Here are some questions to test your mastery of the fundamentals of chemical kinetics. Once you’ve mastered the material, you should be able to answer these questions without reference to your notes or textbook.

For Chemical Kinetics I (Rate Laws):

1. Given the stoichiometric equation for a chemical reaction, e.g. $v_A A + v_B B \rightarrow v_Y Y + v_Z Z$, write down the rate of reaction, $v(t)$, in terms of the time derivatives of the concentrations.
2. What is a rate law? What is a rate constant? What is the order of a reaction? Do all rate laws have a reaction order?
3. Can one determine the rate law only from knowledge of the stoichiometry of a reaction?
4. How does one determine a rate law from experimental data? Specifically, how does one use initial rates (i.e., method of initial rates and method of isolation)?
5. What are characteristic features associated with a first-order reaction? A second-order reaction? How would you plot data in order to determine the order of a reaction?
6. What is a reversible first-order reaction? A reversible first-order reaction also shows an exponential behavior in the time-dependence of concentrations—how does it differ from a first-order reaction that is irreversible (i.e., forward reaction with no reverse reaction)?
7. What is the relaxation time in a reversible first-order reaction? Together with the equilibrium constant, how is it used to determine the rate constants?
8. What is the Arrhenius equation for the temperature-dependence of the rate constant? What is the activation energy and pre-exponential factor? Sketch a diagram illustrating the idea behind the Arrhenius equation. Can the pre-exponential factor be predicted from quantum mechanics?

For Chemical Kinetics II (Reaction Mechanisms):

9. What is an elementary reaction? How does one determine the rate law of an elementary reaction? Is it related to the stoichiometry? Of the reactants? Of the products?
10. What is a reaction mechanism? Is it always a sequence of consecutive steps?
11. Does an observed rate law uniquely determine the mechanism of a reaction?
12. What is the relationship between the equilibrium constant and the rate constants (principle of detailed balance)?
13. What is an intermediate? How can we tell if there is an intermediate? When can or can’t we tell from the apparent rate of reaction?
14. What is a rate-determining step? Is there always one in a mechanism?
15. What is the steady-state approximation? Under which conditions is it justified?
16. What is a chain reaction? What are the initiation, propagation, inhibition, and termination steps?
17. What is the Michaelis-Menten mechanism? What is the behavior in the limit of low and high substrate concentration?
In addition, you should feel comfortable doing problems like those that have been assigned in homework. Here are some additional problems you should feel comfortable doing once you’ve mastered the material.

1. Given the half-life for either a first or second order reaction, calculate the time-dependence of the concentration of a reactant for all times.
2. Apply the steady-state approximation to a given mechanism to derive an expression for the rate law.