Quiz 1: Announcement

Total marks of Quiz: 10 (multiple choice type- only one option will be correct),
Negative marking: NO
Time for the quiz: 15 min, Start time: January 25, 2022, 10:30 a.m. (IST), Finish Time: January 25, 2022, 10:45 a.m. (IST).

Important note:

1) Quiz-1 will start at 10:30 a.m. (IST) sharp on 25th January.
2) Keep pen, pencil, calculator nearby to you. There may be numerical questions, you may have to calculate.
3) Kindly login to your Moodle account at least **10 min before the schedule, preferably 10:20 a.m. or before.**
4) **Password of the quiz will be sent to your email id 3-5 min before the quiz starts**. Around 10:25 a.m., password will be shared. You should login your email account at 10:20 a.m. and be vigilant.
5) Total time of the quiz will be 15 mins. You cannot attempt the quiz anymore after 10:45 a.m. (IST).
6) **The questions will appear in sequential order. Therefore, you cannot go back to the previous question once you move forward.**
7) Any kind of act of group cheating through WhatsApp chats or any other internet forum is highly discouraged (as mentioned in the class). Strong disciplinary actions will be taken if found guilty which may result disqualifying from the entire course in other words failing in the course.
8) No re-quiz request will be entertained. Make sure you attend it at any cost. This point is same for all the exams in this course.
9) **Result of the quiz will be visible to you on 27th January, 2022. Before that no request regarding quiz results will be entertained.**

MLL 100

Introduction to Materials Science and Engineering

Lecture-9 (January 21, 2022)

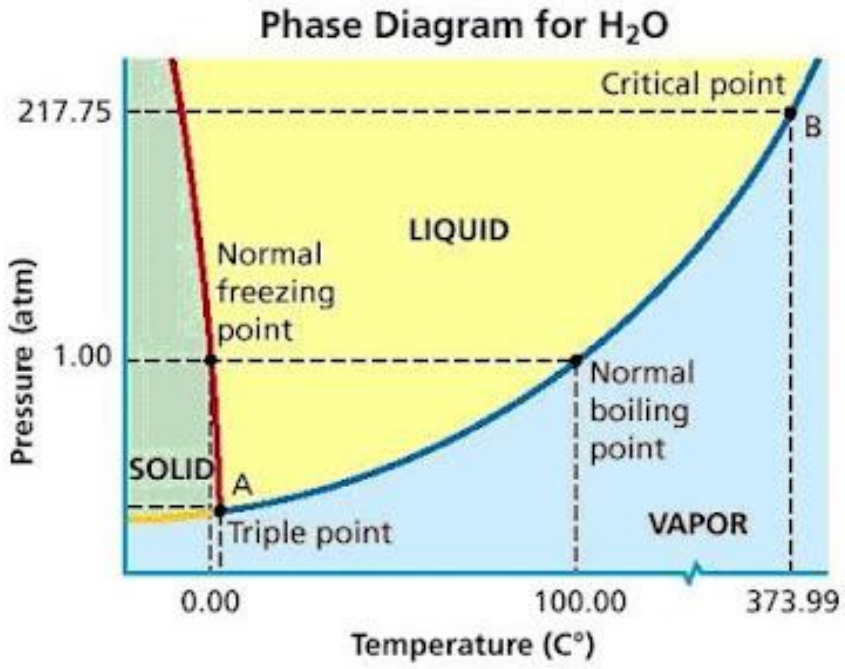
Dr. Sangeeta Santra *(ssantra@mse.iitd.ac.in)*

IIT Delhi
Department of Materials Science and Engineering

Phase Equilibrium, Phase Diagram, Phase Transformation

Phase diagram

Equilibrium phase diagram: Map of phases represented over state variables.



Phase

Happy

Shocking

Sad

Worrisome

Excited

Funny

Silent

Depressed

- Physically distinct

- Chemically uniform: water
- Mechanically separable

- In solids, different crystal structures indicate different phases.

Component

Component

