[TP] In pure water at 25 °C, there is only a tiny, tiny amount of self-ionization, $\sim 10^{-7}$ mol/L. In pure water, how many water molecules are there for every OH^- ion?

14% 1. 1
14% 2. 10
14% 3. 100
14% 4. 10,000
14% 5. 1,000,000
14% 6. 10,000,000
14% 7. More than 10,000,000

BOSTON UNIVERSITY

Lecture 20 CH101 A1 (MWF 9:05 am)

Monday, October 22, 2018

For today ...

- Review: Concentrations after precipitation
- Ionization of molecular solutes
- Self-ionization of water
- Acid-base reactions: Competition for H^+

Next lecture: Balancing oxidation-reduction equations; Complexation as Lewis acid-base reaction

To memorize: Table 6.13, p 194: Common acids and bases

BOSTON UNIVERSITY

A comprehensive example

You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide.

These solutions are mixed and a precipitate forms

$$(NH_4)_2CO_3(s) \rightarrow 2\ NH_4^+(aq) + CO_3^{2-}(aq)$$
$$BaI_2(s) \rightarrow Ba^{2+}(aq) + 2\ I^-(aq)$$
$$Ba^{2+}(aq) + CO_3^{2-}(aq) \rightarrow BaCO_3(s)$$

	$Ba^{2+}(aq)$	$CO_3^{2-}(aq)$	$BaCO_3(s)$
start	0.060 mol	0.030 mol	0
change	−0.030 mol	−0.030 mol	+0.030 mol
end	0.030 mol	0	0.030 mol

BOSTON UNIVERSITY

A comprehensive example

You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide. These solutions are mixed and a precipitate forms.

Write the net-ionic equation for this process.

What are the spectator ions for this process?

What is the limiting reactant?

How many moles of the solid precipitate are formed?

After precipitation, what are the molarities (M) of each ion in solution?

Is the final solution electrically neutral?

BOSTON UNIVERSITY

A comprehensive example

You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide.

These solutions are mixed and a precipitate forms. After the precipitation, the total electrical charge due to the ions remaining in solution is 0.

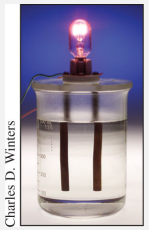
	Moles of ions	Moles of charge
$NH_4^+(aq)$	0.060	0.060 "+"
$I^-(aq)$	0.120	0.120 "−"
$Ba^{2+}(aq)$	0.030	0.060 "+"
Total		0

Ionization of molecular (non-ionic) solutes

Ionization of molecular solutes

$$Cl{:}H(aq) + {:}OH_2(l) \rightleftarrows H{:}OH_2^+(aq) + Cl{:}^-(aq)$$

Nearly complete reaction (~ 100 % theoretical yield)



Charles D. Winters

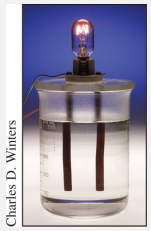
Strong electrolyte

Note: Unlike NaCl(*aq*), HCl(*aq*) does exist

Ionization of molecular solutes

$CH_3C(O)O{:}H(aq) + {:}OH_2(l) \rightleftarrows H{:}OH_2{}^+(aq) + CH_3C(O)O{:}{}^-(aq)$

Only a little reaction (< 100 % theoretical yield)



Charles D. Winters

Weak electrolyte

Ionization of molecular solutes

$CH_3CH_2O{:}H(aq) + {:}OH_2(l) \rightleftarrows H{:}OH_2{}^+(aq) + CH_3CH_2O{:}{}^-(aq)$

Almost no reaction (≪ 100 % theoretical yield)

Charles D. Winters

Non-electrolyte

Memorize: Table 6.13: Common acids and bases

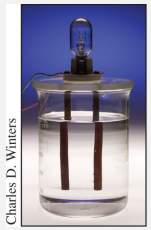
Strong Acids (Strong electrolytes)		Strong Bases (Strong electrolytes)	
HCl	Hydrochloric acid	LiOH	Lithium hydroxide
HBr	Hydrobromic acid	NaOH	Sodium hydroxide
HI	Hydroiodic acid	KOH	Potassium hydroxide
HNO_3	Nitric acid		
$HClO_4$	Perchloric acid		
H_2SO_4	Sulfuric acid		
Weak Acids (Weak electrolytes)*		**Weak Bases (Weak electrolytes)***	
H_3PO_4	Phosphoric acid	NH_3	Ammonia
H_2CO_3	Carbonic acid	$CH_3CH_2NH_2$	Ethylamine
CH_3COOH	Acetic acid		
$H_2C_2O_4$	Oxalic acid		
$H_2C_4H_4O_6$	Tartaric acid		
$H_3C_6H_5O_7$	Citric acid		
$HC_9H_8O_4$	Aspirin		

* These are just a few common examples of the very many weak acids and weak bases.

Water self-ionizes, but only a very, very little

$HO{:}H(l) + {:}OH_2(l) \rightleftarrows H{:}OH_2{}^+(aq) + HO{:}{}^-(aq)$

Almost no reaction (≪ 100 % theoretical yield)



Charles D. Winters

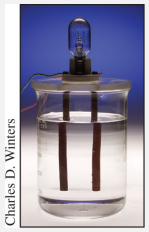
Non-electrolyte

Water self-ionizes, but only a very, very little

$$HO{:}H(l) + {:}OH_2(l) \rightleftarrows H{:}OH_2^+(aq) + HO{:}^-(aq)$$

In pure water at 25 ˚C, there is only a tiny, tiny amount of self-ionization,

$\sim 10^{-7}$ mol/L



Non-electrolyte

[TP] In pure water at 25 ˚C, there is only a tiny, tiny amount of self-ionization, $\sim 10^{-7}$ mol/L. In pure water, how many water molecules are there for every OH^- ion?

