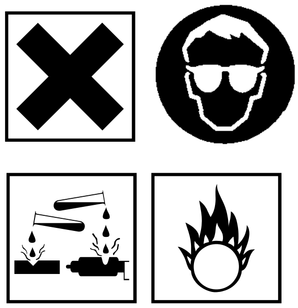
What is the percentage of copper in "copper" coins?

Introduction



"Copper" coins are made of "coinage bronze", an alloy consisting mainly of copper, but which contains other metals as well. In today's experiment, you will determine the percentage of copper in 1p pieces using titrimetric analysis.

The determination takes place in three stages:

Stage 1 A weighed coin is dissolved in concentrated nitric acid. This forms a solution of copper(II) ions.

Stage 2 The solution of Cu^{2+} ions is treated with aqueous potassium iodide. Copper(I) iodide is precipitated as a white solid and iodine is produced, according to the equation below:

$$2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$$

Stage 3 The amount of liberated iodine is found by titrating with standard sodium thiosulphate solution. Knowing the amount of iodine formed, the mass of copper present in the original coin can be calculated.

Apparatus

goggles
gloves
bench mat
1 x 1p piece
1 x 250cm^3 beaker
1 x 250cm^3 conical flask
1 x 250cm^3 volumetric flask with stopper
1 x 25cm^3 bulb pipette
1 x pipette filler
1 x 25cm^3 measuring cylinder
1 x burette and stand
1 x plastic filter funnel

1 x white tile
1 x wash bottle of de-ionised water
3 x teat pipettes

0.2M sodium thiosulphate solution ☒
0.2% (w/v) starch solution
1M (approx.) potassium iodide solution ☒
1M (approx.) sodium carbonate solution
Concentrated nitric acid

Dilute ethanoic acid ☒

Methods

Stage 1

1. Weigh your 1p piece, record its mass, and put it into a 250cm^3 beaker.

2. **Wearing eye protection and gloves**, add about 20cm^3 of concentrated nitric acid to your beaker to start dissolving the coin. **Do this in the fume cupboard** (as toxic nitrogen dioxide is evolved). Allow the coin to dissolve (this should take about 10 minutes, so use the time to clean your burette and fill it with standard 0.2M sodium thiosulphate ready for Stage 3).
Record what happens when the coin is treated with concentrated nitric acid.

3. Transfer the coin solution, with washings from the beaker, to a 250cm^3 standard flask.
Make the solution up to the mark and mix it well.

Stage 2

4. Pipette $25cm^3$ of the brass solution into a conical flask and add sodium carbonate solution until a slight permanent precipitate is obtained (this neutralises excess nitric acid in the solution).

5. Add just enough dilute ethanoic acid to dissolve the precipitate, then add $10cm^3$ of potassium iodide solution. Record your observations.

Stage 3

6. Titrate the liberated iodine from step 5 against standard 0.2M sodium thiosulphate.
This is quite a difficult titration because a thick creamy precipitate is formed. Near to the end-point (when the mixture appears pale) add about $1cm^3$ of starch indicator to produce a purple colour. Continue to titrate until the end-point (which is when the solution appears very pale pink). Confirm the end-point by adding some more starch indicator – no more purple colour should develop.
Record your results neatly.

7. Repeat steps 4, 5 and 6 until concordant results are obtained.

Analysis

Equations

1. Write an equation for the reaction of copper with concentrated nitric acid, HNO_3.

2. Write an equation for the neutralisation of excess nitric acid with sodium carbonate solution.
Why is it necessary to neutralise the excess nitric acid used to dissolve the coin?
(Hint: Nitric acid is an oxidising agent).

3. Write the balanced redox equation for the reaction between thiosulphate ions, $S_2O_3^{2-}$, and iodine, I_2.

Calculations

4. Put ticks against the results in your table that you will use to calculate your mean titre.
Calculate your mean titre of 0.2M sodium thiosulphate.

5. Using your answer to (4), calculate the number of moles of $S_2O_3^{2-}$ which react in the titration.

6. How many moles of I_2 react with this amount of $S_2O_3^{2-}$?

7. How many moles of Cu^{2+} ions are needed to liberate this amount of I_2? (Equation on first side).

8. Your answer to (7) is the number of moles of Cu^{2+} ions in your $25cm^3$ aliquot of "coin solution".
How many moles of Cu^{2+} ions were in the $250cm^3$ of "coin solution"?

9. A_r (Cu) = 63.5 – calculate the number of grams of copper in this "coin solution".

10. Use your answer to (9) and the mass of the original coin to calculate the percentage of copper in your 1p piece.

Evaluation

11. Consider carefully each step of the experiment and the apparatus used. Work out the likely percentage error of each measurement. Explain which procedure contributed most to the errors in the experiment, and suggest how you could reduce this error.

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Technician’s Notes

Apparatus per class

top pan digital balances (minimum of 2)
access to fume cupboard

Apparatus per student

1 x 1p piece

Note: Select old coins only. Newer coins have a steel insert which causes the experiment to fail. Check with a magnet if unsure!

1 x pair of protective gloves
1 x 250cm^3 beaker
1 x 250cm^3 conical flask
1 x 250cm^3 volumetric flask with stopper
1 x 25cm^3 bulb pipette
1 x pipette filler
1 x 25cm^3 measuring cylinder
1 x burette and stand
1 x plastic filter funnel
1 x white tile
1 x wash bottle of de-ionised water (please ensure spare water)
3 x teat pipettes

Reagents

0.2M sodium thiosulphate solution (**accurate molarity please**)	(allow 200cm^3 per student)
0.2% (w/v) starch solution	(allow 10cm^3 per student)
1M (approx.) potassium iodide solution	(allow 50cm^3 per student)
1M (approx.) sodium carbonate solution	(allow 50cm^3 per student)
concentrated nitric acid (leave in fume cupboard please)	(allow 25cm^3 per student)
dilute ethanoic acid	(allow 25cm^3 per student)

