



Professor Herbert Sixta
Biorefineries

EXAM on C-2120 Industrial Processes in Bio and Chemical Technology

Dear Student,

Please be aware of the following instructions:

- Read the questions very carefully!
- Include your answer(s) between the individual questions. There is enough space. Be very short, but precise in your answers. Avoid telling stories!
- The full point(s) are given, see in square bracket, when the question is precisely answered. In the case that the question was not answered precisely leads to the deduction of points in 0.5 increments.
- Good luck!

1. Principles of biobased economy

- 1.1. Explain the sugar cane-to-ethanol biorefinery? [3]
 - 1.1.1. Processes, products, yields?
 - 1.1.2. Challenges? Drawbacks?
 - 1.1.3. First or second generation biorefinery?

1.2. Describe (list) the hierarchical structure of wood? [1]

- 1.2.1. Describe the eight levels?

2. Basics in green chemistry

2.1 What is Green Chemistry? [2]

2.1.1 Drivers?

2.1.2 E-factor concept?

2.1.3 Difference to Sustainable Chemistry?

2.2 Calculation of molecular weights of a cellulose sample [3]

2.2.1 Cellulose molecules with DP= 500 with a share of 10%, DP=700 with a share of 20%, DP=900 with a share of 30%, DP=1100 with a share of 20% and DP=2000 with a share of 20%;

2.2.2 Calculate the number-average degree of polymerization \overline{DP}_n ? Calculate the weight-average degree of polymerization \overline{DP}_w ?

2.2.3 Calculate the weight-average molecular weight?



2.3 Explain material properties? [2]

2.3.1 What is ductility?

2.3.2 How can toughness be calculated?

2.3.3 How to calculate the resilience of a material?

2.3.4 Explain the stress-strain curve of a brittle polymer?

3 Pre-treatment and fractionation of lignocellulose

3.1. Calculate the degree of penetration of a eucalyptus chip [2]

3.1.1. Density=0.55 g/cm³

3.1.2. DS=50%

3.2. Chip dimensions? [2]

3.2.1. How can the chip thickness with a disk chipper be adjusted?

3.2.2. Describe the three dimensions of a wood chip?



- 3.3. Pre-treatments? [2]
 - 3.3.1. Mechanisms of AFEX pre-treatment?
 - 3.3.2. SPORL?

- 3.4. Kraft pulping process? [3]
 - 3.4.1. Mechanism of beta-O-4 cleavage of phenolic lignin during Kraft cooking?
 - 3.4.2. Explain the H-factor concept?
 - 3.4.3. Why is glucomannan less stable in alkaline pulping than cellulose?

4. Biopolymeric Material

- 4.1. Cellulose derivatives? [2]
 - 4.1.1. List the most important cellulose derivatives?
 - 4.1.2. Describe the CMC production steps?



4.2. Properties and chemical structure of chitin and chitosan? [1]

5. Sugar-derived chemicals

5.1. Furfural processes? [2]

5.1.1. Mechanism of furfural production from pentoses?

5.1.2. What are the characteristics of the Suprayield process?

5.2. Itaconic acid and use? [2]

5.2.1. How is it produced?

5.2.2. Formula?

5.2.3. Why important? Current applications?



6. Pulp mill biorefinery

- 6.1. Acid sulphite pulping? [3]
 - 6.1.1. Mechanism(s) of delignification
 - 6.1.2. Result of fractionation?
 - 6.1.2.1. Biorefinery of a hardwood acid sulphite process: What happens with the cellulose, the hemicellulose and the lignin fractions?
 - 6.1.3. Chemical recovery: how can bound and free SO₂ be recycled?

7. Lyocell fiber production

- 7.1. Lyocell fiber production [3]
 - 7.1.1. Scheme of Lyocell process?
 - 7.1.2. Which solvent is used? Pros and cons of the used solvent (what is it)?
 - 7.1.3. Which properties are important to ensure good spinnability?
 - 7.1.4. Principles of solvent recovery?



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8. Economical evaluation of bio-based processes; economic appraisal of large projects

Explain shortly:

a) Internal rate of return (IRR)

b) Working capital

9. How can you update the equipment costs?



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10. What is the operation principle of chromatography column?

11. What is dead end filtration and what is cross flow filtration?

Explain and draw a schematic figure.

12. What is humidity and what kind of applications of humidity there are in process industry?