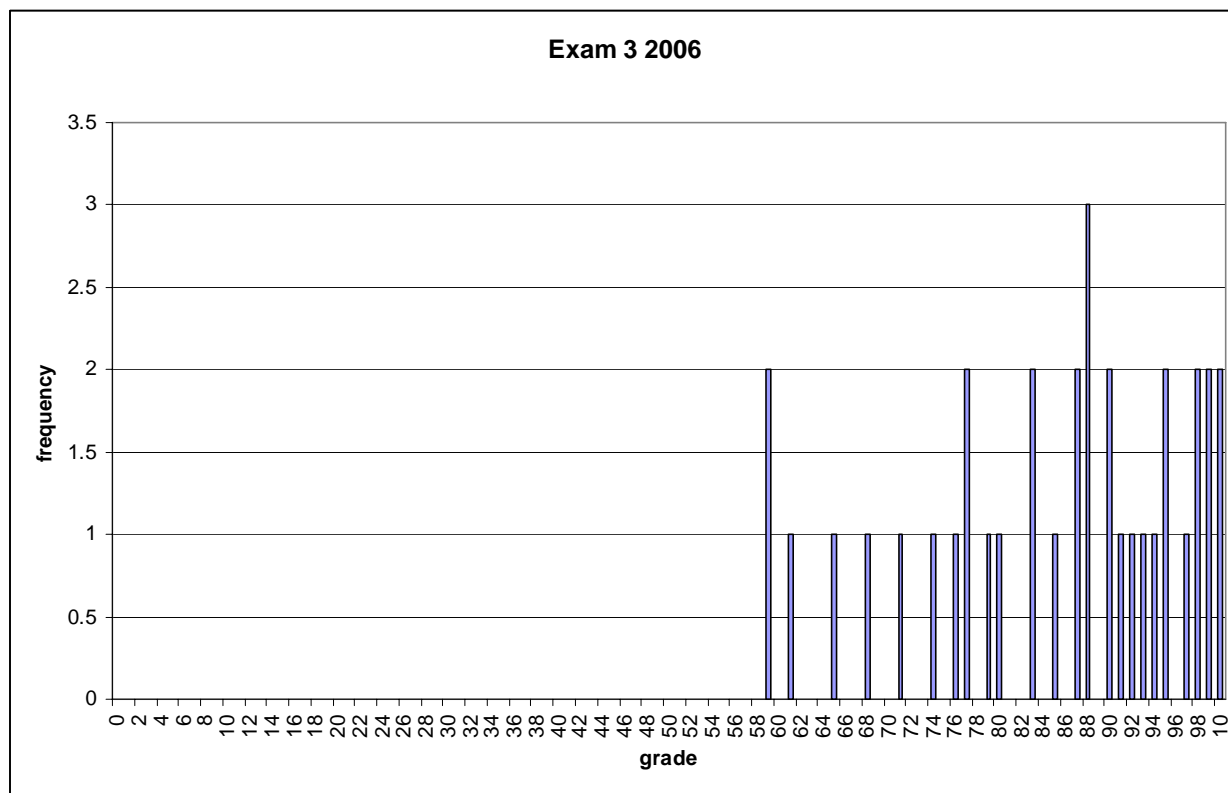


Chem 253 – Exam 3 – November 15, 2006



Average = 84.7

Median = 88

Standard Deviation = 12.2

Please Read carefully

Use the scantron sheets to fill in your answers. Use the exam itself as scratch paper except for the last 3 problems which you must turn in. Questions 1-13 are worth 5 points each for 65 points. Questions 14-16 are worth 25 points. Today's portion is worth 90 points. The last ten points are based randomly taken attendance since the last exam for a total of 100 points.

