Review for Exam 2  
Chem 1721/1821

The following are the major concepts with which you should be well acquainted from Chapters 13, 14, 15, 16.1-16.3:

**Chapter 13: Chemical Kinetics**

**Reaction Rates**
- The rate of a chemical reaction is the change of concentration per unit time - the units are always the same - know them!
- Relating rates of consumption of reactants and rates of formation of products, including stoichiometric relationships
- Instantaneous reaction rates vs. average reaction rates
- Initial rates of reaction

**Rate Laws**
- Rate laws show the dependence of reaction rates on concentration
- Know the general form of a rate law: $rate = k[A]^x[B]^y$
- You should know what is meant by orders of reaction with respect to reactants and overall, including being able to identify a reaction order from a rate law, and being able to write a rate law given the orders.
- Determination of reaction order and rate law by the method of initial rates
- Know the units of $k$ for different order reactions!!!

**Integrated Rate Equations**
- Integrated rate equations show the relationship between concentration and time
- Know the integrated rate equations for zero- first- and second-order reactions
- Know the plots of data that correspond to straight lines for each order of reaction, also know what the slope equals ($k$ or $-k$)
- Half lives - definition and equations for each order of reaction

**Controlling Reaction Rates**
- Temperature dependence of rates and the rate constant - including Arrhenius behavior, the Arrhenius equation and Arrhenius plots of data - know them
- Determination of the rate constant at one temperature if you know that rate constant at another temperature (Arrhenius equation)
- Collision Theory, Activation energy and frequency factor, reaction profiles, activation barriers, transition states (or activated complex) - all that good stuff that deals with how reactions actually occur
- Catalysts - how they work, homogeneous vs. heterogeneous, how to identify a catalyst in a reaction mechanism

**Reaction Mechanisms**
- What is one?
- What is the difference between an elementary step and an overall reaction?
- Writing rate laws for elementary steps
- Molecularity of elementary steps
- Identifying reaction intermediates and catalysts in a reaction mechanism - what is the difference between them?
- Rate determining step
- Determination of a rate law from a reaction mechanism with a slow first step

**Chapter 14: Chemical Equilibrium**

Chemical reactions at equilibrium - what does that mean? Do you understand how that would look on a molecular level?

**Equilibrium Constant, K**
- Relationship between the reaction quotient, $Q$, and the equilibrium constant ($Q_c$ vs $K_c$ and $Q_p$ vs. $K_p$)
- Writing equilibrium expressions - and the law of mass action
- Calculation of $K_c$ or $K_p$ and converting between them
- Making some judgments about a reaction and it’s equilibrium position based on the magnitude of $K$, or comparing $Q$ and $K$
Heterogeneous equilibrium - writing equilibrium expressions and calculating $K_C$ or $K_P$ based on them

Equilibrium Calculations and the use of equilibrium tables to solve problems
- Calculation of an unknown concentration given other equilibrium concentrations and $K_C$
- Calculation of $K_C$ given initial concentrations and one equilibrium concentration
- Determination of equilibrium concentrations given initial concentrations and $K_C$
- Determination of the direction of a reaction and equilibrium concentrations given arbitrary initial data & $K_C$

Le Chatelier's Principle - How does the position of an equilibrium shift in response to changes in concentration of reactants or products, pressure and temperature or the addition of a catalyst?

Chapter 15 – 16.3: Acids and Bases
Fundamentals
- Bronsted-Lowry definitions of acids and bases as $H^+$ donors and acceptors
- Acid and base ionization (dissociation) equations including identification of conjugate pairs
- $K_a$ and $K_b$ expressions
- relationship of acid strength to: $K_a$ value, $[H_3O^+]$, $[HA]_{eq}$, equilibrium position, strength of conjugate base
- relationship of base strength to: $K_b$ value, $[OH^-]$, $[B]_{eq}$, equilibrium position, strength of conjugate acid
- identification of strong acids and bases (only a small number so KNOW THEM!!)

