# BAB I
# Materi dan Perubahannya

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Jurdik Kimia FMIPA
Disampaikan oleh :
Dr. Kun Sri Budiasih

1. Properties of Matter
2. Changes in Matter
3. Clasification of Matter
4. Elements and Compounds
5. Mixture and solution

# 1. PROPERTIES OF MATTER

**Tujuan :**

- **Identify** the characteristics of a substance.
- **Distinguish** between physical and chemical properties.
- **Differentiate** among the physical states of matter.

# Some Criteria for the Classification of Matter

- Properties
- State (solid, liquid, gas)
- Composition

# Properties

- **Physical**: observed without changing the composition of the substance.
- **Chemical**: the ability of a substance to undergo a specific chemical change

Tabel 4.4. Perbedaan perubahan fisika dengan perubahan kimia.

| Perubahan Fisika | Perubahan Kimia |
|---|---|
| • Tidak terbentuk zat yang jenisnya baru.<br>• Reversibel.<br>• Tidak terjadi reaksi kimia. | • Terbentuk zat yang jenis-nya baru.<br>• Irreversibel.<br>• Terjadi reaksi kimia, ditandai dengan pembentukan gas, endapan, warna, dan perubahan energi. |

# Examples of Physical Properties

- Color, odor, hardness, density, melting point, boiling point, state, solubility.

# Example: Physical Properties

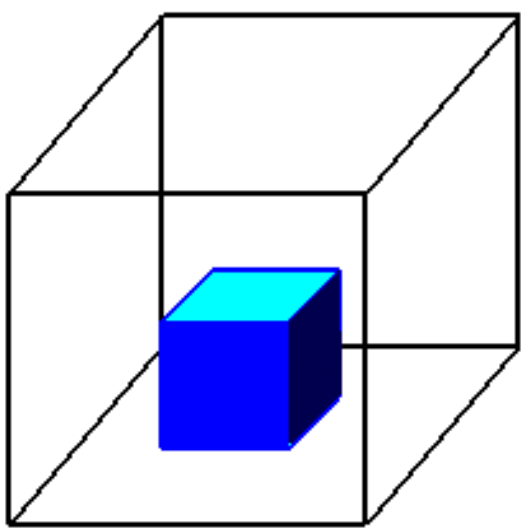
| Substance | | State | Color | Melting Point (C°) | Boiling Point (C°) | Density ($g/cm^3$) |
|---|---|---|---|---|---|---|
| Oxygen | $O_2$ | Gas | Colorless | -218 | -183 | 0.0014 |
| Mercury | Hg | Liquid | Silvery-white | -39 | 357 | 13.5 |
| Bromine | $Br_2$ | Liquid | Red-brown | -7 | 59 | 3.12 |
| Water | $H_2O$ | Liquid | Colorless | 0 | 100 | 1.00 |
| Sodium Chloride | NaCl | Solid | White | 801 | 1413 | 2.17 |

# States of Matter

- Solid : fixed shape and volume, incompressible
- Liquid : fixed volume, takes the shape of its container
- Gas : takes the volume and shape of its container

# States of Matter

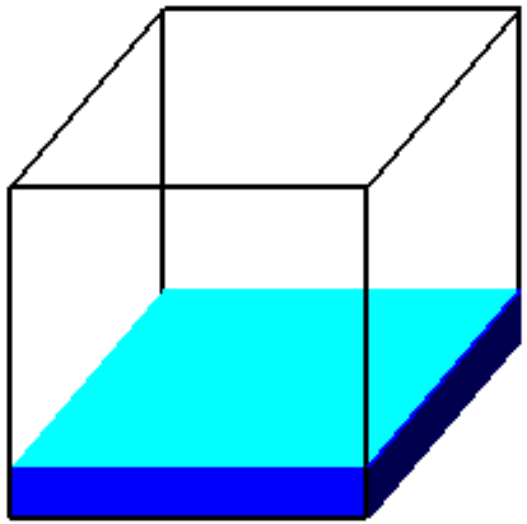
Glenn Research Center



## Solid

Holds Shape

Fixed Volume

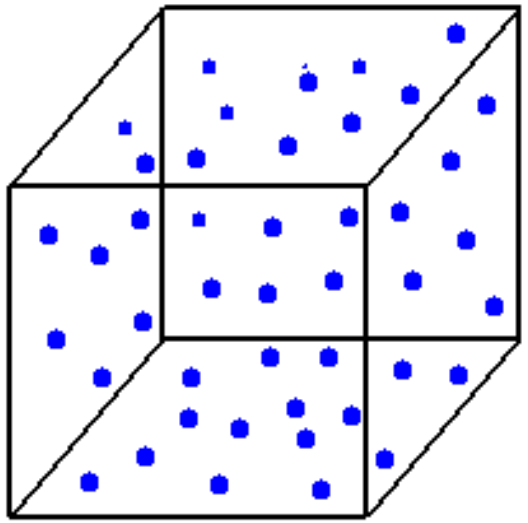


## Liquid

Shape of Container

Free Surface

Fixed Volume

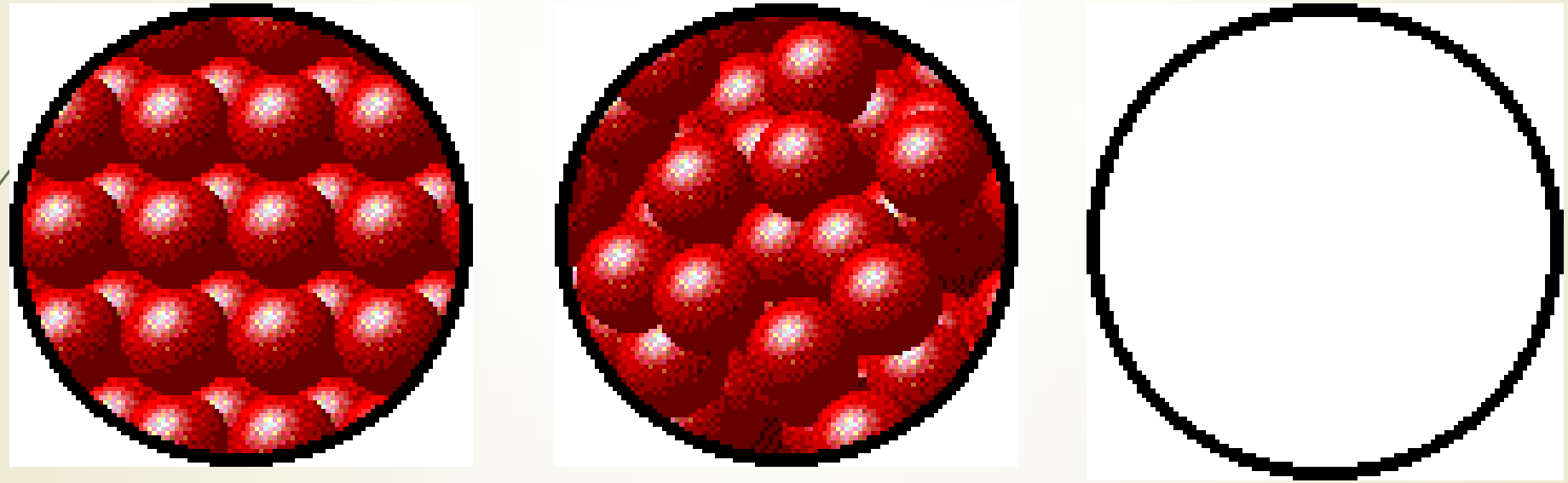


## Gas

Shape of Container

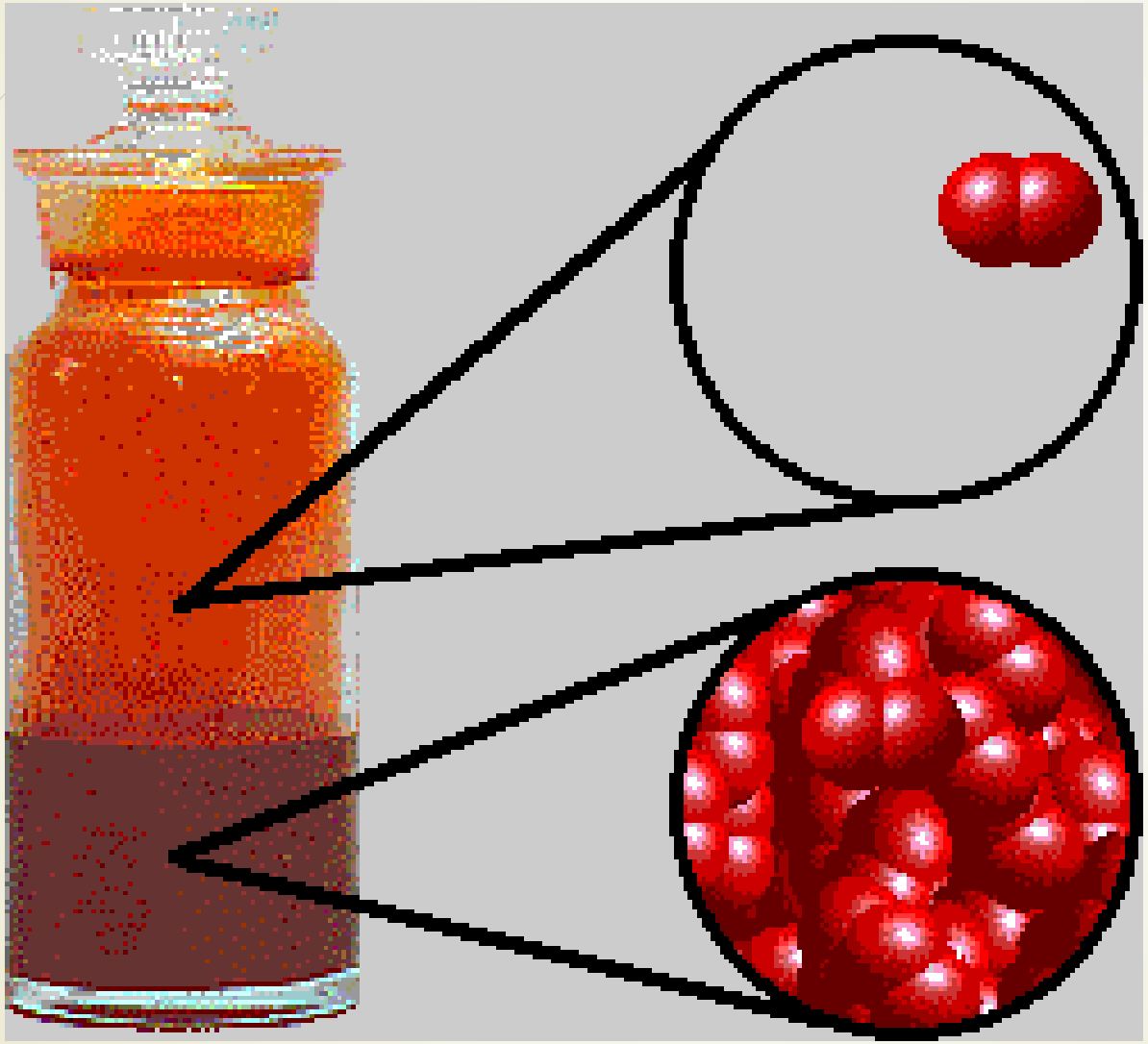
Volume of Container

Solid Liquid Gas



http://www.chem.purdue.edu/gchelp/atoms/states.html

# Bromine



Gas
(Vapor)

Liquid

# Perubahan Materi

- PERUBAHAN FISIKA
- PERUBAHAN KIMIA

# Physical Changes

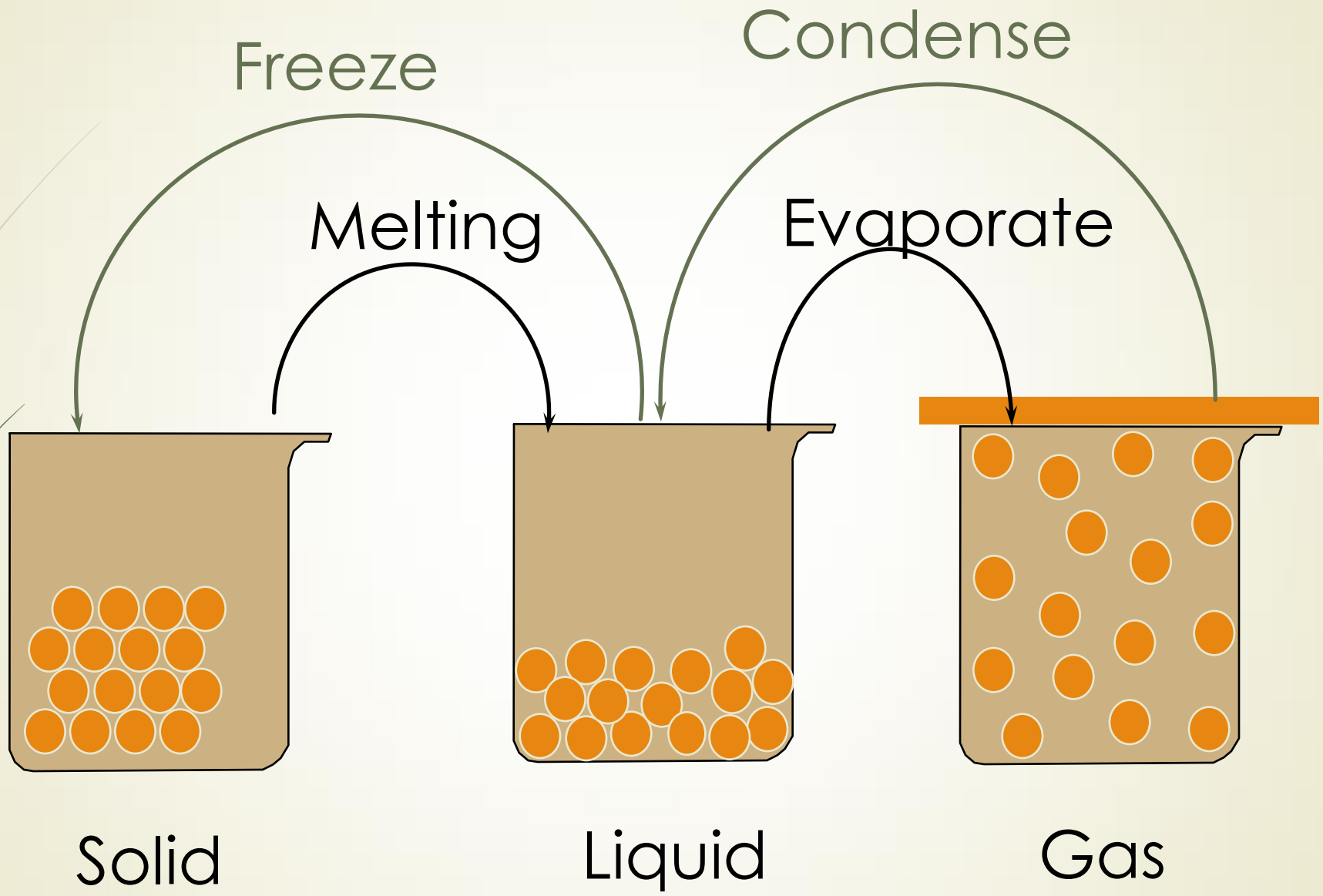
- a change in the physical properties of a substance.
- Composition does not change.
- May be reversible or irreversible.

