

**Science Olympiad**  
**Fairfax Invitational Competition**  
**Forensic Science - KEY**

Team Number: \_\_\_\_\_

Team/School Name: \_\_\_\_\_

Student Names (First & Last):

1. \_\_\_\_\_

2. \_\_\_\_\_

Total Points Possible: 100

Total Points Earned: \_\_\_\_\_

Rank: \_\_\_\_\_

Tiebreaker Needed (Circle): Y / N

**Explain:**

Rules violations (Circle): Y / N **Explain:**

**Crime Scene Scenario:**

On the morning of January 5<sup>th</sup> a home was burglarized. The homeowner returned to find their front window broken and electronics missing. The homeowners immediately called the police. The police obtained shoe impressions found near the broken window and collected a blood sample found on a piece of broken glass. Police also collected a note, hair, fiber, pen and powder found inside the house. A pen was also collected outside of the window on the ground. Three suspects were identified and police collected DNA, a hair, a fibers, a powder, a pen and shoe impressions from each person. Suspect 1 is Amanda, Suspect 2 is Max and Suspect 3 is Shawn. The crime scene evidence was analyzed by the crime lab and the results are listed below. It is your job to analyze and compare the suspect evidence with the results of the crime scene evidence.

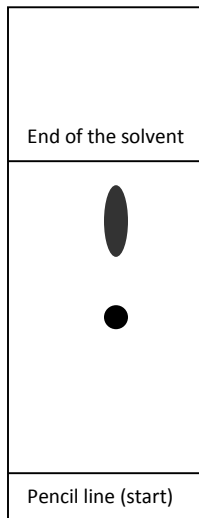
**Crime Scene Evidence**

- White powder: potassium chloride
- Hair: Human
- Fiber: polyester
- DNA profile

Loci	F/M	D3S1358	vWA	FGA	D8S1179	D21S11	D18S51	D5S818	D13S317	D7S820
Crime Scene DNA	XY	15 17	17 18	18 19 20 24	13 14 15	29 30 31.2 32.2	16 18 23 24	11	10 11	9 12 13

- Ink chromatogram:

Impression:



**Part A: Qualitative Analysis (20%)**

**Directions:** Use the materials provided at station A along with the materials you brought to determine the identity of the unknown powders. Substances to identify: sodium acetate, sodium chloride, sodium hydrogen carbonate (sodium bicarbonate), sodium carbonate, lithium chloride, potassium chloride, calcium nitrate, calcium sulfate, calcium carbonate, cornstarch, glucose, sucrose, magnesium sulfate, boric acid and ammonium chloride. There are no mixtures. Write the name of each unknown powder on the line provided below. (5 pts each)

powder 4: sodium bicarbonate

powder 5: cornstarch

powder 6: sodium chloride

\_\_\_ Which chemical reacts with Benedict's Solution and what color does it turn? (1 pt)

a. Glucose, blue

b. Glucose, orange

c. Copper Sulfate, blue

d. Sucrose, orange

\_\_\_ What is a common application or source of calcium carbonate? (1 pt)

a. Heat packs

b. Limestone

c. Fertilizer

d. Meat preservatives

\_\_\_ What is a common application for sodium carbonate? (1 pt)

a. Deicer

b. Baking Soda

c. Laundry Softener

d. Cement

\_\_\_ What color in a flame test will potassium chloride typically give off? (1 pt)

a. Purple

b. Yellow

c. Red

d. Green

\_\_\_ Which powder is hygroscopic? (1 pt)

a. calcium nitrate

b. calcium carbonate

c. sodium carbonate

d. magnesium sulfate

\_\_\_ What gas is produced when calcium carbonate is reacted with hydrochloric acid? (1 pt)

a. water vapor

b. hydrogen gas

c. carbon dioxide

d. carbonate gas

\_\_\_ Which powder has a basic pH when dissolved in distilled water? (1 pt)

a. calcium nitrate

b. calcium carbonate

c. sodium carbonate

d. magnesium sulfate

**Part B: Plastic (20% for all of Part B)**

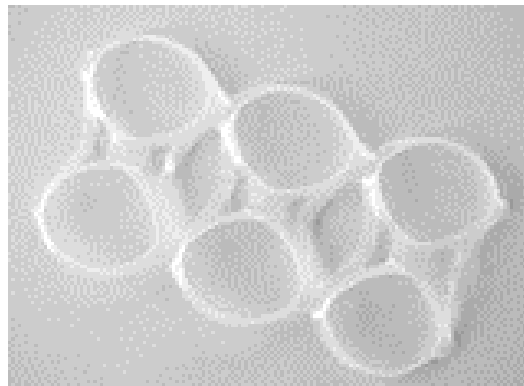
**Content Questions:** Write your answer (A-D) on the line provided below next to each question.

