APS104S **INTRODUCTION TO MATERIALS & CHEMISTRY** **Jan-Apr 2015**

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INSTRUCTORS

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LECTURE SCHEDULE (for room location/description see http://www.osm.utoronto.ca)

For p- o-da e cla room informa ion, ee: http://www.apsc.utoronto.ca/timetable/winter.html

Section	Lecture	Day & Time	Room	Instructors
LEC 01	1 2 3	Mon 10:00 11:00 Tue 11:00 12:00 Thu 10:00 11:00	BA1190	G. Azimi
LEC 02	1 2 3	Mon 10:00 11:00 Tue 11:00 12:00 Thu 10:00 11:00	MC254	C. Chin
LEC 03	1 2 3	Mon 10:00 11:00 Tue 11:00 12:00 Thu 10:00 11:00	BA1180	T. Mirkovic
LEC 04	1 2 3	Mon 11:00 12:00 Wed 11:00 12:00 Thu 11:00 12:00	MC252 MC252 BA1160	J. Nogami

GRADING

1. **Lectures and Tutorial Problem Sets** 15%
2. **Labs** 8%
3. **Term Tests** (1.5 h, 2 term tests) 37%
   Test 1: Tues Feb 10, 2015 - from 12 to 2pm
   Test 2: Tues Mar 17, 2015 - from 12 to 2pm
4. **Final Exam:** (2.5 hr, numerical problems & concepts, Type B exam <u>40%</u>

<u>100 %</u>

RECOMMENDED TEXTBOOKS (available at the UofT Bookstore (College & St.George)) & Eng Bookstore

This course has 2 recommended texts owing to the curriculum consisting of fundamentals and applications of materials science and thermodynamics.

1. "CUSTOM INTRODUCTION TO THERMODYNAMICS Edition 4".
   Package ISBN 10: 1269711830;
   Package ISBN 13: 9781269711838; Suggested list price: 72.95
   Selected chapters from "Physical Chemistry", 3rd Edition, Engel and Reid, Pearson.
   This package contains the following components:
   Introduction to Thermodynamics - 1256948624
   Custom e-book plus chemplace website - 1269640992

2. Introduction to Materials Science
   Selected chapters from "Fundamentals of Materials Science & Engineering: An Integrated Approach", 4th Edition, Callister and Rethwisch, John Wiley & Sons.

   There are two options:
   a) Custom text - $70.95 - 9781118888230
   b) Full e-text - $71.95 9781118297759 – Digital CEI

REFERENCE TEXTS

Fundamentals of Materials Science and Engineering: An Integrated Approach, 4e
William D. Callister, David G. Rethwisch

Materials Science and Engineering: An Introduction, 8th Edition
William D. Callister, David G. Rethwisch

Crystals and Crystal Structures
Richard J. D. Tilley

Electronic Properties of Engineering Materials
James D. Livingston

Foundations of Materials Science and Engineering, 4th Edition
William F. Smith, Javad Hashemi

Materials in Today's World, 2nd Edition
Peter Thrower

Physical Chemistry, 2nd Edition
Thomas Engel, Philip Reid

Physical Chemistry, 4th Edition
Robert J. Silbey, Robert A. Alberty, Moungi G. Bawendi

Physical Chemistry, 6th Edition,
Ira N. Levine

TUTORIAL SCHEDULE

1. The tutorials will commence the week of January 12th 2015. There will be no tutorials during the first week of classes.
2. each Tutorial, there will be a Tutorial Problem Set. The TA will go over the solutions to some of the problems, but one or more problems will be assigned to the students for solution during the last 15 minutes of each session. (open book), and submit each Tutorial Problem Set (which will be marked by the TAs). The marked problems will be returned the following week at the end of the tutorial.
3. Students must bring their text book(s) with them for the open book Tutorial Problem Set. (A Formula Sheet will not be provided.)
4. Each tutorial will be 50m minutes in length.
5. There will also be no tutorials during Reading Week or during the week of March 30 – April 3
6. For the tutorials during the weeks of Feb 9-13 and March 16-20 (i.e. the weeks with the two midterm exams) there will be tutorials, but no marked problems.

