Welcome to 3.091

Lecture 26

November 12, 2004

topical coverage for Test 3

October 20: Lecture 17. ~~X-ray spectra~~, Bragg's Law.

October 22: Lecture 18. X-ray diffraction of crystals: diffractometry, Debye-Scherrer, Laue. Crystal symmetry.

October 25: Lecture 19. Defects in crystals: point defects, line defects, interfacial defects, voids.

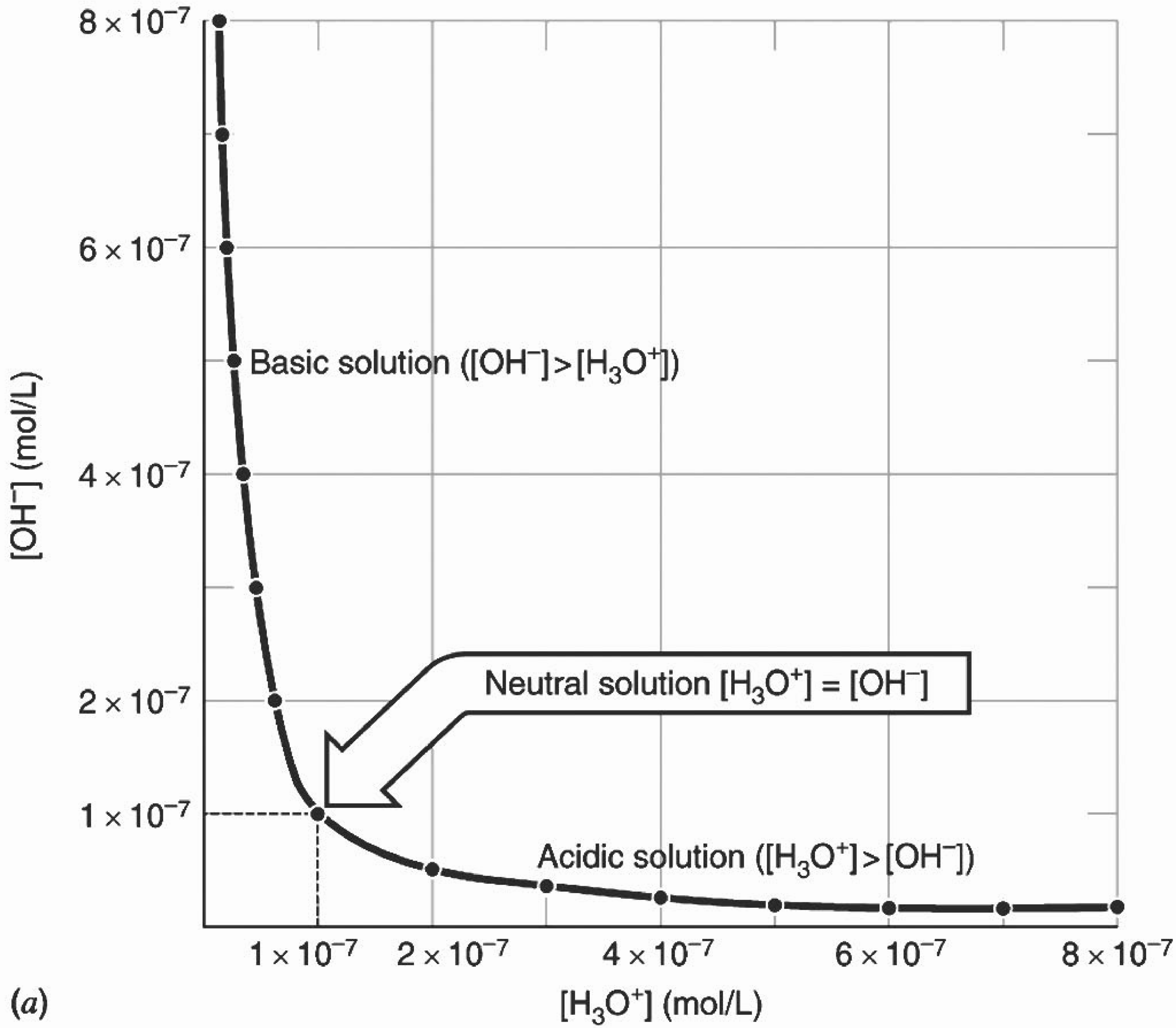
October 29: Lecture 20. Amorphous solids, glass formation, inorganic glasses: silicates.

