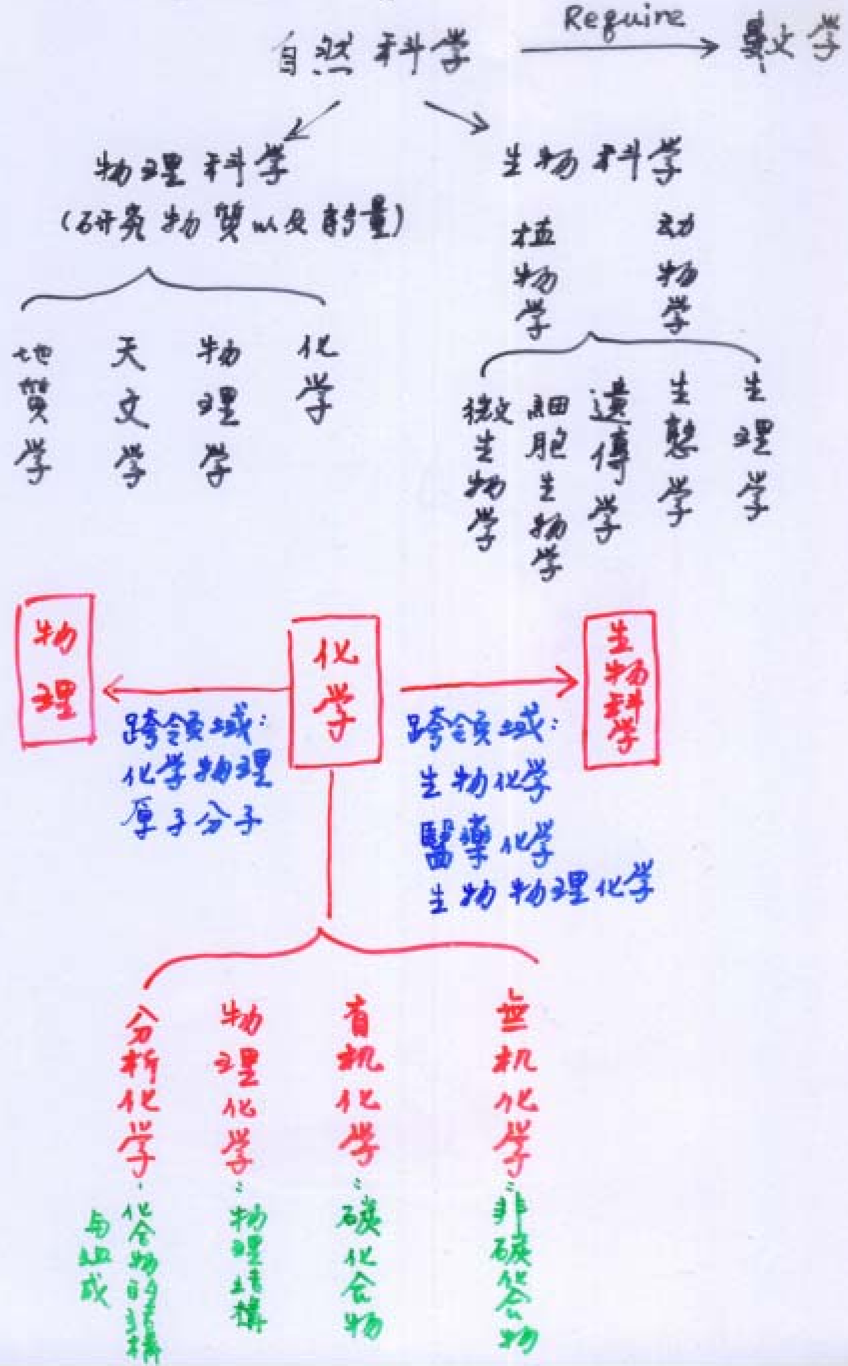
普通化學

科学的範疇


自然科学
Require
數学
物理科学
(研究物質以及能量)
生物科学
地質学
天文学
物理学
化学
植物学
動物学
微生物学
細胞生物学
遺傳学
生態学
生理学
物理
化学
生物科学
跨領域：
化学物理
原子分子
跨領域：
生物化学
醫藥化学
生物物理化学
分析化学：化合物的結構与組成
物理化学：物理結構
有机化学：碳化合物
無机化学：非碳化合物

Lecture I：化学的範疇

What is chemistry ?

↓

the science that tries to understand :

(1) the properties of substances

物質的性質

(2) the changes that substances undergo

物質的變化

Want to understand materials including :

A. Natural substances：天然物質

e.g. mineral , air , water , salt ....

B. chemicals found in living creatures：生物体內化合物

e.g. DNA. protein, carbohydrate, ...

C. New compounds created by chemists：新化合物

e.g. polymer , Nylon, ...

chapter 1.2

科学方法：

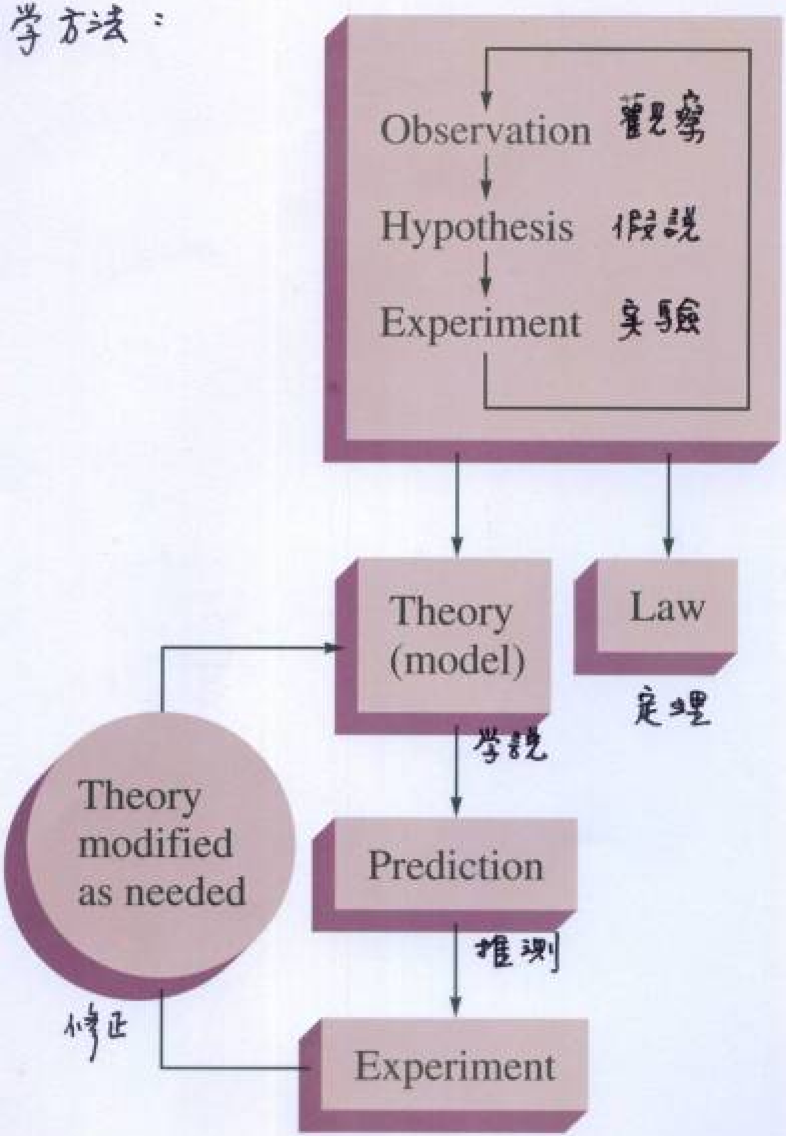


Figure ~~1.2~~ 1.3

Various parts of the scientific method

Chap 1.3 度量單位

英制 (English system

公制 (metric system)

↓ 1960 A.D.

國際統一單位系統

International System (簡稱 SI units)

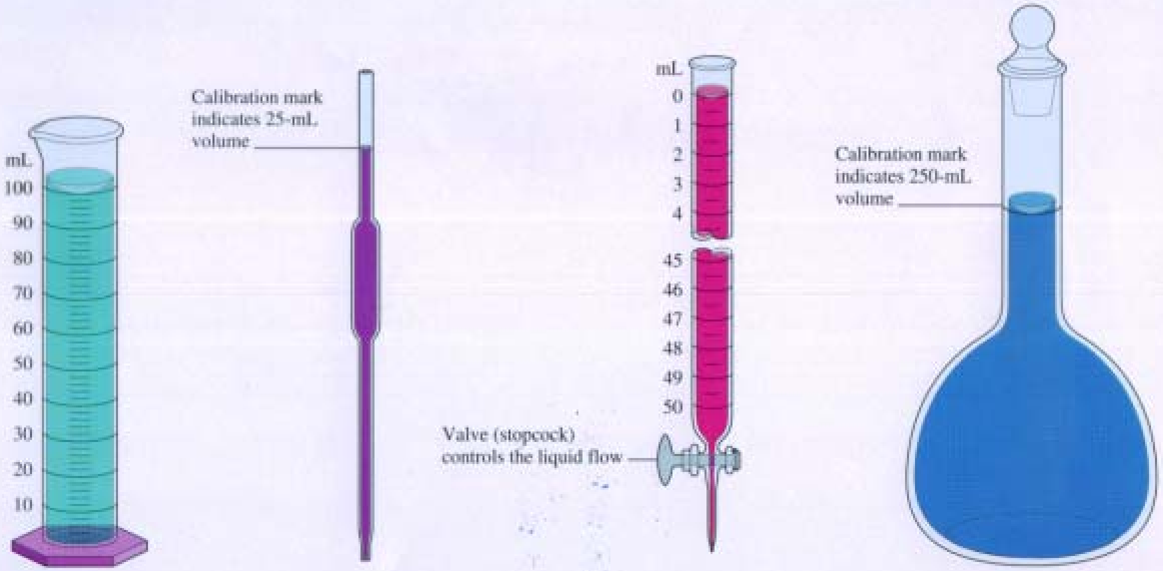
SI system

Table 1.1

physical Quantity	Name of units	Abbreviation
mass (重量)	Kilogram	~~Ab~~ Kg
Length	meter	m
Time	second	s
Temperature	Kelvin	K
Electric current	ampere	A
Amount of substance	mole	mol

