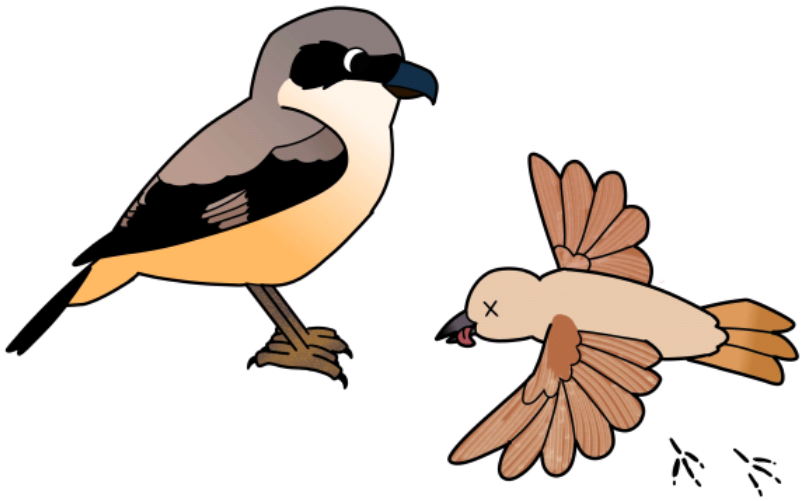


BirdSO Invitational - Forensics

Christina Kasch Camille Zhang Claire Kim

December 18, 2021

Directions:

This test has 94 questions, 360 points, and is 50 minutes long. If you are taking too long on one question or section, don't hesitate to move on - we do not expect every team to complete the test.

- All answers should be spelled correctly, and fill-in-the-blank questions should be answered with **one word** unless specified otherwise.
- This test was written for the **National level** rules.
- This exam is open-note. This does **not** mean open-Internet; looking up information online is strictly prohibited.
- You may use any of the materials outlined in the Science Olympiad Division C Rules Manual 2021-2022 for Forensics.

Team Number: C-_____ Points (of 360):_____

The Crime Scene

It's that time of the year! Squid Game has begun again! This year, Squid Game is held on a small forest island. This time, the VIPs arrived early so they could watch the entire game. When they arrived, they all signed a non-disclosure contract so that Squid Game could remain hidden to the rest of the world. The first round has already taken place, where all the players had to choose a dish to eat during a banquet. However, the catch is some of the dishes are laced with copious amounts of insecticide! The surviving players went back to their quarters to rest and prepare for the next round. Each of them were given some bottled water to stay hydrated. Later that night, the Head of the game heard that there was a disturbance on the island. When bringing some guards to check it out, he noticed a trail of blood! Following that trail, he came to a discrete cave at the edge of the island. He noticed a large swarm of bats surrounding something, and when taking a closer look, he saw it was a dead body! It seems that during the night, Player 420 had been murdered! You are the Head's private investigator, and you must help him figure out who murdered this player so that the Head can punish them properly!

1. **Player 52**

   Apparently during the first round, Player 52 really wanted to eat the chocolate frosted brownies, but Player 420 grabbed and ate it before they could, and Player 52 ended up having to eat the salt and vinegar chips. Even though both ended up surviving, Player 52 was seen to be really upset about it and swore to make sure Player 420 would regret their actions. Player 52 has black hair and blood type O.

2. **Player 403**

   Player 403 ate a donut for the first round and survived. They then decided to form an allied group to help progress through the rest of the rounds. Player 420 was part of this group. However, word on the street says that they are known for betraying people, especially those they see as weak and worthless. Player 403 has dark brown hair and blood type O. Also, all players are dressed in athletic wear.

3. **Worker 15**

   Worker 15 helped prepare for the first round. They cooked and baked various foods, putting some in tupperware, while others were put in styrofoam takeout boxes. There were some drinks as well, served in jugs. They also were in charge of lacing some foods with insecticide. After the round was over, they had to help hose down the area for cleanup. Additionally, Worker 15 was one of the guards who came with the Head to inspect the disturbance. Workers must all wear a nylon jumpsuit and linen underwear. Worker 15 has black hair and blood type A.

