Acids, Bases, and Salts

Chapter 15

Characteristics of Acids and Bases

- Acids
- sour when dilute (acetic acid, citric acid)
- burn skin when concentrated
- react with and neutralize bases
- react with some metals to form $H_2(g)$

- Bases
- bitter when dilute (quinine water, caffeine, milk of magnesia)
- corrosive when concentrated
- react with and neutralize acids

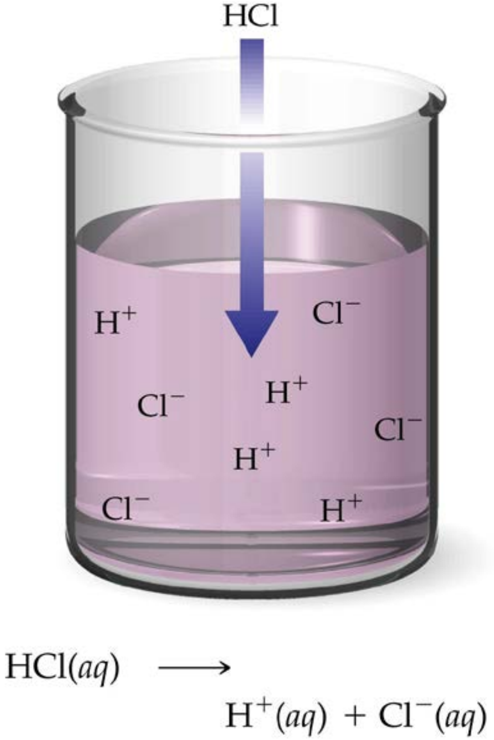
General Acid Base Definitions

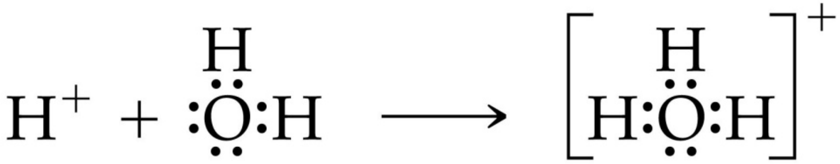
	Arrhenius	**Bronsted-Lowry**
Acid	Forms H^+ in solution	proton donor
Base	Forms $OH^–$ in solution	proton acceptor

Acids

Form H^+ or H_3O^+ in solution.

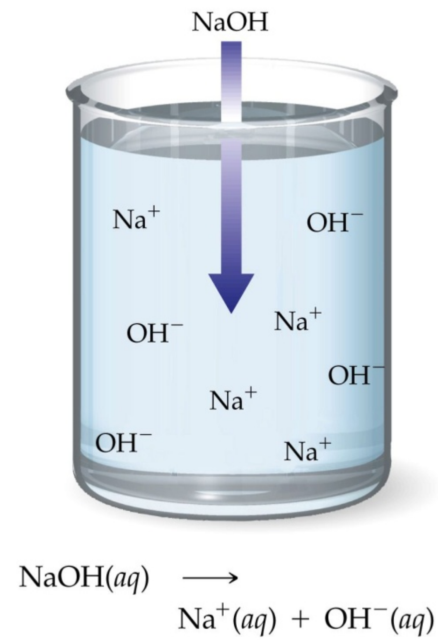
- HA $\leftrightarrow$ H^+ + A
- or
- HA + H_2O $\leftrightarrow$ H_3O^+ + A

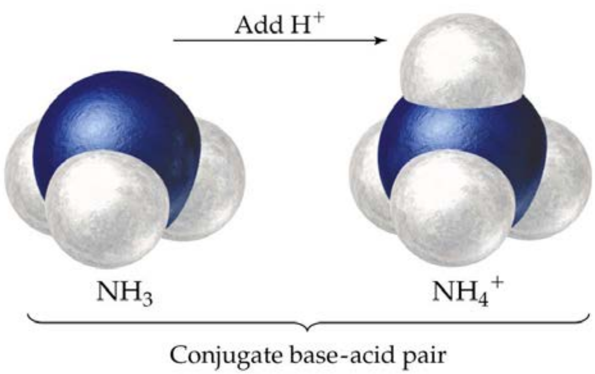


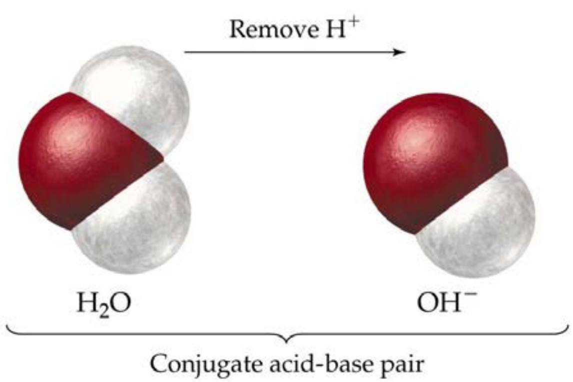


Bases

Forms OH^{-1} in solution.