Table 1.2 The Prefixes Used in the SI System

exa	10^{18}	deci	10^{-1}
peta	10^{15}	centri	10^{-2}
tera	10^{12}	milli	10^{-3}
giga	10^{9}	micro	10^{-6}
mega	10^{6}	nano	10^{-9}
Kilo	10^{3}	pico	10^{-12}
hecto	10^{2}	femto	10^{-15}
deka	10^{1}	atto	10^{-18}



100-mL graduated cylinder

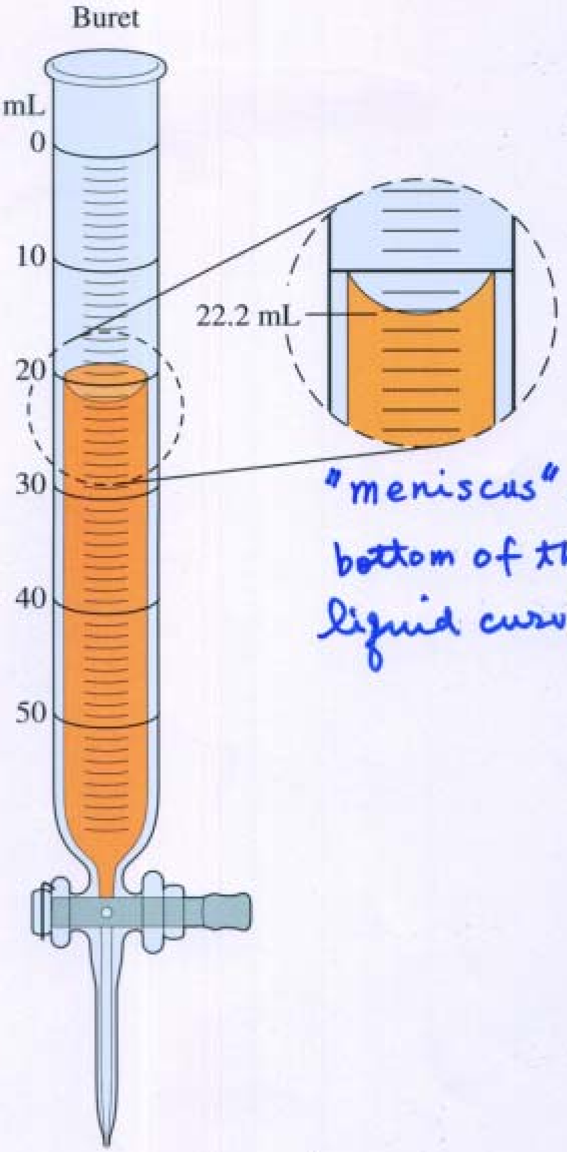
25-mL pipet

50-mL buret

250-mL volumetric flask

1-7

1-8



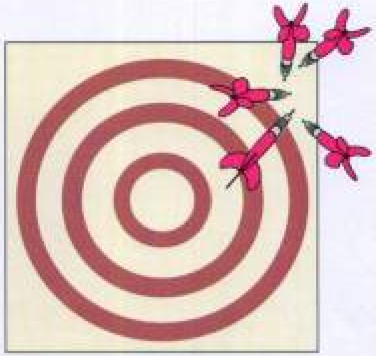
"meniscus".
bottom of the liquid curve

5 1.7 The difference between precision and accuracy

1-9

(a)

not precise
not accurate



(b)

precision
but no accuracy

(c)

accuracy
& precision

§1.5 Significant Figures 有效数字

page 14-18.

1. nonzero integers 都算

2. three classes of zeros

(a) Leading zeros 不算

e.g. $\underbrace{0.00}_{\uparrow}25$

不算

(b) captive zeros 算 (在 nonzero digits 之间)

e.g. $1.\underbrace{00}_{\uparrow}8$

算

(c) trailing zeros 尾巴的 zero

e.g. 100 1 位

100. 3 位

1.00 3 位

+ − 以最不準的位数為準. e.g.

$$\begin{array}{r} 12.11 \\ +18.0 \\ \hline 30.11 \end{array}$$

↓

corrected

30.1

sig. fig 到

小数点第一位

× ÷ 以位数少的為準

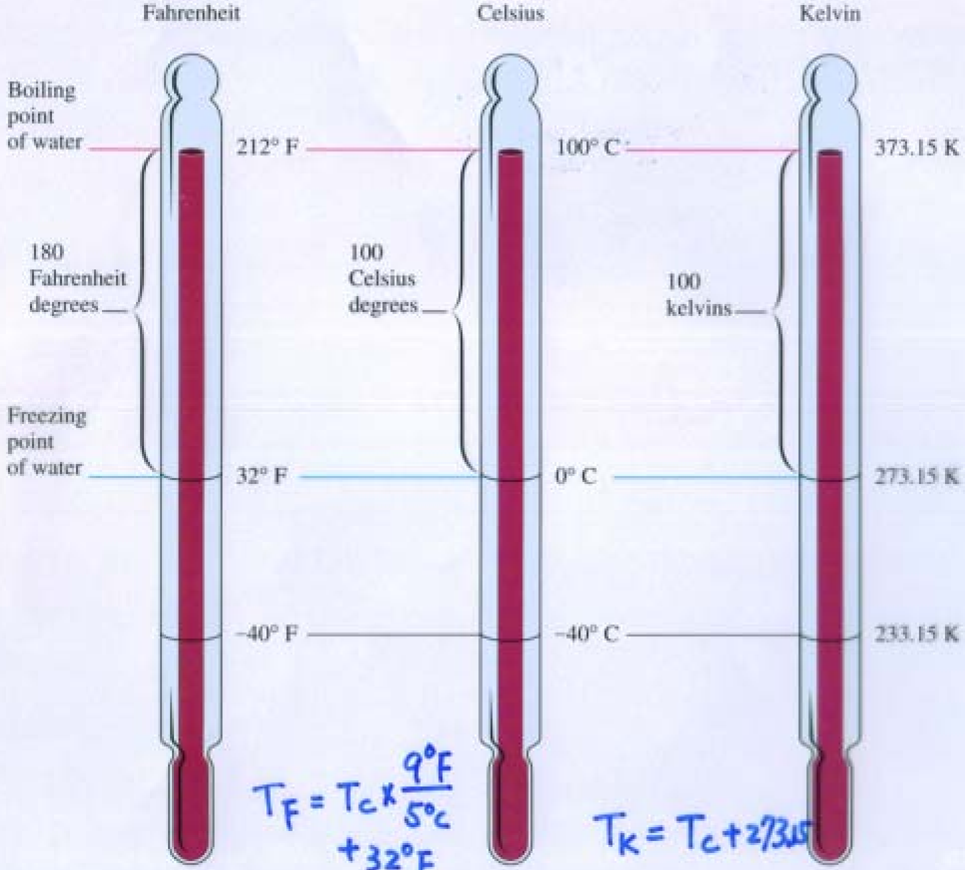
$4.56 \times 1.4 = 6.38$

↓

6.4

2位 sig. fig.

