Subject Aims

This page contains important information for CHEN20010 Material and Energy Balances. It will be assumed that all students will have thoroughly read it by the end of the first week of the semester.

Chemical engineers are concerned with all aspects of the design and operation of processing systems in which materials are transformed into useful products by means of physical, chemical, or biological processes. The material and energy balance calculations that will be covered in this subject are some of the most important calculations that any chemical engineer will need to be able to confidently perform in the course of their professional careers.

The teaching of process safety is critical to any undergraduate chemical engineering program.

Students need to understand their responsibilities to themselves, their work colleagues, and the wider community. They need to be aware of safe practices and also the consequences that may arise when those safe practices are not followed. This subject introduces students to concepts of process safety and the consequences when safety management systems fail.

Intended learning outcomes (ILOs)

On completion of this subject, the student is expected to:

1. Be able to apply knowledge of basic science and engineering fundamentals to solve material and energy balances.
2. Be able to model material and energy flows around reacting chemical systems.
3. Define and scope engineering problems and formulate suitable strategies for problem solution.
4. Have developed an appreciation for the importance of safety in the process industries. Since the development of skills is so important, there will be an emphasis on practice examples and tutorial exercises.

Content summary

The topics covered during the lectures, laboratory classes, and workshops will include the following:

- **Compositions of mixtures:** Compositions and analysis of mixtures including definitions by fractional ratio or component-free bases; definitions by mass fraction, mole fraction, volume fraction, concentration. Conversion between mass fraction and mole fraction and calculation of average molecular weight of mixtures.
- **Units and dimensions:** A review of the important unit systems and the units and dimensions of important physical quantities, including methods for expressing the composition of mixtures. Coherent and non-coherent systems. Units for common quantities including specific gravity, absolute and gauge pressure, temperature, energy.
- **Block diagrams and material balances:** The general material balance equation defining a system and surroundings by system boundaries. The application of material balances in the design and performance evaluation of a processing system. Total, component element balances around complete sections of a process. Computation aspects of material balances, degrees of freedom, direct solution method, key component calculations. Multiple unit operations including mixers, splitters, recycles, by-passes, and purges.
- **Material balances with chemical reactions:** Systems involving chemical reactions: extent of reaction, limiting reactant, excess reactant, conversion, extent of reaction. Systems involving multiple, simultaneous reactions: yield, selectivity, independence of equations.
- **Vapour pressure:** P–T diagram, triple point, critical point, partial pressure versus vapour pressure, Clausius–Clapeyron equation, Antoine equation to predict vapour pressure, vapour pressure from tabulated data. Concepts of humidity and the use of psychrometric charts. Solution of material balances for humid air systems.
- **Energy, heat capacity and enthalpy:** The concepts of energy, work and heat, the units of energy, internal energy, enthalpy, heat capacity, latent heat, evaluation of enthalpy changes. Using steam tables and refrigerant data tables.
- **Energy balances:** The general energy balance equation, enthalpy balances on non-reacting systems, system boundaries. Enthalpies of pure components and selection of enthalpy data conditions.
- **Heats of reactions:** Heat of reaction, definitions of standard heat of reaction, standard heat of formation, standard heat of combustion. Hess' law of adding stoichiometric equations. Evaluating heat of reaction under non-standard conditions.
- **Energy balances with chemical reactions:** Systems involving chemical reactions. Selection of enthalpy datum conditions. Single and multiple simultaneous reactions. Adiabatic reaction temperature.
- **Simultaneous material and energy balances:** Simultaneous material and energy balances on reacting systems.

- **Heats of solution:** Heats of solutions and dilution, and use of enthalpy-concentration charts.

Engineers Australia Stage 1 Competency Mapping

Engineers Australia requires that all graduates from the Master of Engineering programs possess a range of competencies necessary for them to work in industry in graduate entry positions. These are known as Stage 1 competencies. This subject contributes to the development of the following Stage 1 competencies:

- 1.1 Comprehensive, theory-based understanding of natural and physical science
- 1.3 In-depth understanding of specialist knowledge in engineering discipline
- 1.6 Understanding of contemporary engineering practice
- 2.1 Application of engineering methods for complex problem solving
- 3.2 Effective oral and written communication in professional and lay domains
- 3.5 Orderly management of self and professional conduct
- 3.6 Effective team membership and team leadership

Other competencies will be developed in the other subjects in your course.

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