Name Key

You may use your textbook, and notes on this part of the exam. You may not work with other people on this part of the exam. You may use a spreadsheet to determine the activity coefficients, but you must include the spreadsheet (an understandable version) with your exam. Show ALL work for credit. This portion is due by 5:00 PM Monday March 20.

(1) Statistics

Student Group 1 tests an unknown for Ca^{2+} content by EDTA titration with the following results: 121.4 ppm, 124.8 ppm, 120.7 ppm, and 124.9 ppm

Student Group 2 tests the same sample as group 1, but uses Atomic Absorption Spectroscopy with the following result: 125 ppm, 126 ppm, 126 ppm, and 124 ppm.

(a)(15 points) Calculate the means, standard deviations, and the error at 95% CL for the two samples

Group 1

$$\bar{x} = \frac{121.4 + 124.8 + 120.7 + 124.9}{4}$$

$$\bar{x} = 122.95 \text{ ppm}$$

$$s = \sqrt{\frac{(121.4-122.95)^2 + (124.8-122.95)^2 + (120.7-122.95)^2 + (124.9-122.95)^2}{3}}$$

$$s = 2.2 \text{ ppm}$$

$$\frac{ts}{\sqrt{N}} = \frac{(3.18)(2.2 \text{ ppm})}{2}$$

$$95\%CL = \pm 3.5 \text{ ppm}$$

Group 2

$$\bar{x} = \frac{125 + 126 + 126 + 124}{4}$$

$$\bar{x} = 125.25 \text{ ppm}$$

$$s = \sqrt{\frac{(125-125.25)^2 + (126-125.25)^2 + (126-125.25)^2 + (124-125.26)^2}{3}}$$

$$s = 0.96 \text{ ppm}$$

$$\frac{ts}{\sqrt{N}} = \frac{(3.18)(0.96 \text{ ppm})}{\sqrt{4}} = \pm 1.5 \text{ ppm}$$

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s_{pooled}\sqrt{\frac{N_1+N_2}{N_1 N_2}}}$$

$$s_{pooled} = \sqrt{\frac{(121.4-122.95)^2+(124.8-122.95)^2+(122.7-122.95)^2+(122.9-122.95)^2+(125-125.25)^2+(126-125.25)^2+(124-125.25)^2}{6}}$$

$$s_{pooled} = \sqrt{\frac{15.2}{6}} = 1.59$$

$$t = \frac{125.25-122.95}{1.59\sqrt{\frac{4+4}{16}}} = 2.45$$ for 6 degrees of freedom

$t_{table} = 2.45$ so no, you can't say they are different

(c)(10 ponts) Use the F test to determine if there is a significant difference in the precision of the two tests (at the 95% CL).

$$\frac{s_{x_1}^2}{s_{x_2}^2} = \frac{(2.2)^2}{(0.95)^2} = 5.36$$

$F_{table} = 9.28$ for 3 degrees of freedom for both

∴ no significant difference in precision

(d)(5 points) Can a point be discarded by the Q test for either of the two samples above (if yes, show the work)?

(b)(20pts) $Ba(OH)_2$ in distilled water (do NOT neglect activities). Use the Debye-Hückel equation for activities.

1st guess $[Ba^{2+}] = 0.04M$ $[OH^-] = 0.080M$

$\mu = \frac{1}{2}\{(0.04)(2)^2 + (0.080)(1)^2\} = 0.12$

$\gamma_{Ba^{2+}} = 0.35$ $\gamma_{OH^-} = 0.75$

$3\times10^{-4} = (0.35)(x)[(2x)(0.75)]^2$

$3\times10^{-4} = 0.788\,x^3$

$3.8\times10^{-4} = x^3$

$0.072 = x$

2nd Iteration $[Ba^{2+}] = 0.072M$ $[OH^-] = 0.144M$ $\mu = \frac{1}{2}\{(0.072)2^2 + (0.144)1^2\} = 0.216 = \mu$

