# Unit 16 · Fundamentals of Applied Chemistry

STUDY NOTES

**WHAT NEB'S GRADE 11 EXAM ASKS**

- **CDC's grid (2077):** Applied Chemistry (Units 16–17 together): 9 of 75 marks
- **The paper:** 11 MCQs × 1 · 8 short × 5 · 3 long × 8; 3 hours; 1 mark per expected point
- **CDC's model paper:** MCQ: the batch process; short: a challenge for Nepal's chemical industry and how to overcome it
- **MCQ (1 mark)**: prototype; concept testing; commercialization; idea generation first; batch: fixed time per batch; continuous: less contamination, identical product; chemical engineer designs; cash flow is money in and out; sales the main inflow; expansion raises outflow; depreciation no direct effect; cash flow negative at the start
- **Short (5 marks, in parts)**
  - define applied chemistry, cash flow, economics of production, batch processing
  - differentiate: pure/applied, idea generation/screening, batch/continuous, fixed/variable factors, inflow/outflow, concept/product development, designing/running a plant
  - reasons: test marketing; cash flow greatest at maturity; material and energy balances; green solvents
  - chemical industry and three uses; stages of a new product; running a plant safely
- **Long (8 marks)**: stages, R&D's role, three challenges and their fixes; urea plant (raw materials, uses, pollution); batch vs continuous (advantages, an example); a chocolate company's processing; sulphuric acid plant (uses, harm, control); the sales and cash flow curve

## Key terms

**Pure chemistry**: knowledge for its own sake (how atoms bond); **applied chemistry**: uses it to solve real problems, effectively, economically, eco-friendly (fertilizer, medicine, cement).

**Chemical industry**: business turning raw materials into chemicals: **commodity** ($H_2SO_4$, $NH_3$, NaOH, in bulk) or consumer products (soap, paint, medicine).

**Chemical plant**: equipment (reactors, columns, heat exchangers, pumps, tanks, pipes) and technology making chemicals on a large scale.

**Production**: output made from given inputs (labor, capital); **productivity** = output ÷ input.

**Prototype**: first working version of a new product (in chemistry, the **pilot plant**).

**Cash flow**: money into (sales, loans, investors) and out of (raw materials, wages, bills, taxes, new machines) a company over a period; **net** = in − out.

**Cash conversion cycle**: days stock is held + days to collect − days to pay suppliers; shorter is better.

**Batch processing**: a fixed amount through a set sequence of steps, one batch at a time; **continuous**: raw materials in and product out without stopping.

**Green chemistry**: less hazardous chemicals and processes that make less waste.

## Chemical industry

- importance: jobs; fertilizers, pesticides; medicines, vaccines; soap, detergent, petroleum products; plastics; preserving food; research; **GDP** and exports
- types of plant: petrochemical (ethylene, benzene), pharmaceutical, fertilizer (urea, phosphates), chlor-alkali ($Cl_2$, NaOH, $H_2$), agrochemical
- **Nepal**: biggest is **cement** (65 plants by 2023; limestone at home, huge demand, bulky product costly to carry, simple process, hydropower); also paints, soap, medicines, paper, sugar; **no** fertilizer (all urea imported), sulphuric acid, caustic soda
- **challenges in Nepal and their fixes**

| Challenge | How to overcome it |
|---|---|
| raw materials imported (rubber, gas, sulphur) | use what Nepal has (limestone, herbs, water, hydropower); long-term supply contracts |
| little capital, high cost of loans | investment, partners, public–private projects |
| cheap imports from India and China | quality, local fit, lower transport cost; fair trade policy |
| old machines, few skilled people | training, research with universities, new technology |
| transport, power cuts, poor management (Gorkhakali tyre factory shut since 2015) | roads, reliable power, good management |
| pollution | regulation, green chemistry, waste treatment |

## A new product: eight stages




The eight stages of developing a new product, each a step up; at every step the idea can still be dropped, cheapest early.

1. **idea generation**: from R&D, market research, staff, customers, suppliers, competitors; brainstorming
2. **idea screening**: an idea committee keeps the profitable ones (needed? competition? can we make and sell it?)
3. **concept development and testing**: a written concept shown to a few customers
4. **marketing strategy**: positioning, price, distribution, promotion, budget, profit
5. **business analysis**: profit, demand, competitors, launch cost
6. **product development**: **prototype**, pilot plant; R&D, finance, production, advertising
7. **test marketing**: sold in a small market; fix problems, cut the risk before launch
8. **commercialization**: full launch (timing, price, packaging, brand, target market)

- **R&D**: source of new ideas; turns an idea into a working, safe, cheaper product; scales it up; keeps improving it after launch
- challenges: cost and risk (screen and test small first); not knowing customers (market research); competition (differ, patent); fails at scale (pilot plant); rules (safety, green design); money and skills (partners, training)

## Economics of production

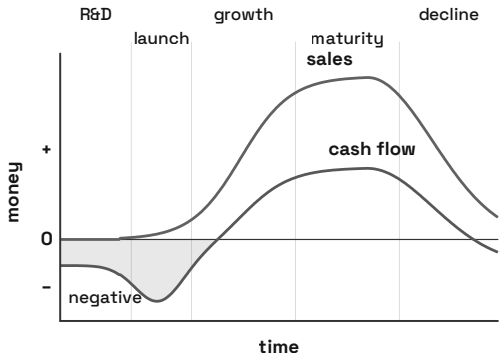
- primary (raw materials: farming, mining, quarrying), **secondary** (making goods: factories), tertiary (services: selling, transport, banks)
- factors: **land, labor, capital, entrepreneurship**

| Fixed factors | Variable factors |
|---|---|
| not readily changed in the short run | change easily with output |
| land, buildings, plant, machinery | labor, raw materials, fuel, electricity |

