Class Announcements

Exam II : Tuesday, November 8 12:45-2:15, In class.

Review ... Sunday, Nov 6, 3:00-4:45, ISB 135

7.7 What Is Le Chatelier's Principle

Changing the Pressure – Summary

1. $O_3(g) + NO(g) \Leftrightarrow O_2(g) + NO_2(g)$ ● + ● ⇔ ● + ●

Action	Equilibrium shift.	Why
V↑, P↓	No shift	K is unaffected
V↓, P↑	No shift	

2. $2\ NOCl(g) \Leftrightarrow 2\ NO(g) + Cl_2(g)$ ● + ● ⇔ ● + ● + ●

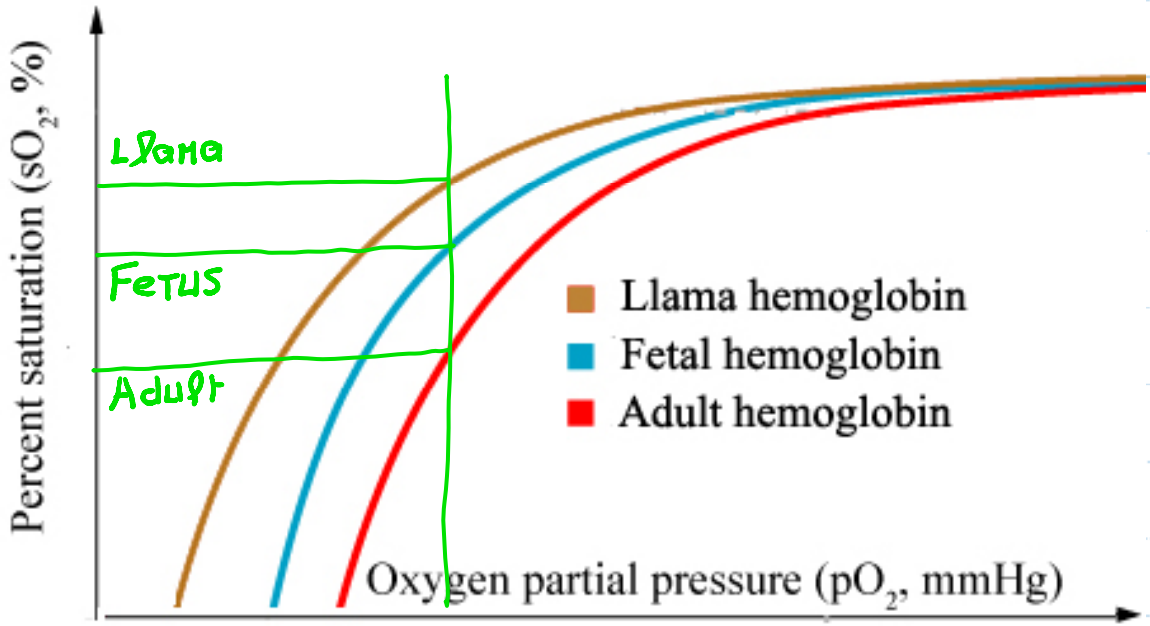
Action	Equilibrium shift	Why
V↑, P↓	Towards products	K↑
V↓, P↑	Towards Reactants	K↓

3. $N_2(g) + 3H_2(g) \Leftrightarrow 2\ NH_3(g)$ ● + ● + ● + ● ⇔ ● + ●

Action	Equilibrium shift	Why
V↑, P↓	Towards Reactants	K↓
V↓, P↑	Towards products	K↑

7.7 Le Chatelier's and Hemoglobin

$Hb + O_2 \Leftrightarrow HbO_2(g)$



8.1 What Are Acids and Bases?

Acid: A substance that produces H_3O^+ ions in aqueous solution.

$$HA(aq) + H_2O(l) \xrightarrow[OR]{} H_3O^+ + A^-$$

Base: A substance that produces OH^- ions in aqueous solution.

