Unit 4: Acid/Base I

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I) Introduction to Acids and Bases

What is an acid?

http://www.kidsknowit.com/flash/animations/acids-bases.swf

What are properties of acids?

1) Acids react with ____________.
2) Acids create ____________________ when in solution and therefore _______________.
3) Acids react with some ___________ to product H_2 gas.
4) Acid turns litmus paper __________.
5) Acids taste ____________.
6) Acids donate _______ to other substances.

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I) Introduction to Acids and Bases

What is an acid?

http://www.kidsknowit.com/flash/animations/acids-bases.swf

a substance that donates H^+ to another substance (thus it must contain hydrogen)

What are properties of acids?

1) Acids react with bases.
2) Acids create electrolytes (ions) when in solution and therefore conduct.
3) Acids react with some metals to product H_2 gas.
4) Acid turns litmus paper red.
5) Acids taste sour.
6) Acids donate H^+ to other substances.

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What is a base?

What are properties of bases?

1) Bases react with ____________.
2) Bases create ______________________ in solution and therefore ______________.
3) Bases feel _________________.
4) Bases turn litmus paper _____________.
5) Bases taste _____________.
6) Bases accept _____ from other substances

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What is a base?

a substance that accepts H^+ from another substance

What are properties of bases?

1) Bases react with acids.
2) Bases create electrolytes (ions) in solution and therefore conduct.
3) Bases feel slippery.
4) Bases turn litmus paper blue.
5) Bases taste bitter.
6) Bases accept H^+ from other substances

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II) Arrhenius Acids and Bases

Svante Arrhenius was a Swedish scientist who lived from 1859-1927. In 1884, he proposed the following definitions for acids and bases:

Arrhenius Acid:

Arrhenius Base:

These definitions stood until 1923, when they were revised by Bronsted (Danish) and Lowry (English), as we will see shortly.

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II) Arrhenius Acids and Bases

Svante Arrhenius was a Swedish scientist who lived from 1859-1927. In 1884, he proposed the following definitions for acids and bases:

Arrhenius Acid:

a substance that releases H^+ in water

Arrhenius Base:

a substance that releases OH in water

These definitions stood until 1923, when they were revised by Bronsted (Danish) and Lowry (English), as we will see shortly.

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When an acid reacts with a base (one which contains OH^-), what is produced?

ex. $HCl_{(aq)} + NaOH_{(aq)} \longrightarrow$
acid + base makes

The OH acts as the base and takes the H^+ to make ________. What type of reaction is this?

Acids and bases are both harmful substances, but if they react in stoichiometric amounts (so that no excess acid or base is left over), the products are not harmful ( ).

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When an acid reacts with a base (one which contains OH^-), what is produced?

ex. $HCl_{(aq)} + NaOH_{(aq)} \longrightarrow H_2O_{(l)} + NaCl_{(aq)}$
acid + base makes water + salt

The OH acts as the base and takes the H^+ to make H_2O. What type of reaction is this?

neutralization (double replacement)

Acids and bases are both harmful substances, but if they react in stoichiometric amounts (so that no excess acid or base is left over), the products are not harmful (water and salt).

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What is a salt?

When the salt is produced in an acid-base reaction, depending on what salt is produced, what two results can occur?

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What is a salt?

an ionic compound made up of a metal cation and a non-metal anion

When the salt is produced in an acid-base reaction, depending on what salt is produced, what two results can occur?

If the salt that's produced is SOLUBLE, it will stay dissociated as aqueous ions in the water.

If the salt that's produced is LOW SOLUBILITY, it will precipitate out as a solid.

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Another example:

$H_2SO_{4(aq)} + Sr(OH)_{2(aq)} \longrightarrow$

What is a net ionic equation?

What is the net ionic equation of the reaction above?

What was the net ionic equation of the first neutralization equation we looked at (remember, only the things that change are included in the net).

http://www.wiley.com/college/chem/brady184764/resources/ch04/index_ch4_bytype.html

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Another example:
$H_2SO_{4(aq)} + Sr(OH)_{2(aq)} \longrightarrow 2H_2O_{(l)} + SrSO_{4(s)}$
acid + base → water + salt (low solub)

What is a net ionic equation?
an equation that includes only the substances that react (chemically change)

What is the net ionic equation of the reaction above?

$2H^+_{(aq)} + SO_4^{2-}{}_{(aq)} + Sr^{2+}{}_{(aq)} + SO_4^{2-}{}_{(aq)} \longrightarrow 2H_2O_{(l)} + SrSO_{4(s)}$

What was the net ionic equation of the first neutralization equation we looked at (remember, only the things that change are included in the net). $H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)}$

http://www.wiley.com/college/chem/brady184764/resources/ch04/index_ch4_bytype.htm

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Assignment 1

Read Hebden pages 109 to 114 and do questions #1-4 on page 112

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Assignment 1

Read Hebden pages 109 to 114 and do questions #1-4 on page 112

answers in the back of Hebden

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III) Bronsted-Lowry Acids and Bases Part 1

Bronsted-Lowry definitions from 1923

Bronsted-Lowry Acid:

Bronsted-Lowry Base:

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III) Bronsted-Lowry Acids and Bases Part 1

Bronsted-Lowry definitions from 1923

Bronsted-Lowry Acid:
a substance that donates H^+ to another substance

Bronsted-Lowry Base:
a substance that accepts H^+ from another substance

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Practice: Label each reactant as an acid or a base depending on if it donates H^+ or accepts H^+. Some of the reactions are 100% and some are at equilibrium. You will learn why soon.

1. $HCl + H_2O \Rightarrow H_3O^+ + Cl^-$

2. $NH_3 + H_2O \Leftrightarrow NH_4^+ + OH^-$

3. $CO_3^{2-} + H_2O \Leftrightarrow HCO_3^- + OH^-$

What's different about H_2O in #1 compared to 2?

Why can CO_3^{2-} only be a base?

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Practice: Label each reactant as an acid or a base depending on if it donates H^+ or accepts H^+. Some of the reactions are 100% and some are at equilibrium. You will learn why soon.

1. $HCl + H_2O \Rightarrow H_3O^+ + Cl^-$
   A B
2. $NH_3 + H_2O \Leftrightarrow NH_4^+ + OH^-$
   B A
3. $CO_3^{2-} + H_2O \Leftrightarrow HCO_3^- + OH^-$
   B A

What's different about H_2O in #1 compared to 2? In #1 it acts as a base and in #2 an acid

Why can CO_3^{2-} only be a base? It doesn't have an H^+

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4. $HPO_4^{2-} + HBr \Rightarrow H_2PO_4^- + Br^-$
5. $HPO_4^{2-} + HCO_3^- \Leftrightarrow H_2PO_4^- + CO_3^{2-}$
6. $H_2PO_4^- + HF \Leftrightarrow H_3PO_4 + F^-$
7. $H_2PO_4^- + H_2O \Leftrightarrow HPO_4^{2-} + H_3O^+$

What's different about $H_2PO_4^-$ in #6 & 7?

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4. $HPO_4^{2-} + HBr \Rightarrow H_2PO_4^- + Br^-$
   B A
5. $HPO_4^{2-} + HCO_3^- \Leftrightarrow H_2PO_4^- + CO_3^{2-}$
   B A
6. $H_2PO_4^- + HF \Leftrightarrow H_3PO_4 + F^-$
   B A
7. $H_2PO_4^- + H_2O \Leftrightarrow HPO_4^{2-} + H_3O^+$
   A B

What's different about $H_2PO_4^-$ in #6 & 7?
in #6 it acts as a base and in #7 it acts as an acid

Jun 13-9:13 AM

Notice from the practice equations that when bases do not contain OH^-, the products are not water and salt. Why is water not a product?

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Notice from the practice equations that when bases do not contain OH^-, the products are not water and salt. Why is water not a product?

Water is made from OH accepting H^+ to make H_2O. If the base is not an 'OH base', then water is not a product.

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Assignment 2

Read Hebden page 116 and do #11 on page 117

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IV) Strong and Weak Acids and Bases

Strong acids and bases react to completion (100%) in solution (in water).

Examples

strong acid: $HCl_{(aq)} + H_2O_{(l)} \longrightarrow$
0.10M

http://www.dlt.ncssm.edu/core/Chapter16-Acid-Base_Equilibria/Chapter16-Animations/StrongAcidIonization.html

strong base: $NH_2^-{}_{(aq)} + H_2O_{(l)} \longrightarrow$
0.200M

strong 'OH' base: $NaOH_{(aq)} \longrightarrow$
1.0M

The $OH^-_{(aq)}$ produced is now ready to act as a base and accept H^+.

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IV) Strong and Weak Acids and Bases

Strong acids and bases react to completion (100%) in solution (in water).

Examples

strong acid: $HCl_{(aq)} + H_2O_{(l)} \longrightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$
0.10M → 0.10M 0.10M

http://www.dlt.ncssm.edu/core/Chapter16-Acid-Base_Equilibria/Chapter16-Animations/StrongAcidIonization.html

strong base: $NH_2^-{}_{(aq)} + H_2O_{(l)} \longrightarrow NH_{3(aq)} + OH^-_{(aq)}$
0.200M → 0.200M 0.200M

strong 'OH' base: $NaOH_{(aq)} \longrightarrow Na^+_{(aq)} + OH^-_{(aq)}$
1.0M → 1.0M 1.0M

The $OH^-_{(aq)}$ produced is now ready to act as a base and accept H^+.

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Weak acids and bases do not react to completion in solution (in water). They create an equilibrium with reactants heavily favoured.

Examples

1.0M weak acid:

$HF_{(aq)} + H_2O_{(l)} \rightleftharpoons$

http://www.dlt.ncssm.edu/core/Chapter16-Acid-Base_Equilibria/Chapter16-Animations/WeakAcidEquilibrium.html

1.0M weak base:

$CO_3^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons$

http://www.chembio.uoguelph.ca/educmat/chm19104/chemtoons/chemtoons.htm

http://www.wwnorton.com/college/chemistry/gilbert2/tutorials/interface.asp?chapter=chapter_16&folder=acid_base_ionization

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Weak acids and bases do not react to completion in solution (in water). They create an equilibrium with reactants heavily favoured.

Examples

1.0M weak acid:

$HF_{(aq)} + H_2O_{(l)} \rightleftharpoons F^-_{(aq)} + H_3O^+_{(aq)}$
~0.95M → ~0.05M ~0.05M

http://www.dlt.ncssm.edu/core/Chapter16-Acid-Base_Equilibria/Chapter16-Animations/WeakAcidEquilibrium.html

1.0M weak base:

$CO_3^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HCO_3^-{}_{(aq)} + OH^-_{(aq)}$
~0.95M → ~0.05M ~0.05M

http://www.chembio.uoguelph.ca/educmat/chm19104/chemtoons/chemtoons.htm

http://www.wwnorton.com/college/chemistry/gilbert2/tutorials/interface.asp?chapter=chapter_16&folder=acid_base_ionization

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V) H^+ and H_3O^+

The most abundant hydrogen atom, by far, is hydrogen-1, which has an atomic weight of 1amu, which means it must be made up of ___ proton, ___ neutron, and ___ electron.

H^+ has lost an _____________, and thus is simply a _____________, which is what it is commonly called.

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V) H^+ and H_3O^+

The most abundant hydrogen atom, by far, is hydrogen-1, which has an atomic weight of 1amu, which means it must be made up of _1_ proton, _0_ neutron, and _1_ electron.

H^+ has lost an __electron__, and thus is simply a __proton__, which is what it is commonly called.

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When an acid such as HCl is put into solution, what happens?
Simple version: $HCl_{(aq)} \longrightarrow$

The equation suggests that HCl gives up a proton 100% in water. However, in the reaction above, no substance is accepting the proton, which is inaccurate. However, we use this reaction to show what HCl does in the presence of any base. If HCl is in solution and just water is present, HCl donates its proton to water, as shown below:

$HCl_{(aq)} + H_2O_{(l)} \longrightarrow$

Both equations are commonly used, so H^+ is analogous to H_3O^+ (called ***hydronium***).

http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/animations/HCl(aq).html

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When an acid such as HCl is put into solution, what happens?
Simple version: $HCl_{(aq)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$

The equation suggests that HCl gives up a proton 100% in water. However, in the reaction above, no substance is accepting the proton, which is inaccurate. However, we use this reaction to show what HCl does in the presence of any base. If HCl is in solution and just water is present, HCl donates its proton to water, as shown below:

$HCl_{(aq)} + H_2O_{(l)} \longrightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

Both equations are commonly used, so H^+ is analogous to H_3O^+ (called ***hydronium***).

http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/animations/HCl(aq).html

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VI) The Acid/Base Table

Where are the acids on the table, and how are they arranged?