\_\_\_\_\_ Which of the following polymers will sink in distilled water? (1 point)

- a. HDPE
- b. LDPE
- c. PP
- d. PC

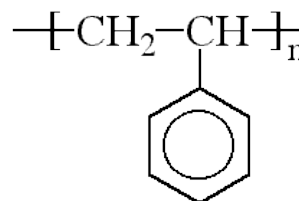
\_\_\_\_\_ Which of the following polymers is used in plastic wrap and the plastic shown to the right? (1 point)

- a. Non-expanded PS
- b. LDPE
- c. PP
- d. PC



\_\_\_\_\_ Which polymer is composed of repeating monomer units shown to the right? (1 point)

- a. PETE
- b. Non-expanded PS
- c. PP
- d. PC



\_\_\_\_\_ Which of the following polymers is recycled under recycling code #1? (1 point)

- a. PVC
- b. PETE
- c. HDPE
- d. PC



**Part B: Hair (20% for all of Part B)**

**Directions:** Identify the species of the hair recovered from each suspects.

**Content Questions:** Write your answer (A-E) on the line provided below next to each question.

\_\_\_\_\_ What is the species of the hair recovered from suspect 1? (2 points)

- a. Human
- b. Bat
- c. Horse
- d. Cow
- e. Squirrel

\_\_\_\_\_ What is the species of the hair recovered from suspect 2? (2 points)

- a. Human
- b. Bat
- c. Horse
- d. Cow
- e. Squirrel

\_\_\_\_\_ What is the species of the hair recovered from suspect 3? (2 points)

- a. Human
- b. Bat
- c. Horse
- d. Cow
- e. Squirrel

\_\_\_\_\_ What species' hair is represented in the picture? (1 point)

- a. Squirrel
- b. Horse
- c. Cow
- d. Bat



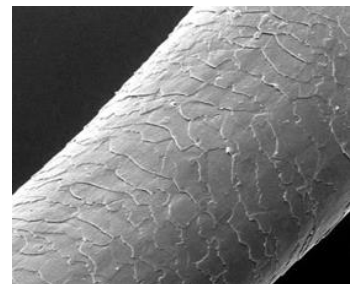
\_\_\_\_\_ What is the medulla pattern of the following hair sample? (1 point)

- a. Continuous
- b. Fragmented
- c. Absent
- d. Coronal



\_\_\_\_\_ What type of scale pattern is this and what species does it belong to? (1 point)

- a. Imbricate, bat
- b. Spinous, cow
- c. Imbricate, human
- d. Coronal, bat



**Part B: Fiber (20% for all of Part B)**

**Directions:** Determine the identity of the fibers recovered from the three suspects. The fibers may be analyzed using microscopes and/or the burn test.

**Content Questions:** Write your answer (A-E) on the line provided below next to each question.

\_\_\_\_\_ What is the composition of the fiber recovered from suspect 1? (3 points)

- a. Cotton
- b. Nylon
- c. Polyester
- d. Wool
- e. Spandex

\_\_\_\_\_ What is the composition of the fiber recovered from suspect 2? (3 points)

- a. Cotton
- b. Nylon
- c. Polyester
- d. Wool
- e. Spandex

\_\_\_\_\_ What is the composition of the fiber recovered from suspect 1? (3 points)

- a. Cotton
- b. Nylon
- c. Polyester
- d. Wool
- e. Spandex

\_\_\_\_\_ Which of the following is correctly matched? (1 point)

- a. Wool – natural – animal source
- b. Linen – synthetic
- c. Spandex – natural – plant source
- d. Cotton – regenerated

