

BirdSO Invitational - Forensics

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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 | Glow, doesn't melt |
| Powder 3 | fizzes | NR | NR | 8 | Glow, 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: _____

Solution: Boric acid, H_3BO_3

2. [2] Powder #2: _____

Solution: Magnesium sulfate, $MgSO_4$

3. [2] Powder #3: _____

Solution: Calcium carbonate, $CaCO_3$

4. [2] Powder #4: _____

Solution: Glucose, $C_6H_{12}O_6$

5. [2] Powder #5: _____

Solution: Sodium chloride, $NaCl$

6. [2] Powder #6: _____

Solution: Cornstarch, $C_{27}H_{48}O_{20}$

7. [2] Powder #7: _____

Solution: Sodium carbonate, Na_2CO_3

8. [2] Powder #8: _____

Solution: Sodium bicarbonate, $NaHCO_3$

9. [2] Powder #9: _____

Solution: Calcium sulfate, $CaSO_4$

10. [2] Powder #10: _____

Solution: Potassium chloride, KCl

11. [2] Powder #11: _____

Solution: Sucrose, $C_{12}H_{22}O_{11}$

12. [2] Powder #12: _____

Solution: Lithium chloride, $LiCl$

13. [2] Powder #13: _____

Solution: Sodium acetate, $NaC_2H_3O_2$

14. [2] Powder #14: _____

Solution: Ammonium chloride, NH_4Cl

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?

Solution: $Cu(NH_3)_4SO_4$

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

Solution: Anhydrous sodium carbonate, sodium citrate, copper(II) sulfate pentahydrate

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?

Solution: Greater than 2%

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

Solution: Yellow light, sodium compounds

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

Solution: $HCl(aq) + CaCO_3(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

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

Solution: $NaOH(aq) + CaNO_3(aq) \rightarrow NaNO_3(aq) + Ca(OH)_2(s)$

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

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

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

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.)

Solution: PMMA, PETE, HDPE/LDPE, PS, PP, N-66, LDPE/HDPE, PC, PVC

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.

Solution: Yes. HDPE has a higher melting point than LDPE, so perform a melting test

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

Solution: Leave the plastic sample in acetone for 20-40 sec, if the plastic is soft and sticky/easily scratched then the test is positive.

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

Solution: Presence of copper halide

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.

Solution: Thermoplastics can melt under heat after curing, while thermoset plastics cannot be reformed after curing and will maintain their solid state.

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.)

Solution: Linen, wool, nylon, silk, polyester, cotton

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

Solution: Number 2, PETE

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.

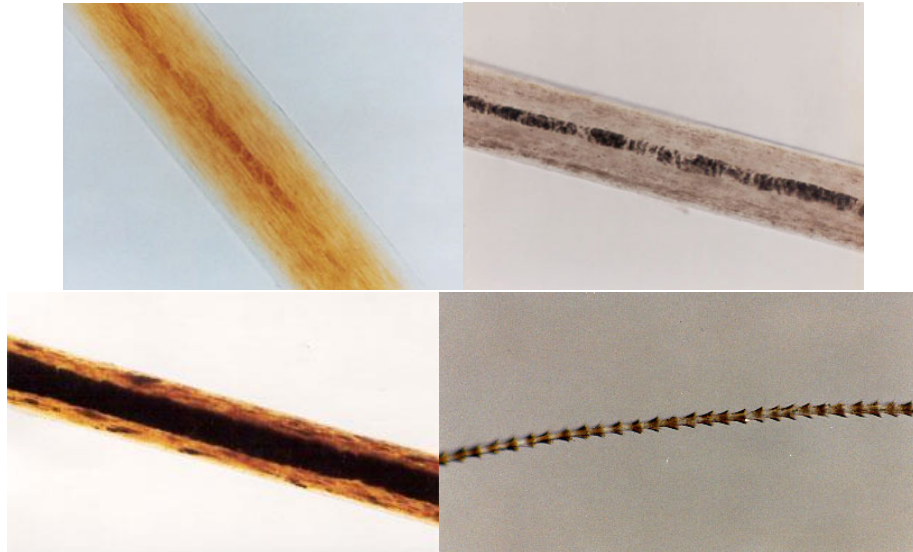
- A. Dissolves polyester
- B. Dissolves cotton
- C. Dissolves silk**
- D. Dissolves linen
- E. Dissolves wool**

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

Solution: HCl dissolves synthetics and NaClO dissolves animal hairs.

