



## Dissolved Oxygen

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Oxygen is critical to the survival of aquatic plants and animals, and a shortage of dissolved oxygen is not only a sign of pollution, it is harmful to the fish. Some aquatic species are more sensitive to oxygen depletion than others, but some general guidelines to consider when analyzing test results are:

- 5 – 6 ppm Sufficient for most species
- <3 ppm Stressful to most aquatic
- 2< ppm Fatal to most species

Because of its importance to the fish's survival, aquaculturists or "fish farmers", and aquarists use the dissolved oxygen test as a primary indicator of their system's ability to support healthy fish.

### Where does the oxygen come from?

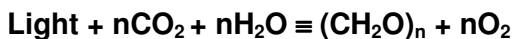
The oxygen found in water comes from many sources, but the largest source is oxygen absorbed from the atmosphere. Wave action and splashing allows more oxygen to be absorbed into the water. A second major source of oxygen is aquatic plants, including algae: during photosynthesis plants remove carbon dioxide from the water and replace it with oxygen.

#### Absorption:

Oxygen is continuously moving between the water and surrounding air. The direction and speed of this movement is dependent upon the amount of contact between the air and water. A tumbling mountain stream or windswept, wave covered lake, where more of the water's surface is exposed to the air, will absorb more oxygen from the atmosphere than a calm, smooth body of water. This is the idea behind aerators; by creating bubbles and waves the surface area is increased and more oxygen can enter the water.

#### Photosynthesis:

In the leaves of plants, one of the most important chemical processes on Earth is constantly occurring – photosynthesis. During daylight, plants constantly take carbon dioxide from the air, and, in the presence of water, convert it to oxygen and carbohydrates, which are used to produce additional plant material. Since photosynthesis requires light, plants do not photosynthesize at night, so no oxygen is produced. Chemically, the photosynthesis reaction can be written as:



Light + Carbon Dioxide + Water  $\equiv$  Carbohydrate + Oxygen

### Where Does The Oxygen Go?

Once in the water, oxygen is used by the aquatic life. Fish and other aquatic animals need oxygen to breathe or respire. Oxygen is also consumed by bacteria to decay, or decompose, dead plants and animals.

#### Respiration:

All animals, whether on land or underwater, need oxygen to respire, and grow and survive. Plants and animals respire throughout the night and day, consuming oxygen, and producing carbon dioxide which is then used by plants during photosynthesis.

#### Decomposition:

All plant and animal waste eventually decomposes, whether it is from living animals or dead plants and animals. In the decomposition process, bacteria use oxygen to oxidize, or chemically alter, the material to break it down to its component parts. Some aquatic systems may undergo extreme amounts of oxidation, leaving no oxygen for the living organisms, which eventually leave or suffocate.



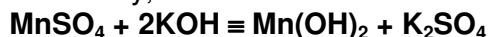
### Other Factors:

The oxygen level of a water system is not only dependent on production and consumption. Many other factors work together to determine the potential oxygen level, including:

- Salty vs. fresh water: Fresh water can hold more oxygen than salt water.
- Temperature: Cold water can hold more oxygen than warm water.
- Atmospheric pressure (Altitude): The greater the atmospheric pressure, the more oxygen the water will hold.

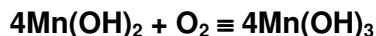
### Testing Dissolved Oxygen:

Dissolved Oxygen is often tested using the Azide modification of the Winkler method. When testing dissolved oxygen, it is critical not to introduce additional oxygen into the sample. Many people avoid this problem by filling the sample bottle all the way and allowing the water to overflow for one minute before capping. The first step in a DO titration is the addition of Manganous sulfate Solution (4167) and Alkaline Potassium Iodide Azide Solution (7166). These reagents react to form a white precipitate, or floc, of manganous hydroxide,  $Mn(OH)_2$ . Chemically, this reaction can be written as:



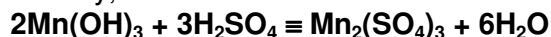
Manganese Sulfate + Potassium Hydroxide  $\equiv$  Manganese Hydroxide + Potassium Sulfate

Immediately upon formation of the precipitate, the oxygen in the water oxidizes an equivalent amount of the manganous hydroxide to brown-coloured manganic hydroxide. For every molecule of oxygen in the water, four molecules of manganous hydroxide are converted to manganic hydroxide. Chemically, this reaction can be written as:



Manganese Hydroxide + Oxygen + Water  $\equiv$  Manganese Hydroxide

After the brown precipitate is formed, a strong acid, such as Sulfamic Acid Powder (6286) or Sulfamic Acid, 1:1 (6141) is added to the sample. The acid converts the Manganese hydroxide to Manganese sulfate. At this point the sample is considered "fixed" and concern for additional oxygen being introduced into the sample is reduced. Chemically, this reaction can be written as:



Manganese Hydroxide + Sulfuric Acid  $\equiv$  Manganese Sulfate + Water

Simultaneously, iodine from the potassium iodide in the Alkaline Potassium Iodide Azide Solution is oxidized by Manganese sulfate, releasing free iodine into the water. Since the Manganese sulfate for this reaction comes from the reaction between the Manganese hydroxide and oxygen, the amount of iodine released is directly proportional to the amount of oxygen present in the original sample. The release of free iodine is indicated by the sample turning a yellow-brown colour. Chemically, this reaction can be written as:



Manganese Sulfate + Potassium Iodide  $\equiv$  Manganese Sulfate + Potassium Sulfate + Iodine

The final stage in the Winkler titration is the addition of sodium thiosulfate. The sodium thiosulfate reacts with the free iodine to produce sodium iodide. When all the iodine has been converted, the sample changes from yellow-brown to colourless.



Sodium Thiosulfate + Iodine  $\equiv$  Sodium Tetrathionate + sodium Iodide