**Table 13-1** Values of  $\alpha_{Y^{4-}}$  for EDTA at 20°C and  $\mu = 0.10$  M

pH	$\alpha_{Y^{4-}}$
0	$1.3 \times 10^{-23}$
1	$1.9 \times 10^{-18}$
2	$3.3 \times 10^{-14}$
3	$2.6 \times 10^{-11}$
4	$3.8 \times 10^{-9}$
5	$3.7 \times 10^{-7}$
6	$2.3 \times 10^{-5}$
7	$5.0 \times 10^{-4}$
8	$5.6 \times 10^{-3}$
9	$5.4 \times 10^{-2}$
10	0.36
11	0.85
12	0.98
13	1.00
14	1.00

**Table 13-2** Formation constants for metal-EDTA complexes

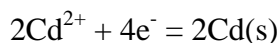
Ion	$\log K_f$	Ion	$\log K_f$	Ion	$\log K_f$
Li <sup>+</sup>	2.79	Mn <sup>3+</sup>	25.3 (25°C)	Ce <sup>3+</sup>	15.98
Na <sup>+</sup>	1.66	Fe <sup>3+</sup>	25.1	Pr <sup>3+</sup>	16.40
K <sup>+</sup>	0.8	Co <sup>3+</sup>	41.4 (25°C)	Nd <sup>3+</sup>	16.61
Be <sup>2+</sup>	9.2	Zr <sup>4+</sup>	29.5	Pm <sup>3+</sup>	17.0
Mg <sup>2+</sup>	8.79	Hf <sup>4+</sup>	29.5 ( $\mu = 0.2$ )	Sm <sup>3+</sup>	17.14
Ca <sup>2+</sup>	10.69	VO <sup>2+</sup>	18.8	Eu <sup>3+</sup>	17.35
Sr <sup>2+</sup>	8.73	VO <sub>2</sub> <sup>+</sup>	15.55	Gd <sup>3+</sup>	17.37
Ba <sup>2+</sup>	7.86	Ag <sup>+</sup>	7.32	Tb <sup>3+</sup>	17.93
Ra <sup>2+</sup>	7.1	Tl <sup>+</sup>	6.54	Dy <sup>3+</sup>	18.30
Sc <sup>3+</sup>	23.1	Pd <sup>2+</sup>	18.5 (25°C, $\mu = 0.2$ )	Ho <sup>3+</sup>	18.62
Y <sup>3+</sup>	18.09	Zn <sup>2+</sup>	16.50	Er <sup>3+</sup>	18.85
La <sup>3+</sup>	15.50	Cd <sup>2+</sup>	16.46	Tm <sup>3+</sup>	19.32
V <sup>2+</sup>	12.7	Hg <sup>2+</sup>	21.7	Yb <sup>3+</sup>	19.51
Cr <sup>2+</sup>	13.6	Sn <sup>2+</sup>	18.3 ( $\mu = 0$ )	Lu <sup>3+</sup>	19.83
Mn <sup>2+</sup>	13.87	Pb <sup>2+</sup>	18.04	Am <sup>3+</sup>	17.8 (25°C)
Fe <sup>2+</sup>	14.32	Al <sup>3+</sup>	16.3	Cm <sup>3+</sup>	18.1 (25°C)
Co <sup>2+</sup>	16.31	Ga <sup>3+</sup>	20.3	Bk <sup>3+</sup>	18.5 (25°C)
Ni <sup>2+</sup>	18.62	In <sup>3+</sup>	25.0	Cf <sup>3+</sup>	18.7 (25°C)
Cu <sup>2+</sup>	18.80	Tl <sup>3+</sup>	37.8 ( $\mu = 1.0$ )	Th <sup>4+</sup>	23.2
Ti <sup>3+</sup>	21.3 (25°C)	Bi <sup>3+</sup>	27.8	U <sup>4+</sup>	25.8
V <sup>3+</sup>	26.0			Np <sup>4+</sup>	24.6 (25°C, $\mu = 1.0$ )
Cr <sup>3+</sup>	23.4				

**Table 14-1** Ordered redox potentials

Oxidizing agent	Reducing agent	$E^\circ$ (V)
$F_2(g) + 2e^- \rightleftharpoons 2F^-$		2.890
$O_3(g) + 2H^+ + 2e^- \rightleftharpoons O_2(g) + H_2O$		2.075
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$		1.507
$Ag^+ + e^- \rightleftharpoons Ag(s)$		0.799
$Cu^{2+} + 2e^- \rightleftharpoons Cu(s)$		0.339
$2H^+ + 2e^- \rightleftharpoons H_2(g)$		0.000
$Cd^{2+} + 2e^- \rightleftharpoons Cd(s)$		-0.402
$K^+ + e^- \rightleftharpoons K(s)$		-2.936
$Li^+ + e^- \rightleftharpoons Li(s)$		-3.040

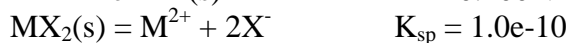
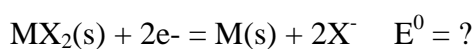
↑  
Oxidizing power increases
↓  
Reducing power increases

1] What is the standard reduction potential ( $E^0$ ) for the following half reaction? See Table 14-1 on page 1 for more data.



