CH40S **Exam Review**

Aqueous Reactions

1. Sulfuric acid is a strong electrolyte when it dissolves in water. Write an equation to show what this means. How could you prove that sulfuric acid is a strong electrolyte?

2. Write a balanced equation to illustrate the neutralization reaction that occurs between the following acids and bases.
   a. magnesium hydroxide and hydrogen bromide
   b. phosphoric acid and sodium hydroxide
   c. sulfuric acid and aluminum hydroxide

3. If 2.56 g of KOH is used to make 125 mL of solution, what will be the concentration of the solution?

4. How much water must be added to 25.0 mL of 6.0 mol/L H_2SO_4 solution to make a 1.0 mol/L solution?

5. What volume of 2.0 mol/L H_2SO_4 is required to neutralize 100 mL of 5.0 mol/L NaOH solution?

6. What volume of 2.50 mol/L H_2SO_4 is required to neutralize 2.50 g of $NaOH_{(s)}$?

7. How many mL of 0.240 mol/L $Mg(OH)_2$ can be neutralized by 50.0 mL of 0.250 mol/L H_3P0_4?

8. How many grams of $Ba(OH)_{2(s)}$ can be neutralized by 75.0 mL of 0.250 mol/L H_3P0_4?

9. What is the concentration of a sulfuric acid solution, if 25.0 mL of it is neutralized by 45.0 mL of 0.24 mol/L $Ga(OH)_3$ solution?

10. Why does the solubility of a solid in water generally increase with temperature? Explain.

11. Write equations to show how each of the following dissolves in water:
    a. sodium sulfate
    b. Copper(II) sulfite
    c. $Na_2C_20_4$
    d. $Mg(N0_3)_2$

12. Write correct formulas for each of the following and determine if they have a high solubility in water.
    a. chromium(II) chloride
    b. magnesium carbonate
    c. silver sulfide
    d. ammonium phosphate
    e. aluminum hydroxide
    f. sodium hydrogen carbonate

13. Write a complete set of balanced equations to show what happens when aqueous solutions of the following are mixed.
    a. lead (II) nitrate and potassium chloride
    b. aluminum sulfate and barium bromide
    c. mercurv(l) nitrate and potassium chloride
    d. iron(III) chloride and sodium hydroxide

14. For the following reactions:
    i. Give the oxidation numbers of all the elements involved.
    ii. Identify the elements being reduced and oxidized.
    iii. Identify the oxidizing agent and the reducing agent.

    a. $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$
    b. $2CrO_2^- + 3ClO^- + 2OH^- \rightarrow 2CrO_4^{2-} + 3Cl^- + H_2O$

15. Balance the following reactions:
    a. $MnO_4^- + VO^{2+} \rightarrow VO_2^+ + Mn^{2+}$ (acid)
    b. $P_4 \rightarrow PH_3 + H_2PO_2^-$ (basic)
    c. $MnO_2 + SO_3^{2-} \rightarrow SO_4^{2-} + Mn(OH)_2$ (basic)
    d. $MnO_4^- + H_2O_2 \rightarrow Mn^{2+} + O_2$ (acid)
    e. $Mn^{2+} + HBiO_3 \rightarrow Bi^{3+} + MnO_4^-$ (acid)
    f. $Zn + H_2O \rightarrow Zn(OH)_4^{2-} + H_2$ (basic)

<u>Atomic Structure</u>

1. What is the relationship between Wavelength, Frequency and Energy in terms of electromagnetic radiation.

2. What is the difference between a continuous spectrum and a line spectrum?

3. How are line spectra formed? (ie. How are the different colours of light created)

4. Make a list of the different models of the atom and the scientist who developed them.

5. List the different types of electron orbitals, which energy level they are found in, and how many there can be in any energy level.

