Score Calculation

**Powders:** \( \frac{\text{points earned} \times 20}{44} = \) ______ +

**Polymers:** \( \frac{\text{points earned} \times 20}{49} = \) ______ +

**Chromatography:** \( \frac{\text{points earned} \times 15}{14} = \) ______ +

**Entomology + Blood + DNA + Glass + Fingerprints:** \( \frac{\text{points earned} \times 15}{95} = \) ______ +

**Analysis:** \( \frac{\text{points earned} \times 30}{113} = \) ______ =

**Score** (scaled percentage) = ______ %
Crime Scene

As the top forensic scientist in the United States, you are often tasked with solving a wide variety of cases. You've recently been contacted by a new client looking to hire you to use your forensics skill to investigate an unusual case. Here's what the client wrote to you:

Hello,

I’m writing to ask for your help in investigating a recent tragic event. My beloved white-headed capuchin monkey, Marcel, has been stolen. A few months ago, I placed him under the care of the San Diego Zoo as I no longer had the capacity to care for him myself. However, when I went to visit him a few days ago, he was missing! When I confronted the zoo officials, they said they had reviewed the security footage around the time they believed Marcel was taken and saw five individuals near his zoo exhibit, though there wasn’t any footage of the specific entry point into Marcel’s exhibit (the crime scene). These five individuals happened to include all of my closest friends and my sister. I don’t know why any of them would do such thing, so I’m trusting you to find out who stole my monkey. Please help me find my dear Marcel.

Ross Geller

The zoo has closed their monkey exhibit and granted you access to the scene, where you have begun your investigation.

You’ve collected the following evidence from the crime scene:

- Powders: answers to questions #1-8 and #14-16
- Polymers: answers to questions #22-28, #37-38, and #40-41
- Mass spectroscopy: mass spectrograph of #48 shows a substance found at crime scene
- Blood: answers to questions #52-53
- DNA: crime scene DNA is shown in #69
- Fingerprints: the complete set of fingerprints in #78

In addition to collecting this physical evidence, you have interviewed each of the suspects and taken blood, DNA, and fingerprint samples from them, which you have recorded below. Ross and Marcel are depending on your forensics skills to solve this crime, so don’t let them down!

Suspects

Monica Geller:

Monica is Ross’s sister. She has always been jealous of Ross because their parents have always favored him and is also extremely competitive with everyone, including Ross. She is a professional chef and likes to cook, bake, grill, etc. at home for her friends. She is also extremely organized. Monica has recently taken on the hobby of indoor gardening.

<table>
<thead>
<tr>
<th>Blood Type</th>
<th>O+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Henry System Primary Classification</td>
<td>25/18</td>
</tr>
<tr>
<td>DNA</td>
<td>![Image of DNA]</td>
</tr>
</tbody>
</table>
Chandler Bing:

Chandler is Ross’s best friend and in a romantic relationship with Monica. He worked for many years in finance but is now working in advertising. Chandler is constantly making jokes and is often sarcastic. He says his humor stems from it originally being used as a defense mechanism to deal with his difficult relationship with his parents. These relationships also led to Chandler not celebrating Thanksgiving and occasionally smoking cigarettes.

<table>
<thead>
<tr>
<th>Blood Type</th>
<th>A-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Henry System Primary Classification</td>
<td>11/17</td>
</tr>
<tr>
<td>DNA</td>
<td><img src="image" alt="DNA Image" /></td>
</tr>
</tbody>
</table>

Rachel Green:

Rachel is in an on-off relationship with Ross and is Monica’s best friend. Ross and Rachel are currently “on a break” due to an argument they had. Rachel moved into Monica’s apartment after having run out of her wedding and is currently roommates with Monica. Rachel and Ross have experienced a lot together, including getting married on a whim in Las Vegas, then getting a divorce, then having a child. She works in and loves fashion and has an obsession with clothes, fabrics, shoes, etc.

<table>
<thead>
<tr>
<th>Blood Type</th>
<th>B+</th>
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</thead>
<tbody>
<tr>
<td>Henry System Primary Classification</td>
<td>7/2</td>
</tr>
<tr>
<td>DNA</td>
<td><img src="image" alt="DNA Image" /></td>
</tr>
</tbody>
</table>

Joey Tribbiani:

Joey is one of Ross’s friends. He is an actor, but often struggles to find roles. He loves all food (and often overeats) but has an intense affection for jam. Joey is also very accident prone. Just the other day, he twisted his ankle severely after tripping over Ross’s foot and now can barely get out of bed. Joey stated, “I’m holding a grudge against Ross because he’s put me out of acting for at least the next couple of weeks.”

