

Introduction to Chemical Engineering

Chapter 01

What is Chemical Engineering?

1.1 Scenario: an assignment

Memo from supervisor:

ABC Chemical Company Memorandum

From: Barbara Magelby, Supervisor, Chemical Process Group

We've just received information indicating that the company that has been disposing of our HCl byproduct is not doing well. We anticipate that they will be going out of business in 6-12 months. This puts us in a very dangerous situation, since we can't operate very long without disposing of that waste. Our marketing people have tried to find a potential buyer for the acid, but the byproduct is apparently not at an appropriate concentration or purity to be valuable to anyone in our local area.

One possibility to consider is treatment of the waste in order to be able to dispose of it in the lake next to our company site. However, at this point, no engineering analysis has been conducted on this or any other strategy.

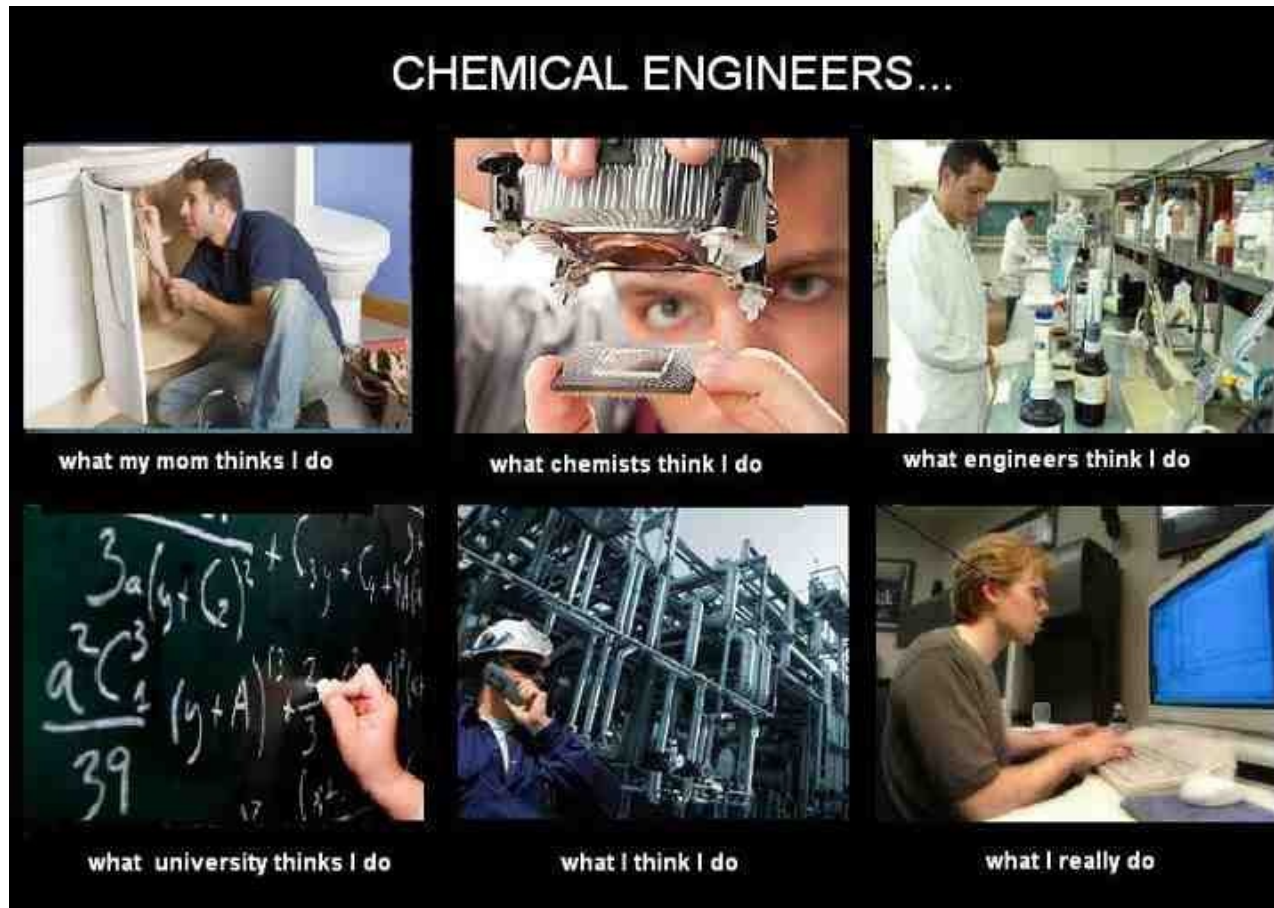
Your assignment is to propose a strategy and design (with a cost analysis) for safely and legally disposing of the acid waste.