November 1: Lecture 21. Engineered glasses: network formers, network modifiers, intermediates. Properties of silicate glasses. Metallic glass.

November 3: Lecture 22. Chemical kinetics: the rate equation, order of reaction, rate laws for zeroth, first, and second order reactions. Temperature dependence of rate of reaction.

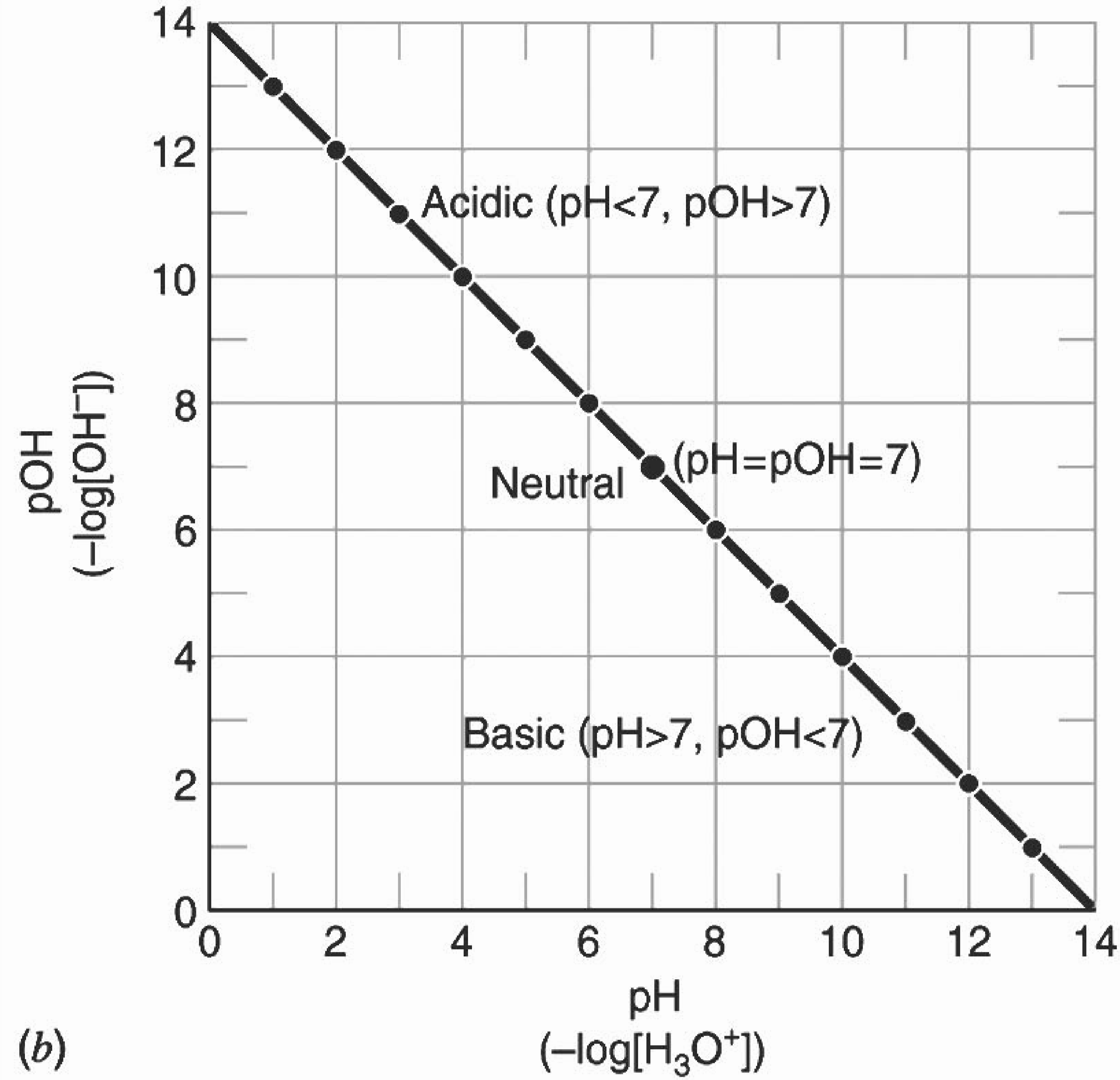
November 5: Lecture 23. Diffusion: Fick's First Law and steady-state diffusion, dependence of the diffusion coefficient on temperature and on atomic arrangement.