<table>
<thead>
<tr>
<th>Blood Type</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Henry System Primary Classification</td>
<td>17/5</td>
</tr>
<tr>
<td>DNA</td>
<td><img src="image" alt="DNA Image" /></td>
</tr>
</tbody>
</table>

Phoebe Buffay:

Phoebe is another of Ross’s friends. She has a very unusual personal history and many unique life experiences but is sweet-natured. She has worked both as a masseuse and as a musical artist. She enjoys knitting and playing guitar at her favorite cafe. In addition, she despises the harming of animals and doesn’t wear or eat animal products.

<table>
<thead>
<tr>
<th>Blood Type</th>
<th>O-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Henry System Primary Classification</td>
<td>13/27</td>
</tr>
<tr>
<td>DNA</td>
<td><img src="image" alt="DNA Image" /></td>
</tr>
</tbody>
</table>
Powders  (worth 20% of score)

Questions 1-8 present a description of the physical and chemical properties of a certain powder. Identify the powder and its chemical formula. [2 points each]

1. Hygroscopic powder, melts in flame, water soluble, pH 7, turns orange w/ Benedict’s test

2. Faint green in flame, water soluble, pH 5

3. Fine powder, insoluble in water, black w/ iodine

4. Green flame, water soluble, pH 6, dark blue in Benedict’s

5. Red-orange sparks in flame, water soluble pH 6, precipitate in NaOH

6. Yellow flame, water soluble, pH 7, no reaction w/ HCl

7. Yellow flame, water soluble, pH 8, no reaction w/ HCl

8. Insoluble in water, fizz in HCl, precipitate in NaOH

For questions 9-10, write the complete, balanced chemical reaction for the two reactants given. [3 points each]

9. Calcium nitrate and sodium hydroxide

10. Sodium bicarbonate and hydrochloric acid

11. Which powders in the Forensics rules are alkaline? [4 points]

12. Which powders in the Forensics rules are covalently bonded? [4 points]

13. Draw a molecule of sucrose. [4 points]
Questions 14-16 give the common uses of different powders. Identify the powder and its chemical formula. [2 points each]

14. Used in crafts, casting, and cement

15. Used in gardening; as a laxative; to control seizures, asthma, and atrial fibrillation; and in baths

16. Used mainly as a treatment for bipolar disorder

17. What are the components of Benedict’s Solution? [2 points]

18. If an aqueous solution has a pOH of 9.2, what is its hydrogen ion concentration? [2 points]

**Polymers** (worth 20% of score)

Three fibers were burned. Based on their description, label each as Animal, Vegetable, or Synthetic. [1 point each]

19. Melted and shriveled

20. Shriveled only

21. Neither shriveled nor melted

Five more fibers were burned (questions 22-26). Write the name of the fiber that is most likely being described. [1 point each]

22. Smells of burning hair or feathers; burns easily

23. Smells of celery; burns slowly; drips beads with white smoke

24. Smells of burning paper; burns quickly; leaves whitish ash

25. Smells of burning hair or feathers; slow to catch fire

26. Smells of burning paper; burns slowly
27. Which of the plastics specified in the Forensics rules has the has resin identification code #1? (1 point)

28. Which of the plastics specified in the Forensics rules has the has resin identification code #3? (1 point)

What do the following plastics stand for? Draw the monomer for each. (2 points per question)

29. PETE ___________________________________________ Monomer:

30. HDPE ___________________________________________ Monomer:

31. LDPE ___________________________________________ Monomer:

32. PP _____________________________________________ Monomer:

33. PVC ___________________________________________ Monomer:

34. PMMA _________________________________________ Monomer:

35. PS _____________________________________________ Monomer:

36. PC _____________________________________________ Monomer:

Questions 37 and 38 give the float test results of different polymers. Identify the polymer in each question. (1 point each)

37. Floats in water, sinks in isopropyl alcohol

38. Sinks in water, floats in sat. NaCl, sinks in 10% NaCl, sinks in 25% NaCl
39. Which of the plastics from questions 29-36 are thermoplastics and which are thermoset plastics? (2 points)

