National Exams December 2008
04-Chem-B5
Pulp and Paper Technology

3 hour duration

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. Candidates may use one of two calculators, the Casio or Sharp approved models. This is a CLOSED BOOK exam.

3. Any 3 questions constitute a complete paper. Only the first three questions as they appear in your answer book will be marked.

4. All questions are of equal value. Marks for question parts are indicated under each question.

5. Most questions require an answer in essay format. Clarity and organization of the answer are important.

Question 1

Parts (a) – (d) are worth 5 marks each. Part (e) is worth 10 marks.

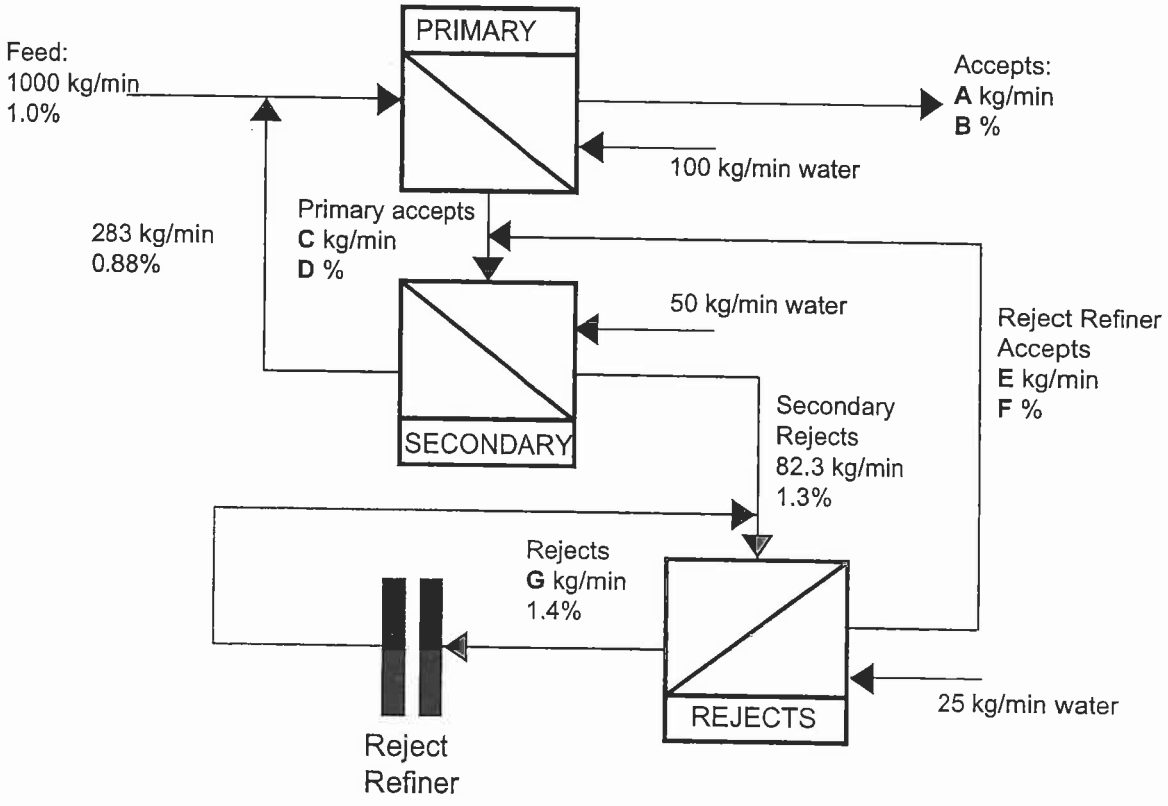
(a) Differentiate between the papermaking properties of groundwood and TMP fibre. What Boreal forest wood species are preferred for making newsprint, and which species are avoided. Explain why.

(b) Explain chemi-mechanical pulping in terms of the chemicals and process used and how the properties of the pulp are changed relative to a purely mechanical pulp like TMP or SGW. What role do semi-chemical pulps play in the manufacture of newsprint?

(c) Sketch the elements of a pulp grinder, giving details on the construction of the pulp stone. How is the stone prepared for grinding?

(d) Describe the elements of a process for preparing old newsprint (ONP) as a recycled papermaking stock.

(e) A simplified diagram of a TMP screening system is shown below. The values shown are the total flows of each stream including water, and the consistencies in mass percent of fibre. Complete the material balance by determining the values A, B, C, D, E, F, and G. The rejects refiner rejects 40% of its total fibre feed.



Question 2.

Parts (a) – (d) are worth 5 marks each. Part (e) is worth 10 marks.

(a) Give a broad classification for the chemical constituents of wood, giving approximate proportions for each component in pine and aspen. Cite any differences that exist in the nature of the chemical components in pine and aspen wood.

(b) The Kappa number of the pulp leaving a Kamyr digester is high. What operating conditions can the operator of the digester use to decrease the Kappa number? How can the operator change these conditions, using which digester operating variables at his or her disposal?

(c) Sketch and describe a pressure diffuser used in brown stock washing. What are the advantages of a pressure diffuser compared to a drum washer.

(d) Sketch a block diagram of the recausticizing section of a kraft mill, from the recovery furnace to white liquor storage. Clearly label all parts, and write any chemical reactions which occur.

(e) A Kamyr digester produces 700 metric tonnes per day of kraft pulp at 46% yield, with an active alkali application of 18% on O.D. wood. The white liquor from recausticizing has a sulphidity of 27%, a causticizing efficiency of 78%, a reduction of 95%. Calculate the flow of smelt from the recovery furnace in kg/min of Na_2O, that the recausticizing plant must process into this white liquor. Also give the flows of each inorganic component in the smelt as kg Na_2O/min. State whatever assumptions you make. (Na - 23.0; S - 32.0; O - 16.0; H - 1.01)

Question 3

Parts (a) – (f) are worth 5 marks each.