November 8: Lecture 24. Fick's Second Law (FSL) and transient-state diffusion; error function solutions to FSL.



8 × 10⁻⁷
6 × 10⁻⁷
4 × 10⁻⁷
2 × 10⁻⁷
1 × 10⁻⁷
[OH⁻] (mol/L)
Basic solution ([OH⁻] > [H₃O⁺])
Neutral solution [H₃O⁺] = [OH⁻]
Acidic solution ([H₃O⁺] > [OH⁻])
1 × 10⁻⁷
2 × 10⁻⁷
4 × 10⁻⁷
6 × 10⁻⁷
8 × 10⁻⁷
[H₃O⁺] (mol/L)

(*a*)



Acidic (pH<7, pOH>7)
(pH=pOH=7)
Neutral
Basic (pH>7, pOH<7)
pOH
(−log[OH⁻])
pH
(−log[H3O+])
0
2
4
6
8
10
12
14

(*b*)

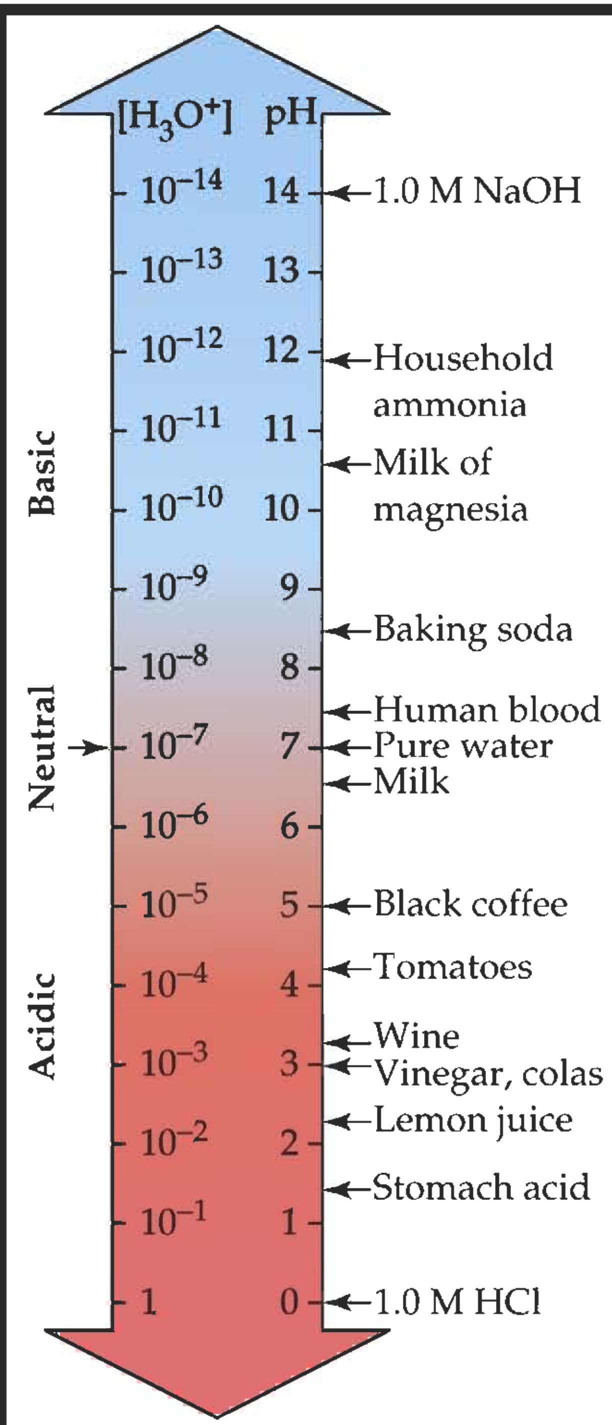

[H3O+]
pH
10−14
14
1.0 M NaOH
10−13
13
10−12
12
Household ammonia
10−11
11
Milk of magnesia
10−10
10
10−9
9
Baking soda
10−8
8
Human blood
10−7
7
Pure water
Milk
10−6
6
10−5
5
Black coffee
Tomatoes
10−4
4
Wine
10−3
3
Vinegar, colas
Lemon juice
10−2
2
Stomach acid
10−1
1
1
0
1.0 M HCl
Basic
Neutral
Acidic

Table 11.3

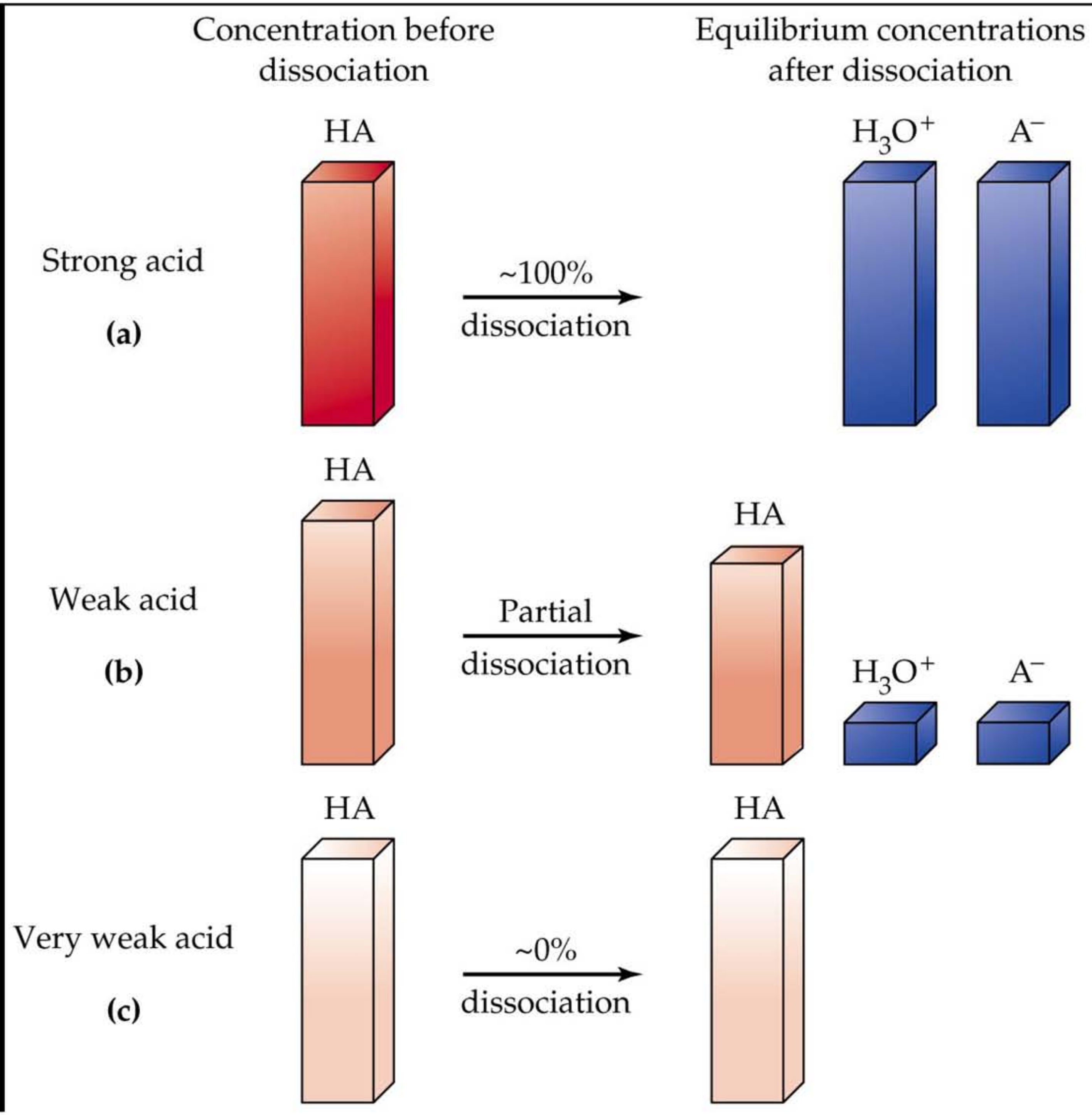
Common Acids and Their Acid Dissociation Equilibrium Constants for the Loss of One Proton

