臺灣大學化學系 NTU CHEMISTRY

普通化學

蔡蘊明

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1, 2

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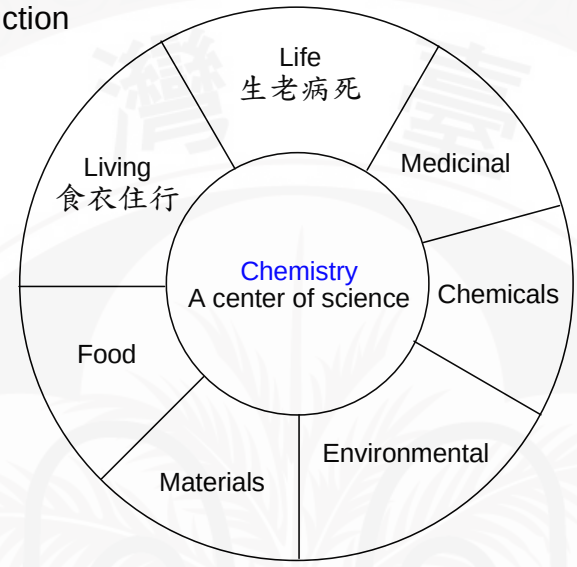
※ Introduction



A science of problem solving

Literature search: understand the structure
the reaction

↓

Identify the mechanism: source of the problem

↓

Propose some solutions

↓

Experiments

Scientific method

1. Observation { Qualitative / Quantitative
2. Hypothesis
3. Prediction
4. Tested by experiments → new observation

⇩

{ Theory – explain what happens (theory may change)
Law – summarizes what happens

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※ Units of measurement

Prefix	Symbol	Exponential Notation
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deka	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
mili	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

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DAILY DOSE

Toxicologically proposed limits on elemental impurities differ among standards groups

ORAL PERMITTED DAILY EXPOSURE (µg/DAY)[a]	USP[b]	ICH[c]	EMA[d]
Arsenic (inorganic)	1.5	15	na
Lead	5	5	na
Mercury (inorganic)	15	40	na
Cadmium	25	5	na
Palladium	100	100	100
Platinum	100	1,000	100
Iridium	100	1,000	100[e]
Osmium	100	1,000	100[e]
Ruthenium	100	1,000	100[e]
Rhodium	100	1,000	100[e]
Molybdenum	100	180	250
Vanadium	100	120	250
Nickel	500	600	250
Copper	1,000	1,300	2,500
Chromium	nc	11,000	250

a Based on a 50-kg (110 lb) person. **b** As of Feb. 1, 2013. **c** As of July 26, 2013. List also includes antimony, barium, cobalt, gold, lithium, selenium, silver, thallium, and tin. **d** EMA 2008 guideline covers metal residues from catalysts and reagents and also includes iron, manganese, and zinc. **e** Total limit for subclass of iridium, ruthenium, rhodium, and osmium. **USP** = U.S. Pharmacopeial Convention. **ICH** = International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for Human Use. **EMA** = European Medicines Agency. **na** = not applicable in this guideline. **nc** = not a safety concern. **SOURCES:** USP, ICH, EMA

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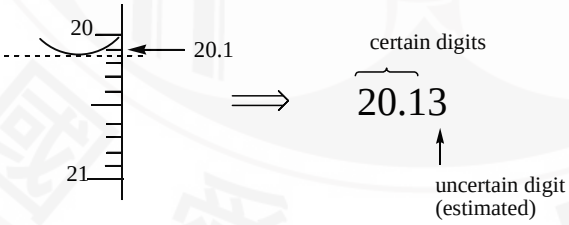
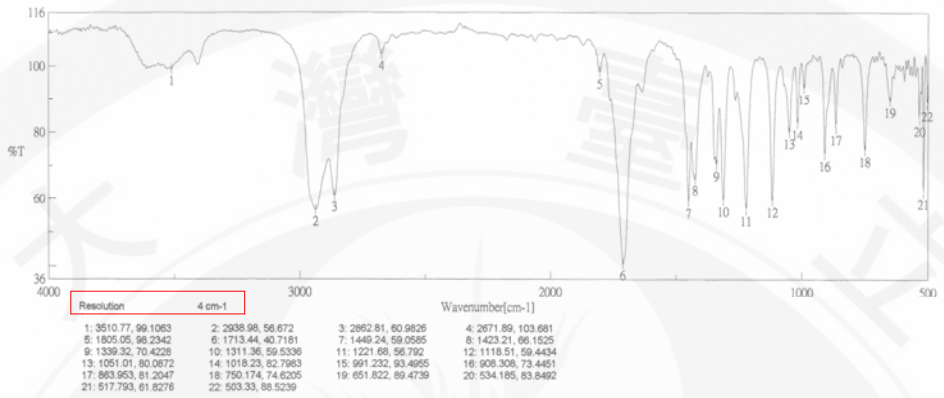
※ Uncertainty in measurement