**Melting** solid → liquid
**Condensation** gas → liquid

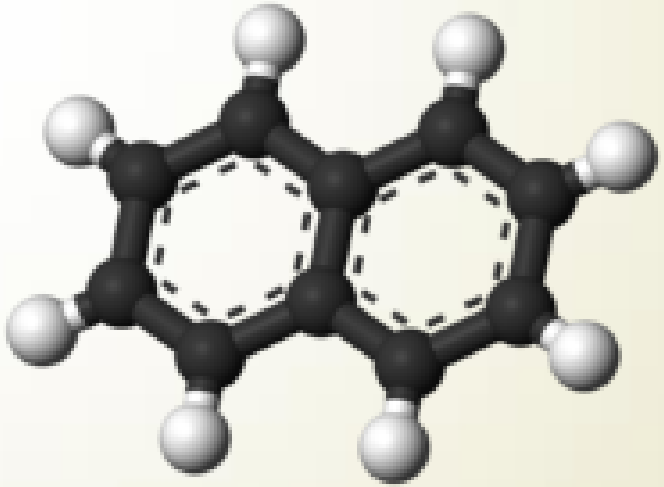
**Freezing** liquid → solid

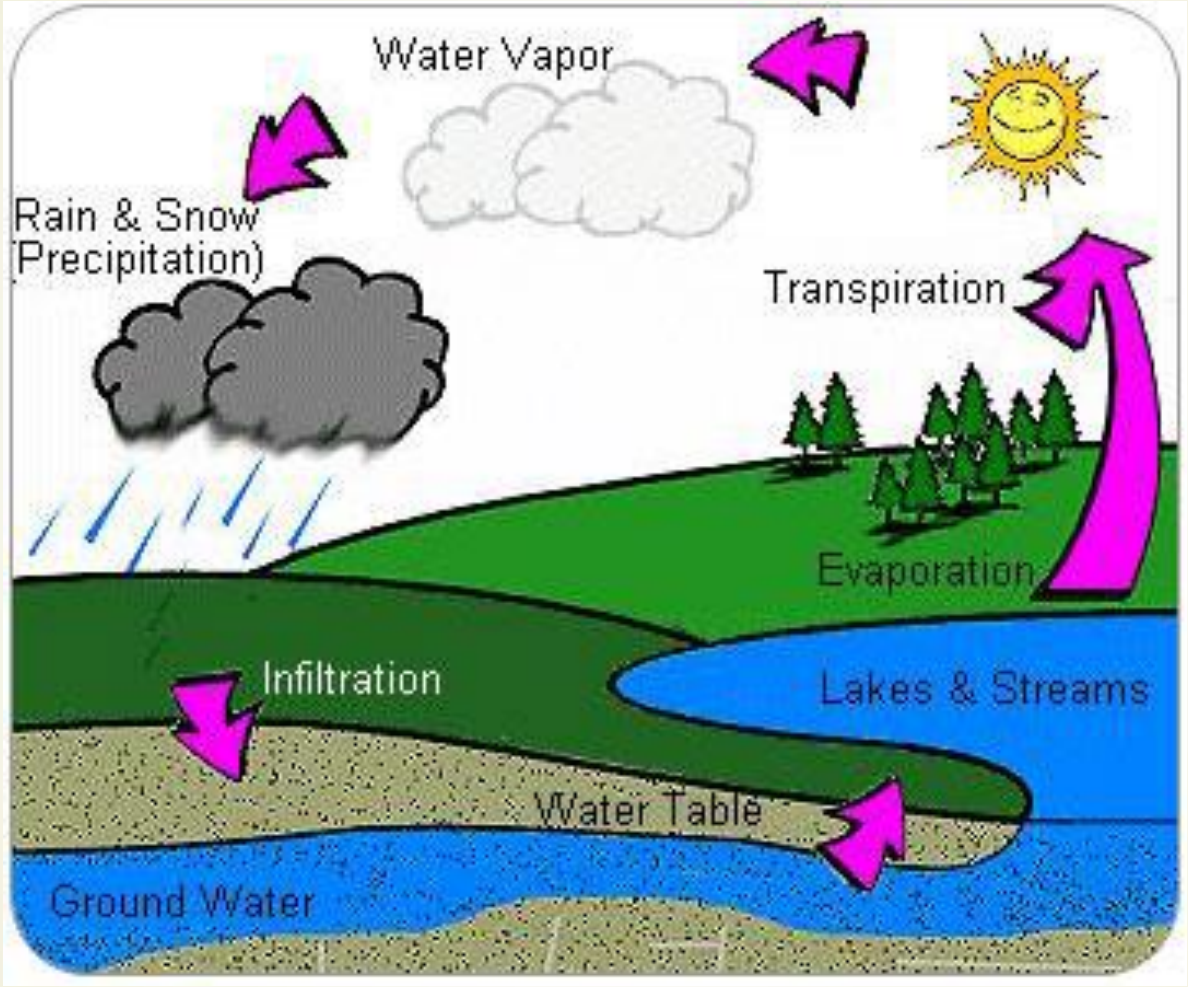
**Evaporation** liquid → gas
**Sublimation** solid → gas

**Boiling:** Evaporation occurring beneath the liquid's surface.


Freeze
Condense
Melting
Evaporate
Solid
Liquid
Gas


happy choice
나프탈렌
Moth Repellent




Water Vapor
Rain & Snow
(Precipitation)
Transpiration
Evaporation
Infiltration
Lakes & Streams
Water Table
Ground Water

# Chemical Change

- A change that produces matter with a different composition than the original matter.
- Atoms rearrange themselves into new combinations.

# Chemical Properties

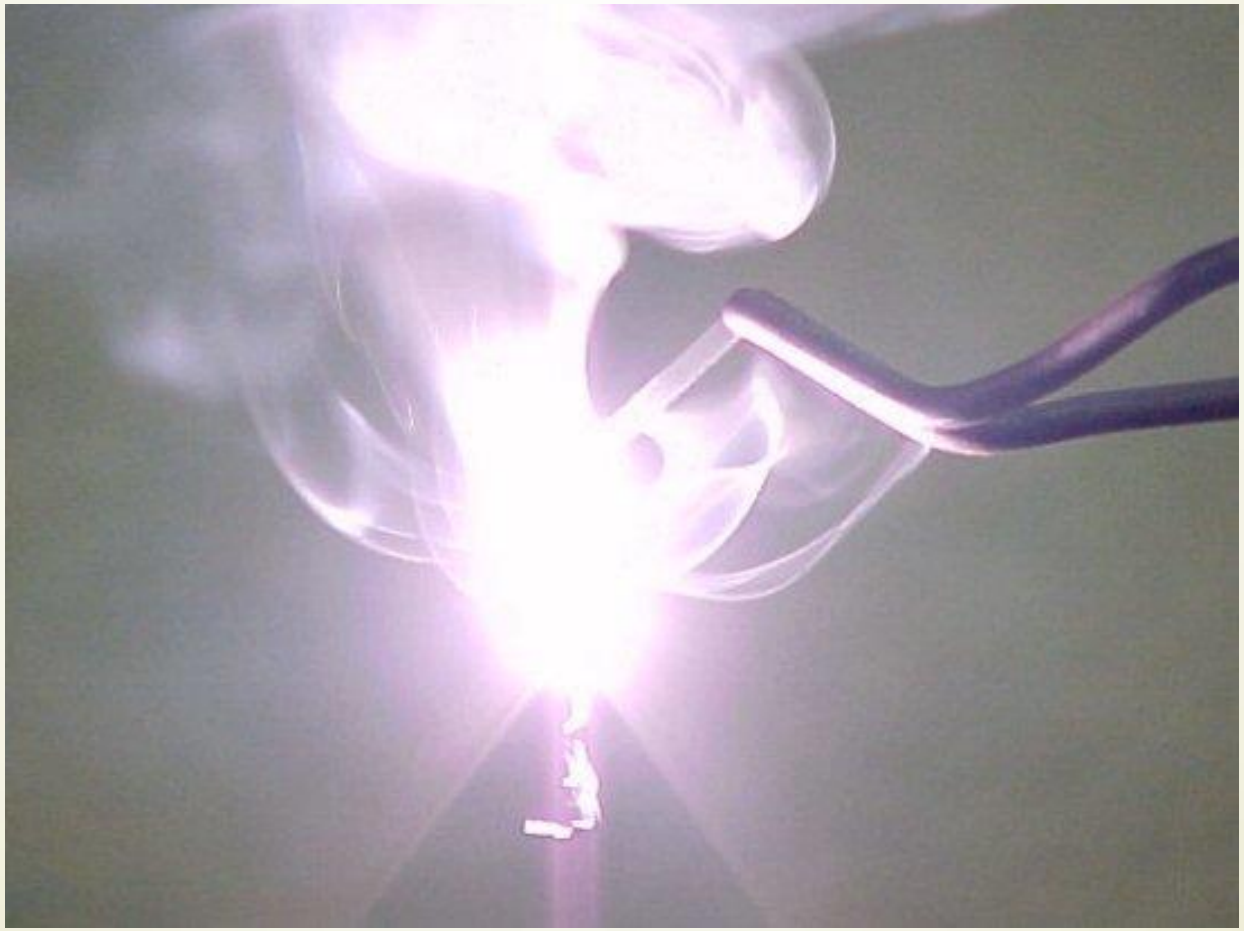
- The ability of a substance to transform into a new substance (to undergo a chemical change).

- Example: Magnesium reacts with oxygen to form magnesium oxide.