	K_a
Strong Acids	
HI	3×10^{9}
HBr	1×10^{9}
$HClO_4$	1×10^{8}
HCl	1×10^{6}
H_2SO_4	1×10^{3}
H_3O^+	**55**
HNO_3	28
H_2CrO_4	9.6
Weak Acids	
H_3PO_4	7.1×10^{-3}
HF	7.2×10^{-4}
Citric acid	7.5×10^{-4}
CH_3CO_2H	1.8×10^{-5}
H_2S	1.0×10^{-7}
H_2CO_3	4.5×10^{-7}
H_3BO_3	7.3×10^{-10}
H_2O[a]	1.8×10^{-16}

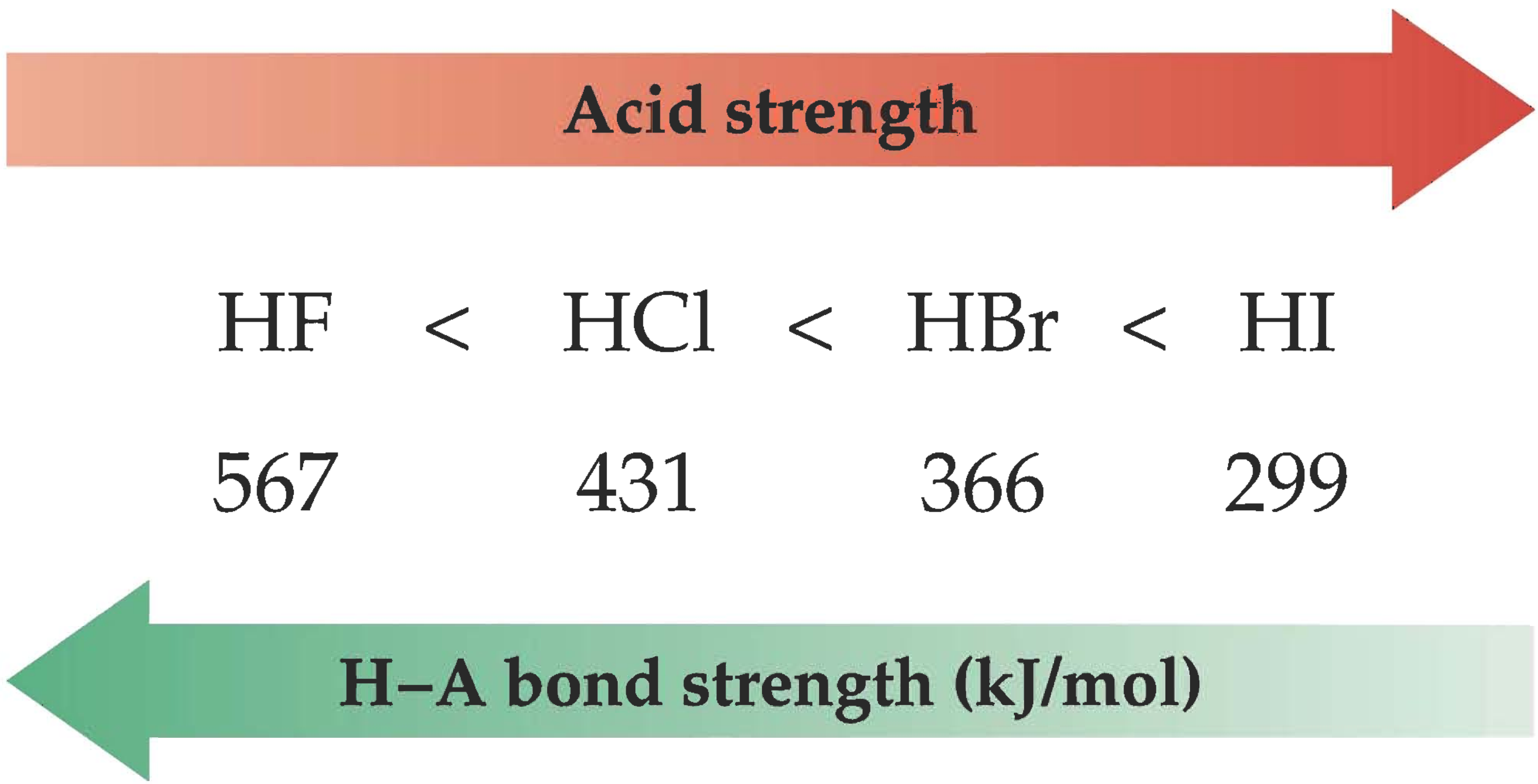
[a]Note that this is the K_a of water as determined by the acid dissociation equilibrium expression, not the K_w described in Section 11.6.

