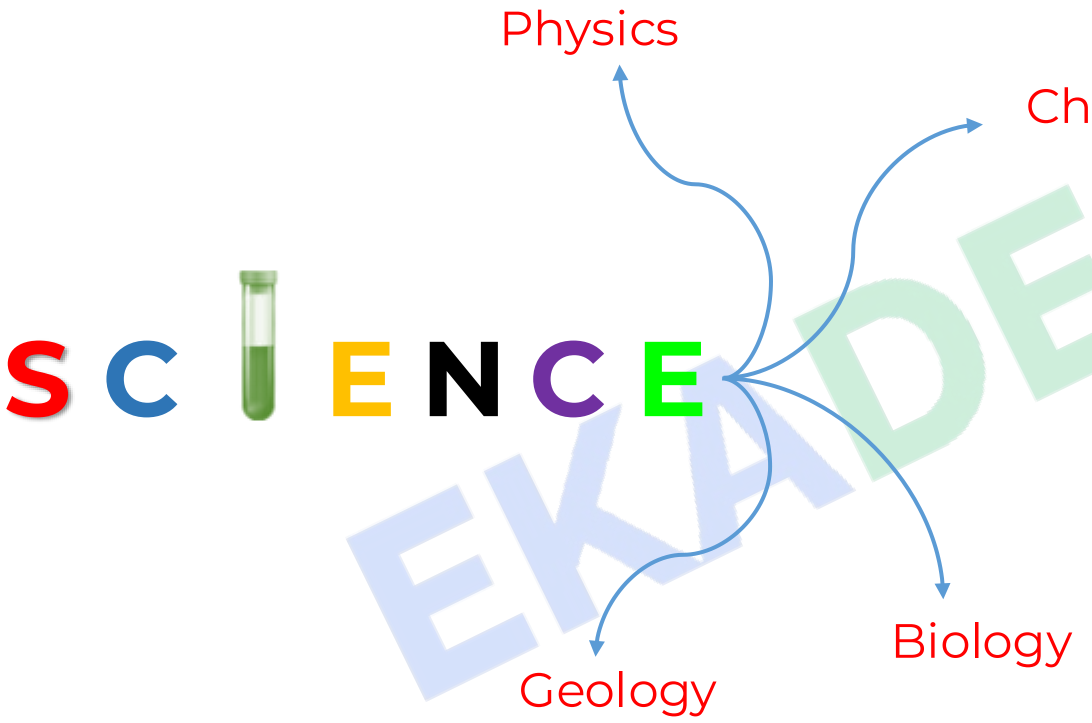
EKADEMY

Abhinav K Singh (AKS)

Some basic concepts of chemistry

Chapter 1

Introduction to Chemistry



- Composition, structure and properties of matter
- Transformations which the matter undergoes under different conditions
- The laws which govern these changes

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Introduction to Chemistry

History of Chemistry

Importance of Chemistry

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History of Chemistry

The name Chemistry is derived from the word Al-Chemy

Philosopher's stone (Paras)

'Elixir of life' which would grant immortality

Modern chemistry developed in Europe as a result of the above two quests of the Arabs

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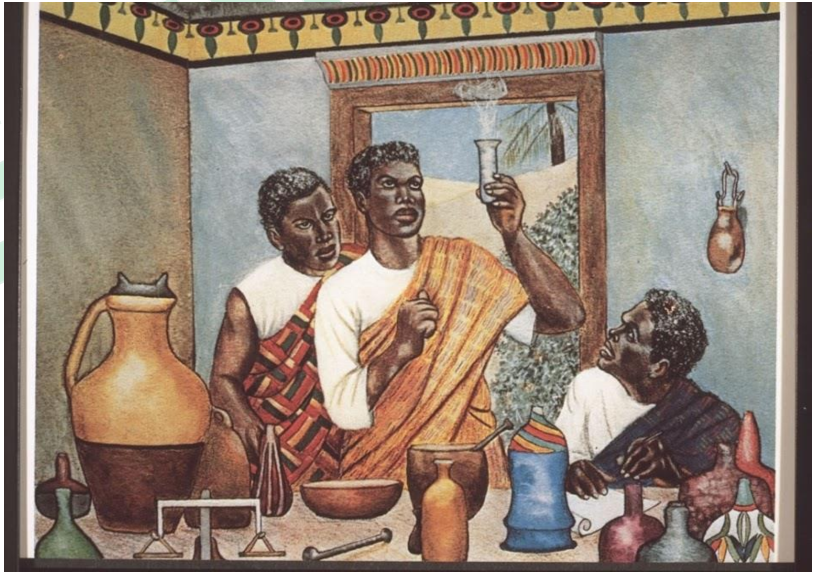
History of Indian Chemistry

Indians had their own alchemical traditions

That included much knowledge of chemical processes and techniques



Chemistry –

- Rasayan Shastra
- Rastantra
- Ras Kriya
- Rasvidya

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History of Indian Chemistry

Metallurgical Knowledge
Chalcolithic cultures

Knowledge of Dyes
Atharvaveda

Ancient Indian Chemistry Included

Ancient Medicines
Charaka Samhita

Cosmetic Products
Varähmihir's Brihat Samhita

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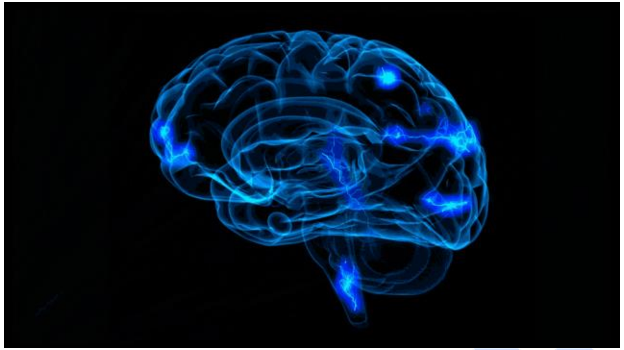
Importance of Chemistry



Functioning of Brain

Life-saving Medicines
Eg. cis-platin & taxol
Cancer treatment
AZT (Azidothymidine)
helping AIDS patients

Agriculture
Making Fertilisers

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1.1

Nature of Matter

EKADEMY

1.1 Nature of Matter

Learning Objectives

Matter and its Physical States

Classification of Matter

EKADEMY

1.1.1

Matter and Its Physical States

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Matter

A matter is defined as anything that occupies space, possesses mass and the presence of which can be felt by any one or more of our senses

Air in Football

Weight

Moving Hair in Wind

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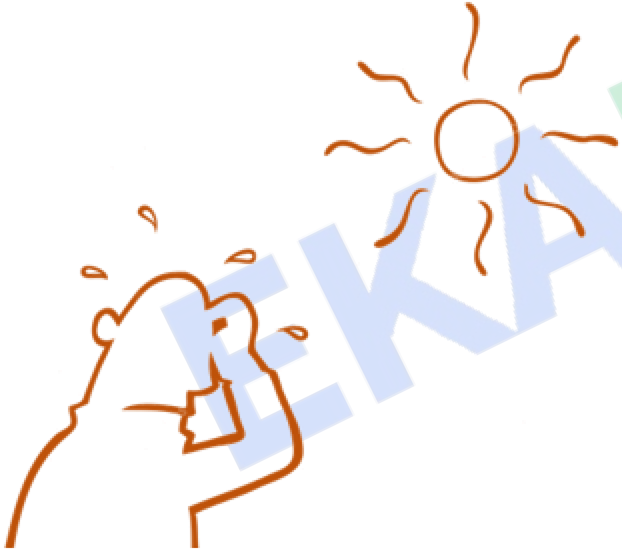
Matter

Not a Matter — Temperature



Feel

Measure

Not Occupy Space

No Mass

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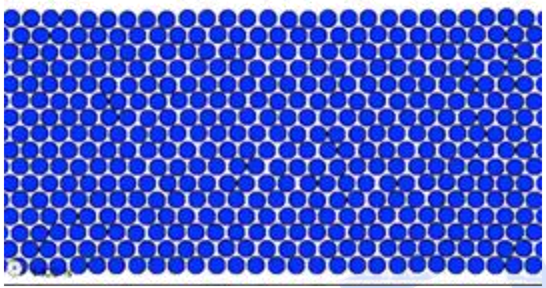
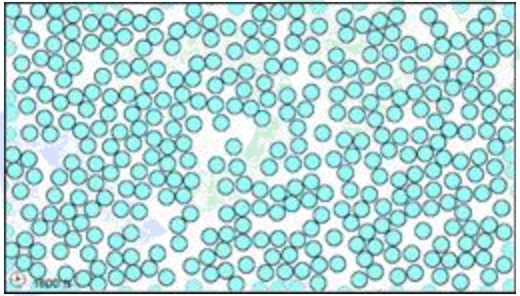
Physical states of Matter



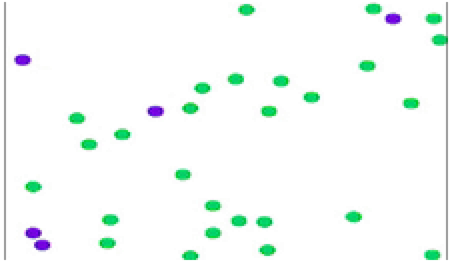
Solid

- Definite volume
- Definite shape



Liquid

- Definite volume
- No definite shape



Gas

- No definite volume
- No definite shape

Properties of Solid, Liquid and Gas

Properties	Solid	Liquid	Gas
Volume	Definite	Definite	Indefinite
Shape	Definite	Indefinite	Indefinite
Intermolecular force	Very high	Moderate	Negligible
Intermolecular space	Very small	Slightly greater	Very large
Compressibility	No	No	Very high
Expansion on heating	Very little	Very little	Very high
Rigidity	Highly rigid	Not rigid	Not rigid
Fluidity	Can't flow	Can flow	Can flow

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1.1.2

Classification of Matter

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Classification of Matter

- Matter
  - Pure Substance
    - Elements
    - Compounds
  - Mixture
    - Homogeneous
    - Heterogeneous

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Pure substances

Are they really Pure

?

