Person’s Forensics Test
SSSS 2018-2019

KEY
Unless otherwise stated, each question/part of a question is worth 1 point.

1. A small pile of whitish crystal is found at the scene. A flame test shows a yellow color. What element is most likely present in the crystal?
   
   Sodium
   
   a. After close examination, you discover that the sample was contaminated. What piece of equipment can be used to view the true color of the flame? 
      Piece of cobalt blue glass
   
   b. Using that piece of equipment, you find that the flame is red. Identify the substance and give its chemical formula.
      Lithium chloride, LiCl
   
   c. Who does this substance implicate?
      Karen

2. Complete the following table. Each cell is worth 0.5 point. All of the following powders were found at the crime scene. [12 pt total]

<table>
<thead>
<tr>
<th>Substance</th>
<th>Formula</th>
<th>Flame Test</th>
<th>Uses (give one)</th>
<th>Implicated suspect(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boric acid</td>
<td>H₃BO₄</td>
<td>Green</td>
<td>Eyewash, antiseptic, insecticide, flame retardant, can be used in making slime</td>
<td>Alexandra</td>
</tr>
<tr>
<td>Potassium chloride</td>
<td>KCl</td>
<td>Purple or lavender</td>
<td>Lethal injection</td>
<td>Stephen</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----</td>
<td>-------------------</td>
<td>-----------------</td>
<td>---------</td>
</tr>
<tr>
<td>Sucrose</td>
<td>C_{12}H_{22}O_{11}</td>
<td>Melts in flame</td>
<td>Culinary, sweetener</td>
<td>Nathaniel</td>
</tr>
<tr>
<td>Calcium nitrate</td>
<td>Ca(NO_3)_2</td>
<td>Red-orange sparks</td>
<td>Fertilizer, concrete, latex production, cold packs</td>
<td>Karen</td>
</tr>
<tr>
<td>Ammonium chloride</td>
<td>NH_4Cl</td>
<td>Polymerizes</td>
<td>Dry cells, expectorant (medicine), textile printing</td>
<td>Nathaniel</td>
</tr>
<tr>
<td>Sodium acetate</td>
<td>NaCH_3COO</td>
<td>Yellow</td>
<td>Deicer, heating packs</td>
<td>Karen</td>
</tr>
</tbody>
</table>

3. Name two medical applications of calcium carbonate. [2 pt]
   Used as an antacid, binds with phosphate to treat hyperphosphatemia, calcium supplement

4. The Solvay process can be used to synthesize which two powders on the list? [2 pt]
   Sodium carbonate, ammonium chloride
   Accept sodium bicarbonate (sodium hydrogen carbonate); although it is not the main product, it is a product in part a.
a. In one of this process’ steps, carbon dioxide is passed through a concentrated aqueous solution of sodium chloride and ammonia. Write the described chemical reaction, giving both reactants AND products. [3 pt]

\[ \text{NaCl} + \text{CO}_2 + \text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NaHCO}_3 + \text{NH}_4\text{Cl} \]

5. How can sucrose and glucose be differentiated? Give a brief 2-3 sentence description. [3 pt]

Glucose and sucrose can be differentiated through Benedict’s test. We dissolve the powder in water, add Benedict’s solution, and put the solution in a hot water bath. A reddish-orange precipitate indicates that the powder is glucose; sucrose has no reaction with Benedict’s test.

Give 1 point for the name of the test and 2 points for an adequate description of the process.

6. Complete the following table of polymers found at the crime scene. Each cell is worth 0.5 pt. [12 pt total]

<table>
<thead>
<tr>
<th>Polymer (name or abbreviation)</th>
<th>Monomer</th>
<th>Flame Test</th>
<th>Uses (list one)</th>
<th>Implicated Suspect (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyvinyl chloride, PVC</td>
<td><img src="https://example.com/monomer.png" alt="Monomer" /></td>
<td>Green</td>
<td>Construction pipes, bank cards, wire insulation, bottles</td>
<td>Leonardo</td>
</tr>
<tr>
<td>Polypropylene</td>
<td><img src="https://example.com/monomer.png" alt="Monomer" /></td>
<td>Yellow</td>
<td>Plastic living hinges, lab materials, reusable containers, ropes</td>
<td>None</td>
</tr>
<tr>
<td>Material</td>
<td>Color</td>
<td>Applications</td>
<td>Author</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>--------</td>
<td>--------------------------------------------------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>Polyethylene terephthalate, PETE</td>
<td>Yellow</td>
<td>Water bottles</td>
<td>Stephen</td>
<td></td>
</tr>
<tr>
<td>Polystyrene, PS</td>
<td>Yellow</td>
<td>Foam containers, egg cartons, plates, coffee cups</td>
<td>Alexandra</td>
<td></td>
</tr>
<tr>
<td>Low density polyethylene, LDPE</td>
<td>Yellow</td>
<td>Six pack rings</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>HDPE</td>
<td>Yellow</td>
<td>Milk bottles, grocery bags, 3d printer filament, bottle caps</td>
<td>Karen</td>
<td></td>
</tr>
</tbody>
</table>

