Experiment no. 5

Solubility : Effect of temperature

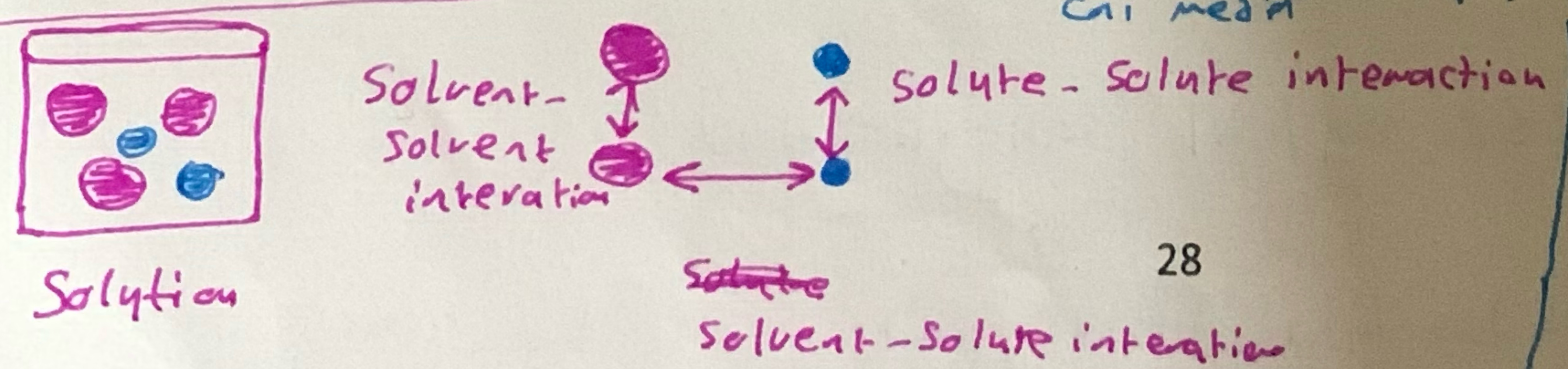
Solubility is the property of a solid, liquid, or gaseous chemical substance called *solute* to dissolve in a liquid solvent to form a homogeneous solution of the solute in the solvent.

The solubility of a substance fundamentally depends on the used **solvent** as well as on **temperature** and **pressure**.

The extent of the solubility of a substance in a specific solvent is measured as the **saturation concentration** where adding more solute does not increase the concentration of the solution. The extent of solubility ranges widely, from infinitely soluble (fully miscible) such as ethanol in water, to poorly soluble, such as silver chloride in water. The term insoluble is often applied to poorly or very poorly soluble compounds.

Term	Parts of solvent required for 1 part of solute
Very soluble	<1 part
Freely soluble	1—10 parts
Soluble	10 to 30 parts
Sparingly soluble	30 to 100 parts
Slightly soluble	100 to 1000 parts
Very slightly soluble	1000 to 10,000 parts
Practically insoluble or insoluble	>10, 000 parts

Solvation (Dissolution): is the process of attraction and association of molecules of a solvent with molecules or ions of a solute. As ions dissolve in a solvent they spread out and become surrounded by solvent molecules. Dissolution is a kinetic process, and is quantified by its rate. Solubility quantifies the dynamic equilibrium state achieved when the rate of dissolution equals the rate of precipitation.



Factors affecting solubility

1. Temperature ↑, Solubility ↑

The solubility of a given solute in a given solvent typically depends on temperature. For many solids dissolved in liquid water, the solubility increases with temperature up to 100 °C. In liquid water at high temperatures, (e.g., that approaching the critical temperature), the solubility of ionic solutes tends to decrease due to the change of properties and structure of liquid water; the lower dielectric constant results in a less polar solvent. then solubility ↓

The solubility of organic compounds nearly always increases with temperature. The technique of liquid recrystallization, used for purification of solids, depends on a solute's different solubilities in hot and cold dissolved solvent. A few exceptions exist, such as certain cyclodextrins in solid

2. **Pressure**

For condensed phases (solids and liquids), the pressure dependence of solubility is typically weak and usually neglected in practice. Assuming an ideal solution, the dependence can be quantified as.

3. **Chemical structure**

The chemical structure of the solute usually determines the solute major properties which can influence its dissolution and bioavailability.

The physical properties of the solute such as the crystalline state and particle size are important in determining its solubility, so minor modifications in the drug molecules (e.g salt formation or esterfication, micronization to decrease particle size and to increase the effective surface area, and complexation with inert water soluble materials), are strategies that have been used to enhance the aqueous solubility of these drugs.

partical size ↓ / Surface are ↑ / Solubilization ↑

Ex:- $CaCO_3 + H_2O$ ---- Add Na_2CO_3

Na_2CO_3 more dissolved in water, it can decrease the solubility of $CaCO_3$

Quantification of solubility

Solubility is commonly expressed as a **concentration**, either by mass (gm of solute per kg of solvent, gm per dl (100 ml) of solvent), mass concentration, molarity, molality, mole fraction or other similar descriptions of concentration. The maximum equilibrium amount of solute that can dissolve per amount of solvent is the solubility of that solute in that solvent under the specified conditions (T + P). The advantage of expressing solubility in this manner is its simplicity, while the disadvantage is that it can strongly depend on the presence of other species in the solvent (for example, the common ion effect).

(heat is released) exothermic reaction

Studying the effect of temperature on solubility

(chemical reactions in which the reactants absorb heat energy from the surrounding to form products) endothermic

The preparation of solutions is one of the most frequent tasks required of a pharmacist. Knowledge of the enthalpy change accompanying a solution process allows the pharmacist to rationalize solvent –solute interactions and thereby obtain better control over the behavior of the finished product.

اقرأ الصفحة (!!)

An example of this additional control would be the ability to predict changes in drug solubility with temperature. If a sparingly soluble drug dissolves exothermically at 25 C, it is obvious that the pharmacist shouldn't make the concentration of the drug in the preparation very close to it 25C solubility since precipitation of the drug would occur upon injection into the body (37C).

In this experiment you will determine the heat of solution of salicylic acid in distilled water (solvent). This will be accomplished by determining solubility of salicylic acid in distilled water at different temperatures and treating this data according to the **Vant Hoff relationship:**

$$\textbf{Log S} = (-\Delta H / 2.303R)(1/T) + \text{constant}$$

(printed: 20303R, corrected by hand to 2.303; ΔH = heat of solubilization)

Where:

S is the solubility in mole fraction

R is the molar gas constant (1.987cal/mol.deg)

T is the absolute temperature (K)

H is the heat of solution (K.cal/mol)

$X_{solute} = \frac{\text{moles of solute}}{\text{total moles of solution}}$

$X_{solvent} = \frac{\text{moles of solvent}}{\text{total moles of solution}}$

where: $X_{solute} + X_{solvent} = 1$

Solubilization بصير عشان (exothermic) release heat ★ عند درجة الغرفة 25 ...

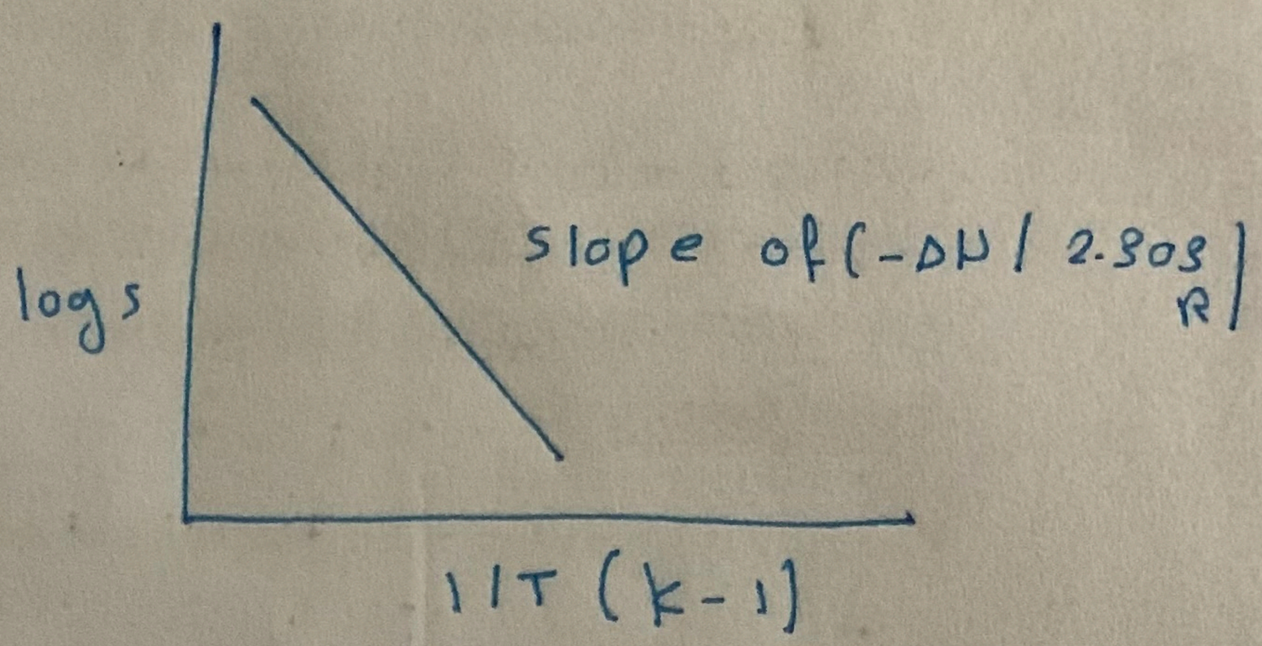
ولازم احضر solution تركيزه اقل وبالتالي لما اعطيه injection على درجة الجسم (37)

نتفادى يصير precipitation

لو اعطيته على درجة (37) مش (25) رح يصير precipitation

According to Vant Hoff equation, if you plot **log S** versus **1/T** should yield a straight line with a slope of (-ΔH /20303R). A knowledge of ΔH makes it possible to predict S at versus temperatures using the following equation.

$$\text{Log } S_1/S_2 = (-\Delta H /20303R) *((T_1-T_2)/ T_1T_2)$$



$$\log s = -\frac{\Delta H_s}{2.303R}\left(\frac{1}{T}\right) + \text{Constant}$$

$$\log \frac{S_1}{S_2} = -(\Delta H / 2.303\,R) * \left(\frac{T_1 T_2}{T_1 - T_2}\right)$$

$$\log \frac{S_2}{S_1} = \frac{\Delta H}{2.303\,R}\,\frac{(T_2 - T_1)}{T_1 T_2}$$

Where:

S_2 is the unknown solubility at T_2

S_1 is the known solubility at T_1

T+273

Studying the effect of temperature on solubility

Procedure

1. Determination the aqueous solubility of salicylic acid at 25C°, 5 C° and 70 C°.
2. Weigh about 0.5gm salicylic acid in 100ml conical flask. Add)ml distilled water to make an over saturated solution.
3. Shake the above solution, in water bath, at the required for 3(min.
4. filter to get rid of the excess (insoluble) salicylic acid
5. dilute the filtrate with distilled water (dilute factor 100)
6. Measure the absorbance of diluted salicylic acid at 310nm using distilled water as solvent.

Note: repeat steps 1-6 at different temperature each time but t 0 C° weigh 0.9gm of salicylic acid and 2gm at 70 C°.