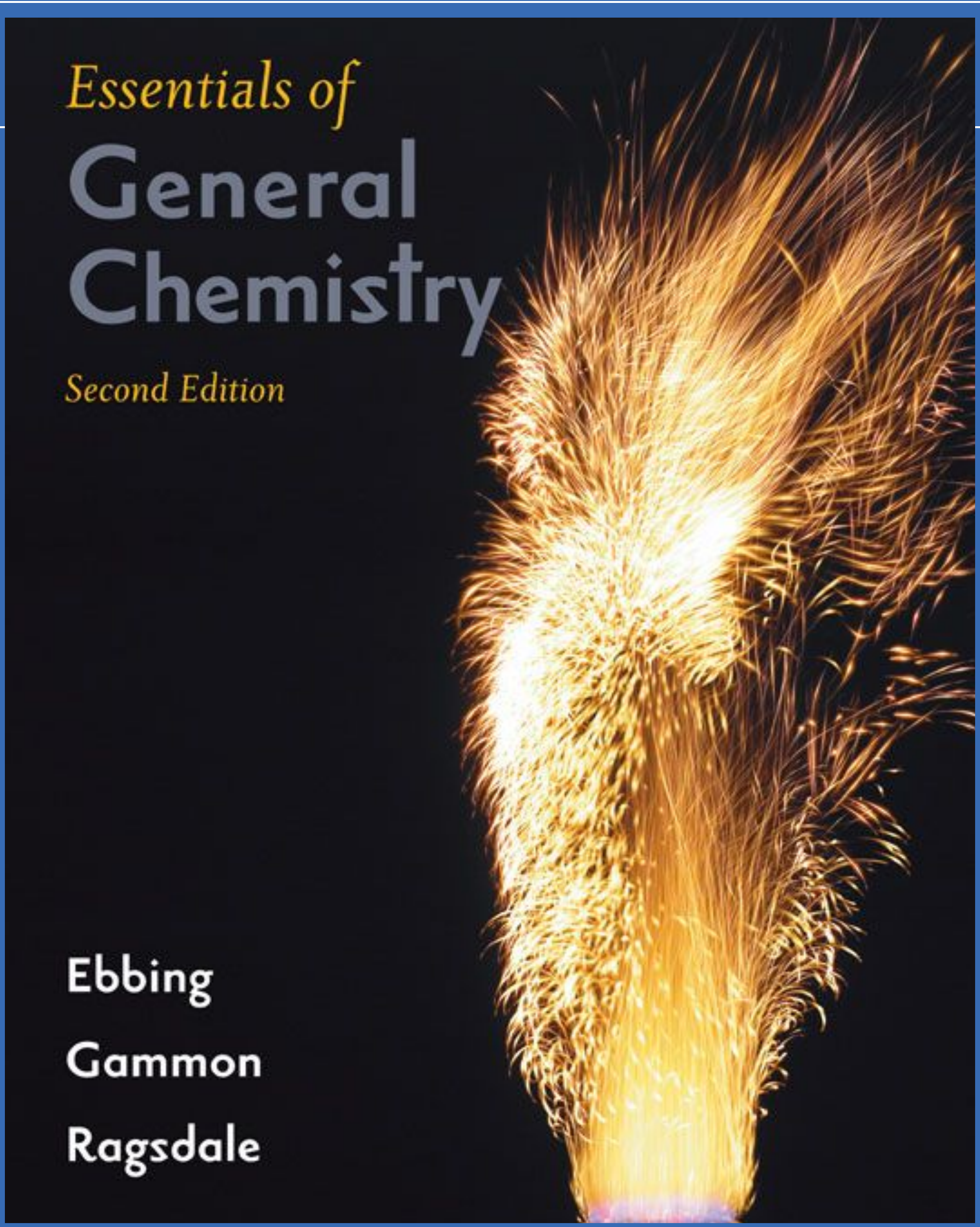


Chapter 16

CRS Questions

Acid-Base Equilibria

Question

Consider the K_a values for the following acids:

1) Cyanic acid, HOCN, 3.5×10^{-4}
2) Formic acid, $HCHO_2$, 1.7×10^{-4}
3) Lactic acid, $HC_3H_5O_3$, 1.3×10^{-4}
4) Propionic acid, $HC_3H_5O_2$, 1.3×10^{-5}
5) Benzoic acid, $HC_7H_5O_2$, 6.3×10^{-5}

Which is the strongest acid?

