Matter

Thursday, 26/9/2019

- Matter: Whatever occupies space and has a mass.

⇒ Mass: The quantity of matter in a material.
⇒ Weight: The force of gravity exertal on material.

- Law of conservation of mass:
  ↳ The total mass remains constant during a chemical change "chemical reaction".

" Mercury + Oxygen $\xrightarrow[\text{heat}]{}$ Mercury oxide
(Silver) (Red-orange).

Ex: If 2.53 g of mercury in air is producing 2.73 g of Red-orange substance, What is the mass of the oxygen?

Mass of Oxygen = 2.73 − 2.53
= $\boxed{0.20}$ g

- Physical state and chemical composition of the matter:

⇒ Physical states:
↳ Solid: Rigid, Incompressible, has fixed volume & shape.

Fluids
↳ Liquid: Incompressible, fixed volume, takes the shape of the container.
↳ Gas: Compressible, takes the shape & volume of the container.

- **Vapor:** Refers to the gaseous state of any kind of matter that normally exists as a liquid or a solid.

- **Physical change:**
  A change in the form of matter but not in its chemical identity.

$$H_2O_{solid} \longrightarrow H_2O_{liquid}.$$

- **Physical properity:**
  Characteristic that can be observed for a material without changing its chemecal properities.
  ↳ Color, Melting point, Boiling point, Density, ...

- **Chemical change:**
  A change in which one or more kinds of matter are transformed into a new kind of matter or several kinds of matter.
  ↳ Change in colour, Burning, ...

- **Chemical properity:**
  Characteristic of a material involving its chemical change.

Thursday, 26/9/19

⇒ Classification of matter ⇐

Matter

Cannot be seperated by physical means.

Two or more substances.

Substance

Mixture

Seperation by Physical means.

Compound

Element

Homogeneous → uniform "Solution"

Heterogeneous → not uniform.

By chemical means.

Two or more elements.

Cannot be seperaterd or decomposed.

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Sunday, 29/9/2019

Physical measurements.

- Accuracy: The closeness of a result (measurement) to the true or accepted value.

- Precision: The closeness of results (measurements) to each other in a set.

Ex: 0.25, 0.50, 0.75 (True value : 0.50)
⇒ Average = 0.50
: Accurate but not precise.

- Significant figure: (Significant number/digit)

2(25) → digits.
number

Digits:
↳ Nonzeroes : (1-9)
↳ Always significant.
↳ Zero → significant → Between non-zeroes digits.
→ To the right of the number in presence of decimal point.
↳ not significant.
↳ To the left of the number.
→ Difficult to judge.
↳ To the right of the number in absence of the decimal point.

Significant figure.

Sun, 29/9/19

Ex: How many significant figures in the following numbers?

① 1.3462 — 5 significant figures.

② 1.03021 — 6 significant figures.

③ 1.300 — 4 significant figures.

④ 0.000421 — 3 significant figures.
$\hookrightarrow = 4.21 \times 10^{-4}$

⑤ 0.003010 — 4 significant figures.
$\hookrightarrow = 3.010 \times 10^{-3}$

⑥ 4000 — Difficult to judge "Might be 1, 2, ... 4"
$\hookrightarrow$? 4×10^{3}
4.0×10^{3}
4.00×10^{3}
4.000×10^{3}
Scientific notation.

1.00 kg ⟹ Ranges between [0.995 → 1.004]
certain — uncertain

⟹ Significant figures in Calculations ⟸

I Substraction & Addition.

We must round it to the smallest # of decimal points.

$$\begin{array}{r} 12.301 \\ -\ 0.34 \\ \hline 1.961 \end{array}$$ ✗

$= 1.96$ ✓

$$\begin{array}{r} 3.601 \\ +\ 1.7040 \\ \hline 5.3050 \end{array}$$

$= \boxed{5.305}$

Significant figures in calculations:

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$\boxed{2}$ Multiplication & Division:

5 s.f → 1.0324

2 s.f → × 0.34

0.351016 ✗

∴ ≈ 0.35 ✓

6.3400 → 5 s.f

÷ 2.40 → 2 s.f

2.641666667 ✗

↳ ≈ 2.64 ✓

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SI units

Tue, 1/10/2019

Past sec. example

$$\begin{array}{r} \overset{4}{\overline{2.000}} \\ \times\ \overset{3}{\overline{6.00}} \\ \hline \underset{3}{\underline{12.0}} \end{array}$$

SI units: International system of units.

Quantity	unit	symbol
Length	meter	m
Mass	Killogram	Kg
Time	second	s
Temperature	Kelvin	K
Amont of substance	mole	mol
Electric current	Ampere	A
Luminous intensity	candela	cd

Base units

- SI prefix: (Numbers)

Mega	10^6	M
kilo	10^3	K
dici	10^{-1}	d
centi	10^{-2}	c
mili	10^{-3}	m
micro	10^{-6}	μ
nano	10^{-9}	n
pico	10^{-12}	p

SI units

Tue 1/10/19

cm
cg
cs
All are acceptable SI units.

$$\text{Argstrom} = \underbrace{10^{-10}\,m}_{SI} = \underbrace{1\,\mathring{A}}_{\text{X not SI}} = \underbrace{0.1\,nm}_{SI}$$

$\underbrace{\begin{array}{l} 1 \text{ hour} = 60 \text{ min} = 3600 \text{ s} \\ 1 \text{ min} = 60 \text{ s} \end{array}}_{\text{not SI units}}$

Temperature:

↳ Degree ~~Celicious~~ Celzious (°C) (t_c)
↳ Degree Fahrenhite (°F) (t_F)
↳ Kelvin (SI unit) (K) (T_K)
↳ also known as Absolute temperature.

$1°C \equiv 1\,K$

$1°C \equiv 1.8°F = \frac{9}{5}°F$

°C	≡ K	≡ °F
0	273.15	32
1	274.15	32 + 1.8 = 33.8
100	373.15	(100 × 1.8) + 32 = 212

			Difference
°C	Range	0 → 100	100
K	Range	273.15 → 373.15	100
°F	Range	32 → 212	180

SI units

Thur. 3/10/2019

$\underbrace{4.18}_{} - \underbrace{58.16}_{4\ s.f} \times \underbrace{(3.38 - 3.01)}_{= \underbrace{0.37}_{2\ s.f}} = ?$

$= 21.\underbrace{5192}_{\times}$

$= 4.18 - 21$

$= -17.3392 = \boxed{-17}$

$T_K = t_{°C} + 273.15$

K ⇒ °C ⇒ °F

$t_{°F} = \left(t_{°C} \times \frac{9\ °F}{5\ °C}\right) + 32$

$t_{°C} = (t_{°F} - 32) \times \frac{5}{9}$

□ Derived units.