A measurement always has some degrees of uncertainty



Take only one uncertain digit

An IR spectrum of cyclohexanone



※ Significant figures and calculations

Significant figures (digits)

Rules

1. Nonzero integers: always count

2. Zeros

a. Leading zeros: preceding all the nonzero digits — does not count.

0.0025

b. Captive zeros - count

1.008
↑↑

c. Trailing zeros

2500
↑↑
do not count

25.00
↑↑
count

$2.500 \times 10^3 = 2500.$
↑↑
count

3. Exact numbers

Not obtained using measuring devices
Arise from definition

Infinite number of digits

例： $2\pi r$
↑
Exact number

8 apples

1 in = 2.54 cm
↑
Definition

Mathematical operations

1. ×, ÷

Same as the least precise measurement

$$4.56 \times 1.4 = 6.384 \xrightarrow{\text{corrected}} 6.4$$

(== two) (== two)

四捨五入

2. ＋ , –

$$\begin{array}{r} 12.11 \\ 18.0 \\ 1.013 \\ \hline 31.123 \end{array} \xrightarrow{\text{corrected}} 31.1$$

※ A historical background of chemistry

Early chemistry: Development of technologies
(Experiments)

Ancient Greeks: What is the nature of this world?
萬物的本質為何？

Revolution

1627-1691	Boyle:	Studied gas, combustion….
1743-1794	Lavoisier:	Law of conservation of mass (quantitative analysis)
1754-1826	Proust:	Law of definite proportion (by 1808 generally accepted)

1766-1844 Dalton: Atomic theory (1808)

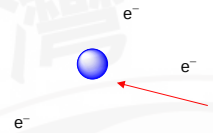
1. Element – composed of atoms
2. Different elements – different atoms
3. Compound – composed of atoms combined in a definite ratio
   Law of multiple proportions
4. Chemical reactions – reorganize atoms

1776-1856 Avogadro: Avogadro hypothesis (1811)
Same T, P
Equal volumes of different gases contain the same # of particles

1826-1910 Cannizaro: Unified atomic weight (1860)
1869 Mendeleev: Periodic table

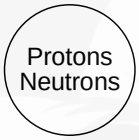
1856-1940 J. J. Thomson: Study of cathode rays
→ electrons

1906 Rutherford: Atomic model



Tiny heavy nucleus
with positive charge

Modern views



Electrons

Representation:

mass number → $^{23}_{11}Na$

atomic number →

Molecules: Atoms combined through chemical bonds
Ions: Cations (ex. Na^+)
Anions (ex. Cl^-)

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※ Naming simple compounds

(nomenclature)

統一命名法則： IUPAC systematic nomenclature

↑國際化學與化工學會
International Union of Pure
and Applied Chemistry

◎ Type I：binary ionic compounds 離子化合物

$M^+ A^-$

M^+ ： metal cation 金屬陽離子(只有一種型態者)

A^- ： anion 陰離子

Rules：

1. cation 的名稱在前。
2. cation 的名稱取其原子的名稱。
   例如： NaCl sodium chloride
3. anion 的名稱在後，取 -ide 的字尾。
   上例： chlorine ⇨ chloride

Some common cations and anions

H^+	hydrogen	H^-	hydride
Li^+	lithium	OH^-	hydroxide
Na^+	sodium	F^-	fluoride
K^+	potassium	Cl^-	chloride
Mg^{2+}	magnesium	Br^-	bromide
Ca^{2+}	calcium	I^-	iodide
Ba^{2+}	barium	O^{2-}	oxide
Al^{3+}	aluminum	S^{2-}	sulfide
		N^{3-}	nitride

