Recitation Worksheet Nine

Name: | MyID:

Textbook:
Chemistry & Chemical Reactivity
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Instructions:

- This recitation worksheet covers Ch. 16.1-16.3
- 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**.
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  - 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.
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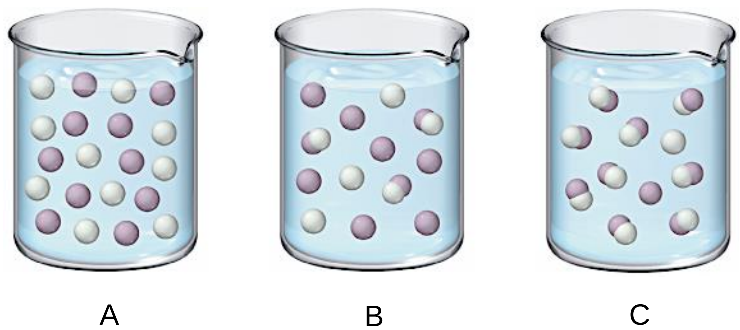
- The following criteria **must** be met to be eligible for full credit:
  - You must make sure the pages are in the correct order and have the same layout as the original worksheet when submitting to Gradescope regardless of your submission type.
  - Answers must be written in the corresponding answer boxes.
  - You must show your work when appropriate.
- This worksheet is due no later than **12:00 PM (noon) on the Saturday, October 26th.**
- 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 following is a conjugate acid-base pair? <u>Select all that apply.</u>
   A. H_2CO_3 and CO_3^{2-}
   B. $HClO_4$ and ClO_3^-
   C. CH_2FCOOH and CH_2FCOO^-
   D. $C_{10}H_7NH_2$ and $C_{10}H_7NH_3^+$
   E. H_2S and S^{2-}

2. The three diagrams below represent three different binary acid solutions with the generic formula HA. Water molecules have been omitted for clarity and H_3O^+ is represented by H^+ instead. Rank the acids in order of decreasing acid strength.



   A. B > C > A
   B. C > B > A
   C. A > B > C
   D. C > A > B
   E. A > C > B

3. Please refer to the <u>figure in question 2</u> to answer the following question. Which of the acids is expected to have the smallest K_a value?
   A. A
   B. B
   C. C
   D. All acids have the same K_a value

4. What is the percent ionization of a 0.337 M HF solution? K_a of HF is 3.5×10^{-4}.

%

5. If benzoic acid is 0.42% ionized in a 0.80 M solution, what is the K_a of benzoic acid?

A. 1.41×10^{-7}
B. 1.41×10^{-5}
C. 1.77×10^{-5}
D. 6.15×10^{4}
E. None of the above choices is correct.

6. Calculate the pH of

A. 0.00213 M $Sr(OH)_2$

B. 5.8×10^{-4} M HI

7. According to the Bronsted-Lowry definition of acids and bases, which of the compounds below is **NOT** a base?
   A. F^-
   B. NO_2^-
   C. NH_3
   D. OH^-
   E. NH_4^+

8. What is the K_a of fluoroacetic (CH_2FCOOH) acid, if a 0.318 M solution has a pH = 1.56? Report your answer using **scientific notation**.

   x 10

9. Which of the following is a strong acid?
   A. CH_3COOH
   B. HF
   C. H_3PO_4
   D. H_2SO_3
   E. H_2SO_4

10. Which of these aqueous solutions has the highest $[H_3O^+]$ at 25 °C?

A. a solution with a pH of 3.0
B. a 1×10^{-4} M solution of HNO_3
C. a solution with a pOH of 12.0
D. pure water
E. a 1×10^{-2} M solution of HF

11. Which of these aqueous solutions is(are) considered basic at 25 °C? Select all that apply.

A. $[H_3O^+] = 5.4 \times 10^{-8}$
B. pOH = 9.0
C. $[OH^-] = 4.3 \times 10^{-4}$

12. What are the $[H_3O^+]$, $[OH^-]$, pH, and pOH of 0.55 M HNO_2? K_a of $HClO_2$ is 4.6×10^{-4}. Report your answer using **scientific notation**.

A. $[H_3O^+]$ ______ x 10 ___

B. $[OH^-]$. ______ x 10 ___

C. pH. ______

D. pOH. ______

13. What is the concentration of hydroxide ions in pure water at 30.0 °C, if K_w at this temperature is 1.47 x 10^{-14}?

A. 1.00×10^{-7} M
B. 1.30×10^{-7} M
C. 1.47×10^{-7} M
D. 8.93×10^{-8} M
E. 1.21×10^{-7} M

14. What is the pH of a 1.2 M pyridine (C_5H_5N) solution that has $K_b = 1.9 \times 10^{-9}$?

A. 4.32
B. 8.72
C. 9.68
D. 10.68

15. Given the acids and their K_a values:

Hydrocyanic acid, HCN $K_a = 4.00 \times 10^{-10}$
Phenol, C_6H_5OH $K_a = 1.00 \times 10^{-10}$
Benzoic acid, $C_6H_5CO_2H$ $K_a = 6.30 \times 10^{-5}$

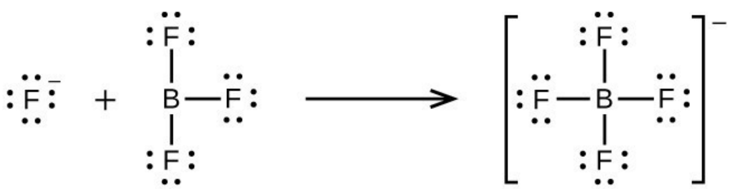
What is the order of **increasing base strength** for CN^-, $C_6H_5O^-$, and $C_6H_5CO_2^-$?