# Magnesium Mg

# Burning of Magnesium

$2Mg + O_2 \rightarrow 2MgO$

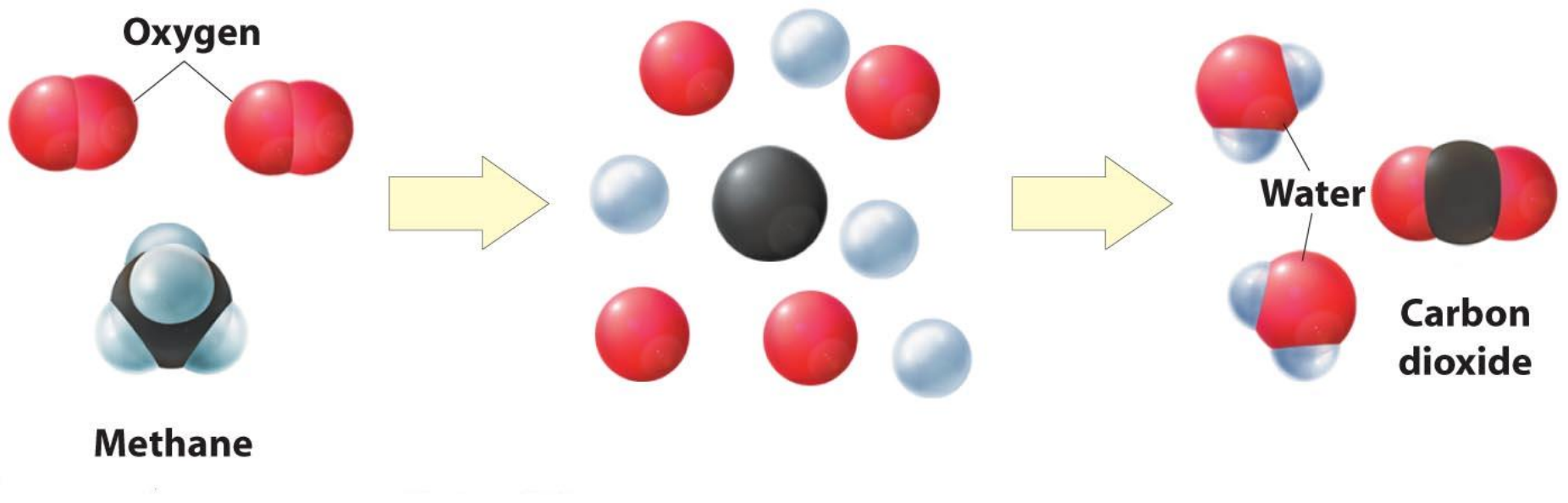


# Burning of Methane

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

# Burning of Methane

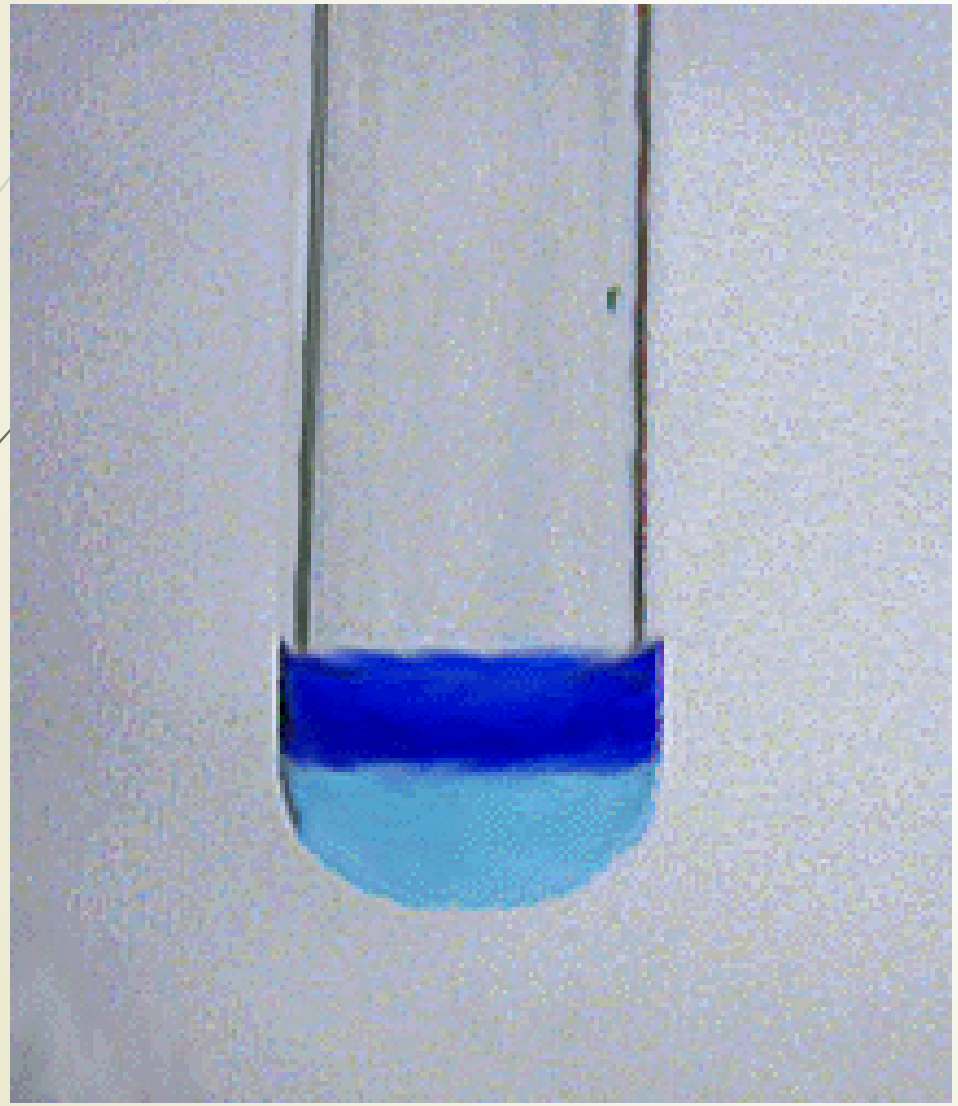
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$



# Recognizing a Chemical Change

- energy exchange
- production of a gas
- color change
- formation of a precipitate
- Odor/smell

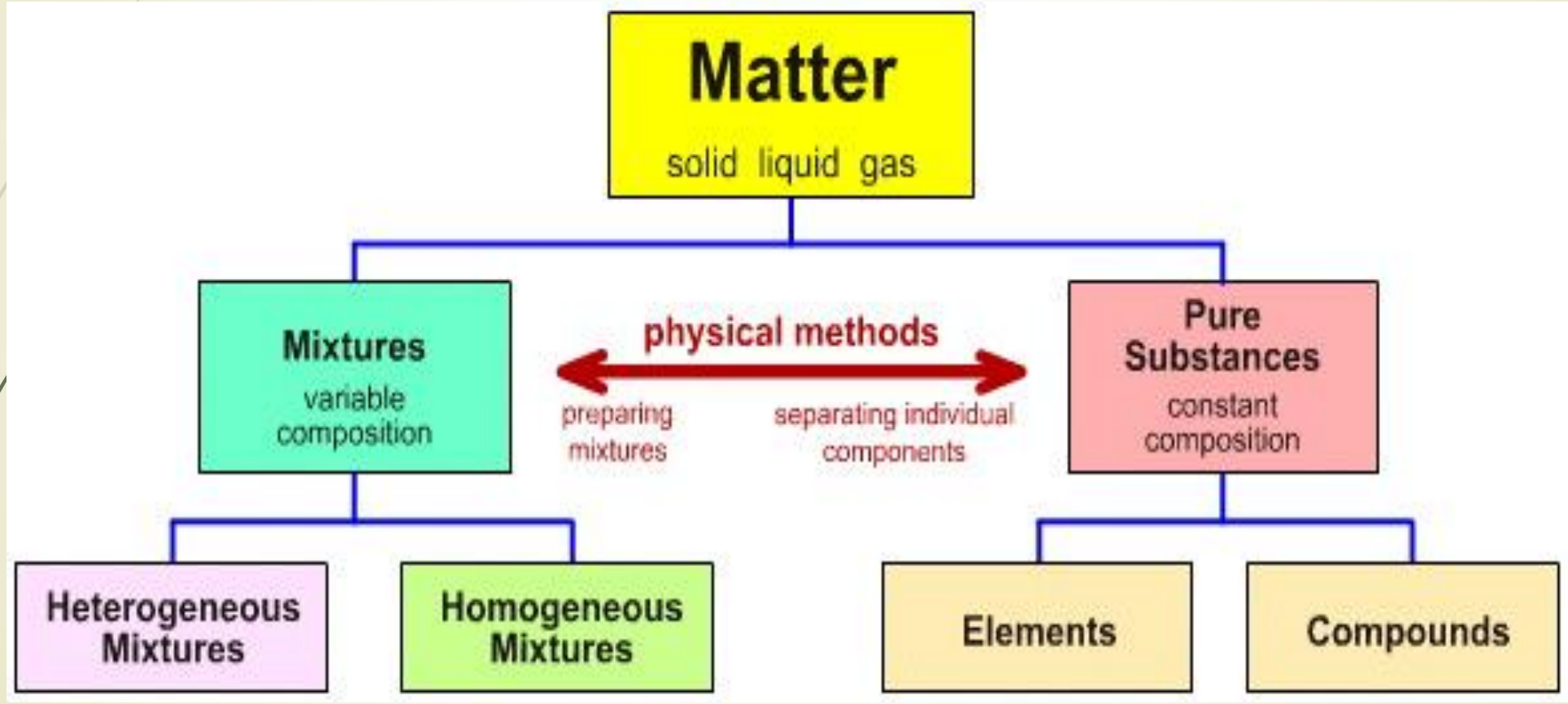
# Formation of a Precipitate

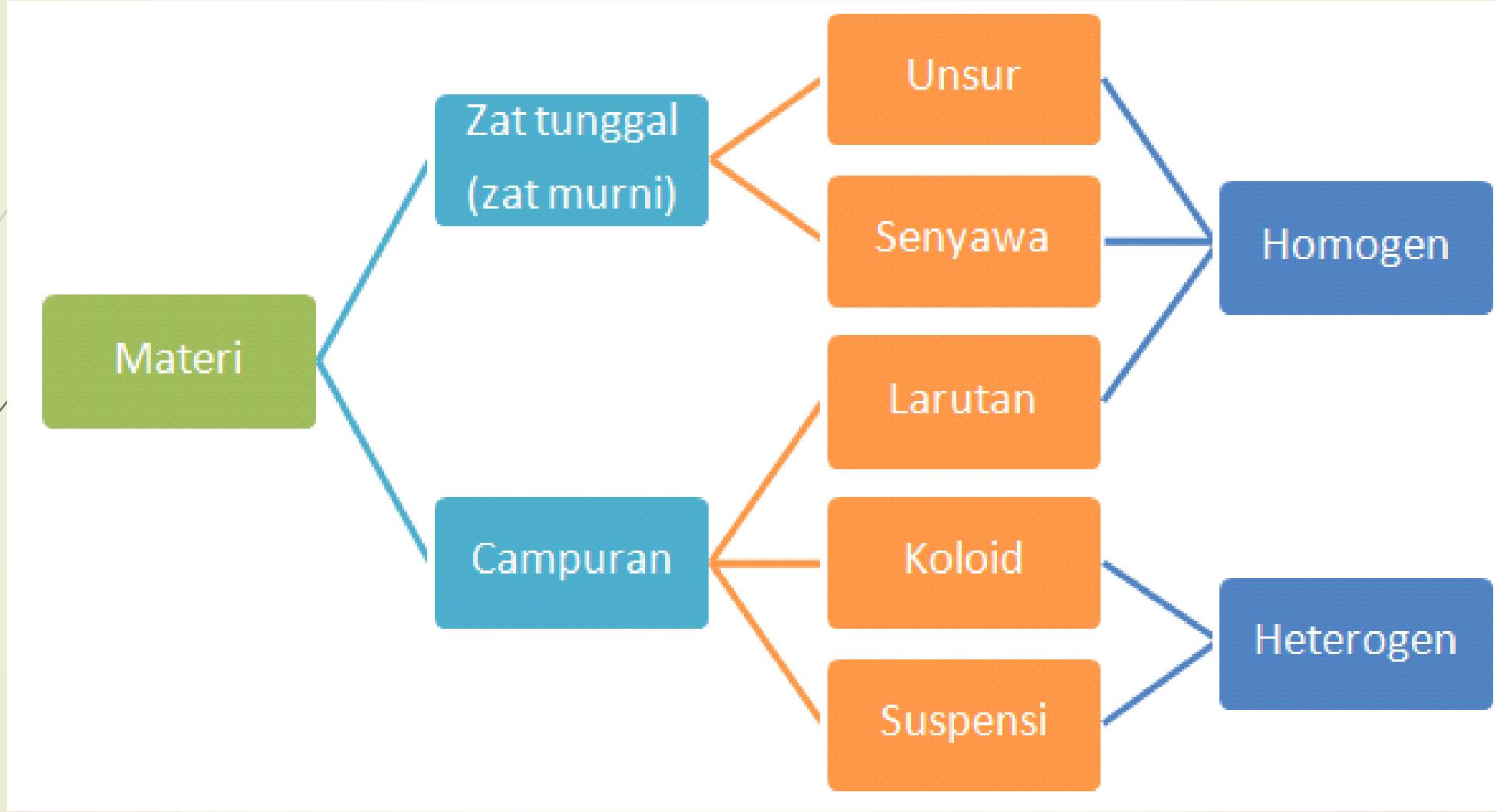


$Cu(OH)_2$

Precipitate

# 3. Classification of Matter (by composition)




Materi
Zat tunggal (zat murni)
Campuran
Unsur
Senyawa
Larutan
Koloid
Suspensi
Homogen
Heterogen

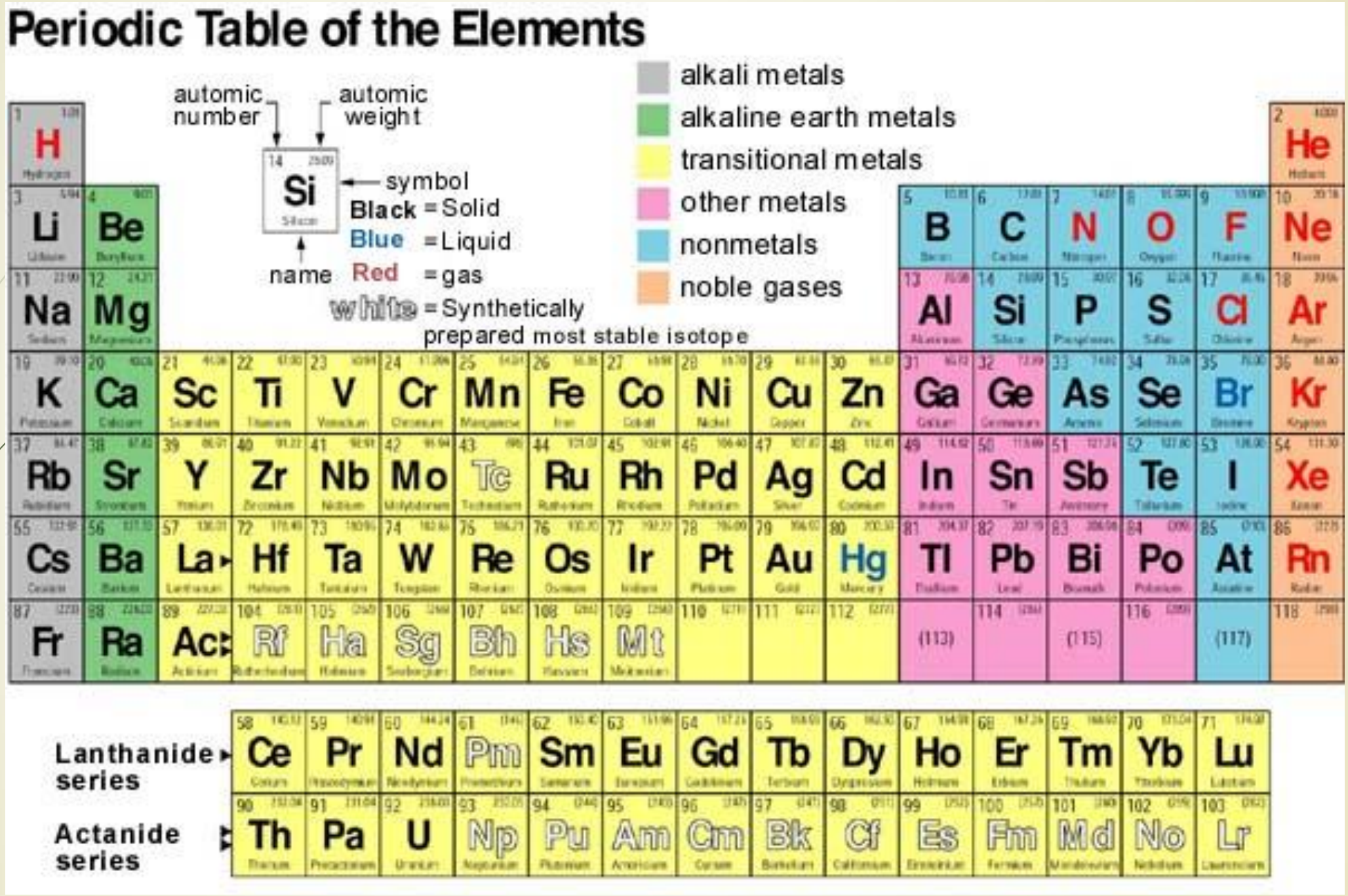
# A. (Pure) Substance

- Matter that has a uniform and definite composition.
  - Elements : atom and structure
  - Compounds

# Elements

- The simplest substances.
- Can not be separated into simpler substances.
- Building blocks of all matter.
- More than 100 known elements.
- Represented by chemical symbols.