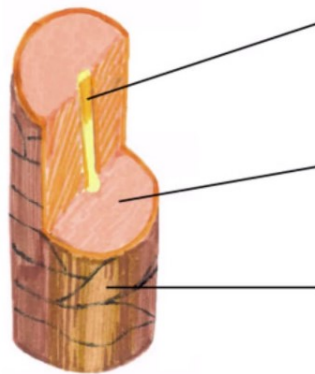
4 Hairs (28 points)

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.

Solution: 1st and 2nd: human, both have thin medulla/small medullary index and fragmented medullas
3rd: cow, has wide medulla/large medullary index and has ovoid bodies 4th: bat, has no visible medulla and has coronal scales



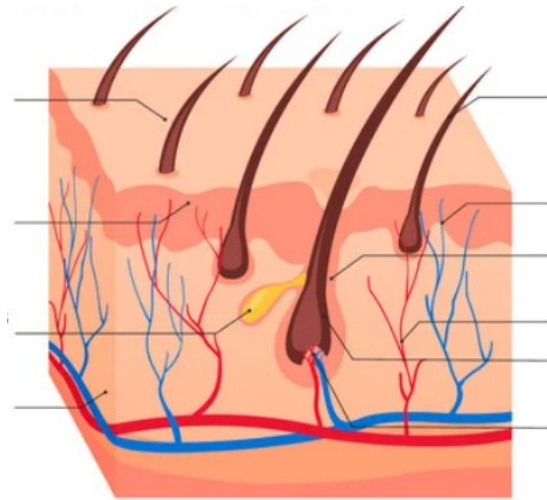
36. [3] Label each part of the hair shown above.

Solution: In order from top to bottom: medulla, cortex, cuticle.



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

Solution: $0.7\text{cm}/1\text{cm} = 0.7$ (or similar ratio), horse hair

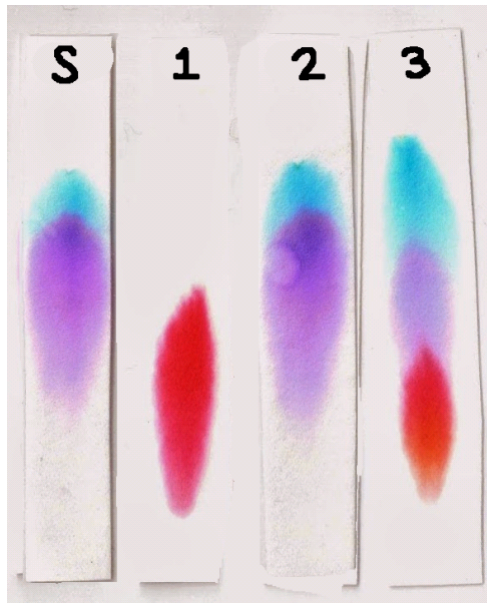


38. [10] Label each part of the diagram above, which depicts a hair follicle in the skin.

Solution: From top to bottom on the left: stratum corneum, epidermis, sebaceous gland, dermis. From top to bottom on the right: hair shaft, vein, hair follicle, artery, hair bulb, hair papilla

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? _____

Solution: Pen #2

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

Solution: 0.75 (accept 0.7 or 0.746)

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

Solution: The polarity of the pigment (1) influences how strongly it is attracted to the mobile and stationary phases. A pigment that is more strongly attracted to the stationary phase will not travel as far as a pigment that is more strongly attracted to the mobile phase. (1)

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

43. [2] You perform paper chromatography using three pens and hexane as your mobile phase. The R_f 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 R_f for each pen to change or stay the same? Explain.

Solution: The R_f would change (1), as the pigment molecules would interact differently with diethyl ether than they do with the hexane and as such would not travel the same distance (1)