$$BOH \leftrightarrow B^{+1} + OH^{1}$$

or

$$B + H_2O \leftrightarrow BH^{+1} + OH^{1}$$

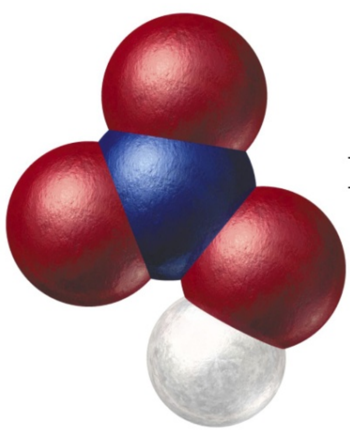
Acids

HCl

Hydrochloric acid

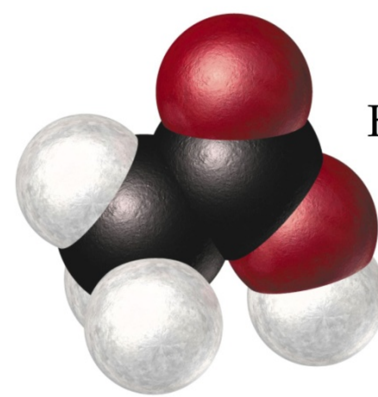
H_2SO_4

Sulfuric acid



HNO_3

Nitric acid



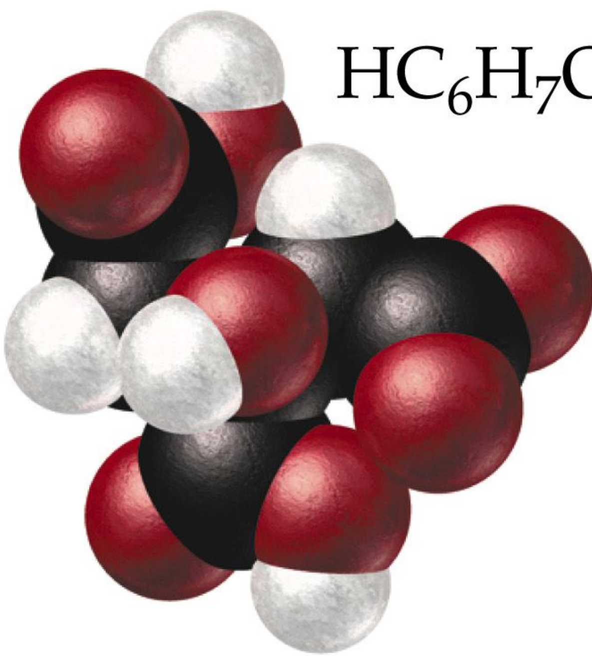
$HC_2H_3O_2$

Acetic acid

Organic acids frequently contain a carboxylic acid group

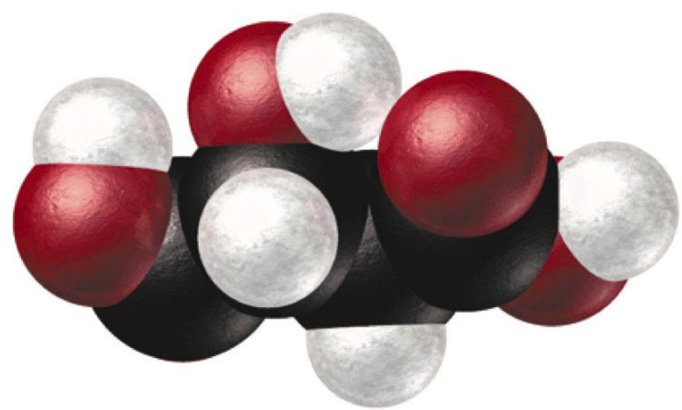
Carboxylic acid group

$HC_6H_7O_7$

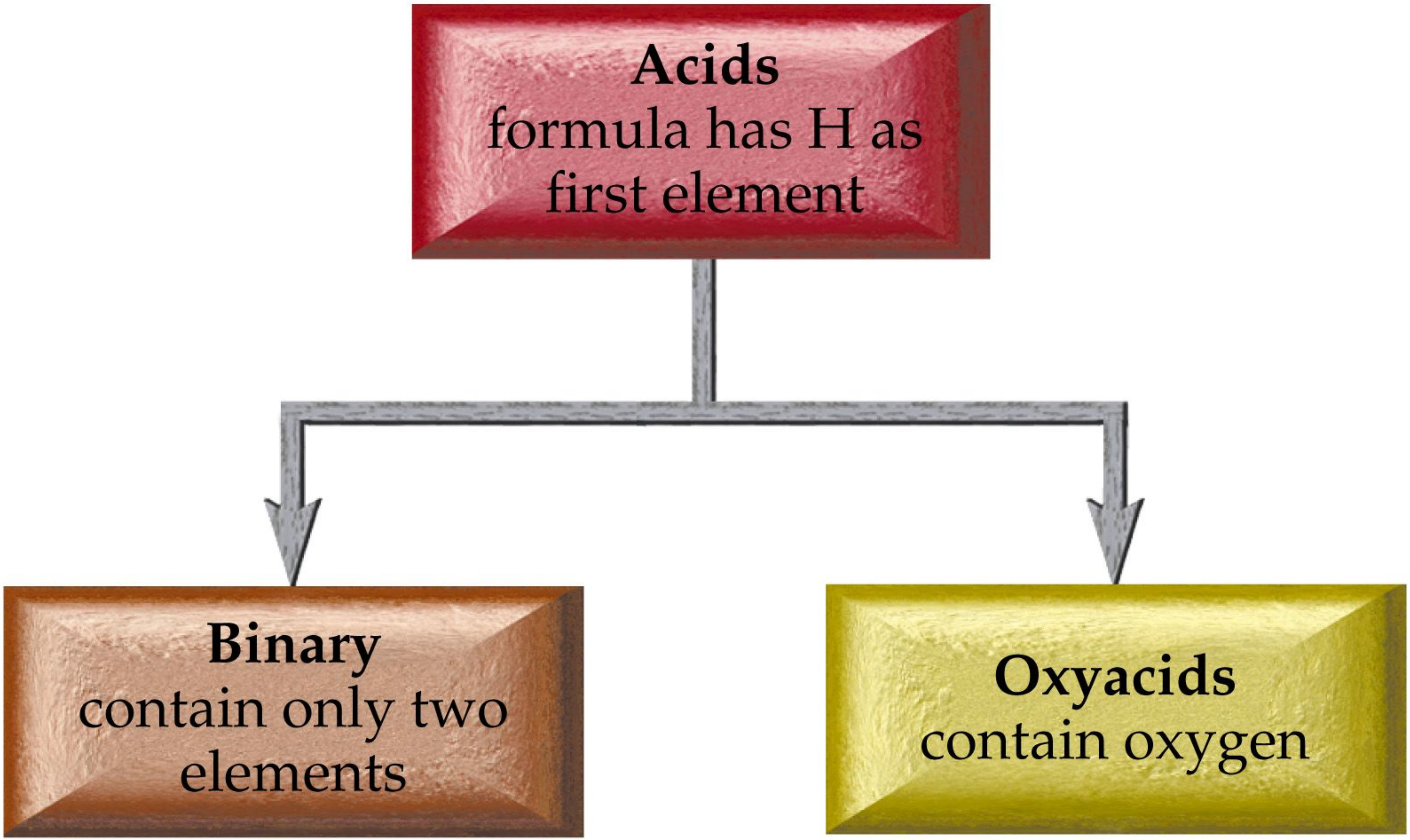


Citric acid

$HC_4H_5O_5$

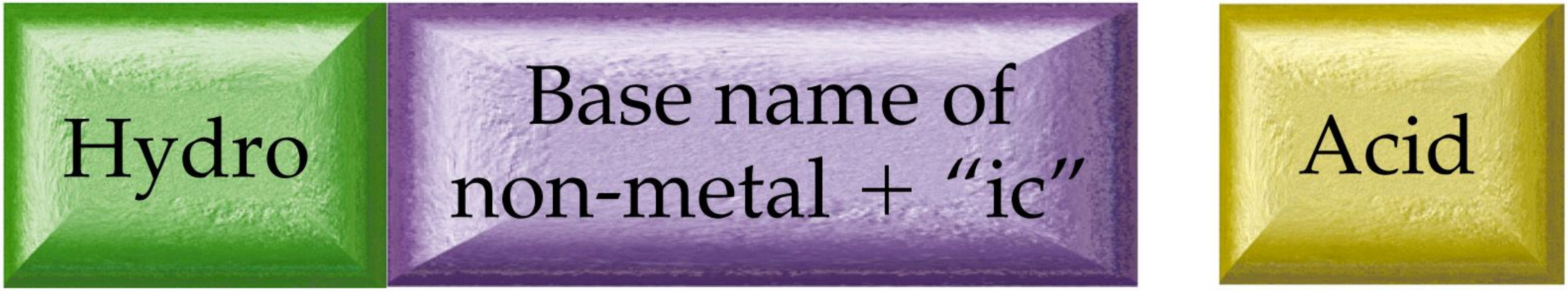


Malic acid


Acids
formula has H as first element
Binary
contain only two elements
Oxyacids
contain oxygen

Acid Nomenclature

- Binary Acids



- HX hydrogen ______ide
  - becomes
- Hydro_______ ic acid

- HCl(g) hydrogen chloride
- HCl (aq) hydrochloric acid

- H_2S(g) hydrogen sulfide
- H_2S(aq) hydrosulfuric acid

- HCN(g) hydrogen cyanide
- HCN(aq) hydrocyanic acid

Base name of oxyanion + “-ous”

Acid

Base name of oxyanion + “-ic”

Acid

Oxyacid Nomenclature

- Hydrogen ____ate → ____ic acid
- Hydrogen ____ite → ____ous acid

- Hydrogen per __ate → per__ic acid