# Periodic Table of the Elements



# Chemical Symbols of Elements

- System started by Jons Berzelius (Sweden, 1779-1848)
- One or two first letters of name of the element.
- Many elements names have roots from: Latin, Greek, mythology, geography, names of scientists.

# Examples:

- Americium, Am
- Einsteinium, Es
- Bromine, Br
- Helium, He
- Lead(Plumbum), Pb
- Niobium, Nb
- Iron (Ferrum), Fe
- Mendelevium, Md

# Compound

- A substance that contains two or more elements chemically combined.

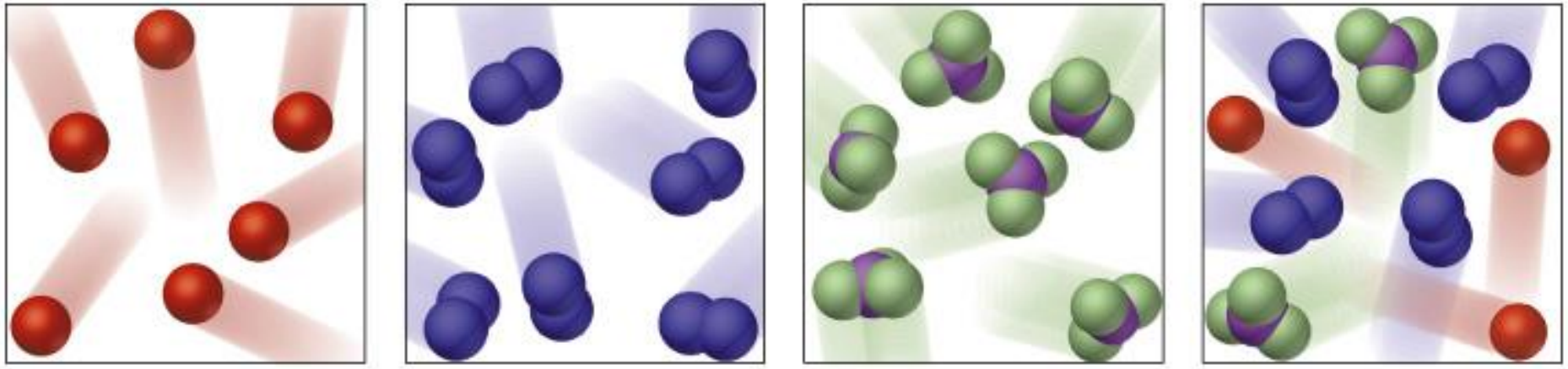
- Compounds have different properties from the individual substances.

  (Ex: $H_2O$)

# Example: $H_2O$

# Substance or mixture?

- If composition is fixed and may not change→substance



(a) Atoms of an element

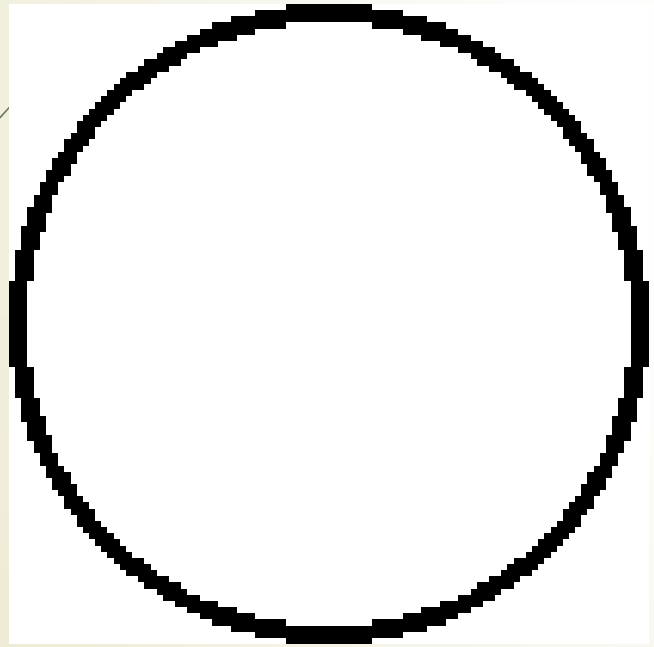
(b) Molecules of an element

(c) Molecules of a compound

(d) Mixture of elements and a compound

# $H_2O$ composition is fixed-compound

Gaseous Phase



Liquid Phase

# ATOM DAN STRUKTUR ATOM

# ATOM DAN STRUKTUR ATOM

**Definisi awal ttg konsep atom → Berlangsung > 2000 thn**

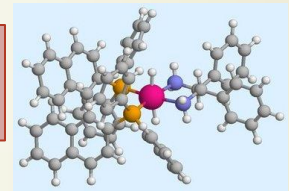

Atom sbg bola keras


Atom sbg awan materi yg kompleks

~ 90 jenis atom

- 1 jenis → 1 unsur


- Jutaan senyawa dihslkan

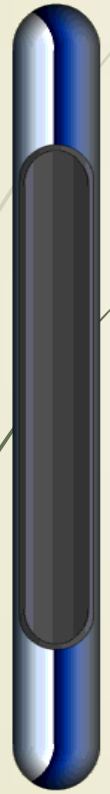


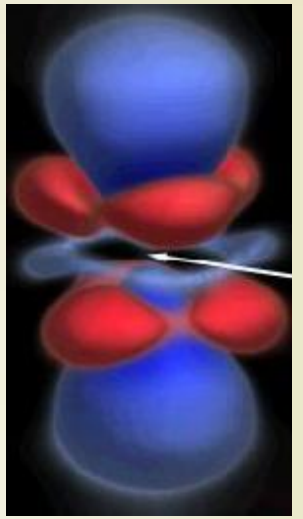
Atom sbg penyusun semua benda
Proses perubahan benda → tdk akan menghilangkan atom penyusunnya

→ Atom Abadi

# ATOM DAN STRUKTUR ATOM

## KONSEP YUNANI TTG ATOM





- **Pandangan filosof Yunani**

  Konsep kemampuan utk dipecah yg tiada berakhir

- **Leucippus** (Abad ke-5 SM)

  Ada batas kemampuan utk dibagi, shg hrs ada bgn yg tdk dpt dibagi lagi

- **Democritus** (380-470 SM)

  **Atomos**: partikel yg tdk dpt dibagi lg

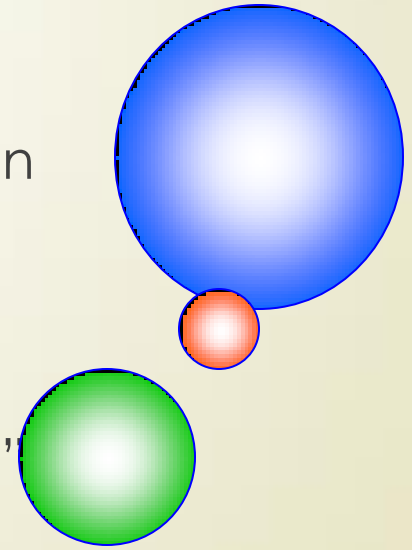
  Atom stp unsur berbeda bentuk & ukurannya

  **Bhn** adl campuran atom-atom berbagai unsur dgn proporsi yg berbeda

  Bhn satu diubah mjd bhn yg lain dgn mengubah proporsinya

- **Lucretius**

  Sifat atom suatu bhn dlm "***On the Nature of Things***"



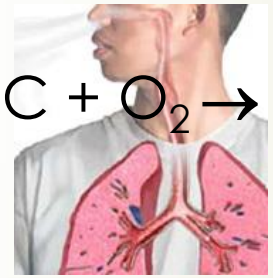
# ATOM DAN STRUKTUR ATOM

## 2.2 HUKUM LAVOISIER

**Antonie Laurent Lavoisier** (1743-1794)

Jk reaksi kimia berlangsung dlm sistem tertutup, mk total bobot sistem tdk berubah

- Reaksi dekomposisi merkuri oksida: $HgO \rightarrow Hg + 1/2\ O_2$
- Reaksi pembakaran batubara: $C + O_2 \rightarrow C$
- Respirasi: $O_2$ (konsumsi) $\rightarrow CO_2$



***Definisi Pemikiran***:

Definisi Kerja **Robert Boyle** dlm ***The Sceptical Chemist*** (1661)

**Unsur** : zat yg tdk dpt dipecah lbh sederhana lg

**Senyawa** : 2 atau lebih unsur yg bergabung membentuk zat yg kompleks

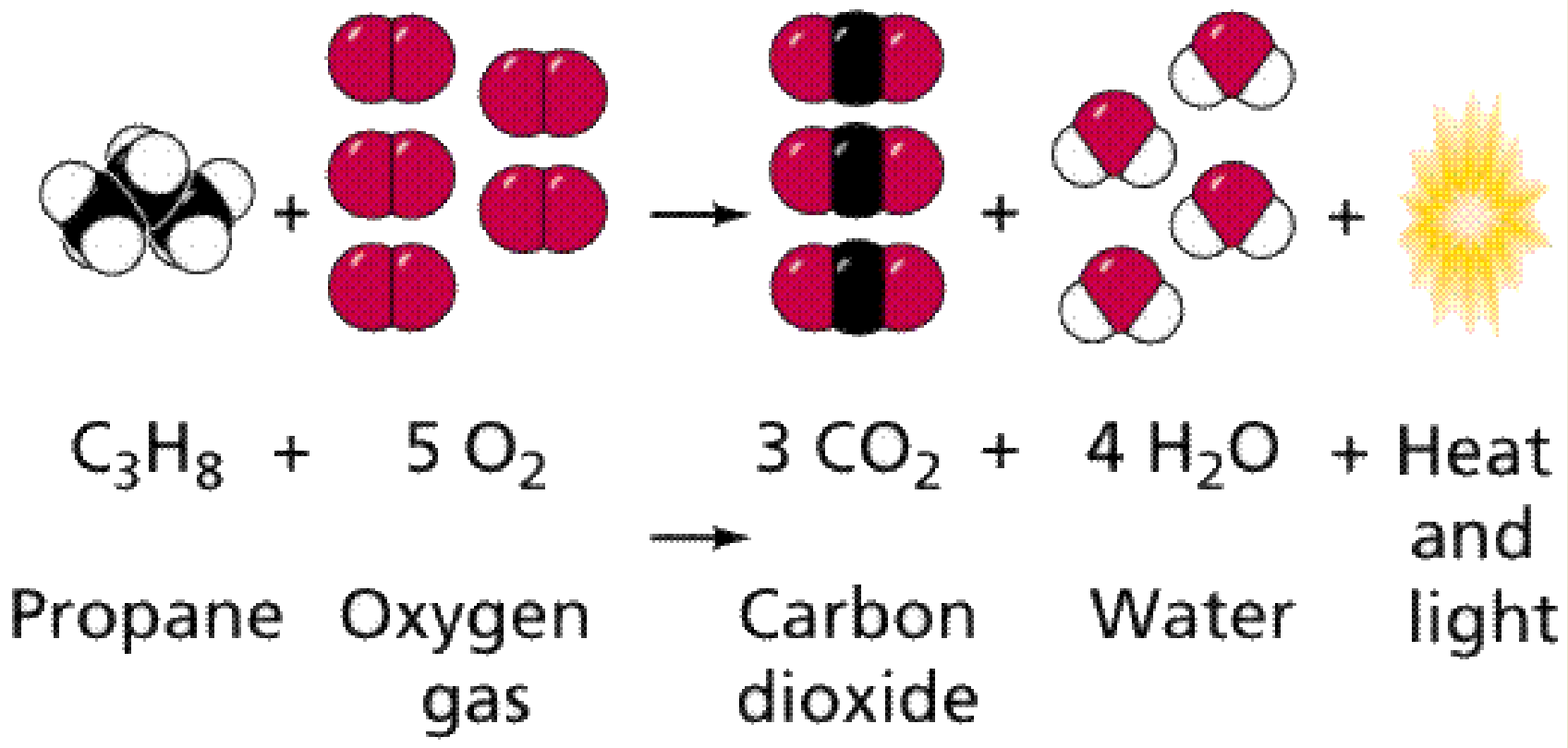
BAPAK ILMU KIMIA (***Elementary Treatise on Chemistry***)