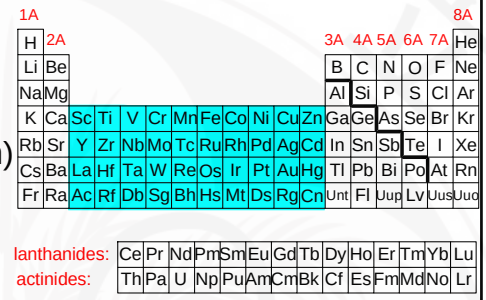
Li_3N	lithium nitride	(氮：nitrogen)
MgO	magnesium oxide	(氧：oxygen)

◎ Type II：binary ionic compounds
cation with more than one type of charge

例如： $Fe(II)Cl_2$, $Fe(III)Cl_3$

$FeCl_2$ 系統命名： iron(II) chloride 俗名： ferrous chloride
$FeCl_3$ 系統命名： iron(III) chloride 俗名： ferric chloride
俗名規則：-ous 爲電荷較低者，-ic 爲電荷較高者

△ 一些常見的 type I 陽離子
IA, IIA 族陽離子
IIIA 族的 Al^{3+} (aluminum)
過渡族金屬的 Zn^{2+}, Ag^+
(Zn: zinc; Ag: silver)



△ 一些常見的 type II 陽離子

Cu^+： cuprous
Sn^{2+}： stannous
Hg_2^{2+}： mercurous

Cu^{2+}： cupric
Sn^{4+}： stannic
Hg^{2+}： mercuric

例 Al_2O_3 aluminum oxide
only one type of charge
$CoBr_2$ cobalt(II) bromide

△ polyatomic anions

SO_4^{2-}： sulfate (硫酸根)
SO_3^{2-}： sulfite (亞硫酸根)

規則：-ate 爲氧數目較多者，-ite 爲氧數目較少者。

ClO^-： hypochlorite (次氯酸根)
ClO_2^-：chlorite (亞氯酸根)
ClO_3^-：chlorate (氯酸根)
ClO_4^-：perchlorate (過氯酸根)
規則：hypo 有氧數目過少之意，per 有氧數目過多之意。

NO_3^-： nitrate (硝酸根)
NO_2^-： nitrite (亞硝酸根)

PO_4^{3-}： phosphate (磷酸根)
HPO_4^{2-}：hydrogen phosphate
$H_2PO_4^-$：dihydrogen phosphate

CO_3^{2-}： carbonate (碳酸根)
HCO_3^-： hydrogen carbonate (亦稱 bicarbonate)

O_2^{2-}： peroxide (過氧根)

△ Polyatomic cation

NH_4^+ ammonium ion
例 NH_4Cl ammonium chloride

△ 一些表示數目的字頭(prefix)

mono-	1
di-	2
tri-	3
tetra-	4
penta-	5
hexa-	6
hepta-	7
octa-	8

◎ Type III：binary covalent compounds
contain two nonmetals

命名法則與離子化合物命名法類似

N_2O dinitrogen monoxide (俗名：nitrous oxide)
NO nitrogen monoxide (or oxide) (俗名：nitric oxide)
NO_2 nitrogen dioxide
N_2O_3 dinitrogen trioxide
N_2O_4 dinitrogen tetraoxide
N_2O_5 dinitrogen pentaoxide

注意： monooxide 而非 monoxide (N_2O and NO are exception)
pentaoxide而非 pentoxide
mono never used for the first element

◎ Acids (酸)

△ Without oxygen

HCl hydrochloric acid (又名 hydrogen chloride)
H_2S hydrosulfuric acid (又名 hydrogen sulfide)
HCN hydrocyanic acid (又名 hydrogen cyanide)

△ With oxygen

SO_4^{2-}： sulfate H_2SO_4： sulfuric acid
SO_3^{2-}： sulfite H_2SO_3： sulfurous acid

HNO_3： nitric acid
HNO_2： nitrous acid

HClO： hypochlorous acid (次氯酸)
$HClO_2$：chlorous acid (亞氯酸)
$HClO_3$：chloric acid (氯酸)
$HClO_4$：perchloric acid (過氯酸)