Forensic Glass Analysis

<table>
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<th>Course</th>
<th>Forensic Science</th>
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<td><strong>Unit V</strong></td>
<td>Forensic Glass Analysis</td>
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**Essential Question**
How do crime scene investigators examine glass?

**TEKS**
§130.295(c)  
(1)(A)(B)  
(2)(F)(G)(H)  
(3)(A)(D)(E)(F)  
(6)(A–F)(H–J)  
(7)(B)

**Prior Student Learning**
- Safety & Scientific Method
- Crime Scene Investigation

**Estimated Time**
3 to 6 hours

**Rationale**
Glass fragments located at a crime scene can be essential to determining the identity and sometimes the location of a suspect. However, in all cases, the forensic scientist is required to draw comparison samples and also determine the class or category of the glass sample or glass fragment.

**Objectives**
The students will be able to:
1. Calculate the direction of a projectile by examining glass fractures.
2. Compare the composition of glass fragments.
3. Process trace evidence (such as soil, grass, blood, fibers, glass, and hair) collected in a simulated crime scene.

**Engage**
Use the following questions for a class discussion. Use the Discussion Rubric for assessment.
- What is glass made of?
- How many types of glass can you name?
- Name as many objects as you can that are composed of glass.
- How do you think forensic scientists use glass in an investigation?

**Key Points**
I. **Key Terms**

A. Glass – a hard, amorphous, transparent material made by heating a mixture of sand and other additives
B. Amorphous – without shape or form; applied to glass, it refers to having particles that are arranged randomly instead of in a definite pattern
C. Density – the ratio of the mass of an object to its volume, expressed by the equation, density = mass/volume
D. Becke line – the line created as refracted light becomes concentrated around the edges of a glass fragment
E. Obsidian – volcanic glass
F. Soda-lime glass – the most common glass – inexpensive and easy to melt and shape
G. Leaded glass – glass containing lead oxide
H. Tempered glass – glass which is strengthened by introducing stress through rapid heating and cooling of the glass surface
I. Laminated glass – two sheets of ordinary glass bonded together with a plastic film
J. Radial fracture – a crack in the glass that extends outward like the spoke of a wheel from the point at which the glass was struck
K. Concentric fracture – a crack in the glass from a rough circle around the point of impact
L. Refraction – the change in the direction of light as it changes speed when moving from one substance into another
M. Refraction index – a measure of how light bends as it passes from
one substance to another
N. Silicon dioxide (SiO$_2$) – the chemical name for silica
O. Normal line – a line drawn perpendicular to the interface surface of two different media

II. The Composition of Glass
A. Is a hard, brittle, amorphous material
   1. Called an amorphous solid because its atoms are arranged in a random fashion
   2. Due to its irregular atomic structure, it produces a variety of fracture patterns when broken
B. Made by melting the following ingredients at extremely high temperatures
   1. Sand
      a) The primary ingredient
      b) Also known as silica or silicon dioxide (SiO$_2$)
   2. Lime or calcium oxide (CaO) is added to prevent the glass from becoming soluble in water
   3. Sodium oxide (Na$_2$O) is added to reduce the melting point of silica or sand
C. Has numerous uses and thousands of compositions
D. Three categories of substances found in all glass
   1. Formers
      a) Makes up the bulk of the glass
      b) Examples: silicon dioxide (SiO$_2$), boron trioxide (B$_2$O$_3$) and phosphorus pentoxide (P$_2$O$_5$)
   2. Fluxes
      a) Change the temperature at which the formers melt during the manufacturing of glass
      b) Examples: sodium carbonate (Na$_2$CO$_3$) and potassium carbonate ($K_2$CO$_3$)
   3. Stabilizers
      a) Strengthen the glass and make it resistant to water
      b) Calcium carbonate (CaCO$_3$) is the most frequently used
E. The raw materials for making glass are all oxides
   1. The composition of any sample can be given in terms of the percentage of each oxide used to make it
   2. Example: the approximate composition of window or bottle glass
      a) Silica (SiO$_2$) – 73.6 %
      b) Soda (Na$_2$O) – 16.0 %
      c) Lime (CaO) – 5.2 %
      d) Potash ($K_2$O) – 0.6 %
      e) Magnesia (MgO) – 3.6 %
      f) Alumina (Al$_2$O$_3$) – 1.0 %

III. Types of Glass
A. Obsidian is a natural form of glass that is created by volcanoes
B. Soda-lime glass
   1. The most basic, common, inexpensive glass – also the easiest to make
2. Used for manufacturing windows and bottle glass

C. Leaded glass
1. Contains lead oxide which makes it denser
2. Sparkles as light passes through it (light waves are bent)
3. Used for manufacturing fine glassware and art glass
4. Is commonly called crystal

D. Tempered glass
1. Stronger than ordinary glass
2. Strengthened by introducing stress through rapid heating and cooling of the glass surface
3. When broken, this glass does not shatter, but fragments or breaks into small squares
4. Used in the side and rear windows of automobiles

E. Laminated glass
1. Constructed by bonding two ordinary sheets of glass together with a plastic film
2. Also used by automobile manufacturers

IV. Comparing Glass
A. Investigation/analysis includes
1. Finding
2. Measuring
3. Comparing
   a) Individual Characteristics
      (1) Only occurs when the suspect and crime scene fragments are assembled and physically fitted together
      (2) Comparisons of this type require piecing together irregular edges of broken glass as well as matching all irregularities and striations on the broken surfaces
      (3) Most glass evidence is either too fragmentary or minute to permit a comparison of this type
   b) Class Characteristics (Density and Refractive Index)
      (1) The general composition of glass is relatively uniform and offers no individualization
      (2) Trace elements in glass may prove to be distinctive and measurable characteristics
      (3) The physical properties of density and refractive index are used most successfully for characterizing glass particles, but only as a class characteristic
      (4) This data (density and refractivity) gives analysts the opportunity to compare and exclude different sources of data

B. Methods of comparison
1. Density and Measurements
   a) Density comparison
      (1) A method of matching glass fragments
      (2) Density (D) is calculated by dividing the mass (M) of a substance by its volume (V)
      (a) \[ D = \frac{M}{V} \]
      (3) Example
(a) A solid is weighed on a balance against known standard gram weights to determine its mass
(b) The solid’s volume is then determined from the volume of water it displaces
(c) Measured by filling a cylinder with a known volume of water \( (v_1) \), adding the object, and measuring the new water level \( (v_2) \)
(d) The difference \( (v_2 - v_1) \) in milliliters is equal to the volume of the solid
(e) Density can now be calculated from the equation in grams per milliliter

b) Flotation comparison
(1) A sample of glass is dropped into and sinks to the bottom of a liquid containing an exact volume of a dense liquid, such as bromobenzene \( (d = 1.52\, \text{g/mL}) \)
(2) Then, a denser liquid, such as bromoform \( (d = 2.89\, \text{g/mL}) \) is added one drop at a time until the piece of glass rises up from the bottom and attains neutral buoyancy
(3) Neutral buoyancy occurs when an object has the exact same density as the surrounding fluid – it neither sinks nor floats, but is suspended in place beneath the surface of the fluid
(4) The same procedure is then performed with another piece of glass, and if the volume needed to attain neutral buoyancy is the same as for the first sample, then the densities of the two samples are equal
(5) The exact density of each sample can be calculated by using the following formula: 

\[
d = \frac{X \cdot (2.89) + Y \cdot (1.52)}{X + Y}
\]

(a) \( X \) and \( Y \) refer to the volumes of the respective liquids, with the numbers in parentheses referring to the densities of each liquid.