Please keep me informed of your progress.

What will happen after the failure of company?

Introduction to Chemical Engineering

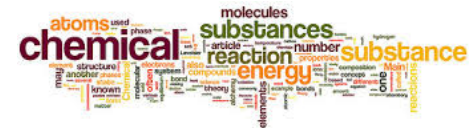
1.2 What is chemical engineering?



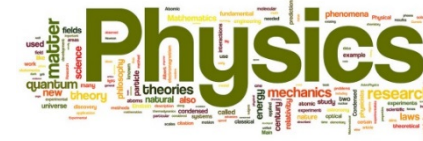
Introduction to Chemical Engineering

1.2 What is chemical engineering?

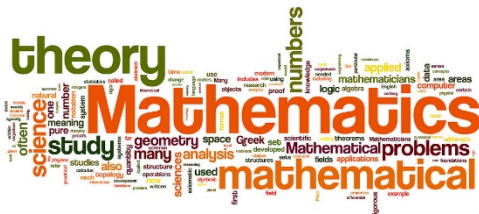
Chemical engineering creatively combines the three basic physical science – chemistry, physics, and biology – along with mathematics to address the world’s needs by creating new technology and solving problems in existing technology.



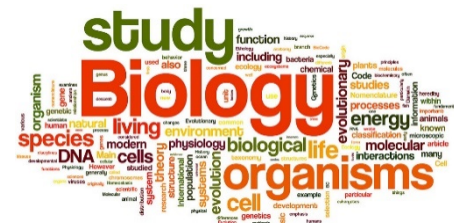
Chemistry



Physics



Mathematics

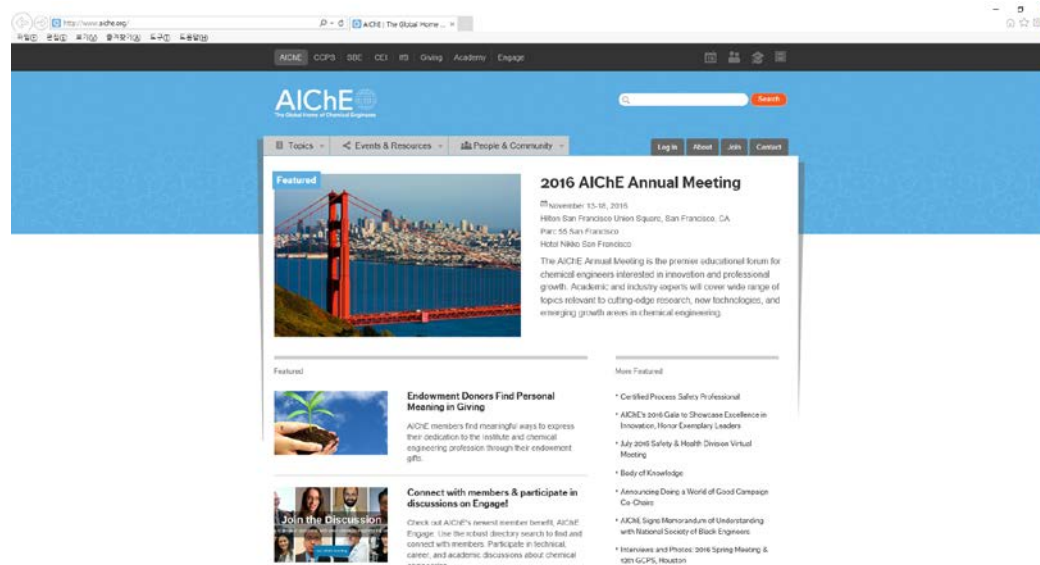


Biology

1.2 What is chemical engineering?

Definition by The American Institute of Chemical Engineers (AIChE):

- *[Chemical engineers] use science and mathematics, especially chemistry, biochemistry, applied mathematics and engineering principles, to take laboratory or conceptual ideas and turn them into value added products in a cost effective, safe (including environmental) and cutting edge process. From the development of smaller, faster computer chips to innovations in recycling, treating disease, cleaning water, and generating energy, the processes and products that chemical engineers have helped create touch every aspect of our lives.*



[<https://www.aiche.org>]

