National Exams December 2010
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) – (e) are worth 5 marks each. Part (f) is worth 10 marks.

(a) Why is spruce a suitable species for making mechanical pulp for newsprint? Why is aspen not a suitable species for newsprint? Name a boreal forest species which is not suited for newsprint and why it is not suitable.

(b) What are two methods for bleaching groundwood pulp? What are the typical conditions for each method of bleaching? What brightness improvement gains may be expected? Which is the most common method and why?

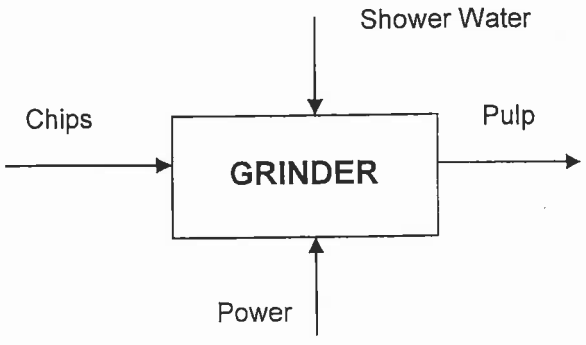
(c) Two methods can be used to produce mechanical pulp for newsprint. What are they? Why is one process more favourable than the other? What are the disadvantages of one process over the other? What equipment is used for each process?

(d) What are the typical yields from groundwood, TMP and CTMP processes? What effect does wood species have on this process? Explain how the properties of TMP pulp are different from Groundwood pulp. What common physical and chemical tests are used to measure and control pulp quality in a TMP mill?

(e) Differentiate between the groundwood, TMP, CTMP and Kraft pulping processes. What are the typical advantages and disadvantages of each process? Which processes are not typically used for high quality, high brightness, high strength papers and why? Where does groundwood, TMP and CTMP pulps have an advantage over kraft pulps?

(f) A 40 ADMT/day grinder consumes 1500/ kWh/ADMT. The wood enters the grinder at 25°C and 42% moisture (total mass basis). For simplicity you may assume that both wood and water have the same heat capacity of 4.18 kJ/kg°C. Also assume 98% yield.

1) How much shower water (kg/s) supplied at 40°C, is required to keep the vat temperature at 70°C?



Question 2

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

(a) A Bleach Plant uses the sequence XDEopDEpD for kraft pulp bleaching. What do each of the letters refer to, in this sequence. What are the typical conditions of the first (X), second (D) and third (Eop) stages of this sequence, including temperature, consistency, pH and chemical dose?

(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 the two technologies for oxygen delignification in use today, giving typical delignification conditions. How does each of these technologies promote the mixing and diffusion of oxygen into the pulp? How much delignification can be reasonably accomplished by each oxygen delignification process and what limits the delignification?

(d) How is bleach plant effluent treated before it is discharged to the environment? What effluent properties are improved by each treatment? How are these measures affected by a kraft mill bleach plant? What effluent property is reduced by mixing the two main streams of bleach effluent prior to treatment and why?

(e) For a D_0 stage producing 950 metric tons per day, calculate the flow of chlorine dioxide in L/min given a chlorine dioxide solution of 10.5 g/L, incoming unbleached Kappa Number of 28.5 and a D_0 Kappa Factor of 0.185. (Cl – 35.45; O – 16.0; H – 1.008)

(f) Chlorine dioxide can be made by the following two net reactions:

(i) $3\ NaClO_3 + 2\ H_2SO_4 + 0.80\ CH_3OH \rightarrow 3\ ClO_2 + Na_3H(SO_4)_2 + 2.3\ H_2O + 0.8\ HCOOH$

(ii) $2\ NaClO_3 + H_2O_2 + H_2SO_4 \rightarrow 2\ ClO_2 + O_2 + 2\ H_2O + Na_2SO_4$

1) What are the reducing agents used in each of the above ClO_2 production process?

2) Describe the differences between the two reactions and why one process may be more favourable than the other? What are the advantages and disadvantages of one over the other?