Pure Ghee

Pure Honey

Pure Milk

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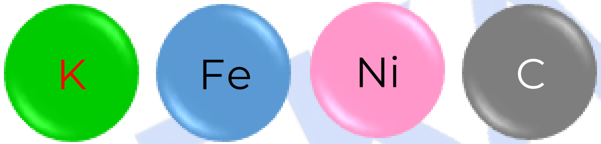
Pure substances

- Made up of single kind of particles

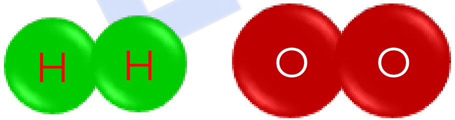
Elements

- Consist of only one type of particles

Atoms



Molecules



Compounds

- Combination of two or more different atoms in a definite ratio.
- Constituents can be separated by chemical methods.

Molecules

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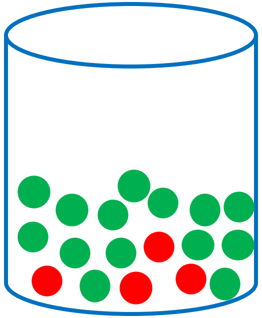
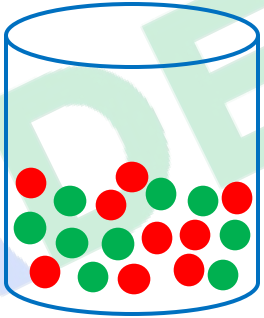
Mixture

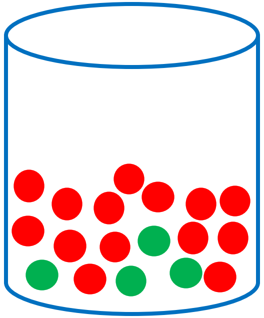
Contains particles of two or more pure substances which may be present in any ratio



Composition is variable



Pure substances forming mixture are called components



Can be separated by filtration, distillation, evaporation etc.

Examples - sugar solution in water, air, tea, dal etc.

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Homogeneous Mixture

- Components are completely mixed
- Particles of components are uniformly distributed

Example - Lemonade

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Heterogeneous Mixture

- Components do not mix completely
- Particles of components are not uniformly distributed

Example - Daal

Cook

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1.1

Problems + Solutions

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Q. Categorise the following as homogeneous and heterogeneous mixtures.
(i) sugar-water solution, (ii) air, (iii) mixture of pulses

Pause the video

Time duration : 1 minute

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Q. Categorise the following as homogeneous and heterogeneous mixtures.
(i) sugar-water solution, (ii) air, (iii) mixture of pulses

Sol.

Water + Sugar

Homogeneous mixture

Effect of Air

Homogeneous mixture of gases

Mixture of pulses

Heterogeneous mixture

Concep Test

Ready for Challenge

EKADEMY

Q. Categorise the following as pure substance and mixtures.
(i) NH_4Cl, (ii) pure ghee, (iii) pure honey, (iv) water, (v) pure milk

Pause the video

Time duration: 1 minute

EKADEMY

Q. Categorise the following as pure substance and mixtures.
(i) NH_4Cl, (ii) pure ghee, (iii) pure honey, (iv) water, (v) pure milk

Sol.

Made up of only NH_4Cl particles- Pure substance

Fat, moisture and vitamin- Mixture

Carbohydrate, sugar, water- Mixture

Made up of only H_2O particles- Pure substance

Calcium, carbohydrate, fat, sugar, water- Mixture

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Summary

History of Chemistry

Importance of Chemistry

Matter and its physical states

Properties of solid, liquid and gas

Classification of matter

Pure substance – elements and compounds

Mixture – homogeneous and heterogeneous

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1.1 Reference questions

Add two/three problems here

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1.2

Properties of Matter and Their Measurement

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1.2 Properties of Matter and their Measurement

Learning Objectives

Properties of Matter and measurement of Physical Properties

Mass, Volume, Density and Temperature

Scientific Notation and Uncertainty in Measurement

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1.2.1

Properties of Matter and measurement of Physical Properties

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Properties of Matter

Physical properties

Chemical properties

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Physical properties

Can be measured without changing the composition of the substance

Colour of Substance

Melting Point

Boiling point

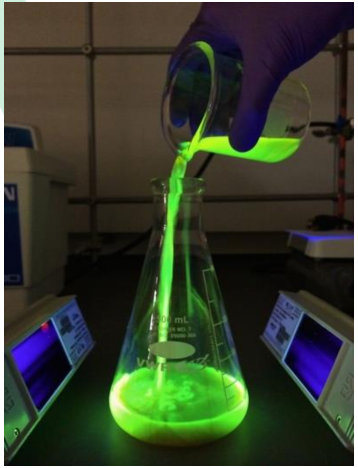
Measurement does not require occurrence of a chemical change

Chemical properties

During measurement, there is a change in composition of the substance

Burning of substance

Acid-base nature



Chemical reactivity

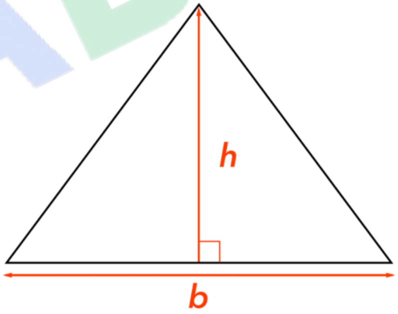
Chemical change will occur during measurement

Measurement of Physical Properties

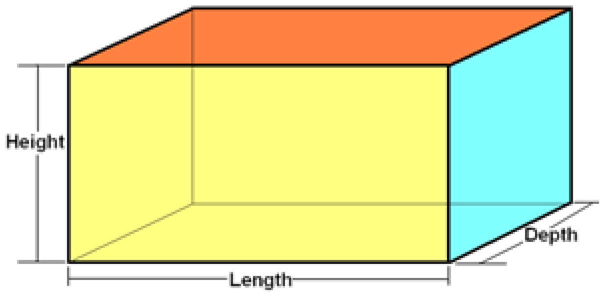
Quantitative measurement of properties is required for scientific investigation

Quantitative physical properties

Length



Area



Volume

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How to measure a Physical quantity ?

Compare the physical quantity with a Reference Standard → Unit

Mass standard is the kilogram

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Representation of Physical Properties

Measuring Length

Magnitude ← 28 m → Unit

Physical Quantity = Magnitude(n) × Unit(u) = n u

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Systems of Measurement

- Earlier Systems
  - English System
  - Metric System
    - Originated in France. Based on decimal system thus, more convenient
- New Systems
  - The International System of Units (SI)

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Units in SI System

Seven Fundamental or Base Units

Related to seven fundamental scientific quantities

Derived Units

Derived with the help of base units

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Seven Base Physical Quantities and their Units

Base Physical Quantity	Symbol of Quantity	Name of SI Unit	Symbol of SI Unit
Length	l	metre	m
Mass	m	kilogram	kg
Time	t	second	s
Electric current	I	ampere	A
Thermodynamic temp.	T	kelvin	K
Amount of substance	n	mole	mol
Luminous intensity	I_v	candela	cd

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1.2.2

Mass, Volume, Density and Temperature

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Mass

Amount of matter present in substance

SI unit of mass is kilogram

Determined by analytical balance

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Volume

Space occupied by a substance

SI unit of volume is m^3

Relation between different units of volume -

$$1\ L = 1000\ mL = 1000\ cm^3 = 1\ dm^3 = 10^{-3}\ m^3$$

Burette

Volumetric flask

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Density

Mass per unit volume

$$\text{SI unit of density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\frac{\text{SI unit of mass}}{\text{SI unit of volume}} = \frac{\text{kg}}{\text{m}^3} \text{ or kg m}^{-3}$$

Chemist often expresses density in g cm^{-3}

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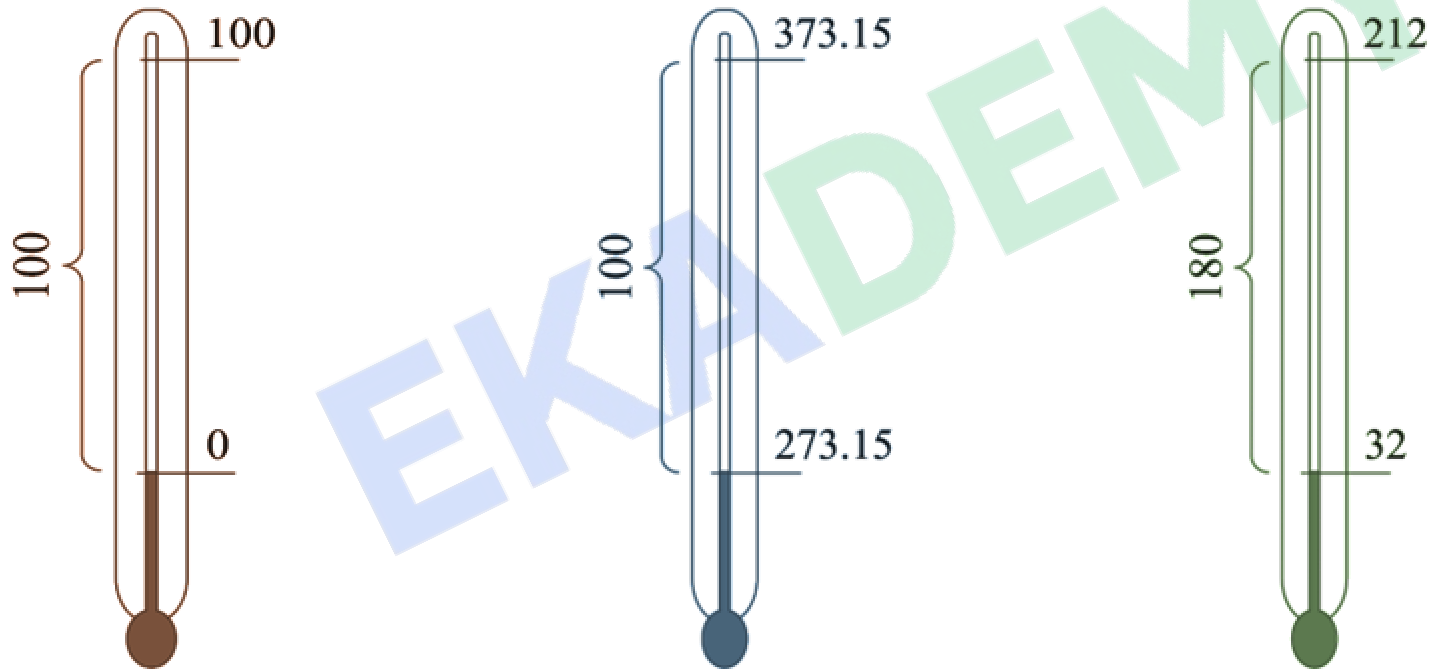
Temperature

°C (degree Celsius)

°F (degree Fahrenheit)

K (kelvin)



Boiling point of water

Freezing point of water

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Temperature

Relation b/w Celsius and Fahrenheit

$$°F = \frac{9}{5}°C + 32$$

Relation b/w Celsius and Kelvin

$$\mathrm{K} = °\mathrm{C} + 273.15$$

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1.2.3

Scientific Notation and Uncertainty in Measurement

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Scientific Notation

To simplify the calculation, any number can be represented in terms of exponential notation

Digit term
varies 1.000 to 9.999

Exponent

$$N \times 10^n$$

232.508 can be written as-

2.32508×10^2

0.00016 can be written as-

1.6×10^{-4}

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Q. Using scientific notation, solve the following

i. $(6.65 \times 10^4) + (8.95 \times 10^3)$ ii. $(2.5 \times 10^{-2}) - (4.8 \times 10^{-3})$

Pause the video

Time duration : 1 minute

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Q. Using scientific notation, solve the following

i. $(6.65 \times 10^4) + (8.95 \times 10^3)$ ii. $(2.5 \times 10^{-2}) - (4.8 \times 10^{-3})$

Sol.

