Aalto University
School of Chemical
Technology

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 <u>very</u> 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. List the second-generation feedstock? [3]
      1.1.1. Composition?
      1.1.2. Reason why it is so difficult to utilize the total sugars?
      1.1.3. List the most important representatives of the second-generation feedstock?

1.2. Levels of cellulose structures? [1]

2. Basics in green chemistry

.1 What is Sustainable Chemistry; list the criteria which differ sustainable from green chemistry? [2]

.2 Calculation of molecular weights of a cellulose sample [3]
    .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 Calculate the number-average degree of polymerization $\overline{DP_n}$? Calculate the weight-average degree of polymerization $\overline{DP_w}$?
    .2.3 Calculate the weight-average molecular weight?
    .2.4 Define the viscosity average degree of polymerization: formula?

.3 Explain material properties? [2]

    .3.1   Difference between elastic and plastic deformation?

    .3.2   Definition of toughness?

    .3.3   Define hardening?

    .3.4   Explain the stress-strain curve of a brittle polymer?

- **Pre-treatment and fractionation of lignocellulose**

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

    3.1.1.   Density=0.35 g/cm3

    3.1.2.   DS=60%

3.2.   Chip dimensions? [2]

    3.2.1.   Describe the three dimensions of a wood chip?

    3.2.2.   Explain why it is necessary to have thin chips rather than short chips?

3.3.   Pre-treatments? [2]

    3.3.1.   Mechanisms of Organosolv fractionation?

    3.3.2.   Describe the three steps of impregnation of wood?

3.4.   Kraft pulping process? [3]

    3.4.1.   Which digester concepts do you know? Describe the two most important cooking principle?

    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 nanomaterial? Production pathway? Properties? (NFC) [2]

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

5. Sugar-derived chemicals

5.1.   Production of formic acid from natural resources and its multifunctional use ? [2]

5.2.   Levulinic acid? [2]
    5.2.1.   Production routes?
    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?

8. Economical evaluation of bio-based processes; economic appraisal of large pro-ejcts (2)

Explain shortly:
    a)   Internal rate of return (IRR)

    b)   Working capital

9. How can you update the equipment costs? (2)

10. Membranes, filtration, drying & humid air (9)

10.1. What kind of applications of chromatography exist in diaries and milk production? (3)

10.2. Explain the term equilibrium moisture of solid porous material? (3)

10.3. What is the role of pure vapour pressure in calculation of humidity of air? (3)

Grading:
Total points 46
5 ≥ 40 points
4 ≥ 34.5 points
3 ≥ 28.5
2 ≥ 24
1 ≥ 15.5