4. **Worker 17**

   Worker 17 was one of the people serving the VIPs during the first round. Worker 17 was also assigned to help prepare the second round that night, which has now been revealed to be a "human sculpture museum", where the VIPs walk around a glass cage, and inside the cage are human sculptures made of marble and plaster, which are then painted with skin color paint to make them more lifelike. The game is that the players must blend in with the sculptures, and if movement is detected, they die. Worker 17 was found with a walkie talkie in their pocket. Worker 17 has dark brown hair and blood type B.

5. **VIP 4**

   VIP 4 has a history of losing bets on which player survives, and is always incredibly salty that VIP 2 seems to always win. This year, VIP 2 bet on Player 420. The other VIPs just dismissed VIP 4's behavior as a result of their bipolar disorder. VIP 4 was heard asking Worker 17 to fetch them a bottle of ketchup, as they were snacking on some fries while watching the games. It seemed that VIP 4 took a liking to Worker 17, and they were requested as a personal servant. Later, VIP 4 told the rest of the group that they had a headache, so they were going to shower and take a long bath to relax. VIP 4 has black hair, blood type A, and was wearing silk pants. It was also noticed that VIP 4 usually wore glasses but wasn't wearing them the next day.

6. **VIP 5**

   VIP 5 had claimed that they had history with Player 420 and hoped that they wouldn't survive the next round (also so they the player VIP 5 on would have a better chance). VIP 5 also noted that VIP 4 had accidentally bumped into them earlier when signing the form, making them drop their pen. VIP 5 reassured that VIP 4 was an unpredictable person (they came to the games riding a cow wearing sunglasses, which is what bumped into VIP 5 and made them drop their pen when signing the form), but a kind person, as they insisted on picking up and giving VIP 5 their pen back. VIP 5 has dark brown hair, blood type O, and was wearing a cashmere scarf.

7. **The Head**

   The Head of the games insists that they would not murder a player in order to maintain the fairness and democracy of the games. However, as they were a reporter of the body, they must be suspected as well. The Head said they were taking pills for high blood pressure when they were notified of the disturbance, and that when they got back, a mysterious walkie talkie appeared on their desk, and there were some batteries missing from their drawer, finding the walkie talkie's old batteries in their trash can. Additionally, there was some bloodied broken glass on the ground, with a ripped piece of paper next to it. The piece of paper seemed to have part of a signature on it from the non-disclosure agreement. The Head has dyed blonde hair, blood type AB, and was wearing corduroy pants.

1 Powders (46 points)

A total of 14 powders were collected from the 7 suspects. Powders 3-11 were also found in the cave, and powders 2, 10, 12, and 14 were found in the Head's office.

For questions 1-14, identify each corresponding powder in the table below (first blank - chemical name; second blank - chemical formula):

Sample #	HCl	Benedict's	Iodine	pH	Flame Test
Powder 1	NR	NR	NR	4	Bright green flame
Powder 2	NR	NR	NR	6	Glows, doesn't melt
Powder 3	fizzes	NR	NR	8	Glows, doesn't melt
Powder 4	NR	Turns red	NR	6	Orange flame, melts
Powder 5	NR	NR	NR	7	Yellow flame
Powder 6	NR	NR	Turns black	6	Burns
Powder 7	fizzes	NR	NR	12	Orange flame
Powder 8	fizzes	NR	NR	8	Orange flame
Powder 9	NR	NR	NR	6	Bright orange flame
Powder 10	NR	NR	NR	7	Violet flame
Powder 11	NR	NR	NR	6	Orange flame, melts
Powder 12	NR	NR	NR	7	Red flame
Powder 13	NR	NR	NR	8	Orange flame
Powder 14	NR	Turns dark blue	NR	5	Faint green flame

1. [2] Powder #1: _____ _____
2. [2] Powder #2: _____ _____
3. [2] Powder #3: _____ _____
4. [2] Powder #4: _____ _____
5. [2] Powder #5: _____ _____
6. [2] Powder #6: _____ _____
7. [2] Powder #7: _____ _____
8. [2] Powder #8: _____ _____
9. [2] Powder #9: _____ _____
10. [2] Powder #10: _____ _____
11. [2] Powder #11: _____ _____
12. [2] Powder #12: _____ _____
13. [2] Powder #13: _____ _____

14. [2] Powder #14: _____ _____

15. [3] What is the formula of the compound that gives the dark blue color when a certain compound is mixed with Benedict's reagent?

