Covered on Quiz #	Covered on P Set #	Covered on Test	Week	Section Title	Concept area	Topic Titles	Learning Objectives	Additional Notes
			January 13, 2025	1. Welcome to the course	1. Introduction and Overview	Welcome to the course	- Recall the course instructors - Locate the contact information for the course staff - Identify where to find course learning resources - Locate the course syllabus, including mark breakdown - Summarize the outline for this course	
				1. Welcome to the course	1. Introduction and Overview 2. Categorization of matter	The three material classes	- Name the three major material classes (Metals, ceramics, and polymers) - Give examples of at least two materials in each class - Elaborate on the shortcomings of this classification scheme - Defend the benefits of this classification scheme	
				2. Elastic behaviour: not only rubber bands	Mechanical Behaviour of Matter	Hooke's Law	- Define Hooke's law, engineering stress, and engineering strain - Explain how elastic stress and strain are related through Hooke's law	
				2. Elastic behaviour: not only rubber bands	Mechanical Behaviour of Matter	Engineering stress and engineering strain	- Explain how stress, and strain are sample size independent, while force and displacement are not	
				2. Elastic behaviour: not only rubber bands	Mechanical Behaviour of Matter	The tensile test	- Describe the conventional uniaxial tensile test - Identify and explain the following on a typical "dog-bone" tensile specimen: reduced section, gauge length, cross sectional area, grip region	
			January 20, 2025	2. Elastic behaviour: not only rubber bands	Mechanical Behaviour of Matter	Elastic Behaviour	- Describe elastic deformation in terms of macroscopic behaviour as well as in terms of atomic positions - Sketch a generalized interatomic force-vs.-separation curve for two atoms in a solid - Using the interatomic force-separation curve, describe how the Young's Modulus is a structure independant property	
				2. Elastic behaviour: not only rubber bands	Mechanical Behaviour of Matter	But what is modulus, really?	- Predict, given Young's modulus, the strain resulting from a given applied elastic stress, or vice-versa - Differentiate between strength, stiffness, strain, and Young's modulus - Calculate engineering stress and engineering strain - Illustrate how Young's modulus is a structure independant property	
				3. Behaviour that's not elastic	Scientific Thinking	The concept of a scientific model	- Justify the statement that a scientific model need only be as good as it needs to be for the present discussion - Using two examples from the fields of materials science or solid state chemistry, demonstrate the usefulness and the limitations of a scientific model	
				3. Behaviour that's not elastic	Mechanical Behaviour of Matter	Plastic Deformation	- Contrast plastic deformation with elastic deformation - Provide at least one atomic level definition of plastic deformation and one macroscopic definition - Explain why the term "plastic" is used to refer to permanent deformation - Sketch generalized curves for the stress-strain behaviour of metals, ceramics, and polymers	
				3. Behaviour that's not elastic	Mechanical Behaviour of Matter	Mechanical Behaviour of Ceramics	- Contrast the mechanical behaviour of ceramics with that of metals and polymers	
			January 27, 2025	3. Behaviour that's not elastic	Mechanical Behaviour of Matter	The three-point bend test	- Summarize the need to test ceramics in bending, rather than in a tensile test - Given all of the others, calculate any one of the following for a 3-point bend test on a rectangular sample: sample height and width, span between lower supports, load, peak stress in sample	
				3. Behaviour that's not elastic	Non-crystalline solids	Glasses - tempered glass: thermally and chemically (ex. Gorilla Glass)	- Describe the general theory behind tempered glass, whether thermally or chemically tempered - Illustrate the final stress distribution through the thickness of a sheet of tempered glass - Explain how residual stresses increase the strength and improve the safety of tempered glass	
				4. A healthy relationship: the structure-property relationship	Properties of Matter	Charts of material properties	- Generalize the relative positions on a logarithmic plot of strength versus density and Young's modulus versus density of several metals, ceramics, and polymers - Identify the region on a plot of Young's modulus versus density where we would like to develop new materials for many applications such as aerospace - OPTIONAL: Demonstrate, given the derivation, how the Materials Perfomance Index for a light stiff beam is determined to be E^(1/2)/"rho"	You may wish to refer to this ebook, availble through the U of T library:http://www.sciencedirect.com.myaccess.library.utoronto.ca/science/article/pii/B9781856174978500155
				4. A healthy relationship: the structure-property relationship	Properties of Matter	The density of solids and an introduction to mictrostructure	- Define the dimensions of density, and name commonly used units - Show how knowledge of a material's crystal structure can be used to calculate the theoretical density	
				4. A healthy relationship: the structure-property relationship	Structure of Matter	Ordered solids, short range and long range order	- Compare and contrast long-range and short range order and no order - Recall several examples of ordered solids in each of the three material classes (metals, ceramics, and polymers) - Illustrate how the macroscopic features or behaviour of a crystal may be representative of features of the atomic arrangement	

