Chemical Properties of Materials

Table of Contents
Course Staff .................................................................................................................. 1
Course Objective ........................................................................................................ 2
Your Course at a Glance ............................................................................................ 2
Timetable .................................................................................................................... 3
Course Content ......................................................................................................... 3
Assessment ............................................................................................................... 5
Recommended Reference Materials ............................................................................ 5
Academic Honesty and Plagiarism ............................................................................ 7
Continual Course Improvement ............................................................................... 8
Administrative Matters ............................................................................................. 9
Rules for Exams ....................................................................................................... 9

Course Staff

<table>
<thead>
<tr>
<th></th>
<th>Room 245, School of Materials Science and Engineering (Building E10)</th>
<th>Room 339, School of Materials Science and Engineering (Building E10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/Prof. Sammy L.I. Chan (SC)</td>
<td>Phone: 9385 4441 <a href="mailto:sli.chan@unsw.edu.au">sli.chan@unsw.edu.au</a></td>
<td>Phone: 9385 7998 <a href="mailto:j.hart@unsw.edu.au">j.hart@unsw.edu.au</a></td>
</tr>
<tr>
<td>Course Coordinator</td>
<td>Consultation hours: by appointment</td>
<td>Consultation hours: by appointment</td>
</tr>
<tr>
<td>Dr Judy Hart (JH)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecturer</td>
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Course Objective
To learn the behaviour of surfaces, wear and friction phenomena, electrochemical series, corrosion and corrosion prevention, and applications of electrochemistry in materials technology. Examples of materials selection for corrosion and wear resistance, energy materials, and processing of materials by electrochemical means will be introduced to illustrate some of these principles involved.

Your Course at a Glance

<table>
<thead>
<tr>
<th>Week</th>
<th>Monday 09:00 – 11:00</th>
<th>Lecturer</th>
<th>Thursday 15:00-17:00</th>
<th>Lecturer</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to surface engineering; thermal hardening of steel</td>
<td>JH</td>
<td>Introduction to corrosion</td>
<td>SC</td>
</tr>
<tr>
<td>2</td>
<td>Surface hardening of steel</td>
<td>JH</td>
<td>Basic principles and classifications of corrosion</td>
<td>SC</td>
</tr>
<tr>
<td>3</td>
<td>Thermal spray coatings; galvanising (guest lecture)</td>
<td>JH</td>
<td>Thermodynamics of corrosion 1</td>
<td>SC</td>
</tr>
<tr>
<td>4</td>
<td>Coating by electrochemical/chemical methods</td>
<td>JH</td>
<td>Thermodynamics of corrosion 2</td>
<td>SC</td>
</tr>
<tr>
<td>5</td>
<td>Physical Vapour Deposition and Chemical Vapour Deposition</td>
<td>JH</td>
<td>Electrode kinetics 1</td>
<td>SC</td>
</tr>
<tr>
<td>6</td>
<td>Comparison of surface coating methods; Revision</td>
<td>JH</td>
<td>Electrode kinetics 2</td>
<td>SC</td>
</tr>
<tr>
<td>7*</td>
<td>Introduction to friction and wear</td>
<td>JH</td>
<td>Mid-sem exam</td>
<td>SC</td>
</tr>
<tr>
<td>8*</td>
<td>Interactions between surfaces and friction</td>
<td>JH</td>
<td>Passivity and pitting</td>
<td>SC</td>
</tr>
<tr>
<td>9*</td>
<td>Abrasive and erosive wear</td>
<td>JH</td>
<td>Atmospheric corrosion and oxidation</td>
<td>SC</td>
</tr>
<tr>
<td>10*</td>
<td>Public holiday</td>
<td>JH</td>
<td>Corrosion in soil and Biological corrosion</td>
<td>SC</td>
</tr>
<tr>
<td>11*</td>
<td>Adhesive wear</td>
<td>JH</td>
<td>Atmospheric corrosion and oxidation</td>
<td>SC</td>
</tr>
<tr>
<td>12*</td>
<td>Fatigue and corrosive wear; Wear of different materials</td>
<td>JH</td>
<td>Corrosion under stress II</td>
<td>SC</td>
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<tr>
<td>13*</td>
<td>Lubrication; Revision of wear mechanisms (venue TBA)</td>
<td>JH</td>
<td>TBA</td>
<td>SC</td>
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</table>