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

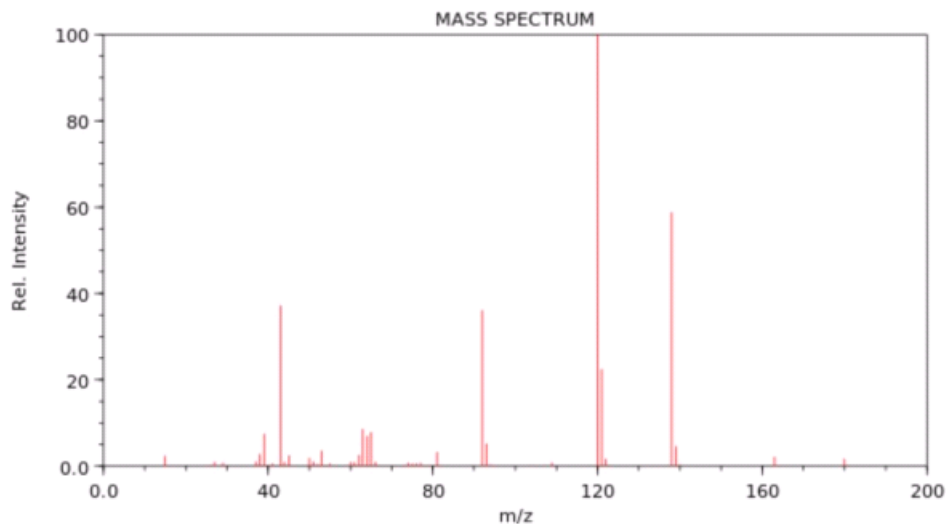
Solution: Less than

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

Solution: Any valid similarity/difference will be accepted—both involve the separation of compounds and a liquid mobile phase, column chromatography uses a powdered stationary phase while planar chromatography uses a rigid one, etc.

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? _____

Solution: 120 g/mol

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

Solution: 180 g/mol

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

Solution: $C_9H_8O_4$

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

Solution: $x = 9, y = 8, z = 0; x - 0.5y + 0.5z + 1 = 9 - 4 + 0 + 1 = 6$

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

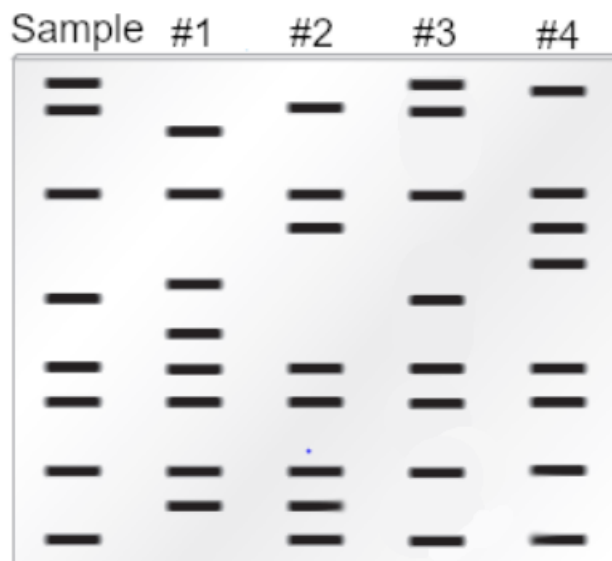
Solution: Aspirin

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

Solution: Ion source, mass analyzer, detector

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? _____

Solution: Sample 3

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?

Solution: Using a DNA ladder/molecular-weight size marker

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

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

Solution: Dideoxynucleotides lack a hydroxyl group (1), which prevents DNA strands from being elongated during replication (1).

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

Solution: Semiconservative means that when DNA is replicated, half of the produced strand comes from the parent molecule and half is newly synthesized.

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

Solution: Restriction enzymes are used to cut DNA in specific places (1). When the lengths of the cut DNA fragments are compared, the suspect's DNA will have the same size fragments as the samples from the crime scene. (1)

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

Solution: Four

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.

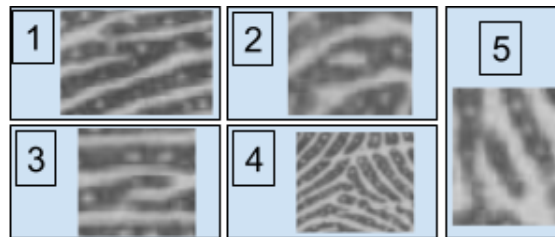
Solution:

1. Tented arch
2. Double loop whorl
3. Ulnar loop
4. Plain whorl
5. Central pocket whorl
6. Accidental whorl
7. Radial loop



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.

Solution: Matches fingerprint 3, results on minutiae will vary (e.g. the delta in the lower right corner of both prints)



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

Solution:

1. Bifurcation
2. Lake
3. Hook/spur
4. Delta
5. Island

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

Solution: Impression/plastic, latent, and visible/patent

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. **True**
65. [1] True or false: Cyanoacrylate fuming works well on porous surfaces such as cardboard and fabric. **False**
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. **True**
67. [4] Describe the process of developing fingerprints through the use of ninhydrin.
- Solution:** Dissolve the ninhydrin in acetone, then soak it on the surface which is to be developed. It will react with amino acids to develop a purple-colored print within 24 hours.
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? _____

Solution: Type A blood

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

Solution: Agglutination (1) occurred because the antibodies on the blood cells and the antigens in the serum bind to each other (1), causing the blood cells to clump.

