

FUNDAMENTALS OF APPLIED CHEMISTRY

Objectives of the lesson

After completion of the chapter, the students will be able to

- 16.1 Explain the chemical industry and its importance.
- 16.2 Explain the stages in the development of a new product.
- 16.3 Explain the economics of production.
- 16.4 Explain cash flow in the production cycle.
- 16.5 Describe running a chemical plant.
- 16.6 Describe the design of a chemical plant
- 16.7 Describe continuous and batch processing.
- 16.8 Explain the environmental impact of the chemical industry.

16.1 Fundamentals of Applied Chemistry

Applied chemistry is the **use of chemical principles and techniques to solve real-world problems and develop new products** or processes.

It **bridges pure chemistry and practical applications** in fields like medicine, engineering, environmental science, and manufacturing.

- a scientific field for understanding the basic chemical properties of materials and for producing new materials with well-controlled functions
- Application of the theories of chemistry to answer specific questions or solve real-world problems
- Covers a variety of chemical fields
- Important to solve environmental problems and contribute to the development of new materials

16.1.2 Chemical industry and its importance

The chemical **industry converts raw materials into valuable products** like plastics, fertilisers, pharmaceuticals, and cleaning agents **through chemical processes**. It plays a vital role in the global economy, supporting sectors such as agriculture, healthcare, and manufacturing through innovation and large-scale production.

- Mainly companies that produce industrial chemicals
- Convert raw materials into more than 70,000 products
- Convert raw materials into desired products that we use in daily life

Importance:

- ✓ Plastic and polymers: more than 80% of the industries
- ✓ Supports agriculture - providing pesticides and fertilisers to boost crop yield and food production
- ✓ Advances healthcare- supplies essential chemicals for pharmaceuticals, medicine, vaccines, and medical equipments
- ✓ food: preservatives, taste enhancers, flavours
- ✓ Help in advanced research like bioengineering, mutation, and genetic reengineering
- ✓ Improves daily life: provides soaps, detergents, perfumes, and packaging materials, among many

Types of Chemical Products

1. Basic chemicals: acids (H_2SO_4), bases (NaOH)
2. Intermediate chemicals: polymers, dyes
3. Finished products: medicines, cosmetics

In Nepal, we can see cement and soap/detergent industries among many others.

1. The chemical industry manufactures
 - a. *Basic chemicals like acid, base, etc.*
 - b. *Chemicals like plastics, pigments, etc.*

- c. *Finished chemical products like drugs, cosmetics, etc.*
- d. *All of the above*

2. The chemical industry supports agriculture mainly by:

- a. Producing machinery
- b. Providing fertilizers and pesticides
- c. Supplying water
- d. Manufacturing tools

1. Discuss the chemical industry and its importance. 2

2. List out 5 chemical industries running in Nepal. 2

Students' activity/Assignment: Do a little deeper Research on chemical industries in Nepal. And make a list of 6 main chemical industries running in Nepal, along with their location and main products.

16.1.3 Stages in producing a new product

Generally, the following eight stages are involved in developing a new product.

I. Idea generation

Ideas can be generated by one or more of the following ways

- Conducting market research to find out consumers' needs and wants in national and international markets
- Inviting suggestions from consumers
- Inviting suggestions from employees
- Getting feedback from agents or dealers about services offered by competitors

It should focus on the customer's needs.

II. Idea screening

These questions may be asked to screen the idea

- Is it necessary?

- Can existing plants, machinery, and manpower produce the new product?
- Can the existing marketing network sell the new product?
- When can it break even?

The positive answers to these questions lead to the selection of the idea.

III. Concept testing

After screening, concept testing is done. In this stage, the following things are found out

- Whether the consumers understand the new product
- Whether the consumers need the product
- Whether the consumers will accept the product

IV. Business analysis

A very important step, by detailed business analysis, whether the new product is commercially profitable or not

- What will be the cost of the new product?
- Will there be demand for the product?
- Whether the demand will be seasonal or regular?
- Are there or will there be competitors?
- What will be the total sales?
- What will be the expenses on advertising, sales promotions, etc?
- How much profit will be earned after considering all expenses, including taxes

V. Product development

At this stage, the company decides to introduce a new product.

Takes all necessary steps to produce and distribute

The production department makes plans for the production process

The marketing department plans for marketing and distribution

The finance department provides finance.