A. $C_6H_5CO_2^- < C_6H_5O^- < CN^-$
B. $C_6H_5O^- < C_6H_5CO_2^- < CN^-$
C. $CN^- < C_6H_5CO_2^- < C_6H_5O^-$
D. $C_6H_5CO_2^- < CN^- < C_6H_5O^-$
E. $CN^- < C_6H_5O^- < C_6H_5CO_2^-$

16. The hydride ion, H^-, is a stronger base than the hydroxide ion, OH^-. The product(s) of the reaction of hydride ion with water is/are

A. $H_3O^+(aq)$
B. $OH^-(aq) + H_2(g)$
C. $OH^-(aq) + 2\ H^+(aq)$
D. No reaction occurs
E. $H_2O_2(aq)$

17. In the gas phase reaction below, F^- is acting as a(n)



A. BrØnsted-Lowry acid
B. BrØnsted-Lowry base
C. Lewis base
D. Lewis acid
E. Arrhenius acid

18. Which of these species is amphoteric?

A. HPO_4^{2-}
B. H_3O^+
C. PO_4^{3-}
D. Cl^-
E. None of the above are amphoteric.

Extra Practice Questions: these questions will not be graded

1. In the reaction $HSO_4^-(aq) + OH^-(aq) \leftrightharpoons SO_4^{2-}(aq) + H_2O(l)$, the conjugate acid-base pairs are

	pair 1	*pair 2*
Row 1	HSO_4^- and SO_4^{2-};	H_2O and OH^-.
Row 2	HSO_4^- and H_3O^+;	SO_4^{2-} and OH^-.
Row 3	HSO_4^- and OH^-;	SO_4^{2-} and H_2O.
Row 4	HSO_4^- and H_2O;	OH^- and SO_4^{2-}.
Row 5	HSO_4^- and OH^-;	SO_4^{2-} and H_3O^+.

   A. Row 1
   B. Row 2
   C. Row 3
   D. Row 4
   E. Row 5

2. What is the $[OH^-]$ in pure water at 50 °C? $K_w = 5.5 \times 10^{-14}$ at 50 °C?

   M

3. Deuterium oxide, D_2O (deuterium is an isotope of hydrogen) has an ion product constant, $K_w = 8.9 \times 10^{-16}$.
   What is the pH of pure D_2O?

4. At 50 °C the value of *Kw* is 5.50×10^{-14}. A basic solution at 50 °C has

   A. $[H_3O^+] < [OH^-] < 2.35 \times 10^{-7}$ M.
   B. $[H_3O^+] < 2.35 \text{ x } 10^{-7}$ M $< [OH^-]$.
   C. $[H_3O^+] = [OH^-] < 2.35 \times 10^{-7}$ M.
   D. $[H_3O^+] > [OH^-] > 2.35 \times 10^{-7}$ M.

5. At 25 °C, what is the hydroxide ion concentration and the pH for a hydrochloric acid solution that has a hydronium ion concentration of 1.50×10^{-4} M? Kw = 1.00×10^{-14} at 25 °C. Use the rules of significant figures to answer this question.

   $[OH^-]$ =

   pH =

6. What is the pH of a 0.020 M $Sr(OH)_2$ solution?

   pH =

7. Which of the following is a Brønsted-Lowry acid?
   A. NH_4^+
   B. Cl_2
   C. BF_3
   D. I_2

8. What would happen to the K_w and pH of neutral water if the water was warmed to 37°C? The K_w would _________ and the pH would _________.
   A. Decrease, increase
   B. Decrease, decrease
   C. Increase, increase
   D. Increase, decrease
   E. The K_w and pH would stay the same

9. Which statement is true about the conjugate bases and their conjugated acids?

Conjugate base	pK_b
F^-	10.85
$CH_3CO_2^-$	9.25
NH_3	4.75
PO_4^{3-}	1.55

   A. The strongest conjugated acid would be HPO_4^{2-}because $PO_4^{3-}$is the strongest base
   B. NH_4^+ would be a stronger acid than CH_3CO_2H because NH_3 has a lower pK_b than $CH_3CO_2^-$
   C. The weakest conjugated acid would be HF because $F^-$is the strongest base
   D. The strongest parent acid would be HF because F^- is the weakest base

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
$c = 2.998 \times 10^8$ m/sec
$h = 6.626 \times 10^{-34}$ $J \cdot sec^{-1}$
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

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

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

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

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

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

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

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

Equilibrium and Acid / Base

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

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

$K_w = 1.0 \times 10^{-14}$ at 25 °C

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

$K_w = K_a \times K_b$

$pK_a = -\log[K_a]$

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

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

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]