TOPIC : ORGANOMETALLIC CHEMISTRY_ANION ANALYSIS BASICS

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Simple Tests

Color – Transition metals tend to form brightly colored compounds.

Odor – Some compounds have very distinctive odors. When testing for odor always remember to WAFT!

pH – Using universal litmus paper determine the pH of the compound.

Solubility – By combining the unknowns and knowing the rules of solubility, one can determine the contents of the test tubes.

Flame Test – Metal ions when introduced into a flame give a distinct emission spectrum. The color of the flame can help identify the unknown metal.

Definitions Applicable to Ionic Reactions

Ions – Charged Species. Metals tend to form cations and Nonmetals tend to form anions.

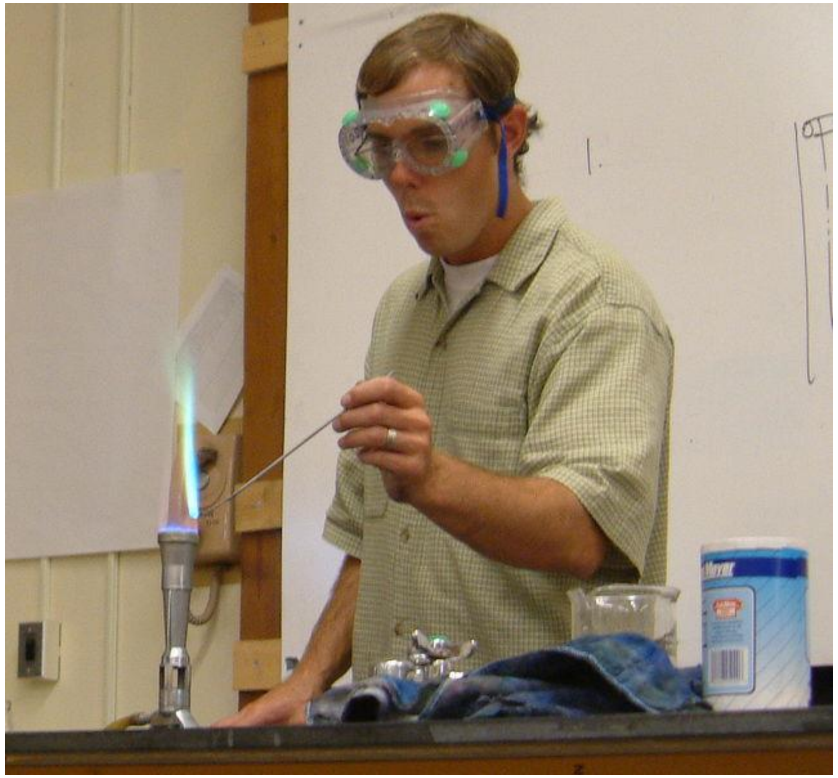
Ionic substances tend to dissolve readily in water to form solutions because they are charged particles that should electrostatically attract the corresponding end of the water dipole. However, not all ionic substances are soluble in water, indicating that they do not have enough energy to break apart the ionic crystal.

Cations – Positively charged ions. Cations in today's experiment include: H^+, Na^+, K^+, Ca^{2+}, Ba^{2+}, Fe^{3+}, Cu^{2+}, Ni^{2+}, and Sn^{2+}.

Solubility Rules

1. All nitrates, chlorates, and acetates of all metals are soluble. Silver acetate is sparingly soluble.
2. All sodium, potassium, and ammonium salts are soluble.
3. All chlorides, bromides, and iodides are soluble except silver, lead (II), and mercury (I).
4. All sulfates are soluble except barium, calcium, strontium, lead (II), and mercury (I).
5. Carbonates, phosphates, borates, sulfites, chromates, and arsenates of sodium, potassium, and ammonium are soluble; all others are insoluble.
6. Sulfides of barium, calcium, magnesium, sodium, potassium, and ammonium are soluble; all others are insoluble.

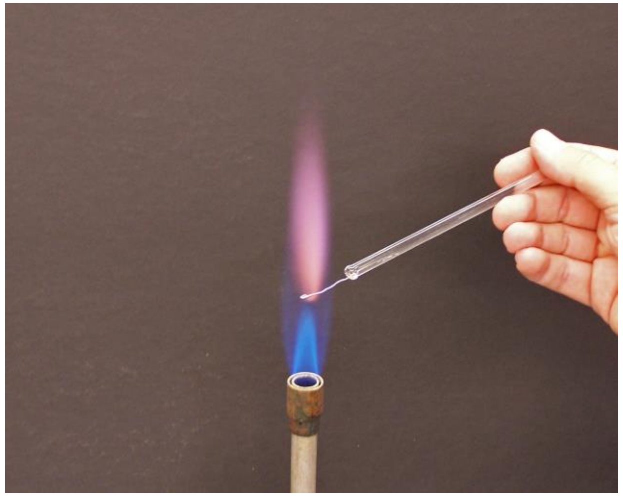
Flame Tests



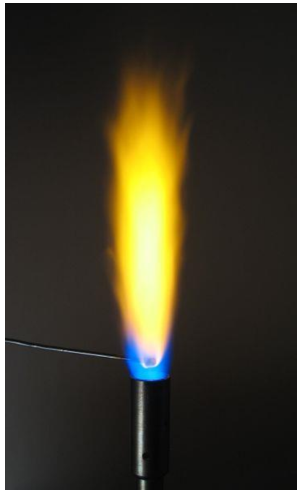
The flame test is a procedure used in chemistry to detect the presence of certain metal ions, based on each element's characteristic emission spectrum. The color of flames in general also depends on temperature.

