Diagnostic test

1. The “chain of custody” plays an important role in forensic investigation. In two sentences, explain what this term means and why it is important? Chain of custody describes the sequence in which the evidence was handled and includes those who handled it. A secure chain of custody ensures the possibility evidence can be tampered with or contaminated.

2. Explain why it is important to be accurate in forensic analysis?
   So that investigators can rely on the data to be a true or realistic representation of the crime scene.

3. Explain why it is important to be thorough in forensic analysis?
   Thoroughness allows investigators to consider all possible alternatives (in terms of what may have occurred) for a crime scene.

4. Write balanced ionic equation for the reaction which occurs when:
   (a) Solutions of calcium nitrate and sodium sulphate are mixed.
   \[ \text{Ca}^{2+} (aq) + \text{SO}_4^{2-} (aq) \rightarrow \text{CaSO}_4 (s) \]
   (b) Solutions of zinc chloride and sodium hydroxide are mixed.
   \[ \text{Zn}^{2+} (aq) + 2 \text{OH}^- (aq) \rightarrow \text{Zn(OH)}_2 (s) \]
   (c) Solutions of Potassium Chloride and Lead (II) nitrate.
   \[ \text{Pb}^{2+} (aq) + 2 \text{Cl}^- (aq) \rightarrow \text{PbCl}_2 (s) \]

5. Describe one simple test (and its possible outcomes) which would determine if the dissolved substance in a solution was barium nitrate or copper nitrate. Write a balanced ionic equation for the possible outcomes.
   Test with a solution of sulphate (K₂SO₄ or Na₂SO₄)
   \[ \text{Ba}^{2+} (aq) + \text{SO}_4^{2-} (aq) \rightarrow \text{BaSO}_4 (s) \]  Barium sulphate will precipitate if Ba²⁺ is present.

6. Students were asked to identify the (one) cation present in a solution. They tested samples of the solution with sulphuric acid, sodium hydroxide and potassium carbonate solutions and obtained precipitates with sulphuric acid and with potassium carbonate but not with sodium hydroxide. Student A decided that the sample contained Pb²⁺, student B that it contained Ca²⁺ and student C that it contained Ba²⁺. Which student or students gave an answer that is consistent with the results? Explain your reasoning.

<table>
<thead>
<tr>
<th>Evidence</th>
<th>THEOREY</th>
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<tbody>
<tr>
<td>SO₄²⁻</td>
<td>Pb²⁺</td>
</tr>
<tr>
<td>OH⁻</td>
<td>X</td>
</tr>
<tr>
<td>CO₃²⁻</td>
<td>ppt</td>
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</tbody>
</table>
7. Which of the eight cations listed in Table 10.2 could be present in a solution which forms a white precipitate with chloride which dissolves in excess ammonia solution (with the filtrate from the precipitate giving no precipitate with sulphate), and a brown precipitate with hydroxide: when ammonia solution is added to this precipitate, none of the precipitate appears to dissolve and the filtrate remains colourless. Describe any additional test(s) needed to confirm your identification.

Evidence

<table>
<thead>
<tr>
<th>Sample</th>
<th>C1&lt;sup&gt;-&lt;/sup&gt;</th>
<th>Pb&lt;sup&gt;2+&lt;/sup&gt;</th>
<th>SO&lt;sub&gt;4&lt;/sub&gt;&lt;sup&gt;2-&lt;/sup&gt;</th>
<th>OH&lt;sup&gt;-&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolves in excess NH&lt;sub&gt;3&lt;/sub&gt;</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

- Only Ag<sup>+</sup> and/or Pb<sup>2+</sup> would ppt in C1<sup>-</sup>. Only Ag<sup>+</sup> then dissolves in excess NH<sub>3</sub>
  \[ \text{Ag}^+ + 2 \text{NH}_3 \rightarrow \text{Ag(NH}_3)_2^+ \]
- Only Ba<sup>2+</sup> or Ca<sup>2+</sup> not present (no ppt with SO<sub>4</sub><sup>2-</sup>)
- Brown precipitate with hydroxide indicates Fe<sup>2+</sup> or Fe<sup>3+</sup> is present. Clear filtrate in excess NH<sub>3</sub>
  Eliminates Cu<sup>2+</sup>
  \[ \text{Fe}^{2+}(aq) + 2 \text{OH}^-(aq) \rightarrow \text{Fe(OH)}_2(s) \]
  \[ \text{Fe}^{3+}(aq) + 3 \text{OH}^-(aq) \rightarrow \text{Fe(OH)}_3(s) \]

8. A sample from a local creek was thought to contain significant levels of sulphate ions, phosphate ions, chloride ions, or possibly all three? Describe tests which you would perform to identify the presence of any of these three anions in the sample. Write balanced chemical reactions for any possible reactions involved in identification.

Possible anion(s) must consider this:

**Test 1** — add HNO<sub>3</sub> to acidify, then add Ba<sup>2+</sup>. If SO<sub>4</sub><sup>2-</sup> is present, BaSO<sub>4</sub> will ppt

\[ \text{Ba}^{2+}(aq) + \text{SO}_4^{2-}(aq) \rightarrow \text{BaSO}_4(s) \]

If no ppt, continue tests

If ppt, centrifuge and separate filtrate

**Test 2** — using solution or filtrate from step 1

- Add NaOH until pH ≈ 8 to 10. If ppt, PO<sub>4</sub><sup>3-</sup> is present

\[ 3 \text{Ba}^{2+}(aq) + 2 \text{PO}_4^{3-}(aq) \rightarrow \text{Ba}_2(\text{PO}_4)_3(s) \text{ (alkaline)} \]

- If no ppt forms add more Ba<sup>2+</sup> to confirm no ppt forms (ie make sure enough Ba<sup>2+</sup> to cause ppt.

- If no ppt, continue test; if ppt then centrifuge and separate filtrate

**Test 3** — acidify soln or filtrate for step 2 and add Ag<sup>+</sup>. If ppt forms C1<sup>-</sup> is present.

These three steps will identify if SO<sub>4</sub><sup>2-</sup>, PO<sub>4</sub><sup>3-</sup>, and/or C1<sup>-</sup> are present.