---

16. [3] Name the compounds that make Benedict's reagent.

---

17. [1] In the evidence table, what is a possible concentration of the powder in the solution that turned red during the Benedict's test?

---

18. [2] What color light does cobalt blue glass absorb? It is usually used to filter out what contaminant?

---

19. [3] Write the chemical equation of the reaction between HCl and CaCO3. Include states.

---

20. [3] Write the chemical equation of the reaction between NaOH and CaNO3. Include states.

---

21. [1] True or false: Lithium chloride has an exothermic heat of solution. _____

22. [1] True or false: Magnesium sulfate has an endothermic heat of solution. _____

23. [1] True or false: Ammonium chloride has an endothermic heat of solution. _____

2 Plastics (22 points)

The following plastics samples were collected from the suspects. Plastics 1-3 were found in the cave, and plastics 7-9 were found in the Head's office.

Use the plastics chart below to assist you in answering the following 2 questions:

Sample #	**Polymerization Type**	**Sliver Test Results**	**Saturated NaCl Float Test**	**10% NaCl Float Test**	**25% NaCl Float test**
Plastic 1	addition	powdery	Yes	No	Yes
Plastic 2	condensation	smooth	No	No	No
Plastic 3	addition	smooth	Yes	Yes	Yes
Plastic 4	addition	smooth	Yes	No	No
Plastic 5	addition	powdery	Yes	Yes	Yes
Plastic 6	condensation	smooth	Yes	No	No
Plastic 7	addition	smooth	Yes	Yes	Yes
Plastic 8	condensation	smooth	Yes	No	Yes
Plastic 9	addition	smooth	No	No	No

24. [10] Identify the unknown plastics by providing their abbreviated names (eg. PETE, N-66, LDPE, etc.) in the order in which they were presented as unknowns. If you believe a particular description could match multiple plastics, write it as such (eg. PETE/N-66/LDPE, PMMA/PC, etc.)

25. [3] Were there any descriptions that matched multiple plastics? If not, leave this question blank. If so, describe a test(s) for those groups of plastics that would allow you to differentiate between each plastic.

26. [3] Describe the process of conducting an acetone test, including how to interpret the results of the test.

27. [1] In a copper wire test, a green flame may appear. What does this color flame denote?

28. [3] Which of the following are true regarding thermoset plastics? Choose all that apply.
    A. In a sliver test, they will produce a powder
    B. They tend not to be recycled
    C. They can be reformed
    D. PETE, LDPE, and PC are all thermoset
    E. An copper wire test can indicate if a plastic is thermoset or thermoplastic

29. [2] Describe the primary difference between thermosetting plastics and thermoplastics.

3 Fibers (15 points)

The following fibers were collected from the suspects. Fibers 1, 3, 5, and 6 were found in the cave, while fibers 4 and 6 were found in the Head's office.

Sample #	**Microscope view description**	**Burn test remains**
Fiber 1	Smooth, bamboo-like	Grey soft ash
Fiber 2	Flattened scales on clustered fibers	Irregular hollow bead-like ash
Fiber 3	Long, smooth cylinder	Dark plastic Drippings
Fiber 4	Long, smooth cylinder	Irregular soft bead-like ash
Fiber 5	Long, smooth cylinder	Crushable dark plastic drippings
Fiber 6	Irregular twisted ribbon	Grey soft ash

30. [6] Identify the unknown fibers listing them in the order in which they were numbered (eg. 1, 2, 3, 4, etc. → wool, nylon, silk, polyester, etc.)

31. [1] Identify which of the unknown plastics make up polyester.