Answer

1) Cyanic acid

Section 16.1 Acid-Ionization Equilibria
(pp. 493–498)

Cyanic acid has the largest K_a and is therefore the strongest acid.

Question

Consider the K_a values for the following acids:

Cyanic acid, HOCN, 3.5×10^{-4}
Formic acid, $HCHO_2$, 1.7×10^{-4}
Lactic acid, $HC_3H_5O_3$, 1.3×10^{-4}
Propionic acid, $HC_3H_5O_2$, 1.3×10^{-5}
Benzoic acid, $HC_7H_5O_2$, 6.3×10^{-5}

Question (continued)

Which of the following is the weakest base?

1) Cyanate ion
2) Formate ion
3) Lactate ion
4) Propionate ion
5) Benzoate ion

Answer

1) Cyanate ion

Section 16.4 Acid-Base Properties of Salt Solutions (p. 505)

The stronger the acid, the weaker its conjugate base. Cyanic acid is the strongest acid listed, so cyanate ion is the weakest conjugate base.

Question

Carbonic acid is a diprotic acid, H_2CO_3, with $K_{a1} = 4.2 \times 10^{-7}$ and $K_{a2} = 4.8 \times 10^{-11}$. The ion product for water is $K_w = 1.0 \times 10^{-14}$.

What is the carbonate-ion, CO_3^{-2}, concentration in a 0.037 M carbonic acid solution?

1) 1.2×10^{-4}
2) 4.2×10^{-7}
3) 7.6×10^{-8}
4) 4.8×10^{-11}
5) 5.2×10^{-19}

Answer

4) 4.8×10^{-11}

Section 16.2 Polyprotic Acids (pp. 498–502)

According to the second dissociation step,

$K_{a2} = \dfrac{[H^+][CO_3^{2-}]}{[HCO_3^-]}$. But, $[H^+]$ and $[HCO_3^-]$ are dominated by the *first* dissociation step so $[H^+] \approx [HCO_3^-]$, and we can cancel these terms out. Therefore, $[CO_3^{2-}] \approx K_{a2} = 4.8 \times 10^{-11}$ M.

Question

	K
$2HPO_4^{2-} \rightleftharpoons 2H^+ + 2PO_4^{3-}$	1.3×10^{-25}
$H_2O + H_2PO_4^- \rightleftharpoons H_3PO_4 + OH^-$	1.33×10^{-12}
$H_2PO_4^- + H^+ \rightleftharpoons H_3PO_4$	133

From a consideration of the equilibrium equations above, calculate K for the following reaction:

$$HPO_4^{2-} + OH^- \rightleftharpoons PO_4^{3-} + H_2O$$

Question (continued)

1) 2.3×10^{-35}
2) 6.4×10^{-23}
3) 7.3×10^{-16}
4) 36
5) 491

Answer

4) 36

Section 16.4 Acid-Base Properties of Salt Solutions (p. 507)

The overall reaction is equivalent to the sum ½(reaction #1) – (reaction #2) + (reaction #3). So,

$$K_{\text{overall}} = \left(K_{\text{reaction 1}}\right)^{1/2}\left(K_{\text{reaction 2}}\right)^{-1}\left(K_{\text{reaction 3}}\right)$$

$$= \frac{\sqrt{K_{\text{reaction 1}}}\,K_{\text{reaction 3}}}{K_{\text{reaction2}}} = \frac{\left(\sqrt{1.3\times10^{-25}}\right)(133)}{1.33\times10^{-12}} = 36$$

Question

Which of the following is **TRUE** with regard to a 0.05 M H_2SO_3 solution?

1) $[H^+] > [H_2SO_3]$
2) $[H_2SO_3] > [H^+]$
3) $[HSO_3^-] > [H_2SO_3]$
4) $[SO_3^{2-}] > [H_2SO_3]$
5) $[SO_3^{2-}] > [HSO_3^-]$

Answer

2) $[H_2SO_3] > [H^+]$

Section 16.2 Polyprotic Acids (p. 499)

H_2SO_3 is a weak acid, which means most of the dissolved acid will be in the undissociated form $H_2SO_3(aq)$. Further, if we assume that $[H^+]$ is dominated by the slight dissociation of H_2SO_3, then $[H_2SO_3] > [H^+]$.

Question

Which one of the following mixtures will be a buffer when dissolved in a liter of water?