$\gamma_{Ba^{2+}} = 0.29$ $\gamma_{OH^-} = 0.70$

$3\times10^{-4} = (0.29)(x)[(2x)(0.70)]^2$

$3\times10^{-4} = 0.568\,x^3$

$5.3\times10^{-4} = x^3$

$0.081 = x$

3rd iteration $[Ba^{2+}] = 0.081$ $[OH^-] = 0.162$ $\mu = \frac{1}{2}\{(0.081)2^2 + (0.162)1^2\} = 0.243$

$\gamma_{Ba^{2+}} = 0.28$ $\gamma_{OH^-} = 0.69$

$3\times10^{-4} = (0.28)(x)[2x\ 0.69]^2$

$[Ba^{2+}] = 0.083M$

(3)(35 points) (Note: You may neglect activity for this problem) A student wants to test water for Fe^{2+} content by precipitation with NaOH.

(a) If the lowest concentration of Fe^{2+} expected is 3 x 10^{-5} M, what is the lowest pH that can be used to precipitate 99.9% of the Fe^{2+}?

$0.001(3\times10^{-5}M) = 3\times10^{-8}M$

$Fe(OH)_{2(s)} \rightleftharpoons Fe^{2+}_{(aq)} + 2OH^-_{(aq)}$ $K_{sp} = 4.1\times10^{-15} = [Fe^{2+}][OH^-]^2$

init same 3×10^{-8} 0 $4.1\times10^{-15} = (3\times10^{-8}M)(x)^2$

fin same $3\times10^{-5}M$ x

$4.1\times10^{-15} = (3\times10^{-5})(x)^2$

$x = 3.69\times10^{-4}M$ pOH = 3.43 pH = 10.6

(b) If Cu^{2+} is present in the ~~water sample~~ with $[Cu^{2+}]$ = 1 x 10^{-9}M. ~~At~~ what pH will $Cu(OH)_2$ begin to precipitate? How much Fe^{2+} will be present at this point?

$Cu(OH)_{2(s)} \rightleftharpoons Cu^{2+}_{(aq)} + 2OH^-_{(aq)}$ $K_{sp} = 4.8\times10^{-20}$

init same $1\times10^{-9}M$ 0 $4.8\times10^{-20} = (1\times10^{-9})x^2$

final same $1\times10^{-9}M$ x $6.93\times10^{-6} = x = [OH^-]$ pOH = 5.16 pH = 8.85

(c) Will the presence of the Cu^{2+} cause a problem?

the $Cu(OH)_2$ will start to precipitate before the Fe^{2+} does!

$Fe(OH)_{2(s)} \rightleftharpoons Fe^{2+} + 2OH^-$ $K_{sp} = 4.1\times10^{-15}$

final same x 6.93×10^{-6}

$4.1\times10^{-15} = [Fe^{2+}](6.93\times10^{-6})^2$

$8.5\times10^{-5}M = [Fe^{2+}]$

(4) (15 points) How would you prepare a 1.00 L solution of pH = 7.00 buffer from Na_2HPO_4 and NaH_2PO_4 with an ionic strength of 0.300?

$H_2PO_4^- + H_2O \rightleftarrows HPO_4^{2-} + H_3O^+ \quad K_a = 6.32 \times 10^{-8}$

$pH = pK_a + \log\frac{[base]}{[acid]}$

$7.00 = 7.20 + \log\frac{[base]}{[acid]}$

$-0.20 = \log\frac{[base]}{[acid]}$

$0.632 = \frac{[HPO_4^{2-}]}{[H_2PO_4^-]}$

$0.632[H_2PO_4^-] = [HPO_4^{2-}]$

$0.300 = \frac{1}{2}\{[Na^+]1^2 + [HPO_4^{2-}]2^2 + [H_2PO_4^-]1^2\}$

$[Na^+] = 2[HPO_4^{2-}] + [H_2PO_4^-]$

$[Na^+] = 2(0.632)[H_2PO_4^-] + [H_2PO_4^-] = 2.26[H_2PO_4^-]$

$0.300 = \frac{1}{2}\{2.26[H_2PO_4^-]1^2 + 0.632[H_2PO_4^-](4) + [H_2PO_4^-]1^2\}$