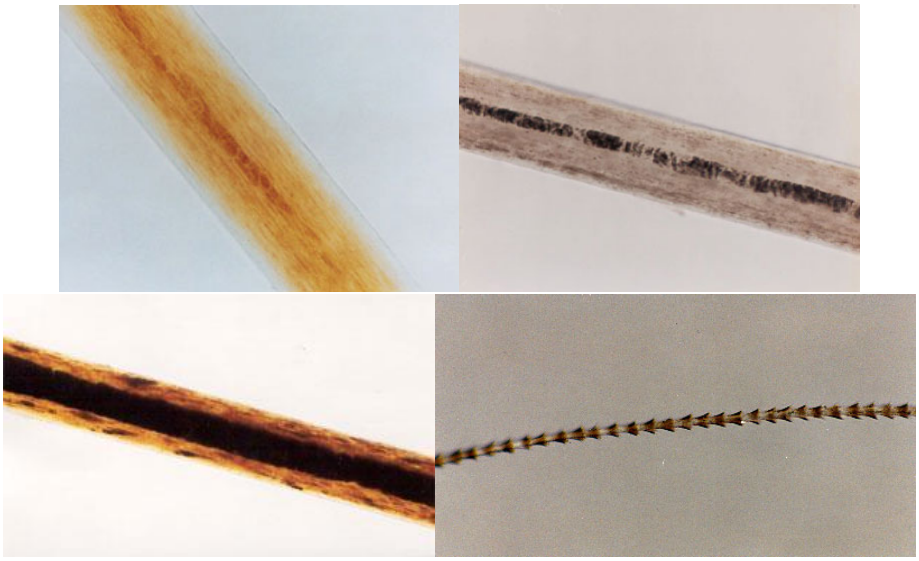
32. [3] Which of the following are true regarding HCl? Choose all that apply.
    A. Dissolves nylon
    B. Dissolves wool
    C. Dissolves cotton
    D. Dissolves linen
    E. Dissolves silk

33. [3] Which of the following are true regarding NaClO? Choose all that apply.
    A. Dissolves polyester
    B. Dissolves cotton
    C. Dissolves silk
    D. Dissolves linen
    E. Dissolves wool

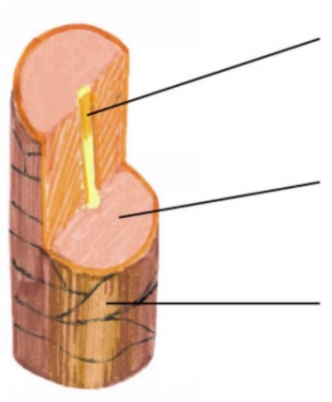
34. [2] How might you utilize the chemicals mentioned in questions 32 and 33 to determine an attribute about a particular fiber?

4 Hairs (28 points)

The first 2 hairs were both found at the cave, the 3rd hair was found in the Head's office, and the last hair was found on Worker 15, Worker 17, and the Head.

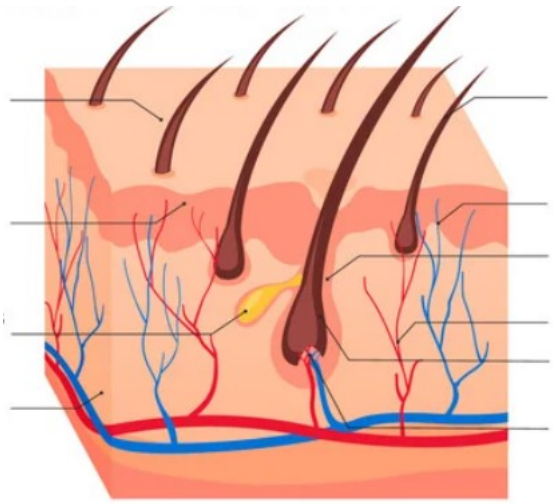


35. [12] Identify the 4 hairs above, and list at least 2 ways you can tell per picture.



36. [3] Label each part of the hair shown above.

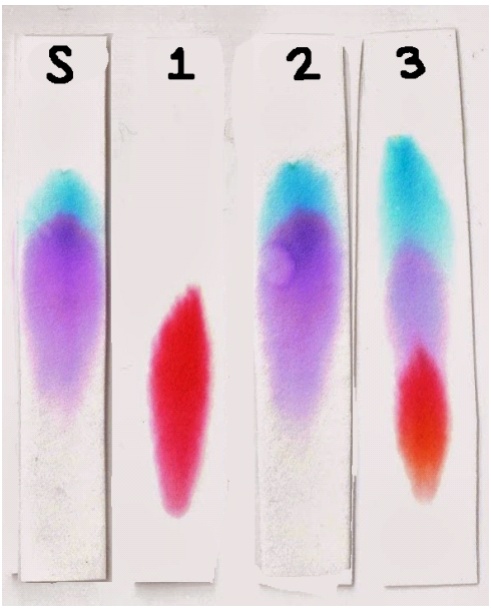
37. [3] Calculate the medullary index of the hair above, showing your work. What type of hair is this?



