Sections 17.1-2
Acids and Bases and pH

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Equilibrium systems

Acid base

Precipitation

Complexation

Simultaneous Equilibria

Acid-Base Equilibria

pH and pOH

- Relationship of Conjugate Pair acid-base strength.
- When acids or bases control pH:
  - determine K
  - predict pH
- When pH controls acid/base state:
  - predict acid/base state
  - use acid/base state to determine pH
- Buffer action
- pH titration curves

Bronsted Acids and Bases

Bronsted Acid: H^+ (proton) donor
Bronsted Base: H^+ acceptor

Acid-Base reactions: H^+ transfer reaction

Conjugate Acid-Base Pairs:

acid	*conjugate base*
HF	F^-
NH_4^+	NH_3

What is the conjugate base of HNO_2?

1. $H_2NO_2^+$
2. HNO_3
3. NO_2^-

What is the conjugate acid of HPO_4^{2-}?

1. $H_2PO_4^-$
2. H_3PO_4
3. PO_4^{3-}

What is the conjugate base of HPO_4^{2-}?

1. $H_2PO_4^-$
2. H_3PO_4
3. PO_4^{3-}

What is the conjugate acid of HPO_4^{2-}?

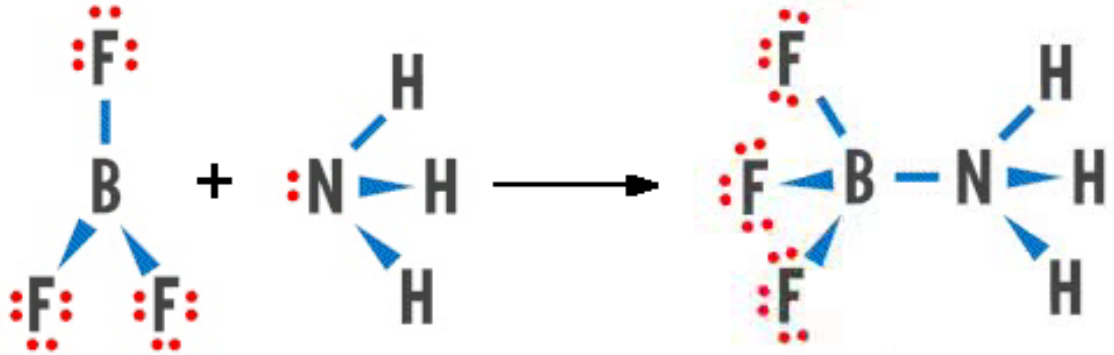
1. $H_2PO_4^-$
2. H_3PO_4
3. PO_4^{3-}

Acid	K_a	pK_a	Base	K_b	pK_b
Perchloric acid $HClO_4$	large	large negative	Perchlorate ion ClO_4^-	very small	large
Sulfuric acid H_2SO_4	large	large negative	Hydrogen sulfate ion HSO_4^-	very small	large
Hydrochloric acid HCl	large	large negative	Chloride ion Cl^-	very small	large
Nitric acid HNO_3	large	large negative	Nitrate ion NO_3^-	very small	large
Hydronium ion H_3O^+	1.0	0	Water H_2O	1.0×10^{-14}	14.00
Sulfurous acid H_2SO_3	1.7×10^{-2}	1.77	Hydrogen sulfite ion HSO_3^-	5.9×10^{-13}	12.23
Hydrogen sulfate ion HSO_4^-	1.2×10^{-2}	1.92	Sulfate ion SO_4^{2-}	8.3×10^{-13}	12.08
Phosphoric acid H_3PO_4	7.5×10^{-3}	2.12	Dihydrogen phosphate ion $H_2PO_4^{2-}$	1.3×10^{-12}	11.89
Hexaaquairon(III) ion $[Fe(H_2O)_6]^{3+}$	4.0×10^{-3}	2.40	Pentaaquahydroxoiron(III) ion $[Fe(H_2O)_5OH]^{2+}$	2.5×10^{-12}	11.60
Hydrofluoric acid HF	7.2×10^{-4}	3.14	Fluoride ion F^-	1.4×10^{-11}	10.85
Nitrous acid HNO_2	4.5×10^{-4}	3.35	Nitrite ion NO_2^-	2.2×10^{-11}	10.66
Formic acid HCO_2H	1.8×10^{-4}	3.74	Formate ion HCO_2^-	5.6×10^{-11}	10.25
Benzoic acid $C_6H_5CO_2H$	6.3×10^{-5}	4.20	Benzoate ion $C_6H_5CO_2^-$	1.6×10^{-10}	9.80
Acetic acid CH_3CO_2H	1.8×10^{-5}	4.74	Acetate ion $CH_3CO_2^-$	5.6×10^{-10}	9.25
Carbonic acid H_2CO_3	4.2×10^{-7}	6.38	Hydrogen carbonate ion (bicarbonate ion) HCO_3^-	2.4×10^{-8}	7.62
Hydrogen sulfide (hydrosulfuric acid) H_2S	1.0×10^{-7}	7.00	Hydrogen sulfide ion HS^-	1.0×10^{-7}	7.00
Dihydrogen phosphate ion $H_2PO_4^-$	6.2×10^{-8}	7.21	Hydrogen phosphate ion HPO_4^{2-}	1.6×10^{-7}	6.80
Hydrogen sulfite ion HSO_3^-	6.4×10^{-8}	7.19	Sulfite ion SO_3^{2-}	1.6×10^{-7}	6.80