- Hydrogen hypo__ite →hypo__ous acid

- H_2SO_4 sulfuric acid
- H_2SO_3 sulfurous acid
- H_2CO_3 carbonic acid
- $HClO$ hypochlorous acid
- H_2TeO_3 tellurous acid
- $HBrO_4$ perbromic acid

Acid Base Reactions

- Conjugate acid base pair
-

  HA + B $\leftrightarrow$ A + BH^+
- acid base base acid

-

  Acid HA $\rightarrow$ Conjugate base A
- Base B $\rightarrow$ Conjugate acid BH^+

$$\underset{\text{Acid}}{H_2SO_4(aq)} + \underset{\text{Base}}{H_2O(l)} \longrightarrow \underset{\text{Conjugate base}}{HSO_4^-(aq)} + \underset{\text{Conjugate acid}}{H_3O^+(aq)}$$

$$\underset{\text{Base}}{\mathrm{NH_3}(aq)} + \underset{\text{Acid}}{\mathrm{H_2O}(l)} \rightleftharpoons \underset{\text{Conjugate acid}}{\mathrm{NH_4}^+(aq)} + \underset{\text{Conjugate base}}{\mathrm{OH}^-(aq)}$$

$$HCO_3^-(aq) + H_2O(l) \longrightarrow H_2CO_3(aq) + OH^-(aq)$$

Base	Acid	Conjugate acid	Conjugate base

Water acting as both an acid and a base

$$\underset{\substack{\text{Acid} \\ \text{(Proton donor)}}}{H_2O(l)} + \underset{\substack{\text{Base} \\ \text{(Proton acceptor)}}}{H_2O(l)} \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