Temperature



$T_F = T_C \times \frac{9°F}{5°C} + 32°F$

$T_K = T_C + 273.15$

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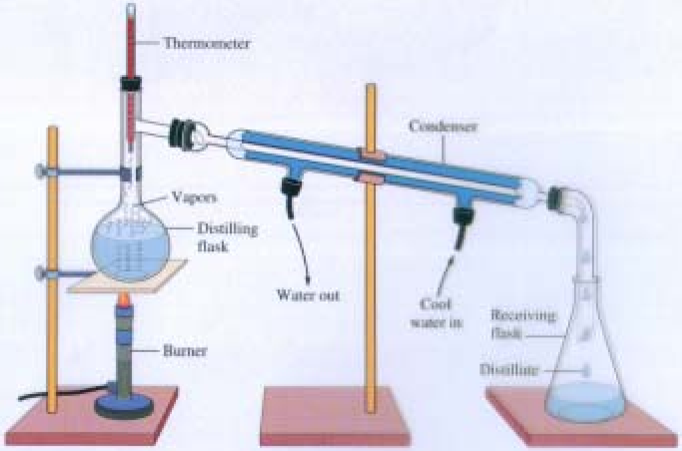
6 1.8 The three major temperature scales

1.10 Simple laboratory distillation apparatus

Distillation apparatus
蒸餾系統



1-11

化学 物质 分類

[illegible]

1+2

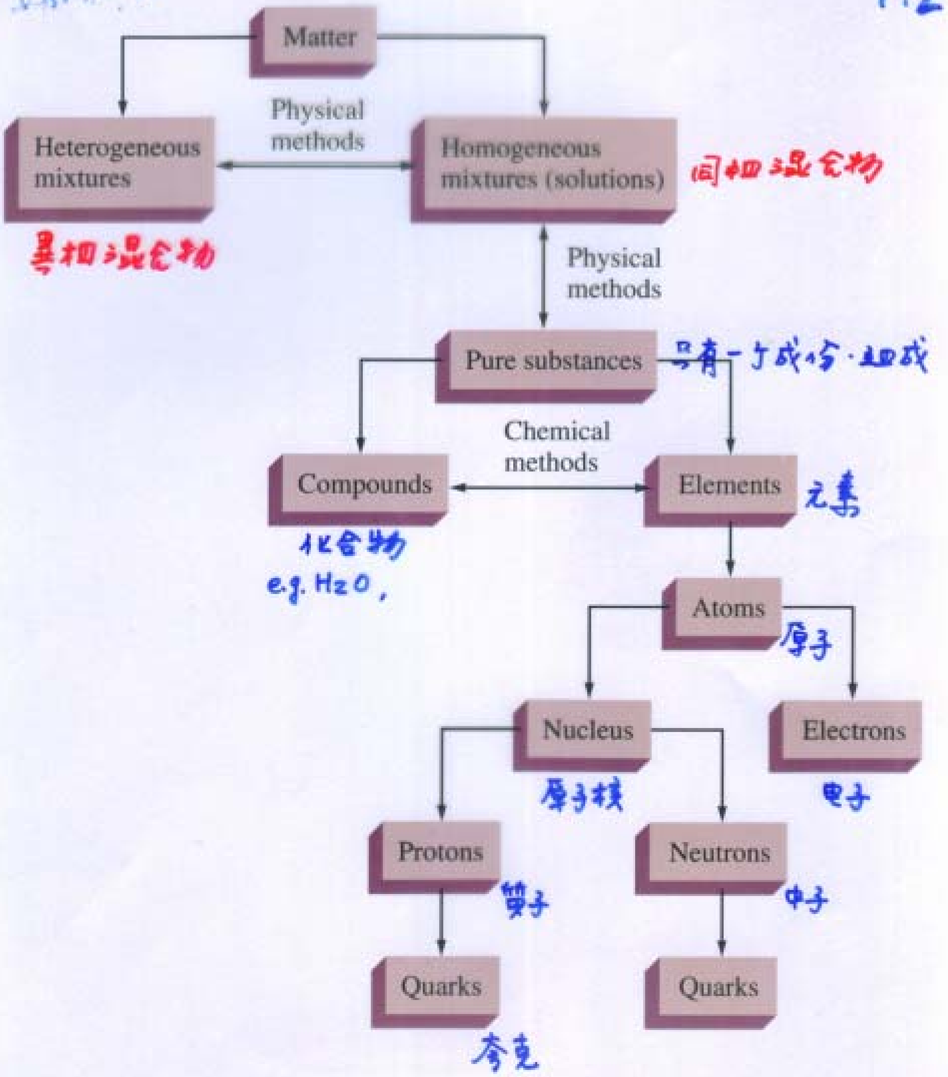


Figure 1.13
The organization of matter

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Chapter 2 Atoms, Molecules, and Ions

2.1 The Early History of Chemistry

A. 古代 → ~400 B.C.

(a) Before 1000 B.C.

利用礦物製造武器及裝飾器皿

防腐液体 → 製造木乃伊

(b) 400 B.C. 希臘人

四大元素 (elements)

Air, Fire, Water, and Earth

物質是否是連續的?

B. 400 B.C. ~ 1600 A.D. (約 2000年左右)

鍊金術

Gold can be turned from other metal

C. Boyle 時代 (1627 -1691 AD)

"定量" 化学家

(a) The Skeptical Chymist (in 1661)
Pressure and Volume of Gases 的
定量関係

(b) Element 的概念

Boyle 時代以後:

A. Antoine Lavoisier

(a) law of conservation of mass
物質守恒定律
"Mass is neither created nor destroyed"

(b) 燃燒利用 O_2
→ 人需要 O_2 与燃燒同

(c) Treatise on Chemistry

B. Joseph Proust

law of definite proportion (定比定律)
" a given compound always contains exactly the same proportion of elements by mass."

C. Dalton

law of multiple proportions (倍比定律)

"when two elements form a series of compounds, the ratios of the masses of the second element that combine w/ 1 gram of the first element can always be reduced to small whole numbers."

Nitrogen and Oxygen compounds

	Nitrogen mass that combines w/ 1g oxyge
compound A	1.750 g
B	0.8750g
C	0.4375 g

$$\frac{A}{B} = \frac{1.750}{0.875} = \frac{2}{1}$$

$$\frac{B}{C} = \frac{0.8750}{0.4375} = \frac{2}{1}$$

$$\frac{A}{C} = \frac{1.750}{0.4375} = \frac{4}{1}$$

Meaning ?

Dalton's Atomic Theory

"A New System of Chemical Philosophy"

1. Each element is made up of tiny particles called atoms.

2. The atoms of a given element are identical; the atoms of different elements are different in some fundamental way or ways.

3. Chemical compounds are formed when atoms combine with each other. A given compound always has the same relative numbers and types of atoms

4. Chemical reactions involve reorganization of atoms - changes in the way that they are bound together. The atoms themselves are not changed in a chemical reaction.

2.4 Early Experiments to Characterize the Atom

The electron

Thomson's experiment

cathode-ray tubes 陰極射線管

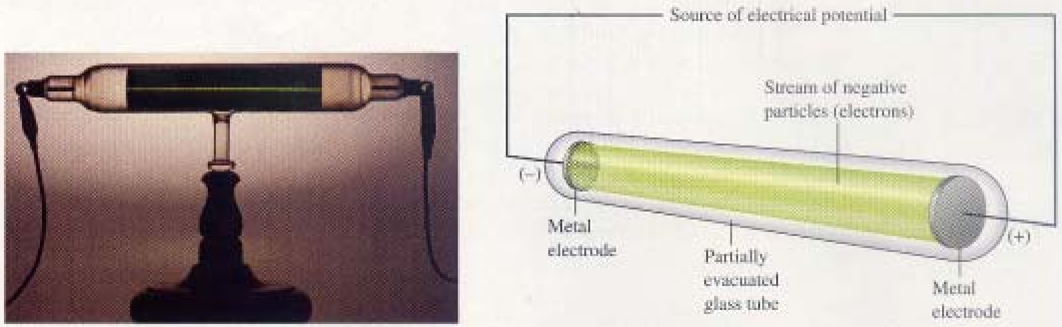


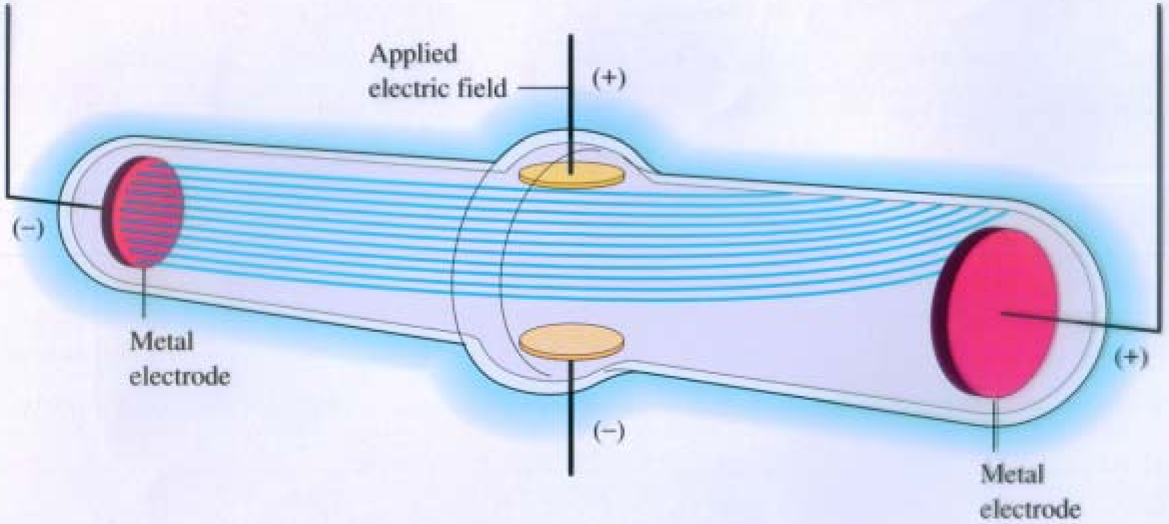
FIGURE 2.7
A cathode-ray tube. The fast-moving electrons excite the gas in the tube, causing a glow between the electrodes. The green color in the photo is due to the response of the screen (coated with zinc sulfide) to the electron beam.

cathode ray : because it emanated from
the negative electrode, or
cathode

(1) The ray was a stream of negatively charged particles, now called "electrons"

(2) $e/m = -1.76 \times 10^8$ C/g

C: coulombs



2-6

Thomson's model on atom

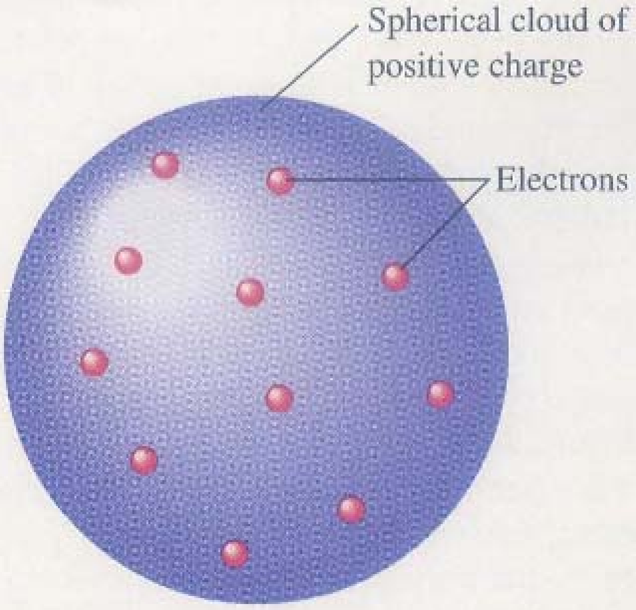


FIGURE 2.9
The plum pudding model of the atom.