⇒ Area = length × length

$= m \times m$

$= \boxed{m^2}$ ⇒ SI unit.

⇒ Volume = length × length × length

$= m \times m \times m$

$= \boxed{m^3}$ ⇒ SI unit.

⇒ $\underbrace{\text{Liter } (L)}$ $= 1\ dm^3 = 10^{-3} m^3$

↳ non-SI unit

$d = 10^{-1}$

$d^3 = 10^{-3}$

⇒ $\underline{mL} = 10^{-3} L = 10^{-3} dm^3 = 1\ \underline{cm^3}$

↳ non-SI unit.

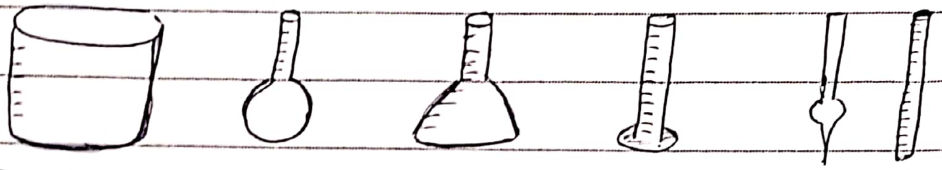
↳ $cc \equiv cm^3$

⇒ Speed = $\frac{\text{length}}{\text{time}}$ = m/s ⇒ SI unit

⇒ Dencity = $\frac{\text{mass of material}}{\text{volume of that material}}$ = $\underbrace{g/cm^3}_{\text{SI unit}}$

= g/mL

not a SI unit but it's more common



Beaker   volumetric flask   Erlenmeyer flask   cylinder   pipette

□ Units & dimentional analysis:
(Factor-label method)

⇒ Given quantity x $\left[\frac{\text{desired unit}}{\text{given unit}}\right]$

↳ conversion factor

Ex: How many meters in 3.54 yards?
(1 in = 2.54 cm)(1 yd = 36 in)

solution:

$3.54\ \cancel{yd} \times \frac{36\ \cancel{in}}{1\ \cancel{yd}} \times \frac{2.54\ \cancel{cm}}{1\ \cancel{in}} \times \frac{1\ m}{10^2\ \cancel{cm}}$

= Exact number

= $\boxed{}$

* Sec 2.1, 2.2 not included.
2.5, 2.6 2.7

Chapter 2: Atoms, molecules and ions.

Sun 6/10/2019

- Atoms
  - → Proton : Nucleus particle that has a positive charge.
  - → Electron : Negative charge.
  - → Neutron : Nucleus particle that has Neutral charge.

Their amount of charge is equal

$$\text{Mass } p^+ > 1800\ m_{e^-}$$

$$m_p \approx m_n$$

- The property of an atom is identified by the number of protons in nucleus.

Number of protons in atom nucleus = Number of electrons in a neutral atom.

- Atomic number (Z) : The number of protons in nucleus of an atom.

- Element : Group of atoms that have same proton number in the nucleus.

- Atomic weight (A) "Mass number" : Number of protons + number of neutrons.

$${}^{A}_{Z}X \rightarrow \text{element}$$

6/10/19

$$A \leftarrow \, ^{23}_{11}Na \, \rightarrow Z$$

- \# of $p = 11$
- \# of $e^- = 11$
- \# of $n = 23 - 11 = 12$

■ Isotopes: are atoms that have the same atomic number but different number of neutrons (mass number)

↳ "Has the same atomic number but differ in the mass number"

Ex:

^1_1H	^2_1H	^3_1H
$p=1$ $e=1$ $n=0$	$p=1$ $e^-=1$ $n=1$	$p=1$ $e=1$ $n=2$

Isotopes.

⇓	⇓	⇓
Hydrogen-1	Hydrogen-2	Hydrogen-3

"1, 2, 3 represent the mass number"

$^{23}_{11}Na^+$: $p=11$, $e^-=10$, $n=12$

$^{35}_{17}Cl^-$: $p=17$, $e=18$, $n=18$

$^{16}_{8}O^{-2}$: $p=8$, $e=10$, $n=8$

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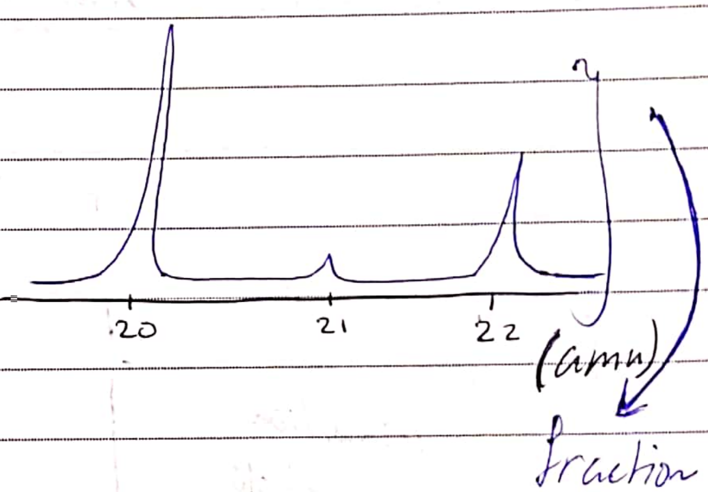
- Mass spectrometer: Is an instrument used to determine the atomic weight.

↳ The seperation is based on $\frac{m \rightarrow \text{mass}}{z \rightarrow \text{charge}}$

Ne-20

Ne-21

Ne-22



(amu) ≡ Atomic mass unit:

One amu $= \frac{1}{12}$ of atomic mass of carbon-12.

