts of the hair, what type of DNA is most easily extracted? [2 pt]

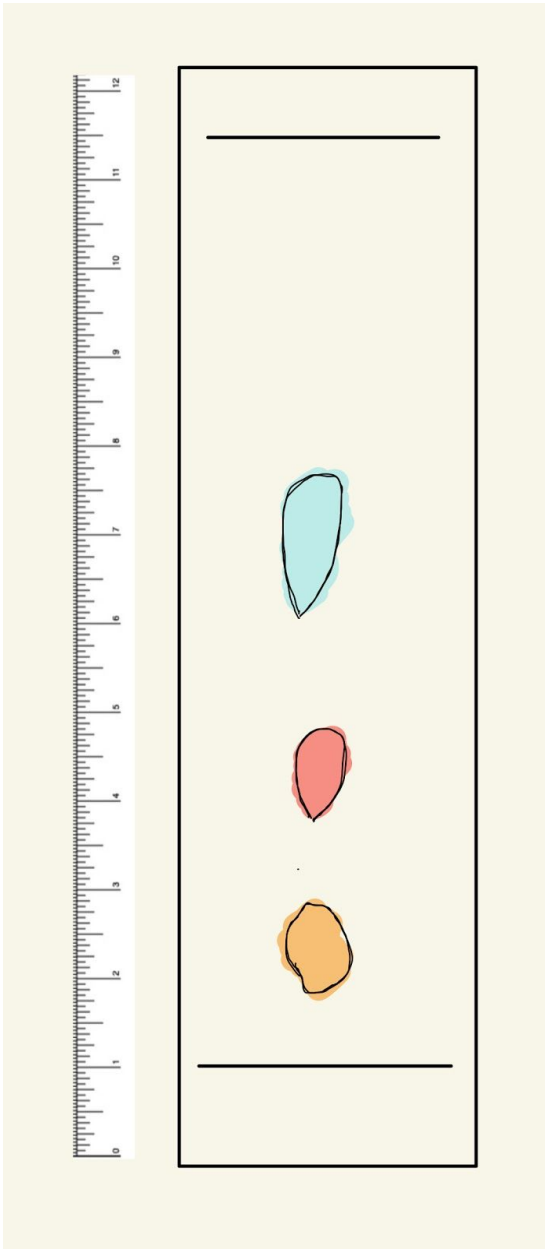
3. What macromolecular feature contributes to the wide variety of hair shapes? [2 pt]

C. Chromatography and Mass Spectroscopy

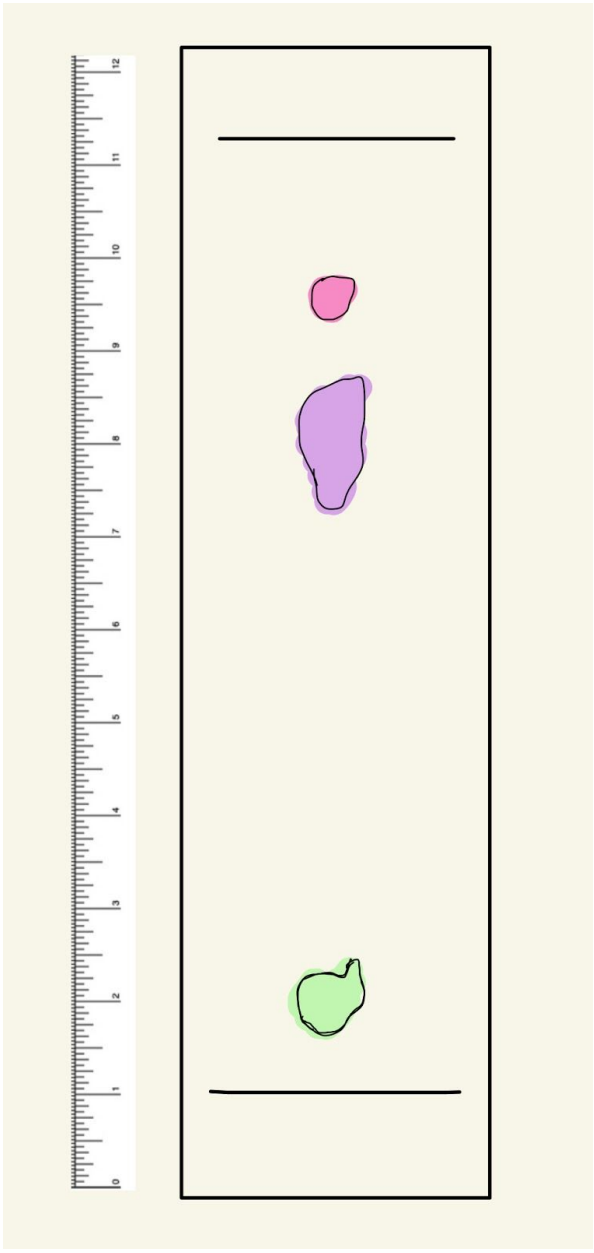
Chromatography:
When Cyan found Yellow's body, she also noticed that there was a note left on top of her forehead with the following scrambled sentence (4 words):

