MWF Exam 3 Review

Solubility

Dissolving a solid in pure water:

- Calculate molar solubility (x) from K_{sp}: $K_{sp} = x^2$, $4x^3$, $27x^4$, or $108x^5$
- Calculate ion concentrations from molar solubility: x times the subscript in the chemical formula
- Calculate K_{sp} from ion concentrations: just plug the ion concentrations into K_{sp} expression
- Calculate K_{sp} from molar solubility: $K_{sp} = x^2$, $4x^3$, $27x^4$, or $108x^5$

Common ion effect:

- Calculate ion concentrations when there is already a common ion in the solution

Mixing two solutions:

- Calculate Q_{sp}, compare to K_{sp}
- Calculate how much precipitate is formed

Kinetics

Determine rate law for a reaction from data table
Understand units on rate constants

Determine rate law from mechanism, with or without an equilibrium step in the mechanism
Be able to determine the correct mechanism for a reaction based on a data table

Integrated rate laws: Calculate amount of A remaining after time t for 0, 1st, and 2nd order reactions
Understand graphs of integrated rate laws

Understand what activation energy is, know what an Arrhenius plot looks like and how to read it
Arrhenius equation for one rate constant k $k = Ae^{(-Ea/RT)}$
Arrhenius equation for 2 rate constant k's at two different temperatures: $\ln(k_2/k_1) = E_a/R\ (1/T_1 - 1/T_2)$

Understand that catalysts create a new reaction pathway with a new mechanism and a lower E_a.
Understand why heating a reaction makes it go faster

Nuclear

Balance nuclear reactions – recognize fission, fusion, decay reactions
Calculate the mass defect in a nuclear reaction and the energy given off

Understand the band of stability and predict modes of radioactive decay for isotopes not on the band

Know how to determine how many half-lives have passed in a radioactive sample
Calculate amount of isotope remaining after x number of half-lives have passed $A = A_0(½)^x$

Exam 3 solubility review problems

72. Calculate the solubility of each of the following compounds in moles per liter. Ignore any acid–base properties. Determine the concentration of each ion in each solution.
    a. PbI_2, $K_{sp} = 1.4 \times 10^{-8}$
    b. $CdCO_3$, $K_{sp} = 5.2 \times 10^{-12}$
    c. $Sr_3(PO_4)_2$, $K_{sp} = 1 \times 10^{-31}$

74. Use the following data to calculate the K_{sp} value for each solid.
    a. The solubility of $Pb_3(PO_4)_2$ is 6.2×10^{-12} mol/L.
    b. The solubility of Li_2CO_3 is 5.47 g/L.

75. For each of the following pairs of solids, determine which solid has the smallest molar solubility.
    a. $CaF_2(s)$, $K_{sp} = 4.0 \times 10^{-11}$ or
       $BaF_2(s)$, $K_{sp} = 2.4 \times 10^{-5}$
    b. $Ca_3(PO_4)_2(s)$, $K_{sp} = 1.3 \times 10^{-32}$ or
       $FePO_4(s)$, $K_{sp} = 1.0 \times 10^{-22}$

76. The K_{sp} for silver sulfate (Ag_2SO_4) is 1.2×10^{-5}. Calculate the solubility of silver sulfate in each of the following.
    a. water b. 0.10 *M* $AgNO_3$ c. 0.20 *M* K_2SO_4

77. Calculate the solubility (in mol/L) of $Fe(OH)_3$ ($K_{sp} = 4 \times 10^{-38}$) in each of the following.
    a. a solution buffered at pH = 5.0
    b. a solution buffered at pH = 11.0

78. The solubility of $Ce(IO_3)_3$ in a 0.20 *M* KIO_3 solution is 4.4×10^{-8} mol/L. Calculate K_{sp} for $Ce(IO_3)_3$.

81. Will a precipitate form when 100.0 mL of 4.0×10^{-4} *M* $Mg(NO_3)_2$ is added to 100.0 mL of 2.0×10^{-4} *M* NaOH?

82. A solution is prepared by mixing 75.0 mL of 0.020 *M* $BaCl_2$ and 125 mL of 0.040 *M* K_2SO_4.
    K_{sp} for $BaSO_4 = 1.1 \times 10^{-10}$. Does a precipitate form? If so, how many grams of precipitate are formed?