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p8

Millikan's experiment

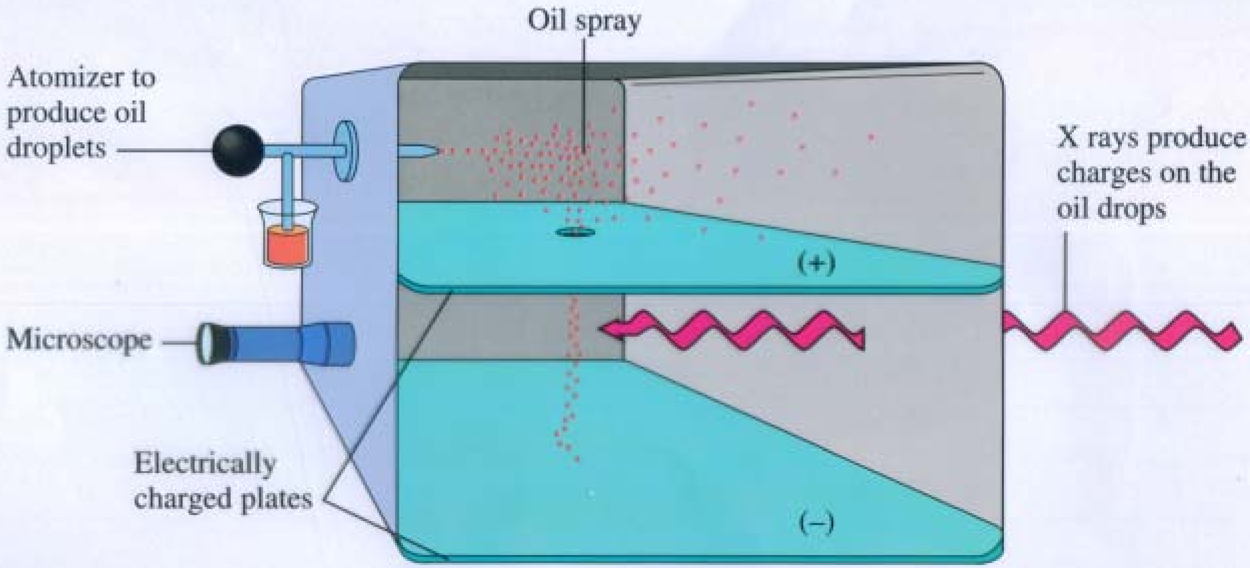

Figure 2.10

Diagram of Millikan apparatus

Millikan's experiment

mass of electron = 9.11×10^{-31} kg

$$F = -qE + mg = \underset{\substack{\uparrow \\ \text{油} \\ \text{滴} \\ \text{不} \\ \text{动}}}{0}$$

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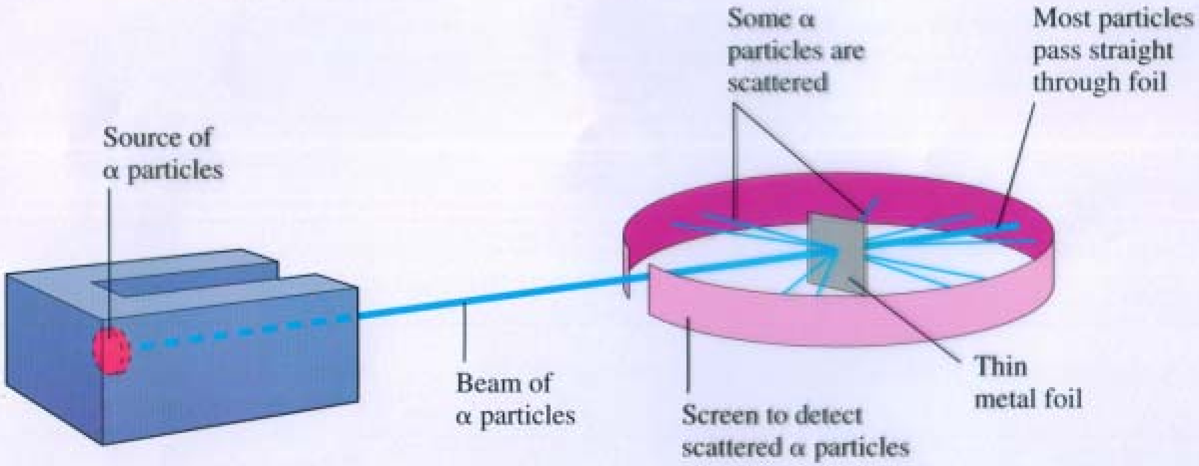
13 2.12 Rutherford's experimental set-up



2-11

Chapter 2.4

Rutherford's Experiment

↓

1. Most of the α particles pass directly through the foil because the atom is mostly open space.

2. The deflected α particles are those which had a "close encounter" w/ the massive positive center of the atom

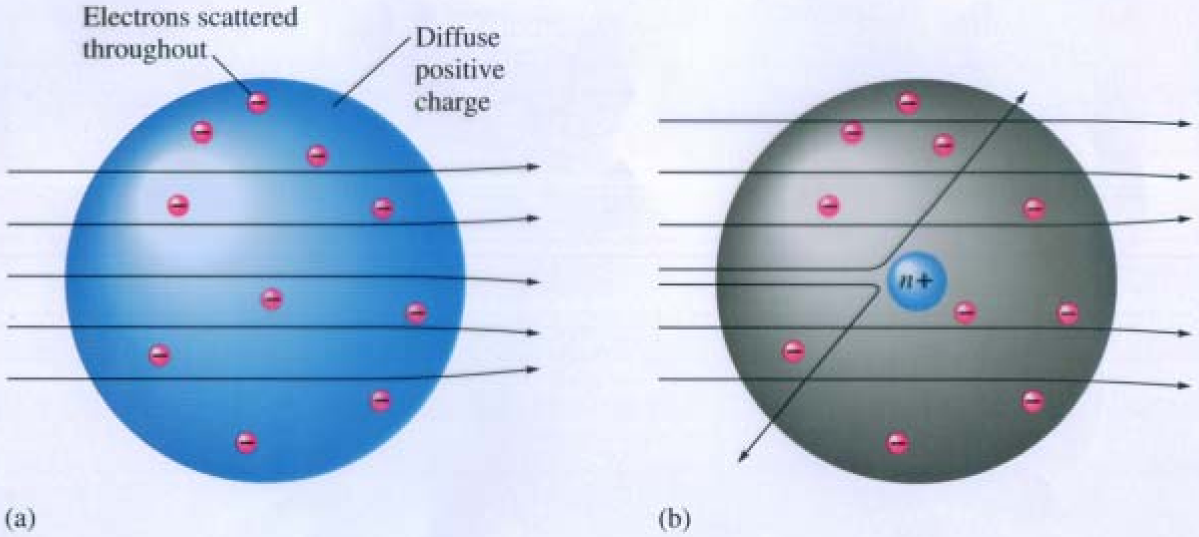
3. The few reflected α particles are those which made a "direct hit" on the much more massive positive center.