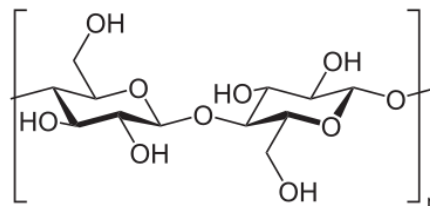
\_\_\_\_\_ What fiber matches the following results? (1 point)

Not self-extinguishing, Odor of a burning campfire, Creates a grey ash

- a. Wool
- b. Nylon
- c. Spandex
- d. Cotton

\_\_\_\_\_ What fiber is a polymer of the repeating monomer shown to the right? (1 point)

- a. Nylon
- b. Spandex
- c. Cotton
- d. Polyester

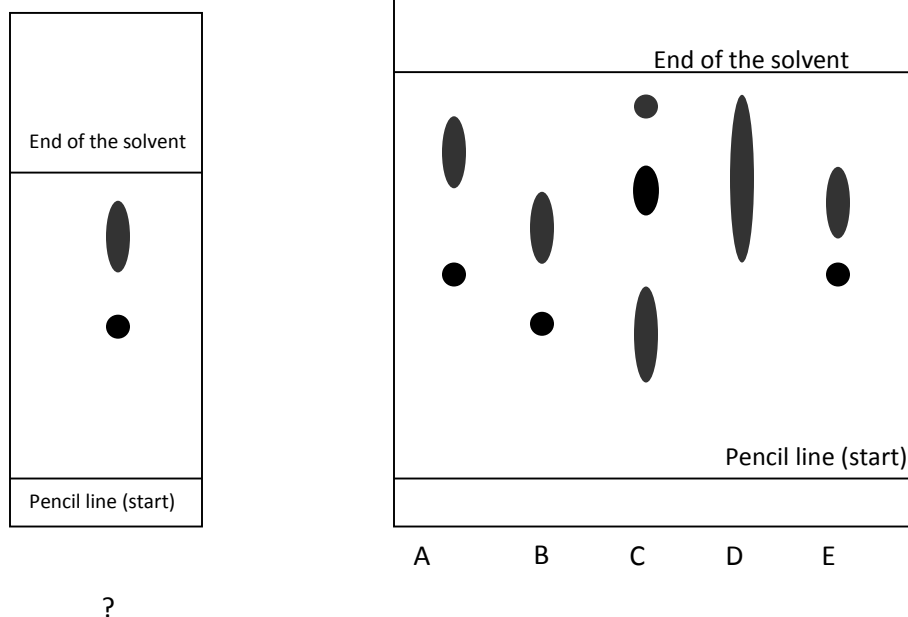


\_\_\_\_\_ A synthetic fiber is defined as a fiber that is: (1 point)

- a. Made from animal hair
- b. Man made from natural fibers such as rayon.
- c. Man made using the waste from the oil and coal industry such as polyester
- d. Extracted from plant material

**Part C: Chromatography (15%)**

**Directions:** Examine the two chromatograms below. The “?” ink sample is the ink sample recovered from the note found at the crime scene. Sample A ink was from a pen found with suspect 1. Sample B ink was from a pen found with suspect 2. Sample C ink was from a pen found with suspect 3. Sample D ink was from a pen found outside of the crime scene near the window. Sample E ink was from a pen found at the crime scene.



**Content Questions:** Write your answer (A-E) on the line provided below next to each question.

\_\_\_\_\_ What are the  $R_f$  values of the crime scene ink sample? (3 points)

- a. .5 and .8
- b. .48 and 0.7
- c. .45 and .85
- d. .3 and .7

\_\_\_\_\_ Which ink sample has the same  $R_f$  values as the crime scene ink sample? (2 points)