(a) A bleach plant uses the sequence DEopDED for kraft pulp bleaching. To what do each of the letters in this sequence refer? What are the typical conditions of the first (D), second (Eop), and third (D) stages of this sequence, including temperature, consistency, pH, chemical dose and residence time?

(b) What chemical tests are performed on bleached pulp to determine how well bleached it is, and how degraded it is? Give typical values for these measures that you would expect for unbleached and fully-bleached pulp.

(c) Describe two ways in which mechanical pulp is bleached. Give conditions of chemical dose, pH, temperature, consistency and residence time. How does the strategy of mechanical pulp bleaching differ from that of kraft pulp?

(d) How is bleach plant effluent treated before it is discharged to the environment? What effluent properties are improved by each treatment? Your answer may apply to either mechanical or kraft pulp bleaching effluent.

(e) Chlorine dioxide is made by the following net reaction:

$$2NaClO_3\ (aq) + SO_2\ (g) \longrightarrow 2ClO_2\ (g) + Na_2SO_4\ (aq)$$

If a 45 metric tonne per day ClO_2 plant (100% efficient) produces 3400 L/min of ClO_2 solution by absorbing ClO_2 in water, what is the concentration of ClO_2 produced? What flow rate (kg/min) of 30 wt% $NaClO_3$ solution is required? (Cl - 35.45; O - 16.0; H - 1.008; Na - 23.0);

(f) For a D_1 stage producing 650 metric tons per day, calculate the flow of chlorine dioxide in L/min given a chlorine dioxide solution of 8.3 g/L and a dose rate of 2.5% equivalent chlorine on pulp. (Cl - 35.45; O - 16.0; H - 1.008)

Question 4

Parts (a) – (e) are worth 5 marks each. Parts (f) is worth 10 marks.

(a) Describe the test for Canadian Standard Freeness (CSF). What does it measure? As pulp is refined in preparation for papermaking, what happens to the Canadian Standard Freeness?

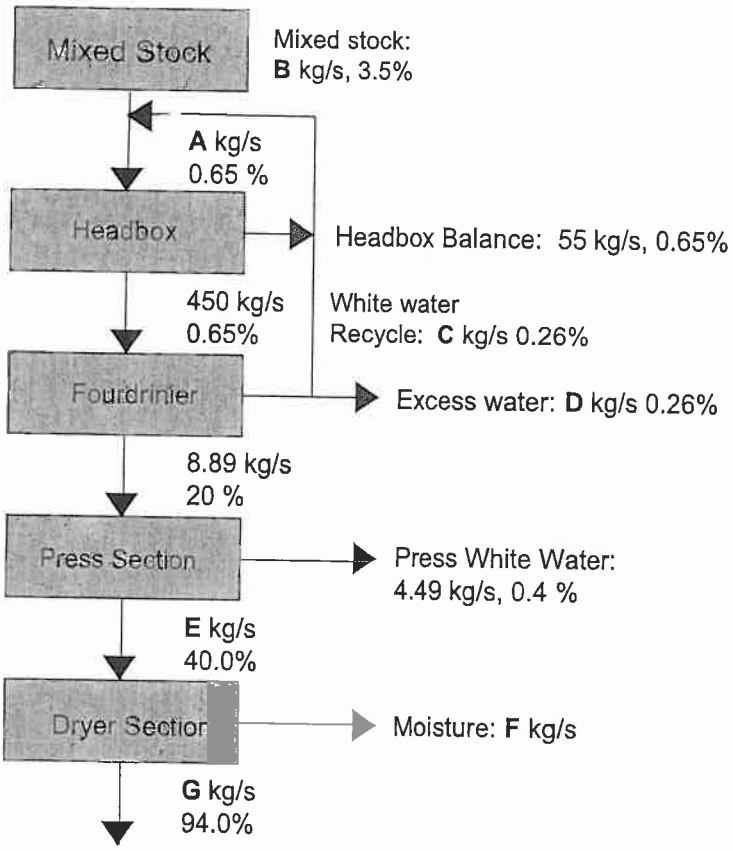
(b) Give typical values with units for tensile index, tear index and burst index for a kraft pulp. How do these properties vary as the pulp is refined in preparation for papermaking?

(c) With the help of simple sketches, distinguish between air-padded headboxes and hydraulic headboxes, and explain the control requirements for each.

(d) Sketch a diagram of a fourdrinier wet end, showing and clearly labeling the drainage elements.

(e) The pressure of a nip of a papermachine press causes moisture flow from the sheet. Describe various approaches in press design to take this water away so it can't rewet the sheet?

(f) Complete the water and fibre balance in the following block diagram of a paper machine, by determining the values for A, B, C, D, E, F and G. The stock flows in kg/s are total flows, including water, and the stock consistencies are in mass percent. See the block diagram on the next page..


Mixed Stock
Mixed stock:
B kg/s, 3.5%
A kg/s
0.65 %
Headbox
Headbox Balance: 55 kg/s, 0.65%
450 kg/s
0.65%
White water
Recycle: C kg/s 0.26%
Fourdrinier
Excess water: D kg/s 0.26%
8.89 kg/s
20 %
Press Section
Press White Water:
4.49 kg/s, 0.4 %
E kg/s
40.0%
Dryer Section
Moisture: F kg/s
G kg/s
94.0%