Introduction to Chemical Engineering

1.3 The impact of chemical engineering

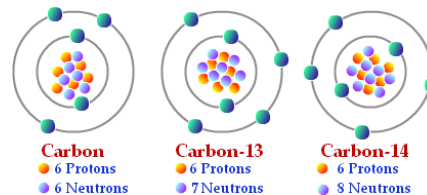
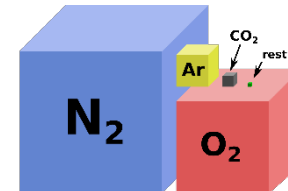
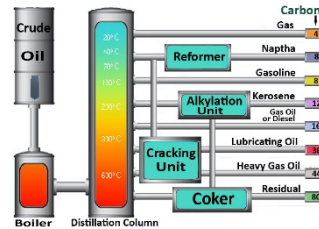


Introduction to Chemical Engineering

1.3 The impact of chemical engineering

1.3.1 Chemical engineering achievements

- Semiconductor fabrication
- Medicine
- Environmental protection
- Crude oil processing
- Plastics
- Synthetic fibers
- Synthetic rubber
- Gases from air
- Food
- Separation and use of isotopes
- Antibiotics



1.3 The impact of chemical engineering

1.3.2 Grand challenges

A graphic featuring a large solar panel array under a bright sun. A green puzzle piece on the left contains a sun icon. Below the puzzle piece, the text reads "Make solar energy economical" and "Solar energy provides less than 1% of the world's total energy, but it has the potential to provide much, much more." A row of icons at the bottom includes a smartphone, VR, gears, a building, a water drop, a radiation symbol, a CO2 molecule, and a DNA helix.

Make solar energy economical

Solar energy provides less than 1% of the world's total energy, but it has the potential to provide much, much more.

- New materials for solar collectors
- New materials for battery
- Unique properties
- Reducing cost
- Increasing efficiency

A graphic featuring a central point of light with radiating lines, symbolizing fusion. A green puzzle piece on the left contains a fusion symbol. Below the puzzle piece, the text reads "Provide energy from fusion" and "Human-engineered fusion has been demonstrated on a small scale. The challenge is to scale up the process to commercial proportions, in an efficient, economical, and environmentally benign way." A row of icons at the bottom is identical to the one in the solar energy graphic.

Provide energy from fusion

Human-engineered fusion has been demonstrated on a small scale. The challenge is to scale up the process to commercial proportions, in an efficient, economical, and environmentally benign way.

- Limitless and clean energy
- Designing conditions and materials
- Development of reactors

1.3 The impact of chemical engineering

1.3.2 Grand challenges



The graphic features a background of an industrial facility with smokestacks emitting thick plumes of smoke against a hazy, yellowish sky. A large green puzzle piece is positioned on the left, containing a white icon of a CO₂ molecule. Below the puzzle piece, the text reads: "Develop carbon sequestration methods" and "Engineers are working on ways to capture and store excess carbon dioxide to prevent global warming." A horizontal row of various white icons is overlaid on the bottom right of the image, including symbols for a smartphone, VR, a gear, a building, a water drop, a radiation symbol, a CO₂ molecule, a recycling symbol, a sun, a brain, a plus sign, a padlock, a gear, a nitrogen atom, and a chemical flask.

Develop carbon sequestration methods

Engineers are working on ways to capture and store excess carbon dioxide to prevent global warming.

- Decreasing greenhouse effect
- Capture and storage
- Conversion



The graphic features a background of a scientist in a white lab coat and a white face mask, wearing blue gloves and holding a small green plant. A wooden ruler is visible in the background. A large green puzzle piece is positioned on the left, containing a white icon of a nitrogen atom (N). Below the puzzle piece, the text reads: "Manage the nitrogen cycle" and "Engineers can help restore balance to the nitrogen cycle with better fertilization technologies and by capturing and recycling waste." A horizontal row of various white icons is overlaid on the bottom right of the image, including symbols for a smartphone, VR, a gear, a building, a water drop, a radiation symbol, a recycling symbol, a sun, a brain, a plus sign, a padlock, a gear, a nitrogen atom, and a chemical flask.

Manage the nitrogen cycle

Engineers can help restore balance to the nitrogen cycle with better fertilization technologies and by capturing and recycling waste.

- Fertilizer, fuel combustion
- Ozone layer, smog, acid rain...
- Increasing denitrification
- NO_x to N₂ conversion

Introduction to Chemical Engineering

1.3 The impact of chemical engineering

1.3.2 Grand challenges



Provide access to clean water

The world's water supplies are facing new threats: affordable, advanced technologies could make a difference for millions of people around the world.



