

$$K = \frac{[\text{H}_2\text{O}]}{[\text{NO}_2]} = \frac{(9.3 \times 10^{-7})}{\frac{[\text{NO}_2]^2}{(6.5 \times 10^{-3} \text{ mol/L})}} = 2.2 = 2.2 \times 10^0$$

45. (a) Students should expect it to be a base.
 (b) $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_{20} + 8\text{H}^+_{(aq)} \rightleftharpoons 6\text{CaHPO}_4_{(s)} + 2\text{H}_2\text{O}_{(l)} + 4\text{Ca}^{2+}_{(aq)}$
 (c) Candy contains sucrose, which will remove hydroxyapatite from teeth by reacting with it at low pH to give $\text{Ca}^{2+}_{(aq)}$ and $\text{H}_2\text{PO}_4^-_{(aq)}$ that are in soluble form.

46.

	$\text{NH}_3 - (\text{CH}_3)_2\text{NH}_2$	$\text{NH}_3 - (\text{CH}_3)_2\text{NH}_2$	OH^-
initial conc.	0.10	0	0
change	-0.0021	+0.0021	+0.0021
equilibrium	0.0979	0.0021	0.0021

$$K_b = \frac{(0.0021)^2}{0.0979} = 4.5 \times 10^{-5}$$

47. The conductivity of 0.1 mol/L HCl is higher than for 0.1 mol/L CH_3COOH because the HCl is completely ionized whereas the CH_3COOH is only partly ionized. For solutions of these two acids at a concentration of 1×10^{-7} mol/L, the HCl is still ionized completely and the CH_3COOH again is only partly ionized. However at such a low concentration the conductivity of the HCl is the same as for water. There will be no discernable difference in the conductivities at this low concentration.
48. One drop of concentrated acid will have a high concentration of H_3O^+ ions. (E.g., For HCl $[\text{H}_3\text{O}^+] =$ about 12.5 mol/L, for H_2SO_4 $[\text{H}_3\text{O}^+] =$ about 35 mol/L. When one drop of acid is added to a bucket of water, the H_3O^+ ion concentration is diluted by a very large factor.
49. (a) A triprotic acid is an acid that has three protons that may be dissociated, each with its own K_a value.
 (b) Stepwise Equation 1:
 $\text{H}_3\text{PO}_4_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}_2\text{PO}_4^-_{(aq)} + \text{H}_3\text{O}^+_{(aq)}$
 Stepwise Equation 2:
 $\text{H}_2\text{PO}_4^-_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{HPO}_4^{2-}_{(aq)} + \text{H}_3\text{O}^+_{(aq)}$
 Stepwise Equation 3:
 $\text{HPO}_4^{2-}_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{PO}_4^{3-}_{(aq)} + \text{H}_3\text{O}^+_{(aq)}$
 (c) $\text{H}_2\text{PO}_4^-_{(aq)}$ acts as an acid in equation 2 above. In the equation below, it acts as a base.



- (d) Students may say that $\text{H}_2\text{PO}_4^-_{(aq)}$ is the stronger acid because it is higher in the list of relative strengths of acids and bases. Some students may suggest that $\text{H}_2\text{PO}_4^-_{(aq)}$ is a stronger acid because its K_a value is larger than that of $\text{H}_2\text{PO}_3^-_{(aq)}$ which is a "stronger" answer.
50. Water could have a pH greater than 7.0 at a temperature different from 25°C.
51. (a) Students might suggest either of these equations:
 $\text{NaHCO}_3_{(aq)} \rightarrow \text{Na}^+_{(aq)} + \text{H}^+_{(aq)} + \text{CO}_3^{2-}_{(aq)}$
 $\text{NaHCO}_3_{(aq)} \rightarrow \text{Na}^+_{(aq)} + \text{H}^+_{(aq)} + \text{CO}_2_{(aq)}$
 (b) The litmus test indicates that the solution is basic, so the solution contains a considerable $[\text{OH}^-]$. Neither of these equations, written according to the original Arrhenius theory, is consistent with the litmus test. Equation two above even implies a red litmus result! Accordingly, the litmus test contradicts the Arrhenius theory equations.
 (c) A student could have two frames of thought.
 Perspective I:
 $\text{NaHCO}_3_{(aq)} + \text{H}_2\text{O}_{(l)} \rightarrow \text{Na}^+_{(aq)} + \text{H}_2\text{O}^+_{(aq)} + \text{CO}_3^{2-}_{(aq)}$
 or, without the spectator, Na^+ :
 $\text{HCO}_3^-_{(aq)} + \text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{O}^+_{(aq)} + \text{CO}_3^{2-}_{(aq)}$
 Perspective II:
 $\text{NaHCO}_3_{(aq)} + \text{H}_2\text{O}_{(l)} \rightarrow \text{Na}^+_{(aq)} + \text{H}_2\text{CO}_{3(aq)} + \text{OH}^-_{(aq)}$
 or, without the spectator, Na^+ :
 $\text{HCO}_3^-_{(aq)} + \text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{CO}_{3(aq)} + \text{OH}^-_{(aq)}$
 Note that, if a student writes equations according to Perspective I, the student still has a set of equations that contradict the litmus test. But if the student then realizes that the hydrogen carbonate ion is amphoteric, another valid set of equations according to Perspective II may be written. Given the litmus test, the student should then analyze and evaluate the equations to state that Perspective II is not only correct according to modernized Arrhenius, but also consistent with the litmus test. Some students will have realized this out of part (b), and will present only Perspective II.

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