6. What does “n” represent in terms of atomic structure?

7. How can you determine the number of orbitals that an energy level has?

8. Give the formula for two ions, one positive and one negative, that have the same electron configuration as Krypton

9. How many electrons can have the designation:
    a. 6f
    b. 3p
    c. $4d_{xz}$
    d. n=3

10. Give the **<u>complete</u>** electron configuration for each of the following.
    a. Potassium
    b. Argon
    c. Chromium
    d. P^{2-}
    e. Se^{2+}
    f. Ag^+

11. Write the **valence** electron configurations for each of the following.
    a. Sulfur
    b. Lead
    c. Zinc
    d. Bromine

12. How many unpaired electrons are present in each of the atoms in #2?
    a. Sulfur
    b. Lead
    c. Zinc
    d. Bromine

13. Write the noble gas configuration for the following:
    a. Chlorine
    b. Selenium
    c. Sodium
    d. Cobalt

14. What is a polar molecule? How are they formed?

15. Predict the bond character for:
    a. H_2O
    b. N_2
    c. $AlCl_3$

16. State and explain the trends in:
    a. Electronegativity
    b. Atomic Radius
    c. Ionic Radius
    d. First Ionization Energy

Kinetics

1. State 5 factors that determine the rate of a chemical reaction.

2. State the collision theory of a chemical reaction.

3. According to the collision theory reaction rate depends on which two factors?

4. What Two factors determine the effectiveness of a collision?

5. What is a reaction mechanism?

6. What is the rate determining step in a reaction mechanism?

7. What two things about the nature of the reactants determines the reaction rate?

8. Draw an energy distribution curve for two temperatures, a low one and a high one. Use the graph to show how temperature influences reaction rate.

9. Draw an energy distribution curve for a reaction showing the activation energy without and with a catalyst. Use the graph to explain how a catalyst influences reaction rates.

10. Draw a reaction coordinate graph for an exothermic reaction.
    a) Indicate the position of the reactants, products and the activated complex.
    b) Indicate the following energies: KJ/mol reactants, KJ/mol products and the Δ H.

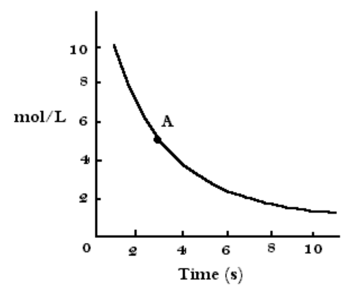
c) Draw the same graph in reverse and determine the energies and the type of graph produced.

11. 3A → 2B. If [A] drops from 0.505M to 0.495 M in 1.8 minutes. What is the average rate of formation of B during this time interval (in M/s)?

12. For the reaction $2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$ the following data was obtained:

Expt	**[NO]**	**[Cl_2]**	**rate M/s**
1	0.010	0.010	1.2×10^{-4}
2	0.010	0.020	2.3×10^{-4}
3	0.020	0.020	9.0×10^{-4}

a) What is the rate law for this reaction?
b) What is the overall order for this reaction?
c) What is the value of k?



13. Determine the rate of reaction at point A on the graph at the right

14. Define rate in words and with an equation

15. For the reaction 2A + 3B C + 2D the initial [A] was 0.25M and 80 seconds later the [A] was 0.050M. What was the average rate of reaction for each of the four substances?

16. From the data below:
    a) determine the average rate of reaction for the interval from 20 to 40 seconds and from the interval of 40 to 60 seconds.
    b) Graph [A] versus time.
    c) Use your graph to find the instantaneous reaction rate at t=40s.

Time (s)	0.000	20.000	40.000	60.000	80.000
[A] (M)	0.340	17.000	0.092	0.052	0.028

17. For the rate law with respect to reactant A write the rate law if it is:
    a) **zero** order
    b) **firs**t order
    c) **second** order

18. From the table below
    a) Determine the order of the reaction with respect to each of the three reactants.
    b) State the overall rate law for this reaction.
    c) Evaluate the rate constant k.
    d) Find the rate of the reaction when [A] – 8.0M, [B] = 10.0M and [C] = 3.0 M.

