Recitation Worksheet Twelve

Name: 　　　　　　　　MyID:

Textbook:
Chemistry & Chemical Reactivity
by John C. Kotz, Paul M. Treichel, John R. Townsend, David Treichel
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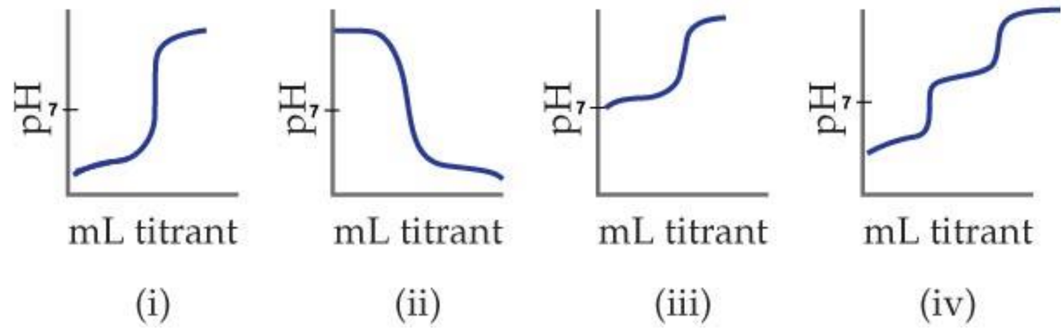
Instructions:

- This recitation worksheet covers Ch. 16.5, 17.1-17.2
- Please enter your first and last name as it appears on the eLC roster (do not use a nickname that is not reflected in eLC).
- Your UGA myID is a combination of letters and numbers (example: Dr. Abdelrahman's MyID is ema88805@uga.edu). **Do not use your 81x number**.
- Your completed worksheet has to be submitted to **Gradescope**. You have multiple options for submission:
    - You may use an app to annotate the worksheet by placing your answers in the answer boxes and showing your work when appropriate. Afterward, submit the worksheet to Gradescope. You will not need to upload anything to eLC.
    - You may print out the worksheet, write your answers in the answer boxes, and show your work on it when appropriate. Afterward, convert the worksheet to a PDF and submit to Gradescope. You will not need to upload anything to eLC.
    - If you do not have access to a printer, you may type your answers directly into the worksheet PDF and then submit it to Gradescope. Write your work on separate sheets of paper, convert them to a PDF, and upload to the appropriate dropbox on eLC.
    - There is a Gradescope app available for both iOS and Android devices that allows you to scan and submit your printed work, or you can submit your fillable PDF directly.
- The following criteria **must** be met to be eligible for full credit:
    - You must make sure the pages are in the correct order and have the same layout as the original worksheet when submitting to Gradescope regardless of your submission type.
    - Answers must be written in the corresponding answer boxes.
    - You must show your work when appropriate.
- This worksheet is due no later than **12:00 PM (noon) on the Saturday, November 16th.**
- A periodic table and formula sheet are attached to the end of this worksheet. Please keep these attached to your worksheet in the correct order when submitting to Gradescope.

1. Which of the aqueous solutions below are buffer solutions? Select all that apply. Insert letters without spaces in the answer box, example **ABCD.**

   A. 0.100 M KBr
   B. 0.200 M NaCl and 0.200 M NH_4Cl
   C. 0.100 M CH_3NH_2 and 0.150 M $CH_3NH_3^+Cl^-$
   D. 0.100 M HCl and 0.050 M $NaNO_2$
   E. 0.100 HCl and 0.200 M $NaCH_3COO$
   F. 0.100 M Na_2HPO_4 and 0.100 M NaH_2PO_4
   G. 0.100 M CH_3COOH and 0.100 M $NaCH_3CH_2COO$

2. Match the titrations curves (i-iv) to the appropriate description (A-E).



A. Titration of a strong base with a strong acid.

B. Titration of a weak acid with a strong base.

C. Titration of a strong acid with a strong base.

D. Titration of a polyprotic acid with a strong base.

3. In the laboratory, you were asked to prepare a buffer solution with pH = 10.50. How many **grams** of NH_4Cl (molar mass = 53.5 g/mol) would you add to 625 mL of 0.258 M NH_3 to prepare a buffer with pH = 10.50? Assume that the solution's volume remains constant. K_b of NH_3 = 1.8×10^{-5}.