Ex: ~~Atomic~~ Calculate the atomic weight of Cr based on the following data:

Mass number	Isotopic mass (amu)	Fraction abundance
50	49.961	0.0435 4.35%
52	51.7105	0.8379 83.79%
53	52.9407	0.0950 9.50%
54	53.9389	0.0236 2.36%
		+ 1

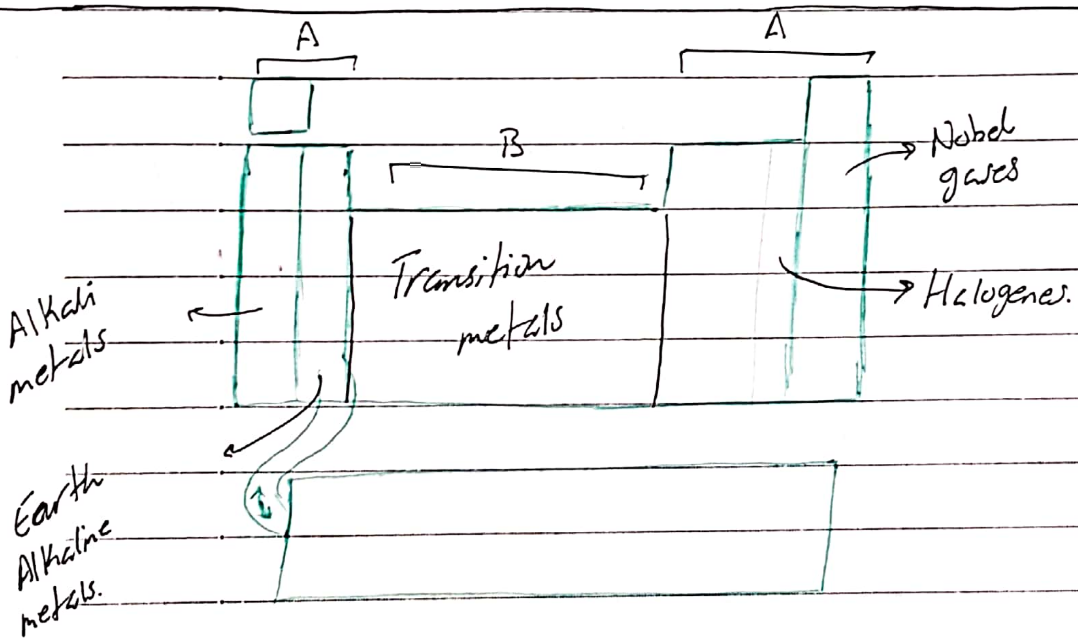
Atomic weight $= (49.961 \times 0.0435) + (51.7105 \times 0.8379) + (52.9407 \times 0.0950) + (53.9389 \times 0.0236)$

$= \boxed{51.99 \text{ amu}}$

$^{51.99}_{24}Cr$

Fast revision Tue, 8/10/2019

- Mass number (A): Number of protons + number of neutrons.
  ↳ Has no unit
- Atomic weight (Average)
  ↳ Has a unit.



metal + non-metal = ionic compounds.

non-metal / metaloides + non-metal / metaloides = molecular compounds.

Naming of simple compounds:
↳ Ionic compounds.
↳ molecular compounds.
↳
↳

Predication of oxidation number — Tue, 8/10/2019

Al^{3+} ↪ oxidation number

1) Most of metals have oxidation number same as their group number.

Ex: Na ⇒ In group # 1 ⇒ Na^{+}

Al ⇒ In group # 3 ⇒ Al^{3+}

2) For metals that have high atomic weight, the oxidation number = Number of the group − 2.

Ex: Lead (4A)

Pb ⇒ Pb^{2+} The most common

→ Based on rule 1:

⇒ Pb^{4+}

3) Most of transition metals have more than one oxidation number.

Ex: Fe^{2+} and Fe^{3+}

Cu^{2+} and Cu^{+}

4) For non-metals oxidation number:

= Number of group − 8

Ex: Cl (7A) ⇒ $7-8=-1$ ⇒ Cl^{-}

O (6A) ⇒ $6-8=-2$ ⇒ O^{2-}

N (5A) ⇒ $5-8=-3$ ⇒ N^{3-}

Naming of ionic compounds:

Ionic compounds:
- +ve ion ⇒ Cation → Mostly metals
- −ve ion ⇒ Anion → Non-metals or group.

Ions

عنصر واحد

Monoatomic ions

Na^+, Cl^-, Ba^{2+}

عنصرين أو أكثر

Polyatomic ions

CN^-, PO_4^{3-}, Cr_2O^{2-}, OH^-

NH_4^+, Hg_2^{2+}

Ammonium ↲ ↳ Mercury (I)

☒ Rules for naming ionic compounds:

1) Monoatomic cations will have the same name of the metals.

K	K^+
Potasium	Potasium ion

2) Monoatomic cations that have more than one oxidation # we will have roman numbers while naming them (I, II, III, IV, V, VI, ...) to indicate the oxidation number.

Pb^{2+} lead (II), Pb^{4+} lead (IV)

Fe^{3+} Iron (III), Fe^{2+} Iron (II)

Cu^{2+} copper (II), Cu^{+} copper (I)

— ic — ons

Forric Ferrons

cupric cuprons

Zn^{2+} Zinc ion or Zinc (II) is acceptable as well.

3: In mono-atomic anions we add -ide to the end of the name:

Cl^-, Chloride.

H^-, hydride. N^{3-}, Nitride.

Br^-, Bromide.

Ex: $Mg_3N_2 \Rightarrow$ magnesium nitride.

$CrSO_4 \Rightarrow$ chromium (II) sulfate.

$PbCrO_4 \Rightarrow$ lead (II) chromate.

$CaO \Rightarrow$ Calcium oxide.

Iron (II) phosphate $\Rightarrow Fe_3(PO_4)_2$

Titanium (IV) oxide $\Rightarrow TiO_2$

Ti^{4+} O^{2-}

$Ti_2O_4 \Rightarrow TiO_2$

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Naming compounds. 10/10/2019

- Molecular compounds:
  - ⇒ Binary compounds: A binary compound is a compound that is composed of two elements.

  - ⇒ Binary compound that contains Hydrogen is named same as the ionic compounds or it has its special name:

$HCl_{(g)}$ ⇒ Hydrogen chloride.
H_2S ⇒ Hydrogen sulfide.
$HBr_{(g)}$ ⇒ Hydrogen bromide.
H_2O ⇒ Water
NH_3 ⇒ Ammonia.

* Order of elements in formulas:

$$\Rightarrow \underset{3A}{B},\ \underbrace{Si\ \ C}_{4A},\ \underbrace{Sb\ \ As\ \ P\ \ N}_{5A},\ H,$$

$$\underbrace{Te\ \ Se\ \ S}_{6A},\ \underbrace{I\ \ Br\ \ Cl}_{7A},\ O,\ F$$

* Molecular compounds are named same as ionic compounds → Keep the same name.
  → Stem + -ide

with extra greek prefix to obtain the number of atoms in the compound.

10/10/2019

Naming of compounds.

mono -1	tetra -4	hepta -7
di -2	Penta -5	octa -8
tri -3	Hexa -6	nona -9
		deca -10

- We do not use mono with the first name.