# ATOM DAN STRUKTUR ATOM

## HUKUM KEKEKALAN MASSA

"Materi tdk dibentuk atau dirusak selama perubahan kimia"

Tdk dpt menciptakan dr sesuatu yg tdk ada, bhn baru dpt



# ATOM DAN STRUKTUR ATOM

## 2.3 HUKUM PROUST

**Joseph Louis Proust** (1799)

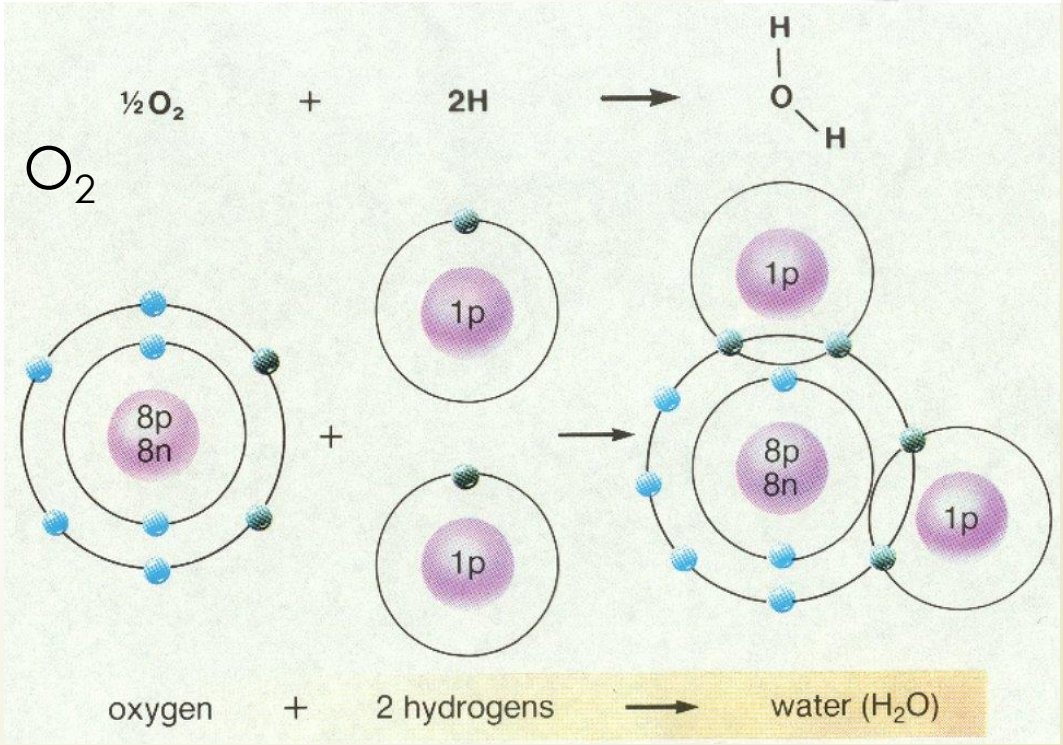
***Hukum Perbandingan Tetap***:

"Suatu bhn tdr dr unsur-unsur dgn perbandin tertentu & perbandingan tsb tetap"

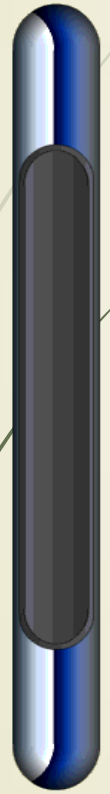
Percobaan Proust:

$CuCO_3 \rightarrow Cu + C + O_2$

5,3 4 1



# ATOM DAN STRUKTUR ATOM

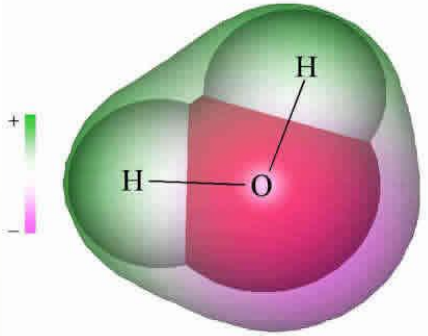


**J. J Berzelius** (1779-1848)

| Pb | + | S | → | PbS |
|---|---|---|---|---|
| Abu-abu | | Kuning | | Hitam mengkilap |
| 10g | | 1,56g | | 11,56g |
| 10g | | 3,00g | | 11,56g + 1,44g S |
| 18g | | 1,56g | | 11,56g + 8g Pb |

**Henry Cavendish** (1783)

$H_2 + 1/2\ O_2 \rightarrow H_2O$

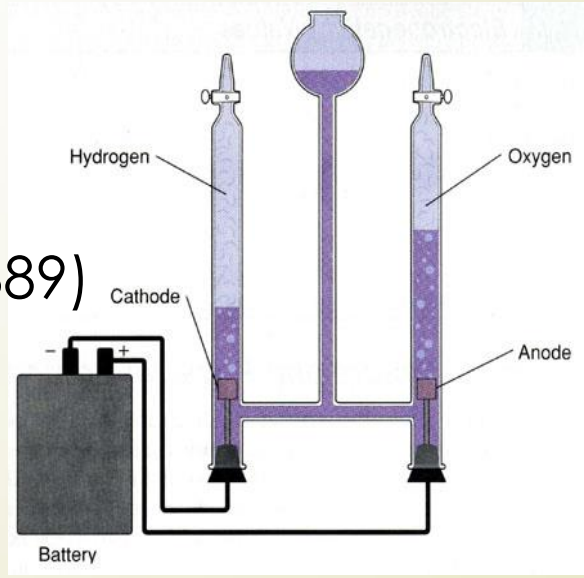



**William Nicholson & Anthony Carlisle** (1889)

Elektrolisis Air:

$H_2O \rightarrow H_2(g) + 1/2\ O_2(g)$

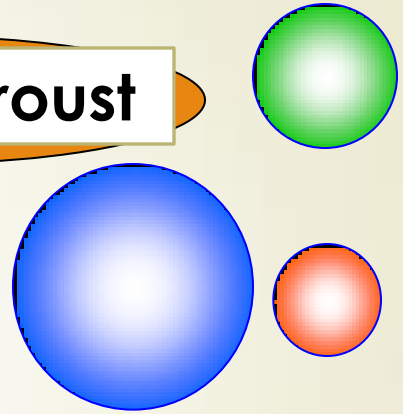
2 bag volume 1 bag volume



# ATOM DAN STRUKTUR ATOM

Hukum Lavoiser

Hukum Proust



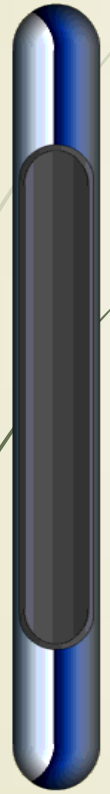
**TEORI ATOM DALTON**

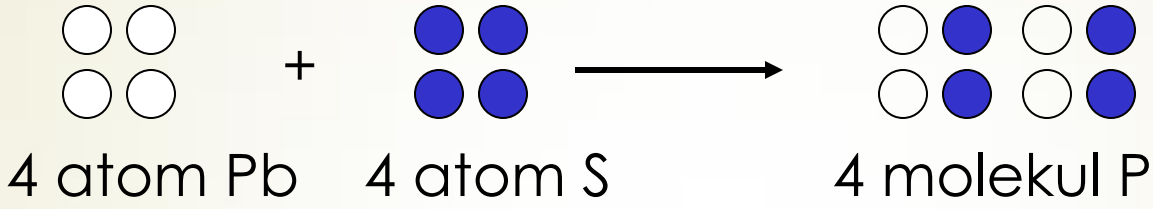
**Asumsi-asumsi Dalton**

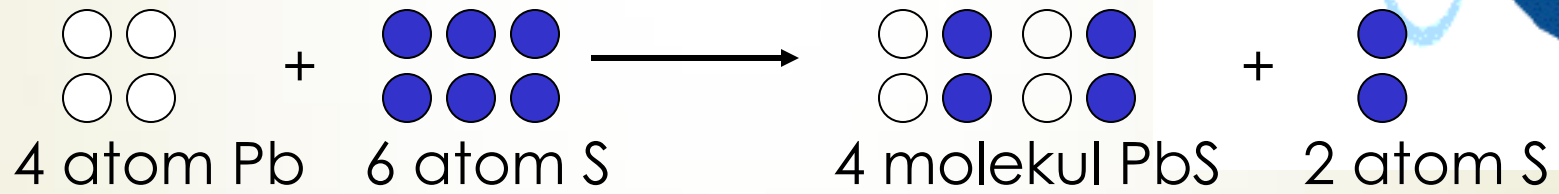
1. Semua unsur terbebtuk dr partikel kecil yg tdk dpt dirusak & tdk dpt dibagi, yg disebut atom
2. Semua atom suatu unsur tertentu, sama, tetapi atom dr unsur-unsur yg berbeda tdk sama
3. Atom-atom dr unsur yg berbeda bergabung membentuk suatu senyawa
4. Reaksi kimia mengubah cara atom-atom bergabung membentuk seny ttp tidak mengubah atom-atomnya

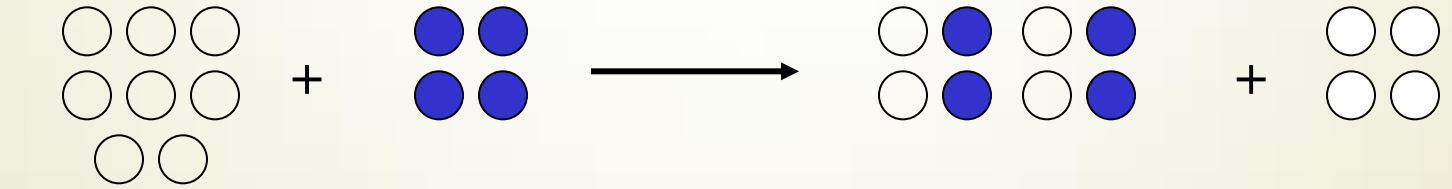
# ATOM DAN STRUKTUR ATOM

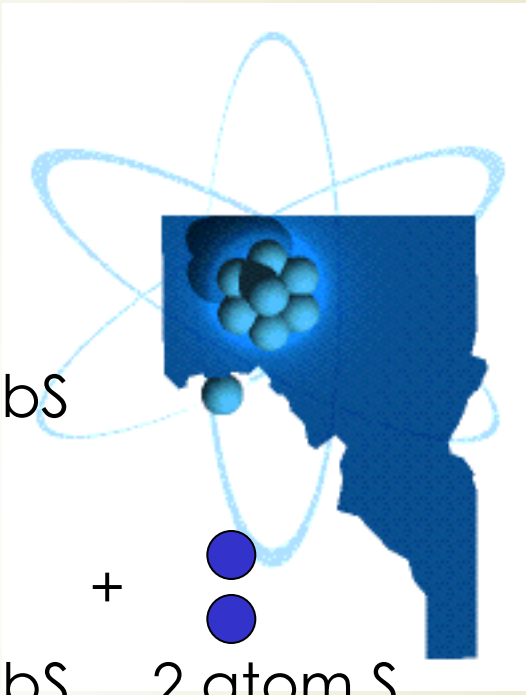
## Hukum Perbandingan Tetap





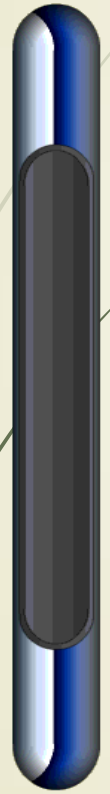



# ATOM DAN STRUKTUR ATOM

## Hukum Perbandingan Berganda



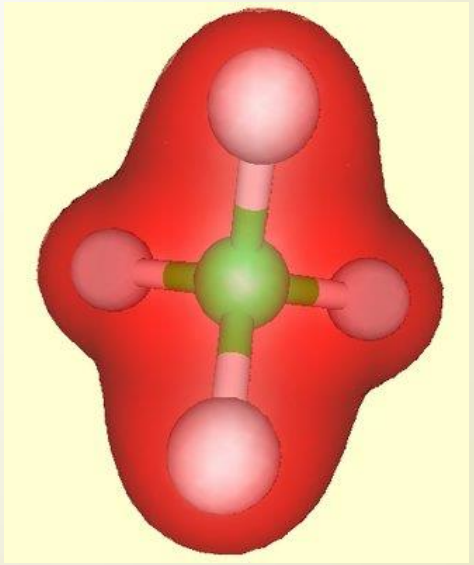
| | Rasio atom O & 2 atom N |
|---|---|
| Nitrit oksida | 1 |
| Nitrat oksida | 2 |
| Nitrogen dioksida | 4 |

● Atom Nitrogen ○ Atom Oksigen

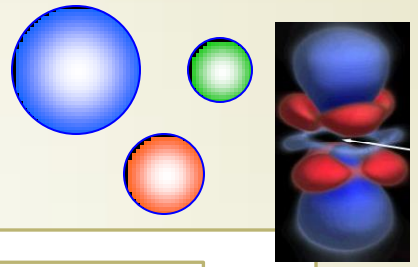
## Hukum Kekekalan Massa

● + ○○ ⟶ ○●○

1 atom C 2 atom O 1 molekul $CO_2$



# ATOM DAN STRUKTUR ATOM



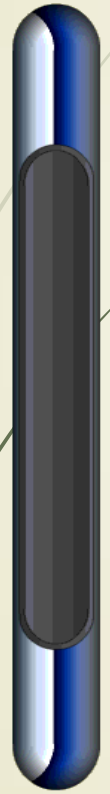
## 2.5 ATOM, NYATA dan RELEVAN

Apakah atom nyata ?
Atom tdk dpt terlihat tp nyata sbg konsep & merupakan konsep yg tinggi manfaatnya