Trial	**[A]**	**[B]**	**[C]**	**Rate of Reaction M/s**
1	6.000	12.600	2.000	0.045

2	12.000	12.600	2.000	0.090
3	12.000	4.200	2.000	0.010
4	12.000	4.200	4.000	0.010

19. For the data below

Time (s)	**0**	**20**	**40**	**60**	**80**	**100**
[A] (M)	2.00	1.64	1.34	1.10	0.90	0.74

a) sketch a graph of [A] vs. t. What is the order of the reaction with respect to A?
b) Determine the rate law.
c) Find the rate law constant.
d) Sketch the graph of reaction rate vs. [A].

Chemical Equilibrium

1. Describe equilibrium as completely as possible.

2. Describe Le Chatelier's Principle.

3. Explain how each of the following affect the rate of a system at equilibrium?
   a) temperature changes
   b) concentration changes
   c) pressure changes
   d) presence of a catalyst

4. Give the mass action expression for the following reactions:
   a) $2N_2O_{5\,(g)} \leftrightarrow 2N_2O_{4\,(g)} + O_{2\,(g)}$
   b) $Bi_2S_{3\,(s)} + 6H^+_{(aq)} \leftrightarrow 2Bi^{3+}_{(aq)} + 3H_2S_{(g)}$

5. Consider the following reaction:
   $$H_{2(g)} + CO_{2(g)} \leftrightarrow H_2O_{(g)} + CO_{(g)}$$
   Two moles of each reactant are allowed to react in a 0.5L container until equilibrium is established. If the equilibrium concentration of CO_2(g) is 0.78M.
   a) What is the equilibrium concentration of each of the other substances?
   b) What is the Kc?

6. Consider the following reaction taking place in a closed container and at equilibrium:
   $$2A + 2B \leftrightarrow C + 2D$$
   The [C] was 3.5 M, [D] was 1.9M and the [A] was 2.6M. The equilibrium constant is 0.78 at this particular temperature. What was the [B]?

7. Kc= 5.0×10^{-5} for the reaction:
   $$2NO_{(g)} + O_{2(g)} \leftrightarrow 2NO_{2(g)}$$
   If we have [NO] = 4.0×10^{-3}M , [O_2] = 3.4×10^{-4}M, [NO_2] = 2.1×10^{-3}M.
   a. Is the system at equilibrium?
   b. If not, which way will the reaction shift to obtain equilibrium?

8. For the reaction: A + B ↔ C + D, the Kc is 64 at a certain temperature. Suppose 6.0 moles of each reactant was placed into a 4.0 L reaction chamber and allowed to go to equilibrium. Find the number of moles of each substance present at equilibrium.

9. For the reaction
   $$2\,A_{(g)} + B_{(g)} \leftrightarrow 2\,D_{(g)} \qquad \Delta H = -74.6\text{ kJ}$$
   Predict the effect on the position of the equilibrium that results from
   a) increasing the total pressure by decreasing volume.
   b) injecting more B gas without changing the volume.

c) increasing the temperature.
d) increasing the volume of the container.
e) adding a catalyst.
f) adding more D gas without changing the volume.

10. Consider the reaction A + H $\leftrightarrow$ B taking place in a closed vessel and at equilibrium. Suppose at equilibrium there is more of A than B.
    a) Draw a reaction rate versus time graph showing the system at equilibrium initially, then responding to a decrease of A and reaching equilibrium again.
    b) Draw a concentration versus time graph showing the system at equilibrium responding to an increase of temperature and returning to equilibrium again.

11. For the following reaction,

$$A_{(g)} + B_{(g)} \leftrightarrow 2\,C_{(g)} \qquad K_C = 41.3.$$

If initially [A] = 1.5 mol/L and [B] = 1.5 mol/L, find the equilibrium concentrations of A, B and C.