Strong Acids:

Weak Acids:

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VI) The Acid/Base Table

Where are the acids on the table, and how are they arranged?

left side, arranged from strongest to weakest (top to bottom)

Strong Acids:

-top left on the table (shaded region)
-all react 100% to donate H^+ (single arrow)
-all strong acids are the same strength (because they all react 100%)

Weak Acids:

-middle left region on the table (unshaded)
-all weak acids donate H^+, but much less than 100% (double arrow)
-the weak acids are ranked from strongest (top) to weakest (bottom), in terms of how much H^+ they donate

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Notice the table uses the 'simple' version of the two reactions described earlier
ex. $HCl \longrightarrow H^+ + Cl^-$
This is because the acids put into water only react with water if it's the only other substance present. If a base different than water is present, it will react with the base. So the reaction above is the 'general form'.

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Notice the table uses the 'simple' version of the two reactions described earlier
ex. $HCl \longrightarrow H^+ + Cl^-$
This is because the acids put into water only react with water if it's the only other substance present. If a base different than water is present, it will react with the base. So the reaction above is the 'general form'.

in just water: $HCl + H_2O \longrightarrow H_3O^+ + Cl^-$

if another base is in water such as ammonia: $HCl + NH_3 \longrightarrow NH_4^+ + Cl^-$

in both cases, HCl gave up H^+, as depicted at the top

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Where are the bases on the acid/base table, and how are they arranged?

Strong Bases:

Weak Bases:

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Where are the bases on the acid/base table, and how are they arranged?
on the right, arranged from strongest (bottom) to weakest (top)

Strong Bases:
-bottom right of table (although most strong bases are not listed in the table - all the 'OH' bases such as NaOH)
-react 100% by accepting H^+ (single arrow)
-all strong bases are the same strength (all react 100%)

Weak Bases:
-middle right of the table (unshaded region)
-weak bases react much less than 100% by accepting H^+ (double arrow)
-weak bases ranked in strength (in terms of how much H^+ they can accept) from bottom (stronger) to top (weaker)

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What strong bases are missing from the acid/base table? How do these types of strong bases behave in water?

How are weak acids/bases different from strong acids/bases, and how does this affect their conductivity? http://www.chembio.uoguelph.ca/educmat/chm19104/chemtoons/chemtoons.htm

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What strong bases are missing from the acid/base table? How do these types of strong bases behave in water?
-the strong bases missing are the group 1 and 2 'OH' bases such as LiOH, NaOH, KOH, $Ca(OH)_2$, $Mg(OH)_2$ etc.

-these strong bases, when in water, dissociate 100% into ions:
$NaOH \longrightarrow Na^+ + OH^-$

-the OH then acts as a base and will accept H^+

How are weak acids/bases different from strong acids/bases, and how does this affect their conductivity? http://www.chembio.uoguelph.ca/educmat/chm19104/chemtoons/chemtoons.htm
-strong acids & bases react 100%, so they create many ions and thus conduct very well
-weak acids & bases react approx. 5%, so create a small number of ions, thus they conduct, but not as well as strongs

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Which substances listed as bases are not bases at all?

Which substances listed as acids are not acids at all?

Where can water be found on the table?

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Which substances listed as bases are not bases at all?
The bases in the top right shaded region are listed as bases, but cannot accept H^+ (no reverse arrow). They are opposite the strong acids.

Which substances listed as acids are not acids at all? The acids on the bottom left shaded region cannot donate H^+ (no forward arrow). They are opposite the strong bases.

Where can water be found on the table?
-as the weakest of the weak acids
-as the weakest of the weak bases

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Water is the weakest of the weak bases, so any other base present in solution will react with any acid put into the solution before water will.

Water is the weakest of the weak acids, so any other acid present in solution will react with any base put into solution before water will.

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VI) Bronsted-Lowry Acids & Bases Part 2

Define the following terms:

Monoprotic Acid (   ):

Diprotic Acid (   ):

Polyprotic Acid (   ):

Amphiprotic Substance:

Jul 30-8:17 AM

VI) Bronsted-Lowry Acids & Bases Part 2

Define the following terms:

Monoprotic Acid (HA **):**
an acid with only one H^+ to donate

Diprotic Acid (H_2A **):**
an acid that has two H^+ to donate

Polyprotic Acid (H_xA **):**
an acid with two or more H^+ to donate

Amphiprotic Substance:

-can act as an acid in the presence of a base AND
-can act as a base in the presence of an acid

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How can you tell if a substance is amphiprotic using the acid/base table? List as many amphiprotic substances as you can find on the table.

For one of those substances, give an example of that substance acting as an acid, and an example of it acting as a base:

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How can you tell if a substance is amphiprotic using the acid/base table? List as many amphiprotic substances as you can find on the table.

-it is on both sides of the table in the middle, unshaded region
H_2O, $H_2PO_4^-$, HPO_4^{2-}, HSO_3^-, HCO_3^-, $HC_2O_4^-$, $H_2C_6H_5O_7^-$, $HC_6H_5O_7^{2-}$

For one of those substances, give an example of that substance acting as an acid, and an example of it acting as a base:

$$HSO_3^- + NH_3 \rightleftharpoons SO_3^{2-} + NH_4^+$$

$$HSO_3^- + HF \rightleftharpoons H_2SO_3 + F^-$$

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Notice that all amphiprotic substances (except for H_2O) are polyatomic groups that contain at least one proton and are negatively charged.

In a reaction between two amphiprotic substances in aqueous solution, how can you use your table to find out which substance will act as the acid and which will act as the base?

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Notice that all amphiprotic substances (except for H_2O) are polyatomic groups that contain at least one proton and are negatively charged.

In a reaction between two amphiprotic substances in aqueous solution, how can you use your table to find out which substance will act as the acid and which will act as the base?

Look for the two substances on the left. Whichever is higher on the left side is better at being an acid, and therefore will act as the acid. The other substance will be the base.

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Practice: Using your table, label each reactant as an acid or base, and determine the products. Then label each product as an acid or base (look at the reverse reaction).

1. $HCO_3^- + H_2PO_4^- \Leftrightarrow$
2. $HPO_4^{2-} + HSO_4^- \Leftrightarrow$
3. $H_2O + HSO_3^- \Leftrightarrow$
4. $HCO_3^- + HSO_4^- \Leftrightarrow$

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Practice: Using your table, label each reactant as an acid or base, and determine the products. Then label each product as an acid or base (look at the reverse reaction).

1. $HCO_3^- + H_2PO_4^- \Leftrightarrow H_2CO_3 + HPO_4^{2-}$
   B A A B
2. $HPO_4^{2-} + HSO_4^- \Leftrightarrow H_2PO_4^- + SO_4^{2-}$
   B A A B
3. $H_2O + HSO_3^- \Leftrightarrow H_3O^+ + SO_3^{2-}$
   B A A B
4. $HCO_3^- + HSO_4^- \Leftrightarrow H_2CO_3 + SO_4^{2-}$
   B A A B

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Assignment 3

Do Hebden page 117 #12, then read pages 117 & 118 and to page 119 #13 & 14

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VII) Conjugate Acid-Base Pairs

Conjugate acid/base pairs are particles that are directly opposite each other on the table

Examples: conjugate acid conjugate base
H_3PO_4 $H_2PO_4^-$

Is HCl/Cl^- a conjugate acid/base pair?

What is the difference between a conjugate acid and its conjugate base?

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VII) Conjugate Acid-Base Pairs

Conjugate acid/base pairs are particles that are directly opposite each other on the table

Examples:	conjugate acid	conjugate base
	H_3PO_4	$H_2PO_4^-$
	HCOOH	$HCOO^-$
	H_2S	HS^-

Is HCl/Cl^- a conjugate acid/base pair?

Yes, HCl / Cl^- is considered a conjugate acid/base paier even though Cl^- is not a base at all

What is the difference between a conjugate acid and its conjugate base?

they differ by one proton (H^+)

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A base has one __________ proton than its conjugate acid, and an acid has one __________ proton than its conjugate base.
Remember to **adjust the charge** when writing a conjugate.
Example: Write the conjugate base of NH_4^+:

Write the conjugate base of CH_3COOH:

Write the conjugate acid of HPO_4^{2-}:

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A base has one less proton than its conjugate acid, and an acid has one more proton than its conjugate base.
Remember to **adjust the charge** when writing a conjugate.
Example: Write the conjugate base of NH_4^+: NH_3

Write the conjugate base of CH_3COOH: CH_3COO^-

Write the conjugate acid of HPO_4^{2-}: $H_2PO_4^-$

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What is the conjugate base of each?
$HClO_4$ / H_3BO_3 /

H_2CO_3 / $HC_2O_4^-$ /

What is the conjugate acid of each?
CN^- / $H_2PO_3^-$ /

NH_3 / PO_4^{3-} /

Using your table, complete the following equation and identify the conjugate acid/base pairs:

$HCO_3^- + H_2PO_4^- \rightleftharpoons$

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What is the conjugate base of each?
$HClO_4$ / ClO_4^- H_3BO_3 / $H_2BO_3^-$

H_2CO_3 / HCO_3^- $HC_2O_4^-$ / $C_2O_4^{2-}$

What is the conjugate acid of each?
CN^- / HCN $H_2PO_3^-$ / H_3PO_3

NH_3 / NH_4^+ PO_4^{3-} / HPO_4^{2-}

Using your table, complete the following equation and identify the conjugate acid/base pairs:

$HCO_3^- + H_2PO_4^- \rightleftharpoons H_2CO_3 + HPO_4^{2-}$
B A A B

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Remember: Strong acids (such as HCl) have a conjugate base (Cl^- - though it's not a base at all), but they are **not** at equilibrium.

Strong bases such as NaOH have a conjugate acid (Na^+ - even though it's not an acid at all), but they are **not** at equilibrium.

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Assignment 4: Complete each equation and identify the conjugate acid-base pairs

1. $HNO_3 + H_2O \Rightarrow$

2. $H_2O + HNO_2 \Leftrightarrow$

3. $HIO_3 + NH_3 \Leftrightarrow$

4. $CO_3^{2-} + HF \Leftrightarrow$

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Assignment 4: Complete each equation and identify the conjugate acid-base pairs

1. $HNO_3 + H_2O \Rightarrow NO_3^- + H_3O^+$
   A B B A

2. $H_2O + HNO_2 \Leftrightarrow H_3O^+ + NO_2^-$
   B A A B

3. $HIO_3 + NH_3 \Leftrightarrow IO_3^- + NH_4^+$
   A B B A

4. $CO_3^{2-} + HF \Leftrightarrow HCO_3^- + F^-$
   B A A B

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5. $HS^- + H_3PO_4 \Leftrightarrow$

6. $HCO_3^- + CN^- \Leftrightarrow$

7. $H_3BO_3 + HO_2^- \Leftrightarrow$

8. $C_2O_4^{2-} + H_2O \Leftrightarrow$

9. $H_2O + H_2SO_3 \Leftrightarrow$

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5. $HS^- + H_3PO_4 \Leftrightarrow H_2S + H_2PO_4^-$
   B A A B

6. $HCO_3^- + CN^- \Leftrightarrow CO_3^{2-} + HCN$
   A B B A

7. $H_3BO_3 + HO_2^- \Leftrightarrow H_2BO_3^- + H_2O_2$
   A B B A

8. $C_2O_4^{2-} + H_2O \Leftrightarrow HC_2O_4^- + OH^-$
   B A A B

9. $H_2O + H_2SO_3 \Leftrightarrow H_3O^+ + HSO_3^-$
   B A A B

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10) Do Hebden page 121 numbers 17-19

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10) Do Hebden page 121 numbers 17-19

answers in the back of Hebden

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VIII) Determining Whether Reactants or Products are Favoured in an Acid/Base Reaction

Finish the reaction and label conjugate acids and bases:

$HCO_3^- + HF \rightleftharpoons$

What do acids do that make them acids?

There is a competition between the two acids HF and H_2CO_3 to donate the proton, and this will have repercussions as to what side is favoured. Which of the two is the stronger acid?

Jul 30-4:46 PM

VIII) Determining Whether Reactants or Products are Favoured in an Acid/Base Reaction

Finish the reaction and label conjugate acids and bases:

$HCO_3^- + HF \rightleftharpoons H_2CO_3 + F^-$

B A A B

What do acids do that make them acids?

donate H^+

There is a competition between the two acids HF and H_2CO_3 to donate the proton, and this will have repercussions as to what side is favoured. Which of the two is the stronger acid? HF

Jul 30-4:46 PM

So which side of the equilibrium will be favoured?

Will the K_{eq} be greater or less than 1?

RULE: The side of the reaction with the ____________ acid is always favoured.

Jul 30-4:51 PM

So which side of the equilibrium will be favoured?

Products, as HF will be better at donating H^+ than H_2CO_3, causing the forward reaction to initially predominate over the reverse reaction, so the products are favoured.

Will the K_{eq} be greater or less than 1?

if products are favoured, the K_{eq} is greater than 1

RULE: The side of the reaction with the WEAKER acid is always favoured.

Jul 30-4:51 PM

Assignment 5: State whether reactants or products are favoured.