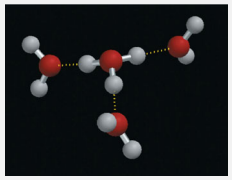
0% 1. 1
0% 2. 10
0% 3. 100
0% 4. 10,000
0% 5. 1,000,000
0% 6. 10,000,000
0% 7. More than 10,000,000

Water self-ionizes, but only a very little

$$HO{:}H(l) + {:}OH_2(l) \leftrightarrows H{:}OH_2^+(aq) + HO{:}^-(aq)$$

In pure water at 25 ˚C, there is only a tiny, tiny amount of self-ionization, $\sim 10^{-7}$ mol/L.

$H{:}OH_2^+(aq)$, usually written $H_3O^+(aq)$, is typically hydrogen bonded to several other water molecules, with the partners continually exchanging with other water molecules.



Acid-base reactions: Competition for H^+

Brønsted-Lowry model:

The H^+ source is called an acid

$$CH_3C(O)O{:}H(aq) + {:}OH_2(l) \rightleftarrows H{:}OH_2^+(aq) + CH_3C(O)O{:}^-(aq)$$

The H^+ destination is called a base

$$HO{:}H(aq) + {:}NH_3(aq) \rightleftarrows H{:}NH_3^+(aq) + HO{:}^-(aq)$$

Practice : Acids and bases

$H_2C_4H_4O_6(aq) + HCO_3^-(aq) \rightleftarrows HC_4H_4O_6^-(aq) + H_2CO_3(aq)$

$H_2C_4H_4O_6(aq)$ proton source, so it is the acid
$HCO_3^-(aq)$ proton destination, so it is the base

BOSTON UNIVERSITY 25

Practice: Acids and bases

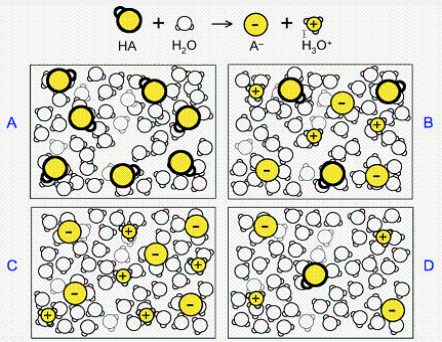
$CH_3NH_2(aq) + H_3O^+(aq) \rightleftarrows CH_3NH_3^+(aq) + H_2O(l)$

$CH_3NH_2(aq)$ proton destination, so it is the base
$H_3O^+(aq)$ proton source, so it is the acid

BOSTON UNIVERSITY 26

[TP] Which solution in the diagram contains the weakest acid?

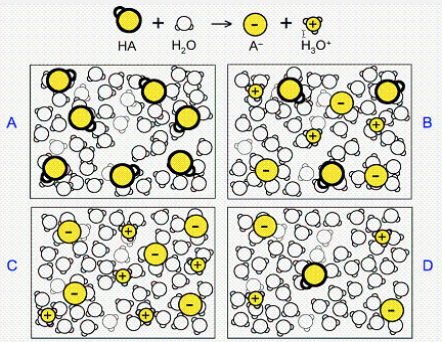
25% 1. A
25% 2. B
25% 3. C
25% 4. D



BOSTON UNIVERSITY 29

[TP] Which solution in the diagram contains the strongest acid?

25% 1. A
25% 2. B
25% 3. C
25% 4. D

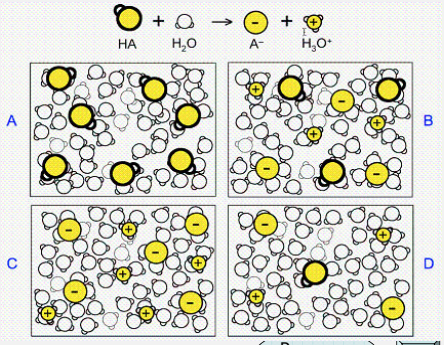


Response Counter 10

BOSTON UNIVERSITY 30

[Quiz] Which solution in the diagram contains the most concentrated acid?

25% 1. A
25% 2. B
25% 3. C
25% 4. D



Response Counter 10

[TP] $HCl(aq)$ means ...

17% 1. H^+ ions and Cl^- ions surrounded by waters
17% 2. H_3O^+ ions and Cl^- ions surrounded by waters
17% 3. HCl molecules surrounded by waters
17% 4. (1) and (2) are correct
17% 5. Doesn't exist
17% 6. None of the above

Response Counter 10

Base strength

Weak bases are weak electrolytes: They react only to a small extent with water

$$HO{:}H(l) + {:}NH_2CH_2CH_3(aq) \rightleftarrows H{:}NH_2CH_2CH_3^+(aq) + HO{:}^-(aq)$$

Only a little reaction (< 100 % theoretical yield)

Base strength

Strong bases are strong electrolytes: They react nearly completely with water

$$Na{:}OH(s) \rightarrow Na^+(aq) + HO{:}^-(aq)$$

Nearly complete reaction (~ 100 % theoretical yield)

$HO{:}^-(aq)$ is a strong proton acceptor

Note that $NaOH(s)$ is a special case: There is no competition for H^+, only hydration of OH^-.