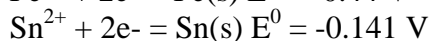
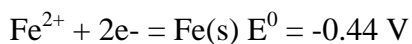
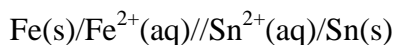
- a) 0.402 V
- b) 0.804 V
- c) -0.804 V
- d) -0.402 V
- e) 0.000 V

2] What is  $E^0$  for the half reaction given the following?



- a)  $E^0 = 0.100 - \frac{0.0592}{2} \ln \frac{1}{K_{\text{sp}}}$
- b)  $E^0 = 0.100 - 0.0592 \log \frac{1}{K_{\text{sp}}}$
- c)  $E^0 = 0.100 - \frac{0.0592}{2} \log K_{\text{sp}}$
- d)  $E^0 = 0.100 + \frac{0.0592}{2} \log \frac{1}{K_{\text{sp}}}$
- e)  $E^0 = 0.100 - \frac{0.0592}{2} \log \frac{1}{K_{\text{sp}}}$

3] The standard cell potential for the following is



- a) -0.030
- b) -0.581
- c) 0.30
- d) 0.44
- e) 0.581

Questions 4-7 involve the titration of 100.0 mL of 0.100 M  $\text{CH}_3\text{COOH}$  ( $K_a = 1.75 \times 10^{-5}$ ) with 0.100 M NaOH

4] What is the pH of the titration solution when 0.0 mL of NaOH is added?

- a) 1.779
- b) 2.879
- c) 3.334
- d) 4.228
- e) 7.321

5] What is the pH of the titration solution when 50.0 mL of NaOH is added?

- a) 4.757
- b) 2.771
- c) 5.667
- d) 6.231
- e) 7.192

6] What is the pH of the titration solution when 100.0 mL of NaOH is added?

- a) 5.772
- b) 4.942
- c) 4.757
- d) 8.730
- e) 6.993

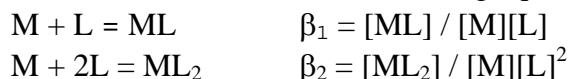
7] What is the pH of the titration solution when 150.0 mL of NaOH is added?

- a) 6.889
- b) 12.301
- c) 7.883
- d) 7.115
- e) 3.779

8] Please refer to Table 14-1 on the cover sheet of your exam. Which of the species in that table represents the strongest oxidizing agent?

- a) Li
- b)  $\text{Li}^+$
- c)  $\text{F}^-$
- d)  $\text{F}_2$
- e) Cu

9] The fraction of free metal in the following equilibrium can be expressed as:



- a)  $\alpha_m = \frac{[M]}{1 + \beta_2}$
- b)  $\alpha_m = \frac{[M]}{1 + \beta_1[L]}$
- c)  $\alpha_m = \frac{1}{1 + \beta_1[L] + \beta_2[L]}$
- d)  $\alpha_m = \frac{1}{1 + \beta_1[L] + \beta_2[L]^2}$
- e)  $\alpha_m = \frac{[M]}{1 + \beta_1[L] + \beta_2[L]^2}$

10] What is the fraction of  $Y^{4-}$  in a solution of EDTA that is at pH 6.00?

- a) 2.3e-5  
b) 0.85  
c) 1.00  
d) 1.3e-23  
e) 5.0e-4

11] What is the conditional formation constant of  $ZnY^{2-}$  at pH 10.00?

- a) 1.9e-7  
b) 1.1e16  
c) 2.8e9  
d) 4.1e10  
e) 6.1e4

12] What is the concentration of  $Ni^{2+}$  in a solution that is 1.00e-3 F in a solution that is 0.100 M  $NH_3$  when  $\alpha_{Ni^{2+}} = 1.34e-4$ ?