3) For the second reaction using hydrogen peroxide to produce ClO_2, if a 40 metric ton per day ClO_2 Plant (94% efficient) produces 2500 L/min of ClO_2 solution by absorbing ClO_2 in 4°C water, what is the concentration of ClO_2 produced? What flowrate (kg/min) of 20% hydrogen peroxide solution is

required? What flowrate of 6.3M sodium chlorate is required? (Cl – 35.45; O – 1.008; H – 1.008; Na – 23.0)

Question 3

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 spruce and birch. Cite any differences that exist in the nature of the chemical components in spruce and birch wood.

(b) Two processes are available to you to cook wood chips using the Kraft process – batch digesters and conventional Kamyr digester. Each process has its advantages and disadvantages over the other process. Describe these differences and why one process would be more advantageous than the other.

(c) The Kappa number of the pulp leaving a batch digester is low. What operating variables can the operator of the digester use to increase the Kappa Number to the desired target range? Sketch a batch digester and indicate how and where changes to these variables are made.

(d) What is Tall Oil? What material is recovered in a kraft mill to produce Tall Oil? How it is produced? Which wood species would you expect to achieve higher yields of Tall Oil and why?

(e) The practice of direct steaming of the batch digester is practiced at this mill. How is the steam added to each batch digester? What impact does this have on steam consumption versus indirect steaming. How would indirect steaming be practised for a batch digester? What advantage would this have over direct steaming? What additional equipment would be required to use direct steaming in a batch digester?

(f) A pulp mill using batch digesters to cook wood chips. Each of the 9 digesters has a volume of 125 cubic meters. During a cook the digester is filled to 80% of its rated volume with softwood chips at a bulk density of 140 kg/m^3. The wood moisture is 35% on total wood mass. The pulp yield on oven dry (O.D.) wood is 44%.

1) Calculate the required application of white liquor on wood in L/batch for an application rate of 16.5 % E.A. (effective alkali) on O.D. Wood. The white liquor has an effective alkali concentration of 90 g/L and its density is 1.1 g/mL.

2) Also calculate the individual chemical application rates, in km/min of Na_2O, NaOH, Na_2S, Na_2CO_3 and Na_2SO_4, given a white liquor sulphidity of 27.5%, a causticizing efficiency of 80%, and reduction of 92%. (Na = 23.0; S = 32.0; O = 16.0; H – 1.01

3) Calculate the volume of black liquor in L/batch, required to maintain a L/W (Liquor / Wood) ratio of 4:1. What is the purpose of the addition of black liquor?

4) The batch digesters are cooked to a constant "H Factor" before they are blown. What does "H Factor" mean and how is it calculated? What is a typical "H Factor" for cooking softwood (spruce) chips and for cooking hardwood (aspen) chips?

Question 4

Parts (a) – (e) are worth 5 marks each. Part (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?

