

Key to chem 103 Test 1

Part I Multiple Choice:

1 E

2 B

3 D  $[H_3O^+][OH^-] = 1 \times 10^{-14}$  (this is not  $> 1.0 \times 10^{-7}$ )

4 A I:  $pH = -\log(4.2 \times 10^{-6}) = 5.4$  III;  $pH = \log(0.25) = 0.60$

5 A

6 C

7 D

8 E  $[H^+] = 10^{-4.14} = 7.24 \times 10^{-5}$ ;  $K_a = (7.24 \times 10^{-5})^2 / .15 = 3.5 \times 10^{-8}$

9 B pKa should be closest to 4.20.

pKa =  $-\log K_a$ : These are respectively: 4.74, 4.20, 3.74, 3.14, 3.35

10 D

11 C

12 B

13 D  $MV = M'V'$   $V = M'V'/M = (50.00\text{mL})(.0950)/(1.060) = 44.81\text{mL}$

14 C

15 B  $AgCl \rightleftharpoons Ag^+ + Cl^-$   $x(.154M) = 1.8 \times 10^{-10}$   $x = (1.8 \times 10^{-10})/(.154M) = 1.2 \times 10^{-9}$

16 B

17 C  $pH = 14 - pOH = 14.00 - (-\log 1.0 \times 10^{-4}) = 10.0$

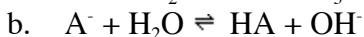
18 E  $[H^+] = 1.0M(1.0\text{mL}/(100)\text{mL}) = 0.01\text{ M HCl}$ ;  $pH = -\log(.01) = 2.0$

19 B  $HOAc \rightleftharpoons H^+ + OAc^-$   $x^2/0.10 \approx 1.8 \times 10^{-5}$ ;  $x = 1.34 \times 10^{-3}$   $pH = -\log x = 2.9$

20 B  $Ca^{2+} + EDTA \rightleftharpoons CaEDTA$   $1.0/x^2 \approx 4.5 \times 10^{10} \Rightarrow x^2 = 2.2 \times 10^{-11}$   $x = 4.7 \times 10^{-6}$

Part II

21



c.

Now  $K_{a,HA} = \frac{[A^-][H_3O^+]}{[HA]}$  and  $K_{b,A^-} = \frac{[HA][OH^-]}{[A^-]}$ . Thus,

$$K_{a,HA} \times K_{b,A^-} = \frac{[A^-][H_3O^+]}{[HA]} \times \frac{[HA][OH^-]}{[A^-]} = [H_3O^+][OH^-] = K_w = 1.0 \times 10^{-14}.$$

22 The declining pH (i.e., declining  $[\text{OH}^-]$ ) clearly indicates that something is reacting with the  $\text{OH}^-$  ions. Carbonate, already in the fully deprotonated form, cannot react with  $\text{CO}_3^{2-}$ , but  $\text{Cu}^{2+}$  can, to form  $\text{Cu}(\text{OH})_2(\text{s})$ . Thus, it seems likely that a small amount of  $\text{CuCO}_3$  is continually dissolving, but that the free  $\text{Cu}^{2+}$  ions in solution then react with  $\text{OH}^-$  ions to precipitate  $\text{Cu}(\text{OH})_2$ . The precipitate changes appearance because it is, at least to some extent, a different precipitate.

The net reaction is  $\text{CuCO}_3 + 2 \text{OH}^- \rightleftharpoons \text{Cu}(\text{OH})_2 + \text{CO}_3^{2-}$ . The  $K_{\text{rxn}}$  for this is easily

$$\text{shown to be } = \frac{K_{\text{sp}}(\text{CuCO}_3)}{K_{\text{sp}}(\text{Cu}(\text{OH})_2)} = \frac{2.5 \times 10^{-10}}{1.6 \times 10^{-19}} = 1.6 \times 10^9. \text{ Thus, the reaction is heavily}$$

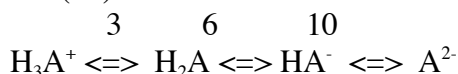
product-favored. The student was in fact successful; the  $\text{CuCO}_3$  does dissolve, and to a greater extent than it would in water. However, the  $\text{Cu}^{2+}$  ions immediately re-precipitate.

23

- The equivalence point of an acid-base titration is the point at which the number of moles of acid is exactly equal to the number of moles of base. The endpoint of a titration is the point at which we *think* the equivalence point has been reached - in this case, when the indicator changes.
- The pH rises fairly rapidly near the equivalence point. If the indicator is indicating the end of the titration prematurely, then it must be changing colour at too low a pH. Another indicator should be selected, one with its color transition range centered as closely as possible on the predicted pH at the equivalence point.

24. solution:

$$V_e = M_1V_1/M_2 = 1(25)/1 = 25 \text{ mLs}$$



a)  $V_2 = 12.5$  is half equiv. so:  $\text{pH} = \text{pK}_a + \log[\text{base}]/[\text{acid}] = 3 + \log 1 = 3.0$

b)  $V_2 = 37.5$ , 1.5 equivalence so,  $\text{pH} = \text{pK}_a2 + 0 = 6.0$

c) isoionic point:  $(1/2)(6+10) = 8$

B.  $\text{pI} = 3+6/2 = 4.5$

25

For  $\text{PbI}_2$ ,  $K_{\text{sp}} = [\text{Pb}^{2+}][\text{I}^-]^2 \Rightarrow [\text{I}^-] = \sqrt{K_{\text{sp}}/[\text{Pb}^{2+}]}$ . When  $\text{PbI}_2$  first starts to precipitate,  $[\text{Pb}^{2+}] = 0.100 \text{ M}$

$$\Rightarrow [\text{I}^-] = \sqrt{K_{\text{sp}}/[\text{Pb}^{2+}]} = \sqrt{(8.7 \times 10^{-9})/0.100} = 2.9 \times 10^{-4} \text{ M.}$$

For  $\text{TlI}$ ,  $K_{\text{sp}} = [\text{Tl}^+][\text{I}^-] \Rightarrow [\text{Tl}^+] = K_{\text{sp}}/[\text{I}^-]$ . Thus, at the point when  $\text{PbI}_2$  first starts to precipitate

$$[\text{Tl}^+] = K_{\text{sp}}/[\text{I}^-] = (6.0 \times 10^{-8})/(2.9 \times 10^{-4}) = 2 \times 10^{-4}$$

Since we we have  $1.0 \times 10^{-3} \text{ M Tl}$  to start with,

this means % remaining Tl is  $(2 \times 10^{-4})/(1.0 \times 10^{-3}) = 20\%$  remains, 80% recovered.