TABLE 15.1 Relative Strengths of Conjugate Acid–Base Pairs

	Acid, HA		Base, A^-		
Stronger acid	$HClO_4$	Strong acids. 100% dissociated in aqueous solution.	ClO_4^-	Very weak bases. Negligible tendency to be protonated in aqueous solution.	Weaker base
	HCl		Cl^-		
	H_2SO_4		HSO_4^-		
	HNO_3		NO_3^-		
	H_3O^+		H_2O		
	HSO_4^-	Weak acids. Exist in solution as a mixture of HA, A^-, and H_3O^+.	SO_4^{2-}	Weak bases. Moderate tendency to be protonated in aqueous solution.	
	H_3PO_4		$H_2PO_4^-$		
	HNO_2		NO_2^-		
	HF		F^-		
	CH_3CO_2H		$CH_3CO_2^-$		
	H_2CO_3		HCO_3^-		
	H_2S		HS^-		
	NH_4^+		NH_3		
	HCN		CN^-		
	HCO_3^-		CO_3^{2-}		
	H_2O		OH^-		
	NH_3	Very weak acids Negligible tendency to dissociate.	NH_2^-	Strong bases. 100% protonated in aqueous solution.	
	OH^-		O^{2-}		
Weaker acid	H_2		H^-		Stronger base



Concentration before dissociation
Equilibrium concentrations after dissociation
HA
H_3O^+
A^-
Strong acid
(a)
~100%
dissociation
HA
Weak acid
(b)
Partial
dissociation
HA
H_3O^+
A^-
HA
HA
Very weak acid
(c)
~0%
dissociation


Acid strength
HF < HCl < HBr < HI
567 431 366 299
H–A bond strength (kJ/mol)

Reducing acid rain from burning coal

* 51% of our electrical energy is generated in coal-fired power plants (17% natural gas; 3% petroleum)