1. $NH_4^+ + H_2O \Leftrightarrow NH_3 + H_3O^+$
2. $H_2S + NH_3 \Leftrightarrow HS^- + NH_4^+$
3. $H_2PO_4^- + HS^- \Leftrightarrow HPO_4^{2-} + H_2S$
4. $H_2O_2 + SO_3^{2-} \Leftrightarrow HO_2^- + HSO_3^-$
5. $CH_3COOH + PO_4^{3-} \Leftrightarrow CH_3COO^- + HPO_4^{2-}$
6. $H_2PO_4^- + C_2O_4^{2-} \Leftrightarrow HPO_4^{2-} + HC_2O_4^-$
7. $H_2SO_3 + SO_4^{2-} \Leftrightarrow HSO_3^- + HSO_4^-$

Jul 30-4:54 PM

Assignment 5: State whether reactants or products are favoured.

1. $NH_4^+ + H_2O \Leftrightarrow NH_3 + H_3O^+$ reactants
2. $H_2S + NH_3 \Leftrightarrow HS^- + NH_4^+$ products
3. $H_2PO_4^- + HS^- \Leftrightarrow HPO_4^{2-} + H_2S$ reactants
4. $H_2O_2 + SO_3^{2-} \Leftrightarrow HO_2^- + HSO_3^-$ reactants
5. $CH_3COOH + PO_4^{3-} \Leftrightarrow CH_3COO^- + HPO_4^{2-}$ products
6. $H_2PO_4^- + C_2O_4^{2-} \Leftrightarrow HPO_4^{2-} + HC_2O_4^-$ reactants
7. $H_2SO_3 + SO_4^{2-} \Leftrightarrow HSO_3^- + HSO_4^-$ products

Jul 30-4:54 PM

IX) Strong, Weak, Concentrated, & Dilute

The terms **strong** and **weak** differ from the terms **concentrated** and **dilute**.

What is a strong acid, and give an example.

What is a weak acid, and give an example.

What is a concentrated acid, and give an example.

What is a dilute acid, and give an example.

Jul 30-4:55 PM

IX) Strong, Weak, Concentrated, & Dilute

The terms **strong** and **weak** differ from the terms **concentrated** and **dilute**.

What is a strong acid, and give an example.
an acid that dissociates 100%: $HCl + H_2O \longrightarrow Cl^- + H_3O^+$

What is a weak acid, and give an example.
an acid that dissociates approx. 5% to create an equilibrium $HF + H_2O \rightleftharpoons F^- + H_3O^+$

What is a concentrated acid, and give an example. an acid with a high molarity ex. 1M HCl

What is a dilute acid, and give an example.
an acid with a low molarity ex. 0.0010M HCl

Jul 30-4:55 PM

The terms **strong, weak, concentrated, and dilute** are used for bases as well.

6M KOH is ____________ and ______________.
0.0001M KOH is _____________ & ___________.
6M CH_3COOH is _____________ & ___________.
0.0001M CH_3COOH is __________ & __________.

Notice that a strong acid can be dilute, and a weak acid can be concentrated.

Jul 30-8:08 PM

The terms **strong, weak, concentrated, and dilute** are used for bases as well.

6M KOH is ___strong___ and ___concentrated___.
0.0001M KOH is ___strong___ & ___dilute___.
6M CH_3COOH is ___weak___ & ___concentrated___.
0.0001M CH_3COOH is ___weak___ & ___dilute___.

Notice that a strong acid can be dilute, and a weak acid can be concentrated.

Jul 30-8:08 PM

X) Leveling Effect

If you had a 1M solution of each strong acid, which would be the strongest (which would create the greatest $[H_3O^+]$)?

So what is the leveling effect?

Jul 30-8:12 PM

X) Leveling Effect

If you had a 1M solution of each strong acid, which would be the strongest (which would create the greatest $[H_3O^+]$)?
none - they would all be level in strength as they all dissociate 100% in solution to create 1M H_3O^+

So what is the leveling effect?
-the idea that the strong acids are level in strength as they all dissociate 100%
-the same is true for strong bases

Jul 30-8:12 PM

What is the strongest acid that actually exists in water?

How does this compare with its position on the acid/base table?

What is the strongest base that actually exists in water?

Jul 30-8:14 PM

What is the strongest acid that actually exists in water?

H_3O^+, as all strong acids dissociate 100% to create it, and it's the strongest of the weak acids (see the table)

How does this compare with its position on the acid/base table?

-it's the strongest of the weak acids
-this is why all weak acid equilibria favour reactants

What is the strongest base that actually exists in water?

-OH^-, as all strong bases dissociate or react 100% to create it, and it's the strongest of the weak bases (see the table)
-this is why all weak base equilibria favour reactants

Jul 30-8:14 PM

Practice Questions:

1) Will the K_{eq} be greater or less than 1 for the following equilibrium? Why?

$$HSO_4^- + NH_3 \rightleftharpoons SO_4^{2-} + NH_4^+$$

2) Which acid has the higher $[H_3O^+]$ when reacting with water, HCN or CH_3COOH? Why?

Jul 30-8:18 PM

Practice Questions:

1) Will the K_{eq} be greater or less than 1 for the following equilibrium? Why?

$$HSO_4^- + NH_3 \rightleftharpoons SO_4^{2-} + NH_4^+$$

product side favoured since HSO_4^- is a stronger weak acid than NH_4^+, so the $K_{eq} > 1$

2) Which acid has the higher $[H_3O^+]$ when reacting with water, HCN or CH_3COOH? Why?

CH_3COOH. It's higher on the weak acid list, so it dissociates to a greater extent to create more H_3O^+ than HCN

Jul 30-8:18 PM

3) Will a reaction occur between NH_2^- and $C_2O_4^{2-}$? Explain why or why not.

4) Write an equation to show the reaction between NH_2 and water, and explain why products are favoured.

Jul 30-8:23 PM

3) Will a reaction occur between NH_2^- and $C_2O_4^{2-}$? Explain why or why not.

No, as they are both bases, so neither can act as the acid and donate H^+

4) Write an equation to show the reaction between NH_2 and water, and explain why products are favoured.

$NH_2^- + H_2O \longrightarrow NH_3 + OH^-$
-products are favoured because the reactio is 100%, so no reactants remain

Jul 30-8:23 PM

Assignment 6

Do Hebden pages 125-126 #21-27 and page 133 #38-46

Jul 30-8:26 PM

Assignment 6

Do Hebden pages 125-126 #21-27 and page 133 #38-46

answers in the back of Hebden

Jul 30-8:26 PM

XI) The Ionization of Water

Water is amphiprotic, meaning it can act as an _________ in the presence of a base, and a base in the presence of an acid. If two water molecules collide with sufficient kinetic energy and correct geometry, what can occur?

$2H_2O_{(l)} + 59kJ \rightleftharpoons$

http://www.media.pearson.com.au/schools/cw/au_sch_derry_ibcsl_1/int/SelfIonisation/tutor/f15/1504.html

http://web.jjay.cuny.edu/~acarpi/NSC/protexch.htm

Write a K_{eq} equation for the reaction above:

The K_{eq} for this equation is called the K_w, as 'w' stands for ___________.

Jul 30-8:27 PM

XI) The Ionization of Water

Water is amphiprotic, meaning it can act as an ___acid___ in the presence of a base, and a base in the presence of an acid. If two water molecules collide with sufficient kinetic energy and correct geometry, what can occur?

$2H_2O_{(l)} + 59kJ \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$

http://www.media.pearson.com.au/schools/cw/au_sch_derry_ibcsl_1/int/SelfIonisation/tutor/f15/1504.html

http://web.jjay.cuny.edu/~acarpi/NSC/protexch.htm

Write a K_{eq} equation for the reaction above:

$K_{eq} = [H_3O^+][OH^-]$

The K_{eq} for this equation is called the K_w, as 'w' stands for ___water___.

Jul 30-8:27 PM

$K_w =$ = ___________ @ 25 C

Notice how small the K_w constant is, meaning ___________ are heavily favoured in the above reaction, which suggests...

http://www.wwnorton.com/college/chemistry/gilbert2/tutorials/interface.asp?chapter=chapter_16&folder=self_ionization

Jul 30-8:31 PM

$K_w =$ $[H_3O^+][OH^-]$ = ___1.0×10^{-14}___ @ 25 C

Notice how small the K_w constant is, meaning ___reactants___ are heavily favoured in the above reaction, which suggests...

that there are very few effective collisions between two water molecules, thus there are very few H_3O^+ and OH^- ions in pure water

http://www.wwnorton.com/college/chemistry/gilbert2/tutorials/interface.asp?chapter=chapter_16&folder=self_ionization

Jul 30-8:31 PM

This small concentration of ions is why water can moderately conduct.

2 in every 550 million water molecules have an effective collision at 25 degrees C

Pure water is neutral. What does 'neutral' mean?

Since $K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$, and pure water is neutral, then $[H_3O^+]=[OH^-]$, so $[H_3O^+]$ in pure water = _______________ and $[OH^-]$ in pure water = _______________

Jul 30-8:36 PM

This small concentration of ions is why water can moderately conduct.
2 in every 550 million water molecules have an effective collision at 25 degrees C
Pure water is neutral. What does 'neutral' mean?

cations = anions, so $[H_3O^+] = [OH^-]$

Since $K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$, and pure water is neutral, then $[H_3O^+]=[OH^-]$, so
$[H_3O^+]$ in pure water = 1.0×10^{-7}M and
$[OH^-]$ in pure water = 1.0×10^{-7}M

Jul 30-8:36 PM

$[H_3O^+]$ and $[OH^-]$ must be the same in **pure water** because every reaction between two water molecules produces ____________________

If an acid is placed in water, the acid will react with water to produce ________ ions, thereby causing $[H_3O^+]$ to be __________ than $[OH^-]$. In this case, we have an ____________ solution. If base is placed in water, more _______ ions will be produced, thereby creating a ___________ solution.

Jul 30-8:42 PM

$[H_3O^+]$ and $[OH^-]$ must be the same in **pure water** because every reaction between two water molecules produces one H_3O^+ and one OH^-

If an acid is placed in water, the acid will react with water to produce H_3O^+ ions, thereby causing $[H_3O^+]$ to be greater than $[OH^-]$. In this case, we have an acidic solution. If base is placed in water, more OH^- ions will be produced, thereby creating a basic solution.

Jul 30-8:42 PM

When an acid or base is placed in water, the concentration of H_3O^+ and OH^- changes, but the K_w remains constant at 1.0×10^{-14} (remember, the only thing that alters K_{eq} is _____________).

Therefore, according to the K_w equation $1.0 \times 10^{-14} = [H_3O^+][OH^-]$, if one of the hydronium ion or hydroxide ion concentrations increase, the other must ______________.

Jul 30-8:48 PM

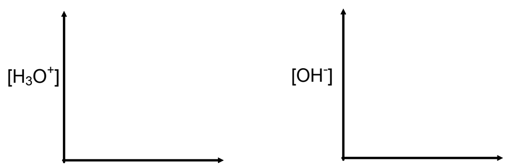
When an acid or base is placed in water, the concentration of H_3O^+ and OH^- changes, but the K_w remains constant at 1.0×10^{-14} (remember, the only thing that alters K_{eq} is temperature).

Therefore, according to the K_w equation $1.0 \times 10^{-14} = [H_3O^+][OH^-]$, if one of the hydronium ion or hydroxide ion concentrations increase, the other must decrease.

Jul 30-8:48 PM

Investigate these scenarios using the water equilibrium and LeChatelier's Principle:
Acid added to water:

$$2H_2O_{(l)} + 59kJ \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

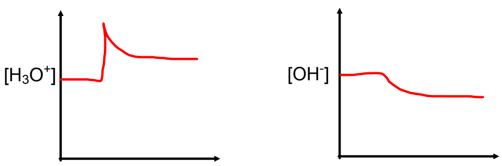


Jul 30-8:50 PM

Investigate these scenarios using the water equilibrium and LeChatelier's Principle:

Acid added to water: ←

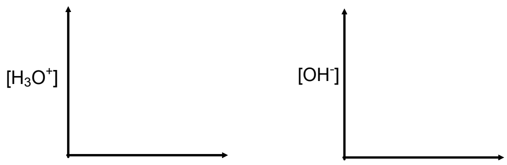
$$2H_2O_{(l)} + 59kJ \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$



Jul 30-8:50 PM

Base added to water:

$$2H_2O_{(l)} + 59kJ \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$



Conclusion:

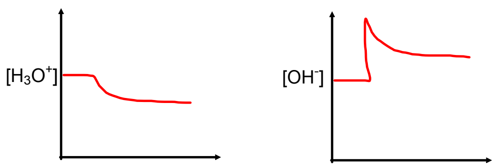
In acid: $[H_3O^+]$ ___ 1.0×10^{-7}M & $[OH^-]$ ___ 1.0×10^{-7}M

In base: $[H_3O^+]$ ___ 1.0×10^{-7}M & $[OH^-]$ ___ 1.0×10^{-7}M

Jul 30-8:50 PM

Base added to water: ←

$$2H_2O_{(l)} + 59kJ \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$



Conclusion:

In acid: $[H_3O^+]$ _>_ 1.0×10^{-7}M & $[OH^-]$ _<_ 1.0×10^{-7}M

In base: $[H_3O^+]$ _<_ 1.0×10^{-7}M & $[OH^-]$ _>_ 1.0×10^{-7}M

Jul 30-8:50 PM

Practice Questions:

1) Calculate the $[OH^-]$ in a solution in which $[H_3O^+]$ is 1.0×10^{-12}M. Is the solution neutral, acidic, or basic?