February 3, 2025	4. A healthy relationship: the structure-property relationship	Structure of Matter	The face centered cubic crystal structure and the theoretical density of metals	- Using the face centred cubic crystal structure, illustrate how the theoretical density of a polycrystalline metal can be calculated from knowledge of the crystal structure, atomic radius, and atomic weight - Calculate the theoretical density of an FCC metal given the atomic weight, crystal structure and atomic radius - Demonstrate that the coordination number for FCC is 12 - Show that the atomic packing factor (APF) for FCC is 0.74	
	5. I need more structure in my life.	Structure of Matter	The rock salt crystal structure and the theoretical density of ceramics	- Calculate the theoretical density of a rock salt type ceramic given the atomic weights, and atomic radii	
	5. I need more structure in my life.	Structure of Matter	The Body centred cubic crystal structure	- Calculate the theoretical density of a BCC metal given the atomic weight, crystal structure and atomic radius - Demonstrate that the coordination number for BCC is 8 - Show that the atomic packing factor (APF) for BCC is 0.68	
	5. I need more structure in my life.	Structure of Matter	Interstitial Sites	- Calculate the geometrically ideal interstitial site size for the following interstitial sites: octahedral, simple cubic	
	5. I need more structure in my life.	Structure of Matter	The hexagonal close packed crystal structure and the stacking of close packed planes	- Using the hexagonal close packed crystal structure, illustrate how the theoretical density of a polycrystalline metal can be calculated from knowledge of the crystal structure, atomic radius, and atomic weight - Calculate the theoretical density of an HCP metal given the atomic weight, crystal structure and atomic radius - Demonstrate that the coordination number for HCP is 12 - Show that the atomic packing factor (APF) for FCC is 0.74 - Demonstrate how the FCC and HCP crystal structures may be formed from stacking close packed planes in an ABCABC or an ABAB pattern	
February 10, 2025	6. Getting more technical with metal behaviour	Properties of Matter	Mechanical Behaviour of Metals	- Identify on the stress-strain curve for a typical metal the following points or regions: proportional limit, yield strength, ultimate tensile strength, fracture strength, linear elastic region - Explain the rationale for the use of the 0.2% offset yield strength	
	6. Getting more technical with metal behaviour	Properties of Matter	Uniform and non-uniform deformation in metals	- Identify on the stress-strain curve for a typical metal the following points or regions: uniform elastic deformation, uniform plastic deformation, non-uniform plastic deformation, onset of necking - Explain why the engineering stress decreases following the onset of necking - Compare and contrast uniform and non-uniform deformation	
	6. Getting more technical with metal behaviour	Deformation of Matter	Mechanism for permanent deformation in metals	- Demonstrate how plastic deformation in metals occurs through the movement of linear crystalline defects - Compare and contrast between elastic and plastic deformation in terms of the movement of atoms in a lattice - Show how knowledge of the mechanism of plastic deformation allows understanding of strengthening mechanisms	
	7. Meddling with matter	Structure of Matter	Imperfections in solids: 0-Dimensional (Point defects)	-Organize crystalline defects according to their dimensionality, that is, zero-dimensional, one-dimensional, two-dimensional, and three-dimensional - Explain how 0-dimensional imperfections occur and how some can increase strength of a metal - Provide several examples of 0-dimensional imperfections - Demonstrate how the vacancy population in a metal changes as a function of temperature	
	7. Meddling with matter	Thermodynamics	The Boltzmann Distribution	- Demonstrate how the distribution of particles over available energy states is characterized by the Boltzmann distribution - Show how changes in temperature are reflected in changes in the Boltzmann distribution	http://www.veryshortintroductions.com.myaccess.library.utoronto.ca/view/10.1093/actrade/9780199572199.001.0001/actrade-9780199572199-chapter-1
February 17, 2025	7. Meddling with matter	Structure of Matter	Imperfections in solids: 1-Dimensional (Linear defects)	-Organize crystalline defects according to their dimensionality, that is, zero-dimensional, one-dimensional, two-dimensional, and three-dimensional - Explain how 1-dimensional imperfections can increase strength of a metal - Describe how the number of linear imperfections can be increased in a metal	
	7. Meddling with matter	Structure of Matter	Imperfections in solids: 2-Dimensional (Interfactial defects)	-Organize crystalline defects according to their dimensionality, that is, zero-dimensional, one-dimensional, two-dimensional, and three-dimensional - Explain how 2-dimensional imperfections can increase the strength of a metal - Provide several examples of 2-dimensional imperfections in metals	
	7. Meddling with matter	Structure of Matter	Imperfections in solids: 3-Dimensional (Volume defects)	-Organize crystalline defects according to their dimensionality, that is, zero-dimensional, one-dimensional, two-dimensional, and three-dimensional - Explain how 3-dimensional imperfections can increase the strength of a metal - Provide several examples of 3-dimensional imperfections in metals - Summarize the four major strengthening mechanisms in metals	