Thermoplastics______________________________________________________________

Thermoset plastics__________________________________________________________

40. The hair to the right is from which animal? (1 point)

41. The hair to the right is from which animal? (1 point)

42. Draw a simple cross-sectional diagram of hair, labeling the three main layers. (4 points)

43. Name and describe the 4 stages of hair growth. (4 points)

44. Draw the cross-sectional shapes of the 3 main different hair textures and label each shape with its corresponding texture. (6 points)

45. Name 3 human characteristics that can be determined or obtained by examining a single human hair. (3 points)
Chromatography and Mass Spectroscopy (worth 15% of score)

46. To the right is the paper chromatography of an ink sample. The line near the bottom represents where the ink sample was initially placed. The blue dot also represents the level to which the solvent traveled. Calculate the Rf values of each pigment to the nearest tenth. [6 points, 1 for each value, 3 for calculations]

Red pigment_______

Blue pigment_______

Yellow pigment_______

47. Why is the developing chamber for TLC always covered? [3 points]

48. Below is the mass spectrograph of a hydrocarbon. Label the base peak and molar peak. Then, identify its chemical formula and name. [5 points]

Chemical formula______________

Chemical name______________
Crime Scene Physical Evidence [worth 15% of score]

Entomology

49. What is the order of stages in the life cycle of a blowfly? [7 points]
1 ___________________2 ___________________3 ___________________4 ___________________
5 ___________________6 ___________________7 ___________________

50. In what order do beetles, blowflies, and moth larvae arrive at a dead body? [1 point]

51. While entomology is often used to assess how long a victim has been dead, other features of a corpse can also be used. If there are no insects in/around a corpse, but it has begun to undergo Rigor Mortis, approximately how long has the victim been dead? [1 point]
A. 2 to 24 hours.
B. 12 to 48 hours.
C. Three days to a week.
D. Unable to tell, since humans experience Rigor Mortis at vastly different rates.

Blood Analysis

52. What is the most common blood type in humans [include Rh factor]? [1 point]

53. What is the least common blood type in humans [include Rh factor]? [1 point]

54. What percentages of the population have those blood types, in the order of most common then least common? [2 points]

55. Anti-A is added to a blood sample, which reacts with clumping. Anti-Rh is added to a different sample of the same blood, which does nothing. The hematologist testing these samples is careless, so he forgot to test the blood with anti-B. What are all the possible blood types indicated from these tests? [1 point]

56. What is the name of the clumping reaction mentioned in Question 55? [1 point]

57. What blood type is a universal donor? A universal recipient? [2 points]
Questions 57-58 refer to the diagram below.

The blood spatter pictured above (with its dimensions and orientation labeled) was found at a crime scene.

58. What is the angle of impact of the blood spatter [calculate to the nearest tenth of a degree]? (3 points, 2 for correct answer, 1 for calculations)

59. Draw an arrow in the direction the blood spatter was travelling on the diagram above. (1 point)

60. The slides above show [in random order] microscopic images of blood from a human, a bird, and a reptile. What type of blood does each sample show? (3 points)

A _________________________ B _________________________ C _________________________

61. What feature of human blood is unique from these other blood samples? (1 point)

62. Describe the Kastle-Meyer Test and the chemical reasoning for why it works. (3 points)
63. While blood does not fluoresce under ultraviolet light without the assistance of luminol or other chemicals, why do certain other bodily fluids (e.g. saliva and semen) fluoresce under UV? [1 point]

   a. What is the name of the most common fluorescing molecule in bodily fluids? [1 point]

   b. To what class of organic compounds does the answer to 63a belong? [1 point]

**DNA Analysis**

64. Draw and label a simple diagram of a nucleotide. [3 points]

65. Classify A, G, C, T, and U as purines, pyrimidines, or neither. [3 points]

   Purines ____________________

   Pyrimidines ____________________

   Neither ____________________

66. From which biological parent can one’s mitochondrial DNA be traced back to? Why? [2 points]

67. A certain biological theory explains the origin of chloroplasts and mitochondria in eukaryotic cells. Name this theory and use it to explain why mitochondria have separate DNA from the rest of a cell’s DNA. [2 points]

68. ________ Which of the following statement about chromatography and electrophoresis is TRUE? [1 point]

   A. In chromatography, heavier, more-polar proteins travel farthest.

   B. In electrophoresis, a sample of no more than 10 base pairs is needed for accurate results.

   C. DNA electrophoresis can identify which species a sample came from.

   D. DNA electrophoresis will 100% accurately identify the person a DNA sample came from, since no two people have exactly the same DNA (excepting identical twins).

