

## Title: Preparation of copper by cementation

### Work instructions

**Task:** Prepare 3 g of Cu by cementation.

### Theory

*Use of the Becketov's series*

Already in the work Dissolution of metals in acids, you have been introduced to the Becketov's metal displacement series (Scheme 1). One of the main pieces of information that can be gleaned from this series is the possibility of displacing one metal from a compound by another. This information can be very useful for the preparation of basic inorganic compounds.

**Li, Cs, K, Ca, Na, Mg, Sc, Al, Ti, Zn, Cr, Ga, Fe, Cd, Co, Ni, Sn, Pb, H, Cu, Ag, Hg, Pt, Au**

*Diagram 1 – Becketov's metal displacement series. In orange (to the left of H) are the non-noble metals. The noble metals are on the right of hydrogen and are shown in green. Underlined are then iron and copper, which we use in this work.*

If we have a metal in a soluble compound in a suitable oxidation state, it is possible to reduce this metal from solution by using the metal to the left of it. For example, copper from blue vitriol can then be recovered by, for example, placing aluminium foil or an iron nail in the blue vitriol solution. It is quite common to use aluminium and iron, which are the cheapest metals for this type of reaction.

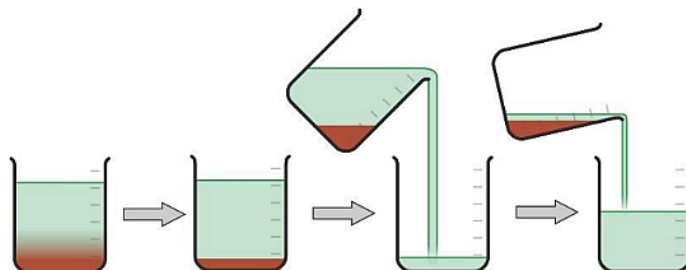


We can say that the metals on the right side of the Becketov's series prefer to occur in elemental form (for example, copper in wire or crystal form), while the left side of the series prefers to occur in a compound (sodium in sodium chloride, elemental sodium does not occur in nature).

### *Decanting*

It is the process of separating solid and solution from a suspension without using a filter baffle. As a rule, it is resorted to if the solid in suspension has a sufficiently high density (metals are almost ideal, otherwise filtration is preferable). The suspension is stirred and then left to rest to allow the solids to sink to the bottom. Then carefully pour off the solution (the solid portion

should not go into it—stop pouring as soon as the precipitate approaches the beaker beak or the rim of the container). If clean water is subsequently added to the liquid-depleted suspension and the process repeated, it is possible to wash the impurities out of the precipitate in this way.



### *Copper*

It is one of the so-called non-ferrous metals. These metals are not silvery or grey, but in the case of copper, for example, they can be reddish brown. Copper is the first metal that humanity learned to modify. The low melting point and the ease of reduction, thanks to its nobility, helped to make it so. When mixed with tin, it forms bronze, which was the first alloy used by humankind on a mass scale. Also significant are its thermal and electrical conductivity, softness, malleability, and ductility, which make it an ideal material for power line wires and wiring.

**Equipment:** beakers (400, 1000 ml), graduated cylinder, glass rod, burner, wire gauze, tripod, scales, crystallisation dish, watch glass, Büchner funnel, suction flask, water jet pump, filter paper

**Chemicals:** copper sulfate pentahydrate, ferrous sulfate heptahydrate, copper, iron

### **Procedures:**

1. Prepare a 10%  $\text{CuSO}_4$  solution in a 1000 ml beaker. First measure 63 ml of water into it and then add 11.8 g of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ .
2. Prepare a 10% solution of  $\text{FeSO}_4$  in a 400 ml beaker. Again, first measure 59 ml of water into it and then add 13.1 g of  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ .
3. Add the  $\text{FeSO}_4$  solution to the  $\text{CuSO}_4$  solution in a 1000ml beaker and heat to boiling.
4. Weigh out the 2.9 g of iron nails needed to prepare the specified amount of Cu and add them into a hot solution of  $\text{CuSO}_4$  and  $\text{FeSO}_4$ .
5. During the reaction, peel off the excluded copper from the Fe nails with a glass rod, stir the reaction mixture and maintain at boiling point.
6. The end of the reaction is indicated by the change in colour of the solution from blue to light green. On the nails, the copper stops being excluded or the nails dissolve completely.