	8. If plastics are polymers, are all polymers plastic?	Properties of Matter	Mechanical Behaviour of Polymers	Represent the structure of a polymer using the model of a collection of strings Apply the string model of polymer structure to explain strengthening of polymers via chain orientation Define the yield strength and tensile strength on the tensile stress-strain curve of a typical polymer	

Date	Module	Topic	Subtopic	Learning objectives
February 24, 2025	8. If plastics are polymers, are all polymers plastic?	Structure of Matter	Mer units as the building blocks of polymers	Explain the mer unit as the logical building block for understanding polymer structure Recognize or draw and rationalize the relative mechanical behaviour, resistance to chemical dissolution, and softening behaviour upon heating of the following mer units: polyethylene, polypropylene, polyvinylchloride, polytetrafluoroethylene, and polymethylmethacrylate
	8. If plastics are polymers, are all polymers plastic?	Deformation of Matter	Strengthening of polymers by changing molecular weight, cross-linking, and mer chemistry	- Use molecular weight as a means of describing the average length of polymer molecules - Compare the number average molecular weight to the weight average molecular weight and explain the importance of each - Determine both the number average molecular weight and the weight average molecular weight of a polymer sample, provided with the molecular weight distribution data - Recognize the mechanistic similarities between melting, plastic deformation, and chemical dissolution
	8. If plastics are polymers, are all polymers plastic?	Deformation of Matter	Strengthening of Polymers by engineering the crystallinity	Differentiate between and infer the property implications of the following microstructural features of polymers: crystallinity, chain length, branching, and extent of cross-linking
	8. If plastics are polymers, are all polymers plastic?	Structure of Matter	Electric dipoles and the secondary bond	Show how differences in electronegativity between atoms in a molecule can create electric dipoles, which in turn can allow secondary bonding
	8. If plastics are polymers, are all polymers plastic?	Properties of Polymers	The influence of time and temperature	Describe the changes in elastic constant and strength for polymers accompanying changes in temperature close to room temperature Explain the changes in mechanical behaviour of polymers with small changes in temperature close to room temperature in terms of the relative magnitudes of the thermal energy and the bond energies
March 3, 2025	8. If plastics are polymers, are all polymers plastic?	Properties of Polymers	Relaxation modulus	Differentiate between the glass transition temperature and the melting temperature of a polymer using an explanation based on microstructure
	8. If plastics are polymers, are all polymers plastic?	Optical Properties of Matter	Optical transparency of Plexiglas(R)	Criticize the shortcomings of the string model of polymer structure as applied to the optical properties of polymers
	8. If plastics are polymers, are all polymers plastic?	Properties of Polymers	The influence of time and temperature	Explain the viscoelastic behaviour of a polymer
	9. Quick! We need a better model!	Optical Properties of Matter	What else can we see through?	Describe the requirements for optical transparency in terms of scattering events Recognize that neither crystallinity nor glassy microstructure are requirements for optical transparency
March 17, 2025	9. Quick! We need a better model!	Electromagnetic Radiation	The electromagnetic spectrum	Explain the electromagnetic spectrum in terms of photon energy and photon wavelength Convert energy from J to eV
	9. Quick! We need a better model!	Structure of Matter	The Bohr model	Use the Bohr model of the atom to explain absorption and emission of energy accompanying transitions in electron energy levels
	9. Quick! We need a better model!	Electromagnetic Radiation	Fluorescent lamps, highlighters, and streetlamps	Identify the shortcomings of the Bohr model, specifically the need for four quantum numbers to fully describe the energy level of an electron
	9. Quick! We need a better model!	Structure of Matter	Electronic configuration, the four quantum numbers - something intuitive	Provide intuitive descriptions of each of the four quantum numbers
	9. Quick! We need a better model!	Structure of Matter	The four quantum numbers - allowable values	Determine the electron configuration of a neutral atom or charged ion Identify the allowable values for each of the quantum numbers
	9. Quick! We need a better model!	Bonding	Electronic configuration, Octet Stability	Apply the principle of octet stability to explain covalent, ionic and metallic (sea-of-electrons) bonding Differentiate between the mechanism of formation of each of the primary bonds and provide examples of several properties that can be explained by each
March 24, 2025	9. Quick! We need a better model!	Bonding	The Covalent Bond	Apply the principle of octet stability to explain covalent, ionic and metallic (sea-of-electrons) bonding Differentiate between the mechanism of formation of each of the primary bonds and provide examples of several properties that can be explained by each