- a. A
- b. B
- c. C
- d. D
- e. E

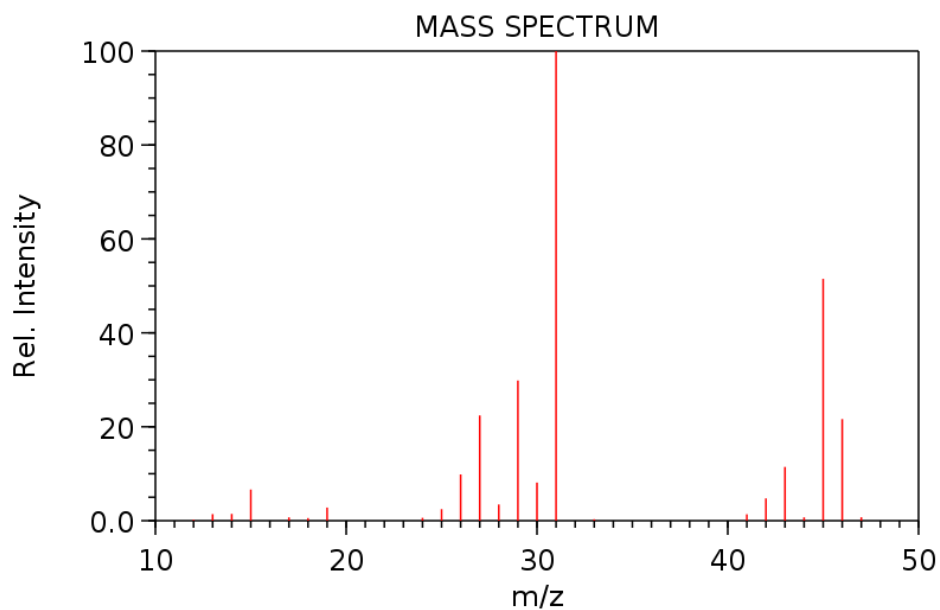
\_\_\_\_\_ In paper chromatography, what is the stationary phase? (1 point)

- a. Silica or alumina
- b. solvent
- c. paper
- d. beaker

\_\_\_\_\_ In paper chromatography, what is the mobile phase? (1 point)

- a. Silica or alumina
- b. solvent
- c. paper
- d. beaker

**Directions:** Answer the following questions using the mass spectrum below.

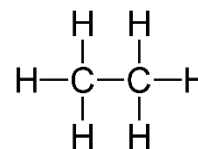
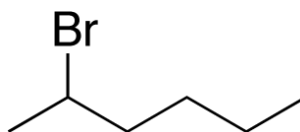
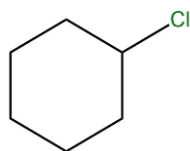
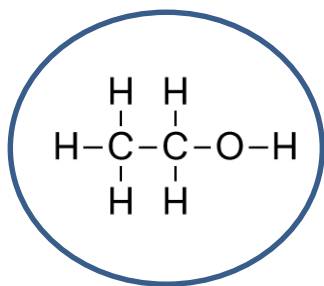


NIST Chemistry WebBook (<http://webbook.nist.gov/chemistry>)

What is the m/z of the base peak? 46 (1 point)

What is the mass of the molecule shown in the spectrum above? 31 (1 point)

Which of the following is a possible structure of the molecule shown in the spectrum above? (1 point) (circle the molecule below)





**Part D: DNA (15% for all of Part D)**

- Electropherograms of the DNA extracted from the three suspect's blood.
- Chart of loci and alleles obtained from the DNA recovered from the blood at the crime scene. (see below)

Loci	F/M	D3S1358	vWA	FGA	D8S117	D21S11	D18S51	D5S818	D13S317	D7S820
Crime Scene DNA	XY	15 17	17 18	18 19 20 24	13 14 15	29 30 31.2 32.2	16 18 23 24	11	10 11	9 12 13

**Content Questions:** Write your answer (A-E) on the line provided below next to each question.

\_\_\_\_\_ Compare the DNA profile from the crime scene to the 3 suspects. Who's DNA was found at the crime scene? (3 points)

- a. Suspect 1 only
- b. Suspect 2 only
- c. Suspect 3 only
- d. Suspect 2 and 3 mixed profile**
- e. Suspect 1 and 2 mixed profile

\_\_\_\_\_ Polymerase Chain Reactions (PCR) is a technique used to: (1 point)

- a. To amplify DNA samples
- b. To copy the entire human genome
- c. To isolate a region of DNA
- d. Both a and c**

\_\_\_\_\_ For the sequence ATTGGACTACTACTACTACTACGGTA how many short/variable tandem repeats are present? (1 point)