Water
- Water is amphoteric (or amphoprotic). What does that mean?
- Auto-ionization of water, and water auto-ionization constant $K_w$
- $K_w = 1.0 \times 10^{-14}$ at 25°C; $K_w = [H_3O^+][OH^-]$

pH (and pOH, $pK_a$, $pK_b$) scale
- logarithmic scale
- $pH = -\log[H_3O^+]$ and $[H_2O] = 10^{-pH}$; $pOH = -\log[OH^-]$ and $[OH^-] = 10^{-pOH}$
- $pK_a = -\log K_a$ and $K_a = 10^{-pK_a}$; $pK_b = -\log K_b$ and $K_b = 10^{-pK_b}$
- $pH + pOH = pK_w$
- Where do acidic, basic, and neutral solutions fall on the pH scale?

You should be able to do the following kinds of calculations from this chapter:
- pH of strong acid and strong base solutions
- pH of weak acid and weak base solutions: this includes identifying the major species in solution, identifying the major source of $H_3O^+$ or $OH^-$ in solution and setting up an equilibrium calculation
- pH of mixtures of weak acids or weak bases
- Calculation of $%$ dissociation or $%$ ionization of weak acids and weak bases
- Determination of $K_a$ or $K_b$ using pH or $%$ ionization values

Some Review Problems:
1. a. The rate of formation of $O_2$ is $1.5 \times 10^{-3}$ Ms$^{-1}$ in the reaction $2 O_3 (g) \rightarrow 3 O_2 (g)$. What is the rate of decomposition of ozone?
   b. The rate of formation of dichromate ions is 0.14 Ms$^{-1}$ in the following reaction:
      $2 CrO_4^{2-} (aq) + 2 H^+ (aq) \rightarrow Cr_2O_7^{2-} (aq) + H_2O (l)$. What is the rate of reaction of $CrO_4^{2-}$ in this reaction?
2. Calculate the initial rate for the decomposition of $N_2O_5$ when 2.0 g $N_2O_5$ are confined in a 1.0 L container and heated to 65°C. $k = 5.2 \times 10^{-3}$ s$^{-1}$ at 65°C.
3. In the reaction $CH_3Br (aq) + OH^- (aq) \rightarrow CH_3OH (aq) + Br^- (aq)$, when the $[OH^-]$ is doubled the rate doubles; when the $[CH_3Br]$ increases by a factor of 1.2, the rate increases by a factor of 1.2. Write the rate law for the reaction.
4. The following kinetic data were obtained for the reaction $A_2 (g) + 2 B_3 (g) \rightarrow \text{product}$:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Initial $[A_2]$, M</th>
<th>Initial $[B_3]$, M</th>
<th>Initial Rate, Ms$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.60</td>
<td>0.30</td>
<td>12.6</td>
</tr>
<tr>
<td>2</td>
<td>0.20</td>
<td>0.30</td>
<td>1.4</td>
</tr>
<tr>
<td>3</td>
<td>0.60</td>
<td>0.10</td>
<td>4.2</td>
</tr>
<tr>
<td>4</td>
<td>0.17</td>
<td>0.25</td>
<td>??</td>
</tr>
</tbody>
</table>

a. What is the order of the reaction with respect to each reactant, and the overall order of the reaction?
b. Write the rate law for the reaction.
c. Determine the value of the rate constant.
d. Use the data to calculate the reaction rate for experiment 4.

5. The following kinetic data were obtained for the reaction $NO_2 (g) + O_3 (g) \rightarrow NO_3 (g) + O_2 (g)$:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Initial $[NO_2]$, M</th>
<th>Initial $[O_3]$, M</th>
<th>Initial Rate, Ms$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$0.21 \times 10^{-3}$</td>
<td>$0.70 \times 10^{-3}$</td>
<td>6.3</td>
</tr>
<tr>
<td>2</td>
<td>$0.21 \times 10^{-3}$</td>
<td>$1.39 \times 10^{-3}$</td>
<td>12.5</td>
</tr>
<tr>
<td>3</td>
<td>$0.38 \times 10^{-3}$</td>
<td>$0.70 \times 10^{-3}$</td>
<td>11.4</td>
</tr>
<tr>
<td>4</td>
<td>$0.66 \times 10^{-3}$</td>
<td>$0.18 \times 10^{-3}$</td>
<td>??</td>
</tr>
</tbody>
</table>

a. Write the rate law for the reaction.
b. What is the overall order of the reaction?
c. Determine the value of the rate constant.
d. Use the data to calculate the reaction rate for exp't 4.

6. Determine the rate constants for the following first-order reactions:
a. $A \rightarrow B$, given that the concentration of $A$ decreases to one-half its initial value in 1000s.
b. $2A \rightarrow B + C$, given that $[A]_0 = 0.050$ M and that after 120 s $[B] = 0.015$ M.