$(6.65 \times 10^4) + (8.95 \times 10^3)$

$= (6.65 \times 10^4) + (0.895 \times 10^4)$

$= (6.65 + 0.895) \times 10^4$

$= 7.545 \times 10^4$

$(2.5 \times 10^{-2}) - (4.8 \times 10^{-3})$

$= (2.5 \times 10^{-2}) - (0.48 \times 10^{-2})$

$= (2.5 - 0.48) \times 10^{-2}$

$= 2.02 \times 10^{-2}$

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Uncertainty in Measurement

Experimental measurement or result has some amount of uncertainty

Uncertainty in experimental values is indicated by significant figures

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Significant figures

Uncertainty is indicated by writing the certain digits and the last uncertain digit

Experimental result

11.2 ml

Certain

Uncertain

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Rules for determining Significant figures

1- All non-zero digits are significant	285 cm	3
	0.25 ml	2
2- Zeros preceding to 1st non-zero digit are not significant	0.0052	2
3- Zeros between 2 non-zero digits are significant	2.005	4

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Rules for determining Significant figures

4- Zeros at the end or right of a number are significant, provided they are on the right side of the decimal point	0.200	3
5- Exact numbers have infinite significant figures	2 balls	Infinite
	30 eggs	Infinite

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Precision and Accuracy

Precision

Closeness of our result in different attempts

Accuracy

Closeness of our result with actual result

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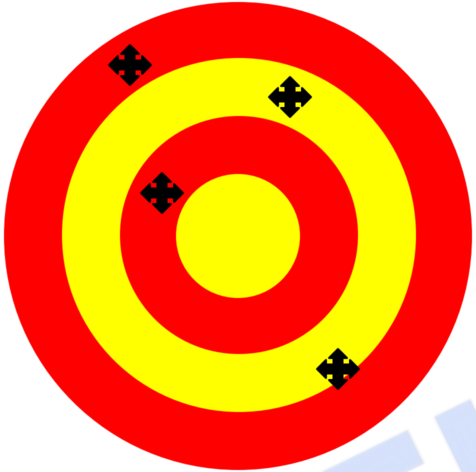
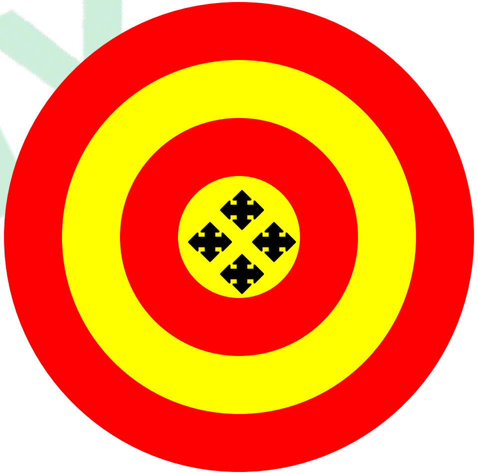
Precision and Accuracy



Neither precise nor accurate

Precise but not accurate



Precise and accurate

11C01.2

Problems + Solutions

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Q. Calculate the significant figure for the following addition-

$12.11 + 18.0 + 1.012$

Pause the video

Time duration : 1 minute

EKADEMY

Q. Calculate the significant figure for the following addition-

12.11 + 18.0 + 1.012

Sol. 12.11 + 18.0 + 1.012 = 31.122

Result cannot have more digits to the right of the decimal point than either of the original numbers

Here, 18.0 has only one digit after decimal

Result should be reported only up to one digit after decimal

31.122

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Q. A jug contains 2 L of milk. Calculate the volume of the milk in m_3

Pause the video

Time duration : 1 minute

EKADEMY

Q. A jug contains 2 L of milk. Calculate the volume of the milk in m^3

Sol.

We know, 1 L = 10^{-3} m^3, Thus

$$\frac{1\ \mathrm{L}}{10^{-3}\ \mathrm{m}^3} = 1 = \frac{10^{-3}\ \mathrm{m}^3}{1\ \mathrm{L}}$$

Called Unit Factors

$$\text{Desired value} = \text{Given value} \times \text{Unit factor}$$

Dimensional Analysis

The numerator should have that part which is required in the desired result

$$2\ \mathrm{L} = 2\ \mathrm{L} \times \frac{10^{-3}\ \mathrm{m}^3}{1\ \mathrm{L}}$$

$$= 2 \times 10^{-3}\ \mathrm{m}^3$$

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Summary

Physical properties

Chemical properties

Measurement of physical properties

SI units

Mass, volume, density and temperature

Uncertainty in measurement – significant figures, precision and accuracy

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1.2 Reference questions

NCERT Exercise Questions: 1.15, 1.16, 1.18, 1.19, 1.20, 1.22, 1.27, 1.31

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1.3

Laws of Chemical Combinations, Atomic and Molecular Masses

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1.3 Laws of Chemical Combinations, Atomic and Molecular Masses

Learning Objectives

Laws of Chemical Combinations

Dalton's Atomic Theory, Atomic and Molecular Masses

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1.3.1

Laws of Chemical Combinations

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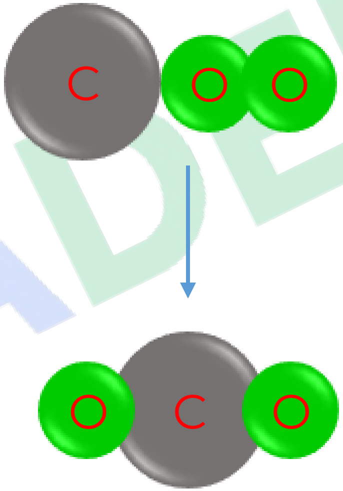
Laws of Chemical Combinations

Elements combine together chemically to form compounds



These chemical combinations are based on some laws

Laws of Chemical Combinations

Law of Conservation of Mass

Law of Definite Proportions

Law of Multiple Proportions

Gay Lussac's Law of Gaseous Volumes

Avogadro's Law

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Law of Conservation of Mass

In all physical and chemical changes, no net change in mass during the process

Antoine Lavoisier

~~Matter~~

Nor be destroyed

Neither be created

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Law of Definite Proportions or Law of Definite Composition

Irrespective of the source, a compound always contains same elements combined together in the same proportion by mass

Joseph Proust

Cupric Carbonate

Natural

Elements	%
Cu	51.35
C	9.74
O	38.91

Synthetic

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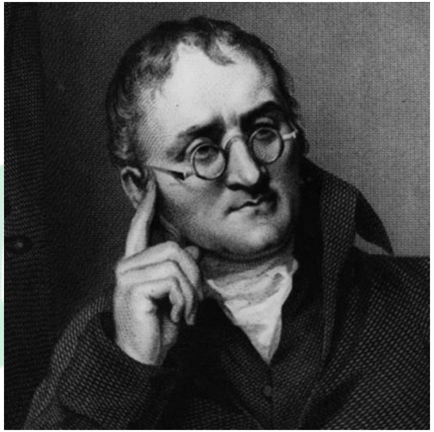
Law of Multiple Proportions

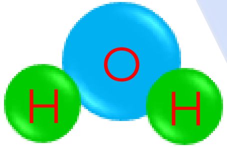


Dalton

If two elements combine to form more than one compounds, masses of one element that combine with fixed mass of the other element, are in ratio of small whole numbers

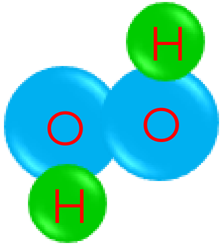
Reaction between Hydrogen and Oxygen

Hydrogen 2 g + Oxygen 16 g



Water 18 g

Hydrogen 2 g + Oxygen 32 g



Hydrogen Peroxide 34 g

Ratio b/w masses of Oxygen

16 : 32 = 1 : 2

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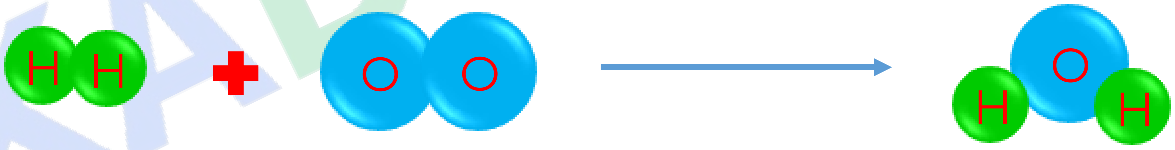
Gay Lussac's Law of Gaseous Volumes

At constant T and P, when gases combine or are produced in a chemical reaction, they do so in a simple ratio by volume

