Recitation Worksheet Eleven

Name: | MyID:

Textbook:
Chemistry & Chemical Reactivity
by John C. Kotz, Paul M. Treichel, John R. Townsend, David Treichel
11th Edition | Copyright 2024

Instructions:

- This recitation worksheet covers Ch. 16.4, 16.8-16.9
- 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 9th.**
- 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 pairs below has the **stronger acid** listed **first**? Select all that apply. Insert letters without spaces in the answer box, example **ABCD.**

   A. $HClO_2$ and $HClO_3$
   B. H_3PO_4 and H_2SiO_3
   C. $I_3CCH_2CH_2COOH$ and $CH_3CH_2CCl_2COOH$
   D. $H_2PO_4^-$ and HPO_4^{2-}
   E. CF_3COOH and CH_3COOH

2. Which of the choices represents the correct order of the acids below in order of **strongest to weakest**?

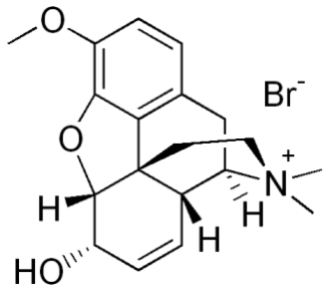
HBr, $CHCl_2COOH$, CH_3CH_2COOH, CH_3F_2CCOOH, I_2CHCH_2COOH

A. $HBr > CHCl_2COOH > CH_3F_2CCOOH > I_2CHCH_2COOH > CH_3CH_2COOH$
B. $CH_3CH_2COOH > I_2CHCH_2COOH > CH_3F_2CCOOH > CHCl_2COOH > HBr$
C. $HBr > CH_3F_2CCOOH > CHCl_2COOH > I_2CHCH_2COOH > CH_3CH_2COOH$
D. $HBr > I_2CHCH_2COOH > CH_3F_2CCOOH > CHCl_2COOH > CH_3CH_2COOH$
E. $CHCl_2COOH > CH_3F_2CCOOH > I_2CHCH_2COOH > CH_3CH_2COOH > HBr$

3. You were asked to prepare an aqueous solution of pH ~ 8.5 and you are provided with a list of salts below. Which of these salts would you use? (K_{a1} H_3PO_4 = 7.08 x 10^{-3}, K_{a2} $H_2PO_4^-$ = 6.31 x 10^{-8}, K_{a3} HPO_4^{2-} = 4.47 x 10^{-13}

A. KNO_2
B. NH_4Cl
C. $NaNO_3$
D. KH_2PO_4
E. CH_3NH_3Cl
F. $FeCl_3$

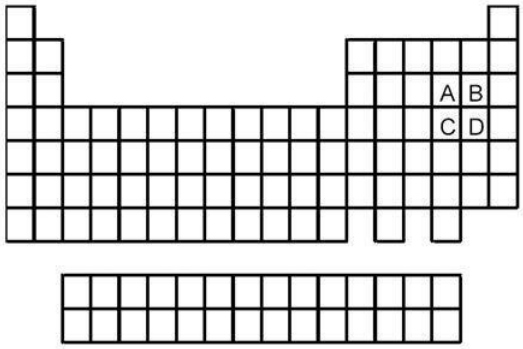
4. The salt of codeine, codeine bromide ($C_{18}H_{21}O_3NH^+Br^-$) has analgesic and antitussive properties. Calculate the pH of a 0.324 M codeine bromide solution. pK_b of $C_{18}H_{21}O_3N$ is 7.95.



5. Which of the following ionic compounds when dissolved in water produce a solution with the **highest** pH?

A. $CaBr_2$
B. NH_4I
C. N_2H_5Cl
D. $Sr(NO_3)_2$
E. $C_6H_5CH_2COONa$

6. Use the picture below to answer the following questions



A. Of the elements indicated on the periodic table shown above, which forms the strongest binary acid, H_2X or HX, where X = A, B, C, or D?

B. Of the elements indicated on the periodic table shown above, which forms the weakest binary acid, H_2X or HX, where X = A, B, C, or D?

