

§ 2-3 Introduction to the Periodic Table

1869 D. Mendeleev (俄): 以原子量大小排列.

1870 L. Meyer (德): 以原子量大小排列.

1912 Moseley 莫子立: 以原子序排列.

Arranged the known elements in order of increasing atomic number from left to right and from top to bottom in groups. Elements that tend to most closely resemble each other are arranged in the same vertical group.

Legend:

- Metals (Yellow)
- Nonmetals (Purple)
- Noble gases (Brown)

Callout for Iron (Fe):

- 26 — Atomic number, Z
- Fe — Chemical symbol
- 55.847 — Atomic mass (weighted average)

	1A		2A										3A	4A	5A	6A	7A	8A
1	H																	He
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg	3B	4B	5B	6B	7B	8B	1B	2B		Al	Si	P	S	Cl	Ar	
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	Ac†	Rf	Db	Sg	Bh	Hs	Mt	Ds	**	**						

*Lanthanide series	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
†Actinide series	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

** Not yet named

Except for hydrogen, those elements to the left of the line are **metals**

Elements to the right of the line are **nonmetals**

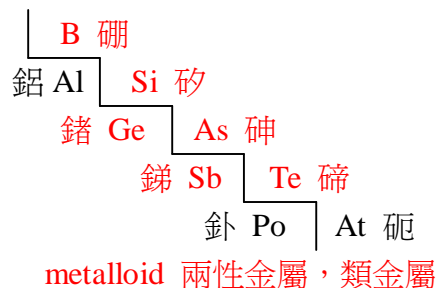
Elements around the line are referred to as **metalloids**

	1												17				18	
1	1																1	2
	H																H	He
2	3	4											5	6	7	8	9	10
	Li	Be											B	C	N	O	F	Ne
3	11	12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Na	Mg											Al	Si	P	S	Cl	Ar
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	55	56	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

Metals
 Metalloids
 Nonmetals

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週期表之相關知識:



週期表:

→ 行 (The horizontal rows) are periods 週期, 共七週期

↓ 列 (The vertical columns) are groups 族, 共 18 族

Group A: Elements falling in Groups 1 (alkali metals), 2 (alkaline earth metals), 13, 14, 15, 16, 17 (halogens), 18 (noble **【unreactive】** gases).

Elements in the same main group show very similar chemical properties.

Group B: In the periods 4 through 6 are called transition metals. They fall in groups 3-12.

週期表之應用:

1. 方便比較, 記憶
2. 命名之依據
3. 幫助研究
4. 解決疑慮
5. 推測新元素之成立與否

第七週期最後一元素原子序: 118 (1)鈍氣 (2)放射性元素 (3)人造元素.

最活潑金屬: Fr.

最活潑非金屬: F.

$_{83}\text{Bi}$ 以上為放射性元素.

氣態: $\text{H}_2, \text{N}_2, \text{O}_2, \text{F}_2, \text{Cl}_2, \text{He}, \text{Ne}, \text{Ar}, \text{Kr}, \text{Xe}, \text{Rn}$ 共 11 種

液態: Hg, Br_2 .

§ 2-4 Molecules and Ions

Isolated atoms rarely occur in nature:

⇒ only the noble gases: *He, Ne, Ar, Kr, Xe, Rn.*

Atoms tend to combine with one another in various ways to form more complex structural units. ⇒ molecules and ions.

Molecules :

Two or more atoms may combine with one another to form an uncharged molecule.

⇓

Nonmetallic element + nonmetallic element

⇓

Intramolecular force 分子內作用力: covalent bonds; bond energy $> 50 \text{ kcal/mol}$

⇓

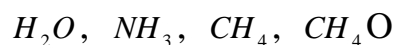
Share pairs of electrons. 例: $\text{Ti} - \text{O} : 160 \text{ kcal/mol}$

Intermolecular force : 分子分子間作用力;

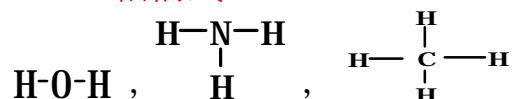
van der Waals force: $2 - 10 \text{ kcal/mol}$

化學式表示方式 :

1. molecular formulas 分子式 :



2. Structural formulas 結構式:



3. Condensed structural formulas: Rational formula 示性式

Suggests the bonding pattern in the molecule and highlights the presence of a reactive group of atoms within the molecules.