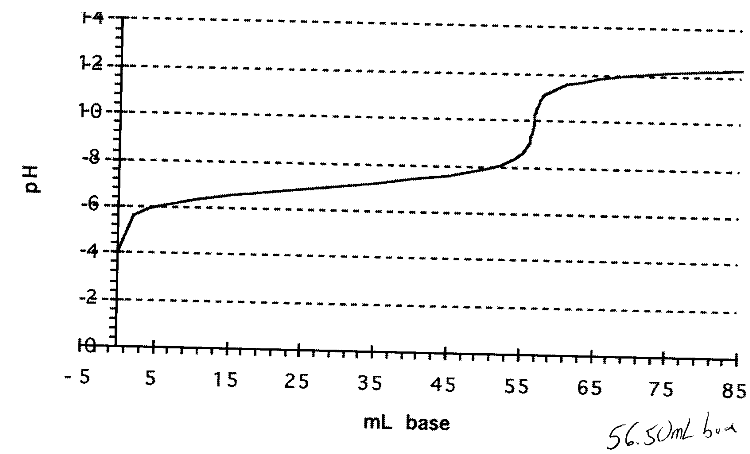
$0.300 = \frac{1}{2}\{5.79[H_2PO_4^-]\}$

$2.89[H_2PO_4^-] = 0.3$

$[H_2PO_4^-] = 0.104\,M$

$0.632(0.104) = 0.0656\,M\ HPO_4^{2-}$

∴ add 0.104 moles NaH_2PO_4 and 0.0656 moles Na_2HPO_4 and dilute to 1.00 L



56.50 mL base = 5.00×10^{-3} moles
[NaOH] = 0.0885 M

pH	Volume
9.14	56.10
9.21	56.15
9.93	56.60
10.22	56.70
10.49	56.87
11.09	58.00

Indicator	pH of Transition
Congo Red	3.0-5.0
Methyl Red	4.8-6.0
Cresol Purple	7.6-9.2
Thymolpthalein	8.3-10.5
Alizarin yellow	10.1-12.0

(a)(10 points) If the K_a for this acid is 3.5×10^{-7}, what is the pH at the equivalence point (which is 56.50 mL of base)?