Aug 3-9:56 AM

Practice Questions:

1) Calculate the $[OH^-]$ in a solution in which $[H_3O^+]$ is 1.0×10^{-12}M. Is the solution neutral, acidic, or basic?

$K_w = [H_3O^+][OH^-]$

$1.0 \times 10^{-14} = (1.0 \times 10^{-12})[OH^-]$

$[OH^-] = \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-12}} = 1.0 \times 10^{-2}$M

Basic, since $[OH^-] > [H_3O^+]$

Aug 3-9:56 AM

2) Calculate the $[H_3O^+]$ in a solution in which $[OH^-]$ is 1.0×10^{-8}M. Is the solution acidic, basic, or neutral?

Aug 3-10:00 AM

2) Calculate the [H_3O^+] in a solution in which [OH^-] is 1.0 x 10^{-8}M. Is the solution acidic, basic, or neutral?

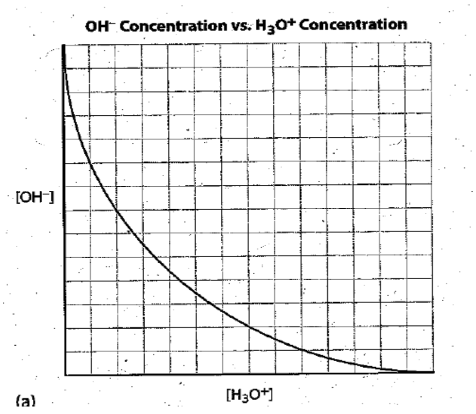
$K_w = [H_3O^+][OH^-]$

$1.0 \times 10^{-14} = [H_3O^+](1.0 \times 10^{-8})$

$[H_3O^+] = \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-8}} = 1.0 \times 10^{-6}M$

Acidic, since [H_3O^+] > [OH^-]

Aug 3-10:00 AM



Sep 11-5:04 PM

3) What is the [H_3O^+] and [OH^-] in 0.0010M HCl?

Aug 3-10:03 AM

3) What is the [H_3O^+] and [OH^-] in 0.0010M HCl?

$$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$$

0.0010M (HCl) → 0.0010M (H_3O^+)

$K_w = [H_3O^+][OH^-]$

$1.0 \times 10^{-14} = (1.0 \times 10^{-3})[OH^-]$

$[OH^-] = \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-3}} = 1.0 \times 10^{-11}M$

Aug 3-10:03 AM

4) What is the [H_3O^+] and [OH^-] in 4.2 x 10^{-2}M $Sr(OH)_2$?

Aug 3-10:06 AM

4) What is the [H_3O^+] and [OH^-] in 4.2 x 10^{-2}M $Sr(OH)_2$?

$$Sr(OH)_2 \longrightarrow Sr^{2+} + 2OH^-$$

4.2 x 10^{-2}M ($Sr(OH)_2$) → 8.4 x 10^{-2}M ($2OH^-$)

$K_w = [H_3O^+][OH^-]$

$1.0 \times 10^{-14} = [H_3O^+](8.4 \times 10^{-2})$

$[H_3O^+] = \frac{1.0 \times 10^{-14}}{8.4 \times 10^{-2}} = 1.2 \times 10^{-13}M$

Aug 3-10:06 AM

Effect of Temperature on K_w

$2H_2O_{(l)}$ + 59kJ ⇌ $H_3O^+_{(aq)}$ + $OH^-_{(aq)}$

This reaction is ______thermic in the forward direction and ______thermic in the reverse direction. If temperature is increased, in what direction will a shift occur?

How does this affect $[H_3O^+]$ and $[OH^-]$?

How does this affect the value of K_w?

If temperature is decreased, in what direction will a shift occur?

How does this affect $[H_3O^+]$ & $[OH^-]$?

How does this affect K_w?

Aug 3-10:10 AM

Effect of Temperature on K_w

$2H_2O_{(l)}$ + 59kJ ⇌ $H_3O^+_{(aq)}$ + $OH^-_{(aq)}$

This reaction is _endo_ thermic in the forward direction and _exo_ thermic in the reverse direction. If temperature is increased, in what direction will a shift occur? right (endo)

How does this affect $[H_3O^+]$ and $[OH^-]$?
they both increase

How does this affect the value of K_w?
$K_w = [H_3O^+][OH^-]$, so if both $[H_3O^+]$ & $[OH^-]$ increase, K_w increases

If temperature is decreased, in what direction will a shift occur? left

How does this affect $[H_3O^+]$ & $[OH^-]$? both decrease

How does this affect K_w? decreases

Aug 3-10:10 AM

Example: If pure water is heated on the stove, explain the effect on $[H_3O^+]$, K_w, and explain if it's acidic, basic, or neutral.

$2H_2O_{(l)}$ + 59kJ ⇌ $H_3O^+_{(aq)}$ + $OH^-_{(aq)}$

Aug 3-10:16 AM

Example: If pure water is heated on the stove, explain the effect on $[H_3O^+]$, K_w, and explain if it's acidic, basic, or neutral.

$2H_2O_{(l)}$ + 59kJ ⇌ $H_3O^+_{(aq)}$ + $OH^-_{(aq)}$

If the water is heated, the temperature has increased, causing a shift endo, which in this case is in the forward direction.

Thus, $[H_3O^+]$ and $[OH^-]$ increase, and K_w increases.

Since $[H_3O^+] = [OH^-]$, the water will be neutral.

Aug 3-10:16 AM

Assignment 7

1) Calculate the $[OH^-]$ for solutions with the given $[H_3O^+]$. Is each solution acidic, basic, or neutral?

a. $[H_3O^+] = 1.0 \times 10^{-3}$M

b. $[H_3O^+] = 2.6 \times 10^{-10}$M

c. $[H_3O^+] = 8.7 \times 10^{-7}$M

Aug 3-10:20 AM

Assignment 7

1) Calculate the $[OH^-]$ for solutions with the given $[H_3O^+]$. Is each solution acidic, basic, or neutral?

a. $[H_3O^+] = 1.0 \times 10^{-3}$M

b. $[H_3O^+] = 2.6 \times 10^{-10}$M

c. $[H_3O^+] = 8.7 \times 10^{-7}$M

a) $[OH^-] = \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-3}} = 1.0 \times 10^{-11}$M

acidic

b) $[OH^-] = \frac{1.0 \times 10^{-14}}{2.6 \times 10^{-10}} = 3.8 \times 10^{-5}$M

basic

c) $[OH^-] = \frac{1.0 \times 10^{-14}}{8.7 \times 10^{-7}} = 1.1 \times 10^{-8}$M

acidic

Aug 3-10:20 AM

2) Calculate the $[H_3O^+]$ for solutions with the given $[OH^-]$. Is each solution acidic, basic, or neutral?

a. $[OH^-] = 1.0 \times 10^{-2}M$

b. $[OH^-] = 3.4 \times 10^{-6}M$

c. $[OH^-] = 9.2 \times 10^{-9}M$

Aug 3-10:21 AM

2) Calculate the $[H_3O^+]$ for solutions with the given $[OH^-]$. Is each solution acidic, basic, or neutral?

a. $[OH^-] = 1.0 \times 10^{-2}M$

b. $[OH^-] = 3.4 \times 10^{-6}M$

c. $[OH^-] = 9.2 \times 10^{-9}M$

a) $[H_3O^+] = \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-2}} = 1.0 \times 10^{-12}M$

basic

b) $[H_3O^+] = \frac{1.0 \times 10^{-14}}{3.4 \times 10^{-6}} = 2.9 \times 10^{-9}M$

basic

c) $[H_3O^+] = \frac{1.0 \times 10^{-14}}{9.2 \times 10^{-9}} = 1.1 \times 10^{-6}M$

acidic

Aug 3-10:21 AM

3) What is the $[H_3O^+]$ and $[OH^-]$ in 0.00345M NaOH?

Aug 3-10:26 AM

3) What is the $[H_3O^+]$ and $[OH^-]$ in 0.00345M NaOH?

$NaOH \longrightarrow Na^+ + OH^-$

0.00345M   0.00345M

$[H_3O^+] = \frac{1.0 \times 10^{-14}}{0.00345} = 2.9 \times 10^{-12}M$

Aug 3-10:26 AM

4) Calculate the $[H_3O^+]$ and $[OH^-]$ in

a. $2.5 \times 10^{-4}M\ HNO_3$

b. 5.0M HCl

c. $6.00 \times 10^{-3}M\ Sr(OH)_2$

Aug 3-10:32 AM

4) Calculate the $[H_3O^+]$ and $[OH^-]$ in

a. $2.5 \times 10^{-4}M\ HNO_3$

b. 5.0M HCl

c. $6.00 \times 10^{-3}M\ Sr(OH)_2$

a) $HNO_3 + H_2O \longrightarrow H_3O^+ + NO_3^-$

$2.5 \times 10^{-4}M$ $2.5 \times 10^{-4}M$

$[OH^-] = \frac{1.0 \times 10^{-14}}{2.5 \times 10^{-4}} = 4.0 \times 10^{-11}M$

b) $HCl + H_2O \longrightarrow H_3O^+ + Cl^-$

5.0M   5.0M

$[OH^-] = \frac{1.0 \times 10^{-14}}{5.0} = 2.0 \times 10^{-15}M$

c) $Sr(OH)_2 \longrightarrow Sr^{2+} + 2OH^-$

$6.00 \times 10^{-3}M$ $1.20 \times 10^{-2}M$

$[H_3O^+] = \frac{1.0 \times 10^{-14}}{1.20 \times 10^{-2}} = 8.3 \times 10^{-13}M$

Aug 3-10:32 AM

5) Hebden page 127, numbers 28 & 29

Aug 3-10:33 AM

5) Hebden page 127, numbers 28 & 29

answers in the back of Hebden

Aug 3-10:33 AM

XII) pH

What does pH stand for?

pH is an indication of the acidity/basicity of a solution.
pH is the negative logarithm of $[H^+]$ or $[H_3O^+]$ in a solution: $-\log[H^+]$ or $-\log[H_3O^+]$
For example, take a solution with $[H_3O^+]$ = 1.0×10^{-7}M. The log is -7, so negative log (the pH) is -(-7) = _____.
What kind of solution has $[H_3O^+] = 1.0 \times 10^{-7}$M

Aug 3-10:38 AM

XII) pH

What does pH stand for?
'power of H^+', meaning the exponent (logarithm) of the H^+ molarity

pH is an indication of the acidity/basicity of a solution.
pH is the negative logarithm of $[H^+]$ or $[H_3O^+]$ in a solution: $-\log[H^+]$ or $-\log[H_3O^+]$
For example, take a solution with $[H_3O^+]$ = 1.0×10^{-7}M. The log is -7, so negative log (the pH) is -(-7) = _7_.
What kind of solution has $[H_3O^+] = 1.0 \times 10^{-7}$M

neutral, such as pure water

Aug 3-10:38 AM

What is the pH of a solution that has $[H_3O^+]$ = 1.0×10^{-4}M, and is the solution acidic, basic, or neutral?

What is the pH of a solution that has $[H_3O^+]$ = 1.0×10^{-11}M, and is the solution acidic, basic, or neutral?

Aug 3-10:43 AM

What is the pH of a solution that has $[H_3O^+]$ = 1.0×10^{-4}M, and is the solution acidic, basic, or neutral?

$pH = -\log(1.0 \times 10^{-4}) = 4.00$

solution is acidic since $[H_3O^+] > [OH^-]$

$[OH^-]$ would equal 1.0×10^{-10}M

What is the pH of a solution that has $[H_3O^+]$ = 1.0×10^{-11}M, and is the solution acidic, basic, or neutral?

$pH = -\log(1.0 \times 10^{-11}) = 11.00$

solution is basic since $[H_3O^+] < [OH^-]$

$[OH^-]$ would equal 1.0×10^{-3}M

Aug 3-10:43 AM

The pH scale is generally considered to be from 0 to 14 at 25 degrees C.

pH scale: http://www.johnkyrk.com/pH.html

pH values can sometimes be below 0 (very __________ solutions) or above 14 (very __________ solutions).

Complete the table on the next slide
(remember: $K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$)

Aug 3-11:16 AM

The pH scale is generally considered to be from 0 to 14 at 25 degrees C.

pH scale: http://www.johnkyrk.com/pH.html

pH values can sometimes be below 0 (very acidic solutions) or above 14 (very basic solutions).

Complete the table on the next slide
(remember: $K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$)

Aug 3-11:16 AM

$[H_3O^+]$ (M)	1.0×10^{1}	1×10^{0}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
pH	-1	0	1	2	3	4	5	6	7
$[OH^-]$	1.0×10^{-15}	10^{-14}							
acidic, basic, or neutral?									