7. Dinitrogen pentoxide, $N_2O_5$ decomposes by first-order kinetics with a rate constant of $3.7 \times 10^{-5}$ s$^{-1}$ at 298 K.
a. What is the half-life (in hours) for the decomposition of $N_2O_5$ at 298 K?
b. Calculate the concentration of $N_2O_5$ after 2.0 h if $[N_2O_5]_0 = 2.33 \times 10^{-2}$ M.
c. How much time, in min, will elapse before the $N_2O_5$ concentration decreases from $2.33 \times 10^{-2}$ to $1.76 \times 10^{-2}$ M?

8. For a second order reaction $A \rightarrow \text{products}$, $t_{1/2} = 50.5$ s (with $[A]_0 = 0.84$ M). Calculate the time required for the concentration of $A$ to decrease to (a) one-sixteenth; (b) one-fourth; (c) one-fifth of its original value.

9. Determine the rate constant for the following second-order reactions:
a. $2A \rightarrow B + 2C$, given that the concentration of $A$ decreases from $2.5 \times 10^{-3}$ to $1.25 \times 10^{-3}$ M in 100s.
b. $3A \rightarrow 2D + C$, given that $[A]_0 = 0.30$ M and that the concentration of $C$ increases to 0.010 M in 200 s.

10. The following data were obtained on the reaction $2A \rightarrow B$:

<table>
<thead>
<tr>
<th>Time, s</th>
<th>[A], mM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>14.1</td>
</tr>
<tr>
<td>10</td>
<td>7.8</td>
</tr>
<tr>
<td>15</td>
<td>5.3</td>
</tr>
<tr>
<td>20</td>
<td>4.0</td>
</tr>
</tbody>
</table>

a. Plot the data to determine the order of the reaction.
b. Determine the rate constant.