- a) 1.34e-4 M  
b) 1.00e-3 M  
c) 2.00e-6 M  
d) 1.00e3 M  
e) 1.34e-7 M

Questions 13-16 concern the titration of 10.00 mL of  $2.50 \times 10^{-3}$  M of  $\text{Zn}^{2+}$  is with  $2.50 \times 10^{-3}$  M EDTA in the presence of 0.100 M  $\text{NH}_3$  at pH 11.

$$K_f'' = 4.8 \times 10^{11} \quad \alpha_{\text{Zn}^{2+}} = 1.79 \times 10^{-5}$$

13] What is pZn when 0.00 mL of titrant is added?

- a) 7.775
- b) 5.771
- c) 7.349
- d) 8.243
- e) 3.996

Turn in this page

Name \_\_\_\_\_

14] What is pZn if 5.00 mL of titrant is added? @ 5.00 mL pZn = \_\_\_\_\_

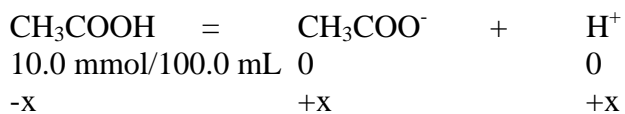
15] What is pZn if 10.00 mL of titrant is added? @ 10.00 mL pZn = \_\_\_\_\_

16] What is pZn if 15.00 mL of titrant is added? @ 15.00 mL pZn = \_\_\_\_\_

### Answers

1] d    2] e    3] c:  $E = -0.141 - (-0.44) = 0.30$  V

4] b:  $\text{mmol CH}_3\text{COOH} = 100.0 \text{ mL} * 0.100 \text{ M} = 10.0$

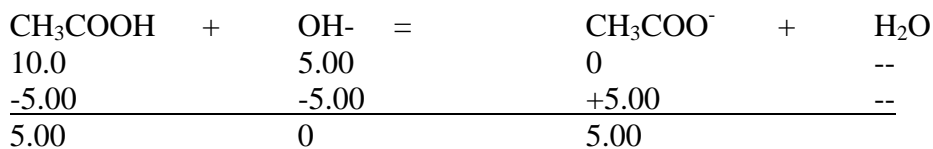


$$1.75 \times 10^{-5} = x^2 / (0.100 - x) \approx x^2 / 0.100$$

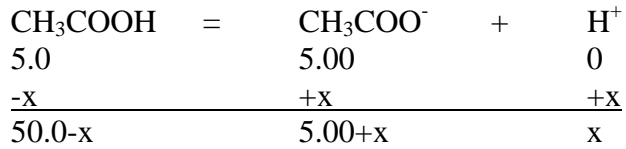
$$x = 1.32 \times 10^{-3} \text{ M}$$

$$\text{pH} = 2.879$$

5]a:  $\text{mmol OH}^- = 50.0 \text{ mL} * 0.100 \text{ M} = 5.00$



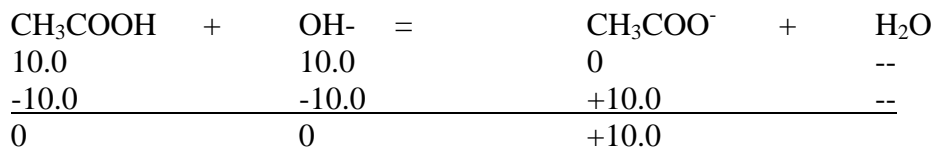
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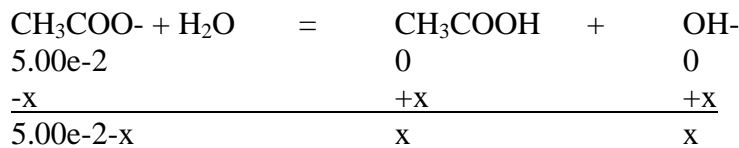
$$1.75\text{e-}5 \approx x(5.00)/5.0.0 \quad x = 1.75\text{e-}5 \text{ M}$$

$$\text{pH} = 4.757$$

6]d: mmol  $\text{OH}^-$  = 100.0 mL \* 0.100 M = 10.0 mmol                      This is the eq. pt.