Tutorial Program

1. All students are required to attend their respective tutorial sections, no exceptions. Do Not Switch Tutorial Sections!
2. All students are expected to solve the assigned problems **prior** to coming to the tutorials. Reading through the additional specified review problems is also recommended.
3. During each weekly tutorial, the TAs will handout a Tutorial Problem Set that students are required to solve and hand-in at the end of the tutorial hour. The TAs will only assist by answering conceptual questions and providing hints as appropriate. Students are more than welcome to discuss with TAs, but should not completely rely on TAs to help solve the Problem Set.
4. Students will work individually and each student will submit a Tutorial Problem Set for marking. Textbook and any handouts are allowed during the tutorial section.
5. In order to succeed in this course, solving the assigned problems and attending the tutorials is essential. Practicing to solve as many problems as possible is the key to success.

Tutorial Sections

Section	Day	Start	Finish	Room	TA
TUT 01	Fri	13:00	14:00	BA2185	Ayman Elzoka
TUT 02	Fri	13:00	14:00	BA1230	Yujin Kim
TUT 03	Fri	13:00	14:00	WB130	David Lynall
TUT 04	Fri	13:00	14:00	BA2165	Hui-Lin Hsu
TUT 05	Fri	13:00	14:00	BA1210	Ivan Matijevic
TUT 06	Fri	13:00	14:00	BA2175	David Wisniewski
TUT 07	Tue	14:00	15:00	BA2175	David Lynall
TUT 08	Tue	14:00	15:00	BA2185	Ayman Elzoka
TUT 09	Tue	14:00	15:00	BA2195	David Wisniewski
TUT 10	Tue	14:00	15:00	BA2145	Ivan Matijevic
TUT 11	Tue	14:00	15:00	BA2155	Yujin Kim
TUT 12	Tue	14:00	15:00	BA2165	Hui-Lin Hsu

LAB SCHEDULE

Up to four experimental labs will be given in this course.

- All labs will be scheduled for Tuesdays 18:00 – 20:00
- The first possible lab date will be Jan 27, 2015
- The four labs are as follows:
  - **Lab 1:** *Cr   allograph*
  - **Lab 2:** *Mechanical Proper ie   of Ma erial*
  - **Lab 3:** *Thermod namic*
  - **Lab 4:** *Energ*

- The labs occur on alternative weeks. Please note "meeting" dates for your Practical Section.
- tentative dates as follows:

Section	Day	Start	Finish	Room	TA	Meets:
PRA 01	Tue	18:00	20:00	HA403	Camila Londono	
PRA 03	Tue	18:00	20:00	GB404	Haiting Cai	Jan 27
PRA 05	Tue	18:00	20:00	GB304	Jianhuai (Jackie) Ye	Feb 10
PRA 07	Tue	18:00	20:00	GB412	Nafees Rahman	Mar 3
PRA 09	Tue	18:00	20:00	SF3201	Nathan Hilker	Mar 24
PRA 11	Tue	18:00	20:00	GB405	Bo Xing	
PRA 02	Tue	18:00	20:00	HA403	Jianhuai (Jackie) Ye	
PRA 04	Tue	18:00	20:00	GB404	Haiting Cai	Feb 3
PRA 06	Tue	18:00	20:00	GB304	Nathan Hilker	Feb 24
PRA 8	Tue	18:00	20:00	GB412	Nafees Rahman	Mar 10
PRA 10	Tue	18:00	20:00	SF3201	Camila Londono	Mar 31
PRA 12	Tue	18:00	20:00	GB405	Bo Xing	

2015 CALENDAR

Sessional Dates of Note

January 2015

S	M	T	W	T	F	S
28	29	30	31	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
1	2	3	4	5	6	7

- Lectures commence Monday January 5th
- Tutorials commence week of January 12th
- Lab 1 – PRA 01 -06 : Tuesday January 27th

February 2015

S	M	T	W	T	F	S
25	26	27	28	29	30	31
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

- Lab 1 – PRA 07 -12 : Tuesday February 3rd
- Term Test 1: Tuesday February 10th, 12:00-14:00 (no tutorials this week)
- Lab 2 – PRA 01 – 06 : Tuesday February 10th
- Family Day: Monday February 16th
- Reading Week: Tuesday Feb 17th to Friday Feb 20th
- Lab 2 – PRA 07 – 12 : Tuesday February 24th

March 2015

S	M	T	W	T	F	S
22	23	24	25	26	27	28
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	1	2	3	4

- Lab 3 – PRA 01 – 06 : Tuesday March 3rd
- Lab 3 – PRA 07 – 12 : Tuesday March 10th
- Lab 4 – PRA 01 – 06 : Tuesday March 24th
- Term Test 2: Tuesday March 17th, 12:00-14:00 (no tutorials this week)
- No Tutorials: week of March 30 – April 3

April 2015

S	M	T	W	T	F	S
29	30	31	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	1	2
3	4	5	6	7	8	9

- Lab 4 – PRA 07 -12 : Tuesday March 30th
- Last Day for Lectures: Thursday April 9th

SYLLABUS SUMMARY

This is an introductory undergraduate course presenting the fundamentals of materials and chemistry. In addition to the material covered in the lectures, students are required to completely study (read and understand) the identified sections/chapters from the recommended course textbooks and any additional handouts, as well as to solve corresponding/assigned problems.