$$B(aq) + H_2O(l) \xrightarrow[OR]{} BH^+ + OH^-$$

8.2 How Do We Define the Strength of Acids and Bases?

Acids:

Strong: $HA(aq) + H_2O(l) \longrightarrow H_3O^+ + A^-$ ~100% ... only 6

HCl, HBr, HI, HNO_3, H_2SO_4, $HClO_4$

Weak: $HA(aq) + H_2O(l) \Leftrightarrow H_3O^+ + A^-$ $K_a = \dfrac{[H_3O^+][A^-]}{[HA]}$

Bases:

Strong: "$B(aq) + H_2O(l) \longrightarrow BH^+ + OH^-$" ~100% ... only 4

$NaOH(aq) \longrightarrow Na^+ + OH^-$

$LiOH$, $NaOH$, KOH, $Ba(OH)_2$

Weak: $B(aq) + H_2O(l) \Leftrightarrow BH^+ + OH^-$ $K_b = \dfrac{[BH^+][OH^-]}{[B]}$

$NH_3(aq) + H_2O(l) \Leftrightarrow NH_4^+ + OH^-$

8.2 How Do We Define the Strength of Acids and Bases?

K_a Values			K_a Values		
Name of Acid	**Acid**	**K_a**	**Name of Acid**	**Acid**	**K_a**
Sulfuric acid	H_2SO_4	large	Hexaaquaaluminum ion	$Al(H_2O)_6^{3+}$	7.9×10^{-6}
Hydrochloric acid	HCl	large	Carbonic acid	H_2CO_3	4.2×10^{-7}
Nitric acid	HNO_3	large	Hydrogen sulfide	H_2S	1×10^{-7}
Hydronium ion	H_3O^+	1.0	Dihydrogen phosphate ion	$H_2PO_4^-$	6.2×10^{-8}
Hydrogen sulfate ion	HSO_4^-	1.2×10^{-2}	Hypochlorous acid	HClO	3.5×10^{-8}
Phosphoric acid	H_3PO_4	7.5×10^{-3}	Ammonium ion	NH_4^+	5.6×10^{-10}
Hexaaquairon(III) ion	$Fe(H_2O)_6^{3+}$	6.3×10^{-3}	Hydrocyanic acid	HCN	4.0×10^{-10}
Hydrofluoric acid	HF	7.4×10^{-4}	Hexaaquairon(II) ion	$Fe(H_2O)_6^{2+}$	3.2×10^{-10}
Formic acid	HCO_2H	1.8×10^{-4}	Hydrogen carbonate ion	HCO_3^-	4.8×10^{-11}
Benzoic acid	$C_6H_5CO_2H$	6.3×10^{-5}	Hydrogen phosphate ion	HPO_4^{2-}	3.6×10^{-13}
Acetic acid	CH_3CO_2H	1.8×10^{-5}	Water	H_2O	1.0×10^{-14}
			Hydrogen sulfide ion	HS^-	1×10^{-19}

For weak acids ... the greater the K_a ... the stronger the acid.

8.5 How Do We Use Acid Ionization Constants?

pKa Versus Ka

$$pK_a = -\log_{10} K_a$$

HF : $K_a = 7.4 \times 10^{-4}$ $\quad pK_a = -\log_{10}(7.4 \times 10^{-4}) = 3.13$

HCN : $K_a = 4.0 \times 10^{-10}$ $\quad pK_a = -\log_{10}(4.0 \times 10^{-10}) = 9.38$