1) 0.1 mol $Ba(OH)_2$ and 0.2 mol HCl
2) 0.3 mol KCl and 0.3 mol HCl
3) 0.4 mol NH_3 and 0.4 mol HCl
4) 0.2 mol CH_3COOH and 0.1 mol NaOH
5) 0.2 mol HBr and 0.1 mol NaOH

Answer

4) 0.2 mol CH_3COOH and 0.1 mol NaOH

Section 16.6 Buffers (pp. 511–514)

A buffer is a solution consisting of a weak acid and its conjugate base in roughly equal concentrations. Only answer (4) meets this criterion. One mole of NaOH will neutralize exactly half of the CH_3COOH, leaving equal-molar amounts of the weak acid CH_3COOH and its conjugate base CH_3COO^-. No weak acids are involved in answers (1), (2), and (5). The solution formed in answer (3) involves a weak acid NH_4^+, but the concentration of the conjugate base NH_3 is essentially zero.

Question

The ionization constants for the diprotic acid H_2S are 1.0×10^{-7} and 1.3×10^{-13}. For 0.1 molar solutions of sodium sulfide and sodium hydrogen sulfide, which of the following is **TRUE**?

1) The solutions are neutral.
2) The sodium sulfide solution is the most basic.
3) Both the solutions are acidic.
4) The sodium hydrogen sulfide solution is the most basic.
5) Both solutions have the same pH.

Answer

2) The sodium sulfide solution is the most basic.

Section 16.4 Acid-Base Properties of Salt Solutions (pp. 505–508)

The Na_2S solution produces S^{2-}, which is a weak base. The NaHS solution produces HS^-, which is amphiprotic. The NaS solution will be basic, which eliminates answers (1) and (3). Also, since the $K_a(H_2S) > K_a(HS^-)$, then $K_b(S^-) > K_b(HS^-)$ (reflecting the inverse relationship between the strengths of an acid and its conjugate base). This means that the NaS solution will be more basic than the NaHS solution. This observation justifies answer (2) and eliminates answer (4).

Question

Indicator	pH Color Change Interval
thymol blue	1.2–2.8
methyl red	4.2–6.3
bromothymol blue	6.2–7.6
phenolphthalein	8.3–10.0
alizarin yellow 66	10.0–12.0

Question (continued)

The **BEST** indicator for the acid–base titration in Figure 3 is

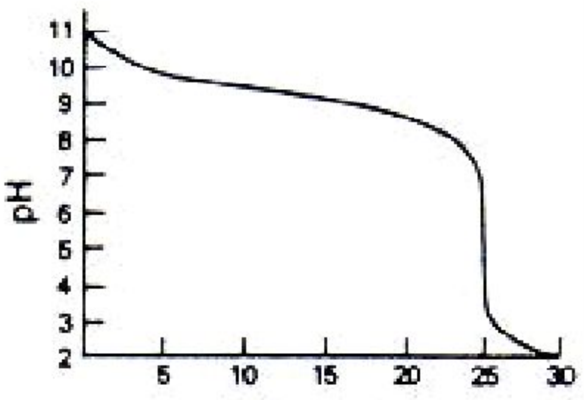


Figure 3

Indicator	pH Color Change Interval
thymol blue	1.2–2.8
methyl red	4.2–6.3
bromothymol blue	6.2–7.6
phenolphthalein	8.3–10.0
alizarin yellow 66	10.0–12.0

1) thymol blue.
2) methyl red.
3) bromothymol blue.
4) phenolphthalein.
5) alizarin yellow 66.

Answer

2) methyl red.

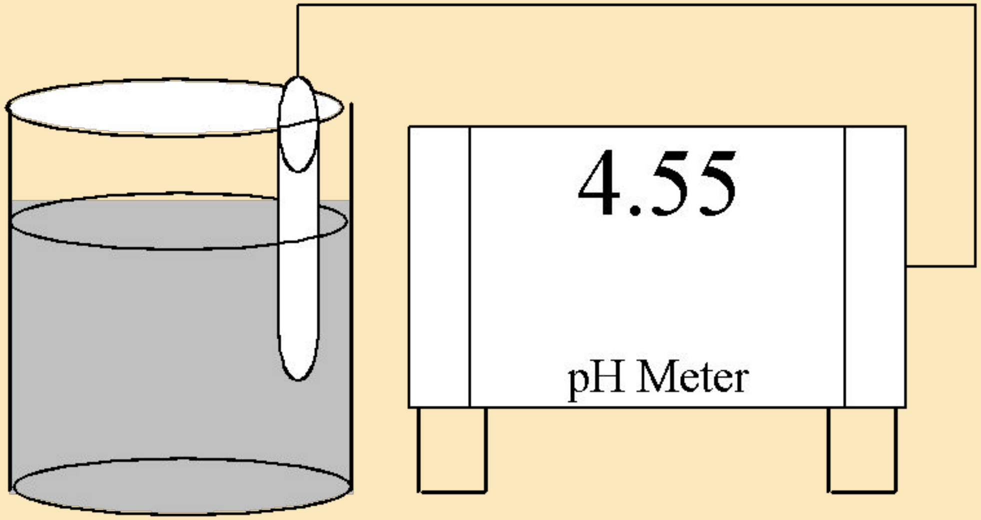
Section 16.7 Acid-Base Titration Curves
(pp. 516–519)

