**OPTIONAL QUIZ QUESTIONS for Course 4: “Dry Strength of Paper”**

Scroll all the way to the bottom to see the answers.

Session 1: Fiber strength and inter-fiber bonding

1A – Increased refining typically has what effect on the energy required to tear paper?

* The required energy decreases monotonically with increased refining.
* The required energy at first rises with increased refining and then it decreases.
* The required energy increases monotonically with increased refining.
* The required energy at first decreases with increased refining and then it rises.

1B – In which case is it expected that many fibers will be broken during tearing of a sheet of paper?

* Low inter-fiber bonding level
* Low level of refining
* When the breaking length is very low
* High inter-fiber bonding level

1C – Which of the following symbols stands for the relative bonded area within a sheet of paper?

* RBA
* A
* B
* Tau

Session 2: Hydrogen bonding & sheet consolidation

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2A – Which of the following parameters is proportional to the capillary suction force pulling fibers together as paper is being dried?

* Gamma (γ), the interfacial tension of the water
* x, the distance between two fiber surfaces
* Lower-case delta (δ), the density of hydrogen bonding
* Lower-case g, the acceleration of gravity

2B – Which type of bonds are reversible, so that ordinary paper comes apart when it is soaked in water?

* Covalent bonds
* Fibrillation bonds
* Hydrogen bonds
* Conjugated bonds

2C – Which of the following terms is a measure of paper’s tensile strength?

* Apparent density
* Breaking length
* Hydrogen bonding
* STFI compression

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Session 3: Cationic starch for dry strength

3A – What accounts for the maximum in measured viscosity as potato starch is being cooked at about 90 degrees C?

* Dissolved starch molecules account for all of the viscosity rise.
* Gelation occurs among the dissolved starch macromolecules.
* Hydrophobic bonding crosslinks the starch together.
* Swollen starch grains fill the whole volume and rub against each other.

3B – Why is cationic starch attracted to cellulosic fiber surfaces?

* Attraction of positively charged starch to negatively charged fiber surfaces
* Attraction of negatively charged starch to positively charged fiber surfaces
* Chemical similarity of the starch and cellulose polysaccharide molecules
* Preferential hydrogen bond formation between the surfaces

3C – Addition at which location in a paper machine system is expected to provide the largest proportion of cationic starch adsorbed onto the surfaces of long fibers?

* To the thin stock after it has been diluted at the fan pump
* To the process water (white water) that is used for stock dilution
* To the thick stock before it is diluted at the fan pump After the hydrocyclone cleaners, minimizing the time of contact

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Session 4: Synthetic dry-strength agents

4A – What chemical groups provide a negative charge at the surface of typical papermaking fibers?

* Hydroxyl (–OH)
* Methoxyl (–OCH3)
* Primary amine (-NH2)
* Carboxyl (–COOH)

4B - What is the sign of charge of soluble species of aluminum at a pH near to 4?

* Neutral
* Undefined
* Positive
* Negative

4C – Why do some papermakers choose to use amphoteric PAM as a dry-strength resin?

* Lower cost than single-charged PAM products
* Higher dry strength increases than single-charged PAM products More tolerant of unbalanced colloidal charge than single-charged PAM products
* Possibility to increase the effective length of the fibers

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Session 5: Points of addition for strength agents

5A – To get the greatest positive impact on paper’s strength, where do you want the dry-strength agent to be situated?

* On cellulosic fines
* In the process water
* On the long fibers
* Within the lumens of fibers

5B – What treatment of the paper base-sheet can best help to hold size-press starch out near to the paper’s surface?

* Hydrophobic sizing (internal sizing)
* Nanocellulose addition
* Cationic starch (wet-end addition)
* Precipitated calcium carbonate (filler)

5C – When a suspension of uncooked starch grains is sprayed onto a wet web of paper, what happens to the starch as the paper is being dried?

* The starch remains completely uncooked.
* The starch becomes fully cooked.
* The starch evaporates and promotes the drying process.
* The starch becomes partly cooked.

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Session 6: Wet-strength additives

6A – Why does ordinary paper become much weaker when a large amount of moisture is added to it?

* The covalent bonds connecting the fibers come apart.
* The fiber-to-fiber hydrogen bonds come apart.
* The wet fibers break more easily than dry fibers.
* The paper sheet becomes brittle and cracks more easily.

6B – Suppose that you are making paper with low-yield kraft fibers that have almost no –COOH (carboxyl) groups, and you are successfully using a poly(amide-amine-epichlorohydrin) (PAE) resin for wet strength. What is the PAE reacting with as the paper is being dried?

* The –OH groups on the fibers
* Nothing (hydrogen bonding takes place)
* Cationic starch (with quaternary ammonium groups)
* Other PAE molecules (amine groups)

6C – When using a gPAM product for temporary wet strength, what type of bond comes apart when the paper is place in water (e.g. for 30 minutes)?

* Covalent (hemi-acetal)
* Ionic (amine groups and carboxyl groups)
* Metallic (aluminum hydroxide)
* Conjugated (double C=C and single C-C bonds)

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Session 7: Advanced dry-strength systems

7A – Why does recycled paper have lower strength when it is repeatedly formed, dried, repulped, and made into paper again without more refining?

* The fibers are shorter with each cycle of papermaking.
* The paper is less uniform with each cycle of papermaking.
* The fibers become more and more ribbon-like in shape.
* The fibers have less ability to bond with each other.

7B – Why can layer-by-layer deposition of polyelectrolytes lead to a very high dry strength of paper, in laboratory tests?

* Large amounts of bonding agent are built up on the surfaces of the fibers.
* The paper has multiple plies, and this makes weak areas unlikely.
* The paper sheet is more uniform (less flocculated within each layer).
* The layers act like a lubricant, leading to highly uniform paper.

7C – With respect to polyelectrolyte complex (PEC) technology, which of the following strategies can be expected to yield the strongest paper?

* Preliminary formation of PECs, followed by their addition to the fiber suspension
* Addition of either positively charged or negatively charged polyelectrolyte as a single additive
* Forming a complex of the polyelectrolyte with alum, then later adding it to the fiber suspension
* In-situ formation of PECs in the presence of agitated fibers in suspension

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Session 8: Nanocellulose as a strength additive

8A – What type of nanocellulose has both crystalline and amorphous cellulose regions?

* Cellulose nanocrystals (CNC or NCC)
* Nanofibrillar cellulose (NFC or CNF)
* Carboxymethyl cellulose in solution (CMC)
* Cellulose acetate (CA)

8B – What mechanism contributes to shear-thinning of nanocellulose suspensions?

* The elongated cellulosic particles tend to become lined up during mixing.
* The elongated cellulosic particles tend to break during mixing.
* The elongated cellulosic particles form a more uniform suspension during mixing.
* The elongated cellulosic particles form a more crosslinked gel structure during mixing.

8C – What additives were needed in order to achieve a combination of high paper strength and a suitable rate of release of paper during paper formation?

* Nanofibrillated cellulose, calcium carbonate, and alum (aluminum sulfate)
* Cationic starch, nanofibrillated cellulose, and colloidal silica
* Poly(diallyldimethylammonium chloride), nanofibrillated cellulose, and calcium carbonate
* Nanofibrillated cellulose, cellulose nanocrystals, and bacterial cellulose

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