$[H_3O^+]$ (M)	10^{-8}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}	10^{-14}	10^{-15}
pH	8	9	10	11	12	13	14	15
$[OH^-]$								
acidic, basic, or neutral?								

Aug 3-11:20 AM

$[H_3O^+]$ (M)	1.0×10^{1}	1×10^{0}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
pH	-1	0	1	2	3	4	5	6	7
$[OH^-]$	1.0×10^{-15}	10^{-14}	10^{-13}	10^{-12}	10^{-11}	10^{-10}	10^{-9}	10^{-8}	10^{-7}
acidic, basic, or neutral?	A	A	A	A	A	A	A	A	N

$[H_3O^+]$ (M)	10^{-8}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}	10^{-14}	10^{-15}
pH	8	9	10	11	12	13	14	15
$[OH^-]$	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
acidic, basic, or neutral?	B	B	B	B	B	B	B	B

Aug 3-11:20 AM

Remember that $[H_3O^+]$ and $[OH^-]$ are inversely related (as one goes up, the other goes down). Thus, a high $[H_3O^+]$ in a solution corresponds to a low $[OH^-]$, as their product must always equal the $K_w = 1.0 \times 10^{-14}$ at 25 degrees C.

If pH decreases by 1, what happens to $[H_3O^+]$? $[OH^-]$?

If pH increases by 1, what happens to $[H_3O^+]$? $[OH^-]$?

Aug 3-11:20 AM

Remember that $[H_3O^+]$ and $[OH^-]$ are inversely related (as one goes up, the other goes down). Thus, a high $[H_3O^+]$ in a solution corresponds to a low $[OH^-]$, as their product must always equal the $K_w = 1.0 \times 10^{-14}$ at 25 degrees C.

If pH decreases by 1, what happens to $[H_3O^+]$? $[OH^-]$? $[H_3O^+]$ increases by 10 times; $[OH^-]$ decreases by 10 times

If pH increases by 1, what happens to $[H_3O^+]$? $[OH^-]$? $[H_3O^+]$ decreases by 10 times; $[OH^-]$ increases by 10 times

Aug 3-11:20 AM

What is the pH of a 1.0 x 10^{-6}M H_3O^+ solution?

Is the pH of a 4.2 x 10^{-6}M H_3O^+ solution greater than 6 or less than 6? How do you know?

pH is defined as -log[H_3O^+], and can be found using a calculator:

How do 'sig figs' work when calculating pH?

Aug 3-11:29 AM

What is the pH of a 1.0 x 10^{-6}M H_3O^+ solution?
pH = 6.00

Is the pH of a 4.2 x 10^{-6}M H_3O^+ solution greater than 6 or less than 6? How do you know?
4.2 x 10^{-6}M > 1.0 x 10^{-6}M, so more H_3O^+, so more acidic, therefore the pH must be less than 6

pH is defined as -log[H_3O^+], and can be found using a calculator:
press (-), then log, then 4.2 EXP (-)6, then =
+/-
pH = 5.38
OR: 4.2 EXP (-)6, then log, then change the sign

How do 'sig figs' work when calculating pH?
However many sig figs the molarity of H_3O^+ has, is how many digits you get AFTER THE DECIMAL for pH

Aug 3-11:29 AM

Find the pH of each solution below with proper sig figs:

[H_3O^+](M)	2.15 x 10^{-2}	8 x 10^{-9}	9.334 x 10^{-5}	5.0 x 10^{-13}	3.500
pH					
A, B, or N					

Aug 3-11:36 AM

Find the pH of each solution below with proper sig figs:

[H_3O^+](M)	2.15 x 10^{-2}	8 x 10^{-9}	9.334 x 10^{-5}	5.0 x 10^{-13}	3.500
pH	1.668	8.1	4.0299	12.30	-0.5441
A, B, or N	A	B	A	B	A

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[H_3O^+] is calculated from pH by the following:
[H_3O^+] = *2nd* log (-pH)
**2nd* same as *shift* or *inv* on claculator

Find [H_3O^+] for each with proper sig figs:

[H_3O^+] (M)					
pH	7.321	4.56	1.3	13.22	15.6257
A, B, or N					

Aug 3-11:37 AM

[H_3O^+] is calculated from pH by the following:
[H_3O^+] = *2nd* log (-pH)
**2nd* same as *shift* or *inv* on claculator

Find [H_3O^+] for each with proper sig figs:

[H_3O^+] (M)	4.78 x 10^{-8}	2.8 x 10^{-5}	5 x 10^{-2}	6.0 x 10^{-14}	2.368 x 10^{-16}
pH	7.321	4.56	1.3	13.22	15.6257
A, B, or N	B	A	A	B	B

Aug 3-11:37 AM

pOH

What is pOH?

How do you calculate it if you know [OH]?

How do you calculate $[OH^-]$ if you know the pOH?

If $[H_3O^+] = 3.45 \times 10^{-5}$M, find pH, $[OH^-]$, and pOH. Is the solution A, B, or N?

Aug 3-11:45 AM

pOH

What is pOH?
'power of hydroxide'

How do you calculate it if you know [OH]?
pOH = -log[OH]

How do you calculate $[OH^-]$ if you know the pOH? $[OH^-]$ = 2nd log (-pOH)

If $[H_3O^+] = 3.45 \times 10^{-5}$M, find pH, $[OH^-]$, and pOH. Is the solution A, B, or N?

$pH = -\log(3.45 \times 10^{-5})$ $\quad [OH^-] = \frac{1.0 \times 10^{-14}}{3.45 \times 10^{-5}}$ $\quad pOH = -\log(2.899 \times 10^{-10})$

pH = 4.462

$[OH^-] = 2.9 \times 10^{-10}$M $\quad$ pOH = 9.54 acidic

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If $[OH^-] = 7.2 \times 10^{-3}$M, find pOH, $[H_3O^+]$, and pH. Is the solution A, B, or N?

Using the results of the last two examples, what relationship exists between pH and pOH at 25 degrees C?

http://www.wwnorton.com/college/chemistry/gilbert2/tutorials/interface.asp?chapter=chapter_16&folder=ph_scale

Aug 3-11:55 AM

If $[OH^-] = 7.2 \times 10^{-3}$M, find pOH, $[H_3O^+]$, and pH. Is the solution A, B, or N?

$pOH = -\log(7.2 \times 10^{-3})$ $\quad [H_3O^+] = \frac{1.0 \times 10^{-14}}{7.2 \times 10^{-3}}$ $\quad pH = -\log(1.389 \times 10^{-12})$

pOH = 2.14

$[H_3O^+] = 1.4 \times 10^{-12}$M $\quad$ pH = 11.86 basic

Using the results of the last two examples, what relationship exists between pH and pOH at 25 degrees C?

pH + pOH = 14

http://www.wwnorton.com/college/chemistry/gilbert2/tutorials/interface.asp?chapter=chapter_16&folder=ph_scale

Aug 3-11:55 AM

Therefore, if pH < 7, then pOH ______, and the solution is ________________.

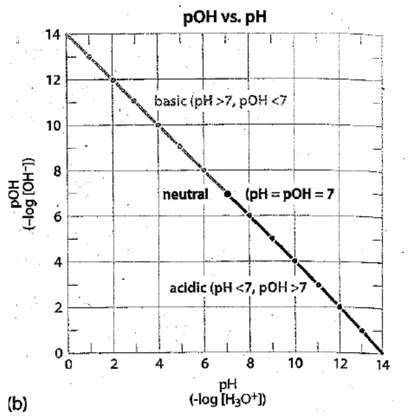
If pH > 7, then pOH _______, and the solution is ________________.

Aug 3-11:59 AM

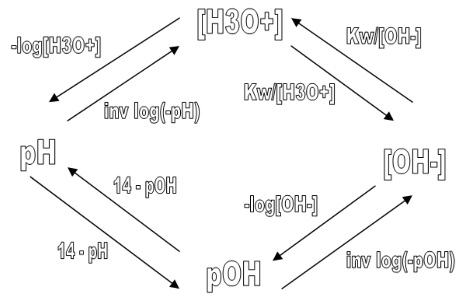
Therefore, if pH < 7, then pOH __> 7__, and the solution is __acidic__.

If pH > 7, then pOH __< 7__, and the solution is __basic__.

Aug 3-11:59 AM



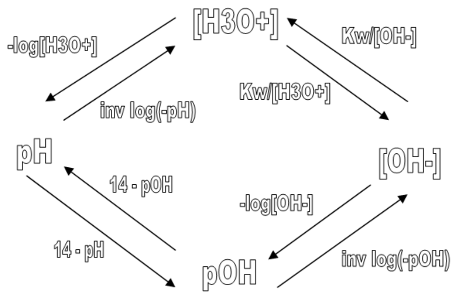
Sep 11-5:06 PM



Example: Find the pH, $[H_3O^+]$, and [OH] of a solution that has a pOH of 8.421.

http://www.quia.com/rr/4051.html

Aug 3-12:01 PM



Example: Find the pH, $[H_3O^+]$, and [OH] of a solution that has a pOH of 8.421.

pH = 14 - 8.421
= 5.579

$[H_3O^+]$ = 2nd log (-5.579)
= 2.64×10^{-6}M

[OH] = 2nd log (-8.421)
= 3.79×10^{-9}M

http://www.quia.com/rr/4051.html

Aug 3-12:01 PM

Assignment 8

1) Find the pH, pOH, and $[OH^-]$ if

a) 1.0×10^{-5}M H_3O^+.

b) 2.65×10^{-7}M H_3O^+.

c) 6.744×10^{-12}M H_3O^+.

Aug 3-12:04 PM

Assignment 8

1) Find the pH, pOH, and $[OH^-]$ if

a) 1.0×10^{-5}M H_3O^+.

b) 2.65×10^{-7}M H_3O^+.

c) 6.744×10^{-12}M H_3O^+.

a) pH = 5.00
pOH = 14 - 5.00 = 9.00
$[OH^-]$ = 2nd log (-9.00)
= 1.0×10^{-9}M

b) pH = -log(2.65×10^{-7})
= 6.577
pOH = 14 - 6.577 = 7.423
$[OH^-]$ = 2nd log (-7.423)
= 3.77×10^{-8}M

c) pH = -log(6.744×10^{-12})
= 11.1711
pOH = 14 - 11.1711 = 2.8289
$[OH^-]$ = 2nd log (-2.8289)
= 1.483×10^{-3}M

Aug 3-12:04 PM

2) Find the $[H_3O^+]$, pOH, and [OH] if

a) pH = 2.35

b) pH = 6.456

c) pH = 10.76

Aug 3-12:54 PM

2) Find the $[H_3O^+]$, pOH, and [OH] if

a) pH = 2.35
b) pH = 6.456
c) pH = 10.76

a) pOH = 14 - 2.35 = 11.65
$[H_3O^+]$ = 2nd log (-2.35)
= 4.5×10^{-3}M
$[OH^-]$ = 2nd log (-11.65)
= 2.2×10^{-12}M

b) pOH = 14 - 6.456 = 7.544
$[H_3O^+]$ = 2nd log (-6.456)
= 3.50×10^{-7}M
$[OH^-]$ = 2nd log (-7.544)
= 2.86×10^{-8}M

c) pOH = 14 - 10.76 = 3.24
$[H_3O^+]$ = 2nd log (-10.76)
= 1.7×10^{-11}M
$[OH^-]$ = 2nd log (-3.24)
= 5.8×10^{-4}M

Aug 3-12:54 PM

3) Find the $[OH^-]$, $[H_3O^+]$, and pH if

a) pOH = 2.34
b) pOH = 12.59
c) pOH = 7.10

Aug 3-12:59 PM

3) Find the $[OH^-]$, $[H_3O^+]$, and pH if

a) pOH = 2.34
b) pOH = 12.59
c) pOH = 7.10

a) pH = 14 - 2.34 = 11.66
$[H_3O^+]$ = 2nd log (-11.66)
= 2.2×10^{-12}M
$[OH^-]$ = 2nd log (-2.34)
= 4.6×10^{-3}M

b) pH = 14 - 12.59 = 1.41
$[H_3O^+]$ = 2nd log (-1.41)
= 3.9×10^{-2}M
$[OH^-]$ = 2nd log (-12.59)
= 2.6×10^{-13}M

c) pH = 14 - 7.10 = 6.90
$[H_3O^+]$ = 2nd log (-6.90)
= 1.3×10^{-7}M
$[OH^-]$ = 2nd log (-7.10)
= 7.9×10^{-8}M

Aug 3-12:59 PM

4) Hebden page 141, numbers 55 & 56

Aug 3-1:07 PM

4) Hebden page 141, numbers 55 & 56

answers in the back of Hebden

Aug 3-1:07 PM

pK_w http://www.quia.com/rd/1975.html?AP_rand=1837719048

The 'p' of any value is the -log of that value. For example, the pH of $[H_3O^+]$ is $-\log[H_3O^+]$, and the pOH of $[OH^-]$ is $-\log[OH^-]$. Therefore, how would you calculate the pK_w at 25 degrees C if $K_w = 1.0 \times 10^{-14}$?

pK_w =

How do pH and pOH relate to each other?