(Zumdahl, Chemical Principles, 5th Edition)

Exam 3 kinetics review problems

19. The following data were obtained for the reaction

$$2ClO_2(aq) + 2OH^-(aq) \longrightarrow ClO_3^-(aq) + ClO_2^-(aq) + H_2O(l)$$

$[ClO_2]_0$ (mol/L)	$[OH^-]_0$ (mol/L)	Initial Rate (mol L^{-1} s^{-1})
0.0500	0.100	5.75×10^{-2}
0.100	0.100	2.30×10^{-1}
0.100	0.0500	1.15×10^{-1}

a. Determine the rate law and the value of the rate constant.
b. What would be the initial rate for an experiment with $[ClO_2]_0 = 0.175$ mol/L and $[OH^-]_0 = 0.0844$ mol/L?

(Zumdahl, Chemical Principles, 5th Edition)

54. What is the activation energy for a reaction if its rate constant is found to triple when the temperature is raised from 600. K to 610. K?

55. For a gas-phase reaction, the pre-exponential factor A is 45.38 and the rate constant is 0.0850 min^{-1} at 273 K. Find the rate constant at 323 K.

56. The rate constant of a reaction is tripled when the temperature is increased from 298 K to 308 K. Find E_a.

(Whitten, Davis, Peck, and Stanley, Chemistry, 8th Edition.)

42. Define each of the following.
    a. elementary step
    b. reaction mechanism
    c. rate-determining step

    Write the rate laws for the following elementary reactions.
    a. $CH_3NC(g) \longrightarrow CH_3CN(g)$
    b. $O_3(g) + NO(g) \longrightarrow O_2(g) + NO_2(g)$
    c. $O_3(g) \longrightarrow O_2(g) + O(g)$
    d. $O_3(g) + O(g) \longrightarrow 2O_2(g)$
    e. ${}^{14}_{6}C \longrightarrow {}^{14}_{7}N + \beta$ particle (nuclear decay)

43. The mechanism for the reaction of nitrogen dioxide with carbon monoxide to form nitric oxide and carbon dioxide is thought to be

$$NO_2 + NO_2 \longrightarrow NO_3 + NO \qquad \text{Slow}$$
$$NO_3 + CO \longrightarrow NO_2 + CO_2 \qquad \text{Fast}$$

    Write the rate law expected for this mechanism. What is the overall balanced equation for the reaction?

44. A proposed mechanism for a reaction is

$$C_4H_9Br \longrightarrow C_4H_9^+ + Br^- \qquad \text{Slow}$$
$$C_4H_9^+ + H_2O \longrightarrow C_4H_9OH_2^+ \qquad \text{Fast}$$
$$C_4H_9OH_2^+ + H_2O \longrightarrow C_4H_9OH + H_3O^+ \qquad \text{Fast}$$

45. Write the rate law expected for this mechanism. What is the overall balanced equation for the reaction? What are the intermediates in the proposed mechanism?

47. The reaction

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$

    exhibits the rate law

$$\text{Rate} = k[NO]^2[O_2]$$

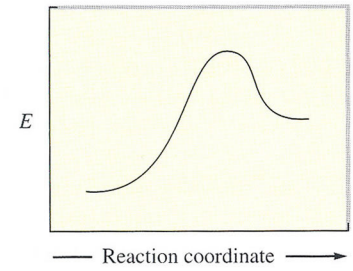
    Which of the following mechanisms is consistent with this rate law?

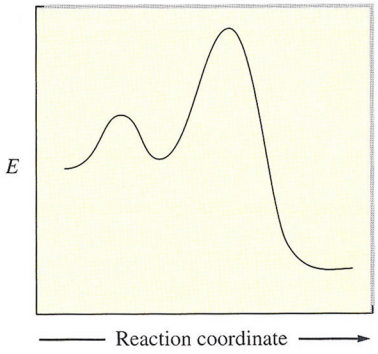
    a. $NO + O_2 \longrightarrow NO_2 + O$ Slow
       $O + NO \longrightarrow NO_2$ Fast
    b. $NO + O_2 \rightleftharpoons NO_3$ Fast equilibrium
       $NO_3 + NO \longrightarrow 2NO_2$ Slow
    c. $2NO \longrightarrow N_2O_2$ Slow
       $N_2O_2 + O_2 \longrightarrow N_2O_4$ Fast
       $N_2O_4 \longrightarrow 2NO_2$ Fast
    d. $2NO \rightleftharpoons N_2O_2$ Fast equilibrium
       $N_2O_2 \longrightarrow NO_2 + O$ Slow
       $O + NO \longrightarrow NO_2$ Fast

(Zumdahl, Chemical Principles, 5th Edition)

64. Draw a rough sketch of the energy profile for each of the following cases.
    a. $\Delta E = +10$ kJ/mol, $E_a = 25$ kJ/mol
    b. $\Delta E = -10$ kJ/mol, $E_a = 50$ kJ/mol
    c. $\Delta E = -50$ kJ/mol, $E_a = 50$ kJ/mol
    Which reaction will have the greatest rate at 298 K? Assume the frequency factor A is the same for all three reactions.

