Unit 18 · Chemistry in the Service of Mankind

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:** short (a part): define condensation polymerization; name the monomers of Bakelite (phenol, methanal); its other part is on cement (Unit 19)
- **MCQ (1 mark)**
  - addition polymer; nylon-6,6 a condensation copolymer, its monomers; natural polymer; fibers by strong forces
  - azo chromophore –N=N–; acid dye for wool and silk; vat dye (indigo); mordant needs metal salts; basic dye; reactive dye bonds covalently
  - drugs; natural drug; paracetamol antipyretic and analgesic; antibiotic for bacteria; drug abuse; insecticide, herbicide (2,4-D)
- **Short (5 marks, in parts)**
  - polythene addition, Bakelite condensation; PVC homopolymer, nylon copolymer; elastomers and fibers
  - monomers of PVC, polythene, Teflon, Bakelite, nylon; chromophore and auxochrome
  - differences: addition/condensation, natural/synthetic dyes and drugs; pest, pesticide, insecticide, fungicide; uses of PVC, mordant dyes, herbicides, nylon

Polymers

Monomer: small molecule that joins; **polymer**: long chain of repeat units; **polymerization**: the joining.

Addition polymerization: unsaturated monomers add, C=C opens, **nothing given off**.

Condensation polymerization: two different groups react, each step giving off a **small molecule** (H_2O, NH_3, HCl, CH_3OH); each monomer has at least two groups.

Homopolymer: one monomer; **copolymer**: two or more.

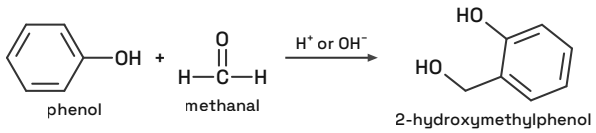
Elastomer: weakest forces, few cross-links, stretches and springs back; **fiber**: strongest forces (H bonds), high tensile strength.

Thermoplastic: softens on heating, again and again; **thermosetting**: cross-linked, sets for good.

Vulcanization: heating rubber with sulphur: S cross-links.

Classified by

- origin: **natural** (starch, cellulose, proteins, nucleic acids, rubber = cis-polyisoprene); **semi-synthetic** (rayon, cellulose acetate); **synthetic** (PVC, polystyrene, nylon, Teflon, Bakelite)
- synthesis: **addition** (polythene, PVC, PTFE, polystyrene); **condensation** (nylon-6,6, PET, Bakelite)
- forces: elastomers (rubber, neoprene, Buna-S) < thermoplastics (polythene, PVC, polystyrene) < fibers (nylon, polyester, rayon, acrylic); thermosetting (Bakelite)
- monomers: homopolymers (polythene, PVC, Teflon, polystyrene, rubber); copolymers (nylon-6,6, PET, Bakelite, **Buna-S**: butadiene + styrene, an addition copolymer)
- $n\,CH_2{=}CH_2 \longrightarrow (-CH_2-CH_2-)_n$ (heat, pressure, catalyst); $n\,CH_2{=}CHCl \longrightarrow (-CH_2-CHCl-)_n$
- nylon-6,6: $n\,HOOC(CH_2)_4COOH + n\,H_2N(CH_2)_6NH_2 \longrightarrow (-OC(CH_2)_4CONH(CH_2)_6NH-)_n + 2n\,H_2O$ (6 C each; Carothers, 1935)
- Bakelite: phenol + HCHO (H^+ or OH^-) → 2-hydroxymethylphenol → $-CH_2-$ bridges, H_2O off → **novolac** (linear) → more HCHO, heat → cross-linked Bakelite (Baekeland, 1907, the first fully synthetic plastic)



Bakelite's first step: phenol and methanal give hydroxymethylphenol.

Polymer	Monomer(s)	Kind	Uses
polythene	ethene, $CH_2=CH_2$	addition	LDPE bags, films; HDPE (Ziegler–Natta) buckets, pipes, cable insulation
PVC	chloroethene, $CH_2=CHCl$	addition	pipes, cable insulation, raincoats, flooring, IV bags
Teflon (PTFE)	tetrafluoroethene, $CF_2=CF_2$	addition	non-stick pans, seals (strong C–F, low friction)
polystyrene	styrene, $C_6H_5CH=CH_2$	addition (benzoyl peroxide)	cups, thermocol, insulation
nylon-6,6	hexanedioic acid + hexane-1,6-diamine	condensation (–CO–NH–, H_2O off)	ropes, fishing nets, parachutes, cloth, gears
PET (Terylene)	ethane-1,2-diol + terephthalic acid	condensation (ester links)	bottles, uniform cloth
Bakelite	**phenol + methanal**	condensation, thermosetting	switches, plugs, handles

Dyes

Dye: colored substance giving **lasting** color to cloth, paper, leather, food.

Chromophore: the group that gives **color**: conjugated double bonds, –N=N– (azo), $–NO_2$, –N=O, >C=O, >C=C<, quinoid ring.

Auxochrome: no color alone; **deepens** or shifts the color and binds the dye to the fiber: –OH, –COOH, $–SO_3H$, $–NH_2$, –NHR, $–NR_2$.