$K_b = \frac{10^{-14}}{3.5\times10^{-7}} = 2.9\times10^{-8}$

$\frac{5.00\times10^{-3} \text{ mols}}{0.1065 \text{ L}} = 4.69\times10^{-2}$ M

$B + H_2O \rightleftharpoons HB^+ + OH^-$ $K_b = 2.9\times10^{-8}$

init 4.69×10^{-2} M 0 0

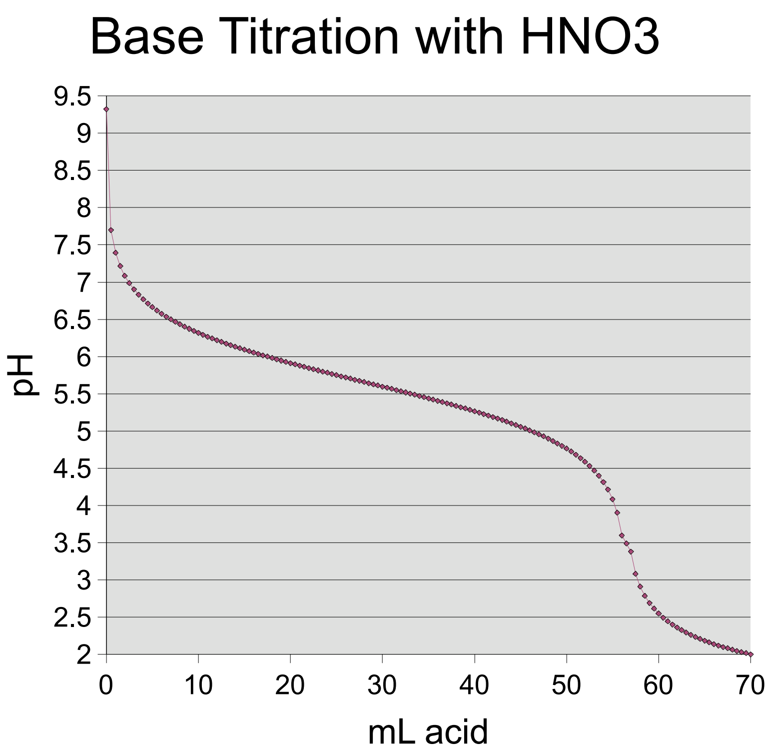
x^2

Problem 6 solution

ML acid	Moles acid	Moles base left	Moles conj acid	PH		
0	0.00E+000	5.00E-003	0.00E+000	9.32	Explicitly	Calculated
0.5	4.43E-005	4.96E-003	4.43E-005	7.7		
1	8.85E-005	4.91E-003	8.85E-005	7.39		
1.5	1.33E-004	4.87E-003	1.33E-004	7.21		
2	1.77E-004	4.82E-003	1.77E-004	7.09		
2.5	2.21E-004	4.78E-003	2.21E-004	6.98		
3	2.66E-004	4.73E-003	2.66E-004	6.9		
3.5	3.10E-004	4.69E-003	3.10E-004	6.83		
4	3.54E-004	4.65E-003	3.54E-004	6.77		
4.5	3.98E-004	4.60E-003	3.98E-004	6.71		
5	4.43E-004	4.56E-003	4.43E-004	6.66		
5.5	4.87E-004	4.51E-003	4.87E-004	6.62		
6	5.31E-004	4.47E-003	5.31E-004	6.58		
6.5	5.75E-004	4.42E-003	5.75E-004	6.54		
7	6.20E-004	4.38E-003	6.20E-004	6.5		
7.5	6.64E-004	4.34E-003	6.64E-004	6.47		
8	7.08E-004	4.29E-003	7.08E-004	6.43		
8.5	7.52E-004	4.25E-003	7.52E-004	6.4		
9	7.97E-004	4.20E-003	7.97E-004	6.37		
9.5	8.41E-004	4.16E-003	8.41E-004	6.34		
10	8.85E-004	4.12E-003	8.85E-004	6.32		
10.5	9.29E-004	4.07E-003	9.29E-004	6.29		
11	9.74E-004	4.03E-003	9.74E-004	6.27		
11.5	1.02E-003	3.98E-003	1.02E-003	6.24		
12	1.06E-003	3.94E-003	1.06E-003	6.22		
12.5	1.11E-003	3.89E-003	1.11E-003	6.2		
13	1.15E-003	3.85E-003	1.15E-003	6.17		
13.5	1.19E-003	3.81E-003	1.19E-003	6.15		
14	1.24E-003	3.76E-003	1.24E-003	6.13		
14.5	1.28E-003	3.72E-003	1.28E-003	6.11		
15	1.33E-003	3.67E-003	1.33E-003	6.09		
15.5	1.37E-003	3.63E-003	1.37E-003	6.07		
16	1.42E-003	3.58E-003	1.42E-003	6.05		
16.5	1.46E-003	3.54E-003	1.46E-003	6.03		

34.5	3.05E-003	1.95E-003	3.05E-003	5.45
35	3.10E-003	1.90E-003	3.10E-003	5.44
35.5	3.14E-003	1.86E-003	3.14E-003	5.42
36	3.19E-003	1.81E-003	3.19E-003	5.41
36.5	3.23E-003	1.77E-003	3.23E-003	5.39
37	3.27E-003	1.73E-003	3.27E-003	5.37
37.5	3.32E-003	1.68E-003	3.32E-003	5.35
38	3.36E-003	1.64E-003	3.36E-003	5.34
38.5	3.41E-003	1.59E-003	3.41E-003	5.32
39	3.45E-003	1.55E-003	3.45E-003	5.3
39.5	3.50E-003	1.50E-003	3.50E-003	5.28
40	3.54E-003	1.46E-003	3.54E-003	5.27
40.5	3.58E-003	1.42E-003	3.58E-003	5.25
41	3.63E-003	1.37E-003	3.63E-003	5.23
41.5	3.67E-003	1.33E-003	3.67E-003	5.21
42	3.72E-003	1.28E-003	3.72E-003	5.19
42.5	3.76E-003	1.24E-003	3.76E-003	5.17
43	3.81E-003	1.19E-003	3.81E-003	5.15
43.5	3.85E-003	1.15E-003	3.85E-003	5.13
44	3.89E-003	1.11E-003	3.89E-003	5.1
44.5	3.94E-003	1.06E-003	3.94E-003	5.08
45	3.98E-003	1.02E-003	3.98E-003	5.06
45.5	4.03E-003	9.73E-004	4.03E-003	5.03
46	4.07E-003	9.29E-004	4.07E-003	5.01
46.5	4.12E-003	8.85E-004	4.12E-003	4.98
47	4.16E-003	8.41E-004	4.16E-003	4.96
47.5	4.20E-003	7.96E-004	4.20E-003	4.93
48	4.25E-003	7.52E-004	4.25E-003	4.9
48.5	4.29E-003	7.08E-004	4.29E-003	4.87
49	4.34E-003	6.63E-004	4.34E-003	4.83
49.5	4.38E-003	6.19E-004	4.38E-003	4.8
50	4.43E-003	5.75E-004	4.43E-003	4.76
50.5	4.47E-003	5.31E-004	4.47E-003	4.72
51	4.51E-003	4.87E-004	4.51E-003	4.68
51.5	4.56E-003	4.42E-004	4.56E-003	4.64