C. Of the elements indicated on the periodic table shown above, which forms the strongest oxoacid acid with the formula H_2XO_3 or HXO_3, where X = A, B, C, or D?

D. Of the elements indicated on the periodic table shown above, which forms the weakest oxoacid acid with the formula H_2XO_3 or HXO_3, where X = A, B, C, or D?

7. Which of the following will be the strongest acid?

A. CH_3CH_2OH
B. $CH_3CH_2NH_2$
C. CH_3CH_2SH
D. $CH_3CH_2CH_3$
E. All the above acids have the same strength

8. You are given the two sets of acids and each set consists of two acids:

Set I: a) H_2Se and b) H_2Te **Set II:** a) H_3PO_4 and b) H_3AsO_4,

Use the two sets of acids to answer the question below:

Which of the acids is the **<u>weaker acid</u>** in each set?

Set I

Set II

9. Calculate the pH of a sulfuric acid (H_2SO_4, K_a HSO_4^- = 1.2 x 10^{-2}) solution that has a concentration of:

A. 5.00 M

B. 0.075 M

10. What is the $[H_3O^+]$, $[SO_3^{2-}]$, and pH of 0.054 M H_2SO_3? (K_{a1} = 1.54 x 10^{-2}, K_{a2} = 1.02 x 10^{-7})

A. $[H_3O^+]$

M

B. $[SO_3^{2-}]$

M

C. pH

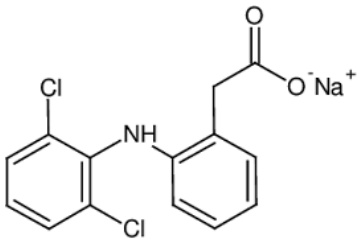
11. Using the table below for the relative acid strength, arrange the following species in order of **decreasing** relative **base strength**: ClO_2^-, Br^-, H_2O, OCl^-, $C_6H_5O^-$

Formula	Name	Value of K_a*
HSO_4^-	Hydrogen sulfate ion	1.2×10^{-2}
$HClO_2$	Chlorous acid	1.2×10^{-2}
$HC_2H_2ClO_2$	Monochloracetic acid	1.35×10^{-3}
HF	Hydrofluoric acid	7.2×10^{-4}
HNO_2	Nitrous acid	4.0×10^{-4}
$HC_2H_3O_2$	Acetic acid	1.8×10^{-5}
$[Al(H_2O)_6]^{3+}$	Hydrated aluminum(III) ion	1.4×10^{-5}
HOCl	Hypochlorous acid	3.5×10^{-8}
HCN	Hydrocyanic acid	6.2×10^{-10}
NH_4^+	Ammonium ion	5.6×10^{-10}
HOC_6H_5	Phenol	1.6×10^{-10}

Increasing acid strength ↑

A. $C_6H_5O^- > OCl^- > ClO_2^- > H_2O > Br^-$
B. $Br^- > H_2O > ClO_2^- > OCl^- > C_6H_5O^-$
C. $ClO_2^- > OCl^- > Br^- > H_2O > C_6H_5O^-$
D. $OCl^- > Br^- > ClO_2^- > C_6H_5O^- > H_2O$
E. $H_2O > OCl^- > Br^- > > C_6H_5O^- > ClO_2^-$

12. Diclofenac sodium is the active ingredient in Voltaren®, is a non-steroidal anti-inflammatory drug used in a gel form for arthritis pain relief. Calculate the pH of 0.435 M diclofenac sodium ($C_{14}H_{11}Cl_2NO_2^-Na^+$) solution. p$K_a$ of $C_{14}H_{11}C_{l2}NO_2H$ is 4.15.