Since much of the course will be self-taught, it is important that you be conscientious in pacing your studies. A breakdown of the main topics of the course and relevant tips are provided below.

Module	Topics	Chapter Titles
I.	MATTER	
	Atomic Theory & Bonding	1. Atomic Structure and Interatomic Bonding (Ch 2, Callister)
	Crystal Structure in Condensed Matter	2. Structures of Metals and Ceramics (Ch 3, Callister) 3. Polymer Structures (Ch 4, Callister)
	Mechanical Properties of Solids	4. Imperfections in Solids (Ch 5, Callister) 5. Mechanical Properties (Ch 7, Callister) 6. Deformation & Strengthening Mechanisms (Ch 8, Callister)
II.	ENERGY AND MATTER	
	Molecular Theory of Gases	7. Fundamental Concepts of Thermodynamics (Ch 1, Ch 7 Engel&Reid)
	Energy and Matter	8. Heat, Work, Internal Energy, Enthalpy, and the First Law of Thermodyamics (Ch2, Engel&Reid) 9. Thermochemistry (Ch4, Engel&Reid) 10. Phase Diagrams (Ch8, Engel&Reid; Ch10, Callister)
	Energy Transformation and Directionality	11. Entropy and the Second and Third Laws of Thermodynamics (Ch5, Engel&Reid) 12. Chemical Equilibrium (Ch6, Engel&Reid)
III.	APPLICATIONS	
	Electrical Properties and Applications	13. Electrical Properties (Ch12, Callister)
	Magnetic Properties and Applications	14. Magnetic Properties (Ch 18, Callister)
	Electrochemistry and Applications	15. Electrochemical Cells, Batteries, and Fuel Cells (Ch 11, Engel&Reid)

STUDY POINTERS

Studying

Effective studying consists of taking lecture notes, active reading of the primary reading material, tutorial attendance and note taking, and solving various exercises on your own. Begin studying your lecture notes by reviewing the lecture outlines. Ask yourself questions about the material; for example, ask yourself to provide definitions, to summarize the purpose, method and results of studies.

Read the chapter "in chunks". The size of these chunks should be determined by natural breaks in the text, and by your ability to assimilate the material being read. Make brief notes in the margins of the text as necessary. It is inadvisable to make extensive notes from the textbook. However, it is helpful to make one- or two-page summary notes per chapter showing the major headings and key concepts.

Note-Taking in Lectures

If you can, read all the relevant text material before attending the lectures on a given topic. Much of learning involves discovering how new information relates to knowledge you already possess. The more you know about a particular subject the easier it is to use new information to expand your current knowledge basis. If you read the relevant text chapters before you attend the lectures on a particular topic, you will learn more from the lectures and you will be able to take better notes. Your familiarity with the key concepts and major theories in a specific area will help you judge what is important in a lecture. Review your lecture notes soon after each lecture and proceed to read and study the required text.

Problems

- Solving assigned problems is absolutely essential in developing a complete understanding of the concepts introduced in the lectures and corresponding chapters/sections.
- The term tests and final exam are largely based on the assigned problems as well as conceptual/definition type questions to test your grasp of the subject matter.
- Please take advantage of the tutorials to clarify issues you do not understand. Do this as questions arise rather than wait until just before a test or exam. Ask specific questions on **how** to solve a given problem, rather than “What is the answer to question 5?”