- pH is a method used to describe the concentration of H_3O^+(H^+) in a solution easily.

- pH = log[H_3O^+]
  - where [H_3O^+] = concentration of H_3O^+ in mol/L or molarity (M)

The pH scale

- pH = 7 ➔ neutral
- pH > 7 ➔ basic solution
- pH < 7 ➔ acidic solution

Acidic/Basic	pH	Example Solution
Strongly acidic	0	1 M HCl
	1	Stomach acid (1–3)
Weakly acidic	2	Lemon juice
	3	Vinegar, wine
	4	Grapes, orange juice
	5	Normal rain, coffee
	6	Milk, pH balanced shampoo
Neutral	7	Pure water
Weakly basic	8	Eggs, seawater
	9	Baking soda, antacids
	10	Milk of magnesia, soap
	11	Household ammonia
	12	Liquid bleach
Strongly basic	13	Drain cleaner
	14	1 M NaOH

Classify each of the following foods as acidic, basic or neutral

- egg white, pH = 7.9
- maple syrup, pH = 7.0
- champagne, pH = 3,8
- sour milk, pH = 6.2
- lime juice, pH = 1.8
- tomato juice, pH = 4.1

- What is the pH of A 0.10 M solution of HCl with $[H_3O^+] = 0.10$ M

- A bottle of table wine has $[H_3O^+] = 3.2 \times 10^{-4}$ M. After one month the $[H_3O^+]$ rises to 1.0×10^{-3} M. Calculate the pH of the new and old bottle of wine and explain the changes observed.