12. Each of the following reactions has come to equilibrium. What will be the effect on the equilibrium amount of each substance in the system when the change described below ismade?
    a) $2H_{2(g)} + 2NO_{(g)} \leftrightarrow N_{2(g)} + 2H_2O_{(g)}$ pressure is increased
    b) $SO_{2(g)} + ½\,O_{2(g)} \leftrightarrow SO_{3(g)}$ + 23 Kcal temperature is increased
    c) $P_{4(g)} + 6H_{2(g)} \leftrightarrow 4PH_{3(g)}$ H_2 gas is added
    d) $FeO_{(s)} + CO_{(g)} \leftrightarrow Fe_{(s)} + CO_{2(g)}$ Fe is removed as rapidly as it is formed.

13. Write Ksp expressions for the following:
    a) $PbS0_{4(s)} \leftrightarrow Pb^{2+}{}_{(aq)} + S0_4{}^{2-}{}_{(aq)}$
    b) $Mg(OH)_{2(s)} \leftrightarrow Mg^{2-}{}_{(aq)} + 2OH^-{}_{(aq)}$

14. Write the equation representing the dissolving of the following solids in water and the Ksp expression for each.
    a) silver phosphate
    b) aluminum carbonate

15. Chalk is $CaCO_3$ (Ksp = 8.7×10^{-9}) what is:
    a) the molar solubility of $CaCO_3$?
    b) the number of grams of $CaCO_3$ that will dissolve in 100 mL of water?

16. If the solubility of $PbSO_4$ in water is 0.0350 g/L, calculate the Ksp for $PbSO_4$

17. At 25 °C the molar solubility of Ag_3PO_4 is 1.8×10^{-3} mol/L. Calculate the Ksp for this salt.

18. If the solubility of lead hydroxide is 7.04 x 10-4 g/300 mL. Calculate the Ksp for this salt.

19. Barium sulfate, $BaSO_4$, is so insoluble that it can be swallowed without significant danger, even though Ba^{2+} (aq) is toxic. At 25 °C, 1.00 L of water dissolved only 0.00245 g of $BaSO_4$.
    a) how many moles of $BaSO_4$ dissolve per litre?
    b) what is the $[Ba^{2+}]$ and $[S0_4{}^{2-}]$
    c) calculate the Ksp for $BaSO_4$

20. Calculate the mass of $BaC0_{3(s)}$ that will dissolve in 100 mL of water. $K_{sp} = 1.6 \times 10^{-9}$

21. From the given solubilities determine the value of the solubility product constant.
    a) AgI, 2.88×10^{-7} g/100 mL
    b) CaF_2, 1.7×10^{-3} g/200 mL
    c) Ag_2CO_3, 1.2×10^{-4} mol/L

22. Experiments show that 0.0059 g of $SrCO_3$ will dissolve in 250 mL of water. What is the Ksp for $SrCO_3$?

23. Magnesium hydroxide, $Mg(OH)_2$, found in milk of magnesia, has a solubility of 7.05 x 10^{-3} g/L at 25 °C.
    a) what is the solubility in mot/L
    b) what is the $[Mg^{2+}]$ and $[OH^-]$
    c) calculate the Ksp

Acid and Base Equilibrium

1. A student is given a clear colorless aqueous solution . Explain how you would identify it as:
    (a) a strong acid
    (b) a weak base
    (c) a solution that is neither an acid or a base.

2. Write a short note to explain what each of the following mean:
    (a) Strong
    (b) Dilute
    (c) Weak
    (d) Concentrated

3. Nitric acid dissolves in water and. produces a hydronium ion and a nitrate ion. Write an equation to illustrate this.

4. $HClO_3$ is a strong acid . Write an equation for its reaction with water.

5. Phosphoric acid is a weak acid that undergoes ionization (donates a proton) in three steps. Write an equation for each step.

6. Write a balanced equation to illustrate each of the following:
    (a) The dissolving of the strong acid , HBr, in water.
    (b) The reaction of (i) NH_3 and (ii) $C0_3^2$- with water to produce hydroxide ions.
    (c) The dissociation of $Ca(OH)_2$ in water.
    (d) The reaction of magnesium with hydrochloric acid.