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4. If 0.100 M of the solutions below were provided to you, which **two solutions** would you use to prepare a buffer with pH = 3.50? Select all that apply. Insert letters without spaces in the answer box, example **AB.**

   A. Formic acid (HCOOH, pK_a = 3.74)
   B. Acetic acid, (CH_3COOH, pK_a = 4.74)
   C. Phosphoric acid (H_3PO4, pK_{a1} = 2.15)
   D. Sodium acetate ($NaCH_3COOH$)
   E. Sodium formate (NaHCOO)
   F. Sodium dihydrogen phosphate (NaH_2PO_4)

5. Calculate the final **pH** in each of the titration scenarios below:

   A. The titration of 25.00 mL of 0.160 M HCl with 15.00 mL of 0.242 M NaOH.

   B. The titration of 25.00 mL of 0.100 M CH_3COOH (K_a of CH_3COOH = 1.7 x 10^{-5}) with 12.5 mL of 0.200 M NaOH.

6. What is the pH of a mixture of 0.012 M of C_6H_5COOH ($K_a = 6.3 \times 10^{-5}$) and 0.033 M NaC_6H_5COO?

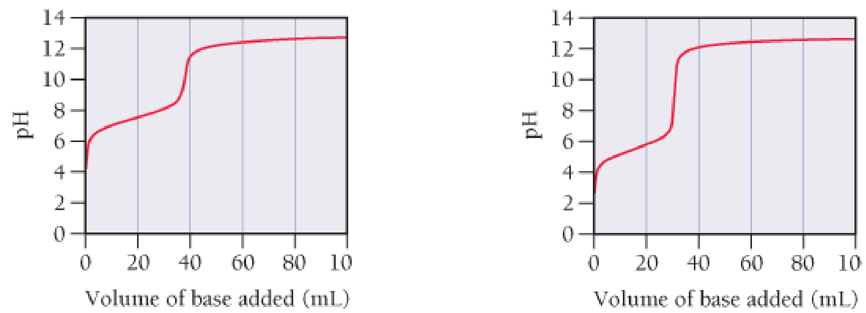
7. A solution is prepared by dissolving 0.23 mol of hypochlorous acid and 0.27 mol of sodium hypochlorite in water sufficient to yield 1.00 L of solution. The addition of 0.05 mol of HCl to this buffer solution causes the pH to drop slightly. The pH does not decrease drastically because the HCl reacts with the ________ present in the buffer solution. The K_a of hypochlorous acid is 1.36×10^{-3}.
   A. H_2O
   B. H_3O^+
   C. Hypochlorite ion
   D. Hypochlorous acid
   E. This is a buffer solution. The pH does not change upon addition of acid or base.

8. In which of the solutions given below would nitrous acid (HNO_2) ionize *less* than it does in pure water?
   A. NaCl
   B. KNO_3
   C. KNO_2
   D. $NaClO_4$

9. To a 0.300 L buffer solution consisting of 0.250 M CH_3COOH and 0.560 M $NaCH_3COO$, 0.0060 mol HCl is added. What are the moles and concentration of CH_3COOH after the addition of HCl? Assume that the volume of the buffer does not change upon the addition of HCl.

A. 0.0060 mol, 0.020 M
B. 0.162 mol, 0.54 M
C. 0.081 mol, 0.27 M
D. 0.075 mol, 0.250 M
E. 0.168 mol, 0.560 M

10. You are provided with the titration curves I and II for two weak acids titrated with 0.100 M NaOH. Refer to the titration curves to answer the following questions:



I II

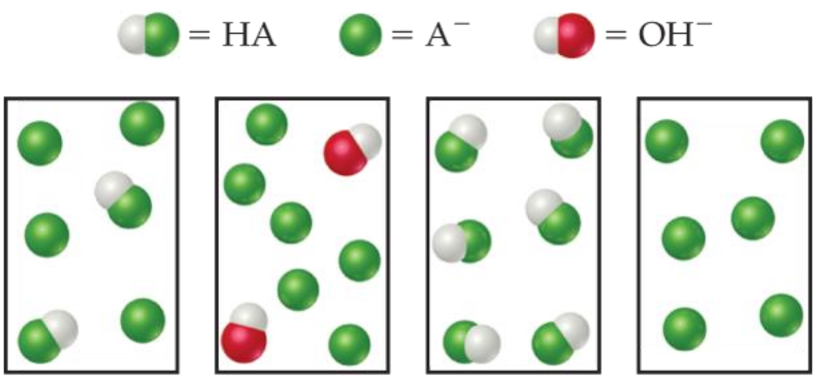
A. Which acid is more concentrated?