- Removing microbes and toxins
- Removing salt



Restore and improve urban infrastructure

Good design and advanced materials can improve transportation and energy, water, and waste systems, and also create more sustainable urban environments.



- Water-treatment systems
- Power plant
- Reducing automobile pollution

1.3 The impact of chemical engineering

1.3.2 Grand challenges



Advance health informatics

Stronger health information systems not only improve everyday medical visits, but they are essential to counter pandemics and biological or chemical attacks.

The graphic features a green gear icon with a medical cross, overlaid on a digital medical monitor. The monitor displays various vital signs: '120 50', '60', 'Pulso 60', 'SpO₂ 100 90', '95', '120/70 (90)', and 'FRV 30'. A green line graph representing a pulse or ECG is visible in the background.

- Developing sensors
- Preventing biological/chemical terror
- Mass production of antidotes



Engineer better medicines

Engineers are developing new systems to use genetic information, sense small changes in the body, assess new drugs, and deliver vaccines.

The graphic shows a woman in a blue lab coat and glasses, holding a small red vial. A green gear icon with a medical cross is overlaid on the left. The bottom of the image features a row of various scientific and medical icons, including a smartphone, VR, a brain, a gear, a building, a water drop, a biohazard symbol, a CO₂ canister, a microscope, and a DNA helix.

- Personalized medicine
- Identification of disease
- Diagnostic technique and instrument
- Drug-delivery systems

1.3 The impact of chemical engineering

1.3.2 Grand challenges



Reverse-engineer the brain

The intersection of engineering and neuroscience promises great advances in health care, manufacturing, and communication.

- Information patterns of the brain
- Effective diagnosis
- Treatment of neurological disease



Prevent nuclear terror

The need for technologies to prevent and respond to a nuclear attack is growing.

- Tracking nuclear materials in reactor

1.3 The impact of chemical engineering

1.3.2 Grand challenges



A graphic illustrating the challenge of securing cyberspace. It features a smartphone with a fingerprint scanner, a 'SCAN COMPLETE' notification, and a 'HACKING DETECTED' warning. The background is a dark blue with glowing lines and icons representing various digital security concepts. A green puzzle piece icon with a padlock is on the left.

Secure cyberspace

It's more than preventing identity theft. Critical systems in banking, national security, and physical infrastructure may be at risk.

- Preventing cyberattack
- Protecting data during transfer



A graphic illustrating the challenge of enhancing virtual reality. It shows a person wearing a VR headset, with a glowing blue beam of light emanating from the lens. The background is a light blue with various icons representing VR applications. A green puzzle piece icon with 'VR' is on the left.

Enhance virtual reality

True virtual reality creates the illusion of actually being in a different space. It can be used for training, treatment, and communication.

- Training professionals
- Psychotherapy
- Behavioral-research

1.3 The impact of chemical engineering

1.3.2 Grand challenges



Advance personalized learning

Instruction can be individualized based on learning styles, speeds, and interests to make learning more reliable.

The image shows a group of diverse children in a classroom setting, focused on a tablet computer. A green gear-shaped graphic is overlaid on the left side, containing a white icon of a smartphone. Below the gear, there is a row of various white icons on a dark blue background, including a smartphone, VR, a gear, a graduation cap, a water drop, a radiation symbol, a CO2 molecule, a sun, a brain, a laptop, a padlock, a gear with a plus sign, a circular arrow, and a chemical structure.

- To professional training
- Systems/programs for all level



Engineer the tools of scientific discovery

In the century ahead, engineers will continue to be partners with scientists in the great quest for understanding many unanswered questions of nature.

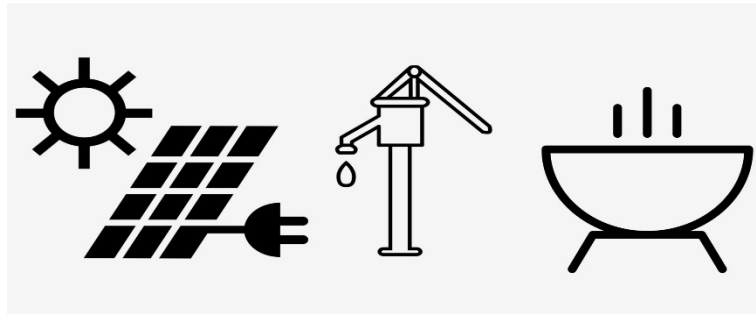
The image shows a Mars rover on a rocky, reddish-brown planet. A green gear-shaped graphic is overlaid on the left side, containing a white icon of a microscope. Below the gear, there is a row of various white icons on a dark blue background, including a smartphone, VR, a gear, a graduation cap, a water drop, a radiation symbol, a CO2 molecule, a sun, a brain, a laptop, a padlock, a gear with a plus sign, a circular arrow, and a chemical structure.