2. Refractivity
a) Refractive Index
(1) A measure of how much an object slows light
(a) Light slows down when it passes through any medium (the denser the medium, the slower the light travels)
(b) Any object that transmits light has its own refractive index
(2) A ratio of the velocity of light in a vacuum to the velocity of light in a particular medium (refractive index = velocity of light in a vacuum / velocity of light in a medium)
(3) Used to compare glass samples
b) When light passes through media with different refractive indexes
(1) Refraction (bending of the light) occurs
(2) This is why objects appear bent or distorted underwater
(3) Every liquid has its own refractive index
(4) If a piece of glass is placed in a liquid (with a different refractive index) an outline of the glass is clearly visible
(5) This line is known as the Becke Line
   c) When light passes through a piece of glass placed in a liquid
      with the same refractive index
      (1) The glass bends light at the same angle as the liquid
      (2) The Becke Line disappears
      (3) The glass seems to disappear

V. Glass Fracture Patterns
   A. Glass has a certain degree of elasticity
      1. It breaks when its elastic limit is exceeded
      2. The elasticity produces fractures when it is penetrated by a
         projectile (i.e. a bullet)
   B. Types of fractures
      1. Radial
         a) Produced first
         b) Always form on the side of the glass opposite to where the
            impact originated
         c) Look like spider webs that spread outward from the impact
            hole
         d) Always terminate into an existing fracture
      2. Concentric
         a) Form next
         b) Encircle the bullet hole
         c) Always start on the same side as that of the destructive force
   C. Determining the sequence of multiple bullet holes
      1. The radial fractures from the second bullet hole always terminate
         into the fractures from the first bullet hole
      2. The radial fractures from a third bullet terminate into the radial
         fractures from the second bullet, and so forth
   D. Determining the first shooter
      1. Examine the termination lines of the radial fractures from each
         bullet hole
      2. Compare the size of the exit and entrance holes of each bullet
   E. Determining the direction from which a bullet was fired
      1. Compare the size of the entrance hole to the size of the exit hole
         a) Exit holes
            (1) Are always larger, regardless of the type of material that
                was shot
            (2) A larger piece of glass is knocked out of the surface
                where the bullet is leaving because glass is elastic and
                bows outward when struck
         b) Entrance holes
            (1) The bullet makes a very small hole when it enters
            (2) The glass always blows back in the direction of the impact
                because of its elasticity
            (3) The glass snaps back violently after being stressed and
                can blow shattered glass back several meters
            (4) Most of the shattered glass lands on the impacted side of
                the glass instead of by the exit hole
VI. Collecting Glass as Evidence

A. Avoid the loss or contamination of any evidence samples
B. Identify and photograph all of the glass samples before moving them
C. Collect the largest fragments
D. Identify the outside and the inside surfaces of any glass
E. Indicate the relative position of multiple window panes in a diagram
F. Note any other trace evidence found on or embedded in the glass, such as skin, hair, blood, or fibers
G. Package all of the collected materials properly in order to maintain the chain of custody
H. Separate the glass by physical property, such as size, color, and texture
I. Catalog the samples and keep them separated in order to avoid contamination between two different sources
J. Separate the glass fragments from any other trace evidence (e.g., hair, blood, fibers) once in the lab
K. Examine any clothing (or other objects that may have been used to break the glass) related to the crime scene for glass fragments and other trace evidence

Activities

1. Glass Analysis Research. Have students write a research paper on the procedure used for the analysis of glass. Students can include a variety of topics (e.g., density, flotation, refraction, glass fragmentations). Use the Research Rubric for assessment.

2. Glass Evidence Collection Research. Have students write a research paper on the proper collection and preservation of glass evidence. The research should include elements such as collecting evidence, including procedures, packaging evidence, obtaining evidence, including control evidence, and labeling evidence. Use the Research Rubric for assessment.