<table>
<thead>
<tr>
<th>Week</th>
<th>Monday 14:00 – 16:00</th>
<th>Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Structure of electric double layer</td>
<td>SC</td>
</tr>
<tr>
<td>8</td>
<td>More applications of Pourbaix diagram</td>
<td>SC</td>
</tr>
<tr>
<td>9</td>
<td>Advanced Electrode kinetics and applications 1</td>
<td>SC</td>
</tr>
<tr>
<td>10</td>
<td>Public holiday</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Advanced Electrode kinetics and applications 2</td>
<td>SC</td>
</tr>
<tr>
<td>12</td>
<td>Energy Materials</td>
<td>SC</td>
</tr>
<tr>
<td>13</td>
<td>Project presentation</td>
<td></td>
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Timetable

<table>
<thead>
<tr>
<th>Week</th>
<th>Day</th>
<th>Time</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>1 – 6</td>
<td>Monday</td>
<td>09:00 – 11:00</td>
<td>Law Theatre G02 (F8-G02)</td>
</tr>
<tr>
<td>1 – 12*</td>
<td>Thursday</td>
<td>15:00 – 17:00</td>
<td>ChemSci M11 (F10-M11)</td>
</tr>
<tr>
<td>7 – 12</td>
<td>Monday</td>
<td>14:00 – 16:00</td>
<td>Webster 250 (G14-250)</td>
</tr>
</tbody>
</table>

* MATS4007 attendance on Thursday 15:00 – 17:00 in Weeks 7-13 is optional but strongly recommended. Students are also welcomed to attend the Wear classes on Monday 09:00-11:00 in Weeks 7-13.

Course Content

The course is divided into three parts: Surface Treatments, Corrosion and Corrosion Control, Advanced Chemistry of Materials:

**Part I - Surface Treatments**

- **Introduction**
  Purposes of surface treatments, types of surface treatments, selection of surface treatments, surface hardening of steel by thermal treatment

- **Surface Hardening of Steel**
  Different case hardening processes, carburising, nitriding, diffusion and equilibrium

- **Thermal Spray Coating**
  Basic theory of thermal spray, properties of thermal spray coating, applications of different thermal spray processes.

- **Coating by electrochemical/chemical methods**
  Electroplating, electrodeposition, electroless plating, anodizing, chemical conversion coatings, galvanising.

- **Physical Vapour Deposition (PVD) and Chemical Vapour Deposition (CVD)**
  Thermal evaporation, sputtering, ion implantation, advantages and disadvantages of PVD, thermal CVD, plasma CVD, thin film coating by CVD, structure building on surface by CVD.

**Part II - Corrosion and Control**

- **Introduction to corrosion**
  Importance of corrosion control, basic principles and classifications of corrosion

- **Thermodynamics of corrosion**
  Electrochemical, galvanic and electrolytic cells, standard electrode potentials, Nernst equation, Pourbaix diagrams and their constructions, applications and limitations.

- **Electrode kinetics**
  Exchange current density, polarization, electrode kinetics, Evans diagrams, combined polarization, effect of polarization on corrosion rate.

- **Passivity and pitting**
  Anodic passivation, stability of passivity and Flade potential, maintenance of passivity and breakdown of passivity.

- **Atmospheric corrosion and oxidation**
Types of atmosphere for corrosion, atmospheric corrosion of different metals, introduction to high temperature corrosion.

- **Corrosion in soil and biological corrosion**
  Corrosivity of soil, control of soil corrosion of metals, types of biological corrosion.

- **Corrosion under stress**
  Stress corrosion cracking, hydrogen embrittlement and corrosion fatigue.

**Part III- Advanced Chemistry of Materials**

- **Structure of electric double layers**
  Interfaces and interphases, electric double layers, structure of interphases, isotherms for ionic adsorption on electrodes, adsorption of molecules at interfaces.

- **More applications of Pourbaix diagrams**
  Use of Pourbaix diagram in battery science, extraction, refining and processing of metals and materials.

- **Advanced electrode kinetics and applications**
  Kinetics of interfacial charge transfer, thermal activation and activation energies of electrochemical reactions, current density/potential correlations for different limiting conditions, reaction controlled current voltage curve, electrocatalysis, electrodeposition, electroforming, electrochemical machining, electrochemical etching, electroplating, electroless plating.