Reaction between Hydrogen and Oxygen

Substance



Volume in ml	100	50	100
Simple Ratio	2	1	2

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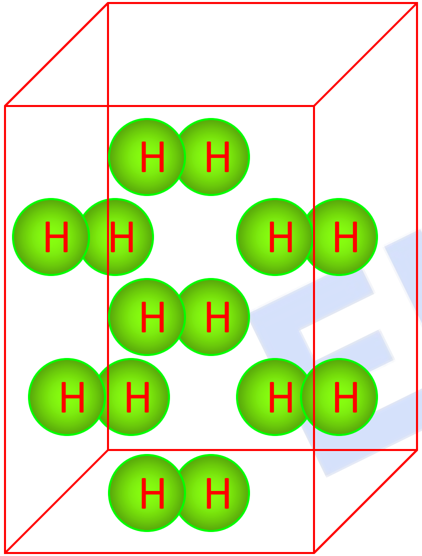
Avogadro’s Law

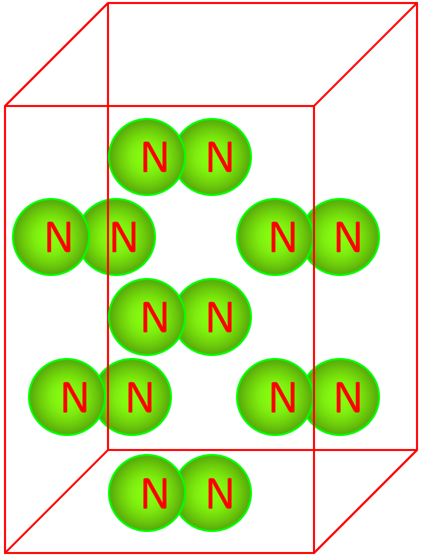
Equal volumes of all gases at same T and P should contain equal number of molecules

Much lighter gas



Volume = V

Heavier than Hydrogen



Volume = V

Number of Molecules

n

$V \propto n$

Irrespective of mass of gas molecule

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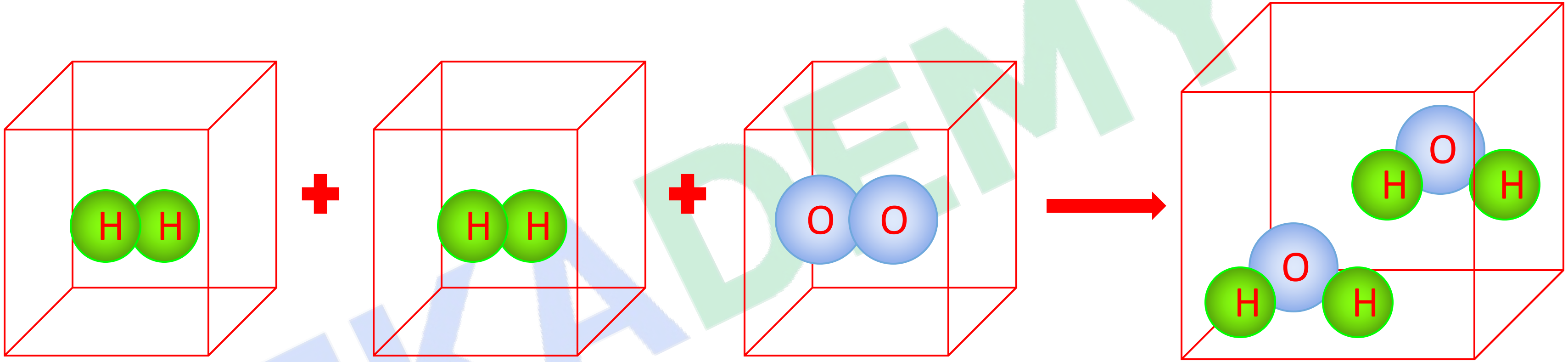
Avogadro's Law

Reaction between Hydrogen and Oxygen



V ml | V ml | V ml | 2V ml

n | **n** | **n** | **2n**

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1.3.2

Dalton's Atomic Theory
Atomic & Molecular Masses

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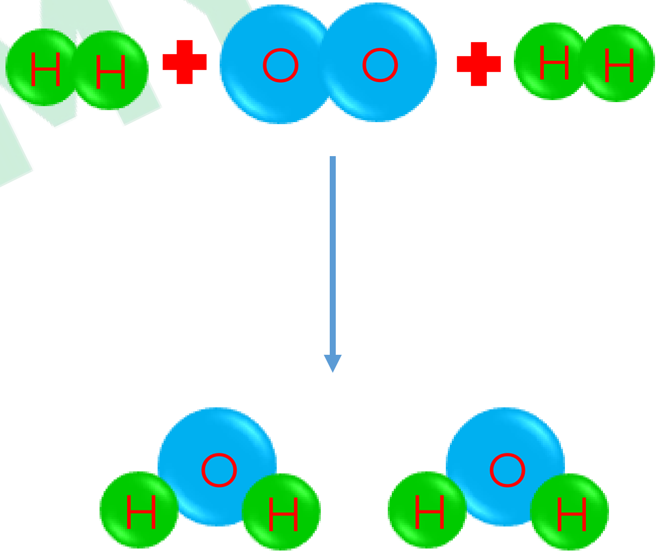
Dalton's Atomic Theory

1 - Matter consists of indivisible atoms

2 - All atoms of a given element have identical properties, including identical mass. Atoms of different elements differ in mass

3 - Compounds are formed when atoms of different elements combine in a fixed ratio

4 - Chemical reactions involve the reorganisation of atoms. These are neither created nor destroyed in a chemical reaction



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Dalton's Atomic Theory

Explain the laws of chemical combination

Could not explain the laws of gaseous volumes

Could not provide the reason for combining of atoms

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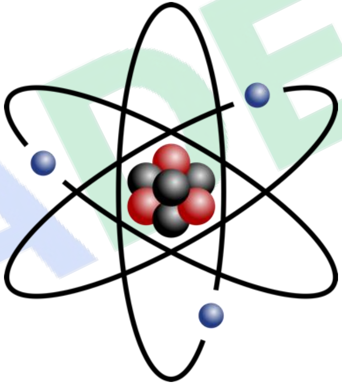
Atomic Mass

The mass of an atom

An atom is very small



Mass of an atom is also extremely small

How to measure ?

Determination of Atomic Mass

In 19th century, scientists could determine the mass of one atom relative to another by experimental means

Lightest atom

~~H~~

Arbitrarily assigned a mass of 1 (without any units)

Other elements were assigned masses relative to it

But was not successful

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Determination of Atomic Mass

Present system of atomic masses is based on C-12

A mass of exactly 12 atomic mass unit (amu)

Masses of all other atoms are given relative to this standard

amu is one-twelfth of the mass of one carbon-12 atom

$$1 \text{ amu} = \frac{1}{12} \times \text{Mass of C} - 12 \text{ atom}$$

$$1 \text{ amu} = 1.66056 \times 10^{-24} \text{ g}$$

amu = u (unified mass)

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1.3

Problems + Solutions

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Q. Atomic mass of hydrogen is 1.6736×10^{-24} g. Calculate atomic mass of hydrogen in amu.

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Pause the video

Time duration : 1 minute

Q. Atomic mass of hydrogen is 1.6736×10^{-24} g. Calculate atomic mass of hydrogen in amu.

Sol. $1 \text{ amu} = 1.66056 \times 10^{-24} \text{ g}$

Mass of an atom of hydrogen = 1.6736×10^{-24} g

$$\text{In amu, mass of H atom} = \frac{1.6736 \times 10^{-24}}{1.66056 \times 10^{-24}}$$

$$= 1.0078$$

$$= 1.008 \text{ amu or u}$$

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Average Atomic Mass

Generally, naturally occurring elements exist as more than one isotope

Different atomic mases

$_{X}A^{Y}$ $_{X}B^{Z}$

Same atomic number

Calculation of Average Atomic Mass

$$\boxed{\text{Avg. Atomic Mass} = \frac{\%\text{ abundance of A}}{100} \times \text{Atomic mass of A} + \frac{\%\text{ abundance of B}}{100} \times \text{Atomic mass of B}}$$

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1.3

Problems + Solutions

EKADEMY

Q. Calculate average atomic mass of carbon using table given below.

Isotope	Relative Abundance (%)	Atomic Mass (amu)
C - 12	98.892	12
C - 13	1.108	13.00335
C - 14	2×10^{-10}	14.00317

EKADEMY

Pause the video

Time duration : 1 minute

Sol.

Isotope	Relative Abundance (%)	Atomic Mass (amu)
C - 12	98.892	12
C - 13	1.108	13.00335
C - 14	2×10^{-10}	14.00317

$$\text{Avg. A. M} = \frac{\%\,C\text{−}12}{100} \times \text{A. M C} - 12 + \frac{\%\,C\text{−}13}{100} \times \text{A. M C} - 13 + \frac{\%\,C\text{−}14}{100} \times \text{A. M C} - 14$$

$$= 0.98892 \times 12\,\text{u} + 0.01108 \times 13.00335\,\text{u} + 2 \times 10^{-12} \times 14.00317\,\text{u}$$

$$\text{Avg. A. M} = 12.001\,\text{u}$$

EKADEMY

Molecular Mass

It is the sum of atomic masses of all the elements present in a molecule

Molecular mass of methane, CH_4

$$1 \times \text{a.m of C} + 4 \times \text{a.m of H}$$

$$(12.011\ \text{u}) + 4\,(1.008\ \text{u}) = 16.043\ \text{u}$$

Molecular mass of water (H_2O)

$$2 \times \text{a.m of H} + 1 \times \text{a.m of O}$$

$$2\,(1.008\ \text{u}) + 16.00\ \text{u} = 18.02\ \text{u}$$

EKADEMY

Concept Test

Ready for Challenge

EKADEMY

Q. Calculate the molecular mass of glucose ($C_6H_{12}O_6$) molecule.

Pause the video

Time duration : 1 minute

EKADEMY

Q. Calculate the molecular mass of glucose ($C_6H_{12}O_6$) molecule.

Sol.

Molecular mass of glucose ($C_6H_{12}O_6$) -

$$6 \times \text{a.m of C} + 12 \times \text{a.m of H} + 6 \times \text{a.m of O}$$

$$= 6(12.011\ \text{u}) + 12(1.008\ \text{u}) + 6(16.00\ \text{u})$$

$$= (72.066\ \text{u}) + (12.096\ \text{u}) + (96.00\ \text{u})$$

$$= 180.162\ \text{u}$$

EKADEMY

Concept Test

Ready for Challenge

EKADEMY

Q. Calculate the molecular mass of crystalline oxalic acid.

Pause the video

Time duration : 1 minute

EKADEMY

Q. Calculate the molecular mass of crystalline oxalic acid.

Sol.