- longer conjugation → absorbs less energy → visible light; we see the color **not absorbed**
- methyl orange: azo chromophore, $–N(CH_3)_2$ auxochrome, $–SO_3^-$ makes it soluble
- natural: indigo, turmeric, cochineal, henna, madder; synthetic: azo dyes, methyl orange, crystal violet, aniline blue

By structure

- **azo** (–N=N–, the largest group; diazo coupling): p-hydroxyazobenzene, p-aminoazobenzene, methyl orange
- **nitro** ($–NO_2$, yellow): picric acid, Martius yellow; **nitroso** (–N=O): 1-nitroso-2-naphthol
- **phthalein** (phthalic anhydride + phenols; quinoid in base, indicators): phenolphthalein, fluorescein
- **anthraquinone**: alizarin; **indigoid**: indigo, Tyrian purple

Mode	Fibers	How applied	Examples
acid (anionic, $–SO_3^-$)	wool, silk, nylon	acidic bath (fiber $–NH_3^+$)	Acid Red 88
basic (cationic)	acrylic, silk, wool	neutral or weakly acidic	methylene blue, malachite green, crystal violet
direct (anionic, long, flat)	cotton, rayon	directly with salt, no mordant	Congo red
vat (insoluble)	cotton, denim	reduced to soluble leuco form, oxidized in air	**indigo**
mordant	protein, cellulose	fixed by a **metal salt** (Al, Cr, Fe, Cu, Sn), a complex	**alizarin** (Al red, Ba blue)
disperse (non-ionic)	polyester, acetate	fine dispersion, hot	Disperse Blue 1
reactive	cotton	**covalent bond** with the fiber	Procion dyes
sulphur	cellulose	reduced, then oxidized	Sulphur Black 1
azoic (ingrain)	cellulose	made **inside the fiber** by coupling, alkaline	Fast Yellow 2G

Drugs

- **drug**: prevents, diagnoses or treats disease; ideal: right place, effective, non-toxic, few side effects, no resistance, **selective**, cheap
- **natural**: plant (morphine: poppy, pain; quinine: cinchona, malaria; atropine: belladonna; caffeine; castor oil; pilocarpine), animal (cod liver oil, antivenoms, hirudin, lanolin, honey, gelatin, thyroxine), mineral (Epsom salt, NaCl, $NaHCO_3$, $Mg(OH)_2$, alum)
- **synthetic**: made in laboratories: aspirin from salicylic acid + ethanoic anhydride (an ester, gentler on the stomach); paracetamol, sulpha drugs

Group	Does	Examples
antipyretic	lowers fever	paracetamol, aspirin
analgesic	relieves pain, **conscious**	aspirin, ibuprofen, paracetamol (opioids: morphine, addictive)
anti-inflammatory	lessens inflammation	ibuprofen, aspirin
antibiotic	kills or stops **bacteria** (made by microbes)	narrow: penicillin G, vancomycin; broad: chloramphenicol, tetracycline, amoxicillin
antiseptic	on **living** tissue	ethanol, povidone-iodine, H_2O_2, chloroxylenol (Dettol), 0.2% phenol
disinfectant	on **non-living** things	bleach, formaldehyde, chlorine, 1% phenol
sulpha drug	antibacterial (synthetic, 1930s)	sulphanilamide, sulphadiazine
tranquilizer	eases stress, anxiety	diazepam, meprobamate
sedative / hypnotic	drowsiness / sleep	barbiturates, benzodiazepines
antimalarial	*Plasmodium*	chloroquine, quinine, artemisinin
antacid (weak base)	neutralizes stomach acid	$NaHCO_3$, $Mg(OH)_2$, $Al(OH)_3$, $CaCO_3$

- NSAIDs: not steroids; act on fever (pyrexia), pain, inflammation (pain, swelling, redness, heat, loss of function)
- $NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$; $Mg(OH)_2 + 2\,HCl \longrightarrow MgCl_2 + 2\,H_2O$
- antibiotics not for viruses; finish the course: **resistance**
- **habit-forming** drugs: physical or psychological dependence: cocaine, methamphetamine, benzodiazepines, opioids, nicotine, alcohol; long use: liver, heart, lung disease, anxiety, depression

Pesticides

- **pest**: insect, weed, fungus or rodent harming people, animals or crops; **pesticide**: chemical that kills, repels or controls pests

Kind	Kills	Examples
insecticide	insects (cockroaches, mosquitoes)	DDT, BHC (lindane), malathion, parathion, permethrin
herbicide	weeds	glyphosate, **2,4-D**, 2,4,5-T
fungicide	fungi (mildew, rust, blight)	Bordeaux mixture, $CuSO_4$, sulphur, captan, chloropicrin, AlP (stored grain)
rodenticide	rats, mice	zinc phosphide, ANTU

COMMON MISTAKES

✗ azo chromophore $–N_2–$
✓ **–N=N–**.

✗ basic dyes have amino as chromophore
✓ an amino group is an **auxochrome**.

✗ antacids include $Ca(OH)_2$
✓ $Ca(OH)_2$ is **caustic**; antacids are $NaHCO_3$, $Mg(OH)_2$, $Al(OH)_3$, $CaCO_3$.

✗ 2,4,5-trichlorophenoxyacetic acid (2,4,5-D)
✓ **2,4,5-T**.

✗ sulpha drugs the first antibiotics
✓ first **antibacterials** (synthetic, not from microbes).

✗ aspirin an anticoagulant
✓ stops **platelets** clumping (antiplatelet).