11. a. Calculate the activation energy for the conversion of cyclopropane to propene from an Arrhenius plot of the following data:

```
<table>
<thead>
<tr>
<th>T, K</th>
<th>k, s$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>$1.8 \times 10^{-4}$</td>
</tr>
<tr>
<td>800</td>
<td>$2.7 \times 10^{-3}$</td>
</tr>
<tr>
<td>850</td>
<td>$3.0 \times 10^{-2}$</td>
</tr>
<tr>
<td>900</td>
<td>$0.26$</td>
</tr>
</tbody>
</table>
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b. Calculate the value of the rate constant at 600°C.

12. The rate constant of the first-order reaction $2N_2O(g) \rightarrow 2N_2(g) + O_2(g)$ is $0.38$ s$^{-1}$ at 1000 K and $0.87$ s$^{-1}$ at 1030 K. Calculate the activation energy for this reaction.

13. At 800°C, $k = 9.7 \times 10^{10}$ M$^{-1}$s$^{-1}$ for the following reaction: $O (g) + N_2 (g) \rightarrow NO(g) + N (g)$ The activation energy for the reaction is 315 kJ/mol. Determine the rate constant at 700°C.
14. The contribution to the destruction of the ozone layer caused by high flying aircraft has been attributed to the following mechanism:

\[
\begin{align*}
\text{Step 1:} & \quad \text{O}_3 + \text{NO} \leftrightarrow \text{NO}_2 + \text{O}_2 \\
\text{Step 2:} & \quad \text{NO}_2 + \text{O} \leftrightarrow \text{NO} + \text{O}_2
\end{align*}
\]

a. What is the catalyst in this reaction?
b. What is the reaction intermediate?

c. What is the reaction intermediate?
25. An analysis of a reaction mixture at 500 K showed that it had the composition $4.8 \times 10^{-3}$ M H$_2$, $2.4 \times 10^{-3}$ M I$_2$, and $2.4 \times 10^{-7}$ M HI. Is this system at equilibrium? If not, is there a tendency to form more reactants or more products? The reaction is: H$_2$ (g) + I$_2$ (g) $\leftrightarrow$ 2 HI (g); $K_c = 160$.

26. Consider the following equilibrium: 2 SO$_3$ (g) + O$_2$ (g) $\leftrightarrow$ 2 SO$_4$ (g); $K_p = 3.0 \times 10^4$. A 500 mL reaction vessel at 700 K contains $1.20 \times 10^{-3}$ mol SO$_2$ (g), $5.0 \times 10^{-4}$ mol O$_2$ (g) and $1.0 \times 10^{-4}$ mol SO$_3$ (g). Will $P_{SO_3}$ increase with time?

27. A 25.0 g sample of solid ammonium carbamate, NH$_4$(NH$_2$CO$_3$), was placed in an evacuated 250 mL flask and kept at 25°C. At equilibrium, 17.4 mg of CO$_2$ was present. What is the value of $K_c$ for the decomposition of ammonium carbamate into ammonia and carbon dioxide?

28. In a gas-phase equilibrium mixture of H$_2$, I$_2$ and HI at 500 K, [HI] = $2.21 \times 10^{-3}$ M and [I$_2$] = $1.46 \times 10^{-3}$ M. What is the molar concentration of H$_2$ at equilibrium? $K_c = 160$ at 500 K.

29. In a gas-phase equilibrium mixture of PCl$_5$, PCl$_3$, and Cl$_2$ at 500 K, $P_{PCl5} = 0.15$ atm, and $P_{Cl2} = 0.20$ atm. What is the partial pressure of PCl$_3$ at equilibrium? PCl$_5$ (g) $\leftrightarrow$ PCl$_3$ (g) + Cl$_2$ (g); $K_p = 25$ at 500 K.

30. The initial concentration of HBr in a reaction vessel is $1.2 \times 10^{-3}$ M. The vessel is heated to 500 K.

Four gases, NH$_3$, O$_2$, NO, and H$_2$O are mixed in a reaction vessel and allowed to reach equilibrium in the following reaction: 4 NH$_3$(g) + 5 O$_2$(g) $\leftrightarrow$ 4 NO(g) + 6 H$_2$O (g). Certain changes are then made to the mixture (see table below). Considering each change separately, state the effect (increase, decrease, no effect) that each change has on the quantity in the second column. The temperature and volume are constant unless otherwise noted:

<table>
<thead>
<tr>