3. Forensic Glass Analysis Experiment. Have the students work in small groups (3–4 students per group) to conduct the Forensic Glass Analysis Experiment – Density of Glass: The Flotation Method Activity. Prior to class, set up each work station with the materials for the experiment (see the lab materials list below). Briefly review the lab safety procedures with the students and then hand out copies of Density of Glass: The Flotation Method Handout and the Density of Glass: The Flotation Method Worksheet. Explain the directions for the lab experiment. Allow the students some time to complete the worksheet and the density equation (approximately 10–15 minutes). Discuss the questions from the worksheet as a class. Use the Discussion Rubric for assessment.

Note: The students’ answers will vary depending on the glass sample size used. Make sure the students have recorded all of the data, either on a separate sheet of paper or on the back of the handout. Also, you may want to engage students in further discussions regarding their perceptions of the importance of scientific data and experiments.
Assessments
Forensic Glass Analysis Exam and Key
Discussion Rubric
Individual Work Rubric
Research Rubric

Materials
Forensic Glass Analysis computer-based presentation
Forensic Glass Analysis Key Terms
Forensic Glass Analysis Experiment
– Forensic Glass Analysis Experiment Guidelines handout
– Apron
– Safety gloves
– Safety goggles
– Glass fragments
– Bromoform \( (d = 2.89g/cm^3) \)
– Bromobenzene \( (d = 1.52g/cm^3) \)
– Pasteur pipettes
– Stirring rods
– Test tubes
– Tweezers
Computer with Internet Access
Science specific calculator
White board/chalk board

Resources
Texas Education Agency, Forensic Certification Training, Sam Houston State University
Forensic Science: Fundamentals & Investigation (1st Edition), Anthony Bertino
Forensic Science: From the Crime Scene to the Crime Lab (1st Edition), Richard Saferstein
ChemMatters, “More Than Meets The Eye” Brian Rohrig
The Science Spot – Forensic Science
http://www.sciencespot.net/Pages/classforsci.html
Investigator/Officer’s Personal Experience
Corning Museum of Glass http://www.cmg.org/default.asp
Federal Bureau of Investigation: Laboratory Services
• Forensic Glass Comparison: Background Information Used in Data Interpretation http://www.fbi.gov/about-us/lab/forensic-science-communications/fsc/april2009/review
Accommodations for Learning Differences
For reinforcement, the students will define and illustrate Forensic Glass Analysis key terms. Use the Individual Work Rubric for assessment.

For enrichment, the students will write research paper on a glass-related topic (e.g., The History of Glass, Glass in America, Methods of Glass Analysis). Use the Research Rubric for assessment.

The following are websites may be useful to research: Corning Museum of Glass site and FBI: Laboratory Services (see the links in the Resources section).

State Education Standards
Texas Essential Knowledge and Skills for Career and Technical Education
§130.295. Forensic Science (One Credit).
(1) The student, for at least 40% of instructional time, conducts laboratory and field investigations using safe, environmentally appropriate, and ethical practices. These investigations must involve actively obtaining and analyzing data with physical equipment, but may also involve experimentation in a simulated environment as well as field observations that extend beyond the classroom. The student is expected to:
(A) demonstrate safe practices during laboratory and field investigations; and
(B) demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials.

(2) The student uses scientific methods and equipment during laboratory and field investigations. The student is expected to:
(F) collect and organize qualitative and quantitative data and make measurements with accuracy and precision using tools such as calculators, spreadsheet software, data-collecting probes, computers, standard laboratory glassware, microscopes, various prepared slides, stereoscopes, metric rulers, electronic balances, gel electrophoresis apparatuses, micropipettors, hand lenses, Celsius thermometers, hot plates, lab notebooks or journals, timing devices, cameras, Petri dishes, lab incubators, meter sticks, and models, diagrams, or samples of biological specimens or structures;
(G) analyze, evaluate, make inferences, and predict trends from data; and
(H) communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports.

(3) The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:
(A) in all fields of science, analyze, evaluate, and critique
scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student;

(D) evaluate the impact of scientific research on society and the environment;

(E) evaluate models according to their limitations in representing biological objects or events; and

(F) research and describe the history of science and contributions of scientists.