⇓

一般用“官能基”表示有機化合物



官能基 (functional group): 具有特殊反應性之原子或原子團.

Ex 2-2: Give the molecular formulas of a) Ethyl alcohol and b) Ethylamine.

Sol:



4. Empirical formula 實驗式:

分子式 = (實驗式)_n

乙烷 C_2H_6 ; 實驗式 $\Rightarrow CH_3$

5. Electronic formula 電子式:



雙原子分子: $H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2, At_2$.

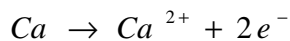
多原子分子: P_4, S_8 .

§ Ions :

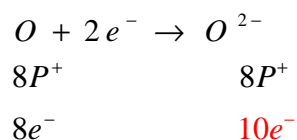
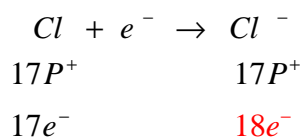
When an atom loses or gains electrons, it forms charged particles called ions.

Cation 陽離子: Metal atoms typically tend to lose electrons to form positively

charged ions.



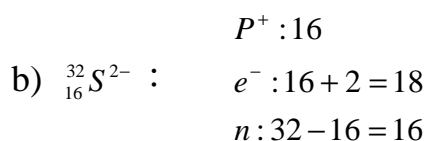
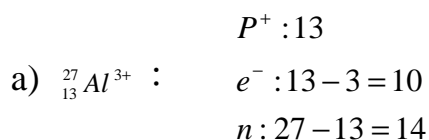
Anion 陰離子: Nonmetal atoms form negative ions by gaining electrons.



Ex 2-3: Give the number of protons, neutrons and electrons ?



Ans:



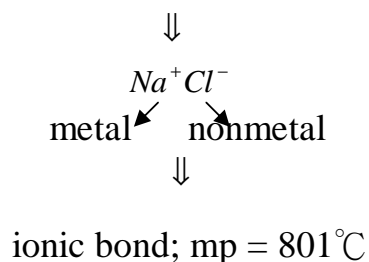
離子固體種類： 單原子離子 monatomic Na^+Cl^- $Ca^{2+}Cl_2^-$

多原子離子 polyatomic $NH_4^+ OH^-$

↓
 氫氧化銨; 原子原子間: 共價鍵

§ Ionic compounds:

Ionic compounds are held together by strong electrical force between oppositely charged ions.



§ Strong electrolyte 強電解質: A substance in the melt state or dissolved in water can conduct the electric current.

non electrolyte 非電解質: 一物質之熔融狀態 or 水溶液不可導電者.

§ 2-5 Formulas of ionic compounds:

The total positive charge of the cations in the formula must equal the total negative charge of the anions. 正電數 = 負電數

Na^+Cl^- $Ca^{2+}Cl_2^-$
metal 寫前面, nonmetal 寫後面, 且總電荷 = 0

Ex : $CaCl_2$ indicating that the simplest ratio of Cl^- and Ca^{2+} ions is 2 : 1.

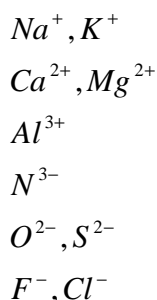
§ Cations and Anions with Nobel-gas structure

最外圍電子達到鈍氣組態 ⇒ 八隅體 (Octet rule)

Octet rule 八隅體理論 :

With the exception of helium, the outmost shell of all the other noble gases (Ne, Ar, Kr, Xe and Rn) has an s^2p^6 electron configuration, which has high chemical stability.

