

# Forensics Rubric and Answer Key

(Total: 278 points, TIEBREAKER: 6pts)

Princeton Science Olympiad 2017

## I. Qualitative Analysis (42 pts)

You are given 12 samples of white powders. Use any method available to you to determine their identities, and then complete the following table, indicating each unknown's name and chemical formula.

**No double jeopardy here, if name is wrong but formula matches, +1**

Powder	Name of Powder (1pts each)	Chemical Formula (1pts each)
A	Sodium hydrogen carbonate/ <b>bicarbonate</b>	NaHCO <sub>3</sub>
B	Lithium chloride	LiCl
C	glucose	C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>
D	Sodium chloride	NaCl
E	sucrose	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>
F	Sodium acetate	NaC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>
G	cornstarch	C <sub>27</sub> H <sub>48</sub> O <sub>20</sub>
H	Magnesium sulfate	MgSO <sub>4</sub>
I	Calcium nitrate	Ca(NO <sub>3</sub> ) <sub>2</sub>
J	Potassium chloride	KCl
K	Ammonium chloride	NH <sub>4</sub> Cl
L	Calcium sulfate	CaSO <sub>4</sub>

Answer the following questions (3pts each).

1. List a common use of powder A.

**Anything pertaining to baking soda -- leavening agent, Solvay process, baking powder**

2. List a common use of powder B.

**Dessicant, red colorant in fireworks, bipolar disorder [lithium and its salts]**

3. List a common use of powder H.

**Epsom salts/sprains, laxative**

4. List a common use of powder K.

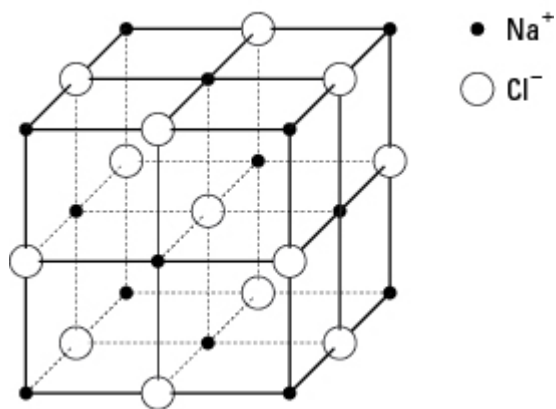
**Dry cell batteries, medical treatments, textile printing**

5. Write the chemical equation of the reaction that takes place upon the addition of Benedict's solution to powder K.

**$4\text{NH}_4\text{Cl} + \text{CuSO}_4 + 4\text{NaOH} \rightarrow \text{Cu}(\text{NH}_3)_4\text{SO}_4 + 4\text{H}_2\text{O} + 4\text{NaCl}$  (accept net ionic form; equation needs the addition of  $\text{Cu}^{2+}$  ion to  $\text{NH}_4\text{Cl}$  to produce the blue  $\text{Cu}(\text{NH}_3)_4^{2+}$  complex ion)**

6. Name and draw the crystal structure of powder D.

**Halite or rock-salt structure (accept fcc)**



## II. Plastics (41 pts)

Identify the polymers given as physical samples (4 pts each).

- |         |         |
|---------|---------|
| A.      | E. HDPE |
| B.      | F.      |
| C. PMMA | G. PP   |
| D.      | H. LDPE |

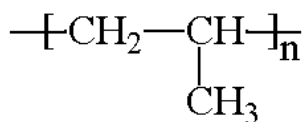
Identify the following polymers with their **name, recycling number, and should the item be recycled and/or reused** based on the picture and/or description. **3 pts each polymer, with one point per each category**

1. HDPE (2) recycle and reuse \*thick plastic milk bottles!
2. HDPE (2) recycle and reuse \*thin film plastic shopping bags, LDPE is thicker shopping bags!
3. LDPE (4) hard to recycle, yes reuse \*thick film plastic!
4. PET/PETE (1) recycled NOT reused
5. PS (6) hard to recycle and cannot reuse

**In general we were very lenient. We gave 1 point for “recycle” and 1 point for “can’t recycle” or “reuse.”**

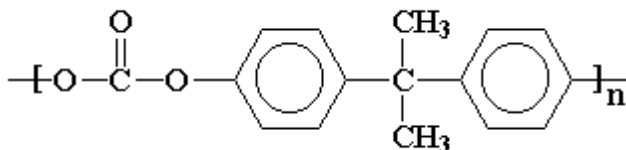
Answer the following questions (2 pts each).

