



CHEMISTRY • CLASS 12

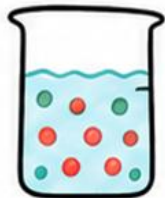
CHAPTER 1

Solutions

CHAPTER NOTES

SOLUTIONS & THEIR TYPES

- **SOLUTION** – homogeneous mixture of two or more substances; composition and macroscopic properties are uniform throughout.



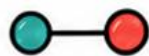
- **SOLVENT** – normally determines the physical state and is often present in larger amount; this is a convention, not an absolute rule.



- **SOLUTE** – other component(s) dissolved molecularly or ionically.

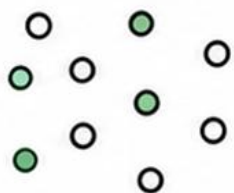


- **BINARY SOLUTION** – exactly two components.

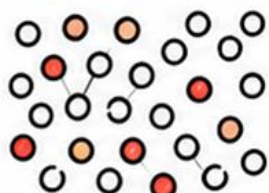


Composition controls properties

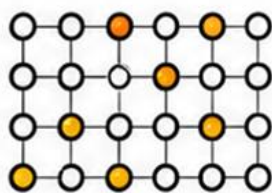
GAS SOLUTION



LIQUID SOLUTION



SOLID SOLUTION



STATE OF SOLUTION	SOLUTE	SOLVENT	EXAMPLE
Gas	Gas	Gas	$O_2 + N_2$ (air)
Gas	Liquid	Gas	chloroform vapour in N_2
Gas	Solid	Gas	camphor vapour in N_2
Liquid	Gas	Liquid	O_2 in water
Liquid	Liquid	Liquid	ethanol in water
Liquid	Solid	Liquid	glucose in water
Solid	Gas	Solid	H_2 in palladium
Solid	Liquid	Solid	mercury-sodium amalgam
Solid	Solid	Solid	copper in gold

CONCENTRATION: %, w/v & ppm



DILUTE / CONCENTRATED = relative descriptions

QUANTITATIVE CONCENTRATION = stated numerical basis



1) MASS % (w/w)

$$\text{mass \%} = \frac{\text{mass of component}}{\text{total mass of solution}} \times 100$$



10% w/w glucose = 10 g glucose in 100 g solution

2) VOLUME % (v/v)

$$\text{volume \%} = \frac{\text{volume of component}}{\text{final volume of solution}} \times 100$$



10% v/v ethanol = 10 mL ethanol in final 100 mL solution
→ component volumes need not be additive.

3) MASS / VOLUME % (w/v)

$$\text{w/v \%} = \frac{\text{mass of solute in g}}{\text{final solution volume in mL}} \times 100$$



10% w/v NaCl = 10 g NaCl
in final 100 mL solution



g solute per 100 mL FINAL SOLUTION — not solvent

4) PARTS PER MILLION (ppm)

$$\text{ppm} = \frac{\text{parts of component}}{\text{total parts of solution}} \times 10^6$$

mass/mass • volume/volume • mass/volume



For dilute water only, $\rho \approx 1.00 \text{ kg L}^{-1}$:
 $1 \text{ mg L}^{-1} \approx 1 \text{ ppm by mass.}$



35% v/v
ethylene glycol —
antifreeze context



trace dissolved O_2 — ppm
Always state the ppm basis.



ETHYLENE GLYCOL IS TOXIC
IF SWALLOWED — KEEP AWAY
FROM CHILDREN & PETS.