Molecular mass of $C_2H_2O_4 \bullet 2H_2O$ -

$$= 2(12.011\,u) + 2(1.008\,u) + 4(16.00\,u) + 4(1.008\,u) + 2(16.00\,u)$$

$$= (24.022\,u) + (2.016) + (64.00\,u) + (4.032\,u) + (32.00\,u)$$

$$= 126.07\,u$$

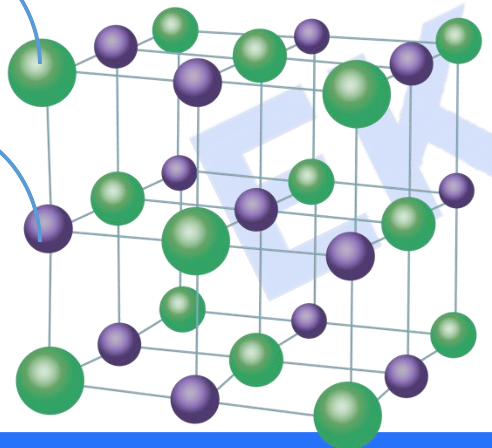
EKADEMY

Formula Mass

Some substances do not contain discrete molecules as their constituent units

Positive and negative entities are arranged in a 3-D structure

1 Na^+ ion is surrounded by 6 Cl^- ion and vice versa



Formula is used to calculate the formula mass instead of molecular mass

Atomic mass of Na + Atomic mass of Cl

$$= 23.0\ u + 35.5\ u = 58.5\ u$$

EKADEMY

Summary

Laws of chemical combinations

Dalton's atomic theory

Atomic mass

Average atomic mass $\frac{\%\text{ abundance of A}}{100} \times \text{Atomic mass of A} + \frac{\%\text{ abundance of B}}{100} \times \text{Atomic mass of B}$

Molecular mass

Formula mass - $NaCl$

EKADEMY

1.3 Reference questions

NCERT Exercise Questions: 1.21, 1.32

EKADEMY

1.4

Mole Concept and Percentage Composition

EKADEMY

1.4 Mole Concept and Percentage Composition

Learning Objectives

- ❑ Mole concept, Avogadro's number & Molar Mass
- ❑ Percentage Composition, Empirical & Molecular Formula

EKADEMY

1.4.1

Mole, Avogadro's number & Molar Mass

EKADEMY

Why Mole?

- Atoms and molecules are extremely small in size.
- Their numbers in even a small amount of any substance is really very large.

≈ 1.67×10^{21} Water molecules

To deal with such large numbers we invented **mole**.

EKADEMY

Mole is just a number, as :

Dozen = 12

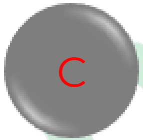
Century = 100

Mole = 6.022×10^{23}

EKADEMY

What is Mole??

The amount of a substance that contains as many particles as there are atoms in exactly 12g of the ^{12}C isotope.

Mass of 1 Carbon atom 

$= 1.992648 \times 10^{-23} g$

Number of Carbon atoms in 12g Carbon $= \dfrac{12 g}{1.992648 \times 10^{-23} g}$

$= 6.022 \times 10^{23}$

= **Avogadro's Number**

EKADEMY

Entities in a Mole:

N_2

1 mole of N_2 = 6.022×10^{23} molecules of N_2

C

1 mole of C = 6.022×10^{23} atoms of C

NH_3

1 mole of NH_3 = 6.022×10^{23} molecules of NH_3

EKADEMY

1.4.1

Problem + Solution

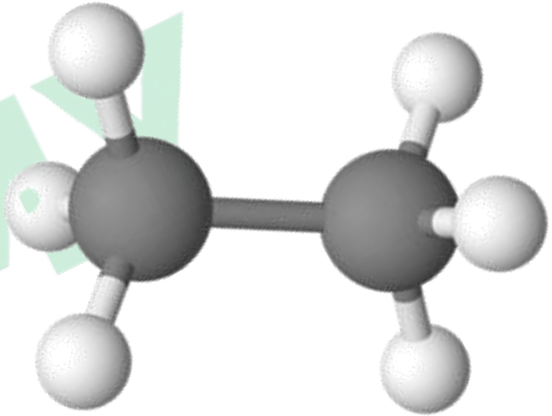
EKADEMY

Q. In three moles of ethane (C_2H_6), calculate the following:

(i) Number of moles of carbon atoms.

(ii) Number of moles of hydrogen atoms.

(iii) Number of molecules of ethane.



Pause the video

Time duration : 1 minute

EKADEMY

Sol.

(i) $\because$ 1 mol of ethane contains $= 2 \text{ mol of C atom}$

$\therefore$ 3 mol of ethane will contain $= \dfrac{3\text{mol}}{1\text{mol}} \times 2 \text{ mol} = 6 \text{ mol of C atom}$

(ii) $\because$ 1 mol of ethane contains $= 6 \text{ mol of H atom}$

$\therefore$ 3 mol of ethane will contain $= \dfrac{6\text{mol}}{1\text{mol}} \times 3 \text{ mol} = 18 \text{ mol of H atom}$

(iii) $\because$ 1 mol of ethane contains $= 6.022 \times 10^{23} \text{ molecules of } C_2H_6$

$\therefore$ 3 mol of ethane will contain $= \dfrac{3\text{mol}}{1\text{mol}} \times 6.022 \times 10^{23} \text{ molecules of } C_2H_6$

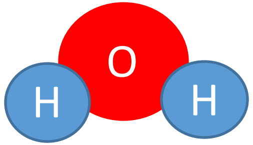
$= 18.066 \times 10^{23} \text{ molecules of } C_2H_6$

EKADEMY

Molar Mass

The mass of one mole of a substance in grams is called its molar mass

Example :



Molar mass of water $= 18.02 \text{ g mol}^{-1}$

Molar mass of sodium chloride $= 58.5 \text{ g mol}^{-1}$

EKADEMY

Concept Test

Ready for Challenge

EKADEMY

Q. Calculate the molar mass of the following :

(i) H_2O (ii) CO_2 (iii) CH_4

Pause the video

Time duration : 1 minute

EKADEMY

Q. Calculate the molar mass of the following :

(i) H_2O (ii) CO_2 (iii) CH_4

Sol. Molar mass of

H = $1 gmol^{-1}$ C = $12 gmol^{-1}$ O = $16 gmol^{-1}$

Therefore,

(i) Molar mass of $H_2O = 2 \times 1 gmol^{-1} + 1 \times 16 gmol^{-1} = 18 gmol^{-1}$

(ii) Molar mass of $CO_2 = 1 \times 12 gmol^{-1} + 2 \times 16 gmol^{-1} = 44 gmol^{-1}$

(iii) Molar mass of $CH_4 = 1 \times 12 gmol^{-1} + 4 \times 1 gmol^{-1} = 16 gmol^{-1}$

EKADEMY

Concept Test

Ready for Challenge

EKADEMY

Q. Calculate number of oxygen atoms in 4.4g of CO_2.

Pause the video

Time duration : 1 minute

EKADEMY

Q. Calculate number of oxygen atoms in 4.4g of CO_2.

Sol.

Number of moles of CO_2 $= \dfrac{\text{Given mass of } CO_2}{\text{Molar mass of } CO_2} = \dfrac{4.4\text{g}}{44\text{gmol}^{-1}} = 0.1\text{mol}$

Since,

1 mol of CO_2 contains $= 2 \times 6.022 \times 10^{23}$ atoms of Oxygen

Therefore,

0.1 mol of CO_2 will contain $= 2 \times 0.1 \times 6.022 \times 10^{23}$ atoms of Oxygen

$= 12.044 \times 10^{22}$ atoms of Oxygen

EKADEMY

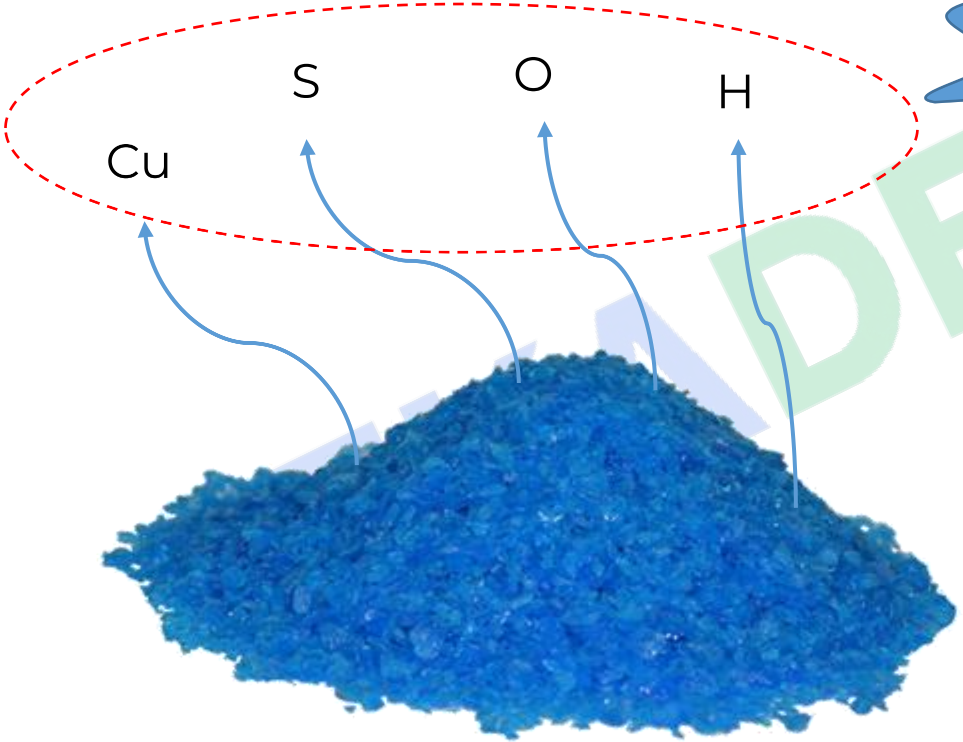
1.4.2

Percentage Composition, Empirical & Molecular Formula

EKADEMY

Percentage Composition

% composition of elements??



