Acid-Base Review Answer Key

1. **(a)** hypochlorous acid
(b) oxalic acid
(c) permanganic acid
(d) nitrous acid
(e) hydroiodic acid

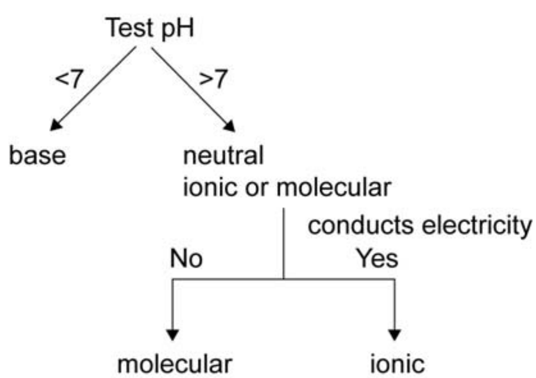
2. **(a)** $HF(aq)$
(b) $HNO_3(aq)$
(c) $H_2SO_3(aq)$

3. Empirical characteristics of an acid could include any three of the following:
- pH <7
- reacts with Mg metal to produce $H_2(g)$
- conducts electricity
- tastes sour
- turns litmus blue to red

4. Empirical characteristics of a base could include any two of the following:
- pH >7
- conducts electricity
- tastes bitter
- fells slippery
- turns litmus red to blue

5. The solution is likely a weak acid.

6. The solution could be a base, a neutral ionic solution, or a neutral molecular solution. The following tests could be carried out to determine the nature of the solution:



7. According to the modified Arrhenius theory, an acid reacts with water to produce $H_3O^+(aq)$, e.g., $HCl(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) + Cl^-(aq)$.

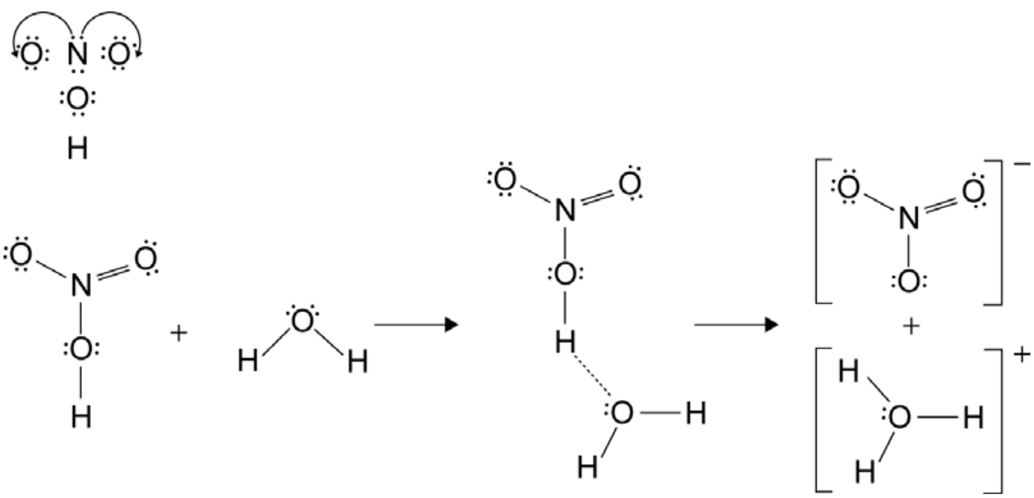
Acid-Base Review Answer Key

(cont'd)

8. According to the modified Arrhenius theory, a base dissociates or reacts with water to produce OH^- ions.
Examples could include either of the following:
$LiOH(aq) \rightarrow Li^+(aq) + OH^-(aq)$

$NH_3(aq) + H_2O(\ell) \rightarrow NH_4^+(aq) + OH^-(aq)$

9.



10.

	pH	conductivity	reaction with Mg
Strong acid	lower pH	high	vigorous
Weak acid	higher pH	low	slow

11. The solution with the pH closer to 7 (e.g., the solution with pH 5.5) is either more dilute or is weaker, or both. Without more testing, it is not possible to determine the relative strength or concentration of the acids.

12. A strong acid ionizes 100% in water and may be concentrated or dilute. A concentrated acid has a large amount of solute dissolved in a small amount of water, but the acid may not dissociate completely if it is a weak acid.

13. Yes. A weak acid will not break up completely in water, but it can be concentrated if a large quantity of the acid is dissolved in solution.

14. A weak base is at least partly undissociated in solution, while much of it probably exists as the molecule. A strong base, on the other hand, has completely dissociated and exists in water as the ion exclusively.

Acid-Base Review Answer Key

(continued)

15. $H_3PO_4(aq)$ is a polyprotic acid because it has more than one acidic proton.

