



# Course Outline

MATS2008

Thermodynamics and Phase Equilibria

Materials Science and Engineering

Science

**T2, 2022**

## 1. Staff

Position	Name	Email	Consultation times and locations	Contact Details
Course Convenor	Dr Rakesh Joshi	<a href="mailto:r.joshi@unsw.edu.au">r.joshi@unsw.edu.au</a>	Room 448 School of Materials Science and Engineering (Building E10) by appointment	Phone: 9385 6726
Lecturer	Dr Ron S Haines	<a href="mailto:r.haines@unsw.edu.au">r.haines@unsw.edu.au</a>	Room 128, School of Chemistry (Dalton Building F12) by appointment	Phone: 9385 4718
Lab Coordinator	Dr Ron S Haines	<a href="mailto:r.haines@unsw.edu.au">r.haines@unsw.edu.au</a>	Room 128, School of Chemistry (Dalton Building F12) by appointment	Phone: 9385 4718
Lecturer	Professor Charles C. Sorrell	<a href="mailto:c.sorrell@unsw.edu.au">c.sorrell@unsw.edu.au</a>	Room 248 School of Materials Science and Engineering (Building E10) by appointment	Phone: 9385 4421

## 2. Course information

Units of credit: 6, Prerequisite: CHEM1011 or CHEM1031 or CHEM1811 or MATS1101 or DPST1031

Teaching times: <http://timetable.unsw.edu.au/2022/MATS2008.html>

**Public Holiday: Mon, 13 June 2022**

Lectures will be online - check Moodle for announcements about how these will be delivered.

Week	Lecture 1 Tuesday	Lecture 2 Wednesday	Lecture 3 Friday	Laboratory (3hrs) Monday
1	Haines	Haines	Haines	Laboratory  Dr Haines
2	Haines	Haines	Haines	
3	Haines (Quiz)	Joshi	Joshi	
4	Joshi	Joshi	Joshi	
5	Joshi	Joshi	Joshi	
6	No class	No class	No class	
7	Joshi	Joshi (revision)	Joshi (Quiz)	
8	Sorrel	Sorrel	Sorrel	
9	Sorrel	Sorrel	Sorrel	
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## 2.1 Course summary

- Thermodynamic functions and properties of materials (chemical, mechanical and magnetic systems); thermodynamic laws and their application to materials: chemical equilibrium, gas-solid equilibria, Ellingham diagrams; electrochemistry: Pourbaix diagrams; thermodynamics of solutions; construction and interpretation of 2 component phase diagrams.
- Fundamentals of thermodynamics (thermodynamics basics; heat, work, and internal energy; heat capacity; enthalpy, entropy, and free energy; three laws of thermodynamics; redox processes).
- Equilibrium and gas-solid phase transitions (chemical equilibrium, first- and second-order phase transitions, fugacity and activity, gas-solid equilibria, Ellingham diagrams)
- Solution thermodynamics and phase diagram construction (ideal and regular solution thermodynamics, Raoult's and Henry's laws, calculation of thermodynamic values, construction of binary phase diagrams)
- Interpretation and applications of binary phase diagrams (unary systems, binary systems, effects on microstructures, applications for processing and performance).

## 2.2 Course aims

- To understand basic thermodynamic principles and to gain the capability of applying these principles to phase transitions and the chemical and electrochemical processes of pure substances, solutions, and multiphase systems.
- To understand the principles of binary phase diagrams and to apply this understanding to the interpretation and application of these diagrams to conditions of processing and performance.

## 2.3 Course learning outcomes (CLO)

At the successful completion of this course you (the student) should be able to:

1. Demonstrate an understanding of the basic concepts of thermodynamics applied to the gas, liquid, and solid states
2. Apply thermodynamic concepts to the behaviour of materials
3. Understand the relation between thermodynamics and phase equilibria
4. Interpret phase diagrams in terms of specifying materials processing parameters and predicting materials performance

## 2.4 Relationship between course and program learning outcomes and assessments

Course Learning Outcome (CLO)	LO Statement	Program Learning Outcome (PLO)	Related Tasks & Assessment
CLO 1	Demonstrate...	1.1, 1.3, 1.5, 2.1, 3.4 & 3.6	1, 2 & 3
CLO 2	Apply...	1.2, 1.3 & 2.1	1, 2 & 3

CLO 3	Understand...	1.1	1, 3 & 4
CLO 4	Interpret...	1.3 & 2.1	3 & 4

## 3. Strategies and approaches to learning

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### 3.1 Learning and teaching activities

(Based on UNSW Learning Guidelines)