69.5	6.15E-003	2.02	1.15E-003
70	6.20E-003	2	1.20E-003
70.5			
71			
71.5			


Base Titration with HNO3
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
pH
0
10
20
30
40
50
60
70
mL acid

52	4.60E-003	3.98E-004	4.60E-003	4.59	
52.5	4.65E-003	3.54E-004	4.65E-003	4.53	
53	4.69E-003	3.10E-004	4.69E-003	4.47	
53.5	4.73E-003	2.65E-004	4.73E-003	4.4	
54	4.78E-003	2.21E-004	4.78E-003	4.32	
54.5	4.82E-003	1.77E-004	4.82E-003	4.21	
55	4.87E-003	1.33E-004	4.87E-003	4.08	
55.5	4.91E-003	8.82E-005	4.91E-003	3.9	
56	4.96E-003	4.40E-005	4.96E-003	3.6	
56.5	5.00E-003	-2.50E-007	5.00E-003	3.49	EXCESS ACID
57	5.04E-003			3.38	4.45E-005
57.5	5.09E-003			3.08	8.88E-005
58	5.13E-003			2.91	1.33E-004
58.5	5.18E-003			2.79	1.77E-004
59	5.22E-003			2.69	2.22E-004
59.5	5.27E-003			2.61	2.66E-004
60	5.31E-003			2.55	3.10E-004
60.5	5.35E-003			2.49	3.54E-004
61	5.40E-003			2.44	3.99E-004
61.5	5.44E-003			2.4	4.43E-004
62	5.49E-003			2.36	4.87E-004
62.5	5.53E-003			2.33	5.31E-004
63	5.58E-003			2.29	5.76E-004
63.5	5.62E-003			2.26	6.20E-004
64	5.66E-003			2.23	6.64E-004
64.5	5.71E-003			2.21	7.08E-004
65	5.75E-003			2.18	7.53E-004
65.5	5.80E-003			2.16	7.97E-004
66	5.84E-003			2.14	8.41E-004
66.5	5.89E-003			2.12	8.85E-004
67	5.93E-003			2.1	9.30E-004
67.5	5.97E-003			2.08	9.74E-004
68	6.02E-003			2.06	1.02E-003
68.5	6.06E-003			2.05	1.06E-003
69	6.11E-003			2.03	1.11E-003