$H_3PO_4(aq) \rightarrow H^+(aq) + H_2PO_4^-(aq)$

$H_2PO_4^-(aq) \rightarrow H^+(aq) + HPO_4^{2-}(aq)$

$HPO_4^{2-}(aq) \rightarrow H^+(aq) + PO_4^{3-}(aq)$

A monoprotic acid, such as $HCl(aq)$, has only one acidic proton.

16. $CO_3^{2-}(aq)$ is a polyprotic base.

$CO_3^{2-}(aq) + H_2O(\ell) \rightarrow HCO_3^-(aq) + OH^-(aq)$

$HCO_3^-(aq) + H_2O(\ell) \rightarrow H_2CO_3(aq) + OH^-(aq)$

17. (a) $pH = -\log(4.5 \times 10^{-4}) = 3.35$

(b) $pH = -\log(1.345 \times 10^{-9}) = 8.871$

(c) $pH = 14 - 3.52 = 10.48$

(d) $pOH = -\log(2.61 \times 10^{-6}) = 5.583$
$pH = 14 - 5.583 = 8.417$

(e) $M_{HClO_4(aq)} = 1.01\text{ g/mol} + 35.45\text{ g/mol} + 4(16.00\text{ g/mol}) = 100.46\text{ g/mol}$

$$n_{HClO_4} = \frac{2.45\text{ g}}{100.46\text{ g/mol}} = 0.0244\text{ mol}$$

$$[HClO_4(aq)] = \frac{0.0244\text{ mol}}{2.5\text{ L}} = 0.00976\text{ mol/L}$$

$HClO_4(aq) \rightarrow H^+(aq) + ClO_4^-(aq)$

$[H^+(aq)] = [HClO_4(aq)] = 0.00976\text{ mol/L}$

$pH = -\log(0.00976\text{ mol/L}) = 2.01$

(f) $M_{Ba(OH)_2(aq)} = 137.33\text{ g/mol} + 2(16.00\text{ g/mol}) + 2(1.01\text{ g/mol})$
$= 171.35\text{ g/mol}$

$$n_{Ba(OH)_2(aq)} = \frac{1.24\text{ g}}{171.35\text{ g/mol}} = 0.00724\text{ mol}$$

$$[Ba(OH)_2(aq)] = \frac{0.00724\text{ mol}}{3.00\text{ L}} = 2.41 \times 10^{-3}\text{ mol/L}$$

$Ba(OH)_2(aq) \rightarrow Ba^{2+}(aq) + 2OH^-(aq)$

Acid-Base Review Answer Key

(continued)

$$\frac{[OH^-]}{0.00241\ mol/L} = \frac{2\ mol\ OH^-(aq)}{1\ mol\ Ba(OH)_2(aq)}$$

$\therefore [OH^-] = 0.00482\ mol/L$

pOH = $-\log(0.00482\ mol/L) = 2.317$

pH = $14 - 2.317 = 11.683$

(g) $[H_3O^+] = 10^{-3.45} = 3.5 \times 10^{-4}\ mol/L$

$C_1V_1 = C_2V_2$

$(3.5 \times 10^{-4}\ mol/L)(0.025) = C_2(10\ L)$

$C_2 = 8.8 \times 10^{-7}$

$pH = -\log(8.8 \times 10^{-7}) = 6.06$

(h) $pOH = 14 - 12.343 = 1.657$

$[OH^-(aq)] = 10^{-1.657} = 0.0220\ mol/L$

$C_1V_1 = C_2V_2$

$(0.0220\ mol/L)(0.0100\ L) = (C_2)(5.00\ L)$

$C_2 = 4.40 \times 10^{-5}\ mol/L$

$pOH = -\log(4.40 \times 10^{-5}\ mol/L) = 4.357$

$pH = 14 - 4.357 = 9.643$

18. Solutions **(a)**, **(e)**, and **(g)** are acidic.

19. No. Dilution cannot make a base more basic. Dilution can only reduce the alkalinity of a base.

20. No. Dilution cannot make a base acidic.

21. $[H_3O^+(aq)] = 5.63\ g\ HCl \times \frac{1\ mol}{36.46\ g} \times \frac{1}{0.5000\ L} = 0.30883\ mol/L\ H_3O^+(aq)$

$pH = -\log[H_3O^+(aq)] = 0.510$

Crystal violet would be green if added to this solution. Bromothymol blue would be yellow.

22. The pH range for the solution is 4.4 to 5.3. For methyl orange to be yellow, the pH must be 4.4 or higher. For bromocresol green to be green, the pH must be 3.9 to 5.3.