* industrial coal contains ~1% sulfur

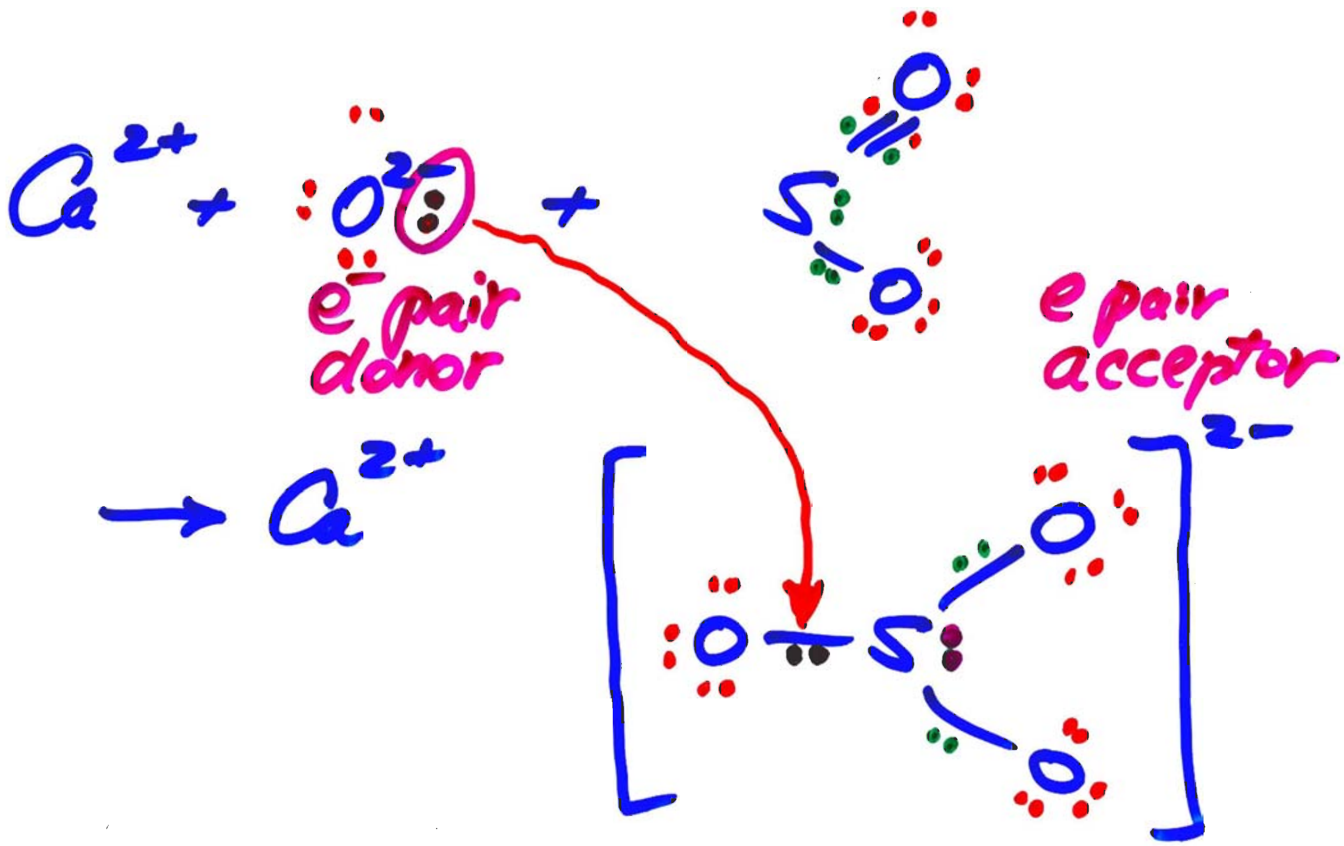
* 1 ton coal = 25×10^6 BTU = 2.64×10^{10} J

  ∴ ~3 tons coal ⇨ 1 MW day (c.f. 1 g U / MW day)