- Advanced and cheaper instruments

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1.3 The impact of chemical engineering

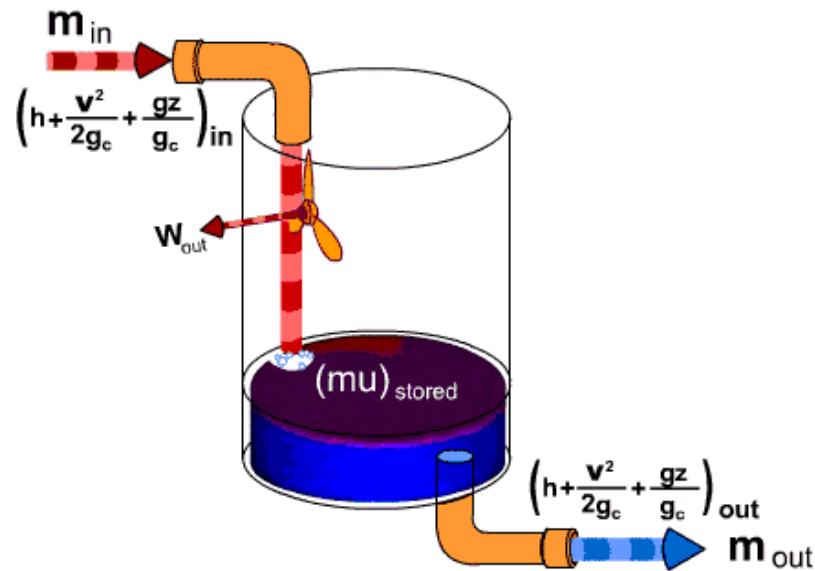
1.3.3 Humanitarian engineering



1.4 The chemical engineering discipline

1.4.1 Fundamental topics in chemical engineering

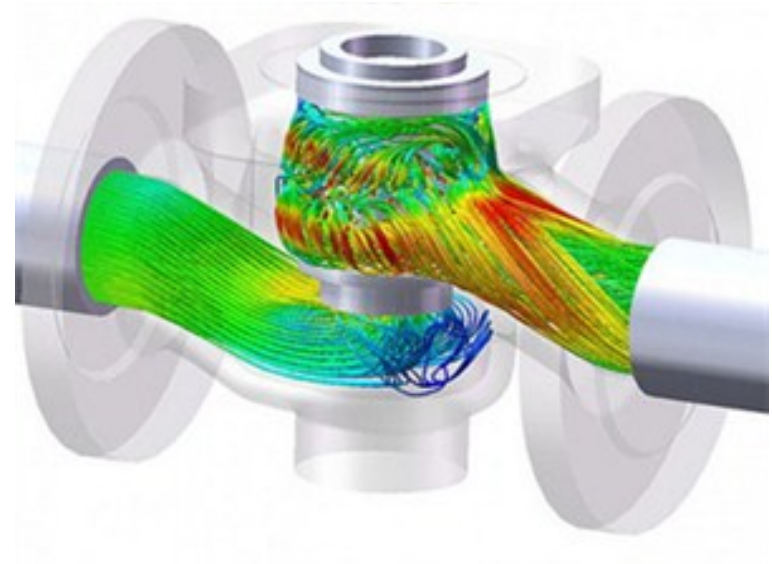
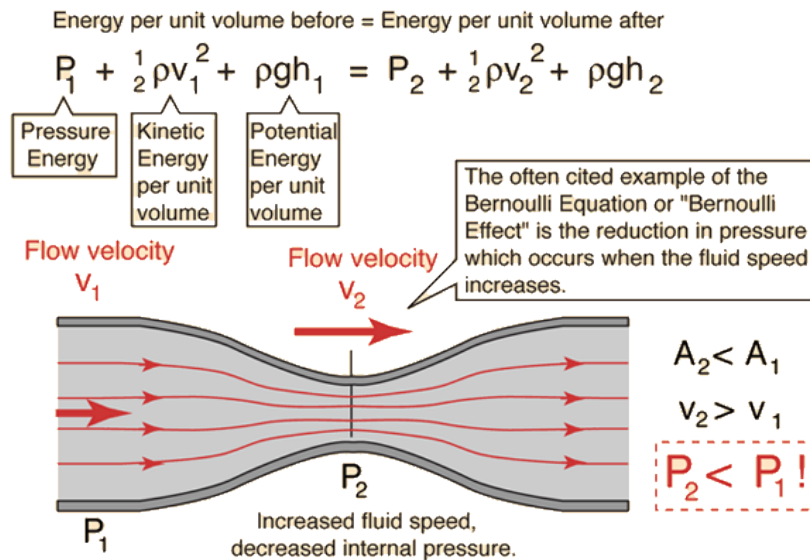
1. Material balances describes how material moves in and out of a process and help us determine how much material is needed to produce the desired products, as well as the amount of specific materials leaving the process, including both the desired products and undesirable products such as pollutants or by products.