B. Which acid has the larger K_a?

11. Which solution has the **greatest** buffering capacity?

A. 0.335M $HC_2H_3O_2$ and 0.497 M $NaC_2H_3O_2$
B. 0.520 M $HC_2H_3O_2$ and 0.116 M $NaC_2H_3O_2$
C. 0.820 M $HC_2H_3O_2$ and 0.715 M $NaC_2H_3O_2$
D. 0.120 M $HC_2H_3O_2$ and 0.115 M $NaC_2H_3O_2$

12. A strong base such as KOH is mixed in a specific proportion with the weak acid HA to make a buffer. Which of the diagrams below is a correct representation of the buffer solution?



A B C D

13. What change will be caused by addition of a small amount of HCl to a solution containing fluoride ions and hydrogen fluoride?

A. The concentration of hydronium ions will increase significantly.
B. The concentration of fluoride ions will increase as will the concentration of hydronium ions.
C. The concentration of hydrogen fluoride will decrease, and the concentration of fluoride ions will increase.
D. The concentration of fluoride ion will decrease, and the concentration of hydrogen fluoride will increase.
E. The fluoride ions will precipitate out of solution as its acid salt.

14. A 1.00 L buffer solution is 0.150 M in $HC_7H_5O_2$ and 0.250 M in $LiC_7H_5O_2$. Calculate the pH of the solution after the addition of 100.0 mL of 1.00 M HCl. The Ka for $HC_7H_5O_2$ is 6.5×10^{-5}.

A. 4.19
B. 5.03
C. 4.41
D. 3.34
E. 3.97

15. You are working in the lab with three acidic solutions. **Solution 1** is 0.1 M of a **weak monoprotic acid**, **solution 2** is 0.1 M of a **strong monoprotic acid** and **solution 3** is a 0.1 M **weak diprotic acid**. Each of the former solutions has been titrated with a 0.2 M KOH solution. Which *quantity* is the same for all the three solutions?

A. The volume required to reach the final equivalence point.
B. The volume required to reach the first equivalence point.
C. The pH at the first equivalence point.
D. The pH at one-half the first equivalence point.
E. None of the quantities is the same for the three solutions.

16. Which of the following statements is **accurately** describes the common-ion effect?

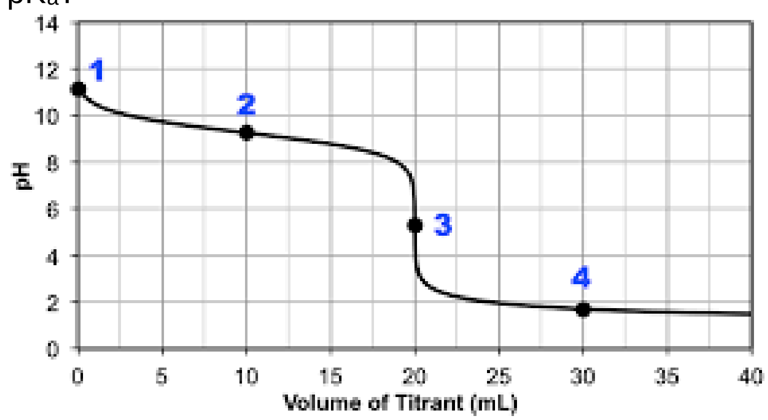
A. The extent of ionization of a weak electrolyte is increased by adding to the solution a strong electrolyte that has an ion in common with the weak electrolyte.
B. The solubility of a slightly soluble salt is increased by the presence of a second solute that provides a common ion to the system.
C. The common ion effect occurs when a solubility equilibrium is shifted due to a second compound that contains an ion common with the first.
D. The common ion effect is that common ions precipitate all counter-ions.
E. None of the above statements accurately describe the common-ion effect.

17. To simulate the pH of blood, which is 7.4, an undergraduate researcher in a biology lab produced a buffer solution by dissolving sodium dihydrogen phosphate (NaH_2PO_4, $K_a = 6.2 \times 10^{-8}$) and sodium hydrogen phosphate (Na_2HPO_4) together in an aqueous solution. What mole ratio of Na_2HPO_4/NaH_2PO_4 was needed?