- a. 4
- b. 5**
- c. 18
- d. 12

\_\_\_\_\_ What is the purpose of heating the DNA sample to approximately 95°C in PCR? (1 point)

- a. To separate the DNA strands**
- b. To anneal the primers
- c. To elongate the strands
- d. To optimize the temperature for TAQ polymerase

\_\_\_\_\_ All of the following are added to a PCR tube to perform PCR except \_\_\_\_\_. (1 point)

- a. Template DNA
- b. Primers
- c. Free nucleotides
- d. Antibodies**

\_\_\_\_\_ Which of the following is not a step in the PCR process? (1 point)

- a. Denaturation
- b. Copying**
- c. Annealing
- d. Extension

## Part D: Impressions (15% for all of Part D)

**Directions:** Compare the crime scene impression with the inked impression from the 3 suspects. All of the impressions are shrunk proportionally.

### Content Question:

Whose shoe impression matches the crime scene impression? (3 points)

None of the above.

Choose 1 impression you determined was definitely not a match with the crime scene impression and explain why. Feel free to label evidence on the impressions above. (3 points)

Size with measurement or tread design.

Choose 1 individual characteristic in one of the shoes above. Circle and describe why it is an individual characteristic.

Scratch/piece missing from the bottom of the shoe - A marking that was made after it was manufactured. An individual characteristic is unique to that shoe specifically.

## Parts E and F: Analysis of the Crime (30%)

Describe what evidence supports and/or refutes the following suspects as being guilty of committing the crime. Use evidence analyzed from parts A-D. Be specific.

### SUSPECT 1

- Powder: Suspect 1 was found with sodium bicarbonate whereas the crime scene powder was potassium chloride. (not a match)
- Ink: Ink sample from crime scene note is consistent with the pen ink found on suspect 1. Ink is mass manufactured so the ink cannot be matched exclusively back to suspect 1.
- Hair: Horse hair found on suspect 1 whereas the crime scene hair was human. (not a match)
- Fiber: The fiber found on suspect 1 was cotton. The crime scene fiber was polyester (not a match)
- DNA: The mixed profile from the blood sample from the crime scene does not match the electropherogram from suspect 1 (not a match)
- Impression: suspect 1 tread is not consistent with the crime scene impression (not a match)

- NO PHYSICAL EVIDENCE (other than the pen ink) to link suspect 1 to crime scene.

#### SUSPECT 2

- Powder: Suspect 2 was found with cornstarch whereas the crime scene powder was potassium chloride. (not a match)
- Ink: Ink sample from crime scene note does not match the ink from the pen found on suspect 2 (not a match)
- Hair: Human hair found on suspect 2, which is the same species of hair found at the crime scene. Without DNA tests of the root the hair is class evidence and cannot be linked to suspect 2.
- Fiber: The fiber found on suspect 2 was polyester, the same type of fiber found at the crime scene. Without an individual characteristic to link the crime scene fiber to suspect 2, the fiber is class evidence and cannot be linked to suspect 2.
- DNA: The mixed profile from the blood sample from the crime scene contains all of the alleles in common with suspect 2. (probably match)
- Impression: suspect 2's shoe size is different from the crime scene impression (not a match)
- DNA, HAIR (possible), FIBER (possible) link suspect 2 to the crime scene.

#### SUSPECT 3

- Powder: Suspect 2 was found with sodium chloride whereas the crime scene powder was potassium chloride. (not a match)
- Ink: Ink sample from crime scene note does not match the ink from the pen found on suspect 3 (not a match)
- Hair: Human hair found on suspect 3, which is the same species of hair found at the crime scene. Without DNA tests of the root the hair is class evidence and cannot be linked to suspect 3.
- Fiber: The fiber found on suspect 3 was wool which is different than the one found at the crime scene (not a match)
- DNA: The mixed profile from the blood sample from the crime scene contains all of the alleles in common with suspect 3. (probably match)
- Impression: suspect 3's shoe size and tread is a class characteristic match with the crime scene impression, however, there are not any individual characteristics linking the shoes.
- DNA, HAIR (possible), link suspect 3 to the crime scene.