↓

a dense center of positive charge

Nuclear atom (nucleus)

Zumdahl CHEMISTRY Fifth Edition
14 2.13 Expected and actual results of Rutherford's experiment



2-12

2.5 The Modern View of Atomic Structure : An Introduction

particle	mass	Charge
Electron	9.11×10^{-31} kg	1 −
Proton	1.67×10^{-27} Kg	1+
Neutron	1.67×10^{-27} Kg	0

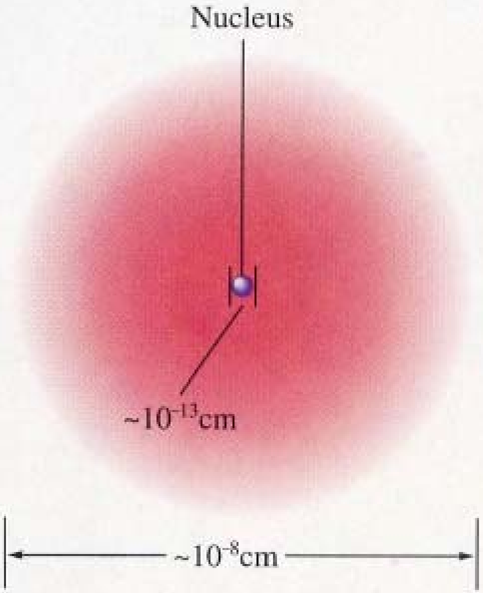


FIGURE 2.14
A nuclear atom viewed in cross section. Note that this drawing is not to scale.

mass #

↑

$${}^{A}_{Z}X$$

Atomic # → Z

↑ element symbol

Ex:

$${}^{23}_{11}Na$$

\# of electron = 11

\# of proton = 11

\# of neutron = 23 − 11 = 12

2-15

2.6 Molecules and Ions

The forces that hold atoms together in compounds — chemical bonds

Covalent bonds : sharing electrons
共價鍵
e.g. H_2 $A(\psi_1 \pm \psi_2)$

Ionic bonds : attraction between
離子鍵 oppositely charged ions
e.g. NaCl

$a\psi_1 + b\psi_2$
↑ — ↑
90% 10%

分子的表示法

Fig 2.16

spacing - filling models

Fig. 2-17 & 2-18 Ball-and-stick

P7
2-16

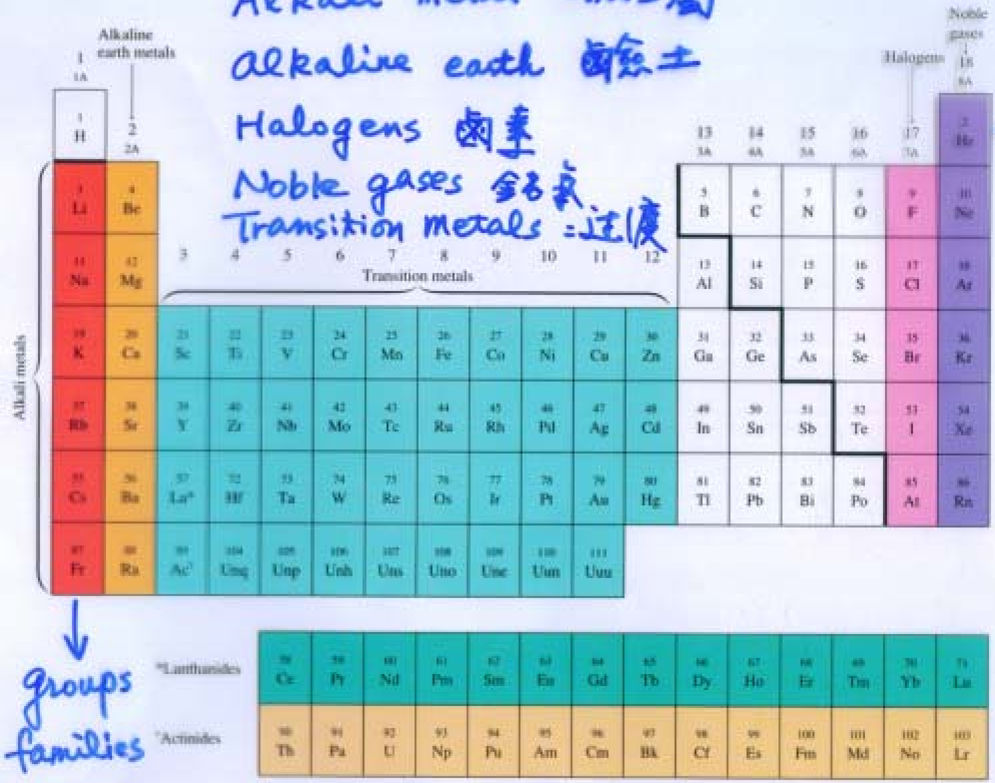
Alkali metal 鹼金屬

Alkaline earth 鹼土

Halogens 鹵素

Noble gases 鈍氣

Transition metals ∶過渡



→ period

groups or families

Figure 2.21
The periodic table

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P8
2-1

2.8 Nomenclature (命名)

I. Binary Ionic Compounds (Type I)

：含两种~~原子~~元素的離子化合物

1. cation → first
   anion → second

2. cation → from the name of the element

3. anion → take the root of the name of the element and add -ide
   （root：字根）

Ex: ① NaCl element names : sodium
chlorine

sodium chloride

② $MgCl_2$ element names : magnesium
chlorine

magnesium chloride

☆ Type I cations: 通常只有一种电價
Table 2.3
See Fig. 2.22

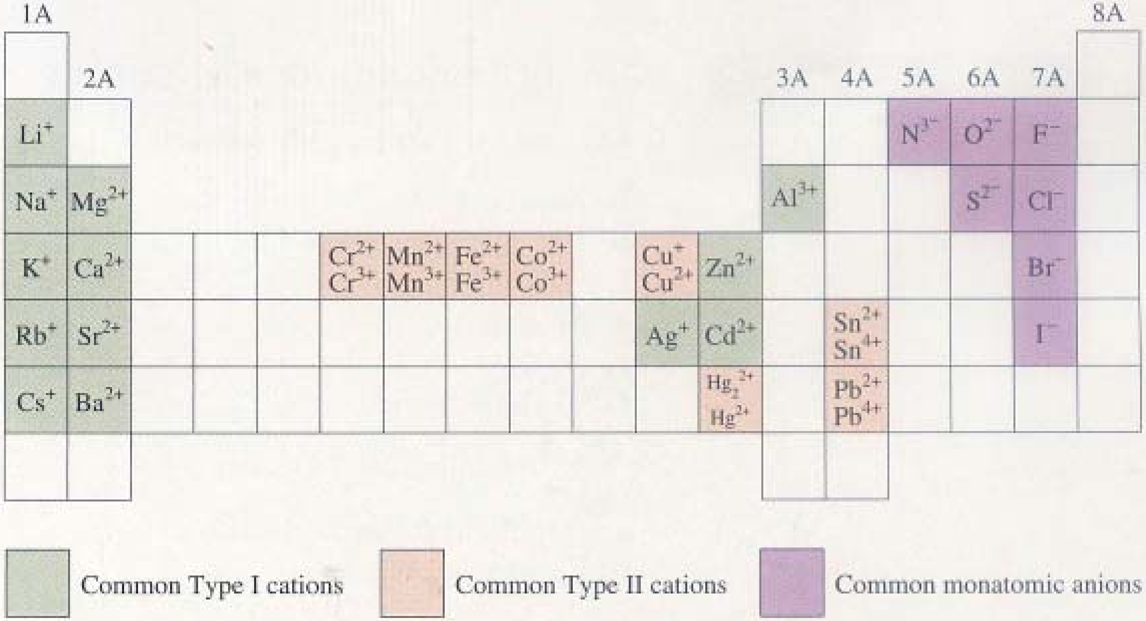
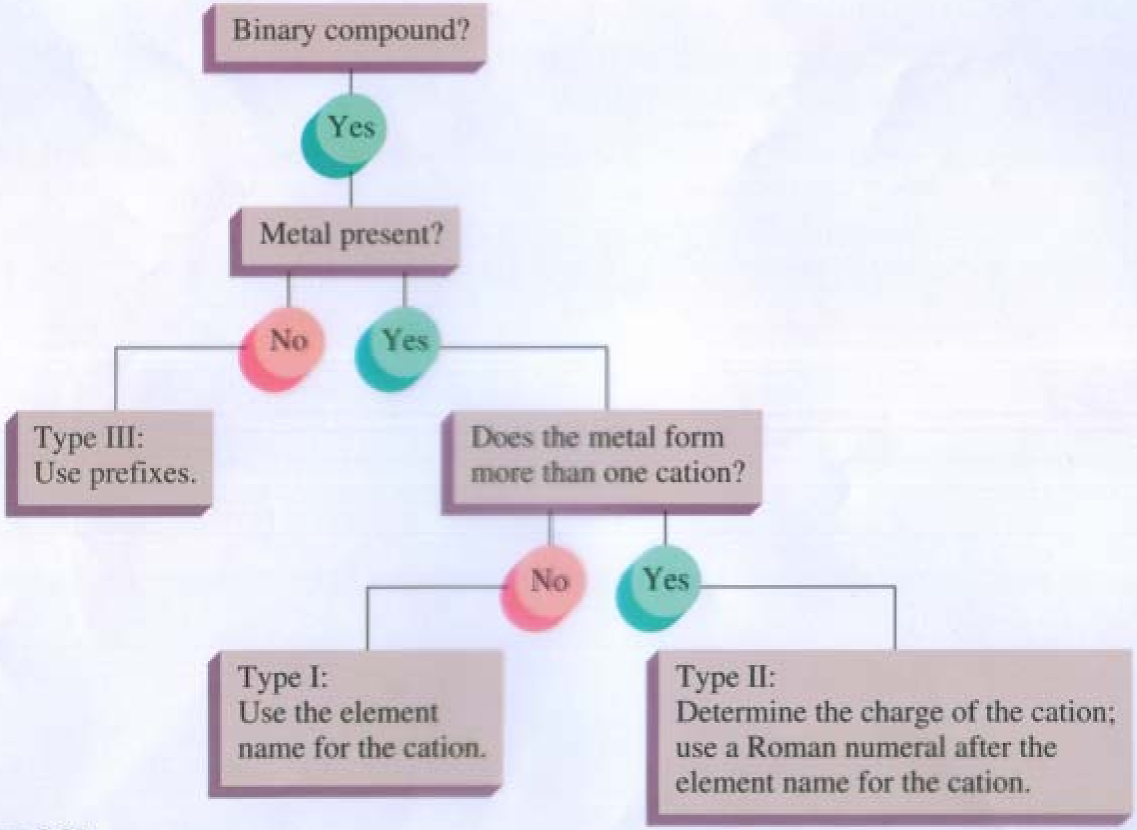


FIGURE 2.22
The common cations and anions.