A. 1.2/1.0
B. 1.0/1.0
C. 1.6/1.0
D. 0.96/1.0
E. 0.90/1.0

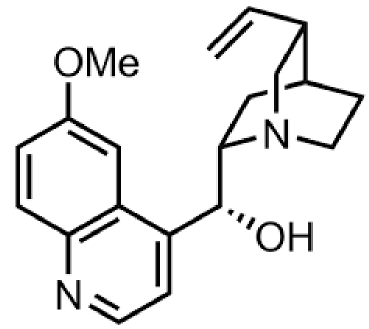
18. At what point in this titration curve is the pH = pK_a?

A. 1
B. 2
C. 3
D. 4
E. Not enough information to determine



19. Quinine is a weak base that is used to treat malaria which is caused by the parasite Plasmodium falciparum. A 25.0 mL solution of quinine was titrated with 1.00 M hydrochloric acid. It was found that the solution originally contained 0.125 moles of quinine. What was the pH of the solution after 50.00 mL of the HCl solution were added? Quinine is monobasic with pK_b = 5.10.

A. 5.10
B. 4.92
C. 8.90
D. 9.08
E. 8.72



20. For the reaction shown, which of the following statements would be **false**?

$$HF(aq) + CN^-(aq) \leftrightharpoons HCN(aq) + F^-(aq) \quad K_{eq} = 1.8 \times 10^6$$

A. HF is the strongest acid
B. Fluoride anion is the strongest base
C. Cyanide anion is the strongest base
D. The solution will contain more HCN than HF at equilibrium

21. On which side of the equation does the equilibrium lie for this reaction?

A. Product favored
B. Reactant favored

22. What is the pH of an aqueous solution that contains 0.226 M potassium hydrogen phosphate, K_2HPO_4, and 0.451 M potassium dihydrogen phosphate, KH_2PO_4?

(K_a for H_3PO_4 = 7.52×10^{-3}, K_a for $H_2PO_4^-$ = 6.23×10^{-8}, K_a for HPO_4^{2-} = 4.8×10^{-13})

A. 1.824
B. 6.562
C. 6.905
D. 7.208
E. 12.019

Extra Practice Questions: these questions will not be graded

1. How many grams of sodium benzoate (NaC_6H_5COO, MW: 144.11) would need to be added to 250. mL of a 0.200 M benzoic acid (C_6H_5COOH) solution to achieve a pH of 3.98? The pK_a of benzoic acid is 4.20.

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2. Which of these statements regarding a solution of HNO_2 is false?
   A. Addition of NaOH will increase dissociation of HNO_2, and the pH of the final solution will be higher
   B. Addition of $NaNO_2$ will decrease dissociation of HNO_2, and the pH of the final solution will be higher
   C. Addition of HNO_3 will decrease dissociation of HNO_2, and the pH of the final solution will be lower
   D. Addition of $NaNO_2$ will decrease dissociation of HNO_2, and the pH of the final solution will be lower

3. Which of these would not result in a buffer solution if 100 mL of each solution is mixed?
   A. 0.10 M $NaCH_3COO$ and 0.15 M CH_3COOH
   B. 0.2 M NaCN and 0.1 M HNO_3
   C. 0.15 M $HClO_4$ and 0.12 M $NaClO_4$
   D. 1.2 M C_5H_5N and 0.9 M C_5H_5NHCl
   E. 0.7 M NaOH and 1.2 M NaH_2PO_4

4. The following compounds are available as 0.10 M aqueous solutions: pyridine (pK_b = 8.82), triethylamine (pK_b = 3.25), $HClO_4$, phenol (pK_a = 9.96), HClO (pK_a = 7.54), NH_3 (pK_b = 4.74) and NaOH. Identify two solutions that could be used to prepare a buffer with a pH of approximately 5.

   A. pyridine and $HClO_4$
   B. triethylamine and $HClO_4$
   C. phenol and NaOH
   D. HClO and NaOH
   E. HClO and NH_3

5. In the titration of 50.0 mL of 0.0200 M C_6H_5COOH(aq) with 0.100 M NaOH(aq), what is/are the major species in the solution after the addition of 5.0 mL of NaOH(aq)?

