

2019 Forensics Test

After months of planning, Billy Bill's family finally started a long-anticipated trip to the beach. His parents, little brother, and **pet bat (bat hair)** came along, and they all piled into the family car. After fifteen hours of sleeping, munching on **salt and vinegar potato chips (Sodium Acetate)**, and **eating cookies (sucrose)**, they reached the golden sands of the beach. However, the weather was extremely rainy, so they were unable to immediately hit the waves. Because of the inclement weather, Billy Bill's family chose to head over to the hotel and unpack their belongings first. They had the usher bring in their luggage from their car, and put them on the floor of the hotel lobby. They then took half their suitcases upstairs to their room after checking in, and went downstairs to get the other half. Billy Bill opened one of the suitcases that were left downstairs to get out his **polyester jacket (polyester)** when he suddenly shouted,

“Oh my gosh, our suitcases are empty!”

Someone had picked the locks, disappeared with half the family's belongings, and only left a note that read, “Y'all are suckers, watch your stuff better next time”. The hotel staff was immediately notified of the crime, and the police quickly rushed to the scene. Unfortunately, the security cameras were currently in maintenance and did not record anything useful. However, an old woman walking by reported that she saw someone run out of the hotel and into a car while clutching a full garbage bag not too long ago. She was unable to name the license plate, but fortunately the police were able to recover tracks that had not been washed away by the rain.

A set of muddy footprints were recovered from the scene that were tracked all around the suitcases. The mud-like soil from the footprints was also collected for analysis. A mass spec was done on the powders collected from the scene, and paper chromatography was done for the ink used to write the note. Powders, fingerprints, hair, and fibers were also collected from the crime scene.

The main suspects have been determined to be the usher, the man who was rooming next to them, the desk clerk, and the security camera repairman. It's your job as the chief detective to find out who committed this theft and help the Bill family save their vacation. Good Luck!

The following is other evidence recovered from the scene:

- Powders **U1 (from Billy's family)** and **U2 (from Billy's family)** were found on the note
- Fingerprints **U1 (Billy's)** and **U2 (Joey's)** were found on the suitcase zippers
- Hairs **U1 (Billy's)** and **U2 (Joey's)** were found on the suitcases
- Fibers **U1 (from the suitcase)** and **U2 (from Joey)** were recovered from the inside the suitcases

Suspects:

Name: Joey Joe

Job: Usher

Motive: Joey was annoyed that he had to bring the family's heavy luggage into the hotel by walking through the rain. Mud had also gotten on his new **wool (wool)** pants.

Alibi: Joey was warming up his hands with a **heat pack (sodium acetate)** after getting soaked in the rain. He was also having **heartburn (Sodium bicarbonate)** after drinking too much coffee. After moving their suitcases into the hotel, Joey went to go help the repairman fix some of the hotel's deteriorating **drywall (Calcium sulfate)**, but not before making sure his **pet bat (bat hair)** was safely inside his pen. He also chatted with Willy Will for a bit about their pets before going to help the repairman Sammy with the walls. After coming back from fixing the walls, Joey found out about the theft.

Evidence: Powders P1 and P2, Hair H1, and Fiber F1 were found on him. Joey uses Pen 3

Name: Willy Will

Job: Escape room manager

Motive: Willy was in the room next to the Bill family, and was annoyed that they were being so loud. Billy's little brother also stepped on his favorite **polyester shoes (polyester)**, getting them all muddy.

Alibi: Willy had a headache from working the entire day to clean all of the escape room lock picking kits, and was taking a bath with **epsom salts (Magnesium sulfate)** to relax. He took medication for his **bipolar disorder (Lithium Chloride)**, then chatted with the usher for a bit about their pets in the lobby before taking a walk with **pet horse (horse hair)** outside. When he got back to the hotel, he argued with the Bill family for half an hour about how loud they were before going back into his room.

Evidence: Powders P3 and P4, Hair H2, and Fiber F2, Willy uses Pen 2

Name: Molly Mo

Job: Hotel Clerk

Motive: Billy's family wiped their muddy shoes all over the newly polished lobby floors, which immensely irritated Molly, who had just paid the repairman Sammy to clean them.

Alibi: She was taking the recycling to the nearby recycling facility. She had to take her own car there because the hotel car had been invaded by **squirrels (squirrel hair)**. She had attempted to chase them out, but only ended up getting squirrel hair all over her **cotton uniform (cotton)**. She has a tendency to stress eat, and ended up eating all of the hotel's complimentary **cookies (sucrose)** after returning, as well as any leftover snacks in the kitchen.