This is because when you multiply powers in math, the shortcut is to add their exponents!

Aug 3-1:04 PM

pKw http://www.quia.com/rd/1975.html?AP_rand=1837719048

The 'p' of any value is the -log of that value. For example, the pH of $[H_3O^+]$ is $-\log[H_3O^+]$, and the pOH of $[OH^-]$ is $-\log[OH^-]$. Therefore, how would you calculate the pK_w at 25 degrees C if $K_w = 1.0 \times 10^{-14}$?

$pK_w = -\log K_w = -\log(1.0 \times 10^{-14}) = 14.00$

How do pH and pOH relate to each other?

pH + pOH = 14.00 so pH + pOH = pK_w

This is because when you multiply powers in math, the shortcut is to add their exponents!

Aug 3-1:04 PM

Outside the pH scale (below 0 & above 14)

What is the pH of 1.00M HCl?

Therefore, what would pH be if [HCl] > 1.00M?

Very concentrated acidic solutions (solutions that have $[H_3O^+]$ > ____M have pH values less than 0. Very concentrated basic solutions (solutions that have $[OH^-]$ > ____M; $[H_3O^+]$ < __________M) have pH values greater than 14.

Aug 3-1:15 PM

Outside the pH scale (below 0 & above 14)

What is the pH of 1.00M HCl?

$1.00M = 1.00 \times 10^{0}M$, so pH = 0.000

Therefore, what would pH be if [HCl] > 1.00M?

pH would be a negative number

Very concentrated acidic solutions (solutions that have $[H_3O^+]$ > 1.0 M have pH values less than 0. Very concentrated basic solutions (solutions that have $[OH^-]$ > 1.0 M; $[H_3O^+]$ < 1.0×10^{-14} M) have pH values greater than 14.

Aug 3-1:15 PM

Example:

Find the pH and pOH of:

a) 5.0M HNO_3 b) 1.5M $Sr(OH)_2$

Aug 3-1:20 PM

Example:

Find the pH and pOH of:

a) 5.0M HNO_3

$HNO_3 + H_2O \rightarrow H_3O^+ + NO_3^-$
5.0M 5.0M

pH = -log(5.0)
= -0.70

pOH = 14 - (-0.70)
= 14.70

b) 1.5M $Sr(OH)_2$

$Sr(OH)_2 \rightarrow Sr^{2+} + 2OH^-$
1.5M 3.0M

pOH = -log(3.0)
= -0.48

pH = 14 - (-0.8)
= 14.48

Aug 3-1:20 PM

Practice Questions:

1) Find the pH of a 0.0020M solution of HNO_3.

2) Calculate the pH of a 0.010M NaOH solution.

3) If the pH is decreased from 5 to 2, what happens to the $[H_3O^+]$ and $[OH^-]$?

Aug 3-1:25 PM

Practice Questions:

1) Find the pH of a 0.0020M solution of HNO_3.

HNO_3 + H_2O ⟶ H_3O^+ + NO_3^-
0.0020M 0.0020M

pH = -log(0.0020)
= 2.70

2) Calculate the pH of a 0.010M NaOH solution.

NaOH Na^+ + OH^-
0.010M 0.010M

pOH = -log(0.010)
= 2.00
pH = 14.00 - 2.00 = 12.00

3) If the pH is decreased from 5 to 2, what happens to the [H_3O^+] and [OH^-]?

every change in pH by 1 unit = 10 times change in concentration

[H_3O^+] increases by 10 x 10 x 10 = 10^3 = 1000 times
[OH^-] decreases by 1000 times

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4) If pH is increased from 7.2 to 8.9, what happens to the [H_3O^+]?

5) Calculate the pH of the final solution if 100.0mL of a strong acid with pH = 4.500 is diluted by adding 50.0mL of water.

Aug 3-1:30 PM

4) If pH is increased from 7.2 to 8.9, what happens to the [H_3O^+]?

8.9 - 7.2 = 1.7 [H_3O^+] decreases by 50 times

$10^{1.7}$ = 50

5) Calculate the pH of the final solution if 100.0mL of a strong acid with pH = 4.500 is diluted by adding 50.0mL of water.

Before dilution:
[H_3O^+] = 2nd log(-4.500)
= 3.16 x 10^{-5}M

$M_iV_i = M_fV_f$
(3.16 x 10^{-5})(0.1000) = M_f(0.1500)
[H_3O^+] after dilution
= 2.1081 x 10^{-5}M

pH = -log(2.1081 x 10^{-5})

= 4.676

Aug 3-1:30 PM

6) By how many pH units does the pH change if 80.0mL of 0.0200M HCl is diluted to a final volume of 160.0mL?

Aug 3-1:38 PM

6) By how many pH units does the pH change if 80.0mL of 0.0200M HCl is diluted to a final volume of 160.0mL?

HCl + H_2O ⟶ H_3O^+ + Cl^-
0.0200M 0.0200M

$M_iV_i = M_fV_f$
(0.0200)(0.0800) = M_f(0.1600)

[H_3O^+] before dilution
= 0.200M

[H_3O^+] after dilution
= 0.0100M

pH before dilution
= 1.699

pH after dilution
= 2.000

pH change = 2.000 - 1.699 = 0.301 increase

Aug 3-1:38 PM

7a) Using your acid/base table for assistance, which has a lower pH, a 0.01M solution of HF or a 0.01M solution of CH_3COOH? Why?

b) Which of the above solutions will conduct better? Why?

Aug 4-12:57 PM

7a) Using your acid/base table for assistance, which has a lower pH, a 0.01M solution of HF or a 0.01M solution of CH_3COOH? Why?

HF is higher on the acid side (left side), therefore it reacts to a greater extent to produce more H_3O^+. Thus, 0.01M HF will have a lower pH

b) Which of the above solutions will conduct better? Why?

0.01M HF. Since it reacts to a greater extent, it creates more ions, and the more ions in solution, the better is conducts.

Aug 4-12:57 PM

Assignment 9

1) Hebden page 139, numbers 49deh & 50ef

2) Calculate the pH, pOH, and [OH] of a 0.00100M solution of HNO_3.

3) Calculate the pOH, pH, and $[H_3O^+]$ of a 2.34×10^{-4}M solution of $Ca(OH)_2$.

Aug 4-1:01 PM

Assignment 9

1) Hebden page 139, numbers 49deh & 50ef

answers in the back of Hebden

2) Calculate the pH, pOH, and [OH] of a 0.00100M solution of HNO_3.

$HNO_3 + H_2O \longrightarrow H_3O^+ + NO_3^-$

1.00×10^{-3}M $\quad$ 1.00×10^{-3}M

pH = -log(1.00×10^{-3}) = 3.000

pOH = 14 - 3.000 = 11.000

$[OH^-]$ = 2nd log (-11.000) = 1.00×10^{-11}M

3) Calculate the pOH, pH, and $[H_3O^+]$ of a 2.34×10^{-4}M solution of $Ca(OH)_2$.

$Ca(OH)_2 \longrightarrow Ca^{2+} + 2OH^-$

2.34×10^{-4}M $\quad$ 4.68×10^{-4}M

pOH = -log(4.68×10^{-4}) = 3.330

pH = 14 - 3.330 = 10.670

$[H_3O^+]$ = 2nd log (-10.670) = 2.14×10^{-11}M

Aug 4-1:01 PM

4) If the pH is increased from 1 to 6, how do the $[H_3O^+]$ and $[OH^-]$ change?

5) If the pH decreases from 9.3 to 6.5, how does $[H_3O^+]$ change?

Aug 4-1:13 PM

4) If the pH is increased from 1 to 6, how do the $[H_3O^+]$ and $[OH^-]$ change?

increase in 5 pH units, meaning a decrease of 10^5 in $[H_3O^+]$, so $[H_3O^+]$ decreases by 100 000 times

5) If the pH decreases from 9.3 to 6.5, how does $[H_3O^+]$ change?

$10^{9.3-6.5} = 10^{2.8}$ = 631 times increase in $[H_3O^+]$

Aug 4-1:13 PM

6) What is the pH of the final solution if 35.00mL of a strong acid at pH 3.56 is diluted by adding 100.0mL of water?

Aug 4-1:19 PM

6) What is the pH of the final solution if 35.00mL of a strong acid at pH 3.56 is diluted by adding 100.0mL of water?

Before dilution:

$[H_3O^+]$ = 2nd log(-3.56)
= 2.754×10^{-4}M

$M_iV_i = M_fV_f$

$(2.754 \times 10^{-4})(0.03500) = M_f(0.13500)$

$[H_3O^+]$ after dilution
= 7.1406×10^{-5}M

pH = $-\log(7.1406 \times 10^{-5})$

= 4.15

Aug 4-1:19 PM

7) You have 50.00mL of a 0.00345M solution of $HClO_4$. How does the pH change if you dilute the solution to a final volume of 175.0mL?

Aug 4-1:25 PM

7) You have 50.00mL of a 0.00345M solution of $HClO_4$. How does the pH change if you dilute the solution to a final volume of 175.0mL?

$HClO_4 + H_2O \rightarrow H_3O^+ + ClO_4^-$
0.00345M → 0.00345M

$M_iV_i = M_fV_f$

$(0.00345)(0.05000) = M_f(0.1750)$

$[H_3O^+]$ before dilution
= 0.00345M

$[H_3O^+]$ after dilution
= 9.857×10^{-4}M

pH before dilution
= 2.462

pH after dilution
= 3.006

pH change = 3.006 - 2.462 = 0.544 increase

Aug 4-1:25 PM

8) Hebden page 139 #53 and page 141 #57

9) You dissolve 0.4g of $Ca(OH)_2$ in 500mL of solution. What is the pH?

Aug 4-1:29 PM

8) Hebden page 139 #53 and page 141 #57

answers in the back of Hebden

9) You dissolve 0.4g of $Ca(OH)_2$ in 500mL of solution. What is the pH?

$0.4\text{g} \times \frac{1\text{mol}}{74.1\text{g}} = 5.398 \times 10^{-3}$mol $Ca(OH)_2$

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

5.398×10^{-3}mol → 1.08×10^{-2}mol

$[OH^-] = \frac{1.08 \times 10^{-2}\text{mol}}{0.5\text{L}}$

pOH = $-\log(2.16 \times 10^{-2})$
= 1.67

pH = 14 - 1.67 = 12.3

Aug 4-1:29 PM

Temperature and pH

$$2H_2O_{(l)} + 59kJ \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

At 25 degrees C: $K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$
so $pK_w = 14.00$

The pH scale is generally thought of from 0-14 because the pK_w is 14. However, this is only the case at 25 degrees C. Why?

Aug 4-1:36 PM

Temperature and pH

$2H_2O_{(l)} + 59kJ \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$

At 25 degrees C: $K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$ so $pK_w = 14.00$

The pH scale is generally thought of from 0-14 because the pK_w is 14. However, this is only the case at 25 degrees C. Why?

K_w at 25 degrees C is 1.0×10^{-14}, so $pK_w = 14$, and this is what determines the pH scale. K_w changes due to a temperature change, so pK_w does as well and thus the pH scale also changes.

Aug 4-1:36 PM

If the temperature is increased, what happens to the equilibrium and the resulting K_w? What will happen to the pH scale?

What if the temperature is decreased?

Aug 4-1:40 PM

If the temperature is increased, what happens to the equilibrium and the resulting K_w? What will happen to the pH scale?

increase in temp = shift endo = shift right, therefore both $[H_3O^+]$ and $[OH^-]$ increase, therefore K_w increases, therefore pK_w decreases, and thus the pH scale shrinks

What if the temperature is decreased?

decrease in temp = shift exo = shift left, therefore both $[H_3O^+]$ and $[OH^-]$ decrease, therefore K_w decreases, therefore pK_w increases, therefore the pH scale gets larger

Aug 4-1:40 PM

Example: An increase in temperature to 50 degrees C results in a K_w of 5.48×10^{-14}. Calculate the pH, pOH, $[H_3O^+]$, and $[OH^-]$ in pure water. Is the water acidic, basic, or neutral?

Aug 4-1:50 PM

Example: An increase in temperature to 50 degrees C results in a K_w of 5.48×10^{-14}. Calculate the pH, pOH, $[H_3O^+]$, and $[OH^-]$ in pure water. Is the water acidic, basic, or neutral?

$pK_w = -\log(5.48 \times 10^{-14})$
$= 13.261$

pH scale 0 - 13.261

$pH = pOH = \frac{13.261}{2} = 6.631$

$[H_3O^+] = [OH^-]$ = 2nd log (-6.6305)
$= 2.34 \times 10^{-7}$ M

pure water is always neutral as $[H_3O^+] = [OH^-]$

Aug 4-1:50 PM

Example: A sample of distilled, pure water has a pH of 7.50. Is the temperature greater than or less than 25 degrees C? Explain.