(6) The student analyzes the evidence collected from a crime scene using scientific methods. The student is expected to:

(A) demonstrate conversions of measurements between English and International System (SI) of units;

(B) distinguish between physical and chemical properties of matter using the periodic table;

(C) determine the elements within a compound or mixture;

(D) identify the four types of chemical reactions;

(E) explain properties of refractive index;

(F) explain dispersion of light through a prism;

(H) explain the examination of trace evidence using instruments such as a spectrophotometer, stereoscope, electron microscope, and compound microscope;

(I) calculate the direction of a projectile by examining glass fractures; and

(J) compare the composition of glass fragments.

(7) The student recognizes the methods to process and analyze trace evidence commonly found in a crime scene. The student is expected to:

(B) process trace evidence such as soil, grass, glass, blood, fibers, and hair collected in a simulated crime scene;

College and Career Readiness Standards

English/Language Arts Standards

II. Speaking

B. Develop effective speaking styles for both group and one-on-one situations.

1. Participate actively and effectively in one-on-one oral communication situations.

2. Participate actively and effectively in group discussions.
Forensic Glass Analysis Key Terms

**Amorphous** – without shape or form; applied to glass, it refers to having particles that are arranged randomly instead of in a definite pattern

**Becke line** – the line created as refracted light becomes concentrated around the edges of a glass fragment

**Concentric fracture** – a crack in the glass from a rough circle around the point of impact

**Density** – the ratio of the mass of an object to its volume, expressed by the equation, density = mass/volume

**Glass** – a hard, amorphous, transparent material made by heating a mixture of sand and other additives

**Laminated glass** – two sheets of ordinary glass bonded together with a plastic film

**Leaded glass** – glass containing lead oxide

**Normal line** – a line drawn perpendicular to the interface surface of two different media

**Obsidian** – volcanic glass

**Radial fracture** – a crack in the glass that extends outward like the spoke of a wheel from the point at which the glass was struck

**Refraction** – the change in the direction of light as it changes speed when moving from one substance into another

**Refraction index** – a measure of how light bends as it passes from one substance to another

**Silicon dioxide (SiO₂)** – the chemical name for silica

**Soda-lime glass** – the most common and inexpensive glass, easy to melt and shape

**Tempered glass** – glass which is strengthened by introducing stress through rapid heating and cooling of its surface
Forensic Glass Analysis Exam

Matching

a. Radial fracture  
b. Concentric fracture  
c. Silicon dioxide  
d. Obsidian  
e. Amorphous  
f. Refraction  
g. Density  
h. Refraction index  
i. Becke line  
j. Glass

1. _____ A measure of how light bends as it passes from one substance to another

2. _____ The ratio of the mass of an object to its volume, expressed by the equation
   \[ X = \frac{\text{mass}}{\text{volume}} \]

3. _____ Volcanic glass

4. _____ A hard, amorphous, transparent material made by heating a mixture of sand and other additives

5. _____ Without shape or form; applied to glass, it refers to having particles that are arranged randomly instead of in a definite pattern

6. _____ SiO\(_2\) the chemical name for silica

7. _____ A crack in the glass that extends outward like the spoke of a wheel from the point at which the glass was struck

8. _____ The line created as refracted light becomes concentrated around the edges of the glass fragment

9. _____ The change in the direction of light as it changes speed when moving from one substance into another

10. _____ A crack in the glass from a rough circle around the point of impact

Multiple Choice

11. _____ Glass containing lead oxide.  
    a. Soda lime glass  
    b. Leaded glass  
    c. Tempered glass  
    d. Laminated glass
12. ____ Two sheets of ordinary glass bonded together with a plastic film
   a. Soda lime glass
   b. Leaded glass
   c. Tempered glass
   d. Laminated glass