The advertising department plans for advertising and promotions

VI. Test marketing

It means to introduce the product on a small scale. If it is successful, then it is distributed on a large scale. If it fails, the reasons for failure are analysed, necessary changes are made and reintroduced into the market. If it fails again, it is abandoned.

VII. Commercialisation

After successful test marketing, the company launches the new product on a large scale. The company has invested a large amount in the product. It produces, markets, and advertises the product in mass media.

VIII. Review of market performance

The company must review the market performance of the new product. They must make necessary changes in their marketing plans and strategies so as not to fail with the product.

3. The first step in developing a new product is:
 - a. *Business analysis*
 - b. *Idea generation*
 - c. *Test marketing*
 - d. *Commercialisation*
4. *The steps in producing a new product include*
 - a. *Research of a new product*
 - b. *Pilot study*
 - c. *Decision and review of the product*
 - d. *All of the above*
5. Checking whether a product is needed by consumers is done in:
 - a. *Idea screening*
 - b. *Concept testing*
 - c. *Commercialisation*
 - d. *Production*

6. Introducing a product on a small scale is called:
 - a. *Screening*
 - b. *Business analysis*
 - c. *Test marketing*
 - d. *Review*
7. Which of the following is the last step in producing a new product?
 - a. *Pilot survey*
 - b. *Decision*
 - c. *Selling of the product*
 - d. *Review*

10. The final stage of product development is:

- a. *Marketing*
- b. *Commercialisation*
- c. *Review of market performance*
- d. *Production*

3. List out the main stages involved in the development of a new product.

2

16.1.4 Economics of production

Production involves the process of combining various material and immaterial inputs. It is the act of creating good, useful, affordable goods or services that have value to the consumer.

The basic function of a company is to make a profit from its existence.

In the simplest form, the production can be related to the costs of production and revenues generated from it.

The generation cost mainly involves

- Research cost
- Labour
- Raw materials
- Energy
- Packaging

Transport
Licenses/ Patents
Management
Maintenance
Depreciation
Taxes, local charges, etc.

Revenue: money earned from sales

8. Profit is calculated as:
 - a. Cost – Revenue
 - b. Revenue – Cost
 - c. Cost $\times$ Revenue
 - d. Revenue $\div$ Cost
 9. *Interest and operating expenses are related to*
 - a. *Design development*
 - b. *Cash flow*
 - c. *New product*
 - d. *Environmental impact*
2. Write any two areas of production cost for running a chemical plant/ industry.

1

16.1.5 Cash flow in the production cycle

Cash flow can be defined as the difference between cash or equivalents being transferred into (inflows) and out of the business (outflows).

Or, it is the movement of money into and out of a business.

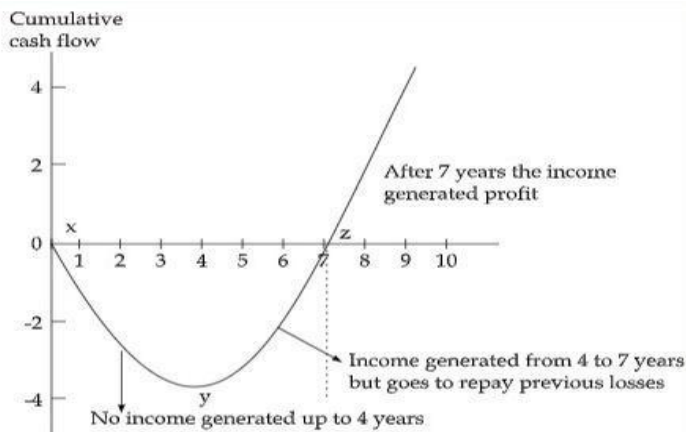


FIG. 16.3 Graph showing how cash flow changes during the life of project

The cash flow in the production cycle is the time it takes a company to turn raw materials into cash. It is also known as the conversion cycle.

Different projects might have different cash cycles.

- **Short cash cycle = faster recovery of investment**
- **Long cash cycle = financial difficulty**

The following parameters have to be considered to find the cash flow of the production cycle.