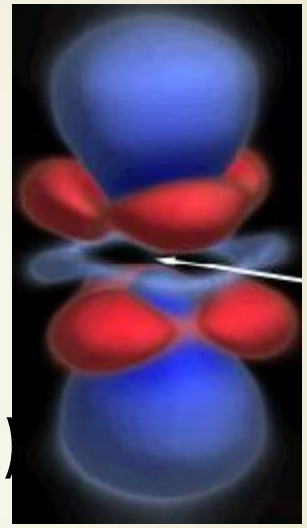
Apakah atom relevan ?
Ilmu & teknologi modern berdasarkan pd konsep atom

# ATOM DAN STRUKTUR ATOM

## 2.6 STRUKTUR ATOM

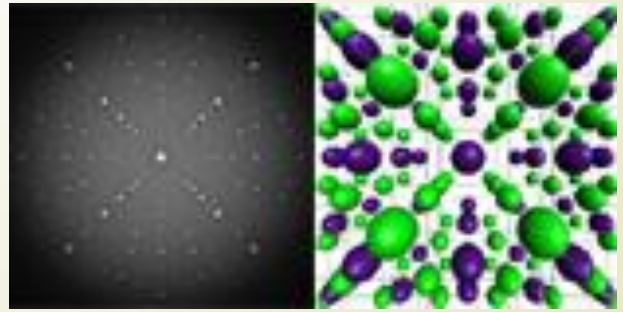


Atom sgt kecil & tdk dpt dilihat



Rekaman bayangan atom:

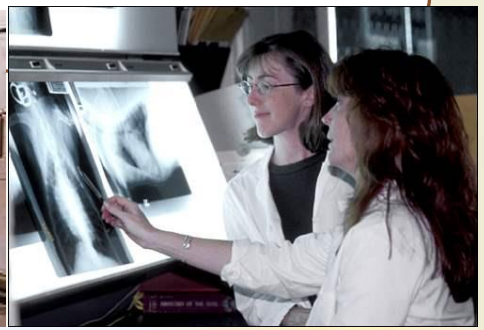
1. Prof. Albert Crewe (Univ. Chicago, 1970)
   Bayangan atom U & Th
2. Gert Erlich & W.R.Graham (Univ. Illinois, 1974)
   Bayangan atom pd permukaan kristal
3. G.W. Stroke (Univ. New York, 1976)
   Lokasi & ukuran relatif atom C, Mg, & O dlm satu bagian kristal

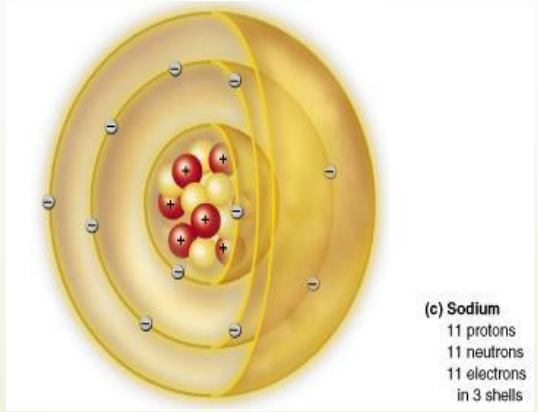


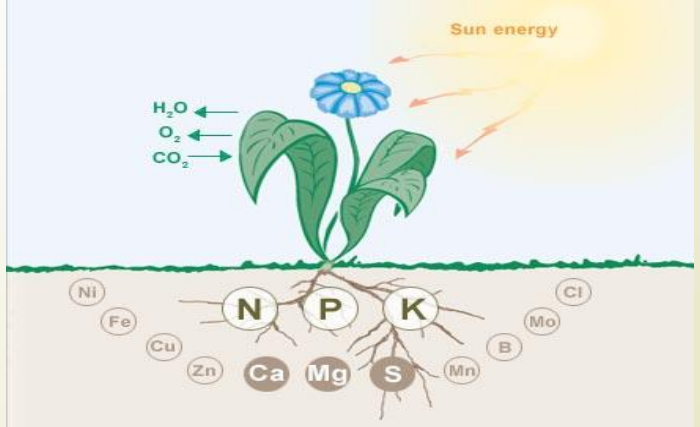
# ATOM DAN STRUKTUR ATOM

**Mengapa struktur atom dipelajari?**

1. Penyusunan bagian-bagian atom akan menentukan sifat materi
2. Mengetahui bgm atom bergabung,
   & bgm mengubah bhn sesuai dgn yg dibthkan
3. Berguna utk kesehatan
4. dll

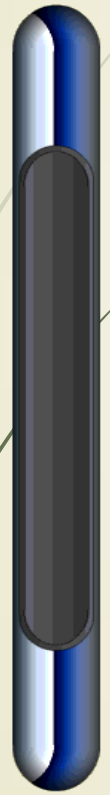





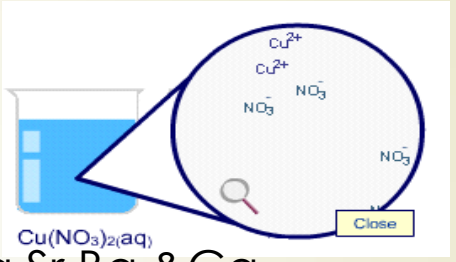



# ATOM DAN STRUKTUR ATOM

## 2.9 ATOM DALAM ABAD 19

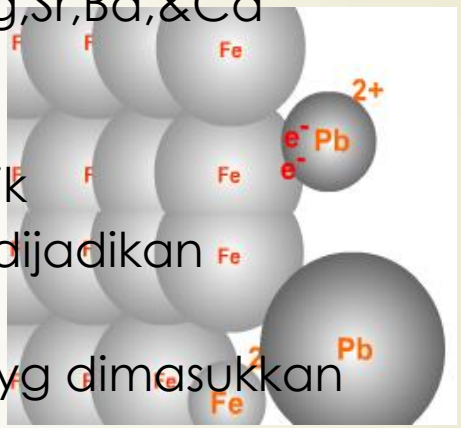


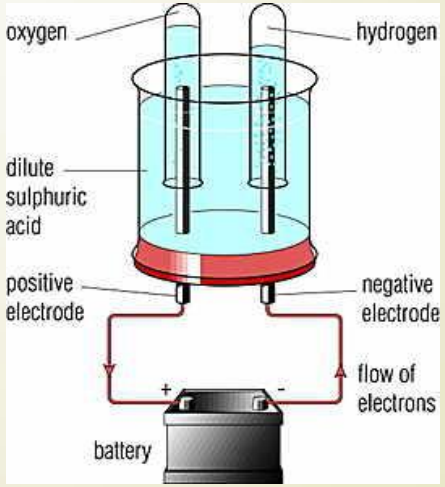
**Dalton** (1803): Atom tdk dpt dibagi & keras
**Nicholson & carlisle** (1889): Materi bersifat listrik
**Sir humpry Davy** (1807): Membuat batere→K,Na,Mg,Sr,Ba,&Ca




**Michael Faraday** (1791-1867): Elektrokimia

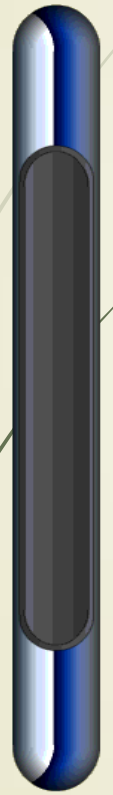
- Elektrolisis : Pemecahan senyawa oleh arus listrik
- Elektrolit : Suatu senyawa yg ketika cair atau dijadikan larutan,dpt melewatkan arus listrik
- Elektroda : Batang karbon/lempengan logam yg dimasukkan ke dlm cairan/larutan
- Katoda : Elektroda yg bermuatan negatif
- Anoda : Elektroda yg bermuatan positif
- Ion : Atom-atom yg bermuatan
- Anion : Ion yg bermuatan negatif
- Kation : Ion yg bermuatan positif



# ATOM DAN STRUKTUR ATOM

**Percobaan Faraday**: Atom bersifat listrik
→ gagal krn tabung tdk cukup hampa



**William Crookes** (1875)
Tabung gas hampa

Sinar katoda: Berkas sinar yg dihslkan dari katoda ke anoda

**Joseph John Thomson** (1897)

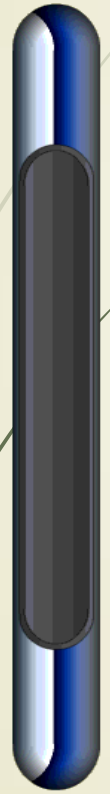
- ✵ Sinar katoda adl sinar yg bermuatan negatif (elektron) yg dibelokkan oleh medan listrik magnet
- ✵ Sinar katoda tdk bergantung pd bhn katoda & gas dlm tabung
- ✵ Mengukur perbandingan m/e

**Eugen Goldstein** (1886)

- ❖ Sinar kanal bermuatan positif (proton), & dibelokkan oleh medan listrik & magnet
- ❖ Sinar katoda mempunyai massa yg beragam, tergantung pd jenis gas
- ❖ Massa yg plg ringan (terbentuk jk ada sedikit $H_2$) = 1837 massa e
- ❖ Massa elektron = $9{,}1 \times 10^{-28}$ g

# ATOM DAN STRUKTUR ATOM

## 2.10 SINAR X dan RADIOAKTIFITAS

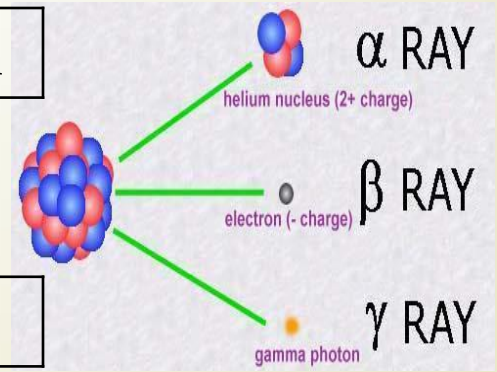
**Wilhelm konrad Roentgen** (1895)
Sinar X : sinar yg keluar dari anoda ketika sinar katoda sdg bekerja, tdk dibelokkan oleh medan listrik & magnet

Antoine Henri Becquerel
Marie Sklodowska Curie
Pierre Curie

→ **Unsur Radioaktifitas**

**Rutherford**:Jenis radiasi radioaktifitas

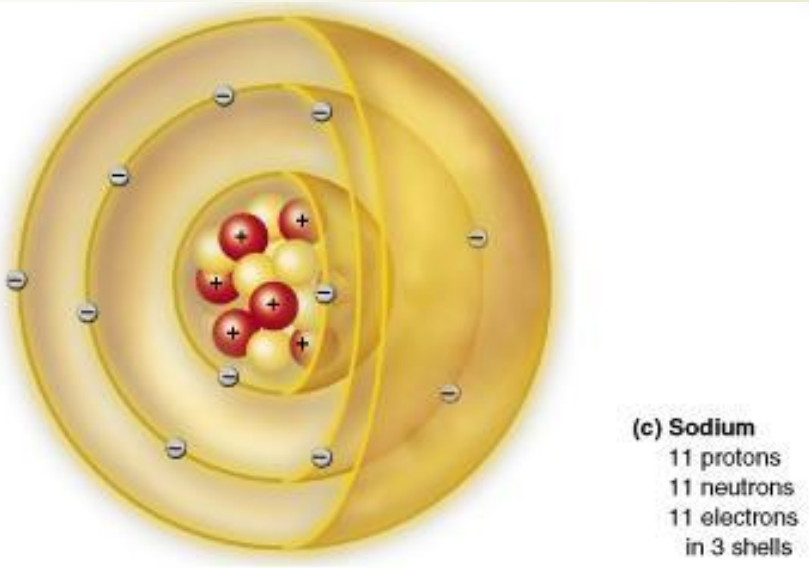
| Nama | Simbol | Massa (sma) | Muatan |
|---|---|---|---|
| Alfa | $\alpha$ | 4 | $2^+$ |
| Beta | $\beta$ | 1/1837 | $1^-$ |
| Gamma | $\gamma$ | 0 | 0 |



# ATOM DAN STRUKTUR ATOM

**MODEL ATOM RUTHERFORD**

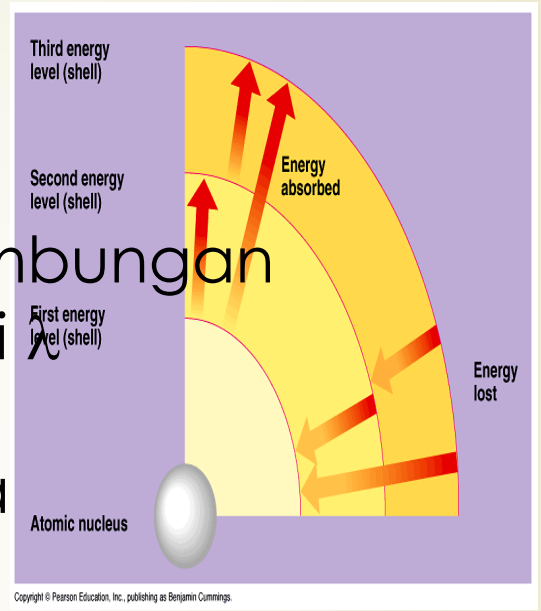
- ✓ Atom tdr inti yg bermuatan positif
- ✓ Massa atom terpusat pd inti yg bermuatan kecil
- ✓ Sebagian atom merupakan ruangan kosong, pd jrk tertentu tdp elektron




| Partikel | Simbol | Massa (sma) | Muatan |
|---|---|---|---|
| Proton | p | 1 | $1^+$ |
| neutron | n | 1 | 0 |
| Elektron | e | 1/1837 | $1^-$ |