Pg 12



Binary compound?

Yes

Metal present?

No

Type III:
Use prefixes.

Yes

Does the metal form more than one cation?

No

Type I:
Use the element name for the cation.

Yes

Type II:
Determine the charge of the cation; use a Roman numeral after the element name for the cation.

Figure 2.23

Flowchart for naming binary compounds

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2-21

II. Binary Ionic Compounds (Type II)

★ Type II cations : 通常不止帶一种电價

E.x. Fe^{3+} & Fe^{2+}

see Fig. 2.22 & Table 2.4

1. cation → first
   anion → second
2. ★ cation → from the name of the element
   But, adding the charge of the cation
   (using Roman numeral !)

   Ex. Fe^{3+} iron (III)
   Fe^{2+} iron (II)
3. anion → take the element name's root
   and add <u>-ide</u>

Ex. CuCl : element names: copper
chlorine

solution: $Cu^{+}Cl^{-}$

Copper (I) chloride

see page ~~65~~ 61. 流程图 for Type I
Type II 的分别

Or

Cation w/ the higher charge

→ -ic

w/ the lower charge

→ -ous

Ex. $FeCl_3$ element names: iron

chlorine

$FeCl_2$

$Fe^{3+}Cl_3$: Ferric chloride

$Fe^{2+}Cl_2$: Ferrous chloride

例题： 2-3 (page 63) Type I

2-4 (page 63) Type II

2-5 (page 64)

C_{60} (page 65) Buckminsterfullerene

60个C（位於顶点）组成 32面球体

20个六面体 12个五面体 交錯

Binary Compounds (Type III; Covalent
- contain two Non-metals)

1. first element in the formula → first
use the full element name

2. second element → name it as
it were anion!

3. Prefixes are added to denote
(字首)
the numbers of atoms present.

1 mono-
2 di-
3 tri-
4 tetra-
5 penta-

4. Prefixes → never used for naming
"mono" the first element

Ex.: N_2O : dinitrogen monoxide
NO : nitrogen monoxide
NO_2 : nitrogen dioxide
N_2O_3 : dinitrogen trioxide
N_2O_2

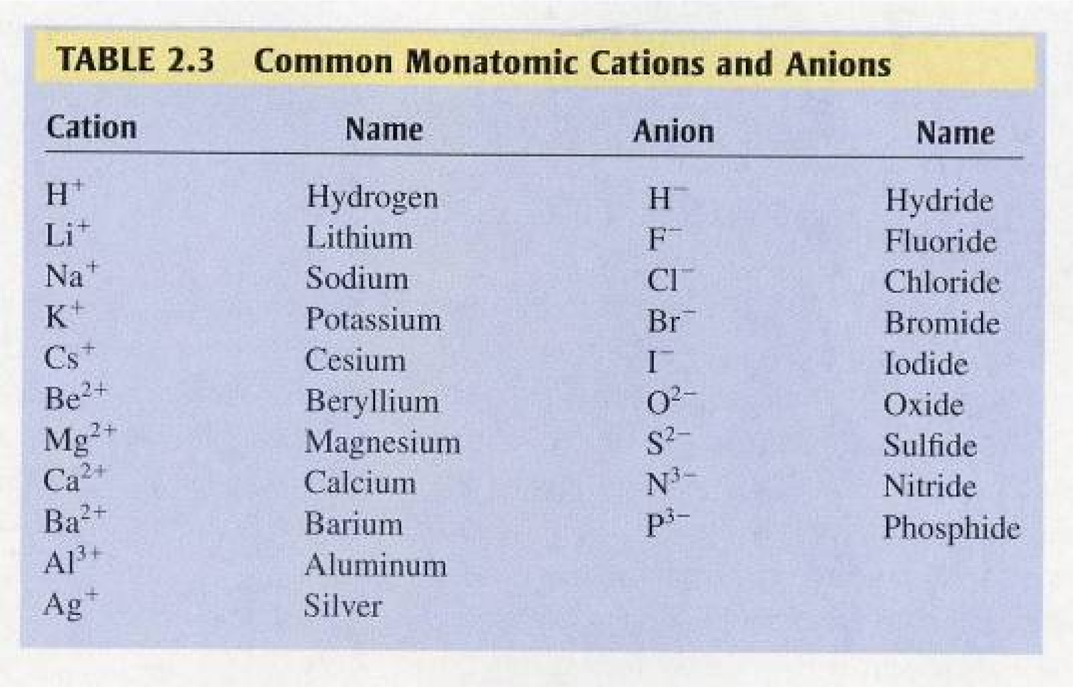


TABLE 2.3 Common Monatomic Cations and Anions

Cation	Name	Anion	Name
H^+	Hydrogen	H^-	Hydride
Li^+	Lithium	F^-	Fluoride
Na^+	Sodium	Cl^-	Chloride
K^+	Potassium	Br^-	Bromide
Cs^+	Cesium	I^-	Iodide
Be^{2+}	Beryllium	O^{2-}	Oxide
Mg^{2+}	Magnesium	S^{2-}	Sulfide
Ca^{2+}	Calcium	N^{3-}	Nitride
Ba^{2+}	Barium	P^{3-}	Phosphide
Al^{3+}	Aluminum		
Ag^+	Silver		

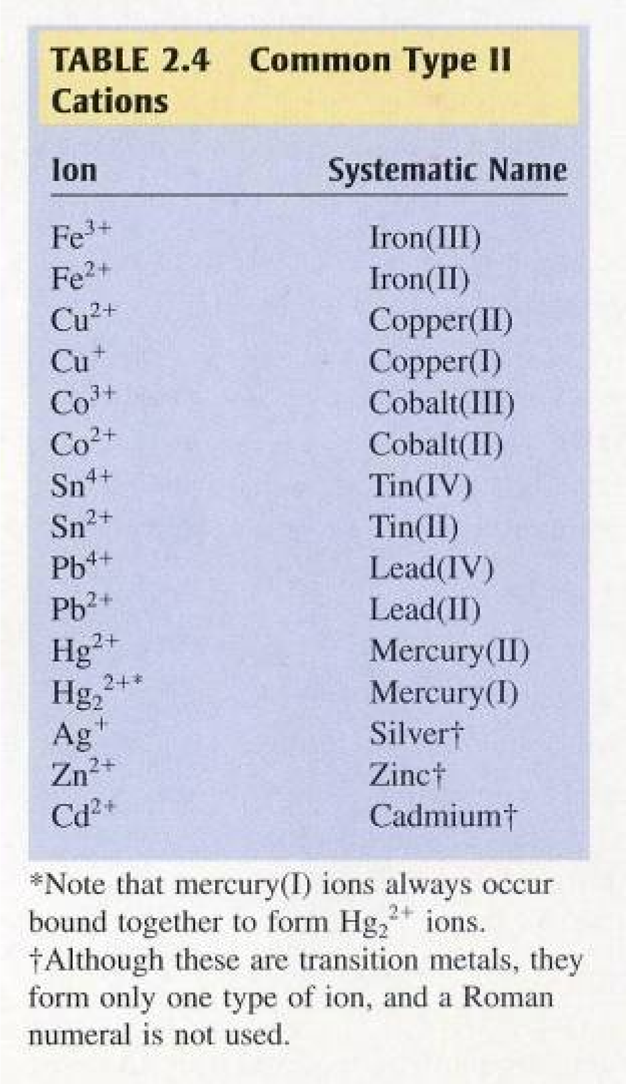


TABLE 2.4 Common Type II Cations

Ion	Systematic Name
Fe^{3+}	Iron(III)
Fe^{2+}	Iron(II)
Cu^{2+}	Copper(II)
Cu^+	Copper(I)
Co^{3+}	Cobalt(III)
Co^{2+}	Cobalt(II)
Sn^{4+}	Tin(IV)
Sn^{2+}	Tin(II)
Pb^{4+}	Lead(IV)
Pb^{2+}	Lead(II)
Hg^{2+}	Mercury(II)
Hg_2^{2+}*	Mercury(I)
Ag^+	Silver†
Zn^{2+}	Zinc†
Cd^{2+}	Cadmium†

*Note that mercury(I) ions always occur bound together to form Hg_2^{2+} ions.

†Although these are transition metals, they form only one type of ion, and a Roman numeral is not used.

Polyatomic Ions Compounds

1. separate polyatomic ions w/ opposite charges

Ex. $\underbrace{NH_4}\underbrace{OH} \Leftrightarrow \boxed{NH_4^+}\ \boxed{OH^-}$

2. polyatomic ions

→ must be memorized !!