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? _____

Solution: Rh(D) or D antigen, do not accept a lowercase d

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. _____

Solution: 32.09 degrees, accept 32 or 32.1

73. [1] What is the probability that an individual with the genotype IAIB and an individual with the genotype IBi will have a child with type AB blood? _____

Solution: 1/4, or 25%

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? _____

Solution: 5 f/s, accept equivalent units

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. False

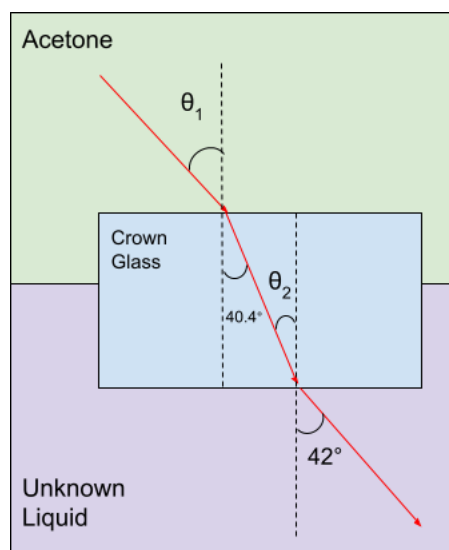
10 Glass (15 points)

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. _____

Solution: Heavy flint glass

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. _____

Solution: 1.81E8



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

Solution: 46.4 degrees

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

Solution: 40.4 degrees

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. _____

Solution: 2.20E8 and 2.20E8

81. [2] Identify the unknown liquid. _____

Solution: Glycerine

11 Soil (15 points)

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

Solution: George Popp was a forensic scientist in Frankfurt, Germany. He was the first to use soil to solve a crime.

83. [2] What is a pollen fingerprint?

Solution: The number and type of pollen grains found in a geographic area at a particular time of year.

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

Solution: Contains iron compounds

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

Solution: Contains humus/manganese, iron/sulfide, and/or pyrite

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

Solution: Contains silica (calcite, dolomite, quartz, etc.)

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? _____

Solution: Silty clay

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

Solution: Loam

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

Solution: Silty clay loam

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

Solution: Clay-based soil

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

Solution: Sand-based soil

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

Solution: Loamy soil

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

Solution: Peaty soil

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!)

Solution: VIP 4 orchestrated the crime, and Worker 17 murdered Player 420.

The evidence found at the crime scene at the cave was powders 3-11, plastics 1-3, fibers 1, 3, 5, and 6, hairs 1 and 2, fingerprint 3, and the soil. The glucose, sodium chloride, cornstarch, sodium bicarbonate, and sucrose found at the cave can be accounted for by the victim, who ate a chocolate frosted brownie in the first round, so the powders that came from the suspects must be calcium carbonate, sodium carbonate, calcium sulfate, and potassium chloride. PETE came from the victim (from the water bottle they were given after the first round), so was left unaccounted for is PMMA and LDPE/HDPE. Polyester came from what the victim was wearing, so what came from the suspects are linen, nylon, and cotton. The dark brown and blonde hair, as well as the fingerprint found on the stick are also likely from the suspects. Additionally, anyone with silty clay found on their shoes could be guilty.

The evidence found in the Head's office was powders 2, 10, 12, and 14, plastics 7-9, fibers 4 and 6, hair 3, ink belonging to pen 2, DNA 3, blood type A, and the glass. All of the evidence can be assumed to come from the suspects.

The evidence associated with Player 52 is sodium acetate, sodium chloride, PETE, polyester, black hair, fingerprint 6, and blood type O. Sodium acetate and sodium chloride can be explained by them eating salt and vinegar chips in the first round, the PETE comes from the water bottle each player was given after the round, polyester comes from their athletic wear, and their hair, fingerprint, and blood type don't match what was found at the crime scenes. Therefore, it seems that Player 52 is innocent.

The evidence associated with Player 403 is sodium bicarbonate, glucose, sucrose, sodium chloride, cornstarch, PETE, polyester, dark brown hair, fingerprint 7, and blood type O. The powders can be explained by them eating a donut in the first round, PETE from the water bottle, polyester from their outfit, and their fingerprint and blood type don't match what was found at the scene. Their hair could be the one in the cave, but since everything else doesn't match it is unlikely that Player 403 is guilty.