# ATOM DAN STRUKTUR ATOM

## 2.13 SUSUNAN ELEKTRON : MODEL ATOM BOHR




Spekrum Cahaya : Kontinu/berkesinambungan
Sinar dgn berbagai λ

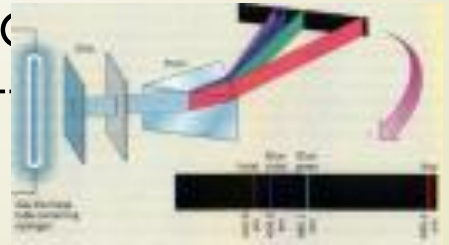
Spektrum Atom : Diskontinu/diskrit
Spektrum garis/pita

⇨ $e^-$ mengorbit sekeliling inti pd lintasan yg berbeda, dgn Ek tertentu & Ep tertentu

⇨ Gerakan $e^-$ mencegah jatuhnya $e^-$ ke dlm inti atom

⇨ $e^-$ dpt berpindah dr lintasan dgn tkt E dasar → E yg lebih tinggi jk menyerap E & sebaliknya

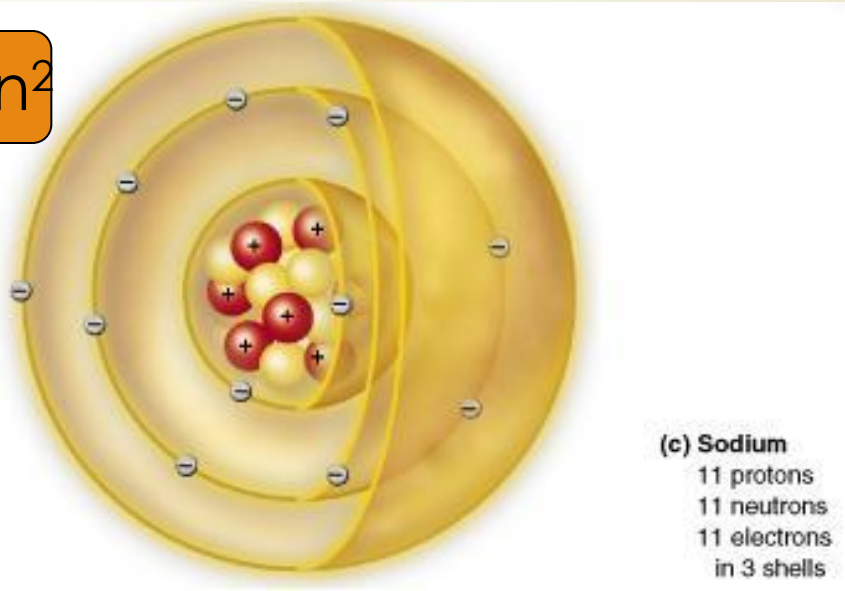
⇨ Stp level lintasan tkt E diisi oleh sjml $e^-$ t



# ATOM DAN STRUKTUR ATOM

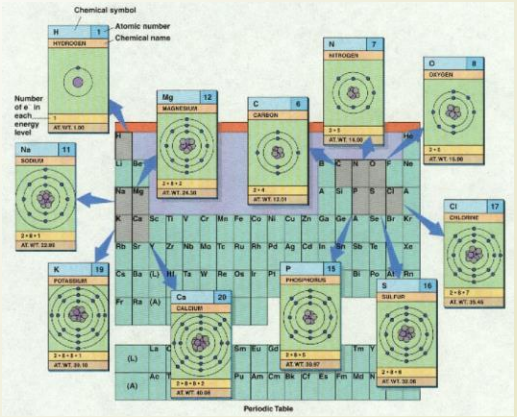
jml $e^-$ max pd lintasan = $2n^2$

Lintasan dgn n=1 → $\Sigma e^- = 2$
n=2 → $\Sigma e^- = 8$
n=3 → $\Sigma e^- = 18$
n=4 → $\Sigma e^- = 32$




## 2.14 TINGKAT ENERGI & DAFTAR PERIODIK

**John Dalton:** - Tabel bobot atom relatif
"**Sistem Baru Falsafah Kimia**"
- Byk yg tdk benar



# ATOM DAN STRUKTUR ATOM

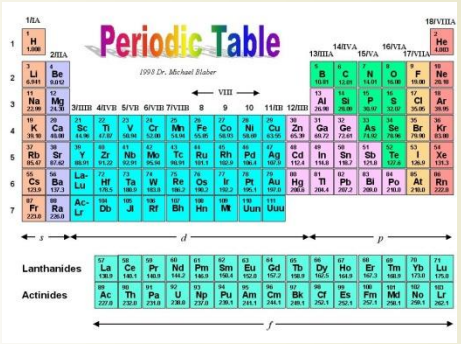
**Berzelius** (1828): - Tabel bobot atom 54 unsur

- Sesuai dgn sistem modern

**D.I. Mendeleev** (1889):

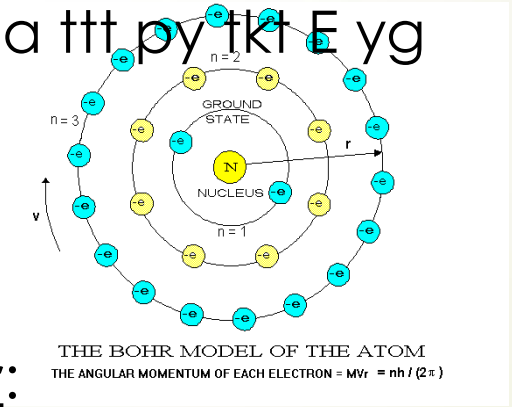
- Daftar periodik bdsrkan peningkatan bobot atom
- Menyediakan ruang kosong utk unsur-unsur yg blm ditemukan
- Unsur yg mempunyai sifat yg sama

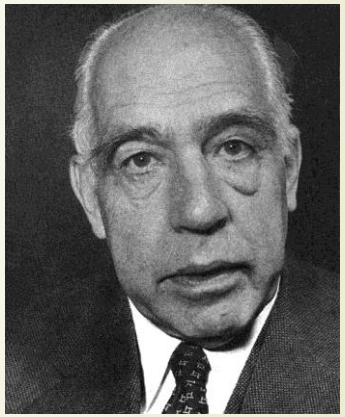
# ATOM DAN STRUKTUR ATOM




**DAFTAR PERIODIK MODERN :**

- Disusun berdasarkan nomor atom
  No atom = ∑ proton dlm inti
  ∑ elektron di luar inti (utk atom netral)
- ***Golongan***: sifat kimia mirip & $e^-$ valensi sama
- ***Perioda***: $e^-$ terluar pd perioda ttt py tkt E yg sama



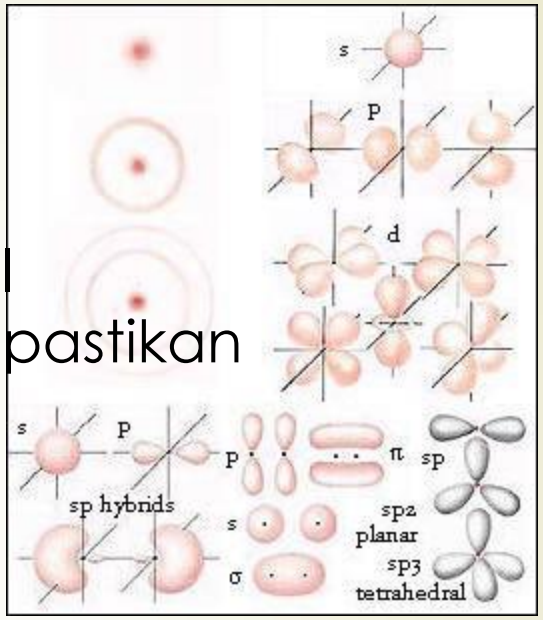



**<u>Kelemahan model atom Bohr</u>**:
Model Bohr didsrkan **Pergerakan Planet Kepler** (Radiasi Kontinu), ***kenyataannya*** : atom hy mhslkan spektrum grs Tdk dpt menjelaskan spektrum atom yg lbh kompleks dr atom H

# ATOM DAN STRUKTUR ATOM

## TEORI ATOM MODERN

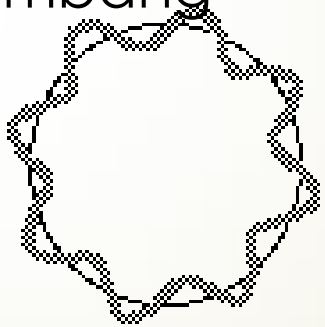
- Teori Kuantum:
  - $e^-$ dianggap sbg gel
  - Lokasinya tdk dpt dipastikan



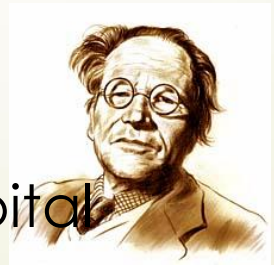

**Louis de Broglie** (1924):

- E bersifat sbg gelombang

$$\lambda = \frac{h}{mv}$$



**Erwin schrodinger** (1927):



fungsi gelombang atau orbital

The Time Dependent Schrödinger Equation

We may write

$$-\frac{\hbar}{i}\frac{\delta\Psi(t)}{\delta t} = \mathcal{H}\Psi(t)$$

where

$$\mathcal{H} = \sum_I \frac{1}{2m_i}\left(p_i - \frac{e_i}{c}\mathcal{A}\right)^2 + V(r) = \mathcal{H}_{molecule} + \mathcal{H}_{radiation} + \mathcal{H}_{int}$$

with

$$\mathcal{H}_{molecule} = \mathcal{H}_o = \sum_i \left(\frac{p_i^2}{2m_i} + V(r)\right); \quad \mathcal{H}_o|n\rangle = E_n^{(o)}|n\rangle$$

$$\mathcal{H}_{rad} = \sum_s \frac{\omega_s}{2}(a_s a_s^+ + a_s^+ a_s); \quad \mathcal{H}_{rad}|N_s\rangle = \sum_s (N_s + \tfrac{1}{2})\hbar\omega_s|N_s\rangle$$

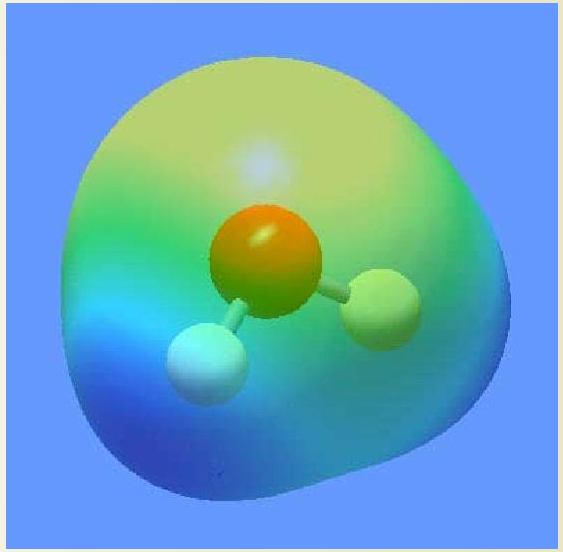
$$\mathcal{H}_{int} = \mathcal{H}_{int}^{(1)} + \mathcal{H}_{int}^{(2)}$$

# ATOM DAN STRUKTUR ATOM

1. Rasio C:H dlm gas CH4 adl 3:1. Berapa hidrogen yg dibutuhkan utk 900 g karbon?

***Jawab:***

$$900\ g\ C \times \frac{1\ g\ H}{3\ g\ C} = 300\ g\ H$$



2. Nitrous oksida tdr 7 bgn bobot N & 4 bgn bobot O. Berapa N yg diperoleh jk O dihslkan sbyk 36 g?

***Jawab:***

$$36\ g\ O \times \frac{7\ g\ N}{4\ g\ O} = 63\ g\ N$$

3. Rasio S:H dlm HS adlh 16:1. Bila bobot S=32 & H=1, berapa perbandingan atom dlm gas tsb?

***Jawab:***

$$\frac{32\ satuan\ S}{1\ atom\ S} \times \frac{1\ satuan\ H}{16\ satuan\ S} \times \frac{1\ atom\ H}{1\ satuan\ H} = \frac{2\ atom\ H}{1\ atom\ S} \approx H_2S$$

# ATOM DAN STRUKTUR ATOM

4. Berapakah jml e max pd tkt E ke 5?

***Jawab:***

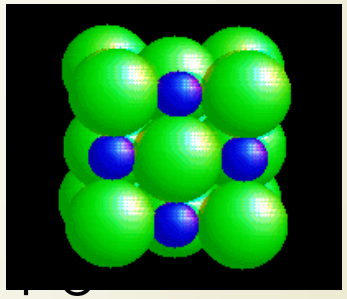
$$2n^2 = 2 \times 5^2 = 50$$

5. Gambarkan kulit $e^-$ Fluor & Natrium?

***Jawab:***

a. F adl unsur dgn no atom 9, mempunyai 9
2 $e^-$ mengisi kulit ke-1, sisanya di kulit ke-2

2 $e^-$ | 7 $e^-$



b. Na adl unsur dgn no atom 11, mempunyai 1[illegible]
2 $e^-$ mengisi kulit ke-1, 8 $e^-$ di kulit ke-2, sisanya di kulit ke-3

2 $e^-$ | 8 $e^-$ | 1 $e^-$

# B. Mixture

Mixture: a physical blend of two or more substances that are not chemically combined.