38. [10] Label each part of the diagram above, which depicts a hair follicle in the skin.

5 Chromatography (10 points)

Chromatography was performed using ink from the non-disclosure agreement (marked S) and ink from pens collected from the facility. Pen 1 was from VIP 4's pocket, pen 2 was from VIP 5's pocket, and pen 3 was from the Head's room.



39. [1] Which pen's ink matches the ink found on the agreement? _____

40. [1] Calculate the Rf for the ink in Pen 1, given that the ink traveled 4.7 cm from the origin and the solvent traveled 6.3 cm.

_____

41. [2] What causes pigments to separate as they travel up the stationary phase in paper chromatography?

_____

_____

_____

42. [1] True or false: Any liquid can be used as a solvent in paper chromatography. _____

43. [2] You perform paper chromatography using three pens and hexane as your mobile phase. The Rf you calculated for each pen was 0.3, 0.6, and 0.7. You perform the chromatography a second time, but you're out of hexane. You swap the hexane for diethyl ether, another non-polar solvent. Allowing the solvent to travel the same distance, would you expect the Rf for each pen to change or stay the same? Explain.

_____

_____

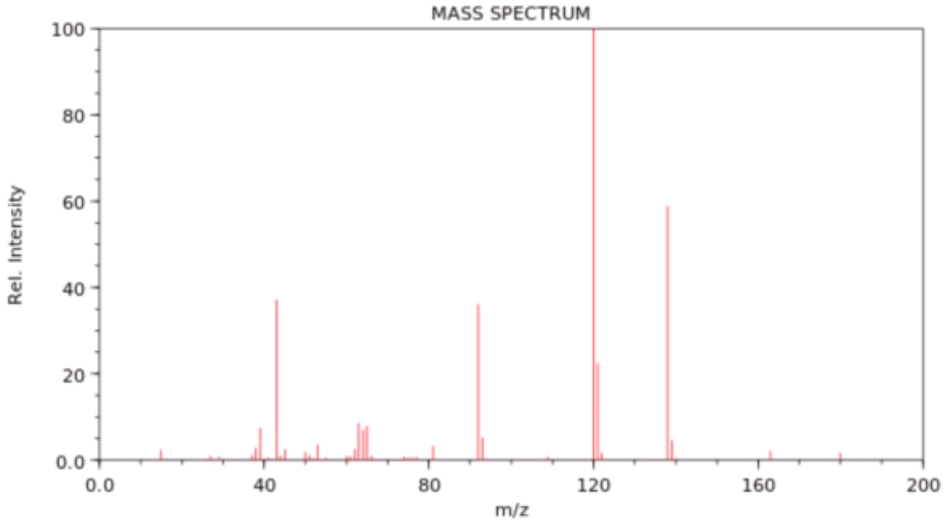
_____

44. [1] Fill in the blank: A Rf value will always be _____ 1. (1)

45. [2] Compare and contrast planar chromatography and column chromatography, listing one similarity and one difference.

6 Spectroscopy (10 points)

A sample found in the Head's office was analyzed using mass spectroscopy. Use the following mass spectrum to answer questions 49-54.