- rising productivity → higher wages, lower prices, higher profits, growing economy
- e.g. 12,000 bags with 150 workers = 80 bags per worker; 9,000 with 100 = 90 (more productive)

## Cash flow

- **inflow** (sales, the main source; loans; investors) vs **outflow** (raw materials, wages, rent, energy, taxes, loan repayments, new plant)
- a profitable company can still run short of cash if its money is tied up in stock or unpaid bills
- e.g. stock 40 days + collect 30 − pay 25 = **45 days**; customers paying in 10 → 25 days
- shorten it: less stock, collect payments quickly, pay suppliers as late as allowed
- depreciation: no cash paid, so no direct effect (lowers tax a little)




Sales (upper curve) and cash flow (lower) through a product's life: negative in development and launch, highest at maturity, falling in decline.

- development: spending, no sales → **negative**; launch: small sales, big costs → still **negative** (lowest)
- growth: positive, rising; **maturity**: highest (sales top, plant paid for, less advertising); decline: falls (rivals, newer products)

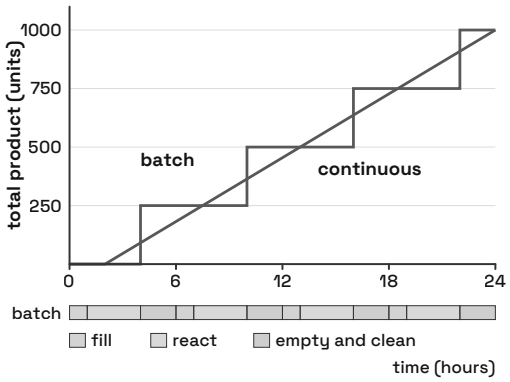
## Running and designing a plant

- **running**: managers, engineers, operators; automation (sensors, control systems); high temperature, pressure, toxic and flammable substances
- **safety**: relief valves, bursting discs, alarms, automatic shut-down; protective clothing; training, drills; inspection, maintenance; safe storage and labels, spill kits, fire equipment; emergency plans for neighbors
- **designing** (chemical engineers): objectives and scope; process and site (near raw materials, market, water, power); equipment and sizing from **material and**

**energy balances**; P&ID; safety and environment; cost; risk; operation and maintenance

- material balance: $N_2 + 3\,H_2 \longrightarrow 2\,NH_3$: 1000 t $NH_3$ a day needs 824 t $N_2$ and 176 t $H_2$
- design challenges: safety; efficient, cheap process; materials that resist the chemicals; running continuously; low emissions

## Batch and continuous processing




Product over one day: a batch plant in steps (fill, react, empty, clean every 6 hours) and a continuous plant in a steady flow.

| | Batch | Continuous |
|---|---|---|
| how | fixed lots, in cycles | non-stop flow |
| conditions | change during a batch | steady |
| products | many, small amounts | one, very large amounts |
| quality | each batch tested and traced; may vary | uniform |
| flexibility | easy to change recipe | hard to change |
| cost | low capital, high cost per kg (time lost filling, cleaning) | high capital, low cost per kg |
| contamination | more risk between batches | less |
| a fault | spoils one batch | affects all until fixed |
| examples | medicines, paints, dyes, perfumes, cosmetics, baking, brewing, chocolate brands | petroleum refining, $NH_3$, $H_2SO_4$, cement, paper, fertilizers |

- chocolate company with several brands, same process with small changes: **batch** (change recipe and shape between batches)

## Environmental impact

- **air**: VOCs, $NO_x$, $SO_2$, dust, $Cl_2$ or $NH_3$ leaks → smog, acid rain, breathing problems
- **greenhouse gases**: fuels; $CaCO_3 \longrightarrow CaO + CO_2$ in cement → climate change, melting Himalayan glaciers
- **water**: untreated acids, heavy metals (Hg, Pb, Cr, Cd), oils, dyes → aquatic life, drinking water; **soil**: dumping and leaks lower fertility; **resources** used up; biodiversity lost
- urea plant: $NH_3$ leaks, run-off of urea → nitrate in water, **eutrophication** (algae; their decay uses up oxygen); $N_2O$
- $H_2SO_4$ plant: $SO_2$, $SO_3$ mist → acid rain; acid spills; fixed by the double absorption process, scrubbers (lime), monitoring
- **prevention**: strict regulation and inspection; **green chemistry** (water, ethanol, supercritical $CO_2$ as solvents); safe handling and storage; waste treatment (scrubbers, filters, treatment plants), recycling; monitoring; public awareness

### COMMON MISTAKES

✗ cash flow cycle = cash flow
✓ cash flow is money in and out over a product's life; the **cash conversion cycle** is the days cash is tied up.

✗ depreciation lowers cash flow
✓ no money is paid out: **no direct effect** (it only lowers tax).

✗ batch processing for bulk chemicals
✓ bulk (ammonia, petrol, cement) is **continuous**; batch for small, varied products.

✗ cash flow is positive from launch
✓ **negative** through development and launch, highest at maturity.