The flame test is fast and easy to perform, and does not require any equipment not usually found in a chemistry laboratory. However, the range of detected elements is small, and the test relies on the subjective experience of the experimenter rather than any objective measurements

Flame Tests



Potassium - Purple



Sodium - Yellow

Barium - Green

Sodium is a common component or contaminant in many compounds and its spectrum tends to dominate over others. Thus the color yellow overpowers the true color.

The test flame is often viewed through cobalt blue glass to filter out the yellow of sodium and allow for easier viewing of other metal ions.

Cation and Anion Analysis

How to find cations and anions

In order to analyse cations and anions a series of tests would have to be performed. These can be used to identify the elements found in a specific compounds. There are three sets of tests: flame tests, tests with bases such as NaOH and NH_4OH and tests for anions.

Flame tests:

Na^{+}: **yellow/orange flame**

K^{+}: **lilac flame**

Mg^{2+}: **no coloured flame**

Ca^{2+}: **red brick flame**

Ba^{2+}: **green flame**

Cu^{2+}: **blue-green flame**

Pb^{2+}: **light blue flame**

NH_4^{+}: **no coloured flame**

Al^{3+}: **no coloured flame**

It must be noted that it is the precipitate that is the most important, and not the colour of the solution even though the solution takes it colour from the ppt. The precipitate is the hydroxide of the cation being analysed.

The reactions taking place are:

$M^+_{(aq)} + OH^-_{(aq)} \rightarrow MOH_{(s)}$ for the formation of precipitates

When the ppt dissolves in excess base a complex would be formed, which would have a charge and therefore it would dissolve in an aqueous solution. An example is:

$Pb^{2+} + OH^- \rightarrow Pb(OH)_2$

$Pb(OH)_2 + OH^- \rightarrow Pb(OH)_4]^{2-}$

Although it is important to know that these complexes exist it is a chemistry of its own and students are not expected to know how these complexes form.

<u>Testing for Anions</u>

CO_3^{2-}: With the addition of an acid a colourless and odourless gas which turns limewater milky is created. This gas is CO_2 and the reaction is as following:

$CO_3^{2-}{}_{(aq)} + 2H^+_{(aq)} \rightarrow H_2O + CO_2$

SO_4^{2-}: The addition of Barium Chloride would form Barium Sulfate which is insoluble. On addition of acid the white precipitate formed does not dissolve.

$SO_4^{2-}{}_{(aq)} + Ba^{2+}_{(aq)} \rightarrow BaSO_{4(s)}$

SO_3^{2-}: The addition of Barium Chloride would form Barium Sulfite which is insoluble. On addition of acid the white precipitate formed disappears. The gas produced when the anion is reacted with an acid turns blue litmus red.

$$SO_3^{2-}{}_{(aq)} + Ba^{2+}{}_{(aq)} \rightarrow BaSO_{3(s)}$$

$$SO_3^{2-}{}_{(s)} + 2H^+{}_{(aq)} \rightarrow H_2O + SO_2$$

S^{2-}: By reacting the anion with an acid a pungent gas is formed.

$$S^{2-} + 2H^+ \rightarrow H_2S$$

Cl^-: Reacting the anion with $AgNO_3$ would form a white ppt.

$$Ag^+{}_{(aq)} + Cl^-{}_{(aq)} \rightarrow AgCl_{(s)}$$

If the chloride ion is reacted with a concentrated acid such concentrated sulfuric acid white fumes would be seen, which would be HCl

$$Cl^- + H^+ \rightarrow HCl$$

Br^-: Reacting the anion with $AgNO_3$ would form a pale yellow ppt.

$$Ag^+{}_{(aq)} + Br^-{}_{(aq)} \rightarrow AgBr_{(s)}$$

If the bromide ion is reacted with a concentrated acid such concentrated sulfuric acid white fumes would be seen, which would be HBr. this might have some brown fumes coming from Bromine.

$$Br^- + H^+ \rightarrow HBr$$

Br^-: Reacting the anion with $AgNO_3$ would form a pale yellow ppt.

$$Ag^+_{(aq)} + Br^-_{(aq)} \rightarrow AgBr_{(s)}$$

If the bromide ion is reacted with a concentrated acid such concentrated sulfuric acid white fumes would be seen, which would be HBr. this might have some brown fumes coming from Bromine.

$$Br^- + H^+ \rightarrow HBr$$

I^-: Reacting the anion with $AgNO_3$ would form a yellow ppt.

$$Ag^+_{(aq)} + I^-_{(aq)} \rightarrow AgI_{(s)}$$

If the iodide ion is reacted with a concentrated acid such concentrated sulfuric acid white fumes would be seen, which would be HI. this might have some purple fumes coming from the Iodine vapour.

$$I^- + H^+ \rightarrow HI$$

If Pb^{2+} is reacted with I^- a very bright yellow ppt is formed. This would PbI_2 and this is the confirmatory test to distinguish Pb^{2+} from Al^{3+}.

NO_3^-: By using Devarda's alloy, a mixture of Zinc, Aluminium and Copper, which is a very strong reducing agent. This would liberate ammonia, which has a pungent smell and turns red litmus blue.

$$6H^+ + NO_3^- \rightarrow NH_3 + 3H_2O + 5e^-$$

(This is the half-reaction depicting the reduction of the nitrate)

Another test is the brown ring test, which comprises of the addition of concentrated sulfuric acid and Iron(II) Sulfate. The resultant of this reaction in the presence of a nitrate would be NO, which would form a brown ring in the middle of the solution.

Reference Books:

- Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
- Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of

Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
- Greenwood, N.N. & Earnshaw. Chemistry of the Elements, ButterworthHeinemann.

1997.
- Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.