46. [1] What is the base peak? _____

47. [1] What is the total molar mass? _____

48. [3] What is the formula of the molecule? _____

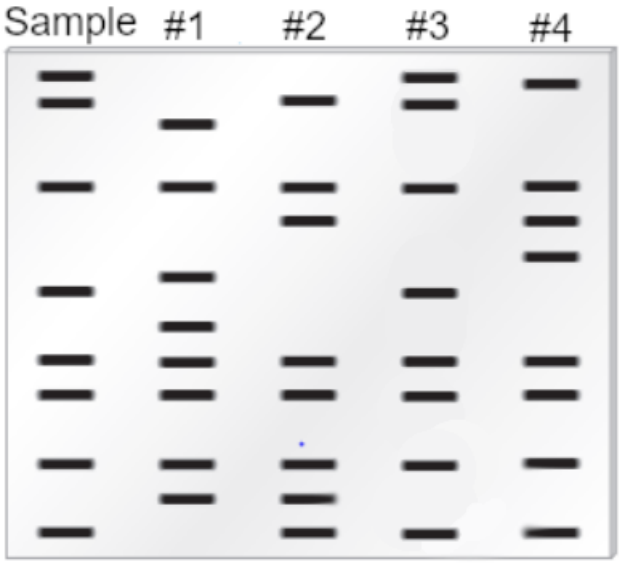
49. [3] Based on the formula, what is the total number of rings and double bonds that this molecule has? Show your calculations.

50. [1] What is the common name of this molecule? _____

51. [1] Name the 3 main components of mass spectrometry. _____ _____ _____

7 DNA (9 points)

DNA was collected from the scene and gel electrophoresis was performed with four different samples. The DNA from the scene was collected from the blood found in the Head's office. DNA samples were collected from the Head, Worker 17, VIP 4, and VIP 5 and labeled 1-4 (in that order).



52. [1] Which sample matches the DNA present at the scene of the crime? _____

53. [1] Gel electrophoresis is a laboratory technology used to order DNA fragments according to size. How can the size of these DNA fragments be measured?

_____

54. [1] True or false: DNA is negatively charged, so it is attracted to the positive electrode in gel electrophoresis. _____

55. [2] How are DNA nucleotides modified for use in Sanger sequencing? What effect does this have on the sequencing process?

_____

_____

56. [1] Define semiconservative in the context of DNA replication.

_____

_____

57. [2] Describe the use of restriction enzymes in forensic analysis, and their importance in DNA profiling.

58. [1] Fill in the blank: There are _____ nucleotides present in DNA.

8 Fingerprints (34 points)

A bloodied stick was found in the cave near the body and a fingerprint was lifted from it. Fingerprints 1-7 belong to the suspects in the following order: the Head, Worker 15, Worker 17, VIP 4, VIP 5, Player 52, and Player 403.

59. [7] Identify each of the fingerprints pictured above with as much specificity as possible. Note: all prints were taken from suspects' left hands.

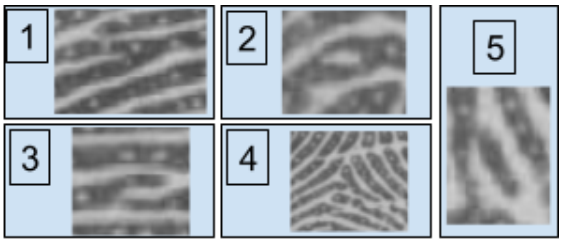
1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

60. [6] This was the fingerprint collected off the branch. Which of the fingerprints, if any, does this one match? If it does match one, specify at least 5 minutiae and their relative locations on each fingerprint that you used to determine that they matched.

_____

_____

_____



61. [5] Using the images above, identify each type of minutiae pictured.

    1. _____
    2. _____
    3. _____
    4. _____
    5. _____

62. [3] Name the three types of fingerprint formations. _____ _____ _____

63. [3] Which of the following is true regarding fingerprints? Choose all that apply.

    A. 50% of the population has loop fingerprints
    B. 25% of the population has whorl fingerprints
    C. 5% of the population has arched fingerprints
    D. Whorls have 2 or more deltas
    E. The average human adult has about 125 ridges on a finger

64. [1] True or false: There is a hereditary impact on fingerprint patterns. _____

65. [1] True or false: Cyanoacrylate fuming works well on porous surfaces such as cardboard and fabric. _____

66. [1] True or false: Prints developed using iodine are only temporary, so it is important to photograph the print for documentation before the print returns to a latent state. _____

67. [4] Describe the process of developing fingerprints through the use of ninhydrin.

_____

_____

68. [1] Which of the following would be most appropriate to collect fingerprints from a gun?