1.



2. PC, polycarbonate

3.



4. Polyethylene Terephthalate

5. addition

6. HDPE is high density -- so it is very minimally branched. LDPE should be very branched compared to HDPE.



Figure 1: Structure of HDPE and LDPE

### III. Hairs & Fibers (32 pts)

Identify the given hairs and fibers from the follow pictures. **2 pts each**

H1) cow

H2) squirrel

H3) horse

H4) human

H5) bat

F1) wool

F2) silk

F3) spandex

F4) polyester

F5) nylon

Answer the following questions (**2 pts each**).

1. Name the fiber that burns with a steady flame, smells like burning paper, and leaves a charred whitish ash.

#### Cotton

2. Name the fiber that burns at a constant rate, does not produce smoke, and produces sparks.

#### Linen

3. Name the fiber that curls, melts, produces hard tan bead residue, and ignites only when brought into flame.

#### Nylon

4. How does one tell if a hair has been pulled out versus fallen out on its own?

**If pulled out, there may be abundance of root material. If fell out, clean root.**

5. What is the most commonly used animal fiber?

#### Wool

6. What protein is hair composed of? (Hint: this protein is also present in nails)

**Keratin**

7. What was the first synthetic fiber? **Tiebreaker**

**Nylon**

#### **IV. Chromatography (16 pts)**

You are given a sample of the ink found at the crime scene, as well as three possible suspect pens. Use the given TLC plate to develop a thin-layer chromatogram of these inks. Determine the R<sub>f</sub> value of each dye and determine the whose pen was found at the crime scene. Show calculations!

Tape your TLC plate to the page below. **Reasonable plate; 6 pts, 2 for each lane (we were very lenient here and gave 6 points to any chromatography strips that showed all three)**

*R<sub>f</sub> value =*

**5 pts, 2 for value and 3 for calculation - very lenient, accepted all close values**

*Calculations:*

Stationary phase: paper plate

**2 pts, all or nothing - we gave points to any response that included "paper;" silica gel does not count!**

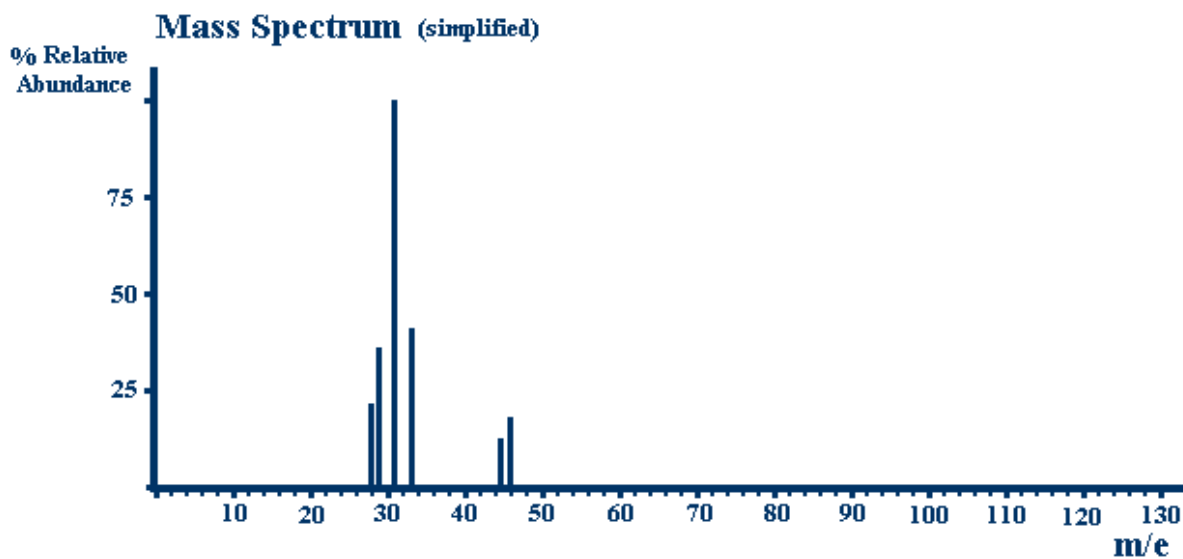
Whose pen was at the scene?