yidrmdnryt1efbaee

From inspection of the note, the crew members found that there were two different types of ink/pens used. But, they realized they could trace the note back to the impostor by running a chromatography of the ink used. Answer the questions about the chromatograms below, using the rulers provided for you:



Pen A



Pen B

1. To two decimal places, calculate the R_f of all spots on both chromatograms. (need to give ± 0.05) [5 pt per entry]
    a. Pen A:
        i. Red:
        ii. Blue:
        iii. Orange:
    b. Pen B:
        i. Light Green:
        ii. Violet:
        iii. Pink:

2. Three suspects, Red, Cyan, and White, all had pens collected from them. Red's pen had an R_f of 0.63, Cyan's pen had an R_f of 0.87, and White's pen had an R_f of 0.56. Whose pen matches up most closely to the spots on either the A or B chromatograms? [5 pt] *Note: there may be more than one person

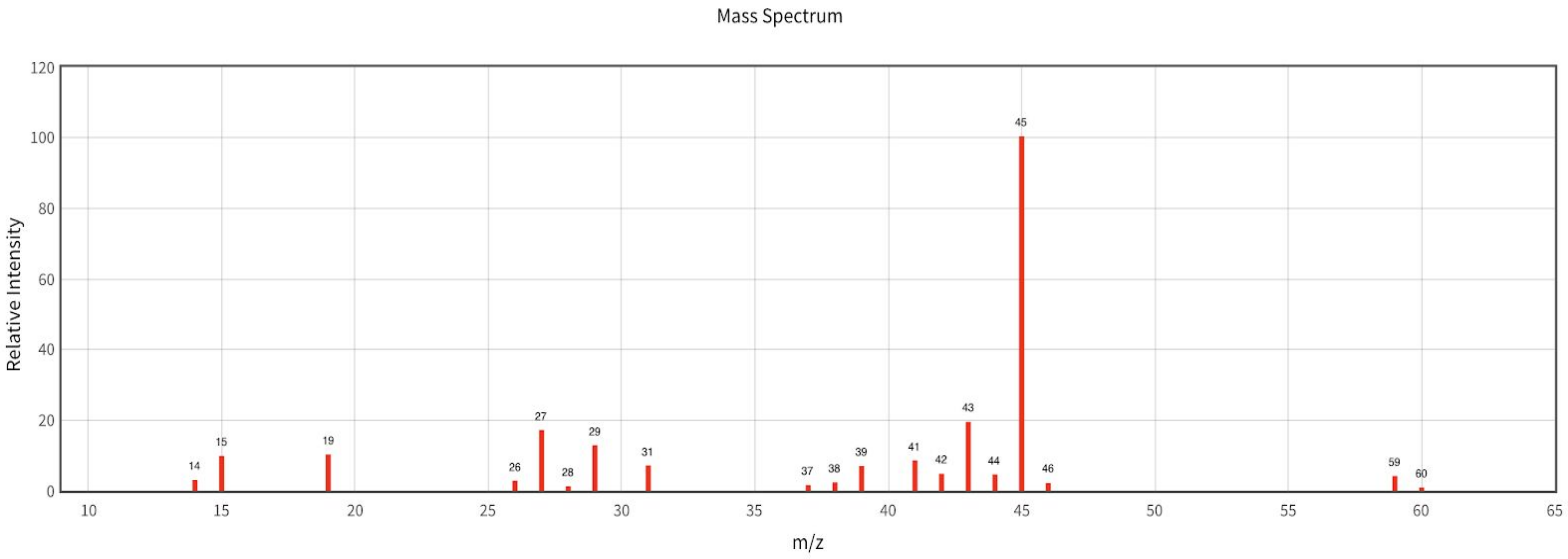
3. [BONUS] What does the secret message say? [1 pt]