1.4 The chemical engineering discipline

1.4.1 Fundamental topics in chemical engineering

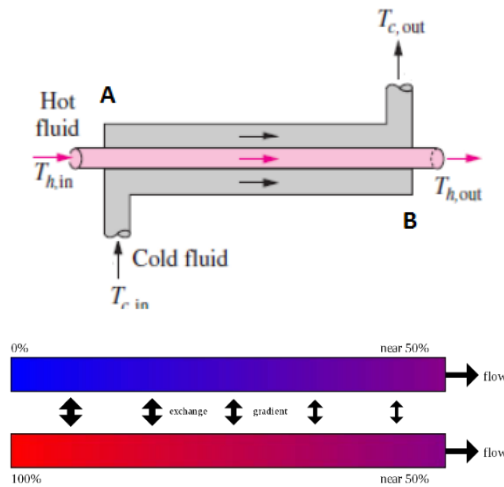
2. Fluid mechanics describes the movement of fluids and help us design systems to produce such movement (e.g., pump-pipeline systems).



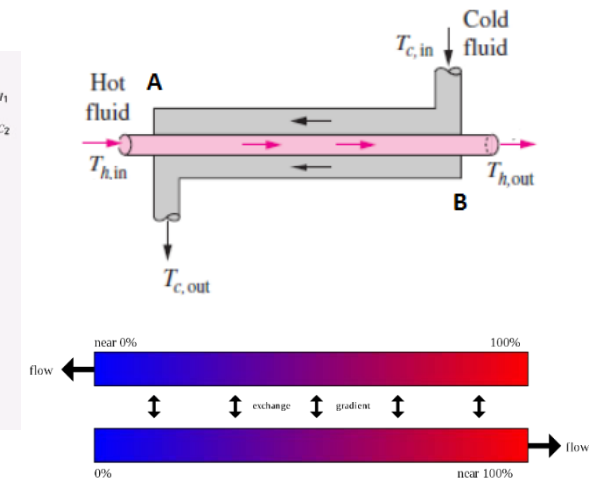
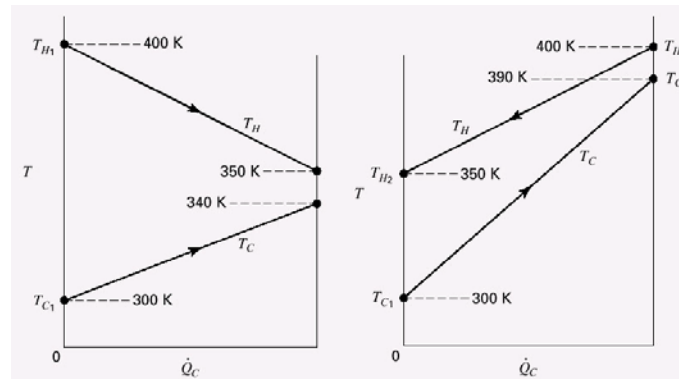
1.4 The chemical engineering discipline

1.4.1 Fundamental topics in chemical engineering

3. Heat transfer describes how heat transfers and helps us design systems (e.g., heat exchangers) to produce the heating or cooling of chemical materials to sustain desired chemical reactions and to recover energy from high-temperature processes.