Choose an indicator with a color change interval that brackets the equivalence point pH. The equivalence point in Figure 3 has a pH of about 5.5. Methyl red changes color in a pH range of about 4.2 to 6.3.

Question

Which salt, K_2CO_3, $LiNO_3$, NaBr, NH_4Cl, or RbCN, is most likely to form an aqueous solution having the pH shown in the figure below?

1) K_2CO_3
2) $LiNO_3$
3) NaBr
4) NH_4Cl
5) RbCN



Answer

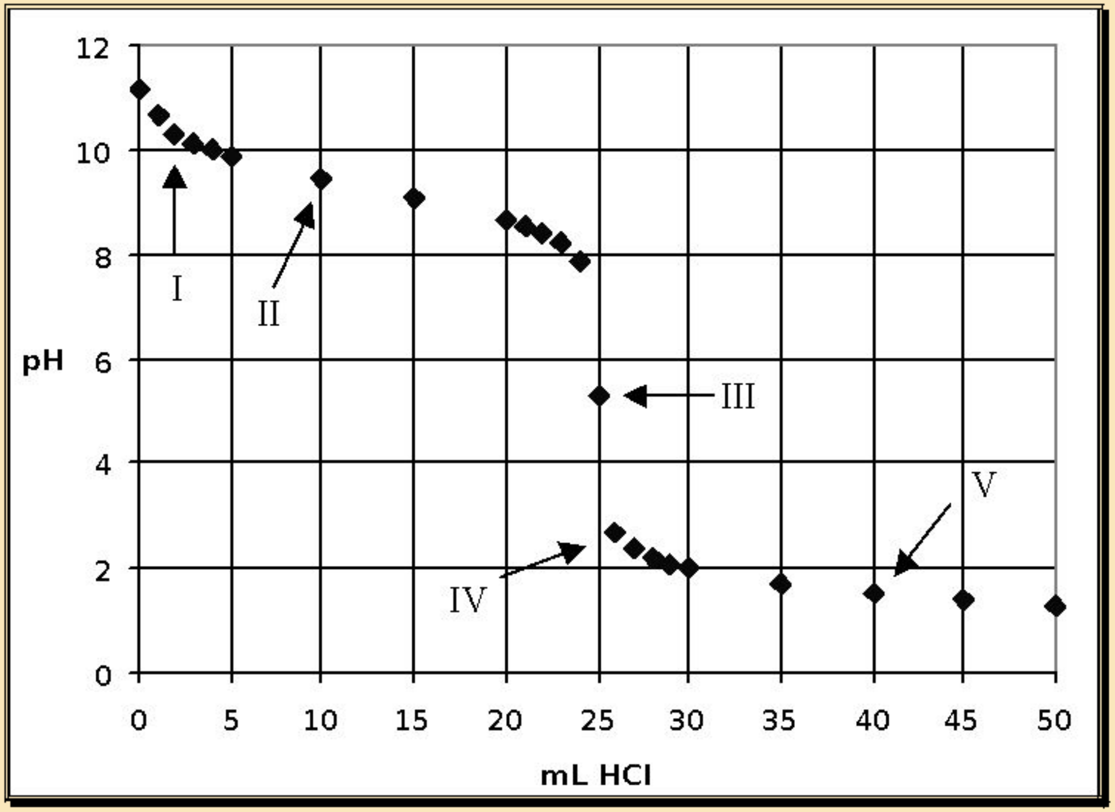
4) NH_4Cl

Section 16.4 Acid-Base Properties of Salt Solutions (pp. 505–506)

The salt produces an acidic solution (pH = 4.55). All the choices except NH_4Cl are salts of weak acids and produce basic solutions. NH_4Cl is the salt of the weak base NH_3 and produces an acidic solution.