- Homogeneous
- Heterogeneous

# Mixture

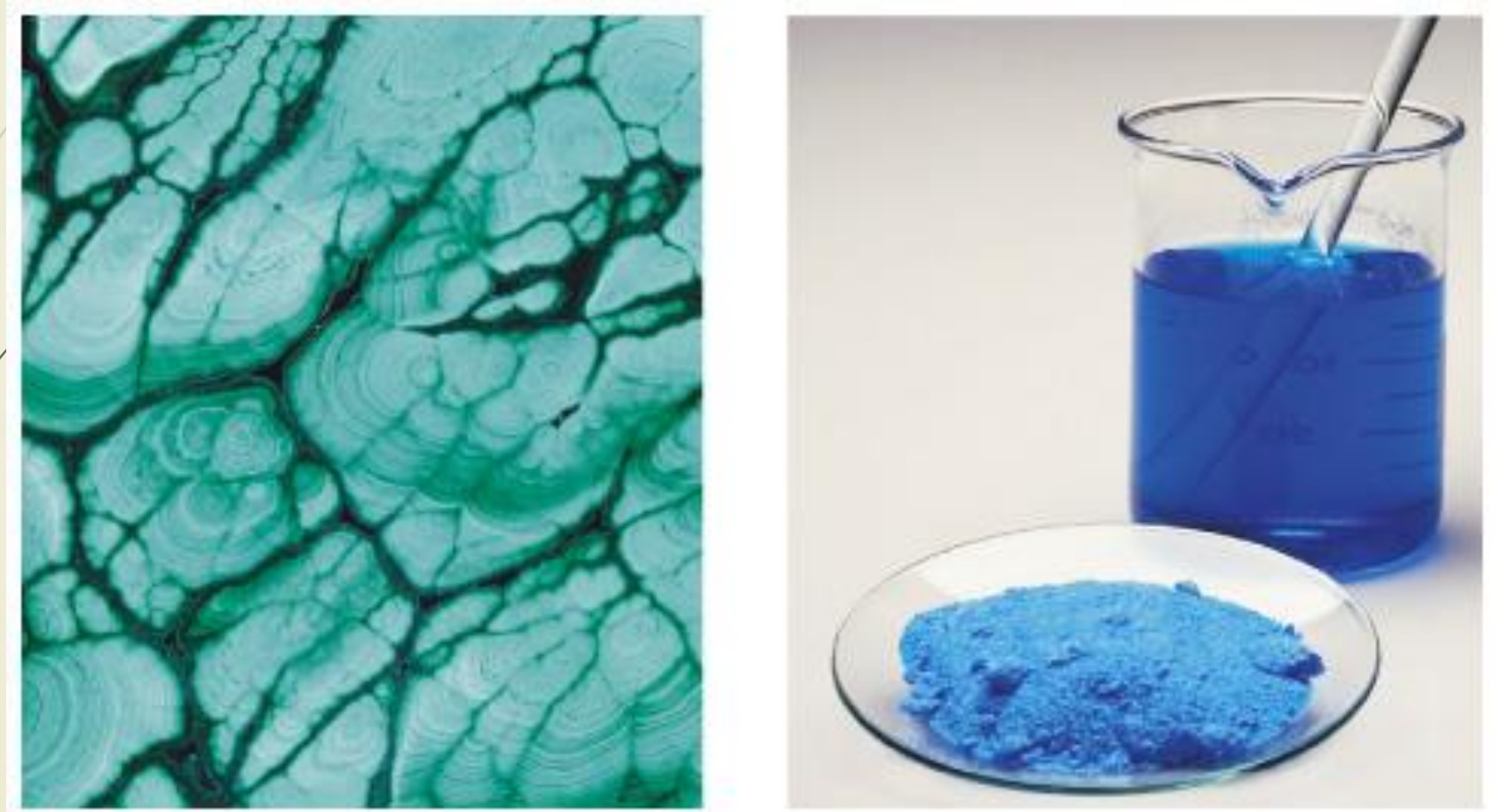
- A physical blend of two or more substances.

# Mixtures

- Homogeneous
  - Uniform composition throughout.
  - One phase.
- Heterogeneous
  - Non-uniform composition throughout the mixture
  - Two or more phases.

A part of a mixture with uniform properties and composition.

# Copper II Sulfate and its solution in water.



(a)

(b)

# Example: Stainless Steel

A homogeneous mixture of:

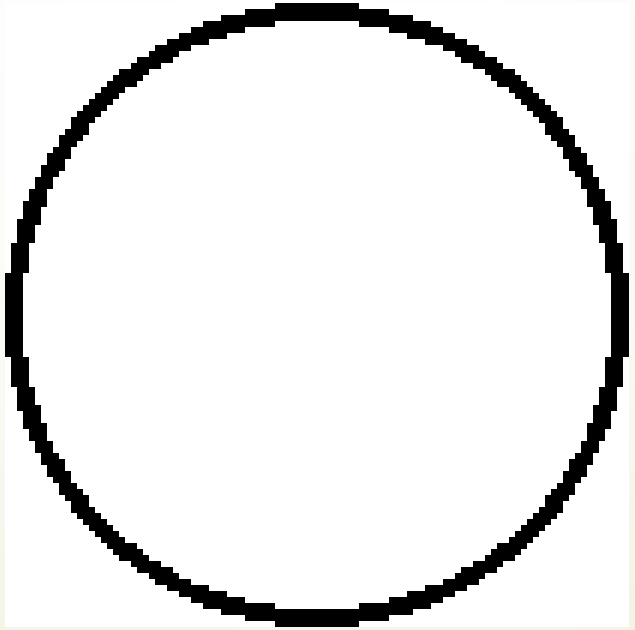
-Iron (Fe)

-Chromium (Cr)

-Nickel (Ni)

# Example: Gaseous Mixture

- Elements argon and nitrogen and a compound (water vapor).



# Heterogeneous Mixtures

Example:

Oil and vinegar

- Non-uniform composition throughout the mixture
- Two or more phases.

# Note:

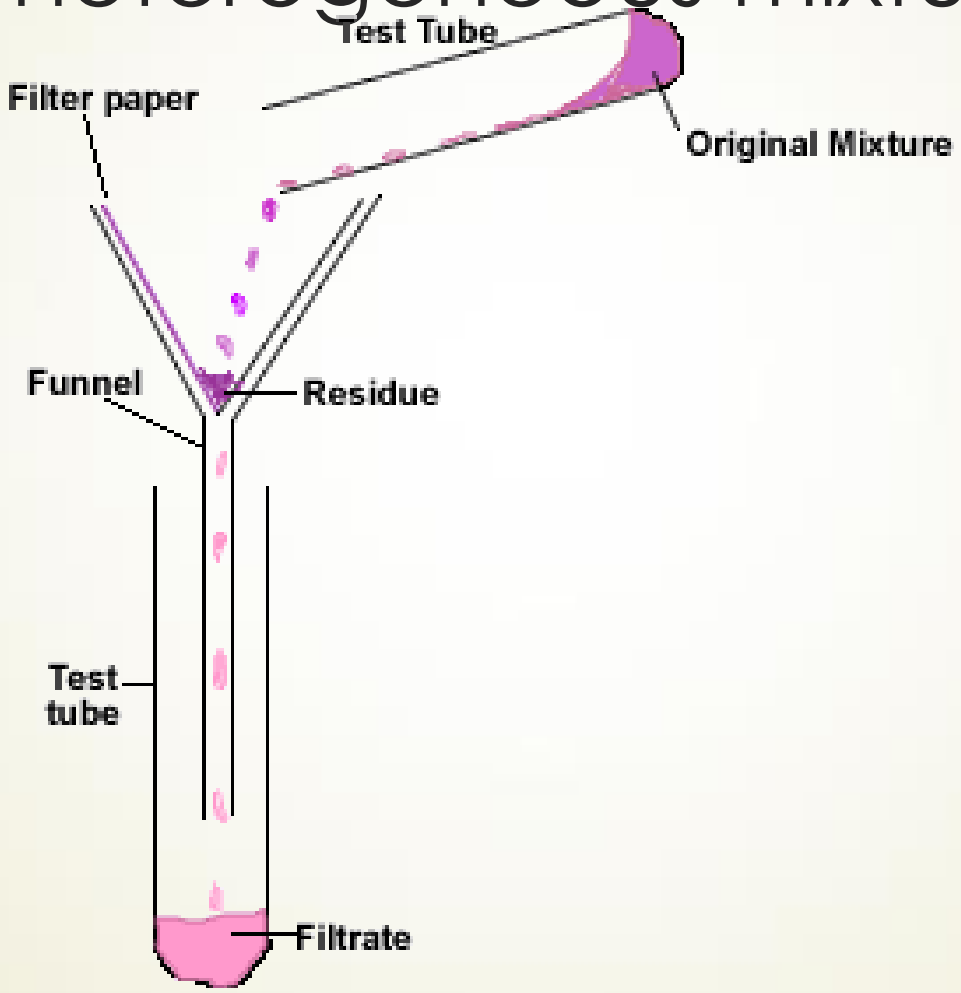
- Mixtures can be physically separated.
- Mixtures exhibit physical properties similar to the components of the mixture.

# Separation Methods

- Use differences in the physical properties of the components of the mixture.

# Example: Separate iron filings from sulfur using a magnet.

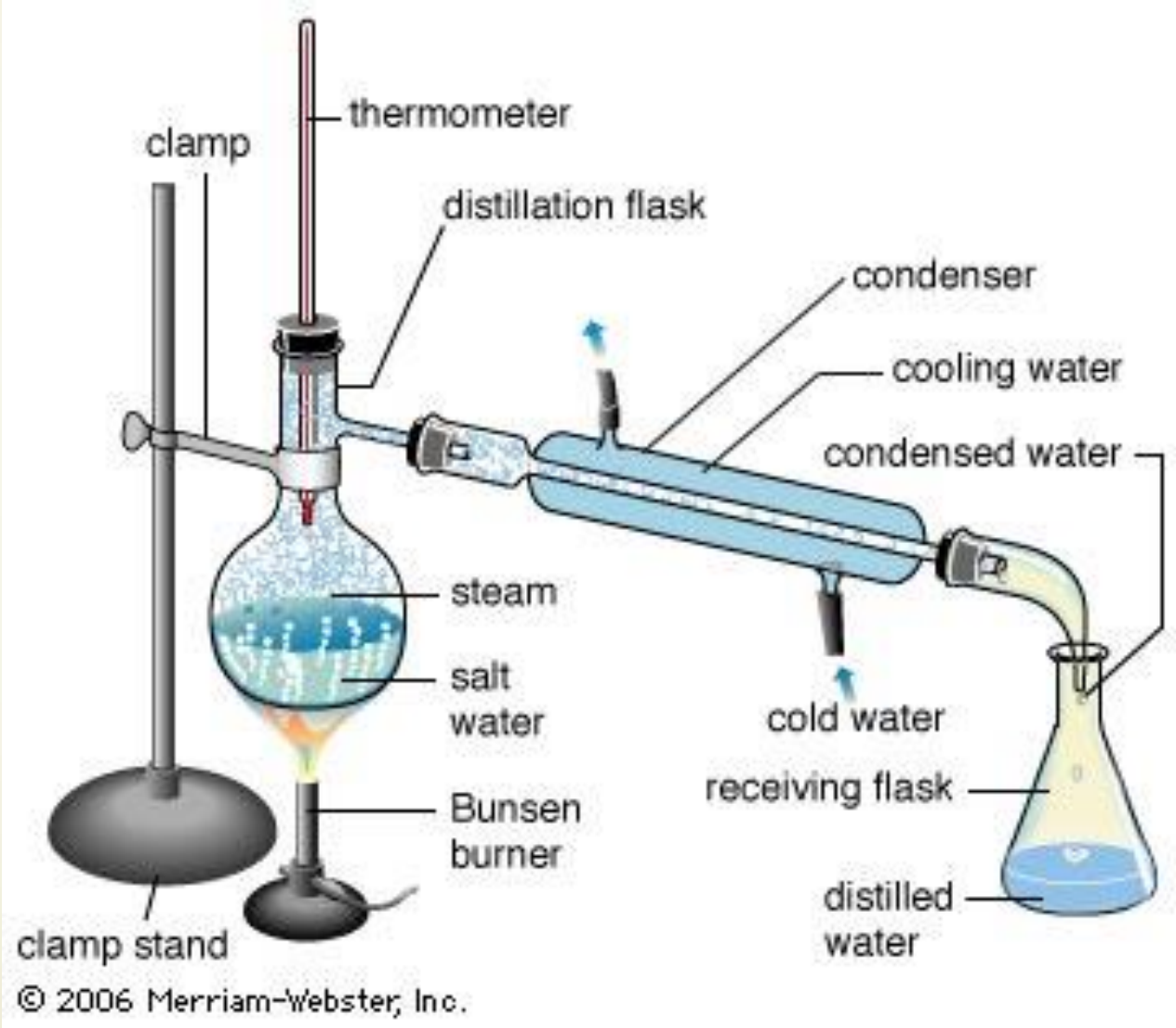
# Filtration: separates a solid from a liquid in a heterogeneous mixture



# Distillation:

-separate dissolved solids from a liquid

-uses boiling and condensation.



# Distillation of Crude Oil (Refining)

- Crude Oil is a mixture of Hydrocarbons

# Distillation of Crude Oil