7. Pour the solution over the copper into a crystallisation dish and leave until the next laboratory exercise.
8. Allow  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  to crystallise by free evaporation of the solvent (to prevent oxidation of  $\text{Fe}^{2+}$  to  $\text{Fe}^{3+}$ , add 1 iron nail and a drop of concentrated  $\text{H}_2\text{SO}_4$  to the solution in the crystallisation dish).
9. Decant the green  $\text{FeSO}_4$  solution from copper into a separate beaker and then wash the copper with 100 ml of water.
10. Decant this water (into the waste beaker) and repeat the whole procedure twice more.
11. Next lab exercise  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  crystals obtained by free evaporation of the solvent by crystallisation are also aspirated on a Büchner funnel, dried and weighed.

### Management of chemical substances

Chemicals	Form	H-statements	P-statements
$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	Solid	H302, H319, H315, H410	P273, P302 + P352, P305 + P351 + P338
$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$	Solid	H302, H319, H315	P305 + P351 + P338, P302 + P352, P280
Cu	Solid, powdered	H228, H410	P210, P273
Fe	Solid, nails	---	---

### Sources of risk and assessment of risk severity

Copper sulfate is harmful if ingested, irritates the skin, and penetrates the skin. Causes serious eye irritation. It is highly toxic to aquatic organisms, with long-term effects. Powdered copper is toxic to aquatic organisms and can be an irritant. Green vitriol has irritating effects on eyes and mucous membranes. Students use protective equipment when working with these substances. Weighing and handling of these substances is done under the supervision of the teacher. Acceptable risk.

### Waste management method

Residues of copper sulfate pentahydrate, powdered copper and green vitriol shall not be disposed of with municipal waste and shall not be discharged to sewers. In the event of spillage, sweep up the substance and place it in a carefully labelled closed container provided for this purpose.

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### **Risk reduction measures**

Wear a face shield or safety glasses. Wear protective gloves. Gloves must be inspected before use. Use proper glove removal technique without touching the outer surface of the gloves to prevent skin contact with this product. Do not eat, drink, or smoke while working. Wash hands with soap and water after work or when work is interrupted or treat with a protective cream. In case of an accident or if you feel unwell, inform the teacher immediately. Prevent further leakage or spillage unless there is a risk involved. Do not allow to enter drains. Prevent discharge into the surrounding environment.

## Worksheet

### Calculations

1. Prepare 3.0 g of copper by cementation. Calculate the theoretical yield of ferrous sulphate heptahydrate.

Response:  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O} + 2\text{H}_2\text{O} + \text{Fe} \rightarrow \text{FeSO}_4 \cdot 7\text{H}_2\text{O} + \text{Cu}$

$M(\text{Cu}) = \dots\dots\dots \text{g} \cdot \text{mol}^{-1}$ ,  $M(\text{FeSO}_4 \cdot 7\text{H}_2\text{O}) = \dots\dots\dots \text{g} \cdot \text{mol}^{-1}$

2. Calculate the practical yield of copper in %.

PV =  $\dots\dots\dots$  g, TV =  $\dots\dots\dots$  g

PV(%) =  $\dots\dots\dots$  %

3. Calculate the practical yield of ferrous sulfate heptahydrate in %.

PV =  $\dots\dots\dots$  g, TV =  $\dots\dots\dots$  g

PV(%) =  $\dots\dots\dots$  %

### Observation

1. Describe the appearance of prepared copper and ferrous sulfate heptahydrate.
2. Search for the basic physicochemical of copper and ferrous sulfate heptahydrate.

Feature	Copper	Ferrous sulphate heptahydrate
Solubility in water		
Solubility in other solvents		
Melting point		

### Yield

1. Record the mass of the prepared copper and ferrous sulfate heptahydrate.

$m(\text{Cu}) = \dots\dots\dots \text{g}$

$m(\text{FeSO}_4 \cdot 7\text{H}_2\text{O}) = \dots\dots\dots \text{g}$

### Questions

1. Write the equations for the reaction of copper preparation by cementation.
2. Explain the importance of decanting in the preparation of copper.
3. Explain how to prevent the oxidation of ferrous cation in ferrous sulfate heptahydrate.
4. Indicate how you can achieve the exclusion of crystals from the saturated solution.
5. Describe the use of ferrous sulfate heptahydrate.

### Conclusion

Briefly summarize the objective of the experiment, the main results and compare them with the expected values.

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