Mer231 – Thermodynamics I - Study Guide for Exam #1

This exam will cover Chapters 1, 2, 3 and 4 (Sections 4.1-4.5 only). The following is a summary of topics in each chapter that you need to understand for this midterm. Please review and come see me if you do not understand the concepts. You should also review all example problems, in-class problems and homework problems. The exam will be part open book, part closed book.

Note: these summaries are slightly modified version of the end of chapter summaries in your book! Make sure that you understand what is listed below and review the Key concepts and Formulas at the end of every chapter.

Chapter 2 Summary (from Borgnakke and Sonntag, p 37) Chapter 2 introduced a thermodynamic system as a control volume, which for a fixed mass is a control mass. Such a system can be isolated, exchanging neither mass, momentum, nor energy with its surroundings. A closed system versus an open system refers to the ability of mass exchange with the surroundings. If properties for a substance change, the state changes and a process occurs. When a substance has gone through several processes, returning to the same initial state, it has completed a cycle. Basic units for thermodynamic and physical properties are mentioned, and most are covered in Table A.1. Thermodynamic properties such as density ρ, specific volume v, pressure P, and temperature T are introduced together with units for these properties. Properties are classified as intensive, independent of mass (like v), or extensive, proportional to mass (like V). Application of Newton’s law of motion leads to the variation of static pressure in a column of fluid and the measurements of pressure (absolute and gauge) by barometers and manometers. The normal temperature scale and the absolute temperature scale are introduced.

You should be able to:

- Define a control volume (CV) around some matter; sketch the content and identify storage locations for mass; and identify mass and energy flows crossing the CV surface.
- Know properties P, T, v, and ρ and their units.
- Know how to look up conversion of units in Table A.1.
- Know that energy is stored as kinetic, potential, or internal (in molecules).
- Know that energy can be transferred.
- Know the difference between (v, ρ) and (V, m) intensive and extensive.
- Apply a force balance to a given system and relate it to pressure P.
- Know the difference between relative (gauge) and absolute pressure P.
- Understand the working of a manometer or a barometer and derive ΔP or P from height H.
- Know the difference between a relative and an absolute temperature T.
- Understand the workings of a thermometer.

Chapter 3 Summary (from Borgnakke and Sonntag, p 77) Thermodynamic properties of a pure substance and the phase boundaries for solid, liquid, and vapor states are discussed. Phase equilibrium for vaporization (boiling liquid to vapor), or the opposite, condensation (vapor to liquid); sublimation (solid to vapor) or the opposite, solidification (vapor to solid); and melting (solid to liquid) or the opposite, solidifying (liquid to solid), should be recognized. The three- dimensional P-v-T surface and the two-dimensional representations in the (P, T), (T, v) and (P, v) diagrams, and the vaporization, sublimation, and fusion lines, are related to the printed tables in Appendix B. Properties from printed tables covering a number of substances are introduced, including two-phase mixtures, for which we use the mass fraction of vapor (quality). The ideal-gas law approximates the limiting behavior for low density. An extension of the ideal-gas law is shown with the compressibility factor Z, and other, more complicated equations of state are mentioned.

You should be able to:

- Know phases and the nomenclature used for states and interphases.
- Identify a phase given a state (T, P).
Locate states relative to the critical point and know Tables A. 2 (F. 1) and 3.2.

Recognize phase diagrams and interphase locations.

Locate states in the Appendix B tables with any entry: \((T, P), (T, v), \) or \((P, v)\)

Recognize how the tables show parts of the \((T, P), (T, v), \) or \((P, v)\) diagrams.

Find properties in the two-phase regions; use quality \(x\).

Locate states using any combination of \((T, P, v, x)\) including linear interpolation.

Know when you have a liquid or solid and the properties in Tables A. 3 and A. 4 (F.2 and F.3).

Know when a vapor is an ideal gas (or how to find out).

Know the ideal-gas law and Table A.5 (F.4).

Know the compressibility factor \(Z\) and the compressibility chart, Fig. D.1.

Know the existence of more general equations of state.

**Chapter 4 Summary (sections 4.1-4.3 only)** (from Borgnakke and Sonntag, p 113) Work and heat are energy transfers between a control volume and its surroundings. Work is energy that can be transferred mechanically (or electrically or chemically) from one system to another and must cross the control surface either as a transient phenomenon or as a steady rate of work, which is power. Work is a function of the process path as well as the beginning state and end state. The displacement work is equal to the area below the process curve drawn in a \(P-V\) diagram in an equilibrium process. A number of ordinary processes can be expressed as polytropic processes having a particular simple mathematical form for the \(P-V\) relation. Work involving the action of surface tension, single-point forces, or electrical systems should be recognized and treated separately. Any nonequilibrium processes (say, dynamic forces, which are important due to accelerations) should be identified so that only equilibrium force or pressure is used to evaluate the work term.

You should be able to:

- Recognize force and displacement in a system.
- Understand power as the rate of work (force \(\times\) velocity, torque \(\times\) angular velocity).
- Know that work is a function of the end states and the path followed in a process.
- Calculate the work term knowing the \(P-V\) or \(F-x\) relationship.
- Evaluate the work involved in a polytropic process between two states.
- Know that work is the area under the process curve in a \(P-V\) diagram.
- Apply a force balance on a mass and determine work in a process from it.
- Distinguish between an equilibrium process and a non-equilibrium process.

**Some (but perhaps not all) things I expect you know (i.e. for the closed portion of the test)**

- Ideal Gas Law
- Definition of quality \(x = \frac{m_i}{m_{\text{total}}}\)
- How to calculate specific volume using quality.
- How to calculate the forces acting on a piston.
- Know how to apply the definition of work (i.e. \(W = \int F dx\)).
- The definition of moving boundary work and how to calculate it (i.e. \(W = \int P dV\)).
- How to draw \(P-v, P-T\) and \(T-v\) diagrams and identify states on those diagrams.
- How to read the property tables.
- Definition of all the “bolded” items above.