	9. Quick! We need a better model!	Bonding	The Ionic Bond	Apply the principle of octet stability to explain covalent, ionic and metallic (sea-of-electrons) bonding Differentiate between the mechanism of formation of each of the primary bonds and provide examples of several properties that can be explained by each	
	9. Quick! We need a better model!	Bonding	The Metallic Bond	Apply the principle of octet stability to explain covalent, ionic and metallic (sea-of-electrons) bonding Differentiate between the mechanism of formation of each of the primary bonds and provide examples of several properties that can be explained by each	
	9. Quick! We need a better model!	Bonding	Ordered solids revisited: acheiving low energy	Conclude that crystals form in ordered solids according to a decrease in energy	
	9. Quick! We need a better model!	The Band Theory of Solids	The band theory of solids	Demonstrate how the allowable energy states in an isolated atom separate into many closely spaced states in the formation of a solid leading to a band structure Apply the band theory of solids to explain the classification of materials as metals, insulators, and semiconductors	
	9. Quick! We need a better model!	The Band Theory of Solids	Extrinsic and Intrinsic semiconductors	Apply the band theory of solids to explain the classification of materials as metals, insulators, and semiconductors	
	9. Quick! We need a better model!	The Band Theory of Solids	Extrinsic and Intrinsic semiconductors	- Given a semiconductor material and a dopant, determine if a p-type or n-type semiconductor is created - Given the electron and hole mobilities and concentrations, calculate the conductivity of a semiconductor	
March 31, 2025	9. Quick! We need a better model!	The Band Theory of Solids	Matter-energy interactions I: All that glitters has a small band gap	Justify the optical transparency or opacity of a material in terms of its band structure and the energy of the incident photons	
	9. Quick! We need a better model!	The Band Theory of Solids	Solid Ionic Conductors	Explain the general principle of solid ionic conductivity	
	9. Quick! We need a better model!	Bonding	Hybridized orbitals	Explain the tetrahedral symmetry found in diamond, silicon or methane in terms of the sp3 hybridized bonding	
	9. Quick! We need a better model!	Structure of Matter	Diamond cubic	Describe the diamond cubic crystal structure, and the tetrahedral interstitial site	
	10. Magnetism (not covered in this course)				
April 7, 2025	11. Free time, free money, free energy?	Thermodynamics	The second law of thermodynamics	Define the entropy Explain the second law of thermodynamics as the sole requirement for the spontaneity of a reaction	https://saylordotorg.github.io/text_general-chemistry-principles-patterns-and-applications-v1.0/s22-chemical-thermodynamics.html
	11. Free time, free money, free energy?	Thermodynamics	Internal energy and the first and second laws of thermodynamics	- Define the internal energy - Explain how the absolute value of internal energy is of little significance - Identify the thermodynamic function or quantity represented by each of the following variables: P, q, R, S, T, U, V, w - Classify each of the preceeding thermodynamic quantities as either a state function or a path function - Demonstrate the significance of a thermodynamic quantity being a state variable	
	11. Free time, free money, free energy?	Thermodynamics	The enthalpy - a book keeping quantity	Calculate the standard enthalpy change for a reaction, given the standard formation enthalpies of reactants and products	
	11. Free time, free money, free energy?	Thermodynamics	Gibbs Energy	- Classify a process as spontaneous or not in terms of the total entropy change of the universe - Show how the Gibbs energy is a restatement of the second law of thermodynamics - Explain phase stability in terms of the Gibbs energy - Calculate the standard Gibbs energy change for a reaction, given the standard formation Gibbs energies of the reactants and products	
	11. Free time, free money, free energy?	Thermodynamics	Enthalpies of phase transformations, standard states, molar heat capacity	- Define the conditions at standard state - Justify the need for a standard state - Calculate the enthalpy of a phase transformation under standard conditions, given the formation enthalpies of both phases involved in the phase transformation - Calculate the heat consumed or released during a phase transformation, given the enthalpy for the transformation and the quantity of material	

	12. Set Phasers to Fun: Phase Equilibrium and Phase Diagrams	Thermodynamics: phase equilibrium	A familiar system: The water-sugar system	- Identify the two-phase regions on the water-sugar or the iron-carbon phase diagram - Determine the phase(s) present under equilibrium conditions given a set of temperature and composition - Evaluate the weight fraction of a given phase within a two-phase region of either the water sugar or the iron carbon phase diagram
April 14, 2025	12. Set Phasers to Fun: Phase Equilibrium and Phase Diagrams	Thermodynamics: phase equilibrium	Binary phase diagrams	Use a binary phase diagram to determine the following for a given overall composition and temperature: what phases are present, the composition of each phase, the amount of each phase Contrast the amount of a phase in a system with the composition of that phase
	12. Set Phasers to Fun: Phase Equilibrium and Phase Diagrams	Thermodynamics: phase equilibrium	Derivation of the lever rule	Derive the lever rule for determining the amount of a phase present within a two-phase region