- If "o" or "a" in the prefix are met with "o" or "a" in the name we delete it.
  - ↳ Ex: SF_4 ⇒ Sulfur dioxide.
    - $Cl\,O_2$ ⇒ Chlorine dioxide
    - Cl_2O_7 ⇒ dichlorine heptoxide.
    - N_2O_4 ⇒ dinitrogen tetroxide.
    - P_4O_6 ⇒ tetraphosphorous hexoxide.

- Hydrate:
  - ↳ Is a compound that contains water molecules weakly bound to its crystal.

$$CuSO_4 \cdot 5H_2O \xrightarrow{\Delta} CuSO_4 + 5H_2O$$

blue | white

Copper (II) sulfate pentahydrate

Anhydrate copper (II) sulfate.

⇒ While naming hydrates we use greek prefix + hydrate.

Acids & Bases:

10/10/2019

- Bases are named similar to ionic compounds:

  $NaOH \rightarrow$ Sodium hydroxide.

  $Ba(OH)_2 \rightarrow$ Barium hydroxide.

  $NH_3 \rightarrow$ Ammonia.

- Acids: Compound donate H^+ when dissolved in water.

  $X_{aq} \rightarrow$ aquous solution.

  $$HCl_{(g)} \xrightarrow{H_2O} HCl_{aq}$$

  $$HBr_{(g)} \xrightarrow{H_2O} HBr_{aq}$$

  Hydrogen Bromide $\Rightarrow$ HydroBromic acid.

- Oxoacids: Are acidic compounds that contains hydrogen H, Oxygen O and another element in its formula.

  is made out of 3 elements

  Ex: $H_2SO_4 \Rightarrow$ Sulfuric acid.

  $H_2CO_3 \Rightarrow$ Carbonic acid

  $HClO_3 \Rightarrow$ Chloric acid.

  $HIO_3 \Rightarrow$ Nitric acid.

  $H_3PO_4 \Rightarrow$ Phosphouric acid.

  $H_2CrO_4 \Rightarrow$ chromic acid.

Acids & Bases. 10/10/19

1] if we add extra "O" then we add "Per" in the begining of the name.

Ex: $HClO_4$ ⇒ Perchloric acid.

$HBrO_4$ ⇒ Perbromic acid.

2] If the acid less in one "O" then we change the (-ic) to (-ous):

Ex: H_2SO_3 ⇒ Sulfurous acid.

$HClO_2$ ⇒ Chlorous acid.

HNO_2 ⇒ nitrous acid.

3] If the acid less in two "O" then we add "Hypo" in the begining & change -ic to -ous.

Ex: $HClO$ → Hypochlorous acid.

$HBrO$ → Hypobromous acid.

HIO → Hypoiodous acid.

Oxaanions: -ic acid $\xrightarrow{\text{change it to}}$ -ate

-ous acid ⇒ -ite

Ex: HNO_3 → Nitric acid. HNO_3^- → Nitate.

HNO_2 → Nitrous acid HNO_2^- → Nitrite.

ClO_4^- ⇒ perchlorate.

ClO^- ⇒ Hyprochlorite.

Writing chemical equations: 13/10

$$\underbrace{2Na_{(s)} + Cl_{2(g)}}_{\text{reactants}} \xrightarrow{} \underbrace{2NaCl_{(s)}}_{\text{products}}$$

yeild.

$$2NaNO_{3(s)} \xrightarrow{\Delta} 2NaNO_{2(s)} + O_{2(g)}$$

Delta =(heating)

$$\underbrace{2H_2O_{2(aq)}}_{\text{hydrogen peroxide}} \xrightarrow{Pt} 2H_2O_{(l)} + O_{2(g)}$$

used as catalyst.

$(O_2{}^{2-})$

Balancing of chemical equation:

1) Start the balancing with atoms that appear once in the reactants and products.
2) Postpone the balancing of hydrogen and oxygento to the end.
   ↳ if both are present we start with the O or the one that appears the least number of times.

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

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

$$4H_3PO_3 \rightarrow 3H_3PO_4 + PH_3 \leftarrow \text{start with } O_2.$$

$$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$$

Start with Fe $\leftarrow$ $Fe_2(SO_4)_3 + 6NH_3 + 6H_2O \rightarrow 2Fe(OH)_3 + 3(NH_4)_2SO_4$

18 + 12 = 30H   30H   6   24

Chapter 3: Chemical Formula calculating & equations.

Compound → ionic ⇒ Formula weight; → molecular ⇒ Molecular weight } The sum of atomic weights in the compound.

Ex: Calculate the molecular weight (MWt) of H_2O (AW of O=16, H=1).

H_2O → 2H $2 \times 1.0 = 2.0$
→ 1 O $16.0 \times 1 = 16.0$ +
18.0 amu.

- Calculate the formula weight of NaCl (A.W of Na = 22.99 amu, and Cl = 35.45 amu).

NaCl → 1 x Na = 22.99
→ 1 x Cl = 35.45 +
$\boxed{58.44 \text{ amu}}$

- Calculate the formula weight of Iron (III) sulfate. (keep sig.fig. in mind).

amu of Fe = 55.8
amu of S = 32.1
amu of O = 16.00

Fe^{3-} X SO_4^{2-}
$Fe_2(SO_4)_3$
→ 2 x Fe
→ 3 x S
→ 3 x 4 x O
→ exact numbers

⇒ $2 \times 55.8 + 3 \times 32.1 + 3 \times 4 \times 16.00$
= (111.6) + (96.3) + (192.0)
= 399.9 amu
⇒ round: 4.00×10^2 amu

*) Mole (mol):

Avogadro's Rule: 12g * carbon-12

$$\Downarrow \text{contains}$$

$$\underbrace{6.022 \times 10^{23} \text{ atom}}_{\text{Mole.}}$$

*) Molar mass: mass (in g) of 1 mol of substance

$$\boxed{\text{mole } (n) = \frac{\text{mass (g)}}{\text{molar mass (g/mol)}}}$$

Tue 15/10

$H_2O \leftarrow O^{2-}$ oxide
$H_2O_2 \leftarrow O_2^{2-}$ peroxide
$HO_2 \leftarrow O_2^{-}$ Superoxide

H_3PO_4 Phosphoric acid.
$H_2PO_4^-$ dihydrogen phosphate.

$$Na_2SO_4 \longrightarrow 2Na^+ + SO_4^{2-}$$

1 molecule	2 ions	1 ion
6.022×10^{23}	$2 \times 6.022 \times 10^{23}$	6.022×10^{23}
1 mol	2 mols.	1 mol

Ex: Calculate the mass in grams of 1 atom chlorine (Cl) given molar mass of Cl = 35.5 g/mol.

$$mass = \frac{35.5 \text{ g/mol}}{6.02 \times 10^{23} \text{ atom/mol}} = 5.90 \times 10^{-23} \text{ g/atom}.$$

⇒ Chlorine atom Cl, chlorine molecule Cl_2.