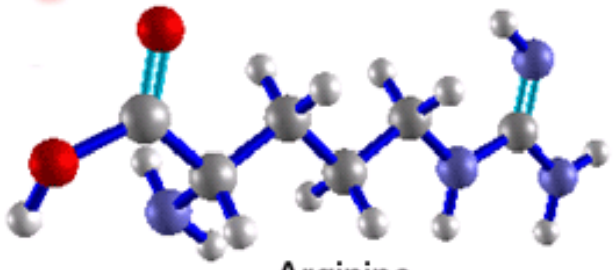
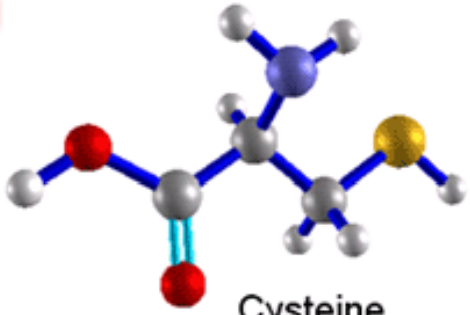
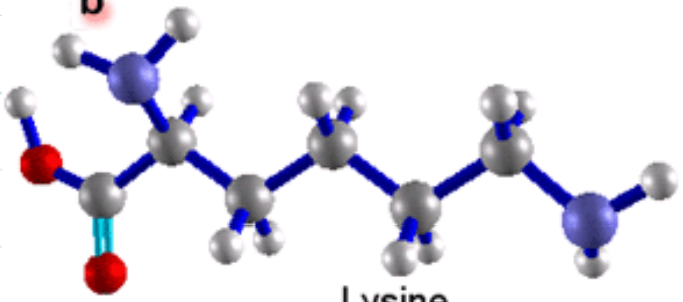
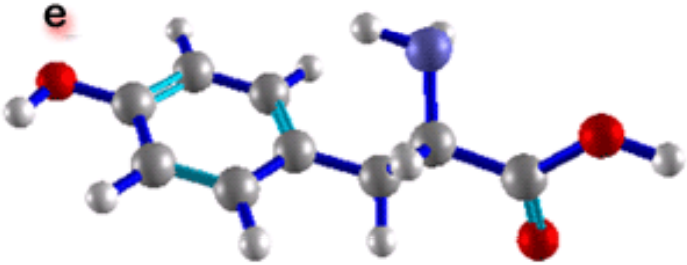
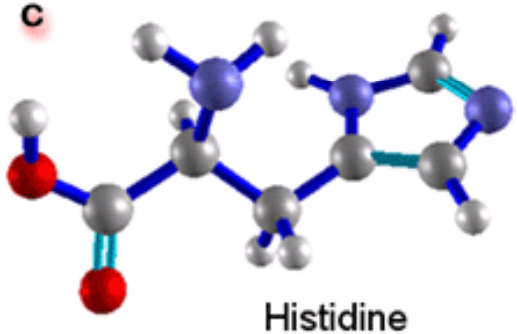
Which is the stronger acid?

