Unit 20 · Paper and Pulp

STUDY NOTES

WHAT NEB'S GRADE 12 EXAM ASKS

- **CDC's grid (2078):** Applied Chemistry (Units 18–21 together): 8 of 75 marks; 3 MCQs and 1 short question, no long one
- **The paper:** 11 MCQs × 1 · 8 short × 5 · 3 long × 8; 3 hours; 1 mark per expected point
- **CDC's model paper:** MCQ: removing lignin from pulp **raises fiber–fiber bonding** (the freed cellulose –OH groups hydrogen-bond)
- **MCQ (1 mark)**
  - primary raw material wood (the trunk); pulping frees the fibers; office paper standard grade; bleaching whitens; final step drying
  - magazines on coated paper; non-wood bagasse, bamboo; cotton for high quality
  - rosin and alum: sizing (ink doesn't spread); wet strength
- **Short (5 marks, in parts)**
  - raw materials, fibrous and non-fibrous; qualities of paper; stages with a flow sheet; pulp yield from a mass
  - paper vs pulp; mechanical vs chemical pulping; why softwood; why lokta for records; paper made of cellulose

Key terms

Paper: thin, flexible sheet of plant fibers pressed from water and dried.

Pulp: mass of separated plant fibers (mostly cellulose) in water, the raw material of paper.

Cellulose (40–50% of wood): long straight chains of glucose, three –OH a unit: the strong white fibers.

Hemicellulose (20–30%): short branched sugar chains; helps bonding.

Lignin (20–30%): hard brown cross-linked aromatic network, the **glue** of wood; yellows paper.

Sizing: rosin + alum (or starch): controls how ink soaks in.

GSM: grams per square meter (newsprint 45, office 70–80, file cover 200–300).

Why a sheet holds: pressed and dried, the **–OH** of neighboring cellulose fibers form **hydrogen bonds**: no glue needed (filter paper); water breaks them (wet paper tears)

- **removing lignin** frees the cellulose surface: fibers are flexible and bond better (more fiber–fiber H bonds), so chemical pulp gives stronger paper
- **beating** (refining) frays fibers into fibrils: more surface to bond

Raw materials

Fibrous

- **softwood** (pine, spruce, fir): long fibers, 3–4 mm: **strength**
- **hardwood** (eucalyptus, poplar, birch, acacia): short, about 1 mm: smoothness, printability
- bamboo; **bagasse** (sugarcane waste); straw; grasses (kush, babiyo, siru, lemon grass); jute; **cotton rags** (almost pure cellulose: high-quality, handmade); **lokta** bast (*Daphne bholua*, *D. papyracea*); recycled paper (fibers shorten: 5–7 times)
- fibers from wood, stems, inner bark (**bast**), seed hairs, leaves

Non-fibrous

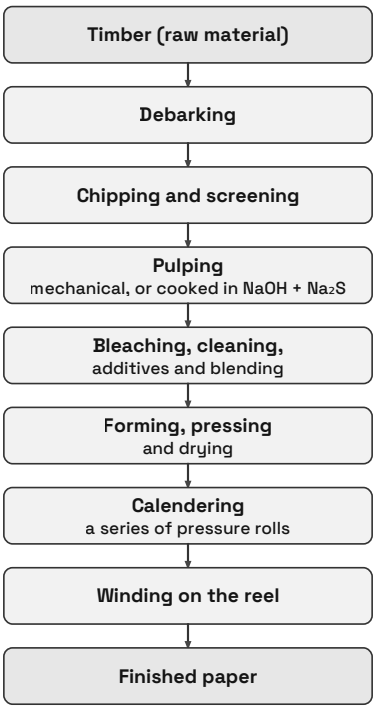
Inorganic	Use	Organic	Use
NaOH (+ Na_2S)	pulping: breaks down lignin	starch	surface strength, printability
alum, $Al_2(SO_4)_3$	sizing with rosin, pH	rosin	with alum: water-resistant, ink doesn't spread
kaolin (china clay), talc	filler: smooth, bright	dyes, pigments	color
$CaCO_3$	filler: white, opaque	optical brighteners	UV in, blue out: whiter
TiO_2	opacity, brightness	binders, glycerol, wax	strength, softness, water-resistance
H_2O_2, Cl_2, NaClO	bleaching		

Making paper

1. **timber** → 2. **debarking** (rotating drum; bark burned as fuel) → 3. **chipping** (2–3 cm) and **screening** → 4. **pulping** → 5. **bleaching**, cleaning, additives, blending → 6. **forming, pressing, drying** → 7. calendering, reeling, cutting

Mechanical pulping	Chemical (kraft) pulping
ground or shredded by machine	chips cooked in **white liquor**, NaOH + Na_2S, digester, about 170 °C, pressure
no (or few) chemicals	lignin dissolves (OH^-, HS^- break its bonds)
yield **90–95%**: lignin stays	yield **45–50%**: lignin removed
short, weak fibers; yellows (newsprint)	long, strong fibers; durable, easy to bleach

- **black liquor** (dissolved lignin) burned in the **recovery boiler**: energy, NaOH and Na_2S recovered
- unbleached kraft brown (bags, boxes); bleaching: Cl_2, NaClO made dioxins; now ClO_2, O_2, O_3, H_2O_2
- **Fourdrinier machine** (Robert, 1799): **headbox** → **wire** (water drains, suction) → **press section** (felts) → **dryer** (steam cylinders: most of the energy) → **calender** (smooth) → **reel**
- 20 t chips at 45% → 9 t pulp



The flow sheet for paper, from log to sheet.

Quality

- depends on **pulp** (chemical > mechanical), **weight** (GSM), **finish** (coated: clay or $CaCO_3$ + binder: glossy; matte), **brightness**, **sizing** (unsized: blotting paper, tissue)
- grades: **premium** (certificates, magazines, brochures); **standard** (office, books, notebooks); **low** (newspapers, flyers); **specialty** (tissue, wrapping); **Nepali (lokta)** paper
- **lokta paper** (Nepali kagaj): bark boiled in alkali (wood-ash lye, now NaOH or soda ash) to dissolve lignin, beaten by mallets, spread on a floating frame, sun-dried; bush regrows from the root
- **why lokta for records**: long strong bast fibers; **no acidic alum** sizing (old book paper eats itself); resists insects and decay: lasts centuries (National Archives)
- wet strength (paper towels): a **wet-strength resin** cross-links the fibers

COMMON MISTAKES

✗ eucalyptus, poplar as softwoods
✓ hardwoods; softwoods are **pine, spruce, fir**.

✗ NaHClO
✓ **NaClO** (sodium hypochlorite).

✗ calender rolls after the reel
✓ sheet **calendered, then** wound.

✗ lignin holds the paper sheet together
✓ **hydrogen bonds** between cellulose –OH; lignin glues fibers only in wood.