1 Chemists and Chemistry

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化學是研究物質的組成、性質、製備及其應用的科學

Chemistry is the study of the compositions, preparations, properties of substances and its applications

Geochemistry

Study the composition, structure, processes, and other physical aspects of the Earth

Understand geochemical information and make informed decisions on a range of industrial and scientific research applications

(From American Chemical Society, https://www.acs.org/content/acs/en/careers/college-to-career/chemistry-careers/geochemistry.html)

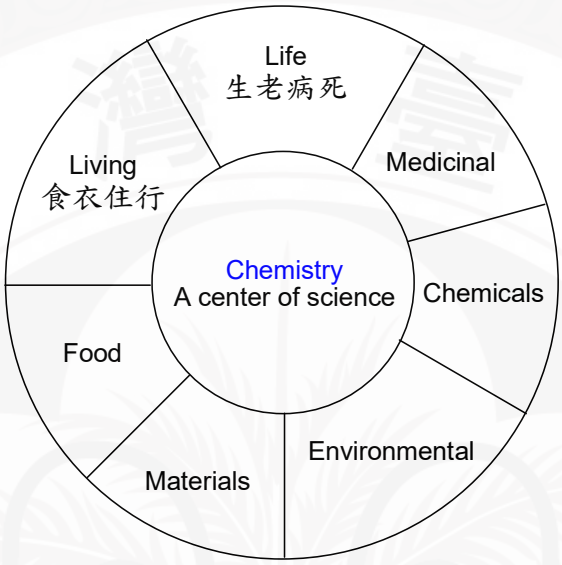
Atmospheric chemistry

Study problems such as acid rain, ozone depletion, photochemical smog, greenhouse gases and global warming

Related to environmental chemistry, oceanography, geology, climatology, etc.

(https://en.wikipedia.org/wiki/Atmospheric_chemistry, CC BY-SA 3.0)

※ Introduction



What is science?

Any system of knowledge that is concerned with the physical world and its phenomena and that entails unbiased observations and systematic experimentation. In general, a science involves a pursuit of knowledge covering general truths or the operations of fundamental laws.

– from Encyclopedia Britannica

任何與物理世界及其現像有關的知識體系，需要無偏見的觀察和有系統的實驗。一般而言，科學涉及追求有關普遍的真理或基本定律運作的知識。

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

⇓

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

◎ Industrial chemistry

Isolation of natural product as raw material
Process raw material → commercial product
The use of chemicals

Economy and safety are critical

Research in industrial chemistry

1. Identify a need
2. Develop a process
3. Evaluation: efficiency, cost, ease of production, safety, environmental impact
4. Pilot plant

↓

Real production

It's no secret that the COVID-19 pandemic has thrown the global economy into the deepest recession in decades, wrecking big chemical end markets such as automotive, aerospace, and oil exploration.

(C&EN, Volume 98, Issue 29, 2020)

Global Top 50

With last year's number 1—DowDuPont—gone, BASF regains the top

RANK 2019	RANK 2018[a]	COMPANY	CHEMICAL SALES ($ MILLIONS)	CHANGE FROM 2018	CHEMICAL SALES AS % OF TOTAL SALES	HEAD-QUARTERS
1	1	BASF	$66,401	–5.4%	100.0%	Germany
2	2	Sinopec	61,596	–7.0	14.7	China
3	—	Dow	42,951	–13.4	100.0	US
4	4	Sabic	34,420	–18.3	92.4	Saudi Arabia
5	6	Ineos	32,009	–8.6	100.0	UK
6	5	Formosa Plastics[e]	31,425	–16.5	66.7	Taiwan

c&en's GLOBAL TOP 50

The industry is recovering from the COVID-19 pandemic

ALEX TULLO, C&EN STAFF

The global chemical industry made it through the worst of the COVID-19 pandemic with scratches and abrasions but few broken bones.

According to data from C&EN's Global Top 50 survey, the world's largest chemical firms posted a 7.1% decline in chemical sales from 2019, to $795.8 billion in 2020, the fiscal year on which the survey is based.

RANK 2020	RANK 2019[a]	COMPANY	CHEMICAL SALES ($ MILLIONS)	CHANGE FROM 2019	CHEMICAL SALES AS % OF TOTAL SALES	HEAD-QUARTERS	CHEMICAL OPERATING PROFIT[b] ($ MILLIONS)	CHANGE FROM 2019
1	1	BASF	$67,491	–0.3%	100.0%	Germany	$4,904	–11.8%
2	2	Sinopec	46,656	–24.3	15.7	China	1,502	–37.5
3	3	Dow	38,542	–10.3	100.0	US	2,556	–27.4
4	6	Ineos	31,310	–4.0	100.0	UK	1,697	–32.8
5	4	Sabic	28,792	–16.4	92.3	Saudi Arabia	1,609	–62.4
6	5	Formosa Plastics[a]	27,711	–16.0	72.4	Taiwan	n/a	n/a
7	12	LG Chem	25,477	5.1	100.0	South Korea	1,523	100.8