$CuSO_4.5H_2O$

Percentage Composition

$$\text{Mass \% of an element} = \frac{\text{Mass of that element in the compound}}{\text{Molar mass of the compound}} \times 100\%$$

Therefore,

Mass % of Cu in $CuSO_4.5H_2O$ $= \frac{63.5}{249.5} \times 100\% = 25.45\%$

Mass % of S in $CuSO_4.5H_2O$ $= \frac{32}{249.5} \times 100\% = 12.82\%$

Mass % of O in $CuSO_4.5H_2O$ $= \frac{144}{249.5} \times 100\% = 57.72\%$

Mass % of H in $CuSO_4.5H_2O$ $= \frac{10}{249.5} \times 100\% = 04.01\%$

EKADEMY

Concept Test

Ready for Challenge

EKADEMY

Q. Calculate the mass percentage of each element in ammonia.

Pause the video

Time duration : 1 minute

EKADEMY

Q. Calculate the mass percentage of each element in ammonia.

Sol.

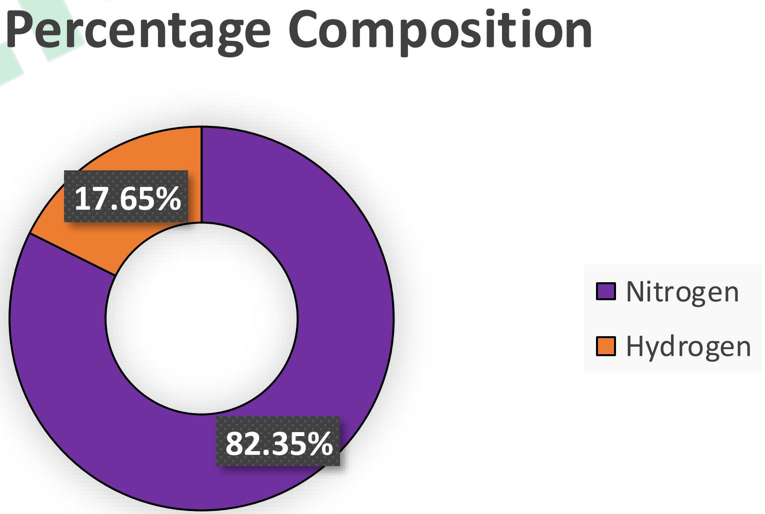
Molar mass of Ammonia (NH_3) = $14g + 3 \times 1g = 17g$

Mass % of Nitrogen = $\frac{14}{17} \times 100\%$

= 82.35 %

Mass % of Hydrogen = $\frac{3}{17} \times 100\%$

= 17.65%



EKADEMY

Empirical Formula

It represents the simplest whole number ratio of various atoms present in a compound.

Molecular formula

It shows the exact number of different types of atoms present in a molecule of a compound.

$$\boxed{\text{Molecular Formula} = n \times \text{Empirical formula}}$$

Where,

$$n = \frac{\text{Molar mass}}{\text{Empirical formula mass}}$$

EKADEMY

11C01.4

PSV 2

EKADEMY

Q. A compound contains 4.07% hydrogen, 24.27% carbon and 71.65% chlorine. Its molar mass is 98.96 g. What are its empirical and molecular formulas?

Pause the video

Time duration : 1 minute

EKADEMY

Sol.

Step 1. Convert mass% into grams assuming 100g sample

Therefore,

H = 4.07g

C = 24.27g

Cl = 71.65g

Step 2. Convert mass into moles of each element

Therefore,

$$n_H = \frac{4.07g}{1.008g} = 4.04 \text{ mol}$$

$$n_C = \frac{24.27g}{12.01g} = 2.021 \text{ mol}$$

$$n_{Cl} = \frac{71.65g}{35.453g} = 2.021 \text{ mol}$$

EKADEMY

Step 3. Calculate simple whole-number molar ratios & determine empirical formula :

	H	C	Cl
	4.04	2.021	2.021
	$= \frac{4.04}{2.021}$	$= \frac{2.021}{2.021}$	$= \frac{2.021}{2.021}$
	$= 2$	$= 1$	$= 1$

Thus the empirical formula is CH_2Cl

Step 4. Writing the molecular formula

Empirical formula mass = 12.01 + (2 × 1.008) + 35.453 = 49.48g

$$\therefore \quad n = \frac{\text{Molar mass}}{\text{Empirical formula mass}} = \frac{98.96}{49.48} = 2$$

$\because$ Molecular Formula = n × (Empirical Formula) = 2 × (CH_2Cl) = $C_2H_4Cl_2$

EKADEMY

Tabular Method for calculation of Empirical formula

Elements in Compound	% Composition	Molar mass (g)	%Composition/ molar mass	Molar ratio	Simple whole number ratio
H	4.07	1.008	4.04	$\frac{4.04}{2.021} = 2$	2
C	24.27	12.01	2.021	$\frac{2.0214}{2.021} = 1$	1
Cl	71.65	35.453	2.021	$\frac{2.021}{2.021} = 1$	1

Thus the empirical formula is CH_2Cl

Summary

Mole and Avogadro's Number

Molar mass

Percentage Composition

Empirical Formula

Molecular Formula Molecular Formula = n × Empirical formula

$$n = \frac{\text{Molar mass}}{\text{Empirical formula mass}}$$

EKADEMY

1.4 Reference questions

NCERT Exercise questions : 1.1, 1.2 , 1.3, 1.8, 1.10, 1.28, 1.30, 1.33, 1.34

EKADEMY

1.5

Balancing, Stoichiometry & Limiting Reagent of a Chemical Equation

EKADEMY

1.5 Balancing, Stoichiometry & limiting reagent of a Chemical Equation

Learning Objectives

- Balancing of Chemical equations
- Stoichiometry & Stoichiometric calculations
- Limiting Reagent

EKADEMY

1.5.1

Balancing of Chemical Equations

EKADEMY

Balancing of a chemical Equation

What is a Balanced chemical Reaction/Equation?

A balanced chemical equation has the same number of atoms of each element on both sides of the equation.

Why is balancing necessary?

The chemical equation needs to be balanced so that it follows the law of conservation of mass.

EKADEMY

How to Balance a Chemical Equation

The best way to balance a chemical equation is by hit & trail method.

Example :

Balance $C_2H_6 + O_2 \longrightarrow CO_2 + H_2O$

Step 1. Start balancing any element (prefer main element) by adjusting Stoichiometry coefficients.

Carbon is balanced

$$C_2H_6 + O_2 \longrightarrow 2CO_2 + H_2O$$

Step 2. Balance other element without disturbing the balancing of previously balanced element.

Hydrogen is balanced

$$C_2H_6 + O_2 \longrightarrow 2CO_2 + 3H_2O$$

Step 3. Repeat the step 2 until all elements are balanced.

Oxygen is balanced

$$\boxed{C_2H_6 + \frac{7}{2}O_2 \longrightarrow 2CO_2 + 3H_2O}$$

EKADEMY

01.5.2

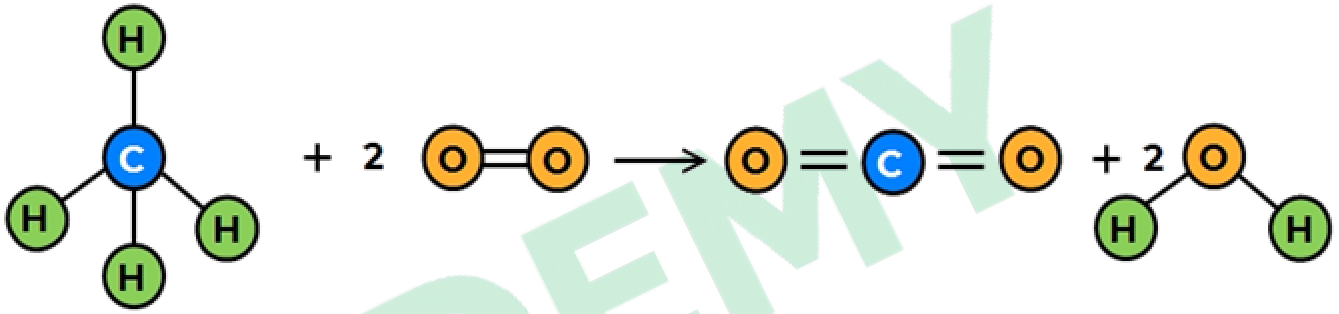
Stoichiometry & Stoichiometric Calculations

EKADEMY

Stoichiometry

Quantitative analysis of a balanced chemical reaction

Example :
Burning of
Methane



	$CH_{4(g)}$	+	$2O_{2(g)}$	$\longrightarrow$	$CO_{2(g)}$	+	$2H_2O_{(g)}$
	1mol		2mol		1mol		2mol
	1molecule		2molecule		1molecule		2molecule
Stoichiometric Observations :	16g		2×32g		44g		2×18g

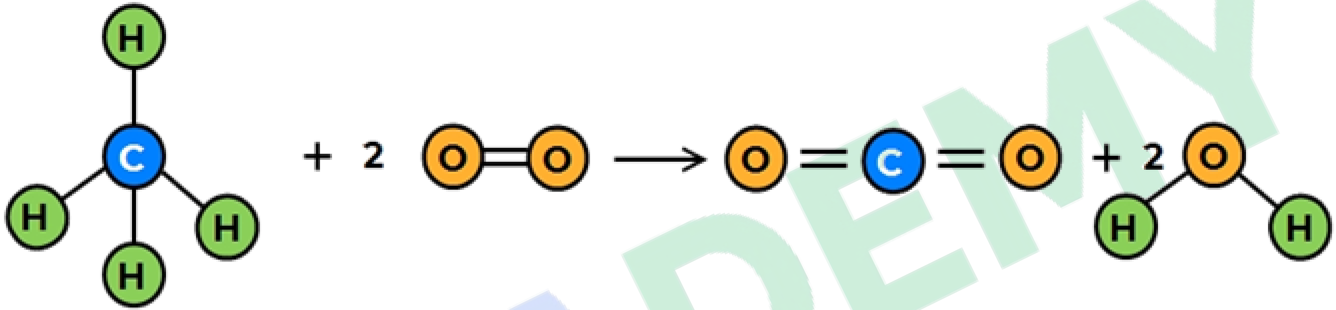
EKADEMY

1.5

Problems + Solutions

EKADEMY

Q. Calculate the amount of water (g) produced by the combustion of 48 g of methane.



Pause the video

Time duration : 1 minute

EKADEMY

Q. Calculate the amount of water (g) produced by the combustion of 48 g of methane.

Sol.