- **Energy materials**
  Battery characteristics, battery specifications, evaluation of battery performance, battery components, present battery systems, batteries under development, fuel cells, other energy materials.

**Assignments**

Three assignments will be given, one for each part of the course. However in line with the tutorials, the Corrosion assignment will be divided into two sections: a. Thermodynamics, and b. Kinetics and Passivity. The issue and submission dates of the assignments are as follows:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Issue</th>
<th>Submission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignment 1a (Corrosion)</td>
<td>Week 4</td>
<td>Week 6</td>
</tr>
<tr>
<td>Assignment 2 (Surface treatment)</td>
<td>Week 5</td>
<td>Week 7</td>
</tr>
<tr>
<td>Assignment 1b (Corrosion)</td>
<td>Week 6</td>
<td>Week 8</td>
</tr>
<tr>
<td>Assignment 3 (Electrochemistry of Material)</td>
<td>Week 9</td>
<td>Week 11</td>
</tr>
<tr>
<td>Group project</td>
<td>Week 7</td>
<td>Week 12</td>
</tr>
</tbody>
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**Laboratory work**

2 corrosion labs will be planned between Weeks 3 and 10. Lab 1 can be performed by each student on their own. For lab 2 the students will be divided into groups of 5 ~ 6, depending on the number of students in the class. Details of the labs will be provided in a later stage. The lab reports will be due two weeks after each lab.

Location for second lab: Materials Science and Eng. Building Room 433B
Guidelines on report writing will be available in the Lab sheets provided during the lab.

**Submission of assignments and lab reports**
Submit hardcopy of your assignments and lab reports in the Assignment Box next to the MSE School Office (Rm 137) by the due date. Also submit electronic copy to Moodle as proof of submission. Late submission without appropriate documentation will receive a penalty of 10% per day late. Work that is more than 10 days late will not be accepted and will receive zero mark.

**Assessment**

<table>
<thead>
<tr>
<th>Assessment Task</th>
<th>Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignments 1, 2 and 3 (Each assignment = 10%)</td>
<td>30%</td>
</tr>
<tr>
<td>2 corrosion Labs (Each lab = 5%)</td>
<td>10%</td>
</tr>
<tr>
<td>Two-hour mid-term examination: The mid-term exam includes questions pertaining to the material learnt in Weeks 1-6 Held: Week 7</td>
<td>30%</td>
</tr>
<tr>
<td>Group project: A detailed review of literature on a topical area selected by the group of students based on course material Due: Week 12</td>
<td>25%</td>
</tr>
<tr>
<td>Class Topical Presentation: A 7-10 minute oral presentation given to the class based on the group’s project Held: Week 12</td>
<td>5%</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
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**NOTE:** Students who fail to achieve a score of at least 40% for the mid-session exam, but achieve a final mark >50% for the course, will be awarded a UF (Unsatisfactory Fail) for the course.

Please refer to the UNSW guide to grades:  [https://student.unsw.edu.au/grades](https://student.unsw.edu.au/grades)

**Recommended Reference Materials**
Some recommended reference material will be provided during class and electronic copies uploaded to blackboard. Text books available from the UNSW library which provide good information are listed below.

**Textbooks**

**References**
- M.G. Fontana *Corrosion Engineering*, McGrew Hill
- K.R. Trethewey and J Chamberlain, Corrosion -- for students of Science and Engineering, Longman
- J.M. West, E. Horwood *Basic Corrosion and Oxidation*, John Wiley & Sons
• U.R. Evans, An Introduction to Metallic Corrosion, Edward Arnold

**Learning and Teaching Philosophy Underpinning the Course**

(based on UNSW Learning Guidelines)

- **Students are actively engaged in the learning process.**
  
  It is expected that, in addition to attending classes, students will read, write, discuss, and engage 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.

**Course Information**

<table>
<thead>
<tr>
<th>Units of credit</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel teaching involved in this course</td>
<td>Yes</td>
</tr>
<tr>
<td>How the course relates to other course offerings and overall program(s) in the discipline</td>
<td>Course applies chemical, physical and mechanical property concepts to a practical situation. The course will require some basic knowledge of materials science, chemistry and electrochemistry. Courses such as General Chemistry, Design and Application of Materials Science and Engineering,</td>
</tr>
</tbody>
</table>
Mechanical Properties of Materials, Physical Metallurgy are useful for this subject. This course is also related to Process Metallurgy, Fracture Mechanics and Fractographic Analysis.