7. Write the formula for the conjugate base for each of the following Bronsted-Lowry acids.
    (a) H_2O (b) HNO_2 (c) NH_4^+ (d) H_3P0_4

8. Write the formula for the conjugate acid of each of the following Bronsted--Lowry bases.
    (a) $S0_4^{2-}$ (b) NH_3 (c) $HP0_4^{2-}$ (d) HO_2^-

9. In the following equation , identify the two Bronsted-Lowry acids and the two Bronsted-Lowry bases.
$$HS0_4^-(aq) + P0_4^{3-}(aq) \leftrightarrow SO_4^{2-}(aq) + HPO_4^{2-}(aq)$$

10. Identify the conjugate acid-base pairs in the following reaction.
$$C_2H_3O_2^-\ (aq) + H_3O^+\ (aq) \leftrightarrow HC_2H_3O_2\ (aq)\ \ H_2O\ (l)$$

11. Write equations to show each of the following acting as a base in aqueous solutions:
    (a) F^- (b) NO_2^- (c) LiOH
12. Identify the conjugate acid--base pairs in the following reaction.
$$HCO_3^-\ (aq)\ HSO_4^-\ (aq) \leftrightarrow H_2CO_3(aq) + S0_4^{2-}\ (aq)$$

13. Give the conjugate base of:
    (a) HCO_3^- (b) HCN (c) H_5IO_6 (d) NH_4^+

14. Write an equation to show the ionization of ammonia in water as an equilibrium.

15. Rank the following acids in order of decreasing strength:
    $HClO_4$ (aq), NH_3 (aq), HNO_2 (aq), H_2S (aq)

16. Rank the following bases in order of decreasing strength:
    Cl^- (aq), $HC0_3^-$ (aq), OH- (aq), $C0_3^{2-}$ (aq), NH_2^- (aq)

17. Calculate the concentration of the excess ion (H_30+ or OH^-) when 20.0 mL of 0.45 mol/L HCl solution is mixed with 30.0 mL of 0.32 mol/L NaOH solution.

18. Write the Ka expression for each of the following:
    (a) nitrous acid (b) carbonic acid (c) monohydrogen phosphate ion.

19. For each of the following,
    i. complete the reaction
    ii. identify the two B-L bases
    iii. determine which side is favoured.

    (a) H_3P0_4(aq) + HS^-(aq) ↔
    (b) $HS0_3^-$(aq) + NH_4^+(aq) ↔
    (c) $HP0_4^{2-}$(aq) + $HC0_3^-$ (aq) ↔
    (d) $Al(H_2O)_6^{3+}$ (aq) + HTe-(aq) ↔

20. Write equations for a $H_2PO_4^{2-}$ ion reacting with water when:
    (a) the ion acts as an acid
    (b) the ion acts as a base.

21. Complete: H_2S(aq) + NH_3(aq) ↔
    (a) identify the strongest acid
    (b) identify the two B-L bases
    (c) which side is favoured?

22. Consider: H_2S(aq) + H_20(1) ←→ H_3O^+(aq) + HS^-(aq) Using Le Chatelier's principle, decide whether the [H_30^+] will be larger or smaller if solid NaHS is dissolved into the H_2S solution.

23. Bromothymol blue (HBb) is an indicator. If it is yellow in an acid and blue in a base, explain which species in the equilibrium accounts for each colour.

24. Use Le Chatelier's principle to explain the change in [H_3O^+] observed when NH_4Cl(s) is added to an NH_3, (NH_40H) solution.

25. If methyl orange (HMo) is an indicator and is yellow at high [H_3O^+] and red in a low [H_3O^+] explain what colour it will show and why in
    (a) KOH
    (b) H_3PO_4.

    Justify your answer.

26. Given 100 mL of water:
    (a) Write an equilibrium equation for the dissociation of water
    (b) Describe in terms of Le Chatelier's Principle how the addition of some:
        i. HCI(g) will affect the [OH^-] (aq), and the [H_30^+](aq).
        ii. NH_4Cl(s) will affect the [OH^-](aq), and the [H_3O^+](aq).