Lewis Acids and Bases

Lewis Acid: Electron-Pair Acceptor
Lewis Base: Electron-Pair Donor

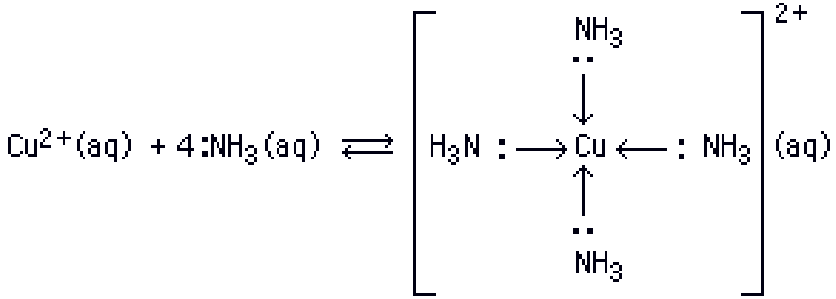
Lewis Acid-Base Reaction: Base uses a lone pair to form a new bond to the acid



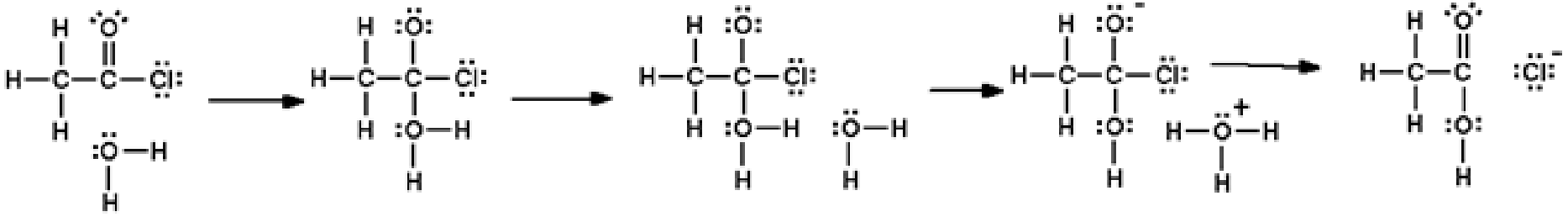
Lewis Acid Lewis Base Lewis Acid-Base Adduct

Lewis Bases are things with Lone Pairs:

Transition Metal Cations are Lewis Acids:



Organic Molecules with carbonyl groups are Lewis Acids:



Also: CO_2 is acidic

pH and pOH

$pH = -\log[H_3O^+]$ $\quad pOH = -\log[OH^-]$

$[H_3O^+] = 10^{-pH}$ $\quad [OH^-] = 10^{-pH}$

pH	$[H_3O^+]$	$[OH^-]$
0	1	10^{-14}
1	0.1	10^{-13}
2	0.01	10^{-12}
3	0.001	10^{-11}
4	10^{-4}	10^{-10}
7	10^{-7}	10^{-7}
10	10^{-10}	10^{-4}
11	10^{-11}	0.001
12	10^{-12}	0.01
13	10^{-13}	0.1

pH + pOH = _____

pH/pOH Relationships and Calculations

$$2\,H_2O \rightleftharpoons H_3O^+ + OH^-$$

$$K_a = 1.0 \times 10^{-14} = [H_3O^+][OH^-]$$

$[H_3O^+][OH^-] = 1.0 \times 10^{-14}$

$pH = -\log[H_3O^+]$ $\qquad$ $pOH = -\log[OH^-]$

$[H_3O^+] = 10^{-pH}$ $\qquad$ $[OH^-] = 10^{-pH}$

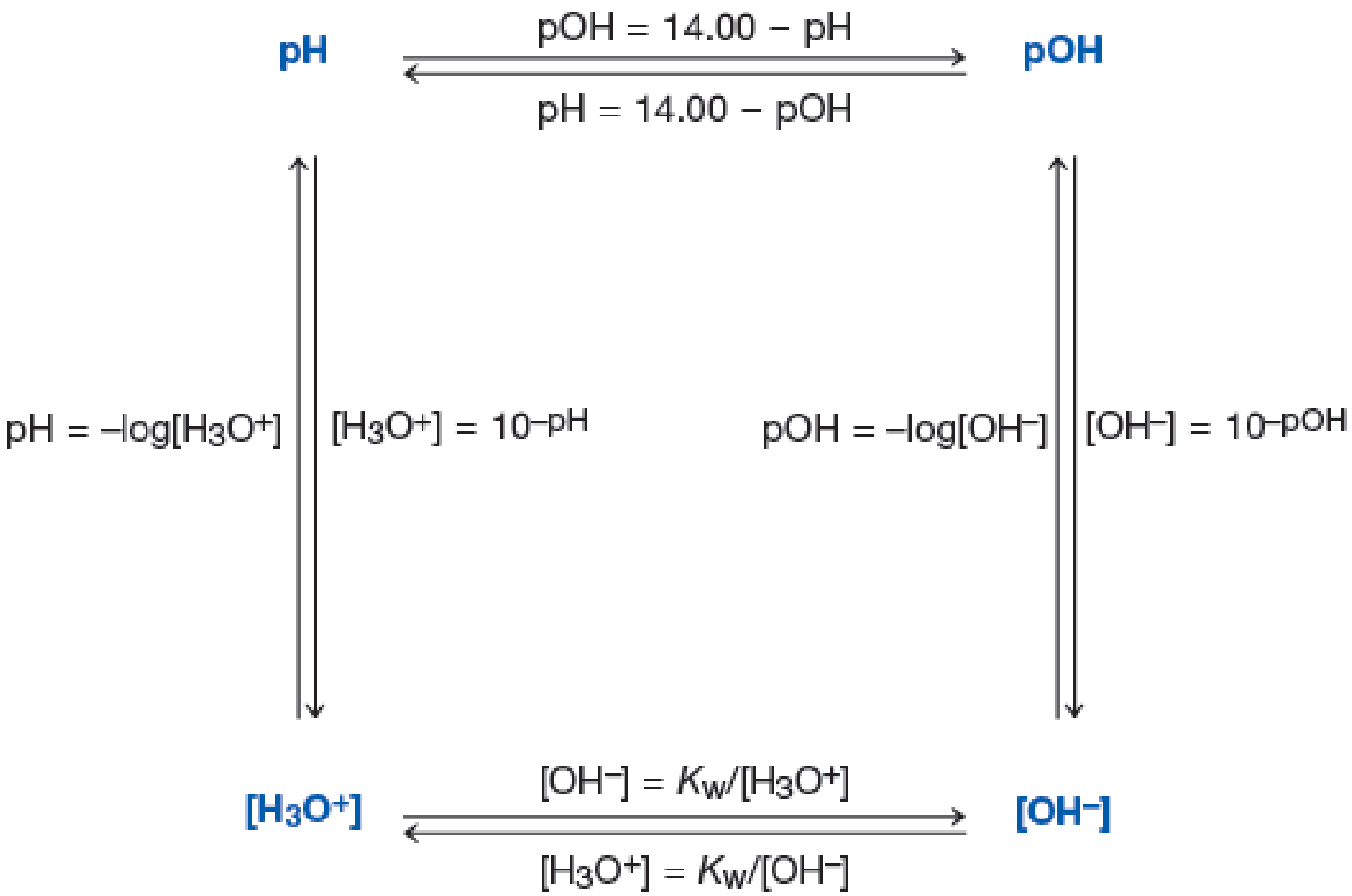
$pH + pOH = 14.00$

Neutral, Acidic and Basic Solutions

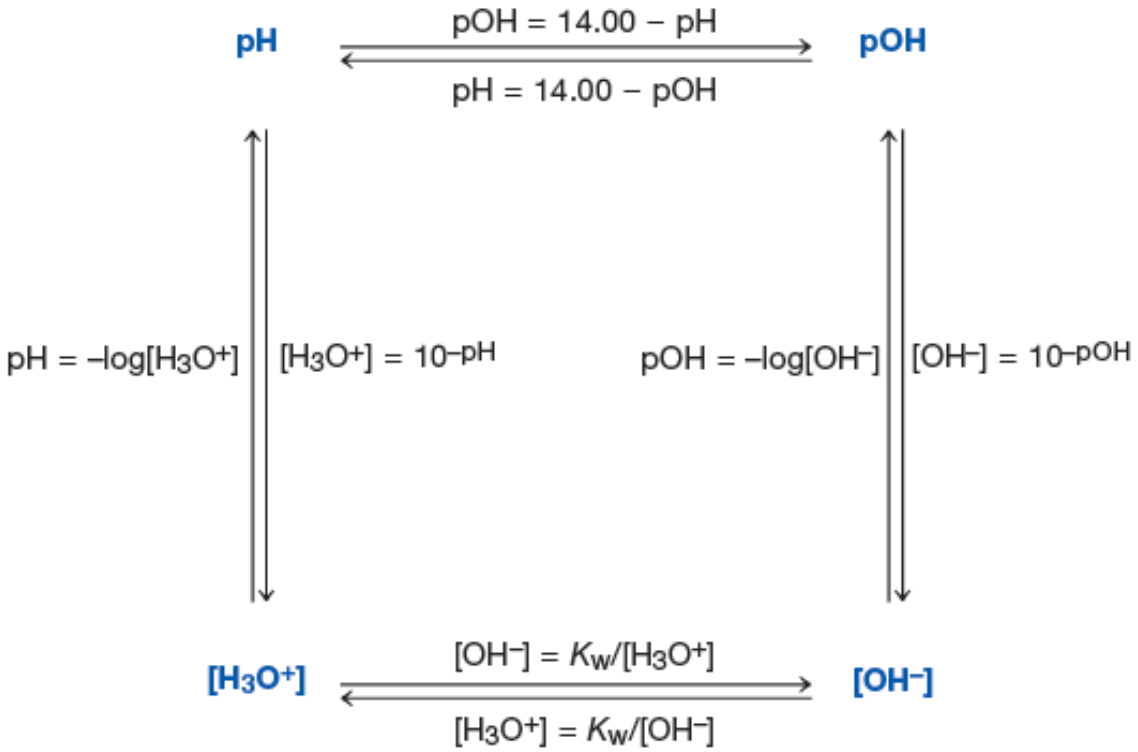
$$2\,H_2O \rightleftharpoons H_3O^+ + OH^-$$