   A. C_6H_5COOH, $C_6H_5COO^-$, and Na^+
   B. C_6H_5COOH
   C. $C_6H_5COO^-$ and Na^+
   D. C_6H_5COOH, OH^-, and Na^+
   E. C_6H_5COOH, OH^-, Na^+,$C_6H_5COO^-$

6. For the following titration, determine whether the solution at the equivalence point is acidic, basic or neutral and why:

   HCl(aq) is titrated with NH_3(aq)

   A. acidic because of hydrolysis of NH_4^+
   B. basic because of hydrolysis of NH_3
   C. acidic because of hydrolysis of Cl^-
   D. acidic because of hydrolysis of HCl
   E. neutral salt of strong acid and strong base

7. Which of the following statements correctly describe a typical titration curve for the titration of a strong acid by a strong base?

I) The beginning pH is low.
II) The pH change is slow until near the equivalence point.
III) At the equivalence point, pH changes by a large value.
IV) Beyond the equivalence point, pH rises rapidly.
V) The equivalence point would be at a pH less than 3.5.

A. I), III) and V)
B. II), III) and IV)
C. I), III) and IV)
D. III), IV) and V)
E. I), II) and III)

8. Choose the expression that gives the molar concentration of a H_2SO_4(aq) solution if 24.3 mL of a 0.105 M NaOH(aq) solution is required to titrate 60 mL of the acid.

A. (60 × 24.3)/0.105
B. (60 × 2)/(24.3 × 0.105)
C. (24.3 × 0.105)/(60)
D. (24.3 × 0.105)/(60 × 2)
E. (60 × 0.105)/(2 × 24.3)

9. For the reaction, $HCO_2H(aq) + CN^-(aq) \rightleftharpoons HCO_2^-(aq) + HCN(aq)$, what is the equilibrium constant and does it favor the formation of reactants or products? The acid dissociation constant, K_a, for HCO_2H is 1.8×10^{-4} and the acid dissociation constant for HCN is 4.0×10^{-10}.

A. $K = 1.00$. The reaction favors neither the formation of reactants nor products.
B. $K = 2.2 \times 10^{-6}$. The reaction favors the formation of products.
C. $K = 2.2 \times 10^{-6}$. The reaction favors the formation of reactants.
D. $K = 4.5 \times 10^{5}$. The reaction favors the formation of products.
E. $K = 4.5 \times 10^{5}$. The reaction favors the formation of reactants.

10. What happens to a $HC_2H_3O_2/C_2H_3O_2^-$ buffer if we add $HC_2H_3O_2$ to it?

A. The pH will go up.
B. The pH will go down.
C. The pH will not change.

Formula Sheet

Length
1 kilometer = 0.62137 mile
1 inch = 2.54 centimeters (exactly)
1 Ångstrom = 1×10^{-10} meter

Energy
1 joule = 1 $kg{\cdot}m^2/s^2$
1 calorie = 4.184 joules
1 Calorie = 1 kilocalorie = 1000 calories
1 L·atm = 101.325 joules

Pressure
1 pascal = 1 N/m^3 = 1 $kg/m{\cdot}s^2$
1 atmosphere = 101.325 kilopascals = 760 mm Hg = 760 torr = 14.70 lb/in^2
1 bar = 1×10^5 Pa (exactly)

Temperature
0 K = −273.15°C
K = °C + 273.15
°C = (5/9)(°F − 32)

Mass
1 kg = 2.205 lbs

Volume
1 mL = 1 cm^3 = 1 cc

Constants
c = 2.998×10^8 m/sec
h = 6.626×10^{-34} $J{\cdot}sec^{-1}$
R = 0.08206 L·atm/mol·K = 8.314 J/mol·K
Specific heat of water = 4.184 J/g·K
Mass of an electron: 9.109×10^{-31} kg
Mass of a proton: 1.673×10^{-27} kg
RH = 2.18×10^{-18} J
Specific heat of water = 4.184 J/g·K
STP = 273.15 K and 1 atm
Avogadro's number: 6.022×10^{23}

Equations
d (density) = m/V
$P_1V_1=P_2V_2$
$V_1/T_1=V_2/T_2$
$P_1V_1/n_1T_1=P_2V_2/n_2T_2$
$PV=nRT$
$(P + a(n^2/V^2))\cdot(V - nb) = nRT$
molar mass (M) = mRT/PV
density (d) = MP/RT
$x_A = n_A/n_{tot} = P_A/P_{tot} = V_A/V_{tot}$
$P_{tot} = P_A + P_B + \ldots$
$n_{tot} = n_A + n_B + \ldots$

$$\mu_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{Rate\ of\ effusion\ A}{Rate\ of\ effusion\ B} = \sqrt{\frac{MW_B}{MW_A}}$$