- Calculate the mass in grams of one molecule of HCl gas: (molar mass of H = 1.0, Cl = 35.5 g/mol).

Molar mass of HCl = MM. H + MM Cl
= 35.5 + 1.0 = 36.5 g/mol.

mass of 1 molecule of HCl:

$$= \frac{36.5}{6.02 \times 10^{23}} = 6.06 \times 10^{-23} \text{ g}.$$

number of moles (n) $= \dfrac{\text{mass (g)}}{\text{molar mass (g/mol) MM}}$ → From the periodic table

Ex: How many moles of C_2H_5OH (46.1 g/mol) in 10 g of C_2H_5OH?

$n = \dfrac{m}{MM} = \dfrac{10}{46.1} = 0.217$ mol C_2H_5OH.

How many molecules in 10 g C_2H_5OH?

$0.217\ \cancel{mol} \times \dfrac{6.02 \times 10^{23}\ molecule}{\cancel{mol}} = \boxed{}$

How many grams of ZnI_2 in 0.0654 mol of ZnI_2?

↳ $M = 319$ g/mol

$m = n \cdot MM = 0.0654 \times 319 = 20.9$ g ZnI_2.

How many grams of I^- in 0.0654 mol ZnI_2?

($I = 127$ g/mol)

1 mol $ZnI_2 \rightarrow$ 2 mol I^-

$0.0654\ mol\ ZnI_2 \times \dfrac{2\ mol\ I}{1\ mol\ ZnI_2} = 0.131\ mol\ I.$

mass $I = 0.131 \times 127$

$= \boxed{}$ g.

~~Calculating~~ Determining chemical formulas. 15/10.

* Percentage composition: mass percent of each element in a compound.

$$\%A = \frac{\text{mass } A}{\text{mass of compound}} \times 100\%$$

$$= \frac{n_A \times MM_A}{n_{Compound} \cdot MM_{Compound}} \times 100\%$$

Ex: What's the mass percentage of C, H & O in CH_2O?
(MM of C = 12.0, H = 1.0, O = 16.0 g/mol).

$MM\ CH_2O = 12.0 + 1.01 \times 2 + 16.0 = 30.0\ g/mol.$

$$\%C = \frac{1 \times 12.0}{1 \times 30.0} \times 100\% = 40.0\%$$

$$\%H = \frac{2 \times 1.01}{1 \times 30.0} \times 100\% = 6.73\%$$

$$\%O = 100 - (40.0 + 6.73) = 53.3\%$$

- How many grams of carbon are there in 83.5 g of CH_2O? ($\%C = 40\%$, $\%H = 6.73$, $\%O = 53.3\%$).

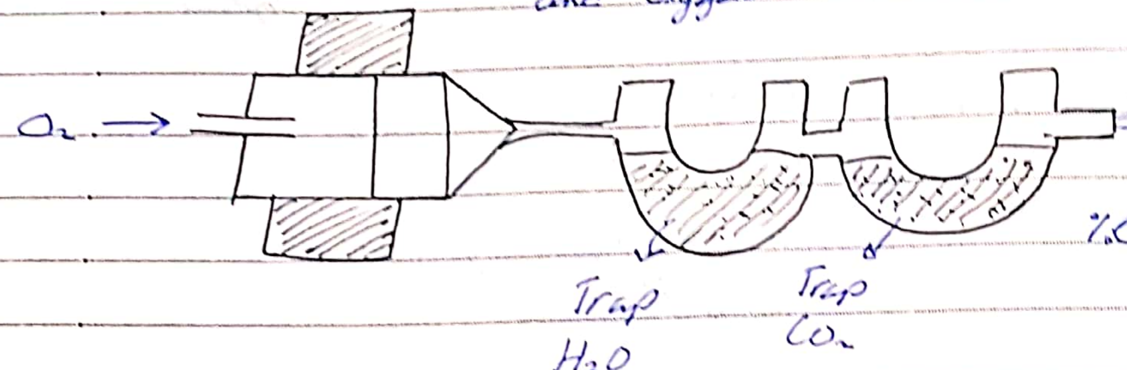
$$\% = \frac{m \text{ of element}}{m \text{ compound}} \times 100\%$$

$$40\% = \frac{m_C}{83.5} \times 100\%$$

$$\Rightarrow m_C = 33.4\ g.$$

Element analysis:

Element analysis: Percentages of carbon, hydrogen and oxygen.



$\%O = 100 - (C+H)\%$

Ex: A compound contains H, C, & O. A 4.24 g of the compound burned to produce 6.21 mg of CO_2 (44.0 g/mol) & 2.54 mg of H_2O (18.0 g/mol). What is the mass percentage of each element?

$$\frac{6.21 \times 10^{-3}}{44.0} \times \frac{1 \cdot C \text{ mol}}{1\ CO_2 \text{ mol}} \times 12.0 \frac{g\ C}{mol\ C} = 1.69 \times 10^{-3} \text{ g of C.}$$

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Thur. 17/10/19

$H_2CO_3 \Rightarrow$ Carbonic acid $\qquad$ $HCO_3^- \rightarrow$ Hydrogen carbonate.

$H_3PO_4 \Rightarrow$ Phosphoric acid

$H_2PO_4^- \Rightarrow$ dihydrogen phosphate. $\qquad$ $HPO_4^{2-} \rightarrow$ monohydrogen phosphate.

Ex: $m_{comp.} = 4.24\ mg$, $m_{CO_2} = 6.21\ mg$, $m_{H_2O} = 2.54\ mg$.

Find the mass of C & H.

= mol CO_2

$$\frac{m_{CO_2}}{MM_{CO_2}} \times \frac{1\ mol\ C}{1\ mol\ CO_2} = 1\ mol\ C \times MM_C = m_C$$

~~1mol C x MMc~~ $(6.21\ mg = 6.21 \times 10^{-3})$

$$\Rightarrow \frac{6.21 \times 10^{-3}}{44.0} \times \frac{1}{1} \times 12.0 = 1.69 \times 10^{-3}\ g\ C.$$

mass of H: $\frac{m\ H_2O}{MM\ H_2O} \times \frac{2mol\ H}{1mol\ H_2O} \times MM_H = m_H$

$$\frac{2.54 \times 10^{-3}}{18.0} \times \frac{2}{1} \times 1.01 = 2.85 \times 10^{-4}\ g\ H.$$

$$\%C = \frac{m_C}{m_{Com}} \times 100\% = \frac{1.69 \times 10^{-3}}{4.24 \times 10^{-3}} \times 100\% = 39.9\%$$

$$\%H = \frac{2.85 \times 10^{-4}}{4.24 \times 10^{-3}} \times 100\% = 6.72\%$$

$$\%O = 100\% - (39.9 + 6.72) = 53.4\%.$$

Determining formulas:

- Empirical formula: The simplest formula of a substance written with the smallest integer.

