

CHEM-E6130 - Metal Recycling Technologies

Final Exam 07.12.2023, at 9:00 – 13:00

Student name:

Study number:

General Instructions

The exam is an open book exam, where all printed and electronic material is allowed. The course content is divided into five topics each topic giving maximum 12 points. Write your answers on a paper given to you by teachers. Return exam questions and all answer papers to teachers at the end of the exam.

It is not allowed to communicate with others during the exam. It is also not allowed to use AI (e.g. ChatGPT) during the exam.

Exam Questions

Topic 1 – General topics and raw materials.

Question 1-1. Explain the concept of urban mining and explain how this concept relates to the Circular Economy. (6 points) ✓

Question 1-2. In recent years, the great effort has been made in academia and industry to develop circularity indicators. Explain what is the goal of circularity indicators, and give an example of a circularity indicator at the micro level (e.g. product, company level). Briefly explain how this indicator can be used in assessing circularity. (6 points)

Topic 2. – Mechanical Processing. ✓

Question 2-1 Explain the concept of liberation in mechanical processing. What methods are available to liberate waste electronic equipment? (6 points)

Question 2-2. What mechanical processing steps would you use to turn an end-of-life smartphones to separate different material streams? (6 points)

Topic 3. – Pyrometallurgy ✓

Question 3-1. (6 points)

Examine factors that should be considered when selecting pyrometallurgical process(es) and process conditions for recycling end-of-life scrap.

Question 3-2. (6 points)

Your task is to recycle shredder scrap containing copper, aluminium, arsenic, zinc, gold, and platinum as well as plastics. Propose pyrometallurgical processing step(s)

for this material and justify your selection. Examine the possibilities to recover the metals from the scrap. Could some of these metals cause problems in the process(es) you choose or in further processing steps?

Topic 4. – Hydrometallurgy

Question 4-1. What alternatives do you have to feed WEEE material to the traditional smelter – converter – electrorefining process used for producing copper? What limits can you have? Is it possible to recover gold or silver from printed circuit boards using this copper production process and how? (6 points) (6 points)

Question 4-2. On an old mine and smelter site the slag heap was noticed to contain a significant amount of copper and cobalt. These valuable metals exist both in metallic form, as oxides, and as sulphides. What kind of hydrometallurgical processing route would you design for such raw material? Consider possible activation treatments, leaching chemistry and technique, solution purification, and recovery. (6 points)

Topic 5. – LCA

Question 5-1. What is the Functional Unit in LCA analysis? What is done in the LCI and LCIA phases of the LCA analysis? What impact categories would you include in a metals production or recycling process? (6 points)

Question 5-2. The traditional copper smelting – converting – electrorefining processing route will have emissions to air, water and soil, and it will produce different wastes and residues. What Life Cycle Impact Assessment categories do you consider relevant to this processing route. What specific releases can be avoided when you use copper scrap as feed material to converters and anode furnaces? Think about the whole life cycle of copper from mine to copper cathodes. (6 points)