Atomic Absorption Spectroscopy
Quantitative Analysis of Copper

The body needs small amounts of copper for normal growth and health. Copper is required in the formation of hemoglobin, red blood cells, and bones. It helps with the formation of the structural proteins elastin and collagen, which are important in healing wounds. It is necessary for the manufacture of the neurotransmitter noradrenaline as well as for the pigmentation of your hair. It is also important for nerve function and in the metabolism of sugars.

If copper is deficient in the body, iron is also normally in short supply, leading to anemia and increasing the likelihood of infections, osteoporosis, thyroid dysfunction, and heart disease.

Copper is found in various foods, including meats (especially liver), seafoods, beans, nuts, and whole-grains. It can come from drinking water (copper pipes), copper cookware, and farm produce.

Recommended Dietary Allowances (RDAs) are the amount of vitamins and minerals that are considered necessary to provide adequate nutrition in most healthy people by the Food & Drug Administration (FDA). RDAs for a given nutrient varies with a person's age, sex, and physical condition (e.g., pregnancy). Copper does not have a set RDA. However, normal daily intakes are generally defined as follows:

Infants and Children:
- Birth to 3 years of age: 0.4 to 1 milligram (mg) per day.
- 4 to 6 years of age: 1 to 1.5 mg per day.
- 7 to 10 years of age: 1 to 2 mg per day.

Adolescent and adult males—1.5 to 2.5 mg per day.
Adolescent and adult females—1.5 to 3 mg per day.

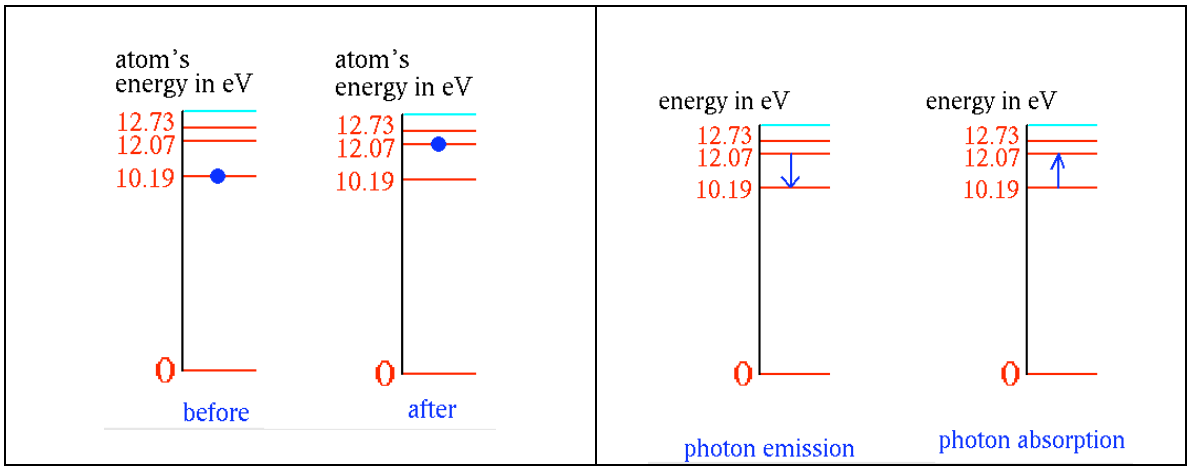
According to recent USDA surveys, the average intake of copper by women 19 to 50 years of age was about 1 milligram, and that of men of the same age was about 1.6 milligrams. For women, this amount is less than the 1.5- to 3-milligram range of Estimated Safe and Adequate Daily Dietary Intakes recommended by the Food and Nutrition Board of the National Academy of Sciences.

Copper does not stand out the way that iron does in dietary supplements, vitamins, and health products, but it is present in many of them. The purpose of this experiment is to introduce an analytical instrumental method, Atomic Absorption (AA) spectroscopy, that is commonly used for the quantitative analysis of very small amounts of metals and other atoms. AA will be applied to the analysis of individual (unknown) commercial vitamin and dietary supplements that contain copper to determine the amount of copper actually present.

Atomic absorption spectroscopy is a quantitative technique for determining the concentration of a particular metal element within a sample. It can be used to analyze the concentration of more than 60 different metals. The technique is highly sensitive and can detect concentration levels of parts per million and in some cases parts per billion.

Atomic Absorption Spectroscopy was first developed during the 1950s by a team of Australian chemists, lead by Sir Alan Walsh. One version of the technique, which you will employ, makes use of a flame to atomize a sample. Other atomizers such as a graphite furnace are also used. Flame AA can only analyze solutions, while graphite furnace AA can accept solutions, slurries, or solid samples.

Atomic-absorption (AA) spectroscopy uses the absorption of light to measure the concentration of gas-phase atoms. Since samples are usually liquids or solids, the atoms or ions must be vaporized in a flame or graphite furnace. The atoms absorb ultraviolet or visible light, which "excite" them to higher quantized electronic energy levels, 10.19 eV to 12.07 eV in the example below. In this case the atom absorbs 1.88 eV, which is a photon of wave length=653 nm. It can then emit energy (emission) equal to 1.88 eV.