DENOMINATOR =
TOTAL /
FINAL SOLUTION

MOLE FRACTION

Mole fraction of component i = its moles divided by total moles of all components.

$$x_i = \frac{n_i}{\sum n_j}$$

EXPANDED (k components):

$$x_i = \frac{n_i}{n_1 + n_2 + \dots + n_k}$$

BINARY SOLUTION (A + B):

$$x_A = \frac{n_A}{n_A + n_B} \quad x_B = \frac{n_B}{n_A + n_B}$$

SUM RULE (BINARY):

$$x_A + x_B = 1$$

SUM RULE (GENERAL):

$$\sum x_i = 1$$

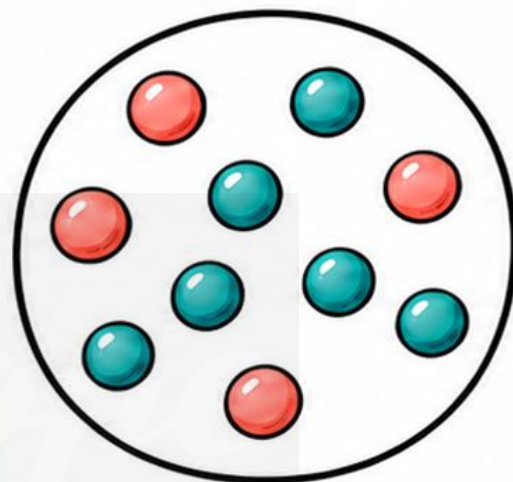
- **DIMENSIONLESS** – no unit

- Use **MOLES**, not masses directly

$$n_i = \frac{w_i}{M_i}$$

- For a closed sample, mole fraction is temperature independent.

SIMPLE CONCEPT ILLUSTRATION



● A ● B

$$n_A = 4$$

$$n_B = 6$$

$$n_{\text{total}} = 10$$

$$x_A = \frac{4}{10} = 0.40$$

$$x_B = \frac{6}{10} = 0.60$$

CHECK:

$$0.40 + 0.60 = 1.00$$

Mole fraction tells each component's share of the total moles.

EXAMPLE — MOLE FRACTIONS

PROBLEM → Calculate the mole fractions of ethylene glycol ($\text{C}_2\text{H}_6\text{O}_2$) and water in a solution containing 20% $\text{C}_2\text{H}_6\text{O}_2$ by mass.

GIVEN → 20% w/w solution
Choose a 100 g solution basis
mass $\text{C}_2\text{H}_6\text{O}_2$ = 20 g
mass H_2O = 80 g

$$M(\text{C}_2\text{H}_6\text{O}_2) = 62 \text{ g mol}^{-1}$$

$$M(\text{H}_2\text{O}) = 18 \text{ g mol}^{-1}$$

REQUIRED → x_{glycol} and x_{water}

FORMULA → $n = \frac{w}{M}$ $x_i = \frac{n_i}{\sum n}$

SUBSTITUTION → $n_{\text{glycol}} = 20 \text{ g} / (62 \text{ g mol}^{-1})$ $n_{\text{water}} = 80 \text{ g} / (18 \text{ g mol}^{-1})$

CALCULATION →
 $n_{\text{glycol}} = 0.3226 \text{ mol}$
 $n_{\text{water}} = 4.444 \text{ mol}$
 $n_{\text{total}} = 0.3226 + 4.444 = 4.7666 \text{ mol}$
 $x_{\text{glycol}} = 0.3226 / 4.7666 = 0.0677 \approx 0.068$
 $x_{\text{water}} = 4.444 / 4.7666 = 0.9323 \approx 0.932$

CHECK → $0.068 + 0.932 = 1.000 \checkmark$ **ASSUMPTIONS** → 20% w/w means 20 g solute per 100 g solution.

FINAL ANSWER

$$x_{\text{glycol}} = 0.068$$

$$x_{\text{water}} = 0.932$$

Mole fraction has no unit.

ETHYLENE GLYCOL IS TOXIC IF SWALLOWED — CALCULATION ONLY.

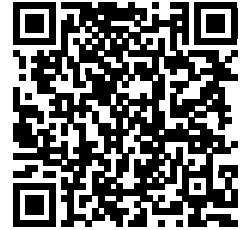


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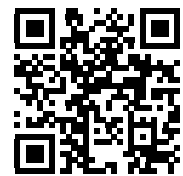


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