1. You have three samples (a) to (c)) and each sample is known to contain one of the six possible anions: \( \text{C}_2\text{H}_5\text{O}_2^- \), \( \text{CO}_2^- \), \( \text{NO}_3^- \), \( \Gamma \), \( \text{Br}^- \) or \( \text{Cl}^- \). 18M \( \text{H}_2\text{SO}_4 \) is added to each solid sample and heated gently for a couple of minutes. Identify the anion and the gas evolved in each of the following samples. (6 points)

(a) Observations: Bubbling is seen when the acid is added; the colorless gas which is evolved has a distinctive vinegar-like odor.

\[ \text{C}_2\text{H}_5\text{O}_2^- \]  (acetate)  \( \text{gas is acetic acid (vague)} \)

(b) Observations: Bubbling is seen immediately and a purple/violet gas is evolved. A smell of rotten eggs is also evident.

\[ \text{I}^- \]  (I\(_2\) (g) is evolved)  \( \text{purple} \)  \( \text{After } \text{H}_2\text{SO}_4 (g) \) (colorless) is evolved)

(c) Observations: Some brown/orange gas forms in the tube as soon as the acid is added.

\[ \text{Br}^- \]  (\( \text{Br}_2 \) is evolved)  \( \text{orange} \)  \( \text{HBr} \) (color) are gases evolved

2. State whether each of the following anion solutions would be expected to give a precipitate when a \( \text{AgNO}_3 \) solution was added. If a precipitate forms, give the formula of the precipitate. (4 points)

\( \text{a) } \text{NO}_3^- \quad \text{No ppt} \)
\( \text{b) } \text{Cl}^- \quad \text{AgCl} \)
\( \text{c) } \text{S}^- \quad \text{Ag}_2\text{S} \)

3. Which of the following equations correctly shows the net ionic equation for the reaction of \( \text{NH}_4^+ \) with \( \text{OH}^- \) ? (1 point)

\( \text{a) } \text{NH}_4^+ \text{aq} + \text{OH}^- \text{aq} \rightarrow \text{H}_2\text{O}^- \text{aq} + \text{H}_2 \) (g)
\( \text{b) } \text{NH}_4\text{aq} + \text{OH}^- \text{aq} \rightarrow \text{NH}_4^+ \text{aq} + \text{O}^- \text{aq} \)
\( \text{c) } \text{NH}_4^+ \text{aq} + \text{OH}^- \text{aq} \rightarrow \text{H}_2\text{O} (l) + \text{NH}_2\text{g} \)
\( \text{d) } \text{NH}_4\text{aq} + \text{OH}^- \text{aq} \rightarrow \text{NH}_4\text{g} (g) + \text{H}_2\text{O} (l) \)
\( \text{e) } \text{NH}_4^+ \text{aq} + \text{OH}^- \text{aq} \rightarrow \text{H}_2\text{O} (l) + \text{NH}_2\text{g} \)

4. Why is it important that you test a fresh (untreated) sample of your unknown for the presence of \( \text{NH}_4^+ \), \( \text{Na}^+ \) and \( \text{K}^+ \) cations? (2 points)

\( \text{NH}_4^+, \text{Na}^+ \text{ and K}^+ \text{ are cations that can easily be added to other tests so then you'd get false positives.} \)
5. Why is it more reliable to test for K⁺ and Na⁺ ions using the diode array spectrophotometer than just to look at the colors in the flame? 
Hint: think of what might happen if BOTH cations are present. (2 points)

The Na⁺ test gives very bright orange light which will hide the much less intense purple light of K⁺. The diode array will have no difficulty seeing both wavelengths & showing both peaks.

6. You have an unknown salt sample that you know contains one of the following salts: NaNO₃, Mn(C₂H₃O₂)₃, CuSO₄, K₂SO₄, NaBr.

For each of the results from the tests below, state any possible deductions you can make at each step about the nature of the anion or cation. If you can eliminate any of the salts at any step, that's fine but you must give your reasoning.

(a) The salt dissolves easily in room temperature water to form a colorless solution. (3 points)

\[ \text{Could be } \text{NaNO}_3 \text{ (gives a neutral solution) or } \text{Mn(C}_2\text{H}_3\text{O}_2)_3 \text{ or } \text{K}_2\text{SO}_4 \text{ or } \text{NaBr} \]

but not CuSO₄ which would be blue.

(due to every group except one double charge)

(b) Upon adding 18M H₂SO₄ and heating the tube gently, no bubbling is seen and no gas is evolved. (2 points)

\[ \text{NO}_3^- \text{ would give brown gas} \]
\[ \text{Br}^- \text{ would give a gas} \]
\[ \text{Cu}^{2+} \text{ would give no reaction} \]

Only SO₄²⁻ has no reaction with H₂SO₄.

(c) Performing a flame test on a solution of the unknown results in a purple flame (corresponding to a wavelength of about 769 nm on the diode array spectrophotometer). (2 points)

\[ \text{Characteristic of K⁺ ion.} \]

Identity of unknown = K₂SO₄