Molecular formula.
↳ gives the # of each element.

Molecular formula	Empirical formula
H_2O_2	HO
C_2H_2	CH
C_6H_6	CH
$C_6H_{12}O_6$	CH_2O

Empirical formula.
↳ gives the type & the ratio.

Ex: A compound of N and O is analyzed, and a sample weighing 1.57g is found to contain 0.483 g N and 1.104 g O. What's the empirical formula of the compound?

$$N: \frac{0.483\ g}{14.1\ g/mol} = 0.0345\ mol\ N$$

$$O: \frac{1.104}{16.00} = 0.06900\ mol\ O.$$

N : O (divide by the smallest # of moles)

$$\frac{0.0345}{0.0345} : \frac{0.06900}{0.0345}$$

$1 : 2 \Rightarrow \boxed{NO_2}$ Empirical formula.

Empirical & Molecular Formulas.

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↪ ionic compound ∴ Emp. f. = Simplist formula.

Ex: A compound that contains 17.5% Na, 39.7% Cr & 42.8% O.

What is the empirical formula?

* ⇒ Assume the mass of compound = 100g.

m → 17.5 g Na , 39.7 g Cr , 42.8 g O

$n_{Na} = \frac{17.5}{23} = 0.761$ mol Na

$n_{Cr} = \frac{39.7}{52.0} = 0.763$ mol Cr

$n_O = \frac{42.8}{16.0} = 2.68$ mol O

Na : Cr : O

$\frac{0.761}{0.761} : \frac{0.763}{0.761} : \frac{2.68}{0.761}$

(1 : 1 : 3.52) x2

2 : 2 : 7 ⇒ $Na_2Cr_2O_7$

- Molecular formula from empirical formula:

$n = \frac{\text{Molecular weight of compound}}{\text{Molecular weight of the emp. formula.}}$

Ex. What is the molecular formula of a compound that contains 39.9% C, 6.72% H & 53.4% O?

Assume the molecular weight of the compound is 60 amu.

$n_C = \frac{39.9}{12.0} = 3.33$ mol. $n_H = \frac{6.72}{1.01} = 6.67$ mol

$n_O = \frac{53.4}{16.0} = 3.34$ mol. C : H : O = $\frac{3.33 : 6.67 : 3.34}{3.33}$

1 : 2 : 1

⇒ CH_2O Emp. formula.

⟹

$\Rightarrow$ Molecular weight of $CH_2O = 12.0 + (2 \times 1.01) + 16.0$

$= 30.0$ amu

$$n = \frac{60.0}{30.0} = \boxed{2}$$

$\Rightarrow CH_2O [\times 2] \Rightarrow \boxed{C_2H_4O_2}$

- **Stoichiometry**: The relationship between substances.
  1) element & compound.
  2) reactants & products.

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

1 mol   3 mol   2 mol

$1\,mol\ N_2 \equiv 3\,mol\ H_2 \equiv 2\,mol\ NH_3$

Let A_nB be a compound:

The relation between $\overset{\rightarrow \text{element}}{A}$ and $\overset{\rightarrow \text{compound}}{A_nB}$:

$$\left.\frac{n \text{ mol } A}{\underset{\text{دائماً 1}}{1} \text{ mol } A_nB}\right] \rightarrow \text{Stoichiometry relation.}$$

$$aA + bB \rightarrow cC$$

relation between $\underset{\text{مطلوب}}{A}$ & $\underset{\text{معطى}}{B}$

$$\left.\frac{a \text{ mol } A}{b \text{ mol } B}\right]$$

mass A $\rightarrow \times \frac{1}{MMA} \rightarrow$ $\boxed{\text{moles of A}}$ $\rightarrow \times$ Stoichiometry ~~ratio~~ ratio $\rightarrow$ $\boxed{\text{moles of B}}$

$\times \left[\frac{b\,mol\,B}{a\,mol\,A}\right]$

$\times MMB \longrightarrow$ $\boxed{\text{Mass of B}}$

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Stoichiometry Sun 20/10/2019

$$\boxed{\text{Mass } A} \xrightarrow{\times \frac{1}{MMA}} \boxed{\text{Mole } A} \xrightarrow[\frac{b \text{ mol } B}{a \text{ mol } A}]{\times \text{ stoichiometry ratio}} \boxed{\text{Mole } B} \xrightarrow{\times MMB} \boxed{\text{Mass } B}$$

Ex $\underset{A}{Fe_2O_3} + 3CO \rightarrow \underset{B}{2Fe} + 3CO_2$

How many grams of iron can be produced from 1.0 kg of Fe_2O_3? (MM = 160).

$$\frac{1.00 \times 10^3}{160} \times \frac{2 \text{ mol } Fe}{1 \text{ mol } Fe_2O_3} \times 55.8 = m_{Fe}$$

$$\Rightarrow m_{Fe} = 698 \text{ g } Fe.$$

Ex: $\underset{B}{4HCl} + \underset{A}{MnO_2} \rightarrow 2H_2O + MnCl_2 + Cl_2$ ⇐ Balanced

How many grams of HCl react with 5.0 g of MnO_2?

$$\frac{5.0}{86.9} \times \frac{4 \text{ mol } HCl}{1 \text{ mol } MnO_2} \times 36.5 = m_{HCl}$$

MM MnO_2 = 86.9

$$\Rightarrow m_{HCl} = 8.4 \text{ g } HCl$$

□ Limiting reagent (limiting reactant): The substance that is consumed first in a chemical reaction.

or هي المادة التي تحدد كمية المادة الناتجة.

$$1 \text{ bread} + \underbrace{2 \text{ Falafil}}_{\text{Limiting}} \rightarrow 1 \text{ Sandwish}$$

If we have 5 breads & 8 Falavil, how many Sandwishes?

$$n_{bread} \times \frac{n \text{ sandwich}}{n \text{ bread}} = ?$$

$$8 \text{ Falafil} \times \frac{1 \text{ Sandwish}}{2 \text{ Falafil}} = 4 \text{ Sandwishes}$$

$$5_{bread} \times \frac{1 \text{ Sandwish}}{1 \text{ bread}} = 5 \text{ Sandwishes}$$

∴ Limiting

Ex: $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

If 0.30 mol Zn is added to 0.52 mol HCl,
How many mol of H_2 are produced?