cocurrent



countercurrent

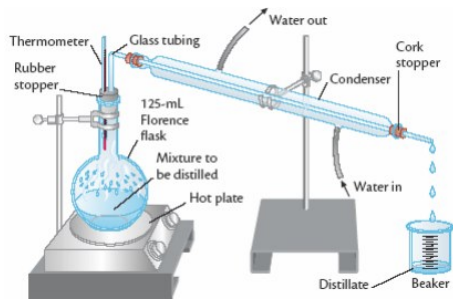
Introduction to Chemical Engineering

1.4 The chemical engineering discipline

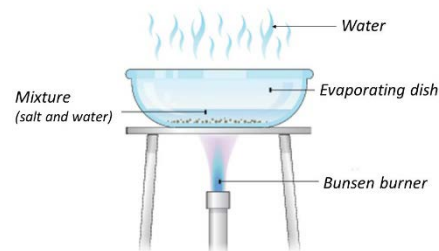
1.4.1 Fundamental topics in chemical engineering

4. Mass transfer describes how molecules move relative to each other and helps us design systems to produce the mixing or separation of chemical species, using such strategies as

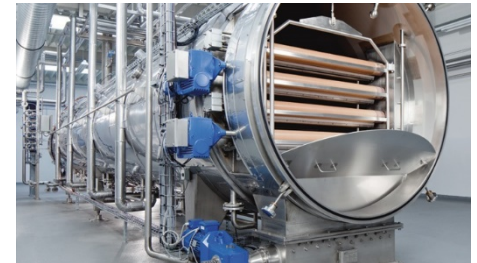
distillation



evaporation



drying (by evaporation)

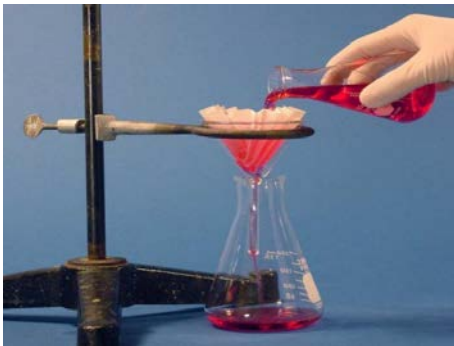
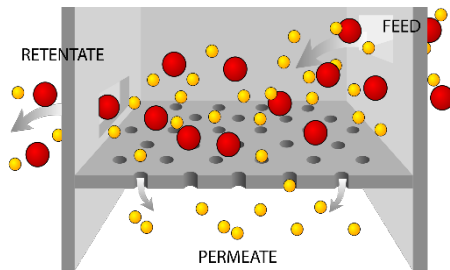


1.4 The chemical engineering discipline

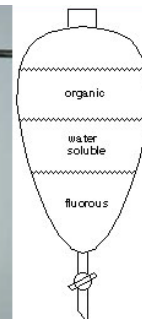
1.4.1 Fundamental topics in chemical engineering

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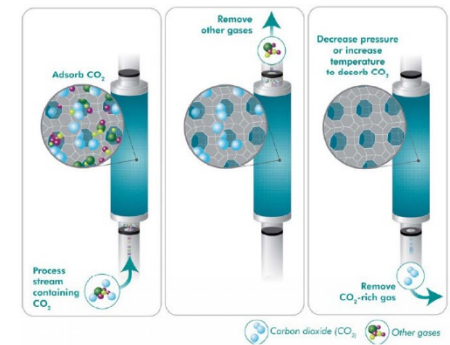
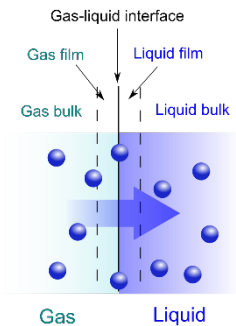
filtration



liquid-liquid transfer (extraction)