The evidence associated with Worker 15 is sodium acetate, sodium chloride, sodium bicarbonate, glucose, sucrose, cornstarch, boric acid, PS, PP, HDPE, N-66, nylon, linen, black hair, bat hair, fingerprint 2, blood type A, and silty clay soil. All of the powders can be explained by the fact that Worker 15 helped prepare for the first round. The PS, PP, HDPE, and N-66 can be explained also by the preparation and cleanup of the first round. Worker 15 was wearing nylon and linen, and the bat hair and silty clay soil can be explained by the fact that Worker 15 came with the Head to investigate the disturbance in the cave. Since the fingerprint and hair don't match what was found at the scene, the fact that the blood type matches isn't of significance and Worker 15 is also likely innocent.

The evidence associated with Worker 17 is calcium sulfate, calcium carbonate, sodium carbonate, PMMA, LDPE, nylon, linen, dark brown hair, bat hair, DNA 2, fingerprint 3, blood type B, and silty clay soil. The powders and PMMA can be explained by Worker 17's preparation of the second round, and the LDPE from handing VIP 4 the ketchup bottle. However, these powders were also found in the cave, and were not from the victim. This also goes for the nylon and linen, which is what Worker 17 was wearing, as well as the dark brown hair, and was also in the cave. Bat hair and silty clay soil were also found on Worker 17, and confirms they were in the cave without an alibi. Lastly, their fingerprint matches what was on the stick, confirming that they indeed murdered Player 420. However, since their DNA and blood type doesn't match what was found in the office, it seems like they didn't commit this crime alone.

The evidence associated with VIP 4 is lithium chloride, magnesium sulfate, ammonium chloride, PC, LDPE, PVC, silk, black hair, cow hair, pen 1, aspirin, DNA 3, fingerprint 4, blood type A, and heavy flint glass. The lithium chloride can be explained by VIP 4's bipolar disorder, magnesium sulfate from the long bath where they likely used epsom salts, PC from the sunglasses, LDPE from the ketchup bottle, PVC from the shampoo container, and aspirin from their headache. They were wearing silk and came to the games riding a cow, both of which were found in the Head's office. Their DNA and blood type also matches the evidence found in the Head's office. Considering that, the ammonium chloride was probably from the batteries that VIP 4 was trying to replace in the walkie talkie, and the heavy flint glass is from their glasses that broke probably when they tripped over something and fell. So even though their black hair and fingerprint doesn't match what was found in the cave, they are probably guilty of planning the crime.

The evidence associated with VIP 5 is wool, dark brown hair, pen 2, DNA 4, fingerprint 5, and blood type O. The only evidence associated with VIP 5 that could indicate them as guilty is the dark brown hair and pen 2. Nothing indicates that VIP 5 was in the cave, so the dark brown hair found there probably isn't theirs. As for pen 2, in the descriptions VIP 5 mentioned VIP 4 bumped into them then handed them a pen, so VIP 4 must have switched their pens, so pen 2 actually belonged to VIP 4 and pen 1 belonged to VIP 5.

The evidence associated with the Head is potassium chloride, cotton, blonde hair, bat hair, pen 3, DNA 1, fingerprint 1, blood type AB, and silty clay soil. Potassium chloride can be explained by the Head's high blood pressure. Even though blonde hair was found in the cave, and bat hair and silty clay soil was found on the Head, that is accounted for by the fact that they said they went to the cave to check the disturbance and that there were bats flying around in the cave (likely got attacked and lost some hairs). Again, potassium chloride and cotton were found in the cave and the Head's office because they went to the cave and of course the Head would have been in his own office. Additionally, their pen, DNA, fingerprint, and blood type do not match what was found at the scene, so they are likely innocent.

So in conclusion, what probably happened was VIP 4 didn't want VIP 2 to win the betting again, so VIP 4 plotted to kill whatever player they bet on this year. They saw Worker 17 as someone to do the dirty work for them, so they were requested as a personal servant and VIP 4 told Worker 17 their plan to carry out, slipping them a walkie talkie to communicate. Since the players were all given water after the first round, it is likely many needed to go to the bathroom. So Worker 17 apprehended Player 420 and killed them in a cave under VIP 4's instructions. However, the walkie talkie ran out of battery when the Head went to check on the disturbance, so VIP 4 frantically ran into the Head's office looking for batteries to alert Worker 17 before the Head got to the cave, but tripped and cut their finger on their broken glasses.