In AA Spectroscopy the concentration is determined from the amount of energy absorbed. Direct application of a "universal" Beer's law in AA spectroscopy is difficult due to variations in the sample, curve linearity and instrumental operating conditions. Therefore the instrument must be calibrated with standards of known concentration, and an absorbance versus concentration curve generated. The standard concentrations are selected from the linear portion of the respective absorption curve for the element at a wavelength at or near the metal's wave length of maxium absorption. The standard concentration ranges vary with the element and some are extremely low. The concentrations are expressed in mg/L, which is equal to parts per million (ppm).

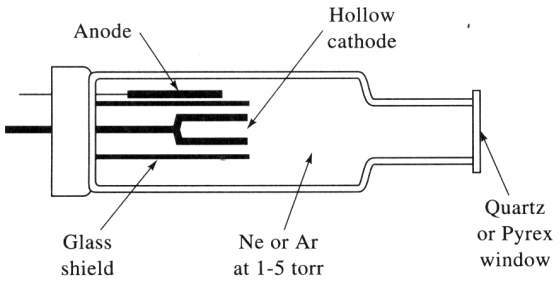
The AA's flame is ~10cm in length and its height is controlled by adjusting the flow of the fuel mixture. In your analysis this mixture is air and acetylene. Sample solutions are usually aspirated with the gas flow into a nebulizing/mixing chamber to form small droplets before entering the flame. A beam of light is passed through the flame and focused on a detector.

Standards Table:

[a] Sens. Check is the concentration giving approximately 0.2 AU. [b] Linear Range is the upper concentration of linear range. [c] Min. mg/L is the concentration giving 0.02 AU (Sens. Check divided by 10) [d] Max. is the upper limit in mg per 25 mL (linear range divided by 40).

Element	Wave- Length (nm)	Sens. Check [a] (mg/L)	Linear Range [b] (mg/L)	Min.[c] (mg/L)	Min. [d] (mg/25 mL)	Expected Abs Units
Antimony	217.6	15.0	100.0 – 1.5	0.038	2.50	0.10–0.20
Barium	553.6	10.0	50.0 – 1.0	0.10	0.20	0.06–0.12
Bismuth	223.1	10.0	50.0– 1.0	0.025	1.25	0.12–0.24
Cadmium	228.8	0.5	3.0 – 0.05	0.075	0.0013	0.18–0.36
Calcium	422.7	0.5	3.0 – 0.05	0.0013	0.075	0.25–0.50
Cobalt	240.7	2.5	15.0 – 0.25	0.0063	0.375	0.08–0.16
Copper	324.8	1.5	10.0 – 0.15	0.0038	0.250	0.11–0.22
Iron	248.3	2.5	15.0 – 0.25	0.0063	0.375	0.20–0.40
Lithium	670.8	1.0	5.0 – 0.10	0.0025	0.125	0.11–0.22
Magnesium	285.2	0.15	1.0 – 0.015	0.0004	0.025	0.25–0.50
Manganese	279.5	1.0	5.0 – 0.10	0.0025	0.125	0.22–0.44
Molybdenum	313.3	15.0	100.0 – 1.50	0.038	2.50	0.13–0.26
Nickel	232.0	4.0	0.40 – 0.01	0.50	20.0	0.18–0.36
Potassium	766.5	0.4	2.0 – 0.04	0.001	0.050	0.20–0.40
Silver	328.1	1.5	10.0 – 0.15	0.0038	0.250	0.11–0.22
Sodium	589.0	0.15	1.0 – 0.015	0.0004	0.025	0.25–0.50
Strontium	460.7	2.0	10.0 – 0.20	0.005	0.250	0.35–0.70
Zinc	213.9	0.4	2.0 – 0.04	0.001	0.050	0.20–0.40

The light source is a hollow cathode lamp. Inside the lamp is a cylindrical metal cathode containing the specific metal being analyzed, and an anode.



When a high voltage is applied across the anode and cathode, the metal atoms in the cathode are excited to produce light with a certain emission spectra. The electrons of the atoms in the flame are promoted to higher energy levels by absorbing energy quanta. The amount of energy is specific to a particular electron transition in a particular element. The energy put into the flame is known, and the energy at the detector is measured. From these proportional values it is possible to calculate the concentration of the element being measured.

Sequence of analysis

* Aspirate calibration blank and establish a blank level
* Aspirate calibration blank and standard solutions and construct a calibration curve. Use at least 3 standard solutions in addition to the calibration blank to cover the linear range. Every point at the calibration curve should, if possible, be based on replicate analysis. Distilled water should be aspirated after each standard and sample.
* A quality control standard should be analyzed to verify the calibration.
* A calibration blank should be analyzed to check for memory effects.
* Aspirate unknown samples.
* Aspirate a quality control standard for every 10th sample to check for drift.
* Samples that are found to have concentration higher than the highest standard should be diluted and reanalyzed.