\_\_\_\_\_

**5 pts for correct identification of the pen; Eli Daniels - the question asked "whose" not "what"**

## V. Spectroscopy (12 pts)

Analyze the mass spectrum given below and answer the following questions. The compound whose spectrum is shown below was found at the crime scene.



### Questions (3 pts each)

1. Which of the following particles would show the greatest deflection in a mass spectrometer (circle)?



2. 46 g/mol
3. 30 or 31
4. CH<sub>3</sub>CH<sub>2</sub>OH, ethanol

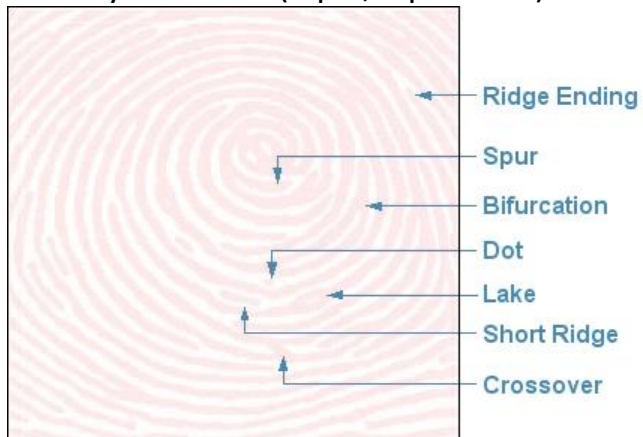
## VI. Fingerprint Analysis (24 pts)

### Crime Scene (2 pts)

Use the given tape and a pencil to take the fingerprint of either team member:  
(legible fingerprint 1pt)

What type of fingerprint do you have (arch, loop, whorl)?  
(correct identification of fingerprint)

Identify Minutiae (7 pts, 1 pts each)



**Also accepted spur/hook, short ridge/island, and crossover/bridge.  
We do understand the picture was distorted and thus graded everyone consistently**

### True/False (5 pts, 1 pts each)

1. Fingerprints are fully formed at about 3 months of fetus development. (False)
2. Parent and child have no similarity in fingerprints. (False)
3. 95% of people have fingerprints with loops or arches. (False)
4. There are an average 300 ridges on a finger. (False)
5. Patent prints have a 3D quality from pushing into a soft substance like wax or soap. (False)

### Questions (6 pts, 3 pts each, 1 pt each method)

1. What are three methods of revealing latent prints?  
**Accepted: Special lighting, powdering, lifting with tape, chemicals (must specify) - cyanoacrylate vapor, iodine fuming, ninhydrin, silver nitrate, small particle reagent**
2. What are three methods of taking fingerprints?  
**Accepted: Ink pad/porelon pad, glass plate, inkless pad, fingerprint scanner, impression, pencil/tape**

### Fingerprint Identification (2pts each)

The following two fingerprints were found at the crime scene. Label the following fingerprints with their patterns.



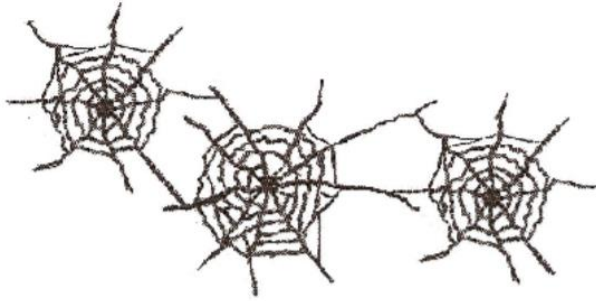
**central pocket whorl**





**ulnar loop**

**VII. Glass Analysis (8 pts, 2 pts each)**



1. the sequence of glass fractures shown above, which shot was fired first (circle one)?

Left

**Middle**

Right

2. Light travels from air into a shattered glass piece and has an angle of incidence of 40 degrees. The angle of refraction of the light is 23.68 degrees. Calculate the index of refraction of the glass.