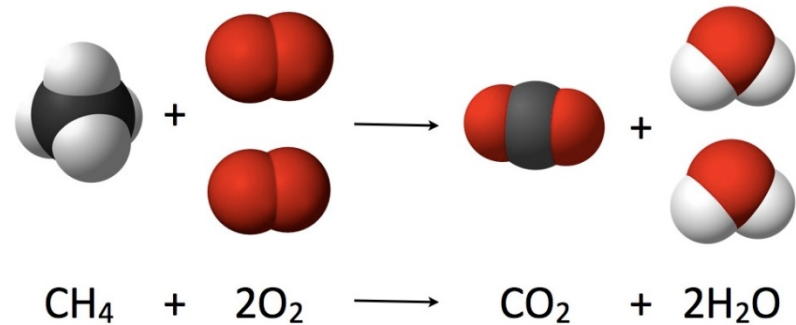
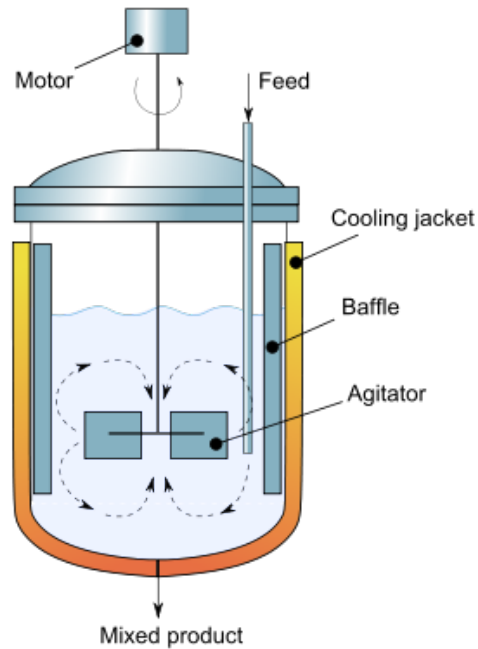
gas-liquid transfer (absorption)



1.4 The chemical engineering discipline

1.4.1 Fundamental topics in chemical engineering

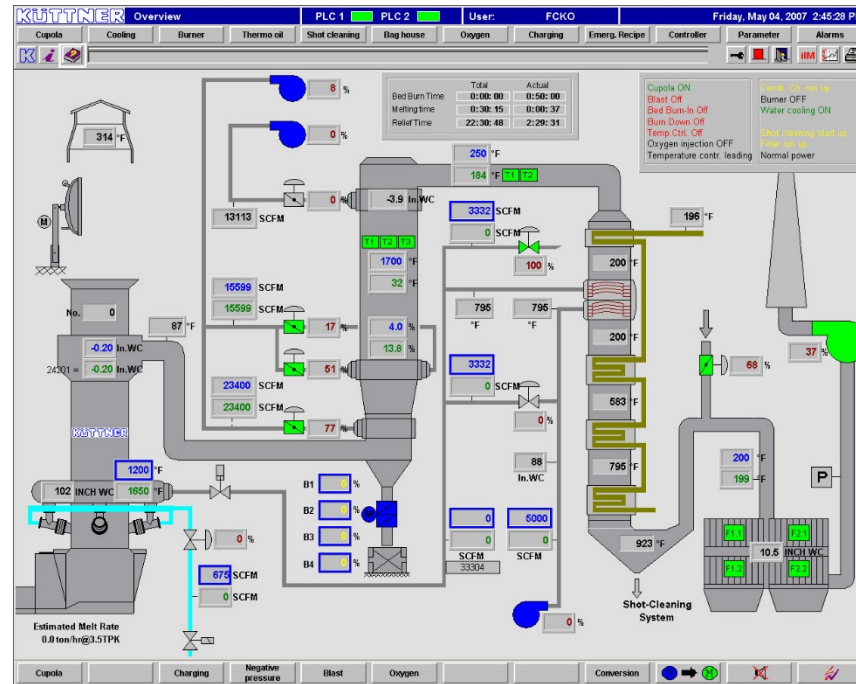
5. Reaction engineering describes how fast chemical reactions occur and helps us design systems (e.g. reactors) to produce desired quantities of material by reactions.



1.4 The chemical engineering discipline

1.4.1 Fundamental topics in chemical engineering

6. Process control describes how the outputs of complex systems respond to changes in input conditions and helps us design and optimize systems to hold product quality within desired specifications and to lower operating costs.



1.4 The chemical engineering discipline

1.4.1 Fundamental topics in chemical engineering

7. Materials describes how materials respond to mechanical and chemical stress and helps us select and fabricate materials with unique properties for desired products and processing equipment.



1.4 The chemical engineering discipline

1.4.1 Fundamental topics in chemical engineering

8. Economics describes the variables that affect the costs of chemical processing equipment and helps us predict the costs of various design and operating options.



The Price?
GOOD QUESTION!

1.4 The chemical engineering discipline

1.4.2 Professional activities in chemical engineering

- Process development research
- Technical chemical sales
- Process engineering
- Plant design and construction
- Environmental engineering
- Fundamental research



Communication skills

From microchips to potato chips...

Reading questions

Reading question 2

After reading about the Grand Challenges for Engineering, go to the following web address and watch the video provided at that site (6 minutes, 27 seconds):

<http://www.engineeringchallenges.org/>

Indicate in writing (one of two sentences each) new knowledge or feelings about each of the Grand Challenges that you gained from watching the video.