27. The formation of products is strongly favoured in this acid-base system:
    HX(aq) + B-(aq) ←→HB(aq) + X-(aq)

(a) Identify the bases competing for hydrogen ions
(b) Which base is stronger?
(c) Which is the weaker acid, HX or HB? D
(d) Des the K for this system have a large or small value?
(e) How is the equilibrium affected by the addition of the soluble salt NaB?

28. Calculate the pH of a blood specimen containing 7.2 x 10-8 mol H_3O^+/ L

29. Find the values of [H30+] that have each of the following pH values and identify them as acidic, basic or neutral.
    (a) 3.85 (pH of sourkraut)
    (b) 11.61 (pH of household ammonia)
    (c) 4.11 (pH of orange juice)
    (d) 8.30 (pH of high lime soils)

30. Nicotinic acid, $HC_2H_4NO_2$, is a B-vitamin. It also is a weak acid with Ka = 1.4 x 10^{-5}. What is the [H_30^+] and the pH of a 0.010 mol/L solution?

31. What is the pH of a 0.0050 mol/L solution of $HN0_3$?

32. What is the percent ionization in a 0.15 mol/L solution of HF? What is the pH of this solution?

33. Calculate the percent ionization of $HS0_3^-$ into in a 0.010 mol/L solution. What is the pH of this solution?

34. The ionization constant for cacodylic acid, HAs, is 6.4 x 10-7, What is the [H_30^+] and the pH of a 0.30 mol/L solution of this acid?

35. A weak acid HX is a weak acid. A 0.150 mol/L solution is 4.5 % dissociated. What is the Ka for this acid?

36. Given that HB is a weak acid, calculate the Ka for HB from the fact that 0.10 mol/L HB has a pH of 4.2

37. The [H_3O^+] of a 0.10 mol/L solution of a weak acid HY is found to be 0.00050 mol/L. What will be:
    (a) [Y^-]
    (b) Ka
    (c) pH
    (d) [OH]

38. A solution of acetic acid is 1.2 % ionized. Determine the [H_3O^+], [OH^-] and pH of a 0.26 mol/L solution of the acid.

39. A solution of hydrofluoric acid contains 2.0 g of HF per litre and has a pH of 2.2, what is the dissociation constant, Ka, for HF?

40. Hypobromous acid, (HBrO) has a dissociation constant of 2.0 X 10^{-9}. A solution of HBrO has a pH of 4.8. What is the concentration of the solution?

41. Calculate the pH of each of the following solutions:
    (a) 0.010 of/L HCI
    (b) 0.50 mol/L CH3COOH
    (c) 0.50 mol/L NaOH
    (d) 0.10 mol/L NH4OH.

Oxidation-Reduction

1. Refer to your reduction potential table to determine if a spontaneous reaction will occur when the following are mixed together. If a reaction does occur write the net reaction.
    a. Ni^{2+} + Al
    b. Ag + Cu^{2+}
    c. Sn + I^-

d. Li + Zn^{2+}

2. Will the following reactions proceed spontaneously in the forward or reverse direction
   a. $Cr_2O_7^{2-}$ + Fe^{2+} + $14H^+$ $\rightarrow$ $2Cr^{3+}$ + $6Fe^{3+}$ + $7H_2O$
   b. $3Cu^{2+}$ + 2NO + $4H_2O$ $\rightarrow$ 3Cu + $2NO_3^-$ + $8H^+$

3. For the example***:***

   Cr(s) + Pb2+ ←→ Cr3+ + Pb (s)

   a. Draw an electrochemical cell that utilizes the above reaction.
   b. Label the anode and the cathode.
   c. Indicate the direction of electron flow.
   d. Write each half-reaction.
   e. Write a balanced net equation.
   f. Calculate the voltage.
4. Calculate the E° values of the following reactions and predict if the reaction is spontaneous in the forward or reverse direction:
   a. MnO_2 + $4H^+$ + $2Cl^-$ $\rightarrow$ Mn^{2+} + Cl_2 + $2H_2O$
   b. $2Fe^{3+}$ + $2I^-$ $\rightarrow$ $2Fe^{2+}$ + $I_2(s)$