Exercise 14.3a

Acid-Base Theories and Reactions - Answers

Name: _____

Date: _____ Per: _____

DIRECTIONS: Answer the following in the space provided.

1. Summarize the three main acid-base theories in the table below:

	Acid	Base
Arrhenius Model:	donates hydrogen ions (H^+) in aqueous solution	donates hydroxide ions (OH^-) in aqueous solution
Brønsted-Lowry Model:	donates protons (still H^+) in a chemical reaction (not necessarily aqueous)	accepts protons (still H^+) in a chemical reaction (not necessarily aqueous)
Lewis Model:	electron pair acceptor in chemical reaction	electron pair donor in reaction

2. Acids may donate one or more *hydrogen ions/protons* when they ionize. An acid capable of donating only one of these particles is referred to as *monoprotic*, whereas acids that donate more than one are referred to as *polyprotic*. H_2SO_4 is considered a(n) *diprotic* acid because it donates *two* of these particles and H_3PO_3 is considered a(n) *triprotic* acid because it donates *three*.

3. Acids that donate multiple protons in solution do so *one at a time in separate ionization reactions*. Each ionization requires additional *energy to remove the hydrogen ion* because the anion produced from the previous ionization exerts a greater *attraction* on the remaining protons. This means that in each step, the acid becomes *weaker (less able to be deprotonated)*.

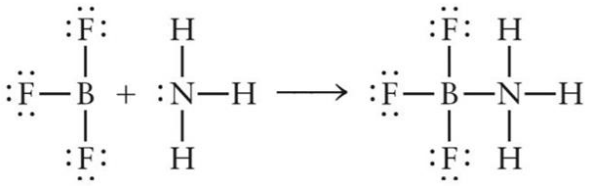
4. For the following polyprotic acids, write the equations for each ionization step.

	H_3PO_4	H_2CO_3
Step 1	$H_3PO_4(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + H_2PO_4^-(aq)$	$H_2CO_3(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + HCO_3^-(aq)$
Step 2	$H_2PO_4^-(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + HPO_4^{2-}(aq)$	$HCO_3^-(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + CO_3^{2-}(aq)$
Step 3	$HPO_4^{2-}(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + PO_4^{3-}(aq)$	

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$ $NH_3 + H_2O \rightleftarrows NH_4^+ + OH^-$

5. According to Arrhenius, HCl would be classified as a(n) *acid* because *it is deprotonated by (or donates H^+ to) in an aqueous solution (i.e., loses H^+ to water)*. NH_3 would be classified as a(n) *B-L base* because *it accepts hydrogen ions (protons) in a chemical reaction to produce OH^-*.

6. In the diagram at right, the Lewis acid is *BF_3* and the Lewis base is *NH_3*.



   a. Explain why: *In the reaction between BF_3 and NH_3, the electrons used to create the bond are donated by the NH_3 and accepted by the boron in BF_3*

7. Explain how H^+ is a Lewis acid. *Hydrogen has no electrons to contribute to a bond so can only accept electrons.*

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DIRECTIONS: Answer the following in the space provided.

8. A(n) ___electrolyte___ is a substance that produces ions in water making a solution that is electrically conductive.

9. When a hydrogen atom ionizes to form H^+ the resulting particle is a(n) ___proton___.

10. An ionic compound that forms from an acid-base neutralization reaction is a(n) ___salt___.

11. A conjugate acid-base pair varies in formula by ___a single hydrogen ion___. When an acid loses a(n) ___proton/H^+___, the residual ion is its ___conjugate base___. Strong acids always have ___weak___ conjugate bases, while weak acids have ___strong___ conjugate bases.

12. The formula H_3O^+ represents the ___hydronium___ ion.

13. Water is ___amphoteric___, which means it can act as an acid or a base. Often in acid-base systems the formula for water is written as "HOH" to clearly illustrate its ability to ionize into ___H^+___ ions and ___OH^-___ ions.

14. Label the conjugate acid-base pairs of the following:

a. Base, Acid, Conj. Acid, Conj. Base: $NH_3(aq) + H_2O(l) \rightleftarrows NH_4^+(aq) + OH^-(aq)$

b. Acid, Base, Conj. Acid, Conj. Base: $HNO_2(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + NO_2^-(aq)$

c. Acid, Base, Conj. Acid, Conj. Base: $HCN(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + CN^-(aq)$

d. Base, Acid, Conj. Acid, Conj. Base: $NH_3(aq) + HCl(aq) \rightleftarrows NH_4^+(aq) + Cl^-(aq)$

e. Base, Acid, Conj. Base, Conj. Acid: $PO_4^{3-}(aq) + HNO_3(aq) \rightleftarrows NO_3^-(aq) + HPO_4^{2-}(aq)$

f. Acid, Base, Conj. Base, Conj. Acid: $HF(aq) + HSO_3^-(aq) \rightleftarrows F^-(aq) + H_2SO_3(aq)$

15. Write balanced chemical equations for the neutralization reactions below:

a. HI and LiOH: ___$HI(aq) + LiOH(aq) \rightarrow H_2O(l) + LiI(aq)$___

b. NaOH and HF: ___$HF(aq) + NaOH(aq) \rightarrow H_2O(l) + NaF(aq)$___

c. H_2SO_3 and $Sr(OH)_2$: ___$H_2SO_3(aq) + Sr(OH)_2(aq) \rightarrow 2H_2O(l) + SrSO_3(aq)$___

d. $Ca(OH)_2$ and H_3PO_3: ___$3Ca(OH)_2(aq) + 2H_3PO_3(aq) \rightarrow 6H_2O(l) + Ca_3(PO_3)_2(aq)$___

e. Hydrobromic acid and barium hydroxide: ___$2HBr(aq) + Ba(OH)_2(aq) \rightarrow 2H_2O(l) + BaBr_2(aq)$___

f. Aluminum hydroxide and nitric acid: ___$Al(OH)_3(aq) + 3HNO_3(aq) \rightarrow 3H_2O(l) + Al(NO_3)_3(aq)$___

g. Sulfuric acid and manganese (III) hydroxide: ___$3H_2SO_4(aq) + 2Mn(OH)_3(aq) \rightarrow 6H_2O(l) + Mn_2(SO_4)_3(aq)$___

h. Nitric acid and calcium bicarbonate: ___$2HNO_3(aq) + Ca(HCO_3)_2(aq) \rightarrow 2H_2O(l) + Ca(NO_3)_2(aq) + 2CO_2(g)$___