  ∴ 10 MW plant burns ~30 tons coal/day ctg ~⅓ ton S which makes ~⅔ ton SO_2

* reduce SO_2 emissions by reacting with lime (CaO) according to

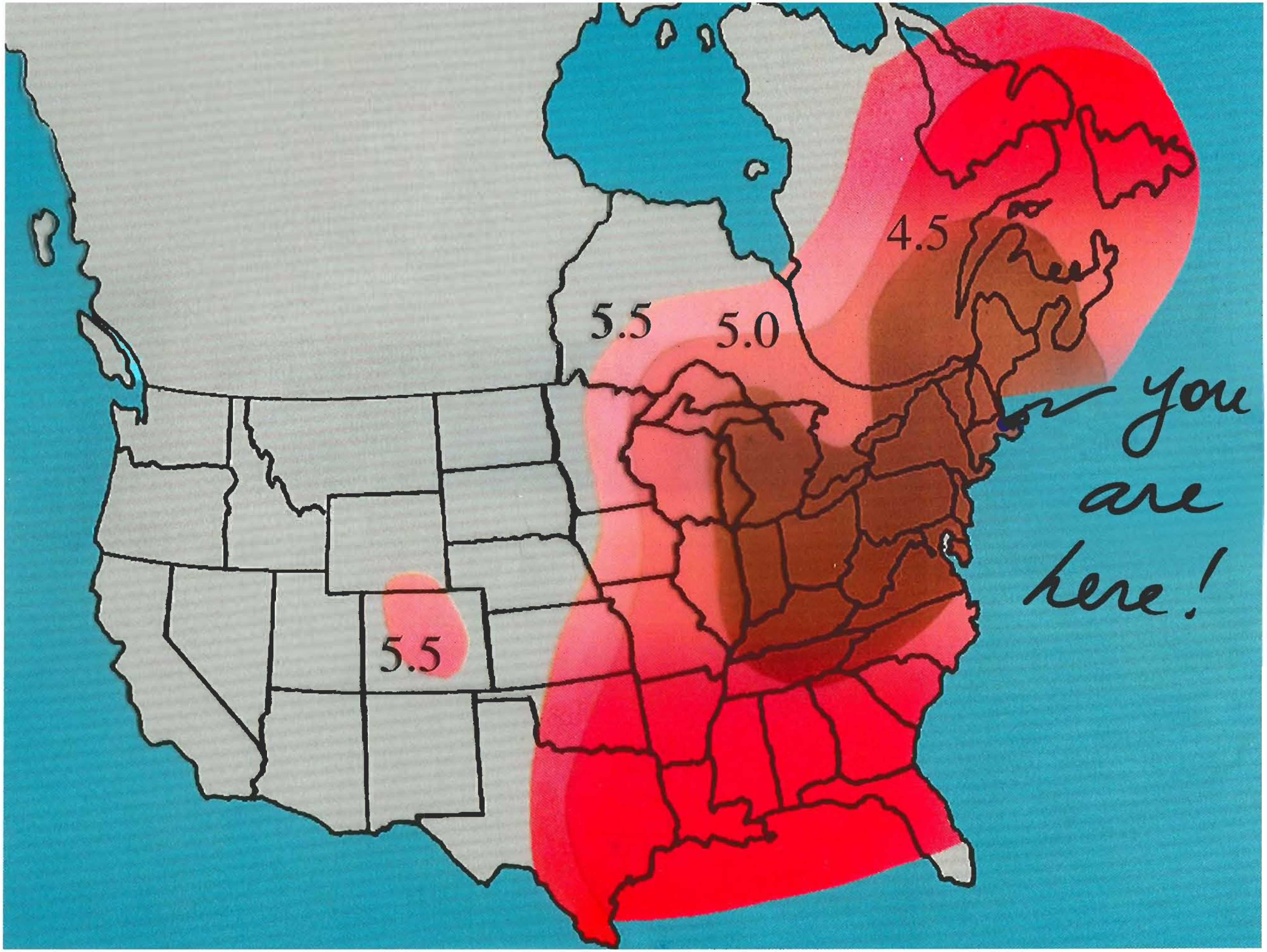
$$CaO_{(s)} + SO_{2(g)} \Rightarrow CaSO_{3(s)}$$



CaO is Lewis base (O^{2-} is Lewis base)

SO_2 is Lewis acid

acid/base concept applied to gas-solid rxn


4.5
5.5
5.0
5.5
you are here!