See Table 2.5

Ex. ① NH_4OH

$NH_4^+\ \underline{OH^-}$ ammonium hydroxide

Ammonium Hydroxide

② $KClO_4$

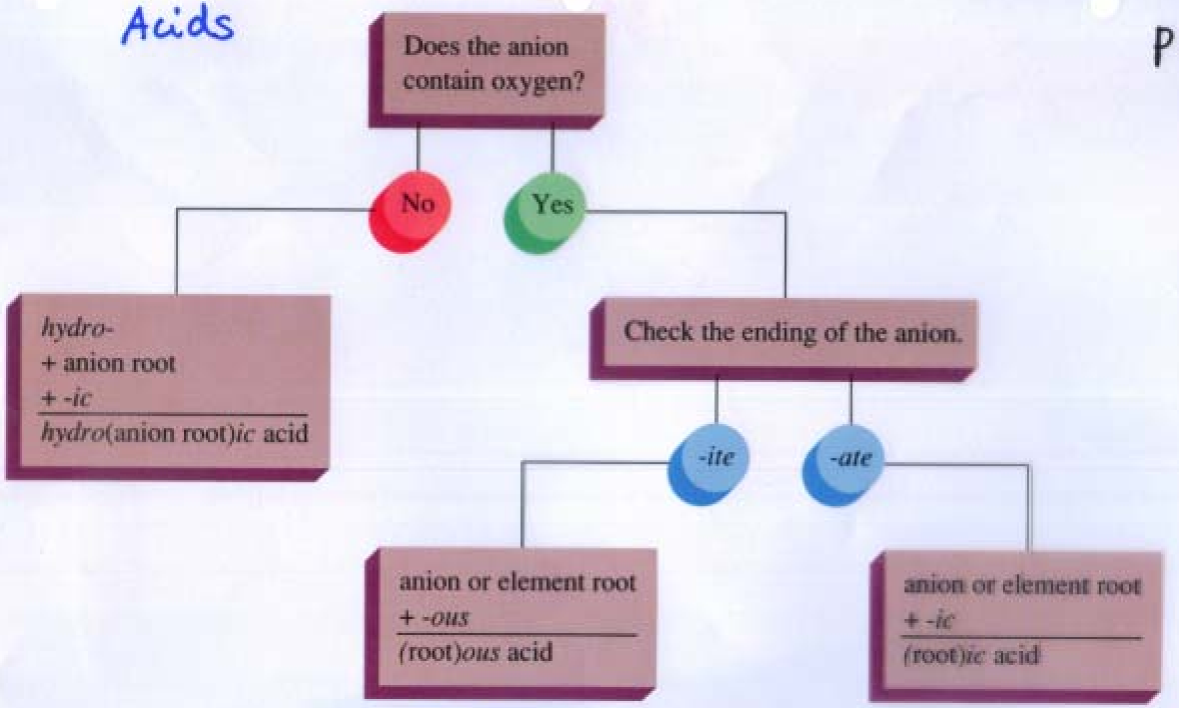
$\underline{K^+}\ ClO_4^-$

potasium perchlorate

Ex. 2.6 (page 67)

Acids

P14



Does the anion contain oxygen?

No

hydro-
+ anion root
+ *-ic*

hydro(anion root)*ic* acid

Yes

Check the ending of the anion.

-ite

anion or element root
+ *-ous*

(root)*ous* acid

-ate

anion or element root
+ *-ic*

(root)*ic* acid

sulfurous acid

sulfuric acid

Figure 2.25

Flowchart for naming acids

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2-23

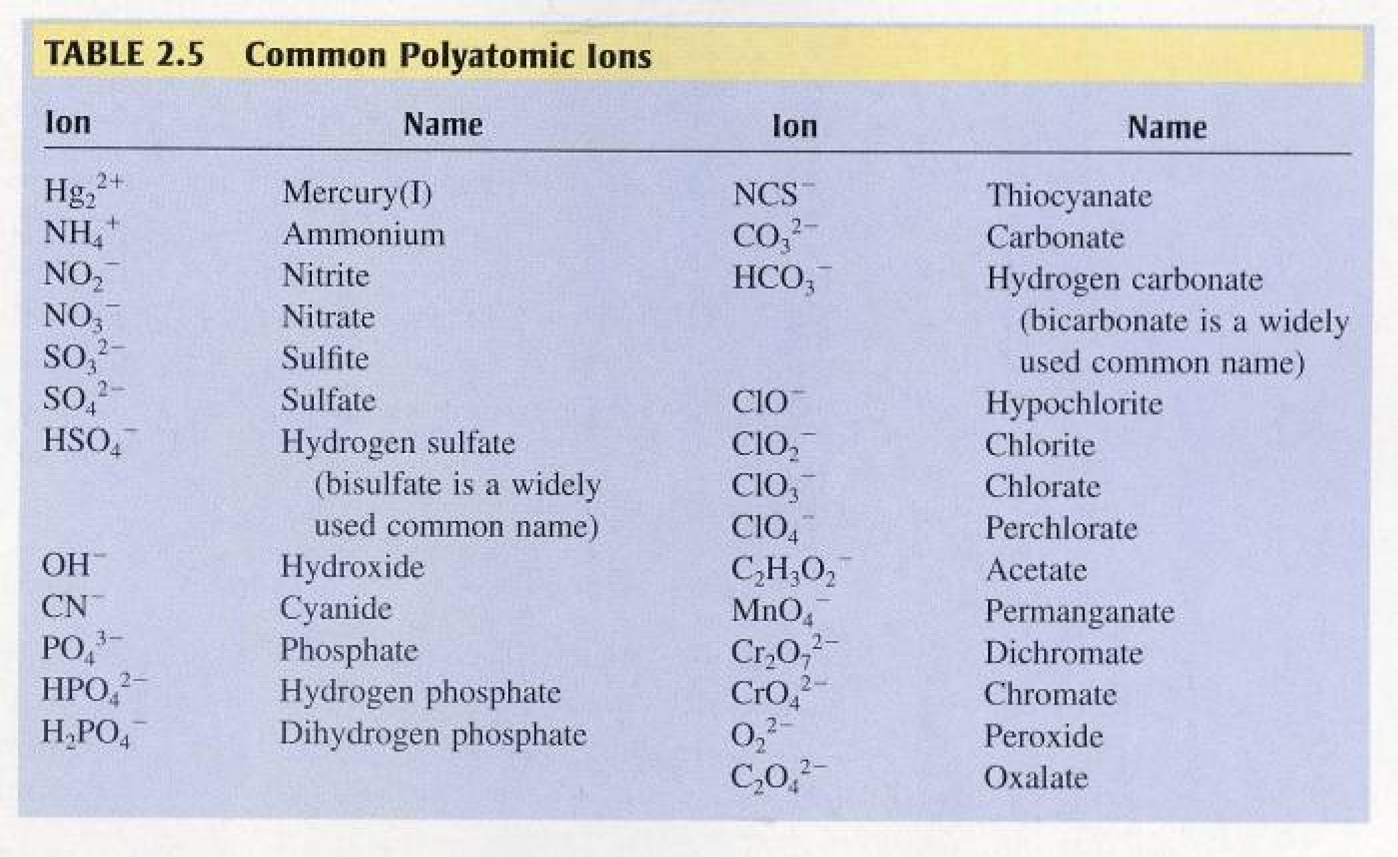


TABLE 2.5 Common Polyatomic Ions

Ion	Name	Ion	Name
Hg_2^{2+}	Mercury(I)	NCS^-	Thiocyanate
NH_4^+	Ammonium	CO_3^{2-}	Carbonate
NO_2^-	Nitrite	HCO_3^-	Hydrogen carbonate (bicarbonate is a widely used common name)
NO_3^-	Nitrate		
SO_3^{2-}	Sulfite		
SO_4^{2-}	Sulfate	ClO^-	Hypochlorite
HSO_4^-	Hydrogen sulfate (bisulfate is a widely used common name)	ClO_2^-	Chlorite
		ClO_3^-	Chlorate
		ClO_4^-	Perchlorate
OH^-	Hydroxide	$C_2H_3O_2^-$	Acetate
CN^-	Cyanide	MnO_4^-	Permanganate
PO_4^{3-}	Phosphate	$Cr_2O_7^{2-}$	Dichromate
HPO_4^{2-}	Hydrogen phosphate	CrO_4^{2-}	Chromate
$H_2PO_4^-$	Dihydrogen phosphate	O_2^{2-}	Peroxide
		$C_2O_4^{2-}$	Oxalate

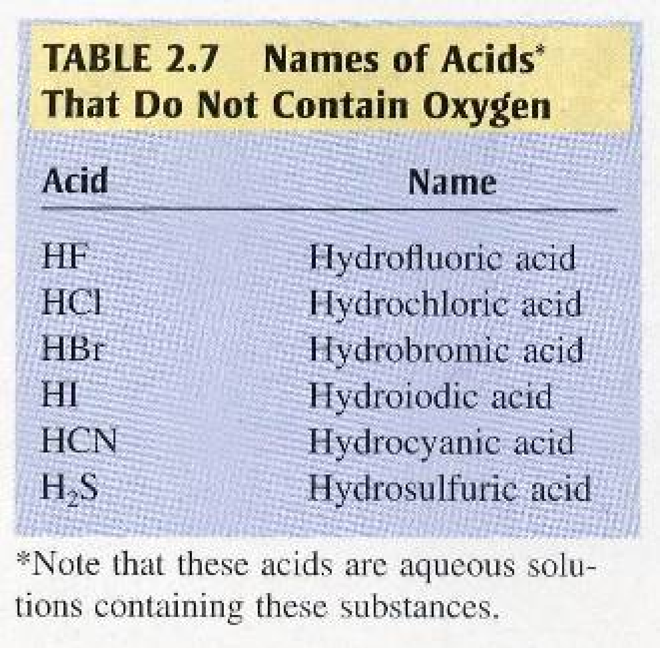


TABLE 2.7 Names of Acids* That Do Not Contain Oxygen

Acid	Name
HF	Hydrofluoric acid
HCl	Hydrochloric acid
HBr	Hydrobromic acid
HI	Hydroiodic acid
HCN	Hydrocyanic acid
H_2S	Hydrosulfuric acid

*Note that these acids are aqueous solutions containing these substances.