Evidence: Powders P5 and P6, Hair H3, and Fiber F3 were found on her. Molly uses Pen 1

Name: Sammy Sam

Job: Repairman

Motive: Sammy was angry that Billy's family dirtied the floors he took hours to scrub and shine with his trusty **ammonium chloride** based floor cleaner.

Alibi: Sammy works part time at a **farm (cow and horse hair)**, and forgot to change out of his **denim overalls (cotton)** when he went to the hotel to work. He and Joey had a friendly conversation about his attire, then Sammy went to work on the cameras. Sammy was fixing the security cameras during the time when the theft occurred. He used some **eye drops (Boric acid)** because his eyes were irritated from staring at screens for too long.

Evidence: Powders P7 and P8, Hair H4, and Fiber F4. Sammy uses Pen 1

Qualitative Analysis: 17 points

1. Sodium Acetate (1)
 - a. Ionic (1)
2. Sucrose (1)
3. Sucrose (1)
4. Sodium bicarbonate or Sodium Hydrogen carbonate (1)
 - a. Carbonates (1)
5. Magnesium sulfate (1)
6. Lithium Chloride (1)
 - a. The increased temperature gives the electrons of the metal ions energy (excites them) (1) and allows them to move to higher energy orbitals. As they come back down to ground state, they give off visible light (1)- a line emission spectrum .
7. Sucrose (1)
8. Sodium Chloride (1)
9. Ammonium Chloride (1)
 - a. Fireworks, Fertilizers, Dry cell batteries, Medical treatments, textile printing (1 point for each use, up to 2 points)
10. Boric acid (1)
 - a. H_3BO_3 (1)

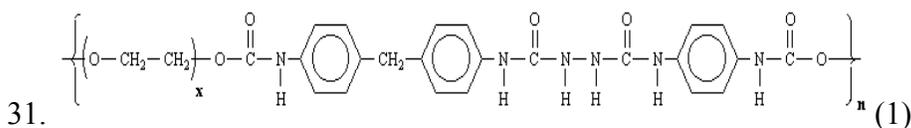
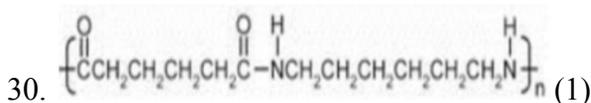
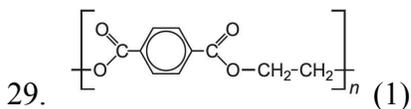
Hair: 13 points

11. Human (1)
12. Bat (1)
13. Human (1)
14. Human (1)
15. Squirrel (1)
16. Cow (1)
17. Medulla, Cuticle, Cortex (2)
18. Shaft (1)
19. The follicular tag/the root (1)
20. Anagen (1)
21. 50 full length hairs from the scalp (1)
22. Imbricate (1)

Fibers: 14 points

23. Polyester (1)
 - a. Clothes, ropes, sails, conveyor belts, safety belts, coated fabrics, plastic reinforcements, etc (1 point for each use, up to 2 points)
24. Wool (1)
 - a. Gabardine, mohair, serge, tweed and worsted, blankets, horse rugs, carpeting, insulation, etc (1 point for each use, up to 2 points)

25. Wool (1)
 26. Polyester (1)
 27. Cotton (1)
 28. Cotton (1)



32. Wool is acidic and bleach is basic. Wool dissolves in bleach due to an acid base neutralization reaction. (1)

Chromatography: 15 points

33. 0.8, 0.6, 0.2 (1)
 34. 0.8, 0.6, 0.2 (1)
 35. 0.5, 0.3 (1)
 36. 0.6, 0.4, 0.1 (1)
 37. Retention factor or Rate of flow (1)
 38. Pen 1 (1)
 39. Molly Mo and Sammy Sam (2)
 40. Paper (1)
 41. Normal-phase chromatography has a polar stationary phase and a nonpolar mobile phase (1). Reverse phase chromatography has a nonpolar stationary phase and a polar mobile phase (1).
 42. Mikhail Tsvet (1)
 43. Thin layer chromatography (1)
 a. Detect pesticide residues in food, analyze dye composition of fibers, separation of pharmaceutical formulations, separation/identification of colors, preservatives, sweetening agents, cosmetic products, etc (1 point for each use, up to 2 points)

Fingerprints: 18 points

44. 4-6 (2)
 45. Dermis/corium (1)
 46. 100-200 strands (1)
 47. Whorls, loops, arches (1)
 a. 60-70% loops, 25-35% whorls, 5% arches (1 point for each in the percent range, up to 3 points)