1.6

3. What type of optical glass is this glass piece?

**Flint Glass**

4. What is the difference between a radial and a concentric fracture?

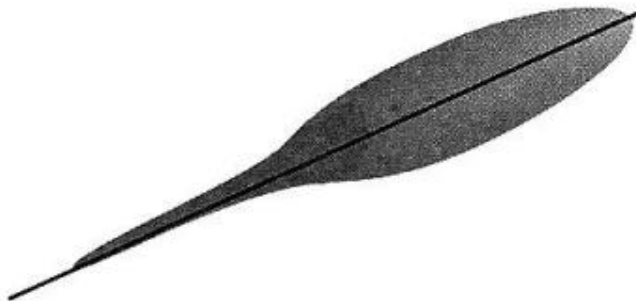
**Radial Fracture - A crack in a glass that extends outward like the spoke of a wheel from the point at which the glass was struck, forms a right angle, identified middle crack in picture, drew a correct picture, impacted from opposite side of surface. (1 pt)**

**Concentric Fracture - A crack in a glass that forms a rough circle, identified right/left crack in picture, drew a correct picture, impacted from same side of surface. (1 pt)**

**VIII. Blood (20 pts)**

1. Here is a blood spatter from the crime scene. What is the angle of impact and the point of origin (height from floor)? Show all drawings and calculations. (6pts)

**ANSWER: angle of impact = 18 degrees (2 pts); 1.89 feet (2 pts); area of convergence (2 pts)**



2. Bloodstain evidence may reveal (check all that apply): **3 pts possible, calculate points by 0.5 points for 2 correct, 1 for 3 correct... 3 points for all 7 correct**

**Answer: All 7 are correct**

3. List three methods to identify the presence of blood. **3 pts**

**Strong light, Luminol, Kastle-Meyer test (phenolphthalein, H<sub>2</sub>O<sub>2</sub>), Fluorescein**

4. What types of bloodstains are these and what is a possible cause? **6 pts**

**1. Answer: low velocity spatter, arterial spurting**

**Also accepted drip/gravity/etc. Very lenient**

**2. Answer: high velocity spatter, gunshot wound**

**3. Answer: wipe/swipe stains, any blood transfer**

5. Complete the following: **2 pts, one pt each**

Mother is type O+ and the father is A-. What are all the possibilities of the offspring's blood type (include type and Rh factor)?

**Answer: A+, A -, O+, O-**

Mother is A+ and the son is A+. Mother's brother is O- and mother's mother is A+. What blood type is the father?

**Answer: Impossible to figure it out**

## **IX. DNA Analysis (18 pts)**

What is the difference between "class evidence" and "individual evidence"? (5 pts)

**ANSWER: Class evidence has no DNA and individual evidence contains DNA.**

What does DNA stand for and what are the 4 components (spelling counts)? (5 pts)

**ANSWER: deoxyribonucleic acid composed of adenine, cytosine, thymine, and guanine**

Identify the component of PCR described (2 pts each)

PCR stands for \_\_\_\_\_.

**ANSWER: Polymerase chain reaction**

In this step, DNA is heated to break hydrogen bonds and form single-stranded DNA. \_\_\_\_\_.

**ANSWER: Denaturing**

Small segment of DNA, usually 20 nucleotides long. \_\_\_\_\_.

**ANSWER: Primer**

A salt solution that stabilizes DNA and other reactions.

\_\_\_\_\_.

**ANSWER: Buffer**

DNA polymerase is active in this step of PCR. \_\_\_\_\_.

**ANSWER: Extension TIEBREAKER**

## **X. Conclusion/Analysis of Crime Scene (65 pts)**

Using the evidence presented and the data given in the information packet, please determine who is responsible for the crime. Assigning evidence to suspects might be helpful! Make sure to support any conclusions based on the evidence and reasoning.

### **Eddie Lee: (8 pts, 2 points for each identification)**

- Glucose/**sucrose**
- H2 - squirrel (evidence)
- F2 - silk
- Plain Whorl

### **John Pilgrim (8 pts, 2 points for each identification)**

- Magnesium sulfate (evidence)
- F1 - wool
- Fancy Pen
- Plain arch

### **MOST LIKELY CULPRIT: Eli Daniels**

**(10 pts for identification of culprit, 3 pts for a statement explaining why Eli is most likely to be the culprit as compared to others)**

- Ammonium chloride (evidence) (5 pts)
- HDPE (evidence) (5 pts)
- Erasable Pen (CULPRIT'S PEN) (5 pts)
- Ulnar Loop (evidence) (5 pts)

### **Lionel Blue (8 pts, 2 points for each identification)**

- PS (evidence)
- Sharpie
- F5 - Nylon
- Radial Loop

### **Ben Quaker (8 pts, 2 points for each identification)**

- PP
- H5 - bat
- F3 - spandex (evidence)
- Double loop Whorl