LONDON SOUTH BANK UNIVERSITY

unit guide

UNIT SCE-2-613

THERMODYNAMICS

Faculty of Engineering, Science & the Built Environment

Department Of Applied Science

Session 2008/2009: Unit Leader: Dr. Clara Piccirillo

STUDY PROGRAMME IN

CHEMICAL ENGINEERING

This guide is designed to help you structure your learning by providing an indicative structure and content for the unit. It is a guide and not a definitive statement of what you will be taught. We will tray to follow this published scheduled as far as possible, but there may be some variation as the unit develops and as we try to match pace and content of our teaching to student needs.

become what you want to be

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UNIT SCE-1-610: THERMODYNAMICS

Basic data

Level:	2	***Subject area:***	SAS1
Credit value	1	***Semester***	1
Class contact hours	Lectures: 48 Practicals: 15	***Student managed study hours***	84
Pre-requisites			
Unit leader	Dr. C. Piccirillo	Room: B335B	Tel:020-7815 7138 07913510581 Email: picciric@lsbu.ac.uk
Other teachers	Dr. J. O. Orrin	Room: M306	Tel:0171-815 7953 Email: j.orrin@sbu.ac.uk
Workshop coordinator	Dr. Emmanuel Obasaju	Room: T815	Tel: 020 78157602 Email: obasajue@lsbu.ac.uk

Assessment

Element	*Description*	*Weighting*
Coursework	• Up to 5 standard reports (See separate instructions on laboratory procedure) • Class tests	30%
Examination	2 hours hour unseen examination	70%

Short introduction to the unit

Thermodynamics is concerned with the study of heat and work, and the transfer of energy from one form to another in physical and chemical transformation. An understanding of thermodynamics is important in many industrial processes. This unit provides a study of the basic chemical and power thermodynamics.

Aims

To provide a thermodynamic basis for the study of chemical processes and energy transfer.

Learning outcomes

On successful completion of this unit, you should be able to:

1. solve material and energy balances for non-reacting and reacting systems using appropriate thermodynamics diagrams and data.
2. apply the first law of thermodynamics to problems involving energy transfer or thermochemistry.
3. apply the second law of thermodynamics to problems involving heat and power.

4. select and make use of thermodynamic property data and relations for the modelling of chemical process systems.

Transferrable skills

The unit contributes to development of the following transferable skills:

- Manipulate, sort and present data in forms useful for understanding. Select, interpreter and validate data, identifying possible errors and inconsistencies.
- Communicate clearly the findings of experiments, projects and other assignments using written reports, oral and visual presentations.
- Work effectively in a team, recognising the roles played by different team members.

Indicative content

CHEMICAL THERMODYNAMICS (50%)

P-v-T behaviour of pure substances (10% contact time)

Gases

- Introduction to non-ideal behaviour:
  - Law of corresponding state & use of compressibility chart
  - Van der Waal's equation & other cubic equations.
  - Virial equation & applications. Use of correlations.

Liquids

- Methods for predicting properties of liquid state.

Thermodynamic properties of fluids mixture (10%)

Properties of pure fluids - Chemical potential, fugacity

Properties of fluids in mixture - Partial molar properties, fugacities in mixtures, applications.

Properties of fluids at high pressure

Introduction to equilibrium (10%)

Condition for equilibrium.

Vapour-Liquid equilibrium properties of ideal and non-ideal mixtures.

Thermochemistry (20% contact time)

Application of thermodynamic laws in Thermochemistry:

Enthalpy: Heats of combustion, formation and reaction.

Hess's law & Kirchoff's law - application to energy balances.

Thermodynamics of mixing. Applications & examples.

POWER THERMODYNAMICS (50%)

First law of Thermodynamics (25% contact time)

Energy transfer in closed systems for pure substances. Heat, work, internal energy. Temperature measurement. Isothermal, isobaric, adiabatic processes. Enthalpy. Enthalpy-composition diagrams. Thermal properties of process fluids. Introduction to steam tables. Mixing of fluids. Steady flow energy equation, and its application to power cycles. Refrigeration.

Second law of Thermodynamics (25% contact time)

Carnot cycle. Thermodynamic efficiency. Entropy. Isentropic efficiency of compressors and turbines. Application to simplified power and refrigeration cycles.

Teaching and Learning Methods

Our study of thermodynamics in this unit will take the form of theory classes with tutorial support, and experimental studies. Where possible, a visit will be organised to a local industry whose processing is based on thermodynamic principles. We shall study the theory of thermodynamics in two parts:

• *Chemical thermodynamics*	Lecture: 2 hrs/w	Lecturer: Dr. C. Piccirillo
• *Power thermodynamics*	Lecture: 2 hrs/w	Lecturer: Dr. John Orrin
Workshop	3 hrs per fortnight	

- **Teaching** will be by combined lectures and problem solving exercises to give you practice in solving problems. Where relevant, audio-visual teaching aid (e.g. video) will be used. There will be regular tutorial exercises to help you assess your understanding of the concepts. It is helpful to bring a calculator to all my lectures.

  Your learning will be aided if you make your own notes. You will be expected to take notes at the lecture and expand on this during your private study period.