$$K_a = 1.0 \times 10^{-14} = [H_3O^+][OH^-]$$

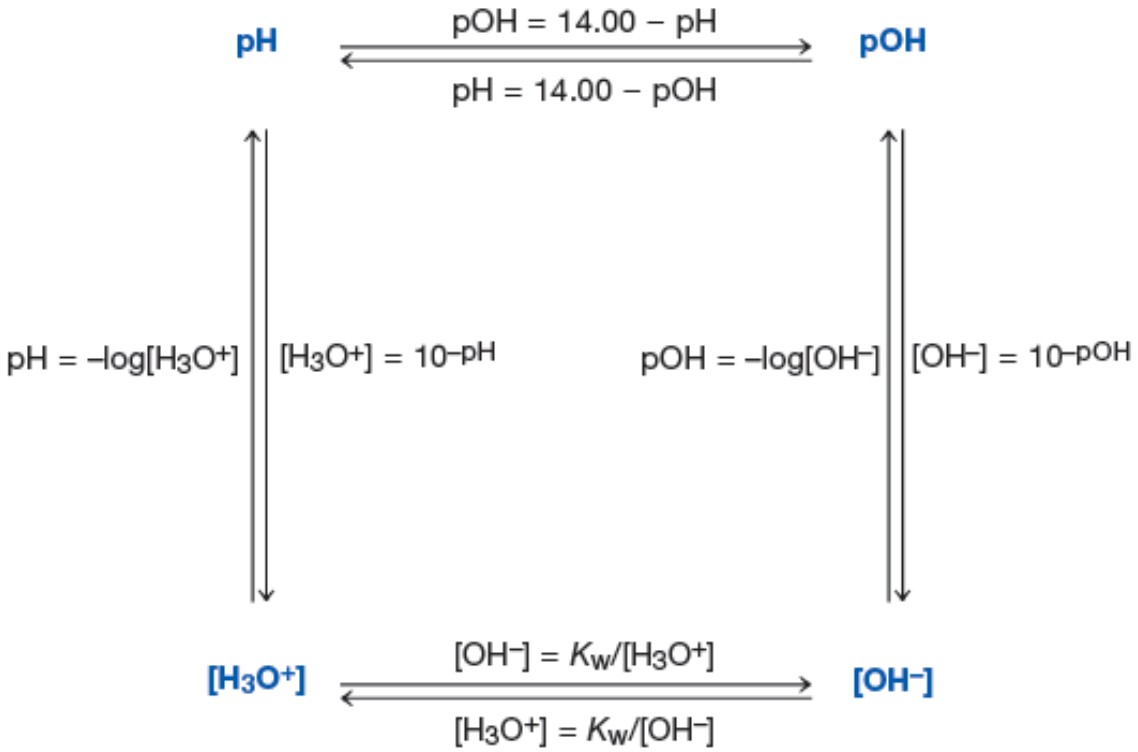
Neutral Acidic Basic


pH
pOH = 14.00 − pH
pH = 14.00 − pOH
pOH
pH = −log[H3O+]
[H3O+] = 10−pH
pOH = −log[OH−]
[OH−] = 10−pOH
[H3O+]
[OH−] = Kw/[H3O+]
[H3O+] = Kw/[OH−]
[OH−]