Balanced chemical reaction for the combustion of methane

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$$

From the above reaction,

16g of methane produces = 36g of water

Therefore,

48g of methane will produce $= \frac{48g}{16g} \times 36g$ of water

= 108g of water

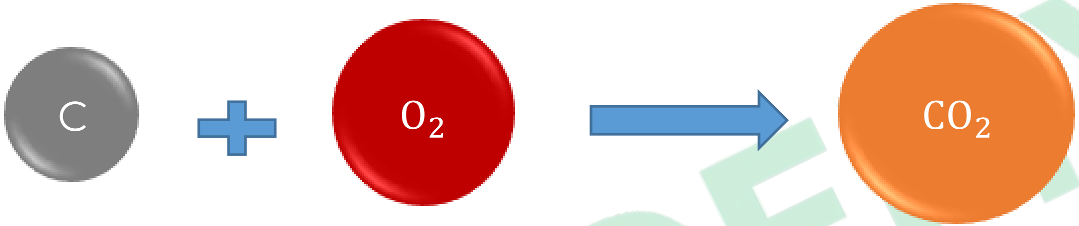
EKADEMY

Concept Test

Ready for Challenge

EKADEMY

Q. Calculate the amount of carbon dioxide that could be produced when 2 moles of carbon are burnt in air.

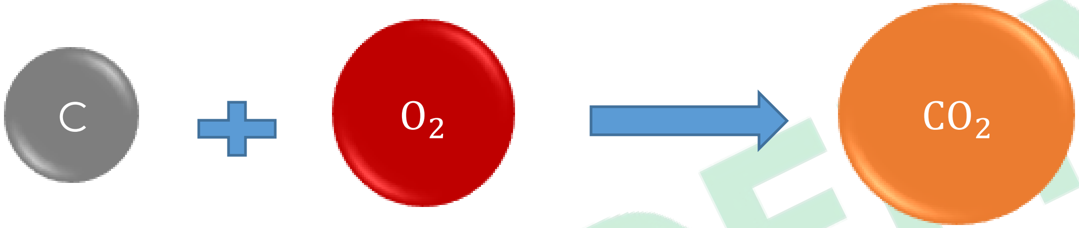


Pause the video

Time duration : 1 minute

EKADEMY

Q. Calculate the amount of carbon dioxide that could be produced when 2 moles of carbon are burnt in air.



Sol. From the above reaction,

1 mol of carbon produces = $44\text{g of } CO_2$

Therefore,

2 mol of carbon will produce $= \dfrac{2\text{ mol}}{1\text{ mol}} \times 44\text{g of } CO_2$

$= 88\text{ g of } CO_2$

EKADEMY

1.5.3

Limiting Reagent

EKADEMY

Limiting Reagent

The reactant which gets consumed first and limits the amount of product formed

Method to solve problems based on the limiting Reagent :

Step 1. Write the balanced chemical equation

Step 2. Calculate moles of each compound

Step 3. Calculate ratio of number of moles to the stoichiometry coefficient.

" Compound with minimum ratio will be the limiting reagent."

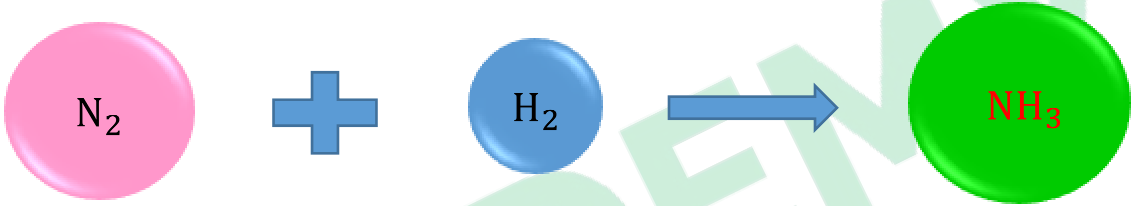
Step 4. Do all calculations based on the availability of the limiting reagent.

11C01.5.3

Problems + Solutions

EKADEMY

Q. 50.0 kg of $N_{2(g)}$ and 10.0 kg of $H_{2(g)}$ are mixed to produce $NH_{3(g)}$. Calculate the amount of $NH_{3(g)}$ formed. Identify the limiting reagent in the production of $NH_{3(g)}$ in this situation.



Pause the video

Time duration : 2 minute

EKADEMY

Sol. **Step 1.** Balanced Reaction

$$N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$$

Step 2. Number of moles of each compounds :

$$\text{Moles of } N_2 = \frac{50kg}{28.0g} = 17.86 \times 10^2 \text{ mol}$$

$$\text{Moles of } H_2 = \frac{10kg}{2.016g} = 4.96 \times 10^3 \text{ mol}$$

Step 3. Number of moles V/s Stoichiometry Coefficient :

N_2		H_2
$\frac{17.86\times10^2}{1}$		$\frac{4.96\times10^3}{3}$
$= 1.786 \times 10^3$	>	$= 1.653 \times 10^3$

Hence H_2 is the limiting reagent.

EKADEMY

Step 4. Calculations based on availability of limiting reagent(H_2) :

Since,

3 mol of H_2 produces = 2 mol of NH_3

Therefore,

$$4.96 \times 10^3 \text{ mol of } H_2 \text{ will produce} = \frac{4.96\times10^3 \text{ mol}}{3 \text{ mol}} \times 2 \text{ mol of } NH_3$$

$$= 3.30 \times 10^3 \text{mol of } NH_3$$

Therefore,

Mass of NH_3 obtained = Number of moles of NH_3 × molar mass of NH_3

$$= 3.30 \times 10^3 \text{mol} \times 17.0 \text{ gmol}^{-1}$$
$$= 56.1 \times 10^3 \text{g}$$
$$= 56.1 \text{ kg}$$

EKADEMY

Concept Test

Ready for Challenge

EKADEMY

Q. Chlorine is prepared in the laboratory by treating manganese dioxide (MnO_2) with aqueous hydrochloric acid according to the reaction

$$4HCl_{(aq)} + MnO_{2(s)} \rightarrow 2H_2O_{(l)} + MnCl_{2(aq)} + Cl_{2(g)}$$

How many grams of chlorine is produced if 10.95g of HCl reacts with 8.7 g of manganese dioxide?

Pause the video

Time duration : 1 minute

EKADEMY

Sol. **Step 1.** Balanced Reaction

$$4HCl_{(aq)} + MnO_{2(s)} \rightarrow 2H_2O_{(l)} + MnCl_{2(aq)} + Cl_{2(g)}$$

Step 2. Number of moles of each compounds :

Moles of HCl $= \frac{10.95g}{36.5g} = 0.3$ mol

Moles of $MnO_2 = \frac{8.7g}{87g} = 0.1$ mol

Step 3. Number of moles V/s Stoichiometry Coefficient :

HCl		MnO_2
$\frac{0.3}{4}$		$\frac{0.1}{1}$
$= 0.075$	<	$= 0.1$

Hence HCl is the limiting reagent.

EKADEMY

Step 4. Calculations based on availability of limiting reagent(HCl) :

Since,

4 mol of HCl produces $= 1 \text{ mol of } Cl_2$

Therefore,

0.3 mol of HCl will produce $= \frac{0.3 \text{ mol}}{4 \text{ mol}} \times 1 \text{ mol of } Cl_2$

$= 0.075 \text{ mol of } Cl_2$

Therefore,

Mass of Cl_2 obtained = Number of moles of Cl_2 × molar mass of Cl_2

$= 0.075\text{mol} \times 71 \text{ gmol}^{-1}$

$= 5.325\text{g}$

EKADEMY

Summary

Stoichiometry & Stoichiometric Observations

Balancing of Chemical Reactions

Method to Determine Limiting Reagent

EKADEMY

1.5 Reference questions

NCERT Exercise questions : 1.4, 1.7, 1.23, 1.24, 1.36 .

EKADEMY

1.6

Reactions in Solution

EKADEMY

1.6 Reactions in Solution

Learning Objectives

Introduction to Solutions

Mass % & Mole Fraction

Molarity

Molality

EKADEMY

1.61

Introduction to Solutions

EKADEMY

Introduction to the world of solutions

A solution is a **homogeneous mixture** of two or more substances

A solution may exist in any phase

Cold drinks

Bronze

Air

EKADEMY

Solute → Substance to be dissolved

Solvent → Substance which dissolve other substances

Solution = Solute + Solvent

Solute is usually present in a smaller amount than the **Solvent**

Examples :

ground coffee (solute)	+	water (solvent)	→	drinking coffee (solution)
salt (solute)	+	water (solvent)	→	salty water (solution)
copper sulfate (solute)	+	water (solvent)	→	copper sulfate solution (solution)

EKADEMY

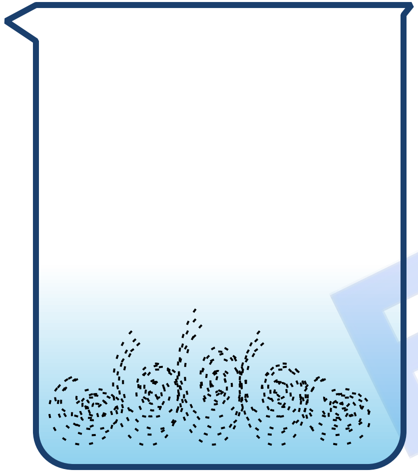
1.6.2

Mass % & Mole Fraction

EKADEMY

Concentration

The quantity of solute present in a given quantity of solution



Concentration can be measured in :

- Mass %
- Mole Fraction
- Molarity
- Molality

Mass Percent

$$\text{Mass percent} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100\%$$

Q. A solution is prepared by adding 2 g of substance A to 18 g of water. Calculate the mass per cent of the solute.

Sol.