<th>Change</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>add NO</td>
<td>[H$_2$O]</td>
</tr>
<tr>
<td>remove H$_2$O</td>
<td>[NO]</td>
</tr>
<tr>
<td>remove O$_2$</td>
<td>[NH$_3$]</td>
</tr>
<tr>
<td>remove NH$_3$</td>
<td>$K_c$</td>
</tr>
<tr>
<td>add NH$_3$</td>
<td>[O$_2$]</td>
</tr>
</tbody>
</table>

31. Consider the following equilibrium: PCl$_5$ (g) $\leftrightarrow$ PCl$_3$ (g) + Cl$_2$ (g); $K_p = 0.36$ at 400 K. If 1.0 g of PCl$_5$ is initially placed in a 250 mL reaction vessel, determine the molar concentrations in the mixture at equilibrium. What percentage of PCl$_5$ is decomposed at 400 K?

32. A reaction mixture consisting of 0.400 mol of H$_2$ and 1.60 mol of I$_2$ is placed into a 3.00 L flask and heated.

H$_2$ (g) + I$_2$ (g) $\leftrightarrow$ 2 HI (g)

At equilibrium 60.0% of the H$_2$ had reacted. Determine $K_c$ for this reaction at this temperature.

33. For each of the following equilibria, state whether reactants or products will be favored by an increase in the total pressure resulting from a decrease in the volume of the container. If no change occurs, explain why.

a. 2 O$_2$(g) $\leftrightarrow$ 3 O$_3$(g)

b. H$_2$O(g) + C (s) $\leftrightarrow$ H$_2$(g) + CO (g)

c. 4 NH$_3$(g) + 5 O$_2$(g) $\leftrightarrow$ 4 NO(g) + 6 H$_2$O (g)

34. Four gases, NH$_3$, O$_2$, NO, and H$_2$O are mixed in a reaction vessel and allowed to reach equilibrium in the following reaction: 4 NH$_3$(g) + 5 O$_2$(g) $\leftrightarrow$ 4 NO(g) + 6 H$_2$O (g). Certain changes are then made to the mixture (see table below). Considering each change separately, state the effect (increase, decrease, no effect) that each change has on the quantity in the second column. The temperature and volume are constant unless otherwise noted:

<table>
<thead>
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<th>Change</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>add NO</td>
<td>[H$_2$O]</td>
</tr>
<tr>
<td>remove H$_2$O</td>
<td>[NO]</td>
</tr>
<tr>
<td>remove O$_2$</td>
<td>[NH$_3$]</td>
</tr>
<tr>
<td>remove NH$_3$</td>
<td>$K_c$</td>
</tr>
<tr>
<td>add NH$_3$</td>
<td>[O$_2$]</td>
</tr>
</tbody>
</table>

35. Predict whether each of the following equilibria will shift toward the products or reactants with a temperature increase, and whether the value of $K_c$ will increase or decrease.

a. N$_2$O$_4$(g) $\leftrightarrow$ 2 NO$_2$(g); $\Delta H = +57$ kJ

b. Ni (s) + 4 CO (g) $\leftrightarrow$ Ni(CO)$_4$(g); $\Delta H = -161$ kJ

36. A reaction mixture consisting of 2.00 mol of CO and 3.00 mol of H$_2$ are placed into a 10.0 L reaction vessel and heated to 1200 K and the following equilibrium is established: CO (g) + 3 H$_2$(g) $\leftrightarrow$ CH$_4$(g) + H$_2$O (g). At equilibrium, 0.478 mol of CH$_4$ was present in the system. Determine the values of $K_c$ and $K_p$ for the reaction:

37. 2.50 g of N$_2$O$_4$ and 0.33 g of NO$_2$ are placed in a 2.0 L reaction vessel and equilibrium is established:

N$_2$O$_4$(g) $\leftrightarrow$ 2 NO$_2$(g); $K_c = 4.66 \times 10^{-2}$ at 25°C. Determine the equilibrium concentrations of N$_2$O$_4$ & NO$_2$ at 25°C.
38. Give the conjugate base of the following acids: HSO₄⁻, H₂S, H₂PO₄⁻, NH₄⁺

39. Give the conjugate acid of the following bases: CN⁻, HCO₃⁻, SeO₄²⁻, PO₄³⁻

40. What are the concentrations of H₃O⁺ and OH⁻ in each of the following:
   a. 1.25 M HCl
   b. 0.25 M NaOH
   c. 0.035 M Ca(OH)₂
   d. 0.50 M HNO₃

41. A solution of washing soda (sodium carbonate) has a hydroxide-ion concentration of 0.0040 M. Calculate the pH of this solution at 25°C.