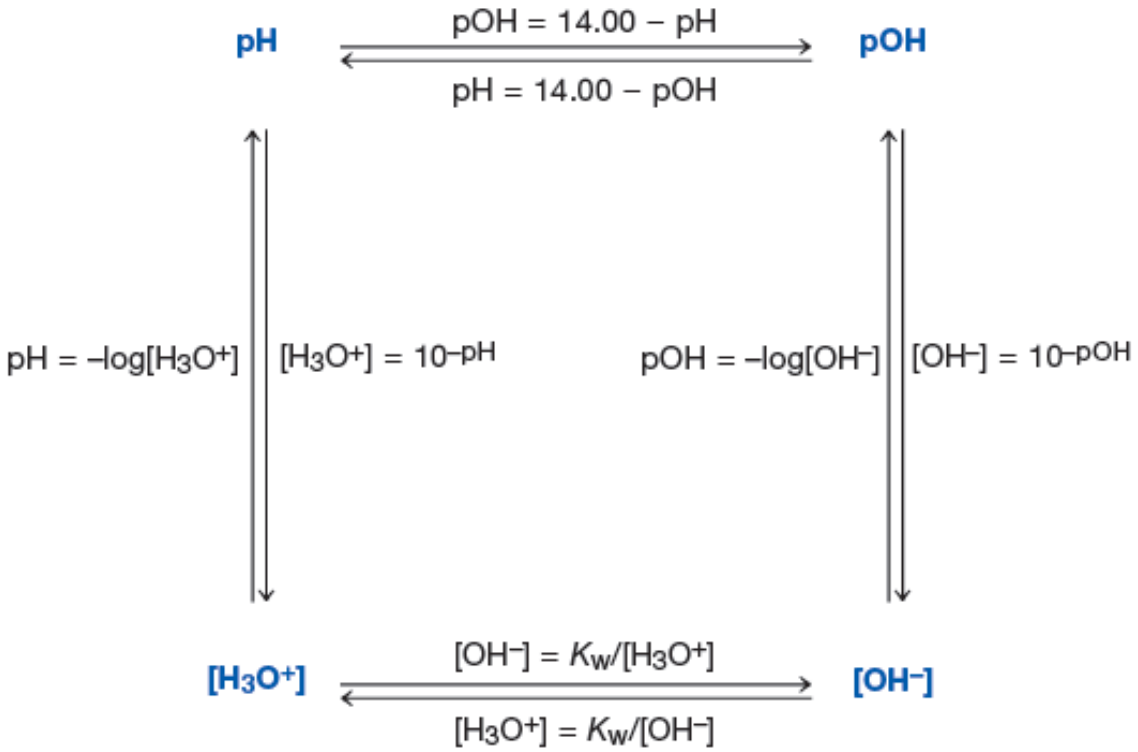
What is $[H_3O^+]$ when $[OH^-] = 5.4 \times 10^{-3}$ M?



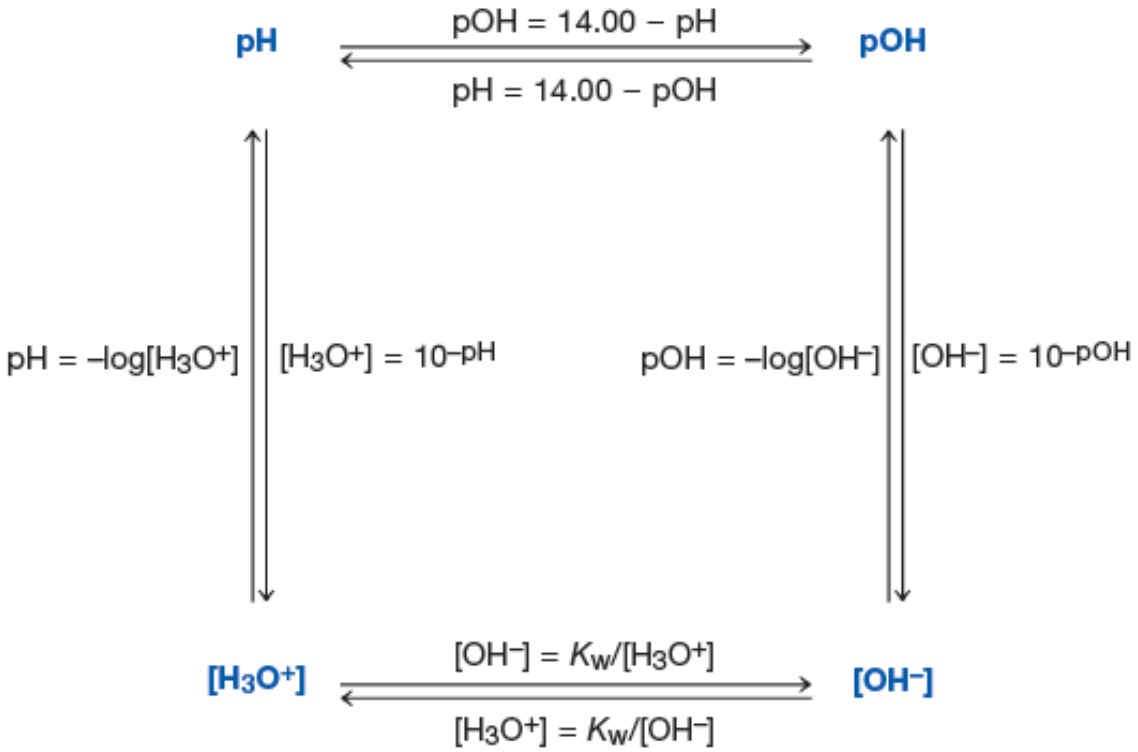
What is the pH of a solution with $[H_3O^+] = 4.6 \times 10^{-5}$ M?