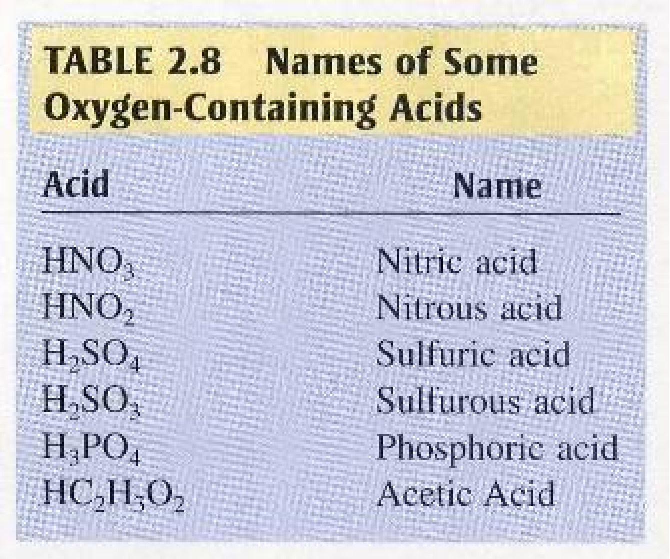


TABLE 2.8 Names of Some Oxygen-Containing Acids

Acid	Name
HNO_3	Nitric acid
HNO_2	Nitrous acid
H_2SO_4	Sulfuric acid
H_2SO_3	Sulfurous acid
H_3PO_4	Phosphoric acid
$HC_2H_3O_2$	Acetic Acid

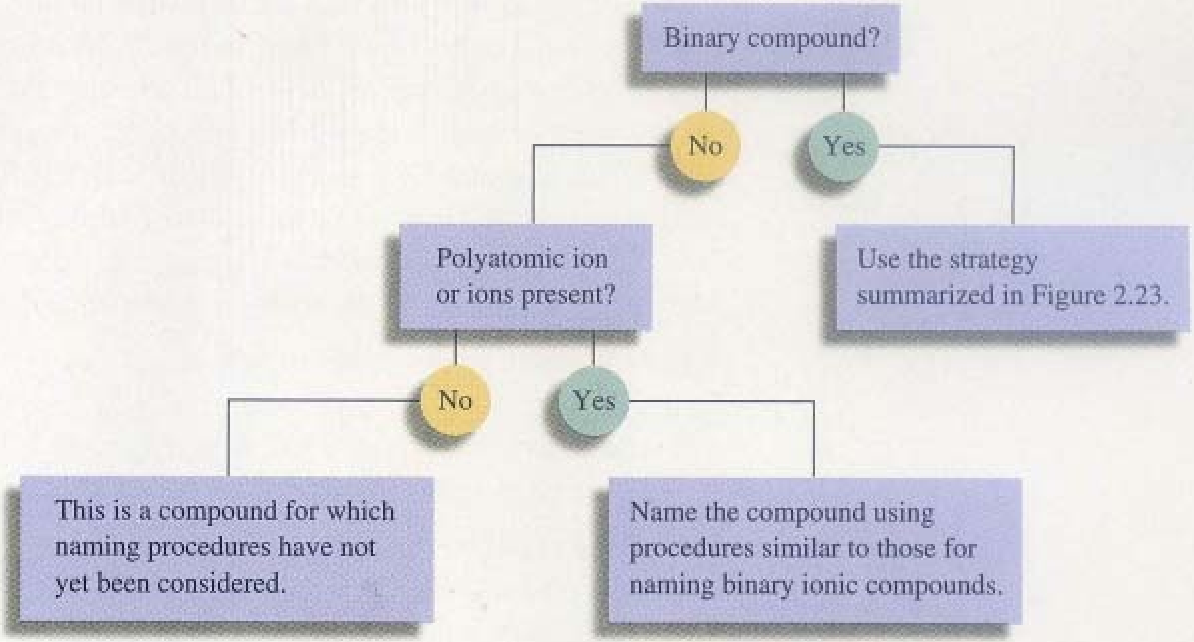
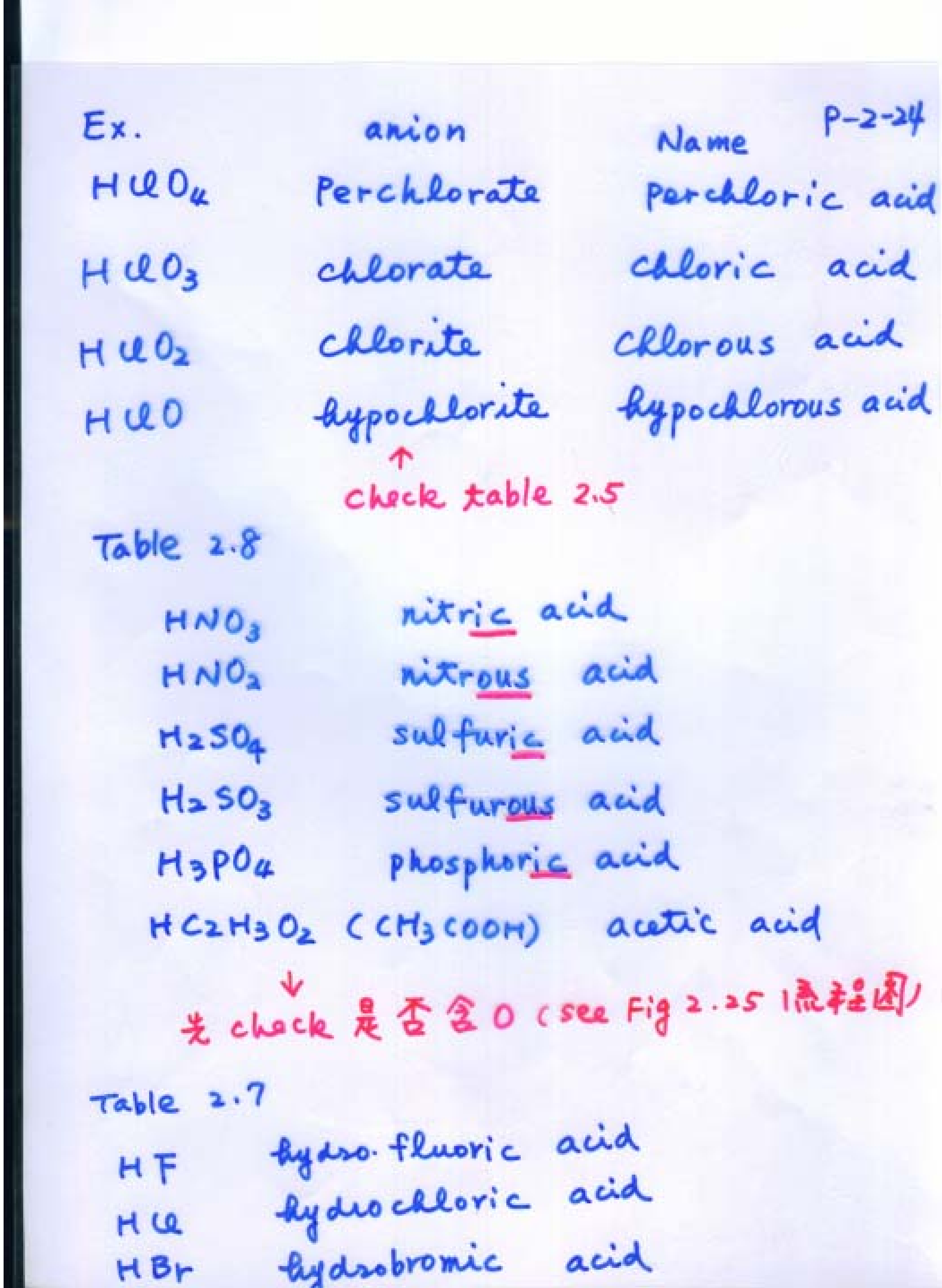


FIGURE 2.24
Overall strategy for naming chemical compounds.



Ex.	anion	Name
$HClO_4$	Perchlorate	perchloric acid
$HClO_3$	chlorate	chloric acid
$HClO_2$	chlorite	chlorous acid
$HClO$	hypochlorite	hypochlorous acid

↑ check table 2.5

Table 2.8

HNO_3	nitric acid
HNO_2	nitrous acid
H_2SO_4	sulfuric acid
H_2SO_3	sulfurous acid
H_3PO_4	phosphoric acid
$HC_2H_3O_2$ (CH_3COOH)	acetic acid

↓
先 check 是否含 O (see Fig 2.25 流程图)

Table 2.7

HF	hydro·fluoric acid
HCl	hydrochloric acid
HBr	hydrobromic acid