65. For the following reaction profiles, indicate:
    a. the positions of reactants and products
    b. the activation energy
    c. ΔE for the reaction





    d. The second reaction profile is representative of a reaction that occurs by a two-step mechanism. Which point on the plot represents the energy of the intermediate in the two-step reaction? Which step in the mechanism is rate determining, the first or the second step? Explain.

66. The activation energy for the reaction

$$NO_2(g) + CO(g) \longrightarrow NO(g) + CO_2(g)$$

    is 125 kJ/mol, and ΔE for the reaction is -216 kJ/mol. What is the activation energy for the reverse reaction [$NO(g) + CO_2(g) \longrightarrow NO_2(g) + CO(g)$]?

67. For a certain process, the activation energy is greater for the forward reaction than for the reverse reaction. Does this reaction have a positive or negative value for ΔE?

(Zumdahl, Chemical Principles, 5th Edition)

Exam 3 nuclear review problems

9. In 1994 it was proposed that element 106 be named seaborgium, Sg, in honor of Glenn T. Seaborg, discoverer of the transuranium elements.
   a. ^{263}Sg was produced by the bombardment of ^{249}Cf with a beam of ^{18}O nuclei. Complete and balance an equation for this reaction.
   b. ^{263}Sg decays by α-particle emission. What is the other product resulting from the α decay of ^{263}Sg?

10. Many elements have been synthesized by bombarding relatively heavy atoms with high-energy particles in particle accelerators. Complete the following nuclear reactions, which have been used to synthesize elements.
   a. _____ + $^{4}_{2}$He → $^{243}_{97}$Bk + $^{1}_{0}$n
   b. $^{238}_{92}$U + $^{12}_{6}$C → _____ + 6$^{1}_{0}$n
   c. $^{249}_{98}$Cf + _____ → $^{260}_{105}$Db + 4$^{1}_{0}$n
   d. $^{249}_{98}$Cf + $^{10}_{5}$B → $^{257}_{103}$Lr + _____

13. Radioactive copper-64 decays with a half-life of 12.8 days.
   a. What is the value of k in s^{-1}?
   b. A sample contains 28.0 mg ^{64}Cu. How many decay events will be produced in the first second? Assume that the atomic mass of ^{64}Cu is 64.0.
   c. A chemist obtains a fresh sample of ^{64}Cu and measures its radioactivity. She then determines that to do an experiment, the radioactivity cannot fall below 25% of the initial measured value. How long does she have to perform the experiment?

17. Phosphorus-32 is a commonly used radioactive nuclide in biochemical research, particularly in studies of nucleic acids. The half-life of phosphorus-32 is 14.3 days. What mass of phosphorus-32 is left from an original sample of 175 mg of $Na_3{}^{32}PO_4$ after 35.0 days? Assume that the atomic mass of ^{32}P is 32.0.

20. A living plant contains about the same fraction of carbon-14 as atmospheric carbon dioxide. The observed rate of decay of carbon-14 from a living plant is 15.3 counts per minute per gram of carbon. How many counts per minute per gram of carbon will be measured from a 15,000-yr-old sample? Will radiocarbon dating work well for small samples of 10 mg or less?

22. A proposed system for storing nuclear wastes involves storing the radioactive material in caves or deep mine shafts. One of the most toxic nuclides that must be disposed of is plutonium-239, which is produced in breeder reactors and has a half-life of 24,100 years. A suitable storage place must be geologically stable long enough for the activity of plutonium-239 to decrease to 0.1% of its original value. How long is this period for plutonium-239?

(Zumdahl, Chemical Principles, 5th Edition)

EXAMPLE 19.4 Radioactive Decay Kinetics

Plutonium-236 is an alpha emitter with a half-life of 2.86 years. If a sample initially contains 1.35 mg of Pu-236, what mass of Pu-236 is present after 5.00 years?

(Tro, General Chemsitry, 9th Edition)