7. PMMA would float in:
   a. 25% NaCl solution
   b. Corn oil
   c. 46% isopropyl alcohol solution
   d. Distilled water
8. Which of the polymers has the recycling number 2?
   HDPE, High Density Polyethylene (either name is acceptable)

9. What is the purpose of a desiccant in PETE production?
   PETE is hygroscopic, so it absorbs water easily. However, water decreases its resilience. A desiccant removes moisture before hydrolysis begins.

10. What makes nylon useful for food packaging?
    It has high temperature resistance and can provide an oxygen barrier.

11. A pair of glasses was found at the scene. Which of the polymers is commonly used to make lenses for glasses?
    PC, Polycarbonate (either name is acceptable)
    a. Who does this implicate?
       Karen

12. Give one example each of a plant, animal, and synthetic fiber. [1 pt each, 3 pt total]
    Plant: cotton, linen
    Animal: wool, silk
    Synthetic: nylon, Spandex, polyester

13. Complete the following table of fibers found at the crime scene. Each cell is worth 0.5 points. [8 pt total]

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Origin</th>
<th>Odor</th>
<th>Ash</th>
<th>Implicated suspect(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool</td>
<td>Sheep</td>
<td>Burning hair</td>
<td>Crisp, dark ash; round/irregular bead (both acceptable)</td>
<td>Karen, Leonardo</td>
</tr>
<tr>
<td>Polyester</td>
<td>Coal + water + petroleum + air, polyethylene terephthalate (PET) is acceptable</td>
<td>Sweet, chemical scent</td>
<td>Round, hard, black bead</td>
<td>Karen</td>
</tr>
</tbody>
</table>
14. What is the scientific name of the organism that produces silk?
   Bombyx mori

15. Why does silk appear to shimmer?
   It is shaped like a triangular prism, which allows it to refract light at different angles.

16. What protein is the structural center of silk?
   Fibroin

17. Draw the cross sections of unmercerized and mercerized cotton. [2 pt]

   Drawings should roughly resemble these. Give points for showing a kidney-like shape for unmercerized and oval/circular shape for mercerized.

   a. How does mercerization affect dye retention?
Mercerization greatly increases dye retention, making the cloth brighter and with more intense color

b. Which other fiber on the list can be mercerized?  
   Linen

18. Identify the following fiber.

   ![Image of wool](image)
   
   Wool

19. In an airplane, where a high level of safety is necessary, should carpets be made out of cotton or wool?  
   Wool should be used
      
      Does not spread flame as fast, does not release as much heat, does not melt/drip, self-extinguishing, does not give off as much toxic gas

   Students do not need to include all of these to get the points

20. Linen is THIS type of fiber:
   a. Bast  
   b. Leaf  
   c. Stalk  
   d. Seed

21. Identify the hair based on its description.
   a. Thin/invisible medulla, club shaped root
      
      Human  
   b. Imbricate scales with few ovoid structures
      
      Horse
c. Fine diameter, coronal scales

Bat

22. Identify the following hair found at the crime scene.

![Squirrel Hair](image)

**Squirrel**

a. Who does this implicate?

Alexandra

23. Which part of hair contains melanin?

Cortex

24. What determines the shape of the hair shaft?

Hair follicle shape

MATCHING: Answer A for anagen phase, C for catagen phase, and T for telogen phase. Each may be used more than once or not at all.