所形成的離子，本身所擁有電子數，應與其最接近的 Nobel-gas 所含之電子數相同



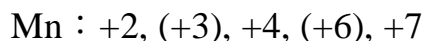
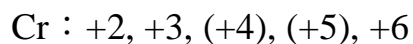
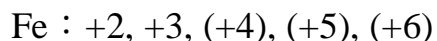
§ Cations of the transition and post-transition metals

過渡 後 過渡

transition 第 3 ~ 12 族金屬 (B 族元素)

post-transition metals 第 13 ~ 15 族金屬

過渡金屬有一種以上之氧化數;一般命名時需標示之.



Ex 2-5 : Predict the formula of the ionic compound:

a) formed by barium with iodine. $\Rightarrow \text{BaI}_2$

b) containing a transition metal with +1 charge in period 4 and Group 11 and oxide ions. $\Rightarrow \text{Cu}^+$ and oxide ions $\Rightarrow \text{Cu}_2\text{O}$

c) containing an alkaline earth in period 5 and nitrogen.
 $\Rightarrow \text{Sr}^{2+}$ and $\text{N}^{3-} \Rightarrow \text{Sr}_3\text{N}_2$

d) containing ammonium and phosphate ions.
 $\Rightarrow \text{NH}_4^+$ and 磷酸根 $\text{PO}_4^{3-} \Rightarrow (\text{NH}_4)_3\text{PO}_4$

§ Polyatomic ions 多原子離子

- 陽離子 cations : 僅有 NH_4^+ 及 Hg_2^{2+} 二種, 其餘皆為單原子金屬離子
- 陰離子 anions : 多為含氧之陰離子 \Rightarrow 統稱 oxoanions 含氧陰離子

表 2.3 N, S, Cl 之含氧多原子離子 :

NO_3^- nitrate 硝酸根離子	NO_2^- nitrite 亞硝酸根離子
SO_4^{2-} sulfate 硫酸根離子	SO_3^{2-} sulfite 亞硫酸根離子
ClO_4^- perchlorate 過氯酸根離子	ClO_3^- chlorate 氯酸根離子
ClO_2^- chlorite 亞氯酸根離子	ClO^- hypochlorite 次氯酸根離子

§ 2.6 Names of Compounds

單原子 ions :

Cations :

Na^+ sodium K^+ potassium
 Fe^{2+} iron(II) Fe^{3+} iron(III)

Anions :

N^{3-} nitride	O^{2-} oxide	H^- hydride
	S^{2-} sulfide	F^- fluoride
	Se^{2-} selenide 硒	Cl^- chloride
	Te^{2-} telluride 碲	Br^- bromide
		I^- iodide

§ Ionic compounds

$NaCl$ 氯化鈉 sodium chloride 中英文顛倒

$Cr(NO_3)_3$ 硝酸鉻 chromium(III) nitrate 順序

$SnCl_2$ 氯化亞錫 tin(II) chloride

Ex 2-6 : Name the following ionic compounds :

- a) CaS calcium sulfide 硫化鈣
b) $Al(NO_3)_3$ aluminum nitrate 硝酸鋁
c) $FeCl_2$ iron(II) chloride 氯化亞鐵

§ Binary molecular compounds

由二種非金屬相互結合所產生化合物

2	di
3	tri
4	tetra
5	penta
6	hexa
7	hepta
8	octa
9	nona
10	deca

Ex 2-7 :

- a) SO_2 sulfur dioxide
- b) SO_3 sulfur trioxide
- c) PCl_3 phosphorus trichloride
- d) Cl_2O_7 dichlorine heptaoxide

§ Acids

A few binary molecular compounds containing H atoms ionize in water to form H^+ ions. These are called acids.

Pure substance		Water solution	
HCl (g)	Hydrogen chloride	H^+Cl^- (aq)	Hydrochloric acid
HBr (g)	Hydrogen bromide	H^+Br^- (aq)	Hydrobromic acid
HI (g)	Hydrogen iodide	H^+I^- (aq)	Hydroiodic acid

Ex 2-8

- a) HCl(g) hydrogen chloride gas 氯化氫氣體
- b) HNO_2 nitrous acid 亞硝酸 (HNO_3 nitric acid 硝酸)
- c) H_2SO_3 sulfurous acid 亞硫酸 (H_2SO_4 sulfuric acid 硫酸)
- d) HIO hypoiodous acid 次碘酸