DETAILED LECTURE SCHEDULE

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	LECTURE	TOPICS	New Editions HOMEWORK QUESTIONS	Old Editions HOMEWORK QUESTIONS	Tutorial Material*
	Lecture 1	**Introduction**			Topics to be covered in **Tutorial 1** (Tutorials commence week of Jan 12th)
	Lecture 2	**Atomic Theory and Bonding** Chapter 2 (Callister) " Atomic Bonding in Solids"			
	Lecture 3	2.5 – 2.8 (Forces and energies)	2.14, 2.16, 2.21	2.9, 2.10, 2.13	
	Lecture 4	**Crystal Structure in Condensed Matter** Chapter 3 (Callister) "Crystal Structures" 3.4, 3.5 (Metallic)	3.5, 3.7, 3.14	3.2, 3.3, 3.7	Tut 2
	Lecture 5	3.6, 3.7 (Ceramic; Densities)	3.24, 3.26, 3.34	3.12, 3.13, 3.17	
	Lecture 6	3.9, 3.13 (Carbon; Directions)	3.40, 3.52, 3.55	3.20, 3.27, 3.29	
	Lecture 7	3.14, 3.15 (Planes and densities)	3.62, 3.63, 3.78	3.35, 3.36, 3.44	Tut 3
	Lecture 8	Chapter 4 (Callister) "Polymer Structures" 4.4 – 4.7; qualitative 4.11, 4.12	4.4, 4.5, 4.9	4.2, 4.4, 4.5	
	Lecture 9	**Mechanical Properties of Solids** Chapter 5 (Callister) "Imperfections in Solids" 5.2 – 5.4, 5.7, 5.8	5.7, 5.11, 5.13	5.4, 5.5, 5.6	
	Lecture 10	Chapter 7 (Callister) "Mechanical Properties" 7.1 – 7.4 (Basic concepts)	7.7, 7.8, 7.14	7.4, 7.5, 7.7	Tut 4
	Lecture 11	7.5, 7.6 (Elastic and tensile)	7.16, 7.20, 7.29	7.8, 7.10, 7.15	
	Lecture 12	7.10 – 7.12 (Ceramics)	7.51, 7.57	7.25, 7.28	
	Lecture 13	7.13 – 7.15 (Polymers)	7.59, 7.66	7.29, 7.32	Tut 5
	Lecture 14	Chapter 8 (Callister) "Deformation/Strengthening" 8.3 – 8.6 (Dislocations)	8.7, 8.13, 8.18	8.4, 8.7, 8.9	
	Lecture 15	8.7, 8.9 – 8.11 (Strengthening)	8.23, 8.28, 8.32	8.12, 8.14, 8.16	
	Lecture 16	**Molecular Theory of Gases** Chapter 1 (Engel & Reid) "Fundamental Concepts of Thermodynamics" Introduction, systems (closed, open, isolated), variables (T,P,V), zeroth law (1.2)	Q 1.4, 1.7	Q1.6, 1.7, 1.9	Tut 6
	Lecture 17	Ideal gas, equations of state, absolute zero (1.4)	P 1.1, 1.2, 1.7, 1.10, 1.16, 1.21, 1.29, 1.33	P1.1, 1.2, 1.7, 1.10, 1.16, 1.21, 1.22, 1.29, 1.33	