$2H_2O_{(l)} + 59kJ \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$

Aug 4-1:54 PM

Example: A sample of distilled, pure water has a pH of 7.50. Is the temperature greater than or less than 25 degrees C? Explain.

$$2H_2O_{(l)} + 59kJ \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

pure water is neutral, so pH = pOH, therefore pK_w = 7.50 x 2 = 15.00

so, K_w = 2nd log (-15.00) = 1.0×10^{-15}

1.0×10^{-15} is less than 1.0×10^{-14} so K_w has decreased, therefore $[H_3O^+]$ and $[OH^-]$ both decreased, thus a shift left, meaning a shift exo, so the temperature must have decreased. Therefore, the temperature is LESS THAN 25 degrees C.

Aug 4-1:54 PM

Assignment 10

1) Hebden page 139, #51, 52

2) Water at a certain temperature has a K_w of 4.4×10^{-15}.
a) Is the water at a temperature above or below 25 degrees C?
b) What is the pK_w?
c) What would the pH scale be at this temperature?
d) Find the $[H_3O^+]$ and $[OH^-]$
e) Find the pH and pOH.
f) Is water at this temperature acidic, basic, or neutral?

Aug 4-2:00 PM

Assignment 10

1) Hebden page 139, #51, 52
answers in the back of Hebden

2) Water at a certain temperature has a K_w of 4.4×10^{-15}.
a) Is the water at a temperature above or below 25 degrees C? below 25 degrees C, since $4.4 \times 10^{-15} < 1.0 \times 10^{-14}$
b) What is the pK_w? $pK_w = -\log(4.4 \times 10^{-15}) = 14.36$
c) What would the pH scale be at this temperature? 0 - 14.36
d) Find the $[H_3O^+]$ and $[OH^-]$ $\sqrt{4.4 \times 10^{-15}} = 6.6 \times 10^{-8}$M
e) Find the pH and pOH. 14.36 divided by 2 = 7.18
f) Is water at this temperature acidic, basic, or neutral? neutral

Aug 4-2:00 PM

XIII) Mixtures of Strong Acids and Bases

Mixing an acid solution with a basic solution produces a solution that can be __________, __________, or __________ depending on the moles of acid compared to the moles of base mixed. H_3O^+ ions react with OH^- ions to make $2H_2O$ molecules, known as neutralization. But if there are more of one ion than the other, the resulting solution will not be neutral.

Aug 4-2:10 PM

XIII) Mixtures of Strong Acids and Bases

Mixing an acid solution with a basic solution produces a solution that can be acidic, basic, or neutral depending on the moles of acid compared to the moles of base mixed. H_3O^+ ions react with OH^- ions to make $2H_2O$ molecules, known as neutralization. But if there are more of one ion than the other, the resulting solution will not be neutral.

Aug 4-2:10 PM

Example: Calculate the pH of a solution obtained by adding 50.0mL of 0.10M HCl to 80.0mL of 0.15M NaOH.

Aug 4-2:13 PM

Example: Calculate the pH of a solution obtained by adding 50.0mL of 0.10M HCl to 80.0mL of 0.15M NaOH.

$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$
0.10M 0.10M

$NaOH \longrightarrow Na^+ + OH$
0.15M 0.15M

mol H_3O^+ = (0.10)(0.0500) = 0.0050

mol OH^- = (0.15)(0.0800) = 0.012

excess OH = 0.012 - 0.0050 = 0.007

$[OH^-] = \frac{0.007}{0.1300}$ = 0.053846M

pOH = -log(0.053846) = 1.2688

pH = 12.7

Aug 4-2:13 PM

Example: Calculate the pH of a solution obtained by adding 1.00g of $Ca(OH)_2$ to 650.0mL of 0.800M HCl.

Aug 4-2:21 PM

Example: Calculate the pH of a solution obtained by adding 1.00g of $Ca(OH)_2$ to 650.0mL of 0.800M HCl.

$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$
0.800M 0.800M

$\frac{1.00g}{} \Big| \frac{1mol}{74.1g}$ = 0.013495 mol

mol H_3O^+ = (0.800)(0.6500) = 0.520mol

$Ca(OH)_2 \longrightarrow Ca^{2+} + 2OH^-$
0.013495mol 0.02699mol

mol OH^- = 0.02699mol

excess H_3O^+ = 0.520 - 0.02699 = 0.493

$[OH^-] = \frac{0.493}{0.6500}$ = 0.758477

pH = -log(0.758477) = 0.120

Aug 4-2:21 PM

Example: What mass of NaOH would have to be added to 500.0mL of 0.100M HCl in order to produce a solution with a pH of 3.200?

Aug 4-2:31 PM

Example: What mass of NaOH would have to be added to 500.0mL of 0.100M HCl in order to produce a solution with a pH of 3.200.

before NaOH added: $HCl + H_2O \longrightarrow H_3O^+ + Cl^-$
0.100M 0.100M

mol H_3O^+ = (0.100)(0.5000)
= 0.0500

after NaOH added, at pH 3.200:
$[H_3O^+]$ = 2nd log(-3.200) = 6.3096×10^{-4}M
mol H_3O^+ = $(6.3096 \times 10^{-4})(0.5000) = 3.1548 \times 10^{-4}$

amount of H_3O^+ lost when NaOH added: 0.0500 - 3.1548×10^{-4}
= 0.049685 mol

amount of OH^- added: 0.049685mol

amount of NaOH added: 0.049685mol

mass NaOH added = $\frac{0.049685\text{mol NaOH}}{} \Big| \frac{40.0g}{1mol}$ = 1.99g NaOH

Aug 4-2:31 PM

Example: How many moles of HCl must be added to 40.0mL of 0.180M NaOH to produce a solution having a pH of 12.500? (Assume that there is no change in volume when the HCl is added)

Aug 4-2:39 PM

Example: How many moles of HCl must be added to 40.0mL of 0.180M NaOH to produce a solution having a pH of 12.500? (Assume that there is no change in volume when the HCl is added)

before HCl added: $NaOH \longrightarrow Na^+ + OH^-$
0.180M 0.180M
mol OH^- = (0.180)(0.0400)
= 0.00720

after HCl added, at pH 12.500:
pOH = 14 - 12.500 = 1.500
$[OH^-]$ = 2nd log(-1.500) = 3.1623 x 10^{-2}M
mol OH^- = (3.1623 x 10^{-2})(0.0400) = 1.2649 x 10^{-3}

amount of OH^- lost when HCl added: 0.00720 - 1.2649 x 10^{-3}
= 0.005935 mol

amount of H_3O^+ added: 0.005935mol

amount of HCl added: 0.005935mol = 0.00594 moles

Aug 4-2:39 PM

Assignment 11

Hebden page 143 #58, 60, 62, 65, 67

Aug 4-2:46 PM

Assignment 11

Hebden page 143 #58, 60, 62, 65, 67

answers in the back of Hebden

Aug 4-2:46 PM

XIV) Titrations

A **titration** is a laboratory technique that is most often used to find the concentration (molarity) of a solution. Acid/base titrations are a common type of titration in which a base is used to find an unknown acid concentration, or *visa versa*.

Suppose you are cleaning up the lab and you find a large container labeled 'hydrochloric acid', but the concentration is not given. A **titration** can be done to find the unknown concentration.

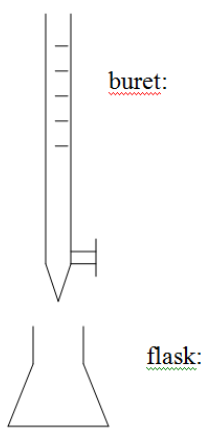
Aug 5-10:20 AM

Titration is a process (procedure and calculations) for determining the concentration of a substance accurately and precisely using a measurable volume of a standardized solution. A **standardized solution** is simply a reactant of known concentration.

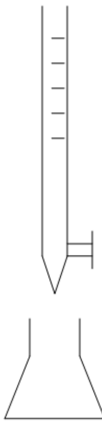
The standardized solution (or **titrant**) used to find the concentration of hydrochloric acid would be a strong base, such as NaOH solution. The volume of NaOH is added to the acid solution would be measured using a skinny tube called a **buret**.

http://www.chem-ilp.net/labTechniques/TitrationAnimation.htm

Aug 5-10:23 AM



Aug 5-10:26 AM



buret: filled with standardized solution (solution of known molarity)
can keep track of volume used

flask: a known volume of the solution that has unknown molarity

Aug 5-10:26 AM

The flask contains a measured volume of the solution of unknown concentration, in this case 10.00mL of $HCl_{(aq)}$, and the buret contains a standardized base, in this case 0.10M $NaOH_{(aq)}$. The standardized base is added from the buret to the flask. The OH^- from the buret reacts with the H_3O^+ from the flask to produce water. This continues until the **equivalence point** is reached, the point at which ____.

http://www.wiley.com/college/chem/brady184764/resources/ch04/index_ch4_bysect.html

Aug 5-10:27 AM

The flask contains a measured volume of the solution of unknown concentration, in this case 10.00mL of $HCl_{(aq)}$, and the buret contains a standardized base, in this case 0.10M $NaOH_{(aq)}$. The standardized base is added from the buret to the flask. The OH^- from the buret reacts with the H_3O^+ from the flask to produce water. This continues until the **equivalence point** is reached, the point at which moles of H_3O^+ = moles of OH^- (moles acid = moles base).

Aug 5-10:27 AM

At this point, what is in the flask?

http://preparatorychemistry.com/Bishop_Solubility_frames.htm

For a strong acid/strong base titration, such as the example we are investigating, the pH at the equivalence point is ______.

Aug 5-10:30 AM

At this point, what is in the flask?

water and salt

$$HCl + NaOH \longrightarrow H_2O + NaCl$$

http://preparatorychemistry.com/Bishop_Solubility_frames.htm

For a strong acid/strong base titration, such as the example we are investigating, the pH at the equivalence point is 7.

Aug 5-10:30 AM

How do you know when the equivalence point has been reached in an acid/base titration?
An **indicator** is used to visually determine when the equivalence point has been reached in an acid/base titration. The indicator changes colour at or very near the equivalence point, signaling an end to the titration. When an indicator changes colour, it's called the **endpoint**, or **transition point**, and this is what signals that the **equivalence point** (neutralization) has been reached.
The chemistry of indicators will be studied in the Acid/Base II unit.

Aug 5-10:34 AM

Since, at the equivalence point, moles OH^- = moles H_3O^+, if we can calculate the moles of OH that vacated the buret, it will be equal to the moles of H_3O^+ that were originally in the flask (since H_3O^+ and OH^- react one to one). The [NaOH] = 0.10M, and we kept track of the volume of NaOH that vacated the buret (using the scale on the buret), therefore we can find the moles of OH^- that went into the flask. If we stop the titration at the equivalence point, the moles of OH^- that went into the flask will be equal to the moles of H_3O^+ in the flask. Since we know the original volume of H_3O^+ solution in the **flask**, we can calculate the unknown [HCl] on the next page:

Aug 5-10:36 AM

Suppose 12.63mL of NaOH is used to reach the endpoint

$NaOH \longrightarrow Na^+ + OH^-$
0.10M 0.10M

mol OH^- used = (0.10M)(0.01263L) = 1.263 x 10^{-3}mol

at equivalence point, mol OH^- = mol H_3O^+

so mol H_3O^+ originally in flask = 1.263 x 10^{-3}

the volume of HCl in the flask was 10.00mL = 0.01000L

$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$
1.263 x 10^{-3}mol 1.263 x 10^{-3}mol

therefore, [HCl] = $\frac{1.263 \times 10^{-3}\text{mol}}{0.01000\text{L}}$ = 0.13M

Now, the HCl solution is **standardized**, as we know the concentration.

Aug 5-10:41 AM

Practice Questions:

1) A 10.00mL sample of an unknown concentration of $LiOH_{(aq)}$ is titrated using 23.62mL of 0.150M HNO_3. Determine [LiOH].

Aug 5-10:46 AM

Practice Questions:

1) A 10.00mL sample of an unknown concentration of $LiOH_{(aq)}$ is titrated using 23.62mL of 0.150M HNO_3. Determine [LiOH].

$HNO_3 + H_2O \longrightarrow H_3O^+ + NO_3^-$
0.150M 0.150M

mol H_3O^+ used = (0.150M)(0.02362) = 0.003543mol

mol OH^- originally in flask = 0.003543mol

mol LiOH in flask = 0.003543mol

[LiOH] = $\frac{0.003543\text{mol}}{0.01000\text{L}}$ = 0.354M

Aug 5-10:46 AM

2) 37.86mL of 0.250M NaOH was required to neutralize a 20.0mL sample of HF. Calculate the [HF]. *Even though HF is a weak acid and in water it will only dissociate under 5%, in the presence of a strong base such as NaOH, it will react 100%.

Aug 5-11:00 AM

2) 37.86mL of 0.250M NaOH was required to neutralize a 20.0mL sample of HF. Calculate the [HF]. *Even though HF is a weak acid and in water it will only dissociate under 5%, in the presence of a strong base such as NaOH, it will react 100%.

