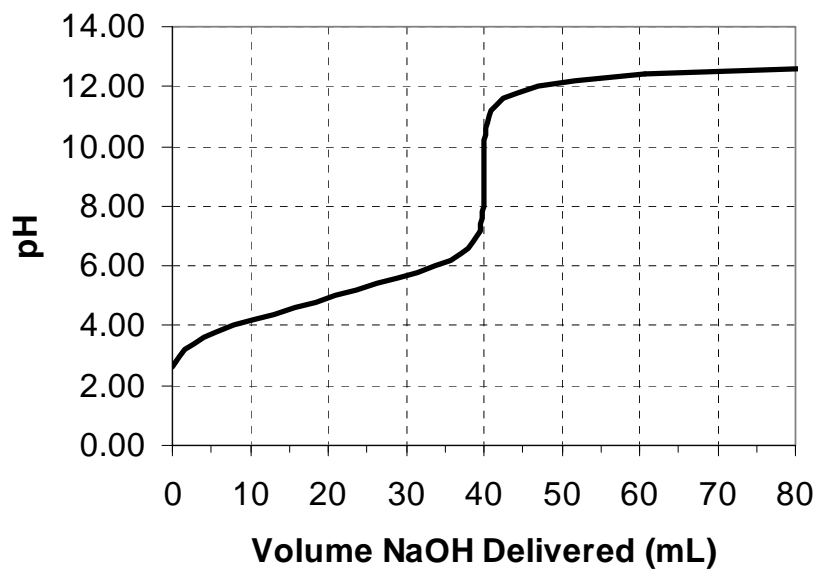


Complete five (5) of the following problems. Each problem is worth 16 points. CLEARLY mark the problems you do not want graded. You must show your work to receive credit for problems requiring math. Report your answers with the appropriate number of significant figures. You do not need to account for activities in your calculations.

1. Find the pH of a solution prepared by dissolving all of the following compounds in one beaker and diluting to a volume of 0.250 L: 0.100 mol benzoic acid ( $pK_a = 4.20$ ), 0.100 mol sodium benzoate, 0.020 mol  $H_2SO_4$ , and 0.050 mol NaOH. Assume sulfuric acid dissociates completely (i.e. it is a strong acid).

2. The titration curve below is the result of the titration of 20.00 mL of a 0.100 M solution of one of the acids below with 0.100 M KOH. Identify the acid. Clearly justify your decision by explaining how you ruled out each of the imposters and arrived at your conclusion.



Acid	pK <sub>a</sub> 's
Acetic	4.75
Phosphoric	2.17, 7.20, 12.15
Succinic	4.21, 5.64
HCl	strong
Maleic	1.91, 6.33
Pyruvic	2.55

3. Complete the following calculations: (8 points each)
- Determine the pH of an  $8.18 \times 10^{-8}$  F solution of sodium hydroxide.
  - A 0.020 F solution of phthalic acid ( $\text{pK}_{\text{a}1} = 2.95$ ,  $\text{pK}_{\text{a}2} = 5.41$ ) is buffered at pH 4.00. What fraction of the phthalic acid is present as the amphiprotic form at this pH?

4. You are asked to prepare 500. mL of a 0.300 M acetate buffer at pH 5.10 using only pure acetic acid (MW=60.05 g/mol,  $pK_a=4.76$ ), 3.00 M NaOH, and water. What mass of acetic acid and volume of 3.00 M NaOH is required to make this buffer?

5. A 20.0 mL sample of 0.150 F freakinacidic acid ( $\text{H}_2\text{A}$ ,  $\text{pK}_{\text{a}1} = 3.00$ ,  $\text{pK}_{\text{a}2} = 7.00$ ) is titrated with 0.100 F NaOH. Calculate the pH at any three of the following volumes of NaOH added: 0.0 mL, 20.0 mL, 30.0 mL, 40.0 mL, 60.0 mL, 70.0 mL.

6. Your new employer has asked you to prepare 1.00 L of a pH 12.00 buffer with a total phosphate concentration of 0.0500 M. You have at your disposal the following compounds

Compound	$K_a$	Molar Mass (g/mol)
$H_3PO_4$	$7.11 \times 10^{-3}$	97.9950
$NaH_2PO_4$	$6.34 \times 10^{-8}$	119.9769
$Na_2HPO_4$	$4.22 \times 10^{-13}$	141.9588
$Na_3PO_4$	--	163.9407

- a. Which two compounds would you use to prepare a buffer of pH 12.00 and how many grams of each of the two selected compounds would you need? (12 points)

- b. If you did exactly what you calculated in part (a), you would not get a pH of *exactly* 12.00. Why? Explain how you would really prepare this buffer in lab. (4 points)

7. Explain how we are able to use initial concentrations in the Henderson-Hasselbalch equation and still get reasonable estimates of the equilibrium pH of a solution? Under what conditions would this not be the case?

### Possibly Useful Information

$V_b \cdot 10^{-\text{pH}} = K_a(V_e - V_b)$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
$[H^+] = \sqrt{\frac{K_{a1}K_{a2}F + K_{a1}K_w}{K_{a1} + F}} \approx \sqrt{K_{a1}K_{a2}}$	$\text{pH} = \frac{1}{2}(\text{p}K_{a1} + \text{p}K_{a2})$
$\text{pH} = \text{p}K_a + \log \frac{[\text{conjugate base}]}{[\text{weak acid}]}$	$\alpha_{H_2A} = \frac{[H^+]^2}{[H^+]^2 + [H^+]K_{a1} + K_{a1}K_{a2}}$
$K_w = 1.0 \times 10^{-14} = [H^+][OH^-]$	$\text{pH} + \text{pOH} = 14.00$

### PERIODIC CHART OF THE ELEMENTS

PERIODIC CHART OF THE ELEMENTS																		INERT GASES	
IA	IIA	IIIB	IVB	VB	VIB	VII B	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA			
1 H 1.00797																1 H 1.00797	2 He 4.0026		
3 Li 6.939	4 Be 9.0122											5 B 10.811	6 C 12.0112	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183		
11 Na 22.9898	12 Mg 24.312											13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 Ar 39.948		
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80		
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30		
55 Cs 132.905	56 Ba 137.34	*57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)		
87 Fr (223)	88 Ra (226)	†89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 ? (271)	111 ? (272)	112 ? (277)								

Numbers in parenthesis are mass numbers of most stable or most common isotope.

Atomic weights corrected to conform to the 1963 values of the Commission on Atomic Weights.

The group designations used here are the former Chemical Abstract Service numbers.

#### \* Lanthanide Series

58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm [147]	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97
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#### † Actinide Series

90 Th 232.038	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (258)	102 No (258)	103 Lr (257)
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