	Lecture 18	Ideal gas mixtures, density, Real gases, (1.5, 7.2., 7.3)	Q1.3, 7.16, 7.18 P1.4, 1.5, 1.12, 1.17, 1.18, 1.26, 1.27	Q1.3, P1.4, 1.5, 1.12, 1.17, 1.18 1.26, 1.27	
	Lecture 19	**Energy and Matter** Chapter 2 & 3 (Engel & Reid)j "Heat, Work, Internal Energy, Enthalpy, and the First Law of Thermodynamics" Definition of heat and work, Definition of internal energy, First law (2.1-2.3)	Q 2.1, 2.9, 2.11, 2.13 P 2.10, 2.36, 2.39	Q2.1, 2.9, 2.11, 2.13, 2.10, 2.36, 2.39	Tut 7
	Lecture 20	Heat capacities (Cp and Cv), state functions, (2.4-2.5)	Q 2.5, 2.14 P 2.4, 2.5, 2.13, 2.25, 2.31, 2.34	Q2.5, 2.14, P2.4, 2.5, 2.13, 2.25, 2.31, 2.34	
	Lecture 21	Equilibrium, reversible and irreversible work, Reversible adiabatic expansion (2.6, 2.7, 2.10)	Q 2.10, 2.15 P 2.1, 2.6, 2.8, 2.11, 2.14, 2.15, 2.17, 2.18, 2.32	Q2.10, 2.15, P2.1, 2.6, 2.8, 2.11, 2.14, 2.15, 2.17, 2.18, 2.32	
	Lecture 22	Enthalpy and relation to internal energy and heat capacity (2.8-2.9 and 3.2-3.6)	Q 3.2 P 2.2, 2.3, 2.7, 2.12, 2.16, 2.20, 2.21, 2.23, 2.26, 2.27, 2.28, 2.30, 2.37, 2.38, 2.43 P 3.3, 3.5, 3.8, 3.12	Q3.2, P2.2, 2.3, 2.7, 2.9, 2.12, 2.16, 2.20, 2.21, 2.23, 2.26, 2.27, 2.28, 2.30, 2.37,2.38, 2.43, 3.3, 3.5, 3.8, 3.12	Tut 8
	Lecture 23	Chapter 4 (Engel & Reid) Enthalpy and chemical reactions, Hess's law (4.1-4.4)	Q 4.6, 4.10, 4.15, 4.17, P 4.1, 4.2, 4.4, 4.5, 4.7, 4.8, 4.9, 4.11, 4.12, 4.16, 4.17, 4.19, 4.23, 4.24, 4.26, 4.27, 4.28, 4.30, 4.31, 4.33	Q4.3, 4.6, 4.7, 4.10, P4.1, 4.2, 4.4, 4.5, 4.7,4.8, 4.9, 4.11, 4.12, 4.16, 4.17, 4.19, 4.23, 4.24, 4.26, 4.27, 4.28, 4.30, 4.31, 4.33	
	Lecture 24	**Energy Transformation and Directionality** Chapter 5 (Engel & Reid) "Entropy and the Second and Third Laws of Thermodynamics" Directionality in natural processes, second law of thermodynamics (5.1-5.2)	Q 5.2, 5.4, 5.9, 5.10, 5.18	Q5.2, 5.3, 5.7, 5.8, 5.14	
	Lecture 25	Entropy (S), relation between S, q, w and T; entropy equations (5.3-5.6)	P 5.6, 5.17, 5.19, 5.22, 5.23, 5.26, 5.29	5.6, 5.17, 5.19,5.22, 5.23,5.26, 5.29	Tut 9
	Lecture 26	…cont'd Entropy (S), relation between S, q, w and T; entropy equations (5.3-5.6)	5.35, 5.36, 5.40, 5.42, 5.43	5.32, 5.34,5.35,5.37, 5.41, 5.43,5.44	
	Lecture 27	Chapter 6 (Engel & Reid) "Chemical Equilibrium" Free energy, and relationships between thermodynamic properties	Q 6.3, 6.4, 6.7, 6.10 P 6.2, 6.6, 6.8, 6.10, 6.11, 6.18, 6.31, 6.32, 6.36	Q3, 4, 7, 10 P2, 6, 8, 10, 11, 18, 31, 32, 36	
	Lecture 28	Gibbs free energy changes in chemical reactions.			Tut 10
	Lecture 29	Chemical potential and equilibrium			

	Lecture 30	Chapter 8 (Engel & Reid) Phase Diagrams of Pure Substances 8.1-8.4, 8.9	Q8.2, P8.5, 8.9, 8.15		
	Lecture 31	Chapter 10 (Callister) "Phase Diagrams" 10.1 – 10.7 (Basic concepts)	10.1, 10.5, 10.12	10.1, 10.3, 10.7	Tut 11
	Lecture 32	10.8, 10.11, 10.12 (Diagram types)	10.19, 10.28, 10.35	10.11, 10.16, 10.20	
	Lecture 33	10.13 – 10.16 (Transformations)	10.39, 10.40, 10.44	10.22, 10.23, 10.25	
	Lecture 34	**Applications** Chapter 11 (Engel & Reid) "Electrochemical Cells, Batteries, and Fuel Cells" 11.1, 11.2, 11.9, 11.3, 11.4	Q 11.4 P 11.1, 11.3, 11.6, 11.11, 11.14, 11.23	Q4 P1, 3, 6, 11, 14, 23	
	Lecture 35	11.5, 11.6, 11.7, 11.10			
	Lecture 36	11.11, 11.12, 11.13			
	Lecture 37	Chapter 12 (Callister) "Electrical Properties" 12.1 – 12.5	12.1, 12.5, 12.7	12.1, 12.3, 12.4	
	Lecture 38	12.6 – 12.9	12.12, 12.14, 12.16	12.6, 12.7, 12.8	
	Lecture 39	Chapter 18 (Callister) "Magnetic Properties" 18.1 – 18.5 *Time Permi ing:* 18.6 – 18.8, 18.9 – 18.12	18.1, 18.4, 18.6 18.16, 18.17, 18.26; 18.28, 18.29, 18.32	18.1, 18.2, 18.3 18.8, 18.11, 18.14; 18.15, 18.16, 18.17	

*The tutorial bracketing indicates the topics scheduled to be covered in the respective tutorials.