$0.3 \text{ mol Zn} \times \frac{1 \text{ mol } H_2}{1 \text{ mol Zn}} = 0.3 \text{ mol } H_2$

$0.52 \text{ mol HCl} \times \frac{1 \text{ mol } H_2}{2 \text{ mol HCl}} = \boxed{0.26 \text{ mol } H_2}$

∴ HCl is the limiting.

Ex: $2CH_3CHO + O_2 \longrightarrow$ ~~$2HC_2H_3$~~ $2HC_2H_3O_2$

The reaction was preformed by mixing 10.0g of O_2 and 20.0g of CH_3CHO, How many grams of $HC_2H_3O_2$ is produced?

$\frac{10.0 g\ O_2}{16 \times 2} \times \frac{2 \text{ mol } HC_2H_3O_2}{1 \text{ mol } O_2} = 0.625 \text{ mol } HC_2H_3O_2$ X

$\frac{20.0 g\ CH_3CHO}{44.1} \times \frac{2 \text{ mol } HC_2H_3O_2}{2 \text{ mol } CH_3CHO} = \boxed{0.454 \text{ mol } HC_2H_3O_2}$

limiting.

$\Rightarrow 0.454 \text{ mol } HC_2H_3O_2 \times \overset{MM}{60.1}$

$= \boxed{27.3 g}\ HC_2H_3O_2$

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From the previous question,
How many grams of the excess reactant remains in the solution?

$$0.454\ mol\ HC_2H_3O_2 \times \frac{1\ mol\ O_2}{2\ mol\ HC_2H_3O_2} \times \underset{}{\overset{MM\,O_2}{32.0}} = \underbrace{\boxed{7.26 g\ O_2}}_{O_2 \text{ reacted}}$$

$\Rightarrow$ Mass Excess = Mass total − Mass unreacted.

$$\underset{unreacted}{m_{O_2}} = 10.0 - 7.26 = 2.7\ g\ O_2$$

Yield → Theoretical: The maximum amount of product that can be obtained. (Calculations)

→ Actual: The amount of product that is actually produced in experiment.

$$\text{Percent yield} = \frac{\text{Actual yield}}{\text{Theoritical yield}} \times 100\%$$

Ex: Calculate the percent yield based on the previous example if the amount that's actually produced of $HC_2H_3O_2$ is 23.8g.

$$\%\ yield = \frac{23.8}{27.3} \times 100\% = 87.2\%$$

End of chapter 3.

Chapter 4 : Chemical reactions. Sun 20/10/2019

Aqueous solution → solvent (water)
→ Solute.

(can be: ionic compounds, acids, bases)
Ex: HClaq, NaCl

(can be molecular compounds)
Ex: $C_6H_{12}O_6$

→ Electrolyte: conduct electricity when disolved in water.

→ Non-electrolyte: does not conduct electricity.

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Types of chemical reactions. Thur. 24/10/19.

1) Precipitation reactions.
2) Acid-base reactions (neutralization reactions).
or (Proton transfer reaction).
3) Oxidation-reduction reaction.
(electron transfer reaction).

1] Precipitation reaction: reaction between two soluble ionic compounds to produce راسب insoluble (precipitate) ionic compound.

$$Ca(NO_3)_{2(aq)} + K_2CO_{3(aq)} \rightarrow CaCO_{3(s)} + 2KNO_{3(aq)}$$

Exchange (motathesis)

$$Ca^{2+} + CO_3^{2-} \rightarrow CaCO_{3(s)}$$ } not ionic equation.

Ex: Predict the possibility of the following reaction:

a) $MgCl_{2(aq)} + 2AgNO_{3(aq)} \rightarrow Mg(NO_3)_{2(aq)} + 2AgCl_{(s)}$

$$Ag^+ + Cl^- \longrightarrow AgCl$$

Possible.

b) $2NaCl_{(aq)} + Fe(NO_3)_{2(aq)} \rightarrow 2NaNO_{3(aq)} + FeCl_{2(aq)}$

no reaction. "not possible"

c) $Al_2(SO_4)_{3(aq)} + 6NaOH_{(aq)} \rightarrow 3Na_2SO_{4(aq)} + 2Al(OH)_{3(s)}$

$$Al^{3+} + 3OH^- \longrightarrow Al(OH)_3$$

∴ possible.

24/10

2) Acid-base reactions: (Proton transfer reactions).

* Acid-base indicator: a dye used to distinguish between acidic and basic medium by colour.

Acetic acid CH_3CO_2H Vinigar.

* Acid: Substance produce Hydrogen ion (proton)(H^+) when disolved in water.

$$HNO_{3(aq)} \xrightarrow{H_2O} H^+ + NO_3^-$$

$$CH_3CO_2H \rightleftharpoons CH_3CO_2^- + H^+$$

* Base: Substance produce Hydroxide ion (OH^-) when disolved in water.

$$NaOH_{aq} \longrightarrow Na^+ + OH^-$$

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

- Strong acids:

  HCl, HI, HBr

  HNO_3, H_2SO_4, $HClO_4$

- Strong bases:

  $NaOH$, KOH, $LiOH$

  $Ca(OH)_2$, $Ba(OH)_2$, $Sr(OH)_2$

Strong acids and bases are strong electrolytes. "Full dissociation"

others are weak acids & bases.

Bronsted acid: Proton donor.

Bronsted base: Proton acceptor.

$$\underset{\text{base}}{NH_3} + \underset{\text{acid}}{H_2O} \rightleftharpoons NH_4 + OH^-$$

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24/10/19

$\overset{H^+}{HNO_3} + H_2O \longrightarrow NO_3^- + H_3O^+$ Hydronium ion.

acid base

weak acids or bases are weak electrolytes.
"partial dissociation"

weak acids

$HCN + H_2O \rightleftharpoons CN^- + H_3O^+$

acid base

$HF + H_2O \rightleftharpoons F^- + H_3O^+$

acid base

weak base

$NH_3 + H_2O \rightleftharpoons NH_4 + OH^-$

base acid

⇒ H_2O is amphiprotic species.
"reacts acid and base at the same time".

Ex: Classify the following acids / bases to strong / weak:

a) LiOH strong base
b) $HC_2H_3O_2$ weak acid
c) HBr strong acid
d) HNO_2 weak acid
e) H_3PO_4 weak acid.