- 48. Small Particle reagent (1)
- 49. It is destructive/corrosive (1)
 - a. Silver nitrate reacts with the salt in most fingerprints (1). It forms silver chloride, which can be seen as visible dark traces under a UV light source. (1)
- 50. Tented arch (1)
- 51. Radial loop (1)
- 52. No one (1)
 - a. none (1)
- 53. Joey Joe (1)
 - a. Right hand ring finger (1)

Mass Spectrometry: 11 points

- 54. 437 atomic mass units (1)
- 55. 361 atomic mass units (1)
- 56. Mass over charge (m/z) (1)
- 57. Relative abundance (1)
- 58. Joey Joe (2 points)
- 59. A presumptive test determines either that something is not a certain substance or probably is a certain substance (1). Confirmatory tests confirm the analysis (1). Mass spectrometry is considered a confirmatory test (1).
- 60. Hard ionization has large degrees of fragmentation (1). Soft ionization has little fragmentation. (1)

Soil: 6 points

- 61. Sandy Loam (1)
- 62. Loam (1)
- 63. Sand (1)
 - a. 0.06-2 mm (1)
- 64. O, A, E, B, C, R (1)
- 65. Calcite (1)

Analysis: 57 points

- a) Joey Joe, Sammy Sam, and Willy Will (5 points for each correct suspect, 20 points for the exact answer, no penalty for missing suspects, 3 point deduction if Molly Mo was put as a suspect)
- b)
- Joey, Sammy, and Willy had similar motivations (dirty mud tracked in by the Bill family)- 2 points
 - No calcium sulfate was found on Joey Joe, so he probably wasn't "fixing the wall"- 2 points
 - Furthermore, it doesn't line up with Sammy Sam's alibi- 3 points
 - The sodium acetate found on the suitcases could implicate Joey Joe since he was using a heat pack- 1 point
 - However, the family was eating chips with sodium acetate in the car, meaning that it can be disregarded- 2 points
 - The sucrose found on the suitcases could incriminate Joey Joe and Molly Mo- 1 point (half credit for only stating one of them)
 - However, sucrose on Molly could have been easily picked up during her cookie eating- 2 points
 - The salt found on Molly is also not surprising for the reasons stated above- 2 points
 - Joey's job was to move the suitcases, so the sucrose found on him could have been from sucrose already on the suitcase (the Bill family was eating cookies). Thus, this evidence can be disregarded- 2 points
 - The mass spec matches Joey- 1 point
 - Polyester was found on Joey Joe- 1 point
 - Although, there were polyester clothes stored in the suitcase that may have left polyester fibers on the outside- 2 points
 - However, Joey's job was to move the suitcases, so that makes sense- 2 points
 - With the same logic, the wool found on the suitcases (likely from Joey's pants) can also be disregarded- 2 points
 - The wool also could have been from clothes stored inside the suitcases- 1 point
 - Willy couldn't have taken his horse on a walk because it was raining outside- 3 points
 - This is supported by the fact that horse hair was not found on him- 2 points
 - The tracks indicate that Molly was the one in the car driving away with the garbage bag, but this didn't necessarily have to be related to the crime- 3 points
 - The squirrel hair found on her also matches her alibi- 2 points
 - Joey's fingerprint was found, as well as an unknown fingerprint (likely Billy's)- 1 point

- This doesn't necessarily incriminate him since he had to move the suitcases- 1 point
- The human hair on the suitcases can be disregarded since it could belong to the family. Also, multiple humans (such as Joey) have also handled the suitcases - 1 point
 - The bat hair could incriminate Joey Joe, but it could have been from the family bat. Also, (again) Joey was supposed to handle the suitcases at one point- 2 points
- The muddy footprints don't necessarily incriminate anyone since everyone went to the lobby. They also don't match any of the suspects, and could belong to other hotel guests- 3 points
 - The composition of the soil found at the scene implicates Joey Joe and Sammy Sam- 1 point.
 - However, the region that this scenario takes place in is at the beach, so it makes sense for them to have sandy soil (in this case, sandy loam) on their shoes- 2 points
- The paper chromatography matches Sammy and Molly's pen- 2 points
- All evidence is circumstantial- 1 point
- Overall, the most incriminatory evidences are the misaligned alibis- 2 points

Extra section (not graded):

Crime Explanation- Sammy, Willy, and Joey were in cahoots to commit the crime. They were in communication with one another, as can be seen from the alibis. Sammy Sam shut off the cameras at the time of the crime. Willy distracted the family in order to keep them from going downstairs during the crime. Joey Joe committed the actual theft.