25. _A_ Most hairs on the head are in this stage

26. _T_ Also known as the “resting” phase

27. _A_ Cells divide to form new fibers

28. _C_ Hair is cut off from blood supply

29. _C_ Lasts 2-3 weeks

30. What are the stationary and mobile phases for paper chromatography?

Stationary = paper, mobile = solvent (water is acceptable for the solvent)

31. Which type of molecules generally has high Rf values?

Nonpolar molecules

32. Calculate the Rf value for the pigment at 3 cm. [2 pt]
3/8 = 0.375

a. Whose pen does this match?
   Karen

33. Label the base peak on the following mass spectrum:

   a. What is the value of the M+ peak?
      137-138 m/z
   b. What substance is this?
      Salicylic acid
   c. Who does this implicate?
      Karen

34. What is Nathaniel’s fingerprint pattern? (be specific)
   Radial loop

35. Make a basic drawing of a tented arch fingerprint.
Drawings should somewhat resemble this. Give points as long as student clearly illustrates the upthrust, in comparison to the more rounded peak of a plain arch. Students need not have very detailed lines.

a. A tented arch fingerprint was found at the site. Who does this implicate? Karen

Identify the minutiae indicated on the following picture:

36. Ridge ending
37. Crossover/ridge crossing
38. Spur
39. Bifurcation
40. Which fingerprinting technique is preferred for nonporous surfaces?
   
   **Dusting and cyanoacrylate are both acceptable**

41. What does ninhydrin react with during fingerprinting?
   
   **Amino acids**

42. Name the 3 layers of skin. [1 pt each, 3 pt total]
   
   **Epidermis, dermis, hypodermis (or subcutaneous)**
   
   a. Which layer contains sweat glands?
      
      **Dermis**
   
   b. Which layer provides insulation for the body?
      
      **Hypodermis**
   
   c. Which layer contains the pigment responsible for skin color?
      
      **Epidermis (basal layer is acceptable)**

43. What are typically the first insects to arrive at a body?
   
   a. **Blowflies**
   
   b. **Flesh flies**
   
   c. **Mites**
   
   d. **Beetles**

44. A body is found to have blowfly pupa in it. Assuming the body has stayed at a constant 70 °F, about how many hours ago did the person die?
   
   ~130 hours

45. A sample of blood agglutinates when treated with anti-A. What ABO type blood is this?
   
   **Type A**
   
   a. What type of blood could this person receive?
      
      **Type A, Type O (must have both)**
46. What is one visible difference between mammal and amphibian blood cells?

Amphibian blood cells have visible nuclei, mammalian do not.

47. A blood spatter has a width of 1.2 inches and a length of 3.4 inches. What was the angle of impact?

\[ \text{arcsin} \left( \frac{1.2}{3.4} \right) = 20.67 \] (accept answers like 20.7, 20.667, etc.)

48. Based on your findings, who committed the crime? Justify your answer. Be sure to include why you chose the suspect, as well as why you did NOT choose the others.

[46 pt]

The evidence overwhelmingly points to Karen committing the crime. [10 pt for implicating Karen] [2 pt for each piece of evidence listed]

- Lithium chloride used for bipolar disorder
- Calcium nitrate from her cold packs, sodium acetate from her heating packs
- HDPE is used in her job (grocery bags)
- Her glasses are made of polycarbonate
- Uses Merino wool in knitting
- Wears polyester (stain-resistant)
- Her pen Rf and fingerprint match those found at the scene
- Salicylic acid in mass spectrum from skincare products
- Has valid motive – was dumped by Harold

Stephen was implicated by the water bottle, but it is plausible that Karen also came in contact with one while picking up litter. Although Stephen’s KCl was found at
the scene, it is weak evidence, since Karen could have encountered it in her health store. [5 pt]

Nathaniel’s sucrose is not strong enough evidence; it is stated that Harold bakes cakes, and he is likely to use table sugar while doing so. Because it is part of some medications, the ammonium chloride may also point towards Karen, so it is inconclusive. [4 pt]

Although Alexandra is implicated by slightly more evidence (the coffee cup, Spandex, squirrel hair, and boric acid), there is overwhelming evidence for Karen. Karen could have encountered the coffee cup while picking up litter and the squirrel hair could have just been from the surrounding woods. [5 pt]

The PVC that implicates Leonardo could have been from Harold’s own house. The wool may implicate his flannels, but Karen also came in contact with wool, and the rest of the evidence overwhelmingly points to her. Moreover, he does not have a strong motive for committing the crime. [4 pt]

TOTAL POINTS: 155