- Neutralization reaction: is a reaction between acid and base to produce a salt & possibly water.

$NaOH + HCl \longrightarrow NaCl + H_2O$

base acid salt water

$NH_3 + HCl \longrightarrow NH_4Cl$

base acid salt

~~$HCN + KOH \longrightarrow KCN + H_2O$~~

Acid base salt water

Types of chemical reactions. Thur. 24/10/19.

1) Precipitation reactions.
2) Acid-base reactions (neutralization reactions).
or (Proton transfer reaction).
3) Oxidation-reduction reaction.
(electron transfer reaction).

1] Precipitation reaction: reaction between two soluble ionic compounds to produce insoluble (precipitate) ionic compound.

$$Ca(NO_3)_{2(aq)} + K_2CO_{3(aq)} \longrightarrow CaCO_{3(s)} + 2KNO_{3(aq)}$$

Exchange (metathesis)

$$Ca^{2+} + CO_3^{2-} \longrightarrow CaCO_{3(s)}$$ not ionic equation.

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a) $MgCl_{2(aq)} + 2AgNO_{3(aq)} \longrightarrow Mg(NO_3)_{2(aq)} + 2AgCl_{(s)}$

$$Ag^+ + Cl^- \longrightarrow AgCl$$

Possible.

b) $2NaCl_{(aq)} + Fe(NO_3)_{2(aq)} \longrightarrow 2NaNO_{3(aq)} + FeCl_{2(aq)}$

no reaction. "not possible"

c) $Al_2(SO_4)_{3(aq)} + 6NaOH_{(aq)} \longrightarrow 3Na_2SO_{4(aq)} + 2Al(OH)_{3(s)}$

$$Al^{3+} + 3OH^- \longrightarrow Al(OH)_3$$

$\therefore$ Possible.

2) Acid-base reactions: (Proton transfer reactions).

* Acid-base indicator: a dye used to distinguish between acidic and ~~basic~~ basic medium by colour.

Acetic acid CH_3CO_2H Vinigar.

* Acid: Substance produce Hydrogen ion (proton)(H$^+$) when disolved in water.

$$HNO_{3(aq)} \xrightarrow{H_2O} H^+ + NO_3^-$$

$$CH_3CO_2H \rightleftharpoons CH_3CO_2^- + H^+$$

* Base: Substance produce Hydroxide ion (OH^-) when disolved in water.

$$NaOH_{aq} \longrightarrow Na^+ + OH^-$$

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-.$$

□ Strong acids:

Strong acids and bases are strong electrolytes. "Full dissociation"

HCl, HI, HBr

HNO_3, H_2SO_4, $HClO_4$

□ Strong bases:

NaOH, KOH, LiOH

$Ca(OH)_2$, $Ba(OH)_2$, $Sr(OH)_2$

others are weak acids & bases.

Bronsted acid: Proton donor.

Bronsted base: Proton acceptor.

$$\underset{\text{base}}{NH_3} + \underset{\text{acid}}{H_2O} \rightleftharpoons NH_4 + OH^-$$

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$HNO_3 + H_2O \xrightarrow{} NO_3^- + H_3O^+$ Hydronium ion.

acid base (H^+)

Weak acids or bases are weak electrolytes.
"partial dissociation"

weak acids

$HCN + H_2O \rightleftharpoons CN^- + H_3O^+$ (H^+)

acid base

$HF + H_2O \rightleftharpoons F^- + H_3O^+$ (H^+)

acid base

weak base

$NH_3 + H_2O \rightleftharpoons NH_4 + OH^-$ (H^+)

base acid

⇒ H_2O is amphiprotic species.
"reacts acid and base at the same time".

Ex: Classify the following acids / bases to strong / weak:

a) $LiOH$ Strong base
b) $HC_2H_3O_2$ weak acid
c) HBr Strong acid
d) HNO_2 weak acid.
e) H_3PO_4 weak acid.

- Neutralization reaction: is a reaction between acid and base to produce a salt & possibly water.

$NaOH + HCl \rightarrow NaCl + H_2O$

base acid salt water

$NH_3 + HCl \rightarrow NH_4Cl$

base acid salt

~~$HCN + KOH \rightarrow KCN + H_2O$~~

Acid base salt water

Archinious acid → Produce H^+ in water.
Archinious base → Produce OH^- in water.

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

Bronstd acid ⇒ Proton donor.
Bronstd base ⇒ Proton accepter

$$\underset{\text{Base.}}{NH_3} + \underset{\text{Acid}}{H_2O} \rightleftharpoons NH_4^+ + OH^-$$

$$HCN + H_2O \xrightarrow{+H} \rightleftharpoons CN^- + H_3O^+$$

Strong acid } → full ionization.
Strong base }

$$NaOH + HCl \rightarrow \underbrace{NaCl}_{\text{Salt}} + H_2O \quad \text{——— ①}$$

↳ ionic compound.

$$NH_3 + HCl \rightarrow NH_4Cl$$

$$HCl + NaOH \rightarrow NaCl + H_2O \quad \text{——— ②}$$

Write an ionic equation of equations ① & ②.

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$NaOH_{aq} + HCl_{aq} \rightarrow NaCl_{aq} + H_2O_l$

$\cancel{Na^+} + OH^- + H^+ + \cancel{Cl^-} \rightarrow \cancel{Na^+} + \cancel{Cl^-} + H_2O$

net ionic equation. [$OH^- + H^+ \rightarrow H_2O$

weak electrolite

$\overbrace{HCN}_{aq} + NaOH_{aq} \rightarrow NaCN_{aq} + H_2O_{(l)}$

$HCN + \cancel{Na^+} + OH^- \rightarrow \cancel{Na^+} + CN^- + H_2O$

net ionic equation [$HCN + OH^- \rightarrow CN^- + H_2O$

weak

$NH_{3\,aq} + HCl_{aq} \rightarrow NH_4Cl_{aq}$

$NH_3 + H^+ + \cancel{Cl^-} \rightarrow NH_4^+ + \cancel{Cl^-}$

net ionic equation. [$NH_3 + H^+ \rightarrow NH_4^+$

weak electrolite

$HNO_{2\,aq} + NaOH_{aq} \rightarrow NaNO_{2\,aq} + H_2O_{(l)}$

$HNO_2 + OH^- \rightarrow NO_2^- + H_2O$] net ionic equation.

[HCl, HNO_2, HF, HBr, HNO_3]

monoprotic acid.

[H_2SO_4, H_2PO_4, H_2SO_3] Polyprotic acid.