a) The one with the largest K_a ... HF

b) The one with the smallest pK_a ... HF

8.5 How Do We Use Acid Ionization Constants?

pKa Versus Ka

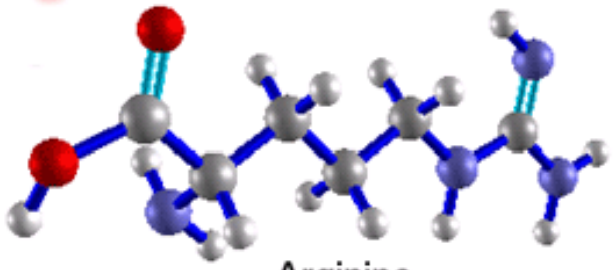
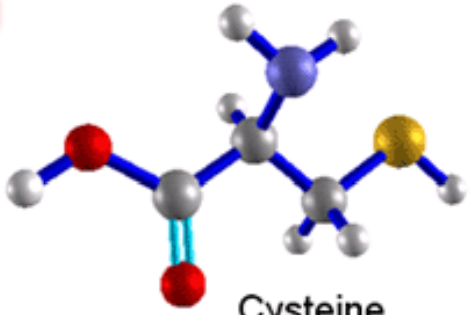
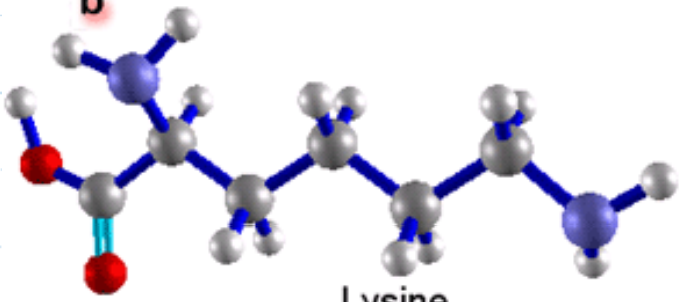
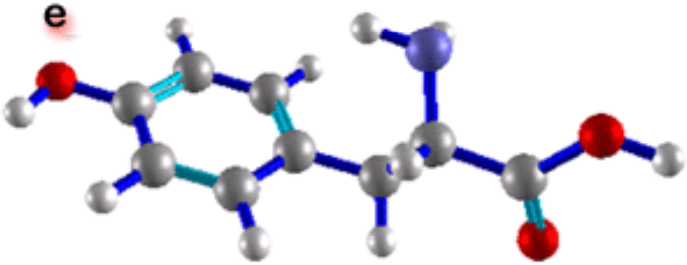
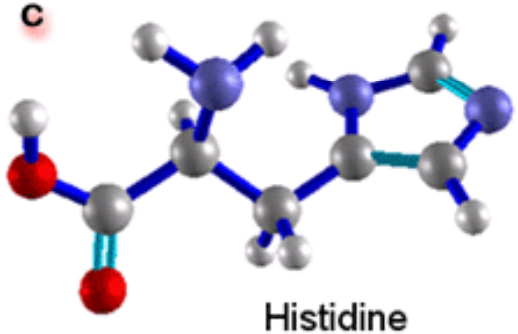
	pKa		pKa
a  Arginine	12.0	d  Cysteine	8.3
b  Lysine	9.0	e  Tyrosine	9.8
c  Histidine	6.1		

The strongest acid depicted?

Smallest pKa

8.5 How Do We Use Acid Ionization Constants?

pKa Versus Ka

	pKa		pKa
a  Arginine	12.0	d  Cysteine	8.3
b  Lysine	9.0	e  Tyrosine	9.8
c  Histidine	6.1		

The one with an acid strength closest to that of NH_4^+, $K_a = 5.6 \times 10^{-10}$ @ 25°C?

$pK_a = -\log_{10}(5.6 \times 10^{-10}) = 9.25$

8.7 Acid Base Properties of Pure Water

Autoionization of Water

$H_2O(l) + H_2O(l) \Leftrightarrow H_3O^+ + OH^-$

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

↳ K_W

@ 25°C, $K_W = 1 \times 10^{-14}$

$[H_3O^+][OH^-] = 1 \times 10^{-14}$

$[H_3O^+] = 1 \times 10^{-7}$

$[OH^-] = 1 \times 10^{-7}$

NEUTRAL: $[H_3O^+] = [OH^-]$

Acidic: $[H_3O^+] > [OH^-]$

Basic: $[OH^-] > [H_3O^+]$

8.7 Acid Base Properties of Pure Water

Curiosity!

The autoionization of water is an endothermic process.

$H_2O(l) + H_2O(l) \Leftrightarrow H_3O^+ + OH^-$

Thus as the temperature increases then – the $[H_3O^+]$ should –

a) Decrease b) Increase c) Remain the same

shift →

$H_2O(l) + H_2O(l) + heat \Leftrightarrow H_3O^+ + OH^-$

↑

Increase T

8.7 Acid Base Properties of Pure Water

Curiosity!

With the $[H_3O^+]$ increasing with increasing temperature this must mean that as the temperature of water increases the water –

a) becomes acidic
b) becomes basic
c) remain neutral

$$H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+ + OH^-$$

$[H_3O^+]\uparrow$ but so does the $[OH^-]$

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