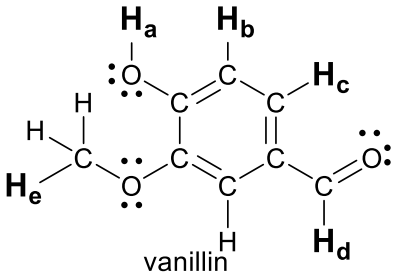


13. Rank the following species from **strongest to weakest base**. Select an answer choice from A-E.

CH_3NH_2, CH_3NH^-, CH_3OH, CH_3O^-, CH_3COO^-

A. $CH_3NH^- > CH_3O^- > CH_3COO^- > CH_3NH_2 > CH_3OH$
B. $CH_3OH > CH_3COO^- > CH_3NH_2 > CH_3O^- > CH_3NH^-$
C. $CH_3NH^- > CH_3O^- > CH_3NH_2 > CH_3COO^- > CH_3OH$
D. $CH_3O^- > CH_3NH^- > CH_3COO^- > CH_3NH_2 > CH_3OH$
E. $CH_3NH_2 > CH_3NH^- > CH_3O^- > CH_3OH > CH_3COO^-$

14. The primary chemical responsible for the flavor associated with vanilla is vanillin.

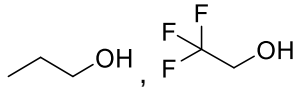
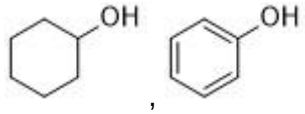
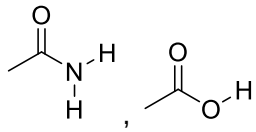


vanillin

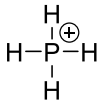
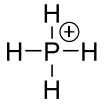
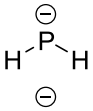
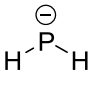
Which of the labeled hydrogens would be the most likely to generate H^+ in solution?

A. H_a
B. H_b
C. H_c
D. H_d
E. H_e

15. Which pair of acids lists the **stronger** acid first? Select all that apply.

A. H_2CO_3, HCO_3^-
B. $HOCl$, $HClO_2$
C. NH_4^+, NH_3
D.  ,
E. HBr, HI
F. H_2S, H_4Si
G.  ,
H.  ,

16. Which statement most accurately explains what would be observed about the acidic nature of these compounds?


A. A solution of H_2S would be more acidic because  is more stable than 
B. A solution of PH_3 would be more acidic because  is more stable than 
C. A solution of H_2S would be more acidic because  is more stable than 
D. A solution of PH_3 would be more acidic because is more stable than 
E. A solution of H_2S would be more acidic because  is more stable than 
F. A solution of PH_3 would be more acidic because  is more stable than 

17. For each of these, define the resulting aqueous solutions as either acidic (A), basic (B) or neutral (N).

A. CH_3CO_2Na

B. $LiNO_2$

C. potassium sulfite

D. ammonium bromide

E. potassium chloride

18. What will be the pH of an aqueous solution made up of 0.514 g potassium cyanide KCN in 125 mL water. K_a HCN = 6.2×10^{-10}.

19. Each of these pairs contains one strong acid and one weak acid EXCEPT:

A. H_2SO_4 and H_2CO_3
B. HNO_3 and $HClO_2$
C. HBr and H_3PO_3
D. $H_2PO_3^{2-}$ and HCN
E. HCl and H_2Se

20. Which of the choices represent the substances below arranged in the correct order of increasing pH? All solutions have the same concentration of 0.10 M.

HI, $NaNO_2$, NaOH, NH_4ClO_4, $LiNO_3$

A. $NaOH < NaNO_2 < NH_4ClO_4 < HI < LiNO_3$
B. $HI < NH_4ClO_4 < LiNO_3 < NaNO_2 < NaOH$
C. $NH_4ClO_4 < HI < NaNO_2 < LiNO_3 < NaOH$
D. $NaNO_2 < NH_4ClO_4 < LiNO_3 < NaOH < HI$
E. $LiNO_3 < NH_4ClO_4 < NaOH < HI < NaNO_2$