A. Iodine

B. Cyanoacrylate

C. Dusting

D. Ninhydrin

9 Blood and Spatters (8 points)

69. [1] Blood was collected from the glass in the Head's room and analyzed. It was treated with two serums: anti-A and anti-B. The blood sample did not react with the anti-B serum, but started clumping when exposed to the anti-A serum. What blood type did this individual possess? _____

70. [2] What process took place when the blood was exposed to the anti-A serum? Explain why this occurs.

_____

_____

_____

71. [1] The Rh and ABO blood typing systems are two of many blood typing systems used to describe the presence or absence of cell-surface antigens. If an individual is Rh positive, what antigen are they said to possess? _____

72. [1] Blood splatters were found on the wall of a cave. Calculate the angle of impact in degrees, given that a blood splatter has a width of 1.7 cm and a length of 3.2 cm. _____

73. [1] What is the probability that an individual with the genotype I^AI^B and an individual with the genotype I^Bi will have a child with type AB blood? _____

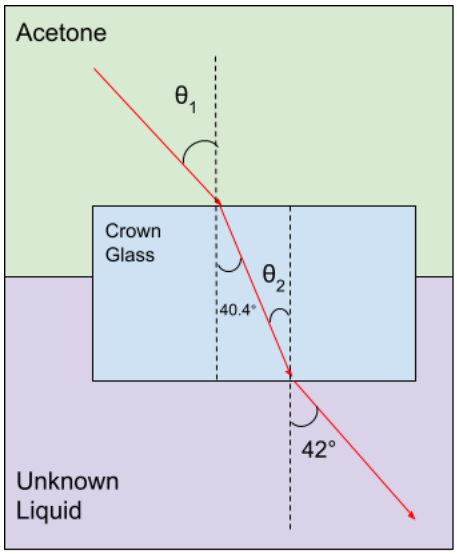
74. [1] While investigating The Head's office you find droplike blood spatters on the floor, signaling that they were formed at a low velocity. What is the maximum velocity at which these spatters could have formed? _____

75. [1] True or false: Without further information, it is possible that two individuals presenting any ABO blood type could have children with the O blood type. _____

10 Glass (15 points)

76. [3] After the blood was cleaned off the glass in the Head's office, it was submerged in water to be analyzed. A beam of monochrome light is incident on the glass and is refracted at 36 degrees. If the angle of incidence is 45 degrees, determine what type of glass was submerged. _____

77. [2] At what speed was the light moving through the piece of glass in the prior question? Round your answer to the nearest hundredth. _____



78. [3] Find θ_1 . Write your answer in degrees to the nearest tenth. _____

79. [3] Find θ_2 . Write your answer in degrees to the nearest tenth. _____

80. [2] At what speed was the light moving through the acetone? Through the unknown liquid? Write your answers in scientific notation, rounding to the nearest hundredth. _____ _____

81. [2] Identify the unknown liquid. _____

11 Soil (15 points)

82. [2] Who is George Popp, and why is he relevant to the use of soil in forensics?

---

83. [2] What is a pollen fingerprint?

---

84. [1] If the color of the soil is red/brown, what might this indicate about its composition?

---

85. [1] If the color of the soil is black/dark brown, what might this indicate about its composition?

---

86. [1] If the color of the soil is white/light grey, what might this indicate about its composition?

---

87. [2] Some soil was collected off the shoes of Worker 15, Worker 17, and the Head. This soil has composition of 50% clay, 45% silt, and 5% sand. What type of soil is this? _____

88. [1] What type of soil has a composition of 50% sand, 20% clay, and 90% silt? _____

89. [1] What type of soil has a composition of 70% silt, 30% sand, and 30% clay? _____

90. [1] What type of soil would be most appropriate for shrubs and fruit trees? _____

91. [1] What type of soil would be most appropriate for planting tulips and daffodils? _____

92. [1] What type of soil would be most appropriate for plants such as bamboo and tubers? _____

93. [1] What type of soil would be most appropriate for growing root vegetables? _____

12 Analysis (150 points)

94. [150] Now that you have analyzed all the evidence, you must solve this murder case! In your analysis, include how each piece of evidence given connects to each suspect, and which pieces of evidence connect to the crime scene and who the evidence indicates as guilty. (Please try to include as much evidence as possible, even the evidence that indicates suspects are innocent!)