Things you should be able to answer for the Final Exam:

From the Lab, *Gases, Diffusion, and Reactions*:

1. Be able to identify a picture of two mobile gas atoms in the rule *Gasstick* a couple of time steps after they start (a) in contact and (b) near each other. What does a vertical or horizontal line of mobile gas atoms that stretches from one side of the container to the other do as time goes on? What does a single mobile gas atom do if it is started exactly in one corner of the container?
2. What does a 25% random fill of mobile gas atoms obeying the rule *Gasstick* do if the whole container is initially filled; if it is initially half filled? What does a vertical line of mobile atoms do in a background of 25% random fill? What do irregularly spaced extra “wall” atoms do to the motion of a vertical line of mobile atoms? Suppose you are told that at one instant a 25% random fill completely fills a container; can you infer that this is a state of thermal equilibrium? Why? What is the primary difference between what occurs in a container initially filled with 5% random fill and another with 50% random fill?
3. Processes using the rule *Dendcoll* occur much more slowly than using the rule *Gasstick*. Is that because the speed of a mobile atom in one time step is much slower in *Dendcoll* or is there some other reason; if the latter, what is the reason?
4. In many biochemical reactions diffusion of small molecules through liquid is the rate-limiting step. What does that mean? In an aggregation reaction whose growth rate is diffusion limited, a region that is depleted of mobile reactant atoms surrounds a growing aggregate. Why? Give an example of a ballistic aggregate. Why is a ballistic aggregate much more compact than a diffusion limited aggregate? A DLA is said to be *dendritic*. What is a *dendrite* and why are DLA dendritic? Be able to assess from mass-radius data collected for an aggregate whether the aggregate is more likely formed by ballistic or diffusion limited growth.

From the Lab “Thermal Equilibrium:”

The big point of this lab is to try to connect macroscopic thermodynamical processes with the world of atoms, so in reviewing what you did try to keep this idea at the center of your thoughts.

The macroscopic part:

5. What was the purpose of placing the aluminum cylinders inside the Styrofoam container? How would the results you observed have differed if the cylinders were not placed in the container?
6. The lab instructions assumed that the temperature probes recorded the *temperatures of the cylinders* at any instant. That assumption could be wrong for two reasons—one operational and one theoretical. What are they? Provided the operational reason was not a problem, how could you argue that the theoretical issue might not be much of a concern?
7. Make sure you can answer the analysis questions A1.1, A1.2, and A3.1.
8. Be able to describe how the entropy versus time graph should have looked and why. Two bodies initially at different temperatures are place in thermal contact. Thermal equilibrium will occur when what is true about temperature, heat flow, and entropy?

The microscopic part:

9. Be able to describe how the simulation worked. For example: What did the two "bodies" look like? What was "energy" in the simulation? What was the initial arrangement of energy? How did energy move in every time step? How was thermal contact modeled? What was plotted on the graph?
10. In what ways did changing the size of the two bodies in contact affect the heating and cooling curves? Why were some plots irregular and others smooth?
11. Be able to answer the Questions.

From the last review sheet:

12. How do you convert between the Fahrenheit, Celsius, and Kelvin temperature scales? How is the Kelvin scale defined?
13. What is *internal energy* and how can the internal energy of a system be changed? What is *thermal equilibrium*? What is meant by *thermal contact*? What is *heat*—in terms of temperature? What do the ideas of thermal equilibrium and heat imply for making a good thermometer? What is the Zeroth Law of Thermodynamics?

From Chapter 14:

14. What is a *mole*? What is *Avogadro's number*?
15. What is the *ideal gas law*? Under what condition is a gas *ideal*?
16. Pressure is related to the translational kinetic energy of atoms or molecules in a material; why? What is the explicit relation between pressure and the average translational kinetic energy per atom or molecule? This relation and the ideal gas law allows one to establish an explicit relation between Kelvin temperature and average translational kinetic energy per atom or molecule in a dilute gas. What is it? What is Boltzmann's constant? What is the universal gas constant? How are the two related? In the ideal gas equation of state, $PV = Nk_BT$, N is the number of atoms OR the number of molecules in the gas; when is it *atoms* and when is it *molecules* , and why? What is the internal energy of an ideal gas? Why is it of this form?

From Sections 13.2 and 14.4:

17. Whenever a steady flow is maintained against a resistance the *steady state* rate of flow obeys *Ohm's Law*: $\Delta V = RI$, where ΔV is a "driving force" R is a "resistance" and I is a "current." (Recall Poiseiulle's Law for steady flow of a viscous fluid: $Q = \pi R^4 \Delta P/8\eta L$.) What are the driving force, resistance, and current for steady state heat conduction and for steady state mass diffusion? From a microscopic point of view, why are the equations of steady state heat conduction and mass diffusion essentially the same?
18. Be sure to be able to do Problems 14.44 and 14.46. What aspect of respiration is controlled by diffusion and what isn't?

From Chapter 15 and the handout notes:

19. State the Zeroth and First Laws of Thermodynamics. State the Second Law in its heat flow, heat engine, and entropy forms.
20. Internal energy and entropy are "state functions." What is a state function? What is a reversible process? Two equilibrium states are connected by two different reversible processes; which of the following could be different and which *must* be the same for the two processes: Q, W, ΔT, ΔP, ΔV, ΔU, ΔS?
21. State what the following reversible processes consist of: isothermal, adiabatic, isobaric, isochoric. Which must be zero in each of these processes for the system: Q, W, ΔT, ΔP, ΔV, ΔU, ΔS?
22. What is a *P-V* diagram? Suppose two curves representing the expansion of an ideal gas are drawn on a *P-V* diagram—one an isothermal expansion, the other an adiabatic expansion. Be able to distinguish between the two and state why. For a process plotted on a *P-V* diagram, what is the work done?
23. What is meant by a cyclic process? Which must be zero for the system in a cyclic process: Q, W, ΔT, ΔP, ΔV, ΔU, ΔS?
24. What is a heat engine? Define what is meant by the efficiency of *any* heat engine. Be able to calculate efficiency given information about works and/or heats. What is a Carnot engine? Why is it important? What is the efficiency of a Carnot engine in terms of operating temperatures? What is a *T-S* diagram? Be able to analyze a Carnot cycle on a *T-S* diagram.
25. State how the entropy difference between two equilibrium states is calculated. What is an irreversible process? What does entropy have to do with irreversibility? What is the meaning of "time's arrow?" How does the entropy form of the Second Law explain the other forms? What is the relationship between entropy and energy available to do work? Understand the free expansion of an ideal gas; show how entropy increases in the expansion and how energy available to do work decreases.
26. State how the existence of low entropy forms of matter (such as solid crystals or living cells) can be compatible with the Second Law of Thermodynamics.

An assigned homework problem from Ch 15 will be on the exam.

From the rest of the course:

27. You should know the content of Newton's Second and Third Laws of Motion and how they are used to solve a mechanics problem. You should be able to draw a free body diagram and be able to state what body is responsible for each force.
28. You should be able to define the work done by a force, define kinetic energy, and state the work energy theorem. You should be able to use the W-E theorem to find the work done by a complicated force without doing any complicated math. Define what is a conservative force. Define potential energy. State the law of conservation of mechanical energy.
29. Define uniform circular motion. State why acceleration is required to maintain circular motion. Relate centripetal acceleration to speed and radius.
30. What is simple harmonic motion? What is the phenomenon of resonance and when does it occur?