Mass of A = 2g

Mass of solution = mass of A + Mass of water

= 2g + 18g = 20g

$$\text{Mass \% of A} = \frac{\text{Mass of A}}{\text{Mass of solution}} \times 100\% = \frac{2\text{g}}{20\text{g}} \times 100\% = 10\%$$

EKADEMY

Mole Fraction

- It is the ratio of the number of moles of a particular component to the total number of moles of the solution

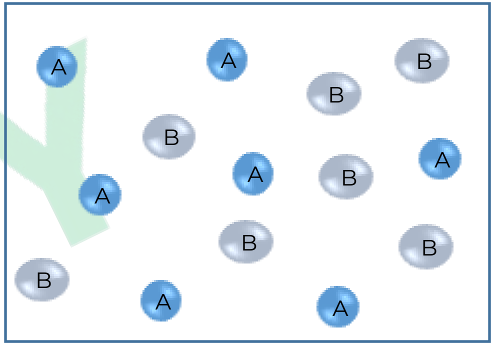
- It is represented by "χ"

$$\text{Mole Fraction of component } (\chi) = \frac{\text{Number of moles of component}}{\text{Total number of moles of all the components}}$$

EKADEMY

Mole Fraction

$$\chi_A = \frac{\text{Number of moles of A}}{\text{Number of moles of solutions}} = \frac{n_A}{n_A + n_B}$$



$$\chi_B = \frac{\text{Number of moles of B}}{\text{Number of moles of solutions}} = \frac{n_B}{n_A + n_B}$$

Note : sum of mole fractions of all the compounds present in the solution is unity

$$\boxed{\chi_A + \chi_B = 1}$$

EKADEMY

1.6

Problems + Solutions

EKADEMY

Q. If 4 moles of alcohol and 6 moles of water are mixed then calculate mole fraction of each component.

Pause the video

Time duration : 1 minute

EKADEMY

Q. If 4 moles of alcohol and 6 moles of water are mixed then calculate mole fraction of each component.

Sol.

Moles of alcohol (n_a) = 4 mol , Moles of water (n_w) = 6 mol

$$\text{Mole Fraction of component } (\chi) = \frac{\text{Number of moles of component}}{\text{Total number of moles of all the components}}$$

$$\chi_a = \frac{n_a}{n_a + n_w} = \frac{4}{4+6} = 0.4$$

$$\chi_w = \frac{n_w}{n_a + n_w} = \frac{6}{4+6} = 0.6$$

EKADEMY

1.6.3

Molarity

EKADEMY

Molarity

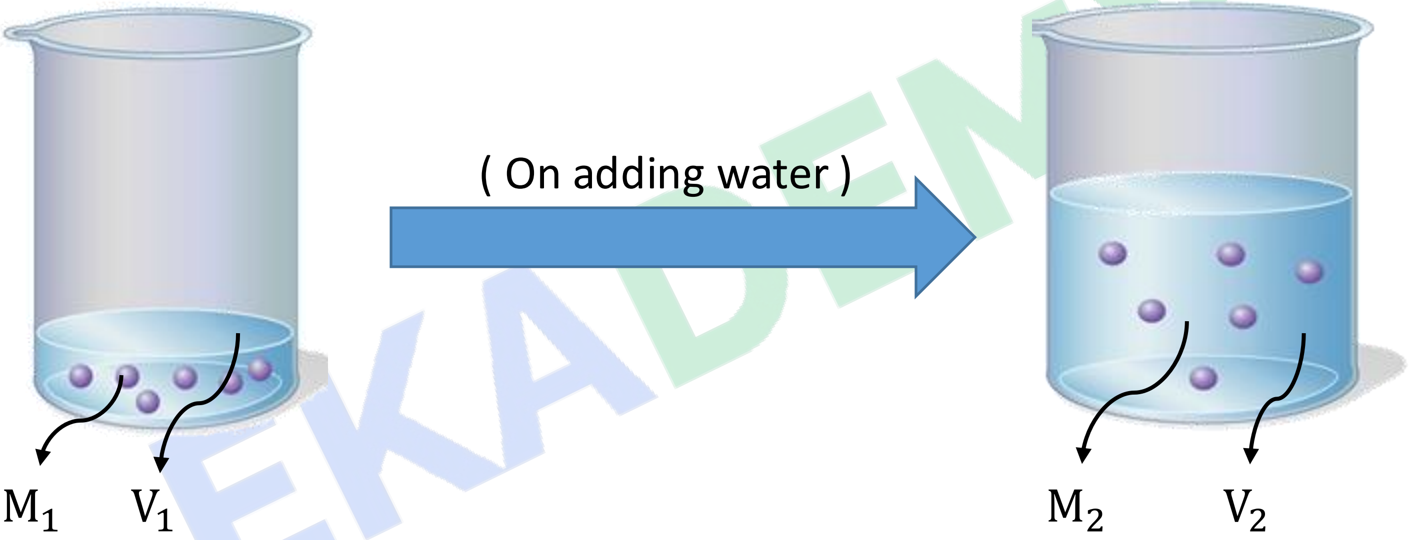
The number of moles of solute present per litre of solution.
It is represented by "M"

$$\text{Molarity (M)} = \frac{\text{Number of moles of solute}}{\text{Volume of solution in litres}}$$

Units of molarity = Mol L^{-1}

EKADEMY

For dilution of solutions



$$M_1V_1 = M_2V_2$$

1.6.3

Problems + Solutions

EKADEMY

Q. Calculate the molarity of aqueous $NaOH$ solution prepared by dissolving 4 g of $NaOH$ in enough water to form 250 mL of the solution.

EKADEMY

Pause the video

Time duration : 1 minute

Q. Calculate the molarity of aqueous $NaOH$ solution prepared by dissolving 4 g of $NaOH$ in enough water to form 250 mL of the solution.

Sol.

$$\text{Moles of NaOH} = \frac{\text{Given mass of NaOH}}{\text{Molar mass of NaOH}} = \frac{4\ \text{g}}{40\ \text{g mol}^{-1}} = 0.1\ \text{mol}$$

Volume of Solution = 250 ml = 0.25L

$$\text{Molarity (M)} = \frac{\text{Number of moles of solute}}{\text{Volume of solution in litres}}$$

$$\text{M} = \frac{0.1\text{mol}}{0.25\text{L}} = 0.4\ \text{mol L}^{-1}$$

EKADEMY

Concept Test

Ready for Challenge

EKADEMY

Q. Calculate the mass of sodium acetate (CH_3COONa) required to make 500 mL of 0.375 molar aqueous solution. Molar mass of CH_3COONa is $82 g mol^{-1}$.

Pause the video

Time duration : 1 minute

EKADEMY

Q. Calculate the mass of sodium acetate (CH_3COONa) required to make 500 mL of 0.375 molar aqueous solution. Molar mass of CH_3COONa is $82 g mol^{-1}$.

Sol.

Molarity of solution = 0.375 M

Volume of solution = 500mL = 0.5L

$$\text{Molarity (M)} = \frac{\text{Number of moles of solute}}{\text{Volume of solution in litres}}$$

$$0.375\text{M} = \frac{n_{CH_3COONa}}{0.5\text{L}}$$

$$n_{CH_3COONa} = 0.1875 \text{ mol}$$

Mass of CH_3COONa = Moles of CH_3COONa × Molar mass of CH_3COONa

$$= 0.1875 \times 82 g mol^{-1} = 15.375 \text{ g}$$

EKADEMY

1.6.4

Molality

EKADEMY

Molality

- It is defined as the number of moles of solute present per kg of solvent
- It is denoted by "m"
- Units of Molality = mol kg^{-1}

$$\text{Molality (m)} = \frac{\text{Number of moles of solute}}{\text{Mass of solvent in Kg}}$$

EKADEMY

1.6.4

Problems + Solutions

EKADEMY

Q. Calculate the molality of 2.5 g of ethanoic acid (CH_3COOH) in 50 g of benzene. Molar mass of ethanoic acid = 60 g mol^{-1}

Pause the video

Time duration : 1 minute

EKADEMY

Q. Calculate the molality of 2.5 g of ethanoic acid (CH_3COOH) in 50 g of benzene. Molar mass of ethanoic acid = 60 g mol^{-1}

Sol.

$$\text{Moles of solute }(CH_3COOH) = \frac{\text{Given mass of solute}}{\text{Molar mass of solute}} = \frac{2.5\text{ g}}{60\text{ g mol}^{-1}} = 0.0417\text{ mol}$$

$$\text{Mass of solvent (benzene)} = 50\text{g} = 0.05\text{ kg}$$

$$\text{Molality (m)} = \frac{\text{Number of moles of solute}}{\text{Mass of solvent in Kg}}$$

$$= \frac{0.0417\text{ mol}}{0.05\text{ kg}}$$

$$= 0.834\text{ molal}$$

EKADEMY

Concept Test

Ready for Challenge

EKADEMY

Q. The density of 3 M solution of NaCl is $1.25\ g\ mL^{-1}$. Calculate the molality of the solution.

Pause the video

Time duration : 1 minute

EKADEMY

Q. The density of 3 M solution of NaCl is $1.25\ g\ mL^{-1}$. Calculate the molality of the solution.

Sol.

Assuming volume of the solution = 1 L

Molarity of NaCl solution $= 3\ mol\ L^{-1}$

$\therefore$ Moles of NaCl $= 3\ mol$

Also, Mass of NaCl $= 3\ mol \times 58.5\ g\ mol^{-1} = 175.5 g$

Since, density of solution $= 1.25\ g\ mL^{-1}$

$\Rightarrow$ mass of 1L solution $= 1.25\ g\ mL^{-1} \times 1000 ml = 1250\ g$

EKADEMY

$\because$ Mass of the solution = Mass of solute + Mass of solvent

$\Rightarrow$ 1250 g = 175.5 g + Mass of solvent

$\Rightarrow$ Mass of solvent = 1074.5 g

$$\text{Molality (m)} = \frac{\text{Number of moles of solute}}{\text{Mass of solvent in Kg}}$$

$$= \frac{3 \text{ mol}}{1.0745 \text{ kg}}$$

$$= 2.79 \text{ molal}$$

EKADEMY

Summary

Introduction to the world of Solutions

$$\text{Mass percent} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100\%$$

$$\text{Mole Fraction of component } (\chi) = \frac{\text{Number of moles of component}}{\text{Total number of moles of all the components}}$$

$$\text{Molarity (M)} = \frac{\text{Number of moles of solute}}{\text{Volume of solution in litres}}$$

$$\text{Molality (m)} = \frac{\text{Number of moles of solute}}{\text{Mass of solvent in Kg}}$$

EKADEMY

1.6 Reference questions

NCERT Exercise questions : 1.5, 1.6, 1.11, 1.12, 1.29, 1.35

EKADEMY

End of the Chapter

EKADEMY