Question

In the titration curve shown below, which point represents the pH of a buffer solution?



Answer

2) II

Section 16.7 Acid-Base Titration Curves (pp. 511–512)

The buffer region occurs in the vicinity of the halfway point, which in this case is around 12 mL.

Question

The following figures are to be used in answering the next three questions.

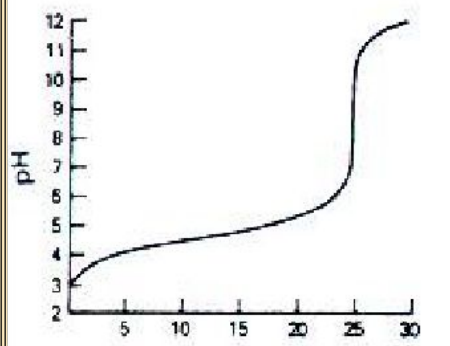


Figure 1

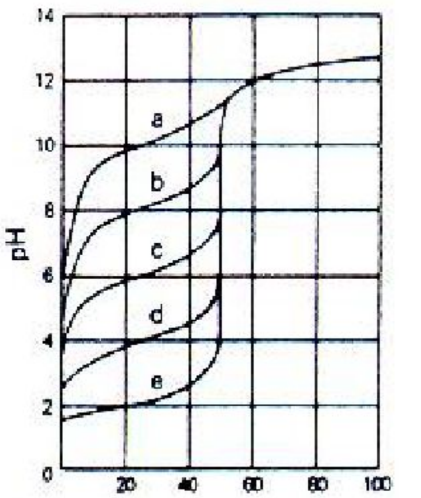


Figure 2

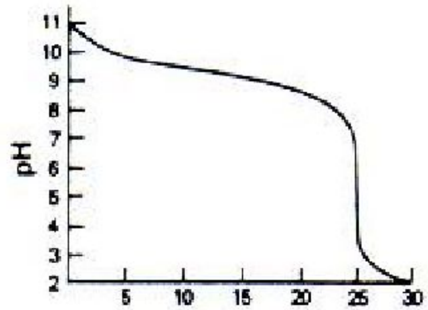


Figure 3

Question (continued)

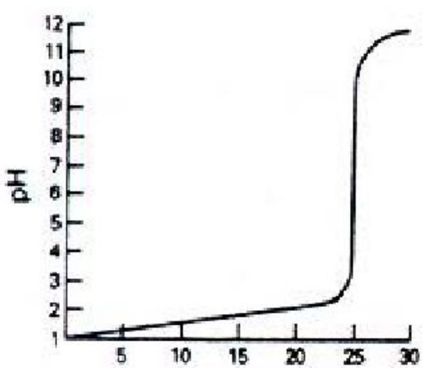


Figure 4

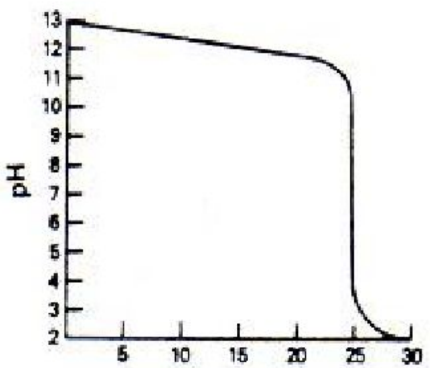


Figure 5

Question (continued)

The titration curve that **BEST** represents the titration of a strong base with a strong acid is

1) Figure 1.
2) Figure 2, curve a.
3) Figure 3.
4) Figure 4.
5) Figure 5.

Answer

5) Figure 5.

Section 16.7 Acid-Base Titration Curves
(pp. 516–517)

The pH should begin with high values that become progressively lower as the volume of strong acid increases. Also, the equivalence point should be at pH = 7 for strong acid/strong base neutralization. Only Figure 5 exhibits both of these characteristics.

Question

In Figure 1, the equivalence point is best represented by

1) pH = 2.9.
2) pH = 4.5.
3) pH = 7.
4) pH = 9.
5) pH = 12.

Answer

4) pH = 9.

Section 16.7 Acid-Base Titration Curves
(pp. 516–519)

The equivalence point is the point that lies halfway up the steep portion of the curve.