21. Which of these would you predict to be the strongest acid?

A. FCH_2CO_2H
B. $ClCH_2CO_2H$
C. $BrCH_2CO_2H$
D. ICH_2CO_2H
E. CH_3CO_2H

Extra Practice Questions: these questions will not be graded

1. When ammonium perchlorate, NH_4ClO_4, is dissolved in water, will it give an acidic, basic, or neutral solution?

A. Acidic
B. Basic
C. Neutral

2. Which of these would you predict to be the **strongest base**?

A. Cl^-
B. ClO^-
C. ClO_2^-
D. ClO_3^-
E. ClO_4^-

3. Which of the salts is(are) considered **basic** when dissolved in water?

I. $NaNO_3$
II. K_3PO_4
III. NH_4Cl

A. I only
B. II only
C. I and II
D. I and III
E. II and III

4. Farmers who raise cotton once used arsenic acid, H_3AsO_4, as a defoliant at harvest time. Arsenic acid is a polyprotic acid with $K_{a1} = 2.5 \times 10^{-4}$, $K_{a2} = 5.6 \times 10^{-8}$, and $K_{a3} = 3 \times 10^{-13}$. What is the pH of a 0.500 *M* solution of arsenic acid?

A. 0.85
B. 1.95
C. 3.90
D. 4.51

5. Arrange these 0.10 M aqueous solutions in order of **increasing pH**:

NaOH, HBr, $NaCH_3CO_2$, KBr, NH_4Br

A. HBr, KBr, NH_4Br, $NaCH_3CO_2$, NaOH
B. NaOH, $NaCH_3CO_2$, NH_4Br, KBr, HBr
C. NaOH, $NaCH_3CO_2$, KBr, NH_4Br, HBr
D. HBr, NH_4Br, KBr, $NaCH_3CO_2$, NaOH

6. Determine the pH of a 0.22 M NaF solution at 25 °C. The K_a of HF is 3.5×10^{-5}.

7. When blue litmus paper is placed in a substance that is acidic, it will turn red. Which solution would cause blue litmus to turn red?

A. a solution of 0.10 M NaBr
B. a solution of 0.01 M NH_3
C. a solution of 0.01 M NH_4ClO_4
D. a solution of 0.005 M KF
E. a solution of 0.10 M $Ca(CH_3CO_2)_2$

8. Calculate the pH of a 0.59 M solution of NH_4Cl. K_b for $NH_3 = 1.8 \times 10^{-5}$.

9. What is the pH of an aqueous solution of 0.184 M carbonic acid, H_2CO_3? ($K_{a1} = 4.2 \times 10^{-7}$, $K_{a2} = 4.8 \times 10^{-11}$)

A. 2.69
B. 2.80
C. 2.97
D. 3.50
E. 3.56

10. Which solution has the highest pH?

A. 0.10 M HBr(aq)
B. 0.10 M HI(aq)
C. 0.10 M HF(aq)
D. 0.10 M HCl(aq)
E. 0.10 M $HClO_4$(aq)

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·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·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·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 x 10^{-31} kg
Mass of a proton: 1.673 x 10^{-27} kg
RH = 2.18 x 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
$x_A = n_A/n_{tot} = P_A/P_{tot} = V_A/V_{tot}$
$P_{tot} = P_A + P_B + \ldots$
$n_{tot} = n_A + n_B + \ldots$

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

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

$Q = C \times \Delta T = c_{specific} \times m \times \Delta T$
$Q = n \times \Delta H\ (kJ/mol) = m \times \Delta H\ (kJ/g)$
$w = -P\Delta V$
$\Delta E = q + w$
$\Delta H° = \Sigma n\Delta Hf°(products) - \Sigma n\Delta Hf°(reactants)$
$\Delta H° = \Sigma n\Delta H°(bonds\ broken) - \Sigma n\Delta H°(bonds\ formed)$
$E=h\nu$
$c=\lambda\nu$
$\lambda = h/m\nu$

$$\Delta E = -2.18 \times 10^{-18} J(\frac{1}{n_f^2} - \frac{1}{n_i^2})$$

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

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

Thermodynamic and Electrochemistry

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

Integrated Rate Laws & half-life

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

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

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

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

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

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

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

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

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

Periodic Table of the Elements

1												13	14	15	16	17	18
1 H 1.01	2																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	3	4	5	6	7	8	9	10	11	12	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]