- *Students are actively engaged in the learning process.*  
It is expected that, in addition to attending classes, students read, write, discuss, and are engaged in analysing the course content.
- *Effective learning is supported by a climate of inquiry where students feel appropriately challenged.*  
Students are expected to be challenged by the course content and to challenge their own preconceptions, knowledge, and understanding by questioning information, concepts, and approaches during class and study.
- *Learning is more effective when students' prior experience and knowledge are recognised and built on.*  
Coursework, tutorials, assignments, laboratories, examinations, and other forms of learning and assessment are intended to provide students with the opportunity to cross-reference these activities in a meaningful way with their own experience and knowledge.
- *Students become more engaged in the learning process if they can see the relevance of their studies to professional and disciplinary contexts*

The course content is designed to incorporate both theoretical and practical concepts, where the latter is intended to be applicable to real-world situations and contexts.

**Lectures:** The core concepts will be taught in lectures, students will have access to the lectures notes before class for annotation during the lecture. Students will be engaged in the learning process through class discussions and problem-solving questions independently and working together with partners and groups.

**Labs:** Experimental techniques and procedures will be taught through laboratories classes and laboratory reports following the class. Students will actively complete the experiments gaining experience of important materials testing and characterisation techniques. Students will be able to reflect on the experiments and learn to process data through the lab reports after class.

### 3.2 Expectations of students

- Students must attend at least 80 % of all classes with the expectation that students only miss classes due to illness or unforeseen circumstances
- Students must read through lecture notes and lab sheets prior to class
- During class, students are expected to engage actively in class discussions
- Students should work through lecture, tutorial and textbook questions
- Students should read through the relevant chapters of the prescribed textbook.
- Students should complete all assessment tasks and submit them on time.
- Students are expected to participate in online discussions through the Moodle page

- Students are expected to think critically in decision making and problem-solving
- Students must communicate with correct terminology in writing
- Students should conduct library and online research
- Students should work effectively to solve problems

## 4. Course schedule and structure

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This course consists of 57 hours of class contact hours. You are expected to take an additional 93 hours of non-class contact hours to complete assessments, readings and exam preparation spread over the term.

<b>Week</b>	<b>Topic</b>	<b>Activity</b>
1	Language of thermodynamics Entropy changes and irreversible processes	
2	Entropy changes and irreversible processes Redox processes	
3	Equilibrium between two phases of a pure substance Chemical equilibrium	Quiz
4	Raoult's and Henry's laws Regular solutions	
5	Thermodynamics of solutions, Fugacity, Activity, Colligative properties,	
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7	Calculation of thermodynamic properties of a solution, Ellingham diagrams, phase diagrams.	Quiz
8	Introduction: Gibbs phase rule, Unary systems and Binary systems	
9	Binary systems: Principles, features, interpretation, microstructures, applications.	
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## 5. Assessment

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### 5.1 Assessment tasks

Assessment task	Details	Weight	Due date
<b>Laboratories:</b>	Students will undertake two laboratory experiments. These will illustrate the principles of: (1) enthalpy of the solution by calorimetry (2) enthalpy of the solution by variation of solubility with temperature. Students will be divided into groups. There will be an induction in Week 1 for all students.	15%	Moodle
<b>Assignment:</b>	Students will be required to complete a problem-based assignment in the areas of equilibrium and gas-solid phase transitions. The assignment will be posted on Moodle in week 4. Submissions after the deadline will not be assessed.	15%	Week 5
<b>Quizzes:</b>	The quizzes will be of 2 h in duration in the areas of (1) fundamentals of thermodynamics ( <b>Haines' part</b> ) (2) solution thermodynamics ( <b>Joshi's part</b> )	(1) 15% (2) 25%	(1) Week 3 (2) Week 7
<b>Final Exam:</b>	<b>The examination will be 2 h in duration and held in the final exam period.</b> The only area covered will be the interpretation and applications of binary phase diagrams ( <b>Sorrell's Part</b> ).	30%	Final exam period

#### Further information

UNSW grading system: <https://student.unsw.edu.au/grades>

UNSW assessment policy: <https://student.unsw.edu.au/assessment>

### 5.2 Assessment criteria and standards

Assessment criteria and standards can be found on the course Moodle page.

**Note:** Students who fail to achieve a score of at least 40% for the average of the quiz and exam components (i.e., two quizzes and final exam grade average), but achieve a final mark >50% for the course, may be awarded a UF (Unsatisfactory Fail).

Please refer to the UNSW guide to grades: <https://student.unsw.edu.au/grades>

Rules governing conduct during exams are given at: <https://student.unsw.edu.au/exam-rules>

### 5.3 Submission of assessment tasks

- Assignments and laboratory reports must be submitted via Moodle before the deadline.
- Assignment must be completed and uploaded to Moodle before the deadline. Submissions after the deadline will not be assessed.
- Students must arrive to the quizzes and final exam on time.
- Students must attend their assigned laboratory sessions.