13. ____ The most common glass, which is inexpensive, and easy to melt and shape
   a. Soda lime glass
   b. Leaded glass
   c. Tempered glass
   d. Laminated glass

14. ____ Glass which is strengthened by introducing stress through rapid heating and cooling of its surface.
   a. Soda lime glass
   b. Leaded glass
   c. Tempered glass
   d. Laminated glass

15. ____ What is the main ingredient in glass?
   a. Sand
   b. Soda (NaCO)
   c. Metal oxides
   d. Lime (CaO)

16. ____ Tempered glass is used in
   a. Windshields in autos manufactured in the United States
   b. Crystal stemware
   c. The side and rear windows of autos manufactured in the United States
   d. Both b and c

17. ____ Flotation is a method used by scientists to determine the ______ of a particle of glass.
   a. Weight
   b. Density
   c. Temperature
   d. Refraction index

18. ____ When a bullet penetrates a panel of glass, it leaves a crater shaped hole that
   a. Is wider on the exit side
   b. Is wider on the entrance side
   c. Forms randomly; the direction of impact cannot be determined by its appearance
   d. Both b and c

19. ____ Which statement is true about the fracturing of glass?
   a. Concentric fractures form first on the same side as the destructive force
   b. Radial cracks form afterwards, starting on the same side as the destructive force
   c. Radial cracks and concentric fractures are formed simultaneously
   d. Radial cracks appear first starting on the side opposite the destructive force
20. A piece of glass is immersed in a liquid, and it proceeds to float on the surface. This shows that the density of the glass is _____ the density of the liquid.
   a. Equal to
   b. Less than
   c. More than
   d. Not comparable

21. If glass cannot be physically pieced together, the control and questioned glass are best compared by their
   a. Weight and density
   b. Color and density
   c. Refractive index and density
   d. Refractive index and weight

22. Stress marks on the edge of a radial crack near the point of impact are
   a. Parallel to the side on which the force was applied
   b. Perpendicular to the side on which the force was applied
   c. Perpendicular to the side of the glass facing the outdoors
   d. Parallel to the side opposite the side on which the force was applied

23. The two most important physical properties of glass for forensic comparison are
   a. Refractive index and weight
   b. Refractive index and color
   c. Color and density
   d. Refractive index and density

24. The larger opening of a crater-shaped hole in glass made by the penetration of a projectile indicates
   a. The exit side of the glass
   b. The entrance side of the glass
   c. The projectile was traveling at a low velocity
   d. That a bullet made the opening

25. The fracture pattern of glass usually has
   a. Radial and concentric lines
   b. Concentric lines
   c. Radial lines
   d. Directional lines

26. Refractive index measures the speed of light in a vacuum to its speed in
   a. Air
   b. Water
   c. Glass
   d. Any given substance

27. The formula for calculating the density of an object is mass per unit volume.
   a. True
   b. False
28. The only way to analyze glass fragments at a crime scene is to assemble the fragments and physically fit them together like a jigsaw puzzle.
   a. True
   b. False

29. Sodium carbonate and calcium dioxide are two substances that are added to silica as glass is made.
   a. True
   b. False

30. It is possible to determine the sequence of impact by observing the existing fracture lines and their points of termination.
   a. True
   b. False

31. In reference to the diagram below what is the correct sequence of impact.
   a. A first
   b. B first
   c. A and B simultaneously
   d. sequence impossible to determine
Forensic Glass Analysis Exam Key

1. H
2. G
3. D
4. J
5. E
6. C
7. A
8. I
9. F
10. B
11. B
12. D
13. A
14. C
15. A
16. C
17. B
18. A
19. D
20. B
21. C
22. A
23. D
24. A
25. A
26. D
27. A
28. B
29. B
30. A
31. A
Forensic Glass Analysis Experiment
Density of Glass: The Flotation Method Handout
(adapted from ChemMatters, “More Than Meets The Eye” Brian Rohrig)

Rationale
There are many methods to examine glass. One method is to measure the density of glass through the flotation method. In the flotation method a glass fragment will either float in a liquid of greater density, sink in a liquid of lower density, or remain suspended in a liquid of equal density.