Purchases

Operating expenses

Interest expenses

Income taxes

And cash collection or revenues

Raw material → Production → Sales → Cash

10. Cash flow refers to:

- a. Flow of raw materials
- b. Movement of money in and out of a business
- c. Flow of chemicals
- d. Production rate

11. A short cash flow cycle is preferred because it:
- Increases cost
 - Reduces efficiency
 - Improves business liquidity
 - Stops production

4. Briefly discuss cash flow in the production cycle.

3

16.1.6 Running a chemical plant

- Chemical plants consist of specialised equipment, units, and technology in the manufacturing process.
- Its general objective is to create new material wealth via chemical or biological transformation and/or separation of materials.
- Advancements in technology offer smart techniques like automation, which make it easy to run a chemical plant.
- Temperature change and pressure changes can be measured by instruments directly connected to computers.
- Computer programming can easily control pumps, heaters, etc., to run the plant smoothly.
- Manpower is mainly required only to monitor through the computers, work in the parts where automation is not possible, and operate some of the equipment.
- This greatly reduces the operating cost and ensures safety to a greater extent.

16.1.7 Designing a Chemical Plant

- It is an art of science, especially done by chemical engineers.
- Designed to increase production while minimizing the cost.
- Automation with a good margin of safety is another aspect.
- Chemical engineering is an integration of different sciences and engineering, like physics, chemistry, civil, mechanical, computer, etc.

- Required balancing of the number of criteria to ensure maximum efficiency.
- E.g., the rate of production using a reaction can be increased by increasing the temperature, but increasing the temperature increases the cost of energy
- If the exothermic reaction is involved, heat energy does not have to be supplied, but high heat hinders the reaction, so the heat evolved can be used by converting it into other forms of energy.
- Similarly, an endothermic reaction can be used to cool hot liquids, which can then be used to cool the exothermic part.

12. *Which of the factors should be considered while designing a chemical plant?*

- Temperature*
- Pressure*
- Energy*
- All of the above*

13. A chemical plant increases the temperature to speed up a reaction, but energy costs rise significantly.

Assertion (A): Increasing temperature always improves plant efficiency.

Reason (R): Higher temperature increases reaction rate.

- Both A and R are true, and R is the correct explanation of A
- Both A and R are true, but R is NOT the correct explanation of A
- A is true, but R is false
- A is false, but R is true

16.1.7 Continuous and batch processing

Continuous production system	Batch production system
Continuous process refers to the flow of a single unit of product between every step of the process without any break in time, substance or extent.	A batch process refers to a process that involves a sequence of steps followed in a specific order.
The quantity of product is large (massive)	The quantity of the product is smaller
The product is identical and standardised	The product is the same, but a different version
There is no variety in this process	There is moderate variety in this process
In this production, the size of the order is large, which is non-repeated	In this production, the size of the order is small, which is repeated
Production planning and control are somewhat complicated (depends on demand)	Production planning and control are simple
Relatively expensive equipment is used	Relatively cheap equipment is used
e.g., Fertilizer, petroleum refining	e.g, Medicine, speciality chemicals

14. Continuous processing is suitable for:

- a. Small-scale production
- b. Specialised products
- c. Large-scale production
- d. Seasonal products

15. Which process provides more flexibility?

- a. Continuous
- b. Batch
- c. Both equal
- d. None

16. *Batch production is suitable for*
- b. Fertilizers*
 - c. Sulphuric acid*
 - d. Specialised chemical*
 - e. All of these*
17. *Which of the following is not true regarding continuous processing*
- a. Useful for the product of high demand*
 - b. Large capacity is necessary*
 - c. Generally automated*
 - d. More human resources are used*
18. *For the development of a new product, inviting suggestions from employees comes under*
- a. Business analysis*
 - b. Commercialisation*
 - c. Idea generation*
 - d. Batch processing*
19. A fertilizer factory produces ammonia continuously to meet high agricultural demand. The plant operates 24 hours a day using automated systems.

Assertion (A): Continuous processing is suitable for fertilizer production.

Reason (R): Continuous processes are efficient for large-scale, high-demand production.

- a. Both A and R are true, and R is the correct explanation of A
- b. Both A and R are true, but R is NOT the correct explanation of A
- c. A is true, but R is false
- d. A is false, but R is true

16.1.8 Environmental impact of the chemical industry

Chemical industries have brought several important products to improve health, provide greater safety, and enhance the quality of life. But these can also release harmful chemicals into the environment during the production, use, and disposal of the products.

The impact of chemical industries on the environment can be studied under the following topics.