- UNSW operates under a Fit to Sit/ Submit rule for all assessments. If a student wishes to submit an application for special consideration for an exam or assessment, the application must be submitted prior to the start of the exam or before an assessment is submitted. If a student sits the exam/ submits an assignment, they are declaring themselves well enough to do so. Information on this process can be found here: <https://student.unsw.edu.au/special-consideration>. Medical certificates or other appropriate documents must be included. Students should also advise the lecturer of the situation.
- Unless otherwise specified in the task criteria, all assignments must be uploaded via Moodle prior to the due date for submission.
- Students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course coordinator prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equity and Diversity Unit: <https://student.unsw.edu.au/disability>. Early notification is essential to enable any necessary adjustments to be made.

## 5.4. Feedback on assessment

Assignments: Feedback will be given two weeks after submission of the assignment and take the form of the mark for the assignment, overall comments on how the class performed, any common areas that were not answered correctly. Additionally, personal feedback and how each student performed may be given.

Lab reports: Students will receive their mark and individualised feedback on the areas they excelled at and which areas of the reports that were not answered correctly. Feedback will be provided through Moodle, two weeks after submission.

Quizzes: Students will receive their marked exams indicating what questions were answered correctly and incorrectly. Overall comments and worked solutions may be provided to the class.

Final exam: Students will receive their final mark.

## 6. Academic integrity, referencing and plagiarism

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**Referencing** is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words, ideas or research. Not referencing other people's work can constitute plagiarism.

Further information about referencing styles can be located at <https://student.unsw.edu.au/referencing>

**Academic integrity** is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits: honesty, trust, fairness, respect, responsibility and courage.<sup>1</sup> At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.

Further information about academic integrity and **plagiarism** can be located at:

- The *Current Students* site <https://student.unsw.edu.au/plagiarism>, and
- The *ELISE* training site <https://subjectguides.library.unsw.edu.au/elise>

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<sup>1</sup> International Center for Academic Integrity, 'The Fundamental Values of Academic Integrity', T. Fishman (ed), Clemson University, 2013.

The *Conduct and Integrity Unit* provides further resources to assist you to understand your conduct obligations as a student: <https://student.unsw.edu.au/conduct>.

## 7. Readings and resources

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- P.W. Atkins and J. de Paula, Elements of Physical Chemistry, 6th Edition. Oxford University Press, Oxford, 2013.
- P.W. Atkins and J. de Paula, Physical Chemistry, 9th Edition. Oxford University Press, Oxford, 2010.
- W.D. Callister, Jr., Materials Science and Engineering: An Introduction, 8th Edition. John Wiley & Sons, New York, 2007.
- D.R. Gaskell, Introduction to the Thermodynamics of Materials, 4th Edition. Taylor & Francis, Oxford, 2003.
- R.A. Higgins, Engineering Metallurgy. Part I: Applied Physical Metallurgy, 6th Edition. Edward Arnold, London, 1993.
- M. Hillert, Phase Equilibria, Phase Diagrams and Phase Transformations: Their Thermodynamic Basis. Cambridge University Press, Cambridge, 1998.
- C.H.P. Lupis, Chemical Thermodynamics of Materials. North-Holland, Amsterdam, 1983.
- D.V. Ragone, Thermodynamics of Materials, Volume 1 & Volume 2. John Wiley & Sons, New York, 1995.
- S. Stolen, T. Grande, and N.L. Allan, Chemical Thermodynamics of Materials. John Wiley & Sons, New York, 2004

## 8. Administrative matters

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School Office: Room 137, Building E10 School of Materials Science and Engineering

School Website: <http://www.materials.unsw.edu.au/>

Faculty Office: Robert Webster Building, Room 128

Faculty Website: <http://www.science.unsw.edu.au/>

## 9. Additional support for students

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- The Current Students Gateway: <https://student.unsw.edu.au/>
- Academic Skills and Support: <https://student.unsw.edu.au/academic-skills>
- Student Wellbeing, Health and Safety: <https://student.unsw.edu.au/wellbeing>
- Disability Support Services: <https://student.unsw.edu.au/disability-services>
- UNSW IT Service Centre: <https://www.it.unsw.edu.au/students/index.html>
- Assessment Implementation Procedure:  
<https://www.gs.unsw.edu.au/policy/documents/assessmentimplementationprocedure.pdf>
- Special Consideration: <https://student.unsw.edu.au/special-consideration>