Percent of copper in a 10 cent coin

Composition of coins

'Nordic' alloy is used to make 10, 20, and 50 euro cents.

Its composition is 89% copper, 5% aluminium, 5% zinc, and 1% tin.

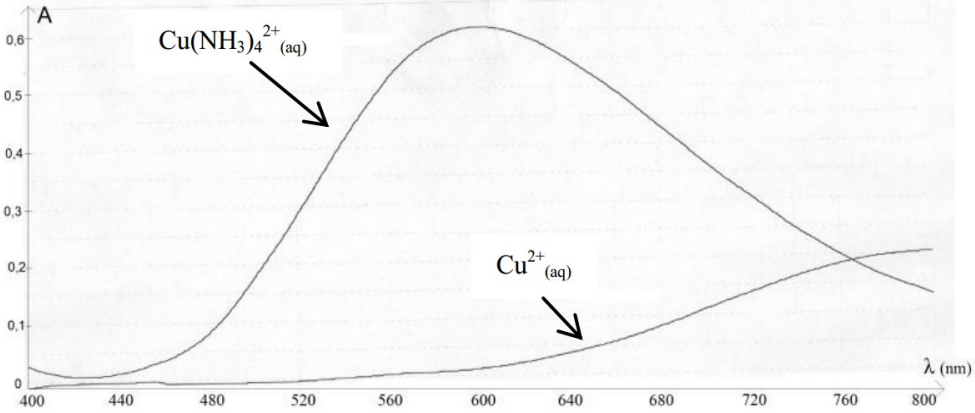
Nickel has been banned in the composition of recent coins, because it is a known allergen.

Coins are an easy way to spread germs. **Copper** is a natural antimicrobial material. Ancient civilizations exploited the antimicrobial properties of copper long before the concept of microbes became understood in the nineteenth century. This is why most coins contain copper.

Absorbance – Beer's law

Absorbance is a direct measure of how much light is absorbed by a sample. Absorbance can take on values between 0 and about 2.

Large values of absorbance are associated with very little light passing through the sample, whereas small values of absorbance are associated with most of the light passing through the sample.



The graph above represents the absorption spectrum for Cu^{2+} ion in pure water and with ammonia NH_3 (at the same concentration).

When ammonia is added to the solution, the copper ion transforms into $Cu(NH_3)_4^{2+}$ (called a *complex ion*). For the same concentration, the absorbance of the complex ion is about 4 times higher than that of the Cu^{2+} ion alone.

Lab part #1

Each pair of students will prepare a different **standard solution** from the **stock solution**, then measure its absorbance. The measurements will be shared among all pairs of lab students.

Step 1: prepare the standard solutions

Stock solution: concentration **12,5 g.L^{-1}**

Standard solutions	A	B	C	D	E	F
Volume of the standard solution (mL)	**50**	**50**	**50**	**50**	**50**	**50**
Concentration (g.L^{-1})	**0.250**	**0.500**	**1.25**	**2.50**	**5.00**	**6.25**
Volume of stock solution needed (mL)						
Volume of ammonia (mL)	**10**	**10**	**10**	**10**	**10**	**10**

- Calculate the volume of stock solution needed to prepare the standard with the assigned concentration as described in the table. Record the result in the table.
- With the appropriate **volumetric pipette**, transfer the sample of stock solution into a 50.0 mL conical flask.
- Use a graduated pipette to add 10 mL of ammonia.
- Fill the conical flask to the mark with distilled water. Stopper and swirl the solution.

Step 2: measure the absorbance of your standard solution

To perform the measurements using the **spectrometer**:

- Set the wavelength to **610 nm**.
- Fill a cuvette with distilled water. This is the **blank** or reference solution.
- Wipe the outside of the cuvette with a paper towel to remove any fingerprint, water or dust particles.
- Place the filled cuvette into the sample compartment.
- Adjust the display to 0. Remove the cuvette.
- Place another cuvette filled at least half-way with a standard solution. Read the value of absorbance.

Standard solutions	A	B	C	D	E	F
Concentration (g.L^{-1})	**0.250**	**0.500**	**1.25**	**2.50**	**5.00**	**6.25**
Absorbance						

Share your measurements with the other pairs of lab students.

Step 3: the calibration curve

Those measurements allow you to draw a **calibration curve** and check Beer's law.

- On a millimeter graph paper, plot a graph of the absorbance of the standard solution vs its concentration.
  Take the graph paper on a **portrait orientation** (not landscape).
  Scale: x-axis: 2 cm for 1 g.L^{-1} y-axis: 1 cm for 0.050

- Don't forget to label the axes and to put a title.
- Draw the **best fit line** through the data points.
- Determine the value of the **molar extinction coefficient ε**: it's the **slope** of the calibration curve.
  Show your calculation in this box:

Lab part #2

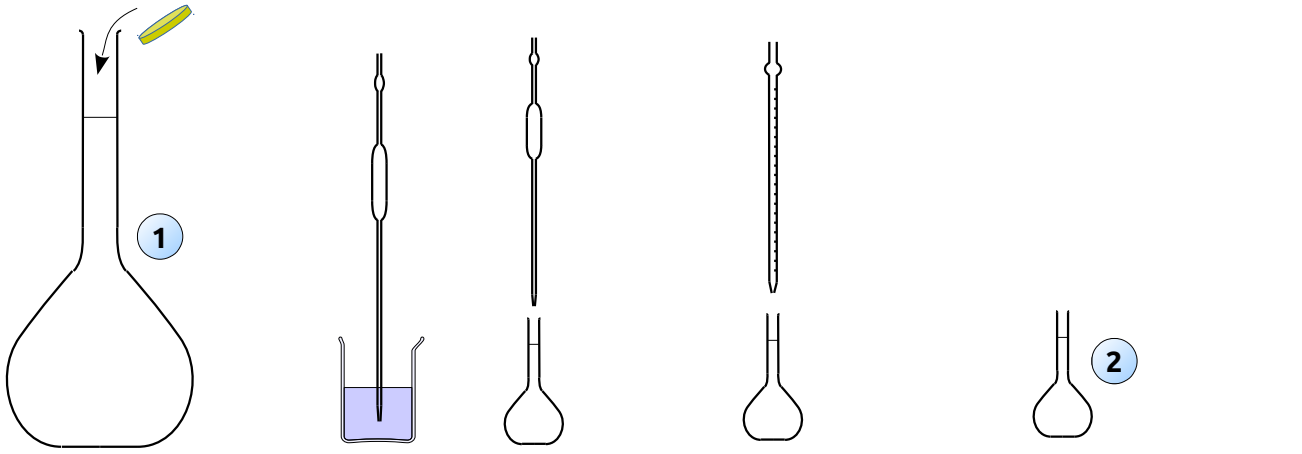
In order to determine the copper content in a 10 cent euro coin we must first **dissolve the coin**. To achieve this we will use concentrated nitric acid, a strong oxidizing acid.

The gas produced in this reaction, nitric oxide NO, quickly transforms into brown NO_2, a toxic gas. The dissolution process therefore must be carried out in a **fume hood**. This step will be carried out by your professor.

Safety

The solution in which the coin has been dissolved is still very acidic. Use **goggles** and **gloves** to handle this solution.

Preparing a less concentrated solution:



1. Solution #2 is less concentrated than solution #1. How are the 2 concentrations related?

Measure the absorbance of solution #2: $A =$ _____

2. Determine the concentration of copper ion in solution #2.

3. Determine the concentration of copper ion in solution #1.

4. Determine the mass of copper in solution #1.

5. A 10 c. euro coin has a mass of **4.00 g**. Determine the percent of copper in this coin.

6. Compare to the figure given in this worksheet. What sources of error could explain the difference?

Remarques pour le professeur :

- Le texte de ce document élève a, pour l'essentiel, été collecté à partir de plusieurs protocoles de chimie trouvés sur le web, traitant du même dosage, ou d'un autre dosage par spectrophotométrie.

  Ainsi, l'essentiel de la rédaction est d'origine anglophone.

- La solution mère est indiquée à **12,5 g.L^{-1}**. C'est la teneur en ions Cu^{2+}. Pour sa préparation, il faut peser **49,1 g** de sulfate de cuivre pentahydraté pour un litre de solution.
- Le coefficient d'extinction molaire pour l'ion $Cu(H_2O)^{2+}$ vaut environ **ε = 12 L.mol^{-1}.cm^{-1}** (à 800 nm).

Pour l'ion $Cu(NH_3)_4^{2+}$, sa valeur passe à environ **ε = 49 L.mol^{-1}.cm^{-1}** (à 610 nm), soit **0,77 L.g^{-1}.cm^{-1}**.

- Ajout d'ammoniac pendant la préparation des solutions filles :

La quantité à ajouter est bien supérieure à la quantité prévue par la simple stoechiométrie du complexe. En effet, l'addition d'ammoniac commence par former un précipité $Cu(OH)_2$. Pour redissoudre totalement ce précipité (qui empêche la mesure d'absorbance), il faut un large excès d'ammoniac.

- Dissolution de la pièce de monnaie dans l'acide nitrique :

  Il suffit d'environ 10 mL d'acide nitrique concentré pour dissoudre entièrement la pièce. La solution prend d'abord une couleur verte. En fin de réaction, la couleur tire sur le bleu. Il est souhaitable de neutraliser cette solution avant de procéder aux prélèvements ; cependant, un ajout trop important de base risque de faire apparaître le précipité d'hydroxyde de cuivre.

- Résultats du dosage :

  Le pourcentage de cuivre a été estimé à 91 % par cette méthode, à comparer à 89 % attendus.

- Il semble assez évident d'adapter ce protocole avec une pièce de monnaie plus 'exotique'... comme un penny britannique ou américain. Il faudra alors revoir complètement les volumes et concentrations de la dernière partie du protocole (préparation de la solution avec l'acide nitrique), car les quantités de cuivre varient notablement.

  A titre d'exemple : pour un penny américain frappé après 1982, la pièce pèse 2,50 g, et contient 2,5 % de cuivre, soit 60 fois moins que la pièce de 10 c. d'euros.