Course aims
To learn the science and engineering of the fields of surface engineering, corrosion and advanced electrochemical properties of materials. The course deals principally with different types of surface treatments and corrosion, emphasizing the interaction between different materials and environments. Theories and applications of corrosion control will be presented and discussed. The course also aims for students to study the application of electrochemistry to materials technology.

Graduate attributes which will be gained through the course
- Research, inquiry and analytical thinking abilities.
- Capability and motivation for intellectual development.
- Ability to work in groups and effective communication.
- Information literacy.

Expected learning outcomes
Students should gain the ability to:
- Understand the theories of different surface treatment processes and the properties of surfaces produced
- Employ surface treatment processes professionally in engineering applications
- Understand the relationships between materials, microstructures and environments on corrosion behaviour of metals.
- Select materials for stopping or prevent corrosion from happening.
- Apply of different methods for corrosion prevention.
- Understand advanced electrochemistry and its applications in materials technology.

1 Based on the professional attributes given in Engineers Australia National Generic Competency Standards - Stage 1 Competency Standard for Professional Engineers and UNSW Graduate Attributes.

Academic Honesty and Plagiarism

What is Plagiarism?
All details regarding plagiarism can be found here: https://student.unsw.edu.au/plagiarism
It is important to understand what plagiarism is. The general concept is plagiarism is using the words or ideas of others and passing them off as your own. Examples of plagiarism, including self-plagiarism, are:

- **Copying**
  Using the same or very similar words to the original text or idea without acknowledging the source or using quotation marks. This includes copying materials, ideas or concepts from a book, article, report or other written document, presentation, composition, artwork, design, drawing, circuitry, computer program or software, website, internet, other electronic resource, or another person’s assignment, without appropriate acknowledgement.

- **Inappropriate paraphrasing**
  Changing a few words and phrases while mostly retaining the original structure and/or progression of ideas of the original, and information without acknowledgement.
This also applies in presentations where someone paraphrases another’s ideas or words without credit and to piecing together quotes and paraphrases into a new whole, without appropriate referencing.

- **Collusion**
  Presenting work as independent work when it has been produced in whole or part in collusion with other people. Collusion includes,
  - students providing their work to another student before the due date, or for the purpose of them plagiarising at any time
  - paying another person to perform an academic task and passing it off as your own
  - stealing or acquiring another person’s academic work and copying it
  - offering to complete another person’s work or seeking payment for completing academic work.

  This should not be confused with academic collaboration.

- **Inappropriate citation**
  Citing sources which have not been read, without acknowledging the 'secondary' source from which knowledge of them has been obtained.

- **Self-plagiarism**
  ‘Self-plagiarism’ occurs where an author republishes their own previously written work and presents it as new findings without referencing the earlier work, either in its entirety or partially.

  Self-plagiarism is also referred to as 'recycling', 'duplication', or 'multiple submissions of research findings' without disclosure. In the student context, self-plagiarism includes re-using parts of, or all of, a body of work that has already been submitted for assessment without proper citation.

  The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:
  - correct referencing practices;
  - paraphrasing, summarising, essay writing, and time management;
  - appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.

  Individual assistance is available on request from The Learning Centre.

  Students are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting, and the proper referencing of sources in preparing all assessment items.

**Continual Course Improvement**

- At the end of the course, students will be asked to provide evaluative feedback through myExperience, the University’s course and teaching evaluation and improvement process
- Students are encouraged to address any problems regarding teaching of this course at the annual staff-student meeting
- Student comments on teaching during the session are welcome and will be appreciated
- At times students may be asked to answer a short questionnaire for feedback on the course
Administrative Matters

- Students should attend at least 80% of all classes.
- Students unable to submit assignments on time or attend the mid-session quizzes or final exams on health grounds should make a request for special consideration. 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.
- Assignments/lab reports submitted after the due date for submission will receive a 10% of maximum grade penalty for every day late, or part thereof.
- 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.

Rules for Exams

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