17	1.50E-003	3.50E-003	1.50E-003	6.02
17.5	1.55E-003	3.45E-003	1.55E-003	6
18	1.59E-003	3.41E-003	1.59E-003	5.98
18.5	1.64E-003	3.36E-003	1.64E-003	5.96
19	1.68E-003	3.32E-003	1.68E-003	5.95
19.5	1.73E-003	3.27E-003	1.73E-003	5.93
20	1.77E-003	3.23E-003	1.77E-003	5.91
20.5	1.81E-003	3.19E-003	1.81E-003	5.89
21	1.86E-003	3.14E-003	1.86E-003	5.88
21.5	1.90E-003	3.10E-003	1.90E-003	5.86
22	1.95E-003	3.05E-003	1.95E-003	5.85
22.5	1.99E-003	3.01E-003	1.99E-003	5.83
23	2.04E-003	2.96E-003	2.04E-003	5.81
23.5	2.08E-003	2.92E-003	2.08E-003	5.8
24	2.12E-003	2.88E-003	2.12E-003	5.78
24.5	2.17E-003	2.83E-003	2.17E-003	5.77
25	2.21E-003	2.79E-003	2.21E-003	5.75
25.5	2.26E-003	2.74E-003	2.26E-003	5.73
26	2.30E-003	2.70E-003	2.30E-003	5.72
26.5	2.35E-003	2.65E-003	2.35E-003	5.7
27	2.39E-003	2.61E-003	2.39E-003	5.69
27.5	2.43E-003	2.57E-003	2.43E-003	5.67
28	2.48E-003	2.52E-003	2.48E-003	5.66
28.5	2.52E-003	2.48E-003	2.52E-003	5.64
29	2.57E-003	2.43E-003	2.57E-003	5.63
29.5	2.61E-003	2.39E-003	2.61E-003	5.61
30	2.66E-003	2.35E-003	2.66E-003	5.6
30.5	2.70E-003	2.30E-003	2.70E-003	5.58
31	2.74E-003	2.26E-003	2.74E-003	5.57
31.5	2.79E-003	2.21E-003	2.79E-003	5.55
32	2.83E-003	2.17E-003	2.83E-003	5.53
32.5	2.88E-003	2.12E-003	2.88E-003	5.52
33	2.92E-003	2.08E-003	2.92E-003	5.5
33.5	2.96E-003	2.04E-003	2.96E-003	5.49
34	3.01E-003	1.99E-003	3.01E-003	5.47

what is the difference (in mL of NaOH) between the endpoint and the equivalence point? What %error is this?

9.21 is before the endpoint, in the buffer region

$pH = 6.45 + \log \frac{[base]}{[acid]} = 9.21$

$\log \frac{[base]}{[acid]} = 2.75$

$576 = \frac{[base]}{[acid]}$

$[acid] = [base]/576$

moles acid left = 8.79×10^{-6} moles acid

8.79×10^{-6} mols ÷ 0.0885 M = 0.098 mL difference

$\%error = \frac{0.098 mL}{56.5 mL} \times 100\% = 0.173\%$

(c)(5 points) If thymolphtalein is used as the indicator and the endpoint is noted at pH = 10.49 what is the difference (in mL of NaOH) between the endpoint and the equivalence point? What is the % error caused by the indicator?

pH = 10.49 excess NaOH pOH = 3.51

$[OH^-] = 3.09 \times 10^{-4} M$

$3.09 \times 10^{-4} M = \frac{(0.0885 M)(x)}{(0.05650 L + x)}$

$1.75 \times 10^{-5} + (3.09 \times 10^{-4} x) = (0.0885 M\ x)$

1.75×10^{-5} moles $= 0.0881 M x$

$2.16 \times 10^{-4} L = x$ = 0.216 mL

$\%error = \frac{0.216 mL}{56.5 mL} \times 100\% = 0.38\%$

base to start with and titrate it with 0.0885 M HNO_3. List explicitly the initial pH and the equivalence point and it's pH. Calculate the point for every 0.5 mL (on the mL). Include the worksheet as well as the graph (please explain it so it is easy to understand). Do you think a color indicator would work well with this titration?

$B + H_2O \rightleftharpoons BH^+ + OH^-$ $K_b = 4.5 \times 10^{-9}$

init 0.100M | 0 | 0

final ~0.100M | x | x

Inital point

$4.5 \times 10^{-9} = \frac{x^2}{0.100}$

2.1×10^{-5} M $= x = [OH^-]$

pH = 9.32

Equivalence Point

initial 5.00×10^{-3} moles base

$\therefore$ 56.50 mL of acid = equivalence point

$[HB^+] = \frac{5 \times 10^{-3} \text{ moles}}{0.1065 \text{ L}} = 0.0469$ M

$K_a = \frac{10^{-14}}{4.5 \times 10^{-9}} = 2.22 \times 10^{-6}$

$HB^+ + H_2O \rightleftharpoons B + H_3O^+$

init 0.0469M | — | 0 | 0

final ~0.0469M | | x | x

$\frac{x^2}{0.0469} = 2.22 \times 10^{-6}$

$x = 3.2 \times 10^{-4}$ M $= [H_3O^+]$

pH = 3.49

A color indicator would be hard to se for this titration.

pKa = 5.65

(7)(20 points) For phosphoric acid, calculate the fractional composition (alpha values) for all species in solution as a function of pH. See pages 420-421 in your books for some ideas. Do this in a spreadsheet and graph it.

