Acids & Bases

Unit: Acids & Bases

MA Curriculum Frameworks (2016): HS-PS1-9(MA)

Mastery Objective(s): (Students will be able to…)

- Define acids and bases based on both the Arrhenius and Brønsted-Lowry theories and give examples.
- Classify acids and bases as strong or weak.
- Identify conjugate acid and base pairs.

Success Criteria:

- Prediction correctly describes the shift in equilibrium when the concentration of one chemical species is changed.

Tier 2 Vocabulary: stress

Language Objectives:

- Explain how a change provokes a response.

Notes:

Acids are one of the first substances that come to mind when we think of chemistry. Acids are the dangerous chemicals that mad scientists in movies throw at people, and the chemicals that impressively dissolve metals and other substances right before your eyes.

Acids have held this sort of fascination for centuries. The American chemist Ira Remsen wrote the following wonderful anecdote of his first encounter with them:

> While reading a text book of chemistry, I came upon the statement, "nitric acid acts upon copper." I was getting tired of reading such absurd stuff and I determined to see what this meant. Copper was more or less familiar to me, for copper cents were then in use. I had seen a bottle marked "nitric acid" on a table in the doctor's office where I was then "doing time!" I did not know its peculiarities, but I was getting on and likely to learn. The spirit of adventure was upon me. Having nitric acid and copper, I had only to learn what the words "act upon" meant. Then the statement "nitric acid acts upon copper," would be something more than mere words.

Use this space for summary and/or additional notes:

> All was still. In the interest of knowledge I was even willing to sacrifice one of the few copper cents then in my possession. I put one of them on the table; opened the bottle marked "nitric acid;" poured some of the liquid on the copper; and prepared to make an observation. But what was this wonderful thing which I beheld? The cent was already changed, and it was no small change either. A greenish blue liquid foamed and fumed over the cent and over the table. The air in the neighborhood of the performance became colored dark red. A great cloud arose: This was disagreeable and suffocating—how should I stop this?
>
> I tried to get rid of the objectionable mess by picking it up and throwing it out the window, which I had meanwhile opened. I learned another fact—nitric acid not only acts upon copper but it acts upon fingers. The pain led to another unpremeditated experiment. I drew my fingers across my trousers and another fact was discovered. Nitric acid acts upon trousers.
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> Taking everything into consideration, that was the most impressive experiment, and, relatively, probably the most costly experiment I have ever performed. I tell of it even now with interest. It was a revelation to me. It resulted in a desire on my part to learn more about that remarkable kind of action. Plainly the only way to learn about it was to see its results, to experiment, to work in a laboratory.

However, not all acids are this dangerous, especially when they are more dilute. We eat and drink vinegar (dilute acetic acid), orange juice (which contains citric acid), and Coca-Cola (which contains phosphoric acid).

<u>acid</u>: a substance that can produce H_3O^+ ions in water, release H^+ ions* in solution, and/or accept electrons from another substance.

<u>base</u>: the "opposite" of an acid; a substance that can produce OH^- ions in water, accept H^+ ions in solution and/or donate electrons to another substance.

* Note that an H^+ ion is a proton. Chemists often use the term "proton" in place of "H^+ ion" for convenience. Thus an acid is a compound that releases protons in water. These protons are just the H^+ ions—there's no nuclear weirdness going on!

Use this space for summary and/or additional notes:

Some Properties of Acids & Bases

Acids

- taste sour
- react with some metals (*i.e.,* the ones above hydrogen on the activity series)
- dissolve plants
- produce H_3O^+ ions in water (Arrhenius definition)
- release H^+ ions (Brønsted-Lowry definition)
- accept electrons (Lewis definition)

Bases

- taste bitter
- feel "slippery" (like soap)
- dissolve people (skin)
- produce OH^- ions in water (Arrhenius definition)
- accept H^+ ions (Brønsted-Lowry definition)
- give electrons (Lewis definition)

dissociation: to dissolve by splitting into positive and negative ions

Acids & bases dissociate in water.

Strong acids & bases dissociate completely; weak acids & bases only dissociate partially.

For example:

$$HCl \rightarrow H^+ + Cl^-$$
$$NaOH \rightarrow Na^+ + OH^-$$

neutralization: a reaction in which an acid and a base react to produce a salt (a type of ionic compound) plus water. For example:

$$HNO_3 + KOH \rightarrow KNO_3 + H_2O$$
$$\text{(acid)} + \text{(base)} \rightarrow \text{(salt)} + \text{(water)}$$

Use this space for summary and/or additional notes:

strong acid: an acid that dissociates completely in water and produces H^+ ions, which then convert H_2O molecules to H_3O^+ ions. Strong acids include HCl, HBr, HI, H_2SO_4, HNO_3, and $HClO_4$.

weak acid: an acid that only partially dissociates in water. HF is an example of a weak acid:

$$HF \rightleftharpoons H^+ + F^-$$

strong base: a base that dissociates completely in water and produces OH^- ions. Strong bases include all of the group 1 hydroxides (LiOH, NaOH, KOH, *etc.*), plus the group 2 hydroxides $Ca(OH)_2$, $Sr(OH)_2$, and $Ba(OH)_2$.

weak base: a base that only partially dissociates in water. NH_3 is an example of a weak base:

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

conjugates: the acid & base forms of a compound. The acid form has an extra H^+ that can dissociate. The base form is the same compound without the H^+.

conjugate base: the base formed by removing H^+ from an acid. For example, the conjugate base of HCl is Cl^-.

conjugate acid: the acid formed by adding H^+ to a base. For example, the conjugate acid of NH_3 is NH_4^+.

polyprotic: an acid that can lose more than one H^+. For example, H_2SO_4 can lose one H^+ to dissociate into H^+ and HSO_4^-. HSO_4^- can then lose a second H^+ to dissociate into H^+ and SO_4^{2-}.

Remember that an H^+ ion is just a proton. A polyprotic acid is just an acid with more than one proton that it can lose by dissociation.

amphoteric: a substance that "can go either way"—*i.e.,* it has both a conjugate acid and a conjugate base. For example, the HSO_4^- ion is amphoteric:

$$H_2SO_4 \rightleftharpoons HSO_4^- \rightleftharpoons SO_4^{2-}$$

Use this space for summary and/or additional notes:

Homework Problems

Give the conjugate base for each of the following acids:

1. HCl
2. H_2S
3. HCO_3^-
4. $H_2PO_4^-$
5. HSO_4^-
6. H_2SO_3
7. NH_3
8. HS^-

Give the conjugate acid for each of the following bases:

9. HSO_4^-
10. SO_3^{2-}
11. ClO_4^-
12. $H_2PO_4^-$
13. SO_4^{2-}
14. PO_4^{3-}
15. CH_3NH_2
16. F^-

Use this space for summary and/or additional notes: