Chapter 4 - Acids, Bases, Salts and Volumetric Analysis

Solution

Aqueous solution

- Solution: homogenous mixture
- In a solution, a solute is dissolved in a solvent
- Water is the "universal solvent"
    - aqueous solution
- Substance can be dissolve in water in different ways
    - ionic compounds dissolve in water by dissociation, where water surrounds the separated ions, e.g. NaCl
    - Molecular compounds interact with water, but most do NOT dissociate. e.g. sucrose form hydrogen bonding with water when dissolved

Electrolytic properties of aqueous solution

- Solubility and Electrolyte Strength do not relevant

  For instance, it's possible that a compound is a strong electrolyte, but just not very soluble.

Types of electrolytes

1. Non electrolytes
    - substances that dissolve in water but do not produce ions
    - do not conduct electricity
    - present in solution as molecules
    - e.g. CH_3OH, acetone, alcohol (covalent compound)
2. Strong electrolytes
    - substances that dissociated completely in water
    - good conductors
    - present in solution as ions
    - $$\mathrm{NaCl_{(aq)} \longrightarrow {Na^+}_{(aq)} + {Cl^-}_{(aq)}}$$
    - including strong acids, strong bases, and most salts
3. Weak electrolytes
    - substances that dissociates partially in water
    - poor conductors
    - different weak electrolytes dissociated to different extents
    - $$\mathrm{CH_3COOH_{(aq)} \rightleftharpoons {CH_3COO^-}_{(aq)} + {H^+}_{(aq)}}$$
    - including weak acids, weak bases

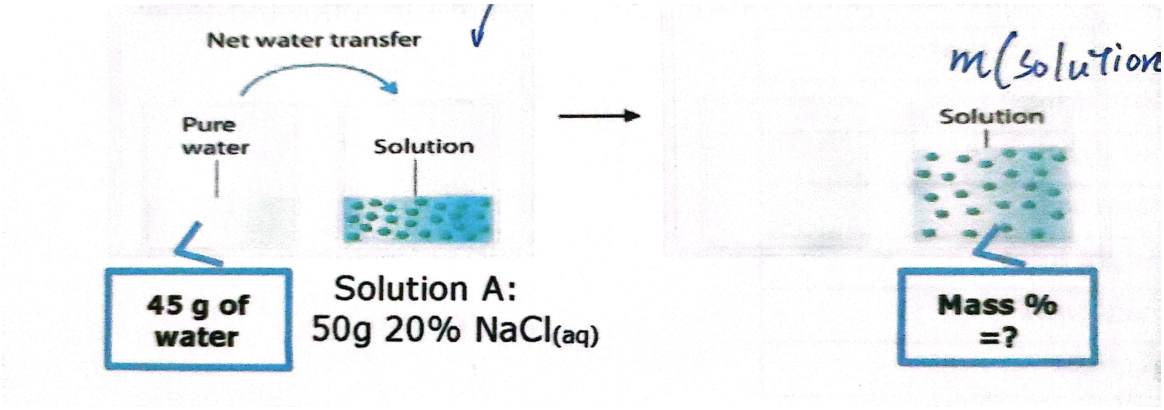
Concentration of Solutions

- refers to the quantity of solute dissolved in a particular quantity of solvent or solution.

Mass percentage / Mass percent

- Mass of solute in grams dissolved in 100g of solution

$$Percent\ by\ mass = \frac{mass\ of\ solute\ (g)}{mass\ of\ solution\ (g)} \times 100\%$$

1. What is the mass percent of glucose in a solution made by dissolving 4.6 g of glucose in 145.2 g of water? [3.07%]
2. Determine the mass % of a NaCl solution if 15.8 grams of NaCl were dissolved in 50 ml of water. (Assume the density of water to be 1 g/ml.) [24.01%]
3. How would you prepare 400 g of a 2.50% solution of sodium chloride? [10g]
4. 

Density of solution

- Mass of 1cm^3 of solution in grams

$$Density\ by\ solution\ (gcm^{-3}/gml^{-1}) = \frac{mass\ of\ solution\ (g)}{volume\ of\ solution\ (cm^{-3})}$$

1. Given the density of 125 ml 20% $HCl_{(aq)}$ at 20°C is 1.098 gml^{-1}, Calculate the mass of

   (i) 125ml $HCl_{(aq)}$

   (ii) mass of solute HCl in the solution

   (iii) mass of water
2. If we wished to prepare 400 ml of a 10% by mass NaCl solution, what mass of NaCl would we use? Given density of the solution is 1.05 g/ml. [42g]
3. What is the mass percent of ethanol in a solution made by dissolving 5.3g of ethanol in 85.0g of water? [5.9% ethanol]
4. How would you make 250 g of a 7.5% solution of glucose in water?
5. A sample of a solution weighing 850.0 g is known to contain 0.223 moles of potassium chloride. What is the mass percent of potassium chloride in the solution?

Mass concentration (C)

- Mass of solute (in grams) dissolved in a liter of solution

$$Mass\ concentration\ (gL^{-1}) = \frac{mass\ of\ solute\ (g)}{volume\ of\ solution\ (dm^3)}$$

1. If 5.0g of NaOH are dissolved in 425ml of solution, what is the concentration in g/L?
2. Calculate the mass, in grams, of calcium hydrogen carbonate $Ca(HCO_3)_2$ that is present in 24.0 L of tap water if analysis indicates that the tap water contains 4.2 x103 g/L $Ca(HCO_3)_2$?

Molar Concentration / Molarity (C_M)

- Number of moles of solute dissolved in a liter of solution

$$Molar\ concentration\ (molL^{-1}) = \frac{no\ of\ \ moles\ of\ solute\ (mol)}{volume\ of\ solution\ (dm^3)}$$

1. A chemist dissolves 98.4 g of FeSO4 in enough water to make 2.000 L of solution. What is the molarity of the solution? [Fe=56, S=32, 0=16]
2. What is the molarity of a 2.50 x 102 cm^3 solution containing 45.0 g of C6H12O6? [C=12, H=1, O=16]
3. How many moles of salt are contained in 300 mL of a 0.40 mol/L NaCl solution?
4. Calculate the molar concentrations of aluminium ion and sulphate ion in 0.25 mol/L of aluminium sulphate solution.
5. Calculate the molar concentration of 5.78 gL^{-1} $CuSO4_{(aq)}$. [Cu=63.5, S=32, O=16]
6. How many grams of potassium permanganate, KMnO4, is needed to make 1.72 liters of 0.29 mol/L solution? [K=39, Mn=55, O=16]
7. What mass (in grams) of hydrogen chloride (HCI) is needed to make up 500cm^3 of a solution of concentration 0.2 mol/dm^3? [H=1, Cl=35.5]
8. Battery acid is generally 3 mol/L H_2SO_4. How many grams of H_2SO_4 are in 400mL of this solution? [H=1, S=32, O=16]
9. How many grams of HCl are in 100ml of a 0.5mol/L hydrochloric acid solution? [H=1, Cl=35.5]
10. A mixture of magnesium chloride and magnesium sulphate is known to contain 0.6 mol of chloride ions and 0.2 mol of sulphate ions. The number of moles of magnesium ions present in the mixture is ___.
11. Given

    I. 300 ml of a 0.40 mol/L NaCl solution

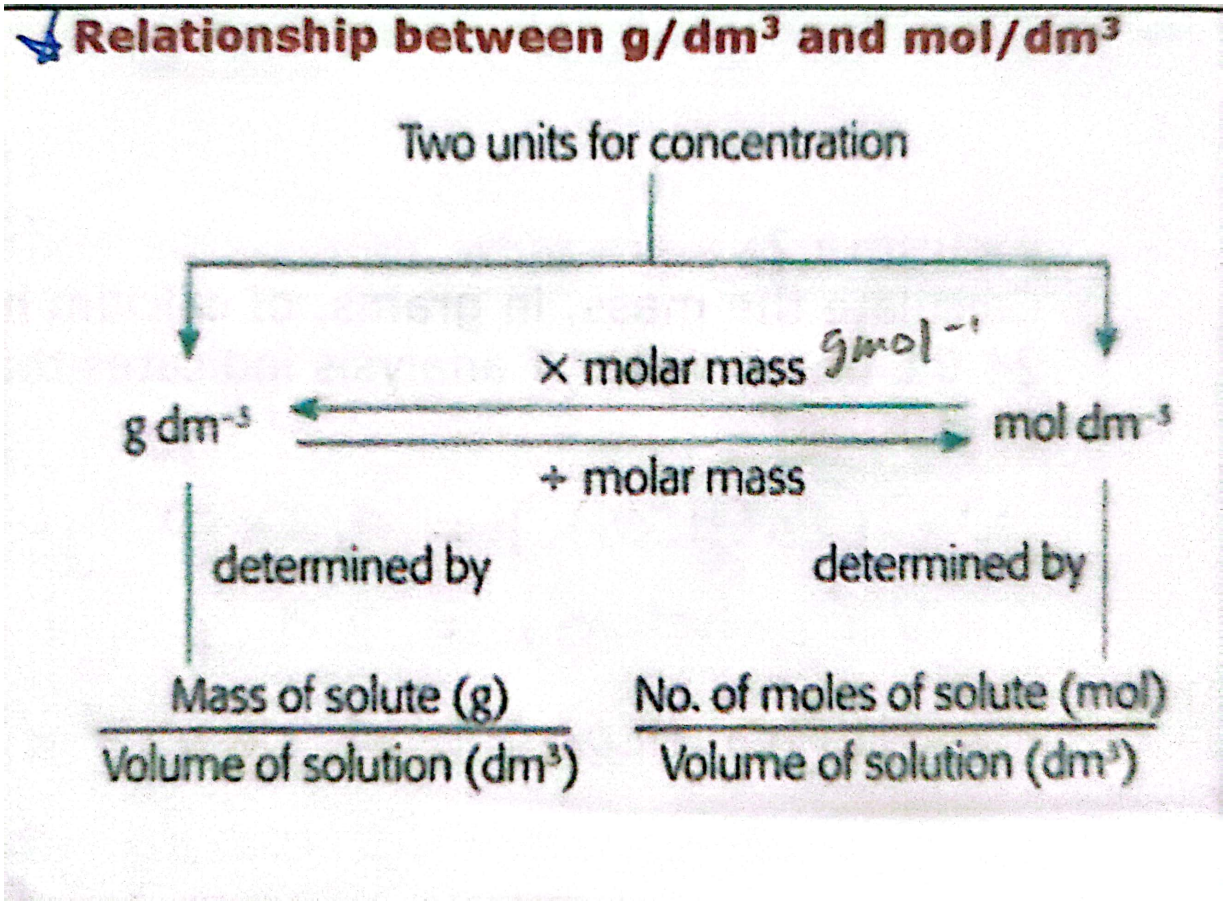
    II 400 ml of a 10% NaCl solution (Given: density of solution =1.05gml^{-1})

    III. 500 ml of a 12 g/L NaCl solution

    Arrange the solutions above in order of

    (i) increasing concentration.

    (ii) increasing no of moles of NaCl



Preparing Standard Solution

- Standard solution: A solution in which its concentration is accurately known.

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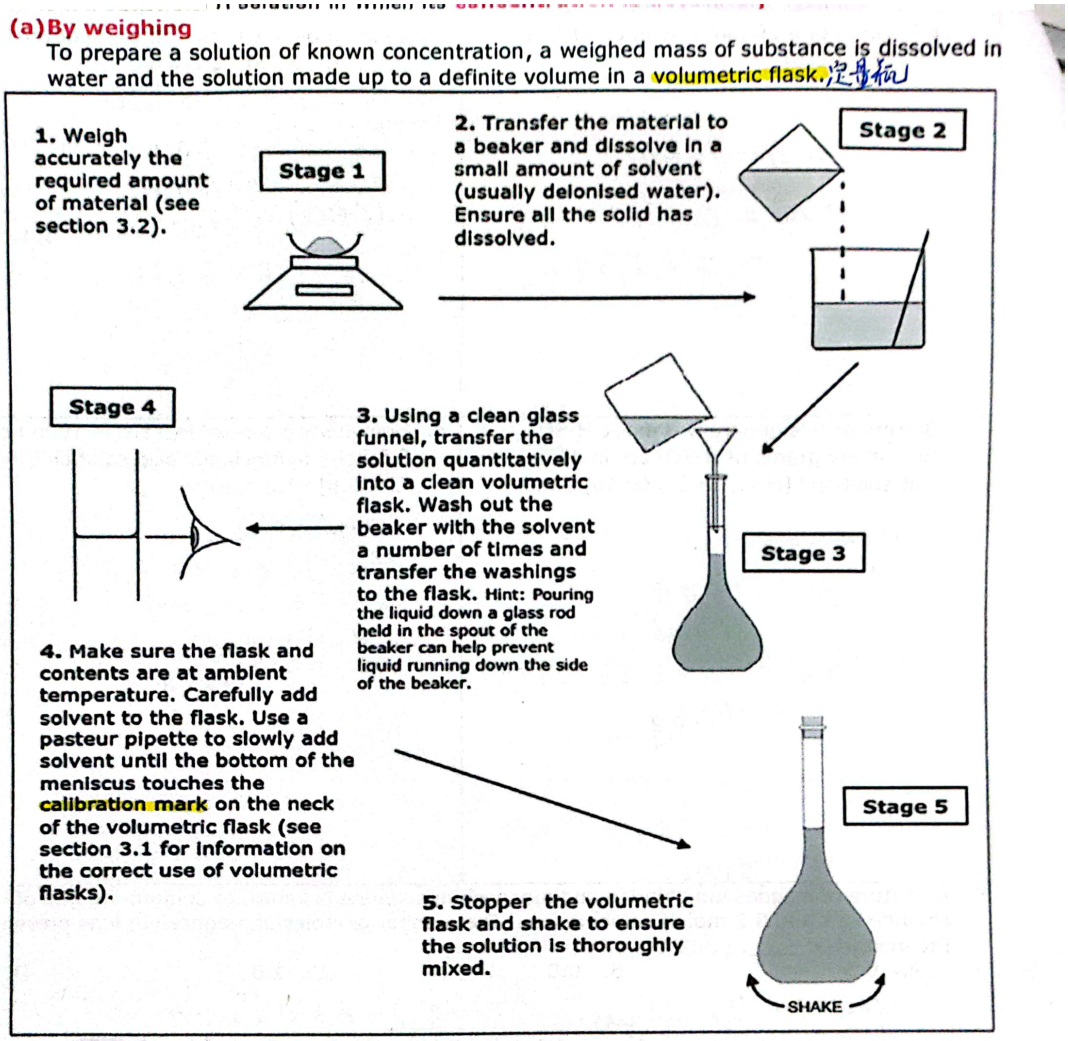
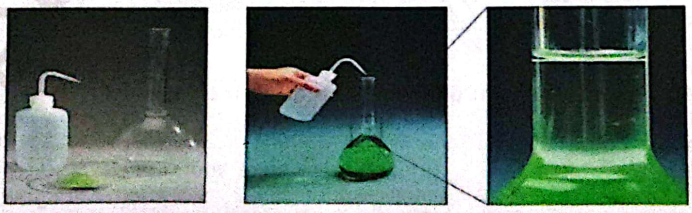


Example: Preparation of 500 ml of 1.20 mol/L of copper (II) chloride solution.



Dilution

$$\text{number of moles of solute before dilution} = \text{number of moles of solute after dilution}$$

$$C_i V i = C_f V_f$$

1. When 40.0 mL of 2.0 mol/L NaCl is diluted to 100.0 mL, what is the new concentration?
2. A chemist wants to make 500 mL of 0.050 mol/L HCl by diluting a 6.0 mol/L HCl solution. How much of that solution should be used?
3. What would be the concentration of a solution made by adding 250 mL of water to 45.0 mL of 4.2 mol/L KOH?

Solution Stoichiometry

1. Chlorine gas can be prepared in the laboratory by the following reaction:

$$2\,\mathrm{KMnO_4\,(s)} + 16\,\mathrm{HCl\,(aq)} \longrightarrow 2\,\mathrm{MnCl_2\,(aq)} + 5\,\mathrm{Cl_2\,(g)} + 8\,\mathrm{H_2O\,(l)} + 2\,\mathrm{KCl\,(aq)}$$

If 6.50g of potassium manganate (VII) react, calculate the following:

(a) the volume of 6.00mol/L hydrochloric acid required. [K=39, Mn=55, O=16]

(b) the volume of chlorine that produced at r.t.p.

2. If 10.0ml of 0.500mol/L of magnesium chloride solution and 15.0ml of 0.500mol/L sodium hydroxide are mixed, a precipitate of magnesium hydroxide is formed. The equation of reaction is:

$$\mathrm{MgCl_2\,(aq) + 2\,NaOH\,(aq) \longrightarrow Mg(OH)_2\,(s) + 2\,NaCl\,(aq)}$$

Calculate the following [Mg=24, Cl=35.5, Na=23, H=1, O=16]

(a) Determine limiting reactant of the reaction.

(b) the mass of magnesium hydroxide produced.

`by jiahuiiiii @ 22th June 2023 2033`

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