$Q = C \times \Delta T = c_{specific} \times m \times \Delta T$
$Q = n \times \Delta H$ (kJ/mol) $= m \times \Delta H$ (kJ/g)
$w = -P\Delta V$
$\Delta E = q + w$
$\Delta H° = \Sigma n\Delta Hf°(\text{products}) - \Sigma n\Delta Hf°(\text{reactants})$
$\Delta H° = \Sigma n\Delta H°(\text{bonds broken}) - \Sigma n\Delta H°(\text{bonds formed})$
$E=h\nu$
$c=\lambda\nu$
$\lambda = h/mv$
$\Delta E = -2.18 \times 10^{-18} J(\frac{1}{n_f^2} - \frac{1}{n_i^2})$

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$C_g = kP_g$
$P_{solution}=P_{solvent}\ X_{solvent}$
$P_{solution}=\sum P_j=\sum P_jX_j$
$\Delta T_b = K_b m i$
$\Delta T_f = K_f m i$
$\pi = MRTi$

Thermodynamic and Electrochemistry

$S = k_b \times \ln(W)$
$k_b = 1.381 \times 10^{-23}$ J/K
$\Delta S = q_{rev}/T$
$\Delta S_{surr} = q_{surr}/T = -q_{rev}/T$
$\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr}$
$\Delta S°_{rxn} = \Sigma \nu S°_{products} - \Sigma \nu S°_{reactants}$
$\Delta H°_{rxn} = \Sigma \nu H°_{products} - \Sigma \nu H°_{reactants}$
$\Delta G°_{rxn} = \Sigma \nu G°_{products} - \Sigma \nu G°_{reactants}$
$\Delta G = \Delta H - T\Delta S$
$\Delta G = \Delta G° + RT\cdot\ln Q$
R=8.314 J/mol.K
$\Delta G° = -RT\cdot\ln K$
$\Delta G = -nFE_{cell}$
F = 96485 J/(V·mol e^-)
$E°_{cell} = RT/nF \ln K$
$E°_{cell} = (0.0257/n) \ln K = (0.0592/n) \log K$
$E_{cell} = E°_{cell} - (RT/nF) \ln Q$
$E_{cell} = E°_{cell} - (0.0257/n) \ln Q$
Electrolysis: Q (total charge) = I × t = n × F

Integrated Rate Laws & half-life

$$\ln \frac{[A]}{[A]_0} = -kt$$

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$

$$[A] = -kt + [A]_0$$

$$t_{1/2} = \frac{[A]_0}{2k}$$

$$t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{1}{k[A]_0}$$

$$ln \frac{k_2}{k_1} = -\frac{\mathrm{E_a}}{\mathrm{R}}(\frac{1}{\mathrm{T_2}} - \frac{1}{\mathrm{T_1}})$$

<u>Equilibrium and Acid / Base</u>

$K_P = K_c \times (RT)^{\Delta n}$

$pH = -\log[H_3O^+]$

$K_w = 1.0 \times 10^{-14}$ at 25 °C

$K_w = [H_3O^+] \times [OH^-]$

$K_w = K_a \times K_b$

$pK_a = -\log[K_a]$

Buffer: $pH = pK_a + \log \frac{[A^-]}{[HA]}$

$$ln \frac{K_2}{K_1} = \frac{\Delta H^\circ_{rxn}}{R}(\frac{1}{T_1} - \frac{1}{T_2})$$

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01																	2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.97	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.95	43 **Tc** [97]	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
37 **Cs** 132.91	56 **Ba** 137.33		72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** [209]	85 **At** [210]	86 **Rn** [222]
87 **Fr** [223]	88 **Ra** [226]		104 **Rf** [267]	105 **Db** [268]	106 **Sg** [269]	107 **Bh** [270]	108 **Hs** [269]	109 **Mt** [277]	110 **Ds** [281]	111 **Rg** [282]	112 **Cn** [285]	113 **Nh** [286]	114 **Fl** [290]	115 **Mc** [290]	116 **Lv** [293]	117 **Ts** [294]	118 **Og** [294]

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** [145]	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
89 **Ac** [227]	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** [237]	94 **Pu** [244]	95 **Am** [243]	96 **Cm** [247]	97 **Bk** [247]	98 **Cf** [251]	99 **Es** [252]	100 **Fm** [257]	101 **Md** [258]	102 **No** [259]	103 **Lr** [262]