Materials
- Apron
- Safety gloves
- Safety goggles
- Glass fragments
- Bromoform (d=2.89g/cm³)
- Bromobenzene (d=1.52g/cm³)
- Pasteur pipettes
- Stirring rods
- Test tubes
- Tweezers

Safety
Students are to handle all scientific equipment in a proper lab environment with the utmost safety in mind. In addition, the chemicals bromoform and bromobenzene are slightly toxic.

Procedures
1. Use tweezers to place a small fragment of glass in a 10cm or smaller test tube
2. Using a Pasteur pipette, add bromoform. The test tube should be a quarter full of the liquid
3. On a separate sheet of paper count and record the number of drops of bromoform used. The glass should float on the surface of the liquid
4. Add bromobenzene
5. On the same sheet of paper count and record the number of drops of bromobenzene used. Adjust the density of the liquid in the test tube so that the fragment is suspended. Use a stirring rod to mix the two liquids before observing the location of the glass each time
6. Record the number of drops of bromobenzene needed
7. Using the formula below, calculate the density of the mixture of bromoform and bromobenzene:

\[ D = \frac{X \cdot (2.89) + Y \cdot (1.52)}{X + Y} \]

D = density
X = drops of bromoform
Y = drops of bromobenzene
Forensic Glass Analysis Experiment
Density of Glass: The Flotation Method Worksheet

Conclusions and Observations

1. What were your calculations based on the equation?

2. How many drops of bromoform were used?

3. How many drops of bromobenzene were used?

4. For discussion: Why does the glass fragment float with bromoform and suspend with bromobenzene?
## Discussion Rubric

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<td>Participates in group discussion</td>
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<td>Encourages others to join the conversation</td>
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<td>Keeps the discussion progressing to achieve goals</td>
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<td>Shares thoughts actively while offering helpful recommendations to others</td>
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<td>Gives credit to others for their ideas</td>
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<td>Respects the opinions of others</td>
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<td>Involves others by asking questions or requesting input</td>
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<td>Expresses thoughts and ideas clearly and effectively</td>
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**Total Points (32 pts.)**

*Comments:*
# Individual Work Rubric

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<td>Follows directions:</td>
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<td>Student completed the work as directed following the directions given, in order and to the level of quality indicated.</td>
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<td>Time management:</td>
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<td>Student used his/her time wisely and remained on task 100% of the time.</td>
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<td>Organization:</td>
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<tr>
<td>Notes and materials were kept in a neat, legible and organized manner. Information was readily retrieved.</td>
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<td>Evidence of learning:</td>
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<tr>
<td>Student documented information in his/her own words and can accurately answer questions related to information retrieved.</td>
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<tr>
<td>*Research/Gathering information (if relevant):</td>
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<tr>
<td>Student used a variety of methods and sources to gather information. Student took notes as they gathered information.</td>
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**Total Points (20 pts.)**

**Comments:**
# Research Rubric

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<tbody>
<tr>
<td><strong>Question/goal:</strong></td>
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<td>Identified and communicated a question or goal of the research.</td>
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<td><strong>Research/Gathering information (if relevant):</strong></td>
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<tr>
<td>Student used a variety of methods and sources to gather information. Student took notes as they gathered information.</td>
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<tr>
<td><strong>Conclusion/Summary:</strong></td>
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<td>Draws insightful conclusions and observations from information gathered. Information is organized in a logical manner.</td>
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<td><strong>Communication:</strong></td>
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<td>Communicates the information gathered and summary/conclusions persuasively. Demonstrates skill in use of media used to communicate the results of research.</td>
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<td><strong>Reflection:</strong></td>
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<td>Reflects on the importance of the research and potential application.</td>
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**Total Points (20 pts.)**

**Comments:**

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