$NaOH \longrightarrow Na^+ + OH^-$
0.250M 0.250M

mol OH^- used = (0.250M)(0.03786L) = 9.465 x 10^{-3}mol

at equivalence point, mol OH^- = mol H_3O^+

so mol H_3O^+ originally in flask = 9.465 x 10^{-3}

mol HF in flask = 9.465 x 10^{-3}

therefore, [HF] = $\frac{9.465 \times 10^{-3}\text{mol}}{0.0200\text{L}}$ = 0.473M

Aug 5-11:00 AM

3) A 15.0mL sample of unknown [$Sr(OH)_2$] was titrated using 18.56mL of 0.350M HNO_3. Find [$Sr(OH)_2$].

Aug 5-11:06 AM

3) A 15.0mL sample of unknown [$Sr(OH)_2$] was titrated using 18.56mL of 0.350M HNO_3. Find [$Sr(OH)_2$].

$HNO_3 + H_2O \longrightarrow H_3O^+ + NO_3^-$

0.350M 0.350M

mol H_3O^+ used = (0.350M)(0.01856) = 0.006496

mol OH^- originally in flask = 0.006496

$Sr(OH)_2 \longrightarrow Sr^{2+} + 2OH^-$

0.003248 0.006496

mol $Sr(OH)_2$ in flask = $\frac{0.006496\text{mol}}{2}$ = 0.003248

[$Sr(OH)_2$] = $\frac{0.003248\text{mol}}{0.0150\text{L}}$ = 0.217M

*Any stoich you do BEFORE the equivalence point step is a multiply. Any stoich you do AFTER the equivalence point step (such as in this example) is a divide.

Aug 5-11:06 AM

4) 50.78mL of 0.020M $Ba(OH)_2$ was required to neutralize a 30.0mL sample of H_2SO_4. Find [H_2SO_4].

Aug 5-11:12 AM

4) 50.78mL of 0.020M $Ba(OH)_2$ was required to neutralize a 30.0mL sample of H_2SO_4. Find [H_2SO_4].

$Ba(OH)_2 \longrightarrow Ba^{2+} + 2OH$

0.020M 0.040M

mol OH^- used = (0.040M)(0.05078L) = 0.00203

at equivalence point, mol OH^- = mol H_3O^+

so mol H_3O^+ originally in flask = 0.00203

$H_2SO_4 \longrightarrow 2H^+ + SO_4^{2-}$

0.001016 0.00203

mol H_2SO_4 in flask = 0.001016

therefore, [H_2SO_4] = $\frac{0.001016}{0.0300\text{L}}$ = 0.034M

Aug 5-11:12 AM

Assignment 12

1) Find the concentration of an HCl solution if 25.00mL is titrated with 28.46mL of a 0.105M standardized solution of NaOH.

Aug 5-11:17 AM

Assignment 12

1) Find the concentration of an HCl solution if 25.00mL is titrated with 28.46mL of a 0.105M standardized solution of NaOH.

$NaOH \longrightarrow Na^+ + OH$

0.105M 0.105M

mol OH^- used = (0.105M)(0.02846L) = 0.002988mol

at equivalence point, mol OH^- = mol H_3O^+

so mol H_3O^+ originally in flask = 0.002988mol

mol HCl in flask = 0.002988mol

therefore, [HCl] = $\frac{0.002988\text{mol}}{0.02500\text{L}}$ = 0.120M

Aug 5-11:17 AM

2) You titrated a 30.0mL solution of HNO_3 with 23.75mL of a 0.25M standardized solution of KOH. What is the [HNO_3]?

Aug 5-11:21 AM

2) You titrated a 30.0mL solution of HNO_3 with 23.75mL of a 0.25M standardized solution of KOH. What is the [HNO_3]?

$KOH \longrightarrow K^+ + OH$

0.25M 0.25M

mol OH^- used = (0.25M)(0.02375L) = 0.0059375

at equivalence point, mol OH^- = mol H_3O^+

so mol H_3O^+ originally in flask = 0.0059375

mol HNO_3 in flask = 0.0059375

therefore, $[HNO_3] = \frac{0.0059375\text{mol}}{0.0300\text{L}} = 0.20\text{M}$

Aug 5-11:21 AM

3) A 35.00mL unknown solution of LiOH is titrated with 17.67mL of 0.200M HI. What is the [LiOH]?

Aug 5-11:25 AM

3) A 35.00mL unknown solution of LiOH is titrated with 17.67mL of 0.200M HI. What is the [LiOH]?

$HI + H_2O \longrightarrow H_3O^+ + I^-$

0.200M 0.200M

mol H_3O^+ used = (0.200M)(0.01767) = 0.003534mol

mol OH^- originally in flask = 0.003534mol

mol LiOH in flask = 0.003534mol

$[LiOH] = \frac{0.003534\text{mol}}{0.03500\text{L}} = 0.101\text{M}$

Aug 5-11:25 AM

4) A 24.00mL sample of H_2SO_4 is titrated with 32.43mL of 0.150M NaOH solution. Find [H_2SO_4].

Aug 5-11:29 AM

4) A 24.00mL sample of H_2SO_4 is titrated with 32.43mL of 0.150M NaOH solution. Find [H_2SO_4].

$NaOH \longrightarrow Na^+ + OH$

0.150M 0.150M

mol OH^- used = (0.150M)(0.03243L) = 0.0048645

at equivalence point, mol OH^- = mol H_3O^+

so mol H_3O^+ originally in flask = 0.0048645

$H_2SO_4 \longrightarrow 2H^+ + SO_4^{2-}$

0.002432 0.0048645

mol H_2SO_4 in flask = 0.002432

therefore, $[H_2SO_4] = \frac{0.002432}{0.02400\text{L}} = 0.101\text{M}$

Aug 5-11:29 AM

5) A 40.00mL sample of $Ca(OH)_2$ is titrated with 16.55mL of 0.100M HCl. Find $[Ca(OH)_2]$.

Aug 5-11:34 AM

5) A 40.00mL sample of $Ca(OH)_2$ is titrated with 16.55mL of 0.100M HCl. Find $[Ca(OH)_2]$.

$HCl + H_2O \longrightarrow H_3O^+ + Cl$
0.100M 0.100M

mol H_3O^+ used = (0.100M)(0.01655L) = 0.001655mol

at equivalence point, mol OH^- = mol H_3O^+

so mol OH^- originally in flask = 0.001655

$Ca(OH)_2 \longrightarrow Ca^{2+} + 2OH^-$
0.0008275 0.001655

mol $Ca(OH)_2$ in flask = 0.0008275

therefore, $[Ca(OH)_2] = \frac{0.0008275}{0.04000L} = 0.0207M$

Aug 5-11:34 AM

6) A 20.00mL sample of H_3PO_4 is titrated with 25.76mL of 0.100M $Ba(OH)_2$ solution. Find $[H_3PO_4]$.

Aug 5-11:41 AM

6) A 20.00mL sample of H_3PO_4 is titrated with 25.76mL of 0.100M $Ba(OH)_2$ solution. Find $[H_3PO_4]$.

$Ba(OH)_2 \longrightarrow Ba^{2+} + 2OH$
0.100M 0.200M

mol OH^- used = (0.200M)(0.02576L) = 0.005152

at equivalence point, mol OH^- = mol H_3O^+

so mol H_3O^+ originally in flask = 0.005152

$H_3PO_4 \longrightarrow 3H^+ + PO_4^{3-}$
0.0017173 0.005152

mol H_3PO_4 in flask = 0.0017173

therefore, $[H_3PO_4] = \frac{0.0017173}{0.02000L} = 0.0859M$

Aug 5-11:41 AM

http://auth.mhhe.com/physsci/chemistry/animations/chang_7e_esp/crm3s5_5.swf

Making Standardized Solutions

How could you make 1.0L of a 0.50M solution of NaOH in the lab? NaOH originates as solid white pellets.

Aug 6-2:29 PM

http://auth.mhhe.com/physsci/chemistry/animations/chang_7e_esp/crm3s5_5.swf

Making Standardized Solutions

How could you make 1.0L of a 0.50M solution of NaOH in the lab? NaOH originates as solid white pellets.

moles NaOH = (0.50M)(1.0L) = 0.50 moles

mass NaOH = $0.50mol \times \frac{40.0g}{1mol}$ = 20g NaOH

Weigh out 20g NaOH and put it in a 1L volumetric flask. Fill halfway, swirl to dissolve NaOH, then fill to the line.

Aug 6-2:29 PM

This method, though sound for making many types of solutions, would actually produce an NaOH solution that is slightly less than 0.50M (probably about 0.48M). This is because NaOH pellets actually absorb water, and so the mass of NaOH you measure is not all due to NaOH; some is due to water absorbed onto the pellets. This problem is the case for many acids and bases, which makes it very hard to create an accurate standardized solution from scratch. These acids and bases are **hygroscopic**, meaning they absorb water.

Aug 6-2:32 PM

There are a few acids and bases that are **non-hygroscopic**, meaning they are pure and dry acids or bases and can be used to make solutions with accurate concentrations. Non-hygroscopic acids and bases are known as **primary standards**, and are used to make standardized solutions.

Examples: Primary Standard Base:
sodium carbonate (Na_2CO_3)
Primary Standard Acids:
potassium hydrogen phthalate
oxalic acid ($H_2C_2O_4$)

Aug 6-2:35 PM

Once a primary standard of known concentration is accurately prepared in the lab, it can be used to **standardize** any other acid or base solution by titration. For example, oxalic acid is a primary standard acid, and once an accurate standardized solution of it is prepared (using your method from the top of the page), it can be used to standardize any basic solution by titration. Then, that same basic solution that is now standardized can be used to titrate an unknown concentration of any acid, thereby standardizing that acid solution, and so on.

Aug 6-2:39 PM

Calculating Unknown Volume by Titration

What volume of 0.0350M $Ba(OH)_2$ will be required to neutralize 50.0mL of 0.0275M HCl?

Aug 6-2:42 PM

Calculating Unknown Volume by Titration

What volume of 0.0350M $Ba(OH)_2$ will be required to neutralize 50.0mL of 0.0275M HCl?

$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$
0.0275M   0.0275M

mol H_3O^+ = (0.0275)(0.0500) = 0.001375

mol OH^- used = 0.001375

$Ba(OH)_2 \longrightarrow Ba^{2+} + 2OH$
6.875×10^{-4}mol   0.001375mol

mol $Ba(OH)_2$ = 6.875×10^{-4}

volume $Ba(OH)_2$ used = $\frac{6.875 \times 10^{-4}\text{mol}}{0.0350\text{M}}$ = 0.0196L or 19.6mL

Aug 6-2:42 PM

Assignment 13

Hebden page 158 #96, 97, 106 &
page 165 #122

Aug 6-2:49 PM

Assignment 13

Hebden page 158 #96, 97, 106 &
page 165 #122

answers in the back of Hebden

Aug 6-2:49 PM

http://dwb4.unl.edu/chemAnime/PH1D/PH1D.html

Aug 9-2:57 PM

Helpful Equations - A Summary

1) Strong acid in water: 100% dissociation

$HNO_3 + H_2O \longrightarrow H_3O^+ + NO_3^-$

.10M .10M .10M

pH = -log(.10) = 1.00

H_2SO_4 in water:

first proton is strong:

$H_2SO_4 + H_2O \longrightarrow H_3O^+ + HSO_4^-$

.10M .10M .10M

second proton is weak:

$HSO_4^- + H_2O \rightleftharpoons H_3O^+ + SO_4^{2-}$

.10M <.10M <.10M

Aug 6-2:53 PM

2) Weak acid in water: not 100% dissociation

$H_3PO_4 + H_2O \rightleftharpoons H_3O^+ + H_2PO_4^-$

.10M 0.0279M 0.0279M

pH = -log(0.0279) = 1.56

3) Strong base (hydroxide base) in water: 100% dissociation (water not in reaction; just a dissociation)

$Sr(OH)_2 \longrightarrow Sr^{2+} + 2OH^-$

.10M .10M .20M

pOH = -log(.20) = 0.70

pH = 13.30

Aug 6-2:56 PM

4) Weak base in water: not 100% dissociation

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

.10M 1.34×10^{-3}M 1.34×10^{-3}M

pOH = $-\log(1.34 \times 10^{-3}) = 2.87$

pH = 11.13

Aug 6-2:59 PM

5) ANY reaction that involves a STRONG acid or base goes to 100% completion. So a weak acid with a strong base is 100% due to the strong base. A strong acid with a weak base is 100% due to the strong acid.

Ex: $H_3PO_4 + 3NaOH \longrightarrow 3H_2O + Na_3PO_4$

weak strong

The OH^- ions take all three protons off of each H_3PO_4 molecule, such as in a titration. If H_3PO_4 was merely in water, only one proton would come off at less than 100% like #2 earlier.

Aug 6-3:01 PM

6) Weak acid and weak base:

$NH_4^+ + SO_4^{2-} \rightleftharpoons NH_3 + HSO_4$

-side with weaker acid is favoured

http://www.media.pearson.com.au/schools/cw/au_sch_derry_ibcsl_1/int/aqueous/tutor/f5/1501.html

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