  - **Practical**: Students will complete up to five laboratory studies from the following list. The experiments have been selected to illustrate some practical applications of thermodynamic principles.

    1. Bomb calorimeter
    2. Falling Film evaporator
    3. Air conditioning
    4. Fluidisation

Details of times and locations of lectures and laboratory workshops are given in the published class timetables. Outside class contact period, meetings with tutors, tutorial assistance and answers to other questions relating to the work, may be obtained through email to tutors.

Weekly teaching and learning programme

The programme of classes below is intended only as a guide and is subject to modification according to rate of progress and unforeseen factors.

<u>Weekly Teaching Activities for Chemical Thermodynamics</u>

<table>
<tr><td>Semester Week</td><td>Topic</td></tr>
<tr><td>Weeks
1– 6</td><td><u>P-v-T behaviour of pure fluids</u>
Gases
• Revise ideal gas law
• Introduction to non-ideal behaviour:
- Law of corresponding state & use of compressibility chart
- Van der Waal’s equation & cubic equations
• Virial equation & application,
Liquids
• Predicting properties of liquid state

<u>Thermodynamics of equilibrium</u>
Introduction to equilibrium. Condition for equilibrium.
Vapour-Liquid equilibrium properties of ideal and non-ideal mixtures.

Application of thermodynamic laws in Thermochemistry:
Enthalpy: Heats of combustion, formation and reaction. Hess’s law & Kirchoff’s law - application to energy balances.
Thermodynamics of mixing processes. Applications. Examples.</td></tr>
<tr><td>Weeks 7-12</td><td><u>Thermodynamic properties of fluids</u>
(a) Thermodynamic properties of pure fluids
Definition of entropy, free energy, chemical potential.

<u>Equilibrium for real systems</u>
(b) Thermodynamics of fluids in mixture
Definition of fugacity, fugacities in mixtures, applications.</td></tr>
</table>

Weekly schedule: Power Thermodynamics

<table>
<tr><th>Semester Week</th><th>Topic</th></tr>
<tr><td>1 – 5</td><td>You must have a set of steam tables for these classes.

First law of Thermodynamics
• Heat, work, internal energy.
• Temperature measurement.
• Properties of substances (1). Importance of properties. Sources: steam tables, graphs, calculation routines.
• Energy transfer in closed systems for pure substances.
• Isothermal, isobaric, adiabatic processes.
• Enthalpy. Enthalpy-composition diagrams.
• Thermal properties of process fluids.
• Introduction to steam tables. Mixing of fluids.
• Steady flow energy equation, and its application to power cycles. Refrigeration.</td></tr>
<tr><td>6– 10</td><td>Second law of Thermodynamics
• The second law. Heat engines. Reversible and irreversible processes. Carnot cycle. Thermodynamic efficiency. Entropy.
• Refrigeration. Concepts, choice of working fluid, and basic cycle.
• Applications of the second law. Use of T-S and Mollier diagrams. Isentropic efficiency of turbines and compressors. Application to simplified power and refrigeration cycles.
• Efficiency of steam power cycles.

WEEK 6: class test covering Weeks 1-5</td></tr>
<tr><td>11 – 12</td><td>Properties of substances (2). Specific heats. Ideal gas properties. Latent heat.</td></tr>
</table>

Note: Advertised weeks of class test are subject to alteration, but students will be given advance notice of any changes.

ASSESSMENT METHODS

This unit will be assessed by coursework and examination.

- **Coursework**: This constitutes 30% of the unit and will be based on:

  (i) Class tests held on week 9 (confirmation and more details will be given by the lecturers during the classes)

  (ii) laboratory attendance, participation in laboratory practical and laboratory reports (attendance on an industrial visit plus submission of a report will be counted in lieu of one laboratory practical). Further details will be given in the laboratory guidelines.

  Details on submission of coursework: All reports should be addressed to the unit leader, and submitted at the Faculty office (Room T313) before 4.30 pm. Any late submission should be discussed with the unit leader in advance of the deadline. You are expected to use the **application form for extension of deadline** for this purpose (*a copy may be obtained from the faculty office).* The University's policy on late submission of coursework and on plagiarism will apply.

- **Examination:** The remaining 70% will be by 2 hours unseen examination.

Recommended reading

For a start, you may use any good text you are able to understand. There are several in the library. You may find the following helpful for the study of this unit:

1. Atkins, P.W. (2001) The Elements of Physical Chemistry. Oxford University Press.

2. M.J. Moran, H.N.Shapiro (2000). Fundamentals of Engineering Thermodynamics, 4th edition, J.Wiley & Sons, New York Chichester.

3. Felder, R. M. And Rousseau, R. W. (2000) Elementary principles of chemical Processes, 3rd edition, J. Wiley & Sons.

4. I.M. Kletz, R.M. Rosenberg; (2000*)*. Chemical Thermodynamics, Basic Theory and Methods, J.Wiley.

5. J.M. Smith, H.C. Van Ness, M.M. Abbott (2001). Introduction to Chemical Engineering Thermodynamics, 5th edition, McGraw-Hill.