[illegible]	[illegible]				
1	1.00E-001	0.93	0.07	0	0
1.2	6.31E-002	0.9	0.1	0	0
1.4	3.98E-002	0.85	0.15	0	0
1.6	2.51E-002	0.78	0.22	0	0
1.8	1.58E-002	0.69	0.31	0	0
2	1.00E-002	0.58	0.42	0	0
2.2	6.31E-003	0.47	0.53	0	0
2.4	3.98E-003	0.36	0.64	0	0
2.6	2.51E-003	0.26	0.74	0	0
2.8	1.58E-003	0.18	0.82	0	0
3	1.00E-003	0.12	0.88	0	0
3.2	6.31E-004	0.08	0.92	0	0
3.4	3.98E-004	0.05	0.95	0	0
3.6	2.51E-004	0.03	0.97	0	0
3.8	1.58E-004	0.02	0.98	0	0
4	1.00E-004	0.01	0.99	0	0
4.2	6.31E-005	0.01	0.99	0	0
4.4	3.98E-005	0.01	0.99	0	0
4.6	2.51E-005	0	0.99	0	0
4.8	1.58E-005	0	0.99	0	0
5	1.00E-005	0	0.99	0.01	0
5.2	6.31E-006	0	0.99	0.01	0
5.4	3.98E-006	0	0.98	0.02	0
5.6	2.51E-006	0	0.98	0.02	0
5.8	1.58E-006	0	0.96	0.04	0
6	1.00E-006	0	0.94	0.06	0
6.2	6.31E-007	0	0.91	0.09	0
6.4	3.98E-007	0	0.86	0.14	0
6.6	2.51E-007	0	0.8	0.2	0
6.8	1.58E-007	0	0.71	0.29	0
7	1.00E-007	0	0.61	0.39	0
7.2	6.31E-008	0	0.5	0.5	0
7.4	3.98E-008	0	0.39	0.61	0
7.6	2.51E-008	0	0.28	0.72	0
7.8	1.58E-008	0	0.2	0.8	0
8	1.00E-008	0	0.14	0.86	0
8.2	6.31E-009	0	0.09	0.91	0
8.4	3.98E-009	0	0.06	0.94	0
8.6	2.51E-009	0	0.04	0.96	0

9.6	2.51E-010	0	0	0.99	0
9.8	1.58E-010	0	0	0.99	0
10	1.00E-010	0	0	0.99	0
10.2	6.31E-011	0	0	0.99	0.01
10.4	3.98E-011	0	0	0.99	0.01
10.6	2.51E-011	0	0	0.98	0.02
10.8	1.58E-011	0	0	0.97	0.03
11	1.00E-011	0	0	0.96	0.04
11.2	6.31E-012	0	0	0.94	0.06
11.4	3.98E-012	0	0	0.9	0.1
11.6	2.51E-012	0	0	0.86	0.14
11.8	1.58E-012	0	0	0.79	0.21
12	1.00E-012	0	0	0.7	0.3
12.2	6.31E-013	0	0	0.6	0.4
12.4	3.98E-013	0	0	0.49	0.51
12.6	2.51E-013	0	0	0.37	0.63
12.8	1.58E-013	0	0	0.27	0.73
13	1.00E-013	0	0	0.19	0.81
13.2	6.31E-014	0	0	0.13	0.87
13.4	3.98E-014	0	0	0.09	0.91
13.6	2.51E-014	0	0	0.06	0.94
13.8	1.58E-014	0	0	0.04	0.96
14	1.00E-014	0	0	0.02	0.98
14.2					
14.4					

Fractional Composition of Phosphoric Acid