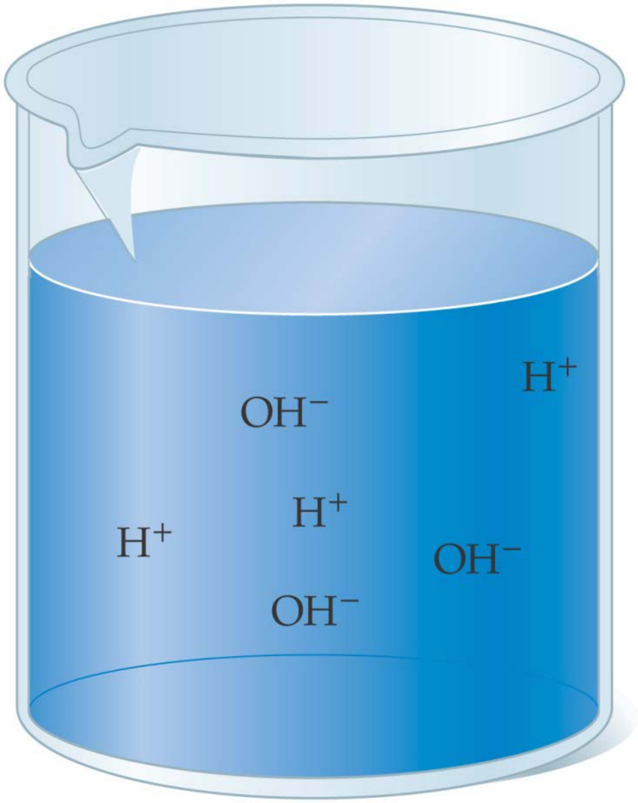
- Calculate the pH of carrot juice with a hydronium ion $[H_3O^+]$concentration of 7.9×10^{-6}M.

- Calculate the pH of pea juice with a hydronium ion $[H_3O^+]$concentration of 3.9×10^{-7}M.

- What is the pH of pure water? $[H_3O^+] = [OH^-] = 1.0 \times 10^{-7}$ M

In pure water

- $H_2O + H_2O \Leftrightarrow H_3O^+ + OH$
- $[H_3O^+] = [OH^-] = 1.0 \times 10^{-7}$ M
- $[H_3O^+] \times [OH^-] = 1.0 \times 10^{-14}$ M^2



- What is the pH of a 0.10 M NaOH solution with $[OH^-] = 0.10$ M?

- What is the pH of a 0.024 M NaOH solution?

pOH

- pOH = log[OH]

- What is the pOH of a solution that is 4.87 $\times 10^{-9}$ M in NaOH?

- What is the $[H_3O^+]$ concentration of a solution with pH = 4.22?

$[H_3O^{+1}]$	$[OH^{-1}]$	pH	pOH
5.98×10^{-11}			
	9.63×10^{-5}		
		9.092	
			10.05

- How many mL of a 0.5223 M solution of NaOH is required to completely react with 3.457 g of oxalic acid ($H_2C_2O_4$)?

- If 58.70 mL of HCl solution were used to titrate 1.077 g of NaOH, what was the molarity of the HCl solution?

- A 25.00 mL sample of vinegar was titrated with 23.55 mL of a 0.4233 M sodium hydroxide solution. What is the concentration of acetic acid in the vinegar solution?

- A 50.00 mL aliquot of phosphoric acid was titrated with 37.29 mL of 0.5277 M potassium hydroxide. Write the equation for the reaction that takes place and calculate the molarity of the phosphoric acid solution.

Buffers

- Compounds that help to maintain a constant pH
- Buffers work by reacting with both acids and bases

Bicarbonate Buffer

- Bicarbonate reacts with acid
- $HCO_3^{-1} + H^{+1} \rightarrow H_2CO_3$

- Bicarbonate reacts with base
- $HCO_3^{-1} + OH^{-1} \rightarrow CO_3^{-2}$

- Both acid and base can be neutralized by bicarbonate

1980 to 1997 SO_2 Emissions from Utilities