Supplemental Questions:

1. To undergo thin-layer chromatography, an important preliminary step is to set ____ ____ conditions. [4 pt]
2. As a follow-up to the previous question, what are the two most common compounds used in these conditions and why? [4 pt]
3. True or False. The visualization method used in TLC impacts the R_f of a compound. [2 pt]

<u>Mass Spectroscopy:</u>

In addition to the other pieces of evidence, the crewmates notice a pungent smell coming from a colorless liquid found on the ground. Just to be safe, they decide to run a sample in the mass spectrometer in the medical laboratory. Answer the following questions below about the mass spec:



1. What is the molecular weight of the compound? [5 pt]

2. The intermittent fragmentation shown in the mass spec suggests what atom is getting added to form the larger product? [5 pt]

3. Identify the base peak in this mass spec. [4 pt]

4. What additional atom is added to this molecule to give the complete structure? [5 pt]

5. What is the name and chemical formula of this compound ? [5 pt]

6. Using the information above, is this compound likely to implicate one of the suspects? Why or why not? [6 pt]

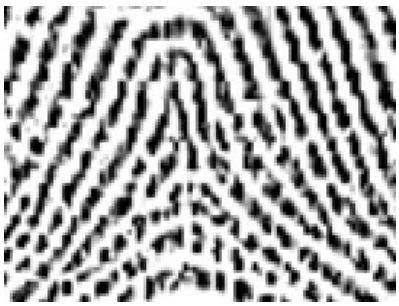
D. Physical Evidence

Fingerprinting

As any good detective would do, the crewmates decide to scan the security area for fingerprints, picking them up on the television screens, keyboards, and floor of the security room. They then also took the fingerprints from each crewmember's right hand to compare with those found at the crime scene

a) The television screens are made of glass.
b) The keyboards seemed a bit dirty and greasy, most likely due to a crew member eating in the room.
c) The floor of the security room was covered with multiple liquids, particularly the one identified in the mass spectroscopy section.

Fingerprint A - Crime Scene	
Fingerprint B - Crime Scene	
Fingerprint C - Crime Scene	

Fingerprint D - Black	
Fingerprint E - Red	
Fingerprint F - White	
Fingerprint G - Cyan	