Air pollution

The natural composition of air is about 78% N₂, 20.9 O₂, 0.9% Ar, 0.53 % H₂O, 0.035 % CO₂, and hundreds of other trace components. Any change in this composition, especially harmful to living beings directly or indirectly, is considered air pollution. In minimising the environmental impact of industrial activity, both directly released pollutants and the release of compounds that have a role in **secondary pollution** production should be considered.

Main pollutants released into the atmosphere by the industries are CO₂ and CO.

generally released during the combustion of fossil fuels

main effect- greenhouse effect, global warming, melting of ice in mountains and poles, change in seasonality, over-rainfall, under-rainfall, melting of glaciers and glacier lakes, and flooding, etc.

CO: toxic

other pollutants are NO, NO₂, SO₂, SO₃ etc.

also released during the combustion of impure fossil fuels

main effect- acid rain, photochemical smog, respiratory problems, etc.

Other compounds, like CFCs, cause ozone layer depletion

Another class of pollutants: volatile organic compounds (VOCs)→ health hazards in humans and other animals.

Water pollution

Some byproducts of the chemical reactions, some used solvents, and hot water after being used for cooling the machinery are released into water bodies like the sea, rivers, lakes, etc. by various chemical industries. Common pollutants are heavy metals like Cd, Hg, Pb, Zn, Cr, Cu, etc., which are highly toxic to aquatic life and humans if they consume such water. Other pollutants are petroleum, pesticides, detergents, fertilizers, polycyclic aromatic hydrocarbons (PAHs), other organic compounds, etc. All of these are harmful to aquatic plants and animals and to humans if they are used.

Soil pollution

The main soil pollutants derived from chemical industries are pesticides, herbicides, ammonia, petroleum hydrocarbons, lead, mercury, naphthalene, polymers like plastics, etc. In the correct way of disposal, different chemical industries cause pollution in the soil. This generally leads to the acidification of soil and degrades the productivity in agriculture and biodiversity in the wild. Disposal of plastics, metallic cans, and electrical appliances like batteries has adverse effects on the soil.

Conclusion

Chemical industries can produce and release a large number of pollutants into the environment directly or indirectly. So, while designing a chemical plant or industry, the environmental impact must be considered, and mitigation measures must be applied. Prevention of the production and release of such harmful chemicals is the best way, but managing the hazards should also be considered.

- | | |
|---|---|
| 6. Make a list of chemicals that cause air pollution. | 2 |
| 7. Discuss the toxicity due to heavy metals present in water. | 2 |
| 8. Describe the environmental impacts of chemical industries. | 4 |

20. Which industry affects the environment to the maximum extent?
- Chemical industry
 - Wood industry
 - Food industry
 - Garment industry
21. Which gas is mainly responsible for global warming?
- O_2
 - N_2
 - CO_2
 - H_2
22. Acid rain is mainly caused by:
- CO_2
 - SO_2 and NO_2
 - O_2
 - H_2O
23. The main source of soil pollution is
- Iron junk
 - Glass junk
 - Copper junk
 - Plastics
24. Which of the following is a heavy metal pollutant?
- Sodium
 - Mercury
 - Calcium
 - Potassium
25. Pollution in the atmosphere is measured in:
- molality
 - Ppm
 - Mass
 - Molarity
26. A factory burns fossil fuels and releases CO_2 into the atmosphere, contributing to rising temperatures.

Assertion (A): CO₂ contributes to global warming.

Reason (R): CO₂ traps heat in the atmosphere.

- a. Both A and R are true, and R is the correct explanation of A
- b. Both A and R are true, but R is NOT the correct explanation of A
- c. A is true, but R is false
- d. A is false, but R is true

9. Chemical industries are useful and harmful to us. Explain.

The Chemicals from chemical industries are used to make virtually every man-made product and play an important role in the everyday life of people around the world. Such products provide protection for crops and increase yields, prevent and cure disease, provide insulation to reduce energy use, and provide countless other benefits that make life better for people.

Whereas hazardous waste is generated by the chemical industry as a by-product of manufacturing and from products that work their way through the supply chain and are eventually disposed of after final use, which cause pollution.

Quick Summary of the chapter:

- Applied chemistry = practical use of chemistry
- Chemical industry = converts raw materials into products
- Continuous process = large-scale, automated
- Batch process = flexible, small-scale
- Pollution = a major disadvantage of industries

*****This is not a complete note. It is to guide you. It is recommended to study the prescribed textbooks along with this material. *****