6 Formosa Plastics

▶ **2020 chemical sales:** $27.7 billion

The $9.4 billion petrochemical complex that Formosa Plastics is planning in St. James Parish, Louisiana, is in hot water. It faces fierce opposition both locally from community organizations worried about pollution and nationally from environmental groups that wish to stop the mounting production of plastics. Sharon Lavigne, head of the local group Rise St. James, recently received the prestigious Goldman Environmental Prize for her efforts, a sign that the Formosa project has high-profile opposition. The project also faces practical hurdles. Notably, the US Army Corps of Engineers suspended a permit for the facility in November. Formosa Plastics had better luck in Point Comfort, Texas, where it started up an ethylene cracker and low-density polyethylene unit last year.

※ Units of measurement

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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}

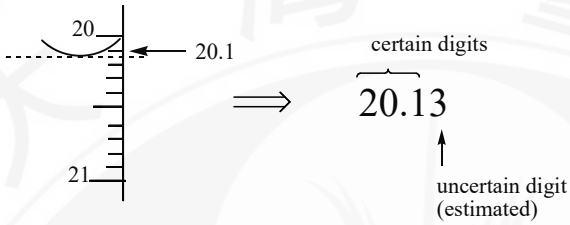
Angstrom: Å

1 Å = 10^{-10} m

= 0.1 nm

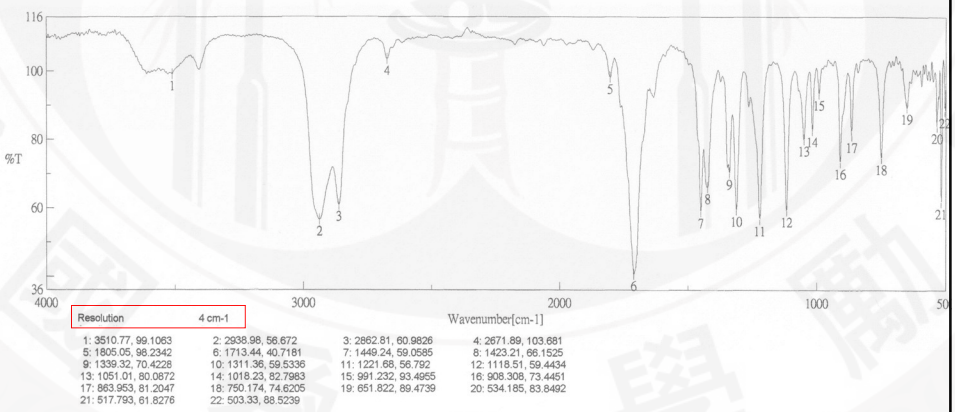
※ Uncertainty in measurement

A measurement always has some degrees of uncertainty



Take only one uncertain digit

An IR spectrum of cyclohexanone



※ Precision and accuracy

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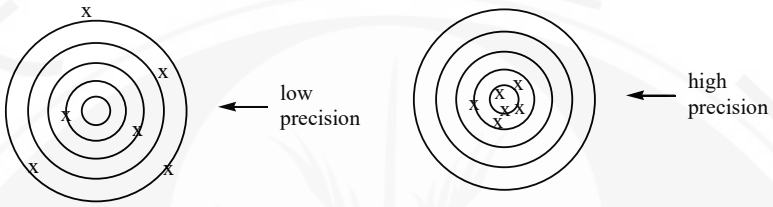
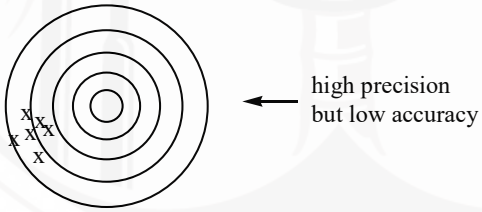
Precision (精確度): The degree of agreement among several measurements.



The error is called random error or indeterminate errors (非定向的)

Accuracy (準確度): Agreement with the true value



The error is called systematic error or determinate error

Ex.

Weighting	Result
1	2.486
2	2.487
3	2.485
4	2.484
5	2.488

Avg: 2.486 ⇨ Without systematic error, this value is the closest to the true value.

May be recorded as 2.486 ± 0.002

※ Significant figures and calculations

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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

Ex. $2\pi r$

Exact number

8 apples

1 in = 2.54 cm

Definition

Mathematical operations

1. ×, ÷

Same as the least precise measurement

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

(1.4: two; 6.4: two)

四捨五入

2. ＋, –

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

Chapter 1: Chemists and Chemistry

Source:

- Geochemistry (defintion), https://www.acs.org/content/acs/en/careers/chemical-sciences/fields/geochemistry.html, fair use.
- Atmospheric chemistry (definition), https://en.wikipedia.org/wiki/Atmospheric_chemistry, CC BY-SA 3.0
- What is science (definition), https://www.britannica.com/science/science, fair use