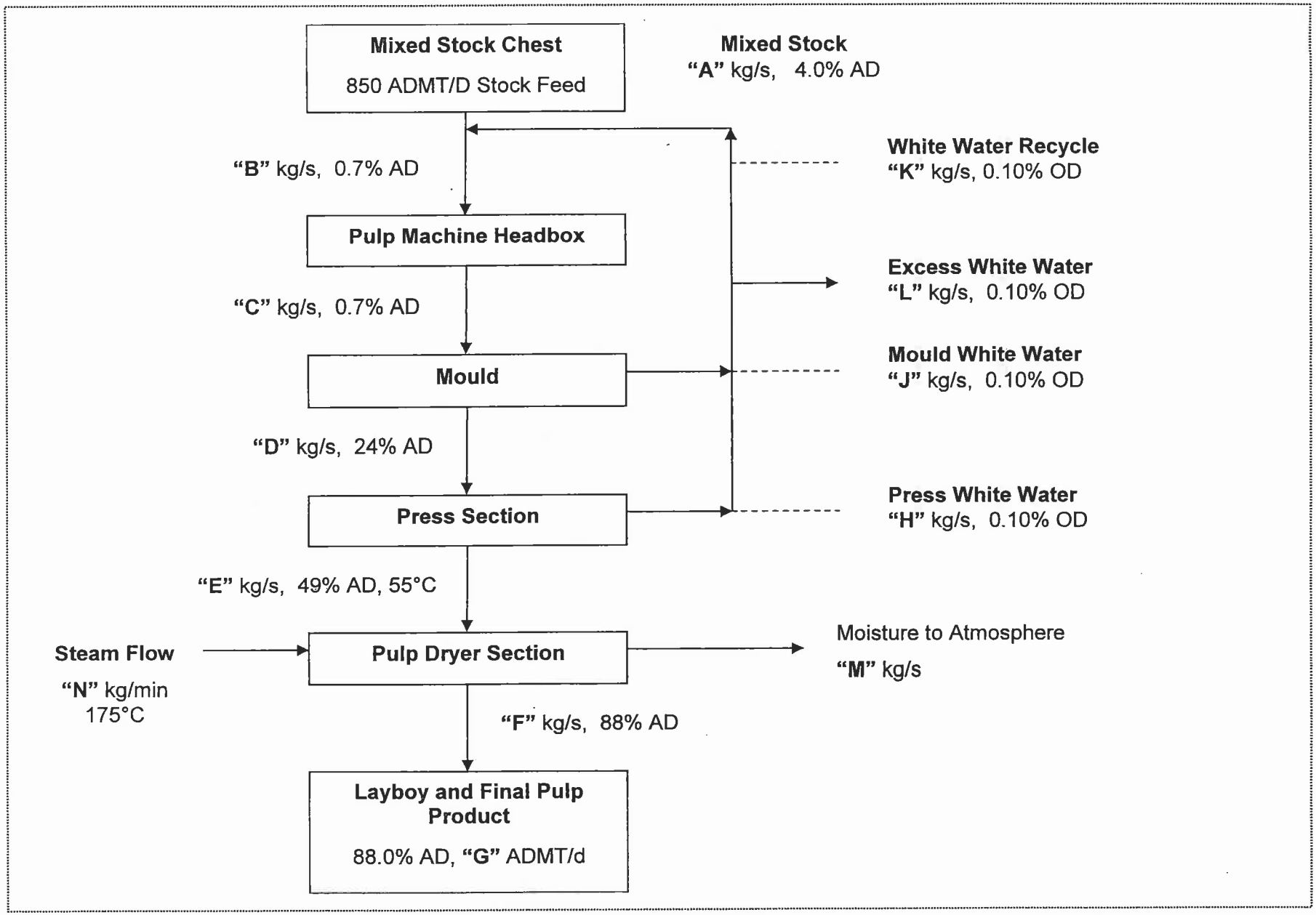
(b) Give typical values with units for tensile index, tear index and burst index for a softwood kraft pulp. How do these properties vary as the pulp is refined in preparation for papermaking?

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

(d) What is calendaring? What are its purposes? Describe and contrast a calendar stack and a supercalendar stack.

(e) Pulp cleaning systems – What is the purpose of pulp cleaning systems prior to the pulp or paper machines and what is the principle of operation? Describe a typical cleaning system. Sketch a system and label the components.

(f) Complete the water and fibre balance in the following block diagram of a pulp machine, by determining the values for A, B, C, D, F, G, H, J, K, L, M and N. The stock flow in kg/s are total flows, including water and the stock consistencies are in mass percent.


Mixed Stock Chest
850 ADMT/D Stock Feed
Mixed Stock
"A" kg/s, 4.0% AD
"B" kg/s, 0.7% AD
White Water Recycle
"K" kg/s, 0.10% OD
Pulp Machine Headbox
Excess White Water
"L" kg/s, 0.10% OD
"C" kg/s, 0.7% AD
Mould
Mould White Water
"J" kg/s, 0.10% OD
"D" kg/s, 24% AD
Press Section
Press White Water
"H" kg/s, 0.10% OD
"E" kg/s, 49% AD, 55°C
Steam Flow
"N" kg/min
175°C
Pulp Dryer Section
Moisture to Atmosphere
"M" kg/s
"F" kg/s, 88% AD
Layboy and Final Pulp Product
88.0% AD, "G" ADMT/d