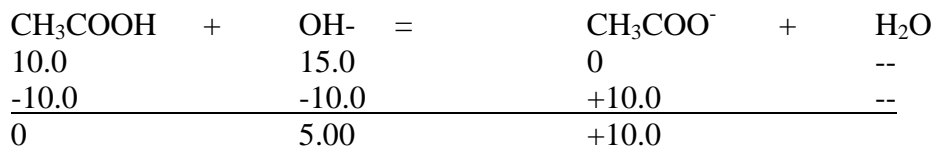
$$[\text{CH}_3\text{COO}^-] = 10.0 \text{ mmol} / 200.0 \text{ mL} = 5.00\text{e-}2 \text{ M}$$



$$K_b = K_w/K_a = 1.01\text{e-}14/1.75\text{e-}5 = x^2 / 5.00\text{e-}2$$

$$x = 5.372\text{e-}6 \quad \text{pOH} = 5.270 \quad \text{pH} = 8.730$$

7]b: mmol  $\text{OH}^-$  = 150.0 mL \* 0.100 M = 15.0                      past eq. pt.



$$[\text{OH}^-] = 5.00 \text{ mmol} / 250.0 \text{ mL} = 2.00\text{e-}2 \text{ M} \quad \text{pOH} = 1.699 \quad \text{pH} = 12.301$$

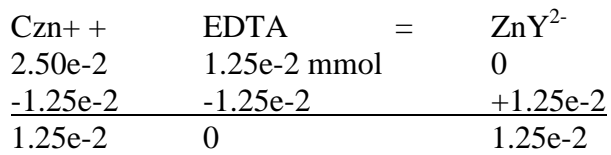
8] d                      9]d                      10] a                      11]b:  $K_f' = 0.36 \cdot 10^{16.50} = 1.1\text{e}16$

12]e:  $[\text{Ni}^{2+}] = \alpha_{\text{Ni}^{2+}} C_{\text{Ni}^{2+}} = 1.34\text{e-}4 \cdot 1.00\text{e-}3 \text{ M} = 1.34\text{e-}7 \text{ M}$

13]c:  $[\text{Zn}^{2+}] = 1.79\text{e-}5 \cdot 2.50\text{e-}3 \text{ M} = 4.48\text{e-}8 \quad \text{pZn} = 7.349$

14]a: mmol  $C_{\text{Zn}^{2+}} = 10.00 \text{ mL} \cdot 2.50\text{e-}3 \text{ M} = 2.50\text{e-}2$

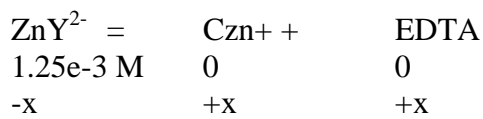
mmol EDTA = 5.00 mL \* 2.50e-3 M = 1.25e-2



$$[Zn^{2+}] = 1.79e-5 * (1.25e-2 \text{ mmol} / 15.00 \text{ mL}) = 1.49e-8 \quad pZn = 7.826$$

15]b: Eq. pt.                      mmol  $Zn^{2+} = 10.00 \text{ mL} * 2.50e-3 \text{ M} = 2.50e-2$

$$[ZnY^{2-}] = 2.50e-2 \text{ mmol} / 20.00 \text{ mL} = 1.25e-3 \text{ M}$$



$$4.8e11 = (1.25e-3 - x) / x^2$$

$$x = 5.10e-8 \text{ M}$$

$$[Zn^{2+}] = 1.79e-5 * 5.10e-8 \text{ M} \quad pZn = 12.039$$

16] excess EDTA =  $5.00 \text{ mL} * 2.50e-3 \text{ M} = 1.25e-2 \text{ mmol}$

$$[EDTA] = 1.25e-2 \text{ mmol} / 25.00 \text{ mL} = 5.00e-4 \text{ M}$$

$$[ZnY^{2-}] = 2.50e-2 \text{ mmol} / 25.00 \text{ mL} = 1.00e-3 \text{ M}$$

$$K_f'' = 4.8e11 = 1.00e-3 / 5.00e-4 * C_{Zn^{2+}} \quad C_{Zn^{2+}} = 4.167e-12$$

$$[Zn^{2+}] = 1.79e-5 * 4.167e-12 \text{ M} = 7.46e-17$$

$$pZn = 16.127$$