Fingerprint H - Orange	

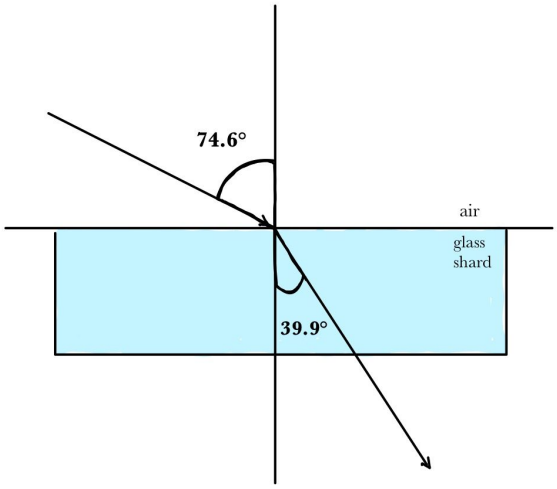
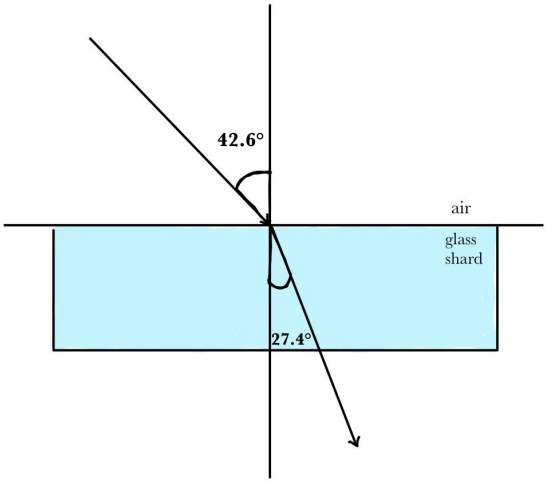
1. What type of fingerprinting technique should be used to take fingerprints at each of these locations? [9 pt; 3 pt each]

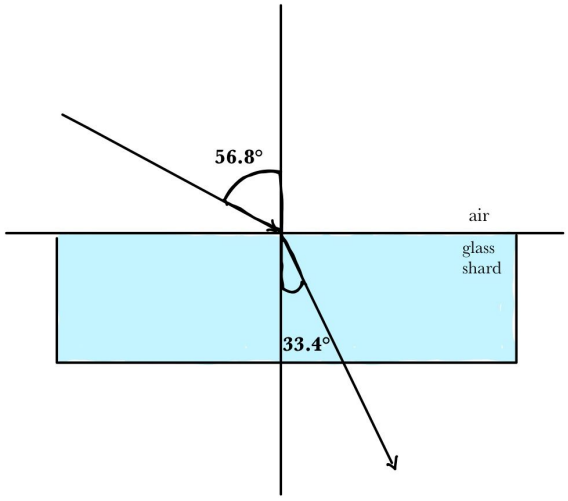
2. After finding Prints A-C at the three areas, it is determined they are all from the right hand of the impostor. With this, prints from the right hand of all the crew members are taken as well. Identify each type of fingerprint and be as specific as possible. [4 pt per fingerprint]
    a. Print A:
    b. Print B:
    c. Print C:
    d. Print D:
    e. Print E:
    f. Print F:
    g. Print G:
    h. Print H:

3. Who do Fingerprints A, B, and C implicate? Note: It is possible a fingerprint does not implicate anyone. [3 pts. total; 1 pt per correct answer]
    a. Print A:
    b. Print B:
    c. Print C:

Glass

Around Yellow's body, the crew members also found glass shards everywhere (possibly due to bullets ricocheting and hitting something). However, what they found weird was that the glass shards were not consistent, meaning they all came from a different location.

Glass	Refraction Graph
Glass A	
Glass B	

Glass C	

1. Calculate the index of refraction of glass shards A, B, and C. [3 pt each]
    a. Glass A:
    b. Glass B:
    c. Glass C:

2. Identify each type of glass. [3 pt each]
    a. Glass A:
    b. Glass B:
    c. Glass C:

3. Based on where the body was found (security room), which of the three types of glass makes most sense to come from that room? [3 pt]
    a. A
    b. B
    c. C

Blood:

Blood typing of the blood sample found at the crime scene was done and you find the following results shown below (spotty blood represents agglutination)

Anti-A Anti-B Anti-D

1. What is the blood type of the sample? [3 pt]

2. Who does the sample implicate, if anyone? [3 pt]

    a. If the sample does not implicate anyone, where did the blood most likely come from? [2 pt] *Note: Answer N/A if the blood sample implicates someone.

E. Analysis

Circle the suspect(s) you believe you should hold for questioning:

Black Red White Cyan Orange

Justify the name(s) you did circle and refute the name(s) you did not circle If you circled more than one name, include who you believe to be the prime suspect in your analysis.