42. The pH of a cup of coffee (at 25°C) was found to be 5.12. Calculate the hydrogen ion concentration in the coffee.

43. Acrylic Acid, H₃C=H₂O₂ is used in the manufacture of plastics. A 0.10 M aqueous solution of acrylic acid has a pH of 2.63. Calculate Kₐ and the percent dissociation of acrylic acid.

44. Write the balanced chemical equations describing the ionization of the following weak acids. In each case identify the acid, the base, the conjugate acid, and the conjugate base.
   a. HOCN (cyanic acid)
   b. HIO₃
   c. HBrO
   d. HCO₂H

45. C₆H₄NH₂COOH, para-aminobenzoic acid (PABA), is used in some sunscreens. Calculate the concentrations of H₃O⁺ and para-aminobenzoate ion, C₆H₄NH₂COO⁻, in a 0.050 M solution of the acid. Kₐ = 2.2 x 10⁻⁵

46. Calculate the % ionization and pH of propionic acid (HC₃H₅O₂) in a 0.45 M solution. For the acid, pKₐ = 4.89.

47. Write the chemical equation for the base ionization of ethylamine, C₂H₅NH₂. Write the Kₐ expression for ethylamine.

48. What is the concentration of hydroxide ion in a 0.080 M aqueous solution of methylamine, CH₃NH₂? What is the pH of this solution? Kₐ = 4.38 x 10⁻⁴

Review for Exam 1 - Answers to Review Problems

1. (a) 1.0 x 10⁻³ mol O₃/Ls; (b) 0.28 mol CrO₄²⁻/Ls
2. 9.9 x 10⁻⁵ mol N₂O₅/Ls
3. Rate = k[CH₃Br][OH⁻]
4. (a) 2nd order WRT A₂, 1st order WRT B₃, 3rd order overall; (b) Rate = k[A₂]²[B₃];
   (c) 1.2 x 10² M⁻²s⁻¹; (d) 0.87 Ms⁻¹
5. (a) Rate = k[NO₂][O₂]; (b) 1st order WRT each reactant, 2nd order overall; (c) 4.3 x 10⁷ M⁻¹s⁻¹; (d) 5.1 Ms⁻¹
6. (a) 6.93 x 10⁻⁴ s⁻¹; (b) 7.6 x 10⁻³ s⁻¹
7. (a) 5.2 h; (b) 1.79 x 10⁻² M; (c) 126 min
8. (a) 7.6 x 10⁻² s; (b) 1.5 x 10⁻⁷ s; (c) 2.0 x 10⁻⁷ s
9. (a) 4.0 M⁻¹s⁻¹; (b) 1.9 x 10⁻³ M⁻¹s⁻¹
10. (a) 1/[A] vs. t gives straight line, therefore 2nd order reaction; (b) slope = k = 12 M⁻¹s⁻¹
11. (a) plot ln k vs. 1/T, slope = -Eₐ/R = 275 kJ/mol; (b) 8.8 x 10⁻² s⁻¹
12. 2.4 x 10² kJ/mol
13. 2.6 x 10⁸ M⁻¹s⁻¹
14. (a) NO; (b) NO₂
15. 3.3 x 10⁶
16. (a) Rate = k[NO]², bimolecular; (b) Rate = k[Cl₂], unimolecular; (c) Rate = k[NO₂]², bimolecular
17. (a) Rate = k[NO][Cl₂]; (b) Step 2 must be the slow (R.D.S.) step, step 1 a fast step
18. 8.0 x 10⁻⁶ Ms⁻¹
19. (a) 0.0506 mg; (b) 0.106 atm
20. Yes, Rate = k[(CH₃)₂CCl]
21. (a) Kₐ = [COCl][Cl]/[CO][Cl₂]; (b) Step 2 must be the slow (R.D.S.) step, step 1 a fast step
22. 8.0 x 10⁻⁶ Ms⁻¹
23. 48.8; 48.9; 48.9
24. 6.9 x 10⁻⁻; 6.40
25. no, Q < Kₐ products
26. Q < K, yes
27. 2.09 x 10⁻⁻ M
28. 19 atm
29. 0.0018 % - approximately 0 %
30. [PCl₂] = [Cl₂] = 1.0 x 10⁻² M; [PCl₃] = 9.0 x 10⁻³ M; 53 % decomposed
31. 1.06
32. Reactants; Reactants; Reactants
33. Decrease; Increase; Increase; No Change; Decrease
34. Products, Kₐ will increase; Reactants, Kₐ will decrease
35. 3.88; Kₐ = 4.00 x 10⁻⁻⁴
36. [NO₂] = 7.1 x 10⁻⁻³ M; [N₂O₄] = 1.2 x 10⁻² M
37. SO₄²⁻; HS⁻; HPO₄²⁻; NH₃
38. HCN; H₂CO₃; HSeO₄⁻; HPO₄²⁻
39. (a) [H⁺] = 1.25 M, [OH⁻] = 8 x 10⁻¹⁵ M; (b) [H₂O⁺] = 4 x 10⁻¹⁴ M, [OH⁻] = 0.25 M;
   (c) [H₂O⁺] = 1.4 x 10⁻⁻⁻⁻³ M, [OH⁻] = 0.070 M; (d) [H₂O⁺] = 0.50 M, [OH⁻] = 2 x 10⁻⁻¹⁴ M
40. 1.160
41. 7.6 x 10⁻⁻⁶ M
42. 5.4 x 10⁻⁻⁻, 2.3%
43. (a) HOCl (aq) + H₂O (l) ↔ OCNO⁻ (aq) + H₂O⁺ (aq); (b) HIO₃ (aq) + H₂O (l) ↔ IO₃⁻ (aq) + H₂O⁺ (aq)
   (c) HBrO (aq) + H₂O (l) ↔ BrO⁻ (aq) + H₂O⁺ (aq); (d) HCO₂H (aq) + H₂O (l) ↔ CO₂H⁻ (aq) + H₂O⁺ (aq)
44. 1.0 x 10⁻⁻⁻⁻ M
45. 0.53 %, pH = 2.62
46. C₃H₇NH₂ (aq) + H₂O (l) ↔ C₃H₇NH₃⁺ (aq) + OH⁻ (aq); Kₐ = [C₃H₇NH₃⁺][OH⁻]/[C₃H₇NH₂]
47. 0.0058 M, pH = 11.76