Exam 2 will cover sections 3.5 - 5.8 (excluding Section 3.10) in Laidler, Meiser and Sanctuary. As before, I’ll give you a list of key equations and the values of important physical constants (a sample equation sheet is on the web site). In addition, you may bring a 3” × 5” index card with whatever information you wish hand written on one side only – these cards must be handed in at the end of the exam. As before, there will be three sections in the exam – multiple choice, longer answer questions and true/false. Below is a list of key points and topics you should be sure you have mastered. Remember that anything that was covered in class lectures, on graded assignments, on ungraded homework assignments or in the textbook could be on this exam.

1. Know the Third Law of Thermodynamics.
2. Know how adiabatic demagnetization can be used to cool substances to near absolute zero.
3. Be able to use tabulated values of absolute entropies to calculate the entropy change for a reaction. Recognize that all substances, even elements in their standard state, have absolute entropies that are greater than zero at temperatures above absolute zero.
4. Know the thermodynamic conditions required for a spontaneous change both in terms of entropy and Gibbs energy.
5. Know the mathematical definitions of Gibbs energy and Helmholtz energy. Know how these two variables differ in what they measure.
6. Be able to calculate the Gibbs energy change for a reaction from tabulated Gibbs energies of formation.
7. Know the meanings of the terms exergonic and endergonic.
8. Be able to calculate the Gibbs energy change for a process from the enthalpy and entropy changes for that process. Be aware that Gibbs energy is a function of temperature, so ∆G for processes not occurring at 298 K will have to be calculated this way instead of with tabulated values.
9. Know the equation for the combined First and Second Laws of Thermodynamics and know the three equations for dH, dG and dA that can be derived from this combined equation. Know the four Maxwell relations that can be derived from these four equations. Know the eight relationships between thermodynamic variables and thermodynamic functions that can be derived from the same four equations. Make sure you’re comfortable in using all of these relationships to simplify other thermodynamic calculations.
10. Know the Gibbs-Helmholtz equation and the van’t Hoff equation (which can be derived from it). Be able to use the van’t Hoff equation to relate equilibrium constants to temperature, ∆H, and ∆S.
11. Know the definitions of fugacity and activity for a gas and know how to adapt standard ideal gas calculations to a real gas by using the fugacity or activity.
12. Know the definition of chemical potential in terms of Gibbs energy.
13. Know the relationship between molar Gibbs energy (or µ) and the pressure and standard molar Gibbs energy; also know how µ is defined in terms of the thermodynamic functions U, H, A and S.
14. Know how Gibbs energy is related to the equilibrium constant and know the definitions of KP and K°P. Know how Kc and Kf relate to KP and be able to convert between the different equilibrium constants, given a balanced chemical equation.
15. Know how the equilibrium constants for different reactions are combined when those reactions are added, subtracted, reversed, or multiplied by some factor.
16. Know the definition of the degree of dissociation (or fraction reacted), α. Be able to calculate α, K, and final concentrations or pressures of reactants and products for systems that participate in equilibrium reactions. This is usually most easily accomplished using an ICE table. Understand the examples from class and from the homework assignments.
17. Know the definition of the reaction quotient, Q, and how it can be used to tell if a system is at equilibrium and which way it will change to reach equilibrium.
18. Know how the expression for the equilibrium constant is modified when it is necessary to use fugacities or activities in place of pressures. Know the equivalent modifications for Kc and Kf.
19. Know how pure solids and liquids are dealt with in equilibrium reactions and know why (mathematically and conceptually) they do not appear in the equilibrium constant expression.
20. Know the definition of the solubility product constant and be able to use it to calculate the solubility of a solid.

21. Know Le Chatelier’s principle and be able to apply it to changes in concentration, pressure and temperature.

22. Be able to interpret a $P$ vs. $T$ phase diagram. Know the definitions of the triple point, a metastable state, and polymorphism.

23. Be able to interpret a $G$ vs. $T$ diagram. Know how to figure out which phase is most stable at a given temperature and why. Know how to identify the temperatures where phase changes occur. Relate the shift in the lines as pressure changes to $V_m$ and relate the slopes of the lines to $S_m$ using Maxwell’s relations. Know why the lines are not straight and why this curvature is most extreme for the gas phase.

24. Know and be able to use the Clapeyron and Clausius-Clapeyron equations. Know the difference in what they can be used for and know the assumptions involved in deriving them.

25. Know Trouton’s Rule and be able to use it to estimate $\Delta_{\text{vap}}H$. Be able to estimate the vapor pressure of a given substance at a particular temperature given its boiling point. Know when Trouton’s Rule is likely to fail.

26. Know the relationship between vapor pressure and applied external pressure on a liquid, and know qualitatively why this relationship is the way it is.

27. Know Raoult’s Law and Henry’s Law and be able to use both. Given a $P$ vs. $X$ or $T$ vs. $X$ diagram, be able to identify whether there are positive or negative deviations from Raoult’s Law.

28. Know what causes these deviations in each case and be able to describe the properties of an ideal solution. Know under what circumstances Raoult’s Law is most likely to be obeyed and under what circumstances Henry’s Law is most likely to be obeyed.

29. Understand the definition of partial molar quantities and know why they are needed. Know the Gibbs-Duhem equation for a two component system.

30. Know how chemical potential applies to a two component system. How do the chemical potentials of the two components relate to each other as the system approaches equilibrium?

31. Know how the activity of the vapor of component $i$ above a solution relates to the fugacity, pressure and mole fraction of component $i$ for an ideal solution.

32. Be able to calculate values for the changes in thermodynamic variables upon mixing for ideal solutions.

33. Know both the rational and practical systems for defining chemical potentials and activities of solutions. Know the definitions of the activity coefficient in each case and know under what circumstances each system works best.

34. Know the general meaning of the term colligative properties.

35. Know the three main colligative properties and know what property can be used to explain all three effects.

36. Know the definition (formula) for the freezing point depression and boiling point elevation constants. Be able to calculate the change in freezing or boiling point for a solution compared to the pure solvent.

37. Know the definition of osmotic pressure and know the van’t Hoff osmotic pressure equation.