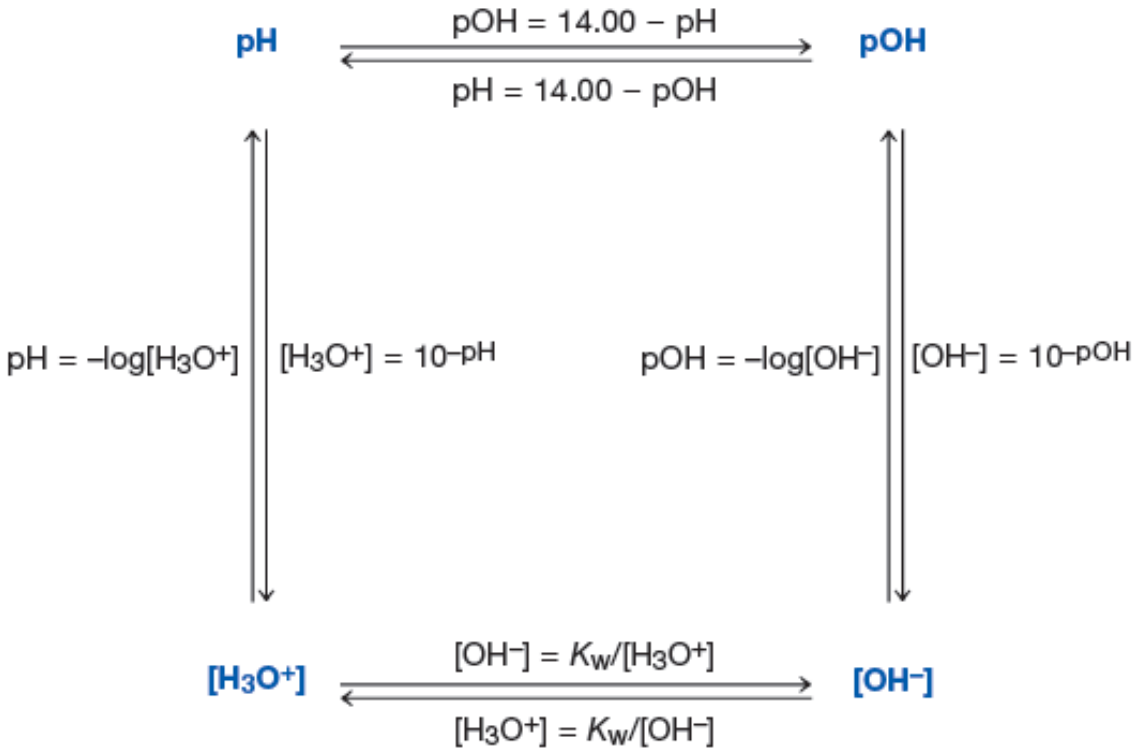
What is $[H_3O^+]$ in a solution with pH = 8.24?



What is the pOH of a solution with $[OH^-] = 3.3 \times 10^{-4}$ M?



What is the pH of a solution with $[OH^-] = 2.4 \times 10^{-3}$ M?



Strong acids and bases

For strong acid solutions, $[H_3O^+]$ = [acid] (except for H_2SO_4)

For strong bases LiOH, NaOH, KOH, RbOH, $[OH^-]$ = [base]

For strong bases $Ca(OH)_2$, $Ba(OH)_2$, etc., $[OH^-]$ = 2 x [base]

What is the pH of a 0.150 M solution of HCl?

What is the pH of a 0.150 M solution of $Ca(OH)_2$?