   E. All are true.
69. Which of the following is/are NOT a suitable source of DNA polymerase for PCR: *T. aquaticus, P. furiosus, E. coli*? Why not? [2 points]

70. Which of the suspects’ DNA (find in suspect info) matches the crime scene DNA (to the right)? [1 point]

71. Rank these DNA bands produced by gel electrophoresis from smallest (1) to largest (6) molecular weight. [3 points]

1_______ 2_______ 3_______ 4_______ 5_______ 6_______

72. In what direction does the charge in gel electrophoresis run, starting from where the wells are loaded?

From __________ to __________. [2 points]

73. What is the cDNA sequence that corresponds to a strand of mRNA that reads: AUGGGCAUCCU? [2 points]

74. List the steps, temperatures, and explanations for each step of PCR. [9 points]
75. Label the components involved in DNA replication in the diagram below. (5 points)

A________________________________________ B________________________________________
C________________________________________ D________________________________________
E________________________________________

76. What class of organic molecule is component A in the diagram above? What is its function? (3 points)

Glass Analysis

Questions 77 and 78 refer to the pictures below.
77. The picture above labeled A shows a baseball bat hitting (most likely) what type of glass: laminated, borosilicate, or leaded? [1 point]

78. In the picture above labelled B, which hole was caused first, the left or the right? Why? [2 points]

Fingerprints

79. Fill in the chart below based on the Henry Classification System using this set of fingerprints. Then, calculate the fingerprints’ primary classification, also based off the Henry System. [8 points, 0.5 points per correct value on chart, 2 points for correct primary classification, 1 point for showing calculations]

<table>
<thead>
<tr>
<th>Finger</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Primary classification ___________________
80. Label these types of fingerprints as **patent**, **latent**, or **plastic**. Define each type. (6 points)

<table>
<thead>
<tr>
<th>Fingerprint</th>
<th>Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Fingerprint 1" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image2.png" alt="Fingerprint 2" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image3.png" alt="Fingerprint 3" /></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(under alternate light source)

81. When developing latent prints, why might it NOT be a good idea for dusting be used as the first method? (2 points)
Identify each of the following patterns of fingerprints. Assume all prints were from suspects' left hands. (4 points total, 0.5 points each)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Fingerprint</th>
<th>Pattern</th>
<th>Sample</th>
<th>Fingerprint</th>
<th>Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td><img src="image1" alt="Sample A Fingerprint" /></td>
<td></td>
<td>E</td>
<td><img src="image2" alt="Sample E Fingerprint" /></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td><img src="image3" alt="Sample B Fingerprint" /></td>
<td></td>
<td>F</td>
<td><img src="image4" alt="Sample F Fingerprint" /></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td><img src="image5" alt="Sample C Fingerprint" /></td>
<td></td>
<td>G</td>
<td><img src="image6" alt="Sample G Fingerprint" /></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td><img src="image7" alt="Sample D Fingerprint" /></td>
<td></td>
<td>H</td>
<td><img src="image8" alt="Sample H Fingerprint" /></td>
<td></td>
</tr>
</tbody>
</table>
83. Which of the following is TRUE about fingerprints? (1 point)
A. Fingerprints form during gestation, with ridges determined by how and what the fetus is touching in the womb.
B. Genetics seems to have no impact on fingerprint formation, which is exemplified by the fact that diabetics have no marked difference in fingerprint patterns.
C. Formation of fingerprints is controlled exclusively by genetics, which is why identical twins have identical fingerprint patterns.
D. Fingerprints are not fully developed until after birth, sometimes as late as two years of age.

84. Similar to the prints of fingers, what other human body parts can be used to identify people? (1 point)
A. Ear prints.
B. Teeth.
C. Tongue prints.
D. All of the above.
E. None of the above.

85. The value of fingerprints in forensic science is described through Locard’s Exchange Principle. Explain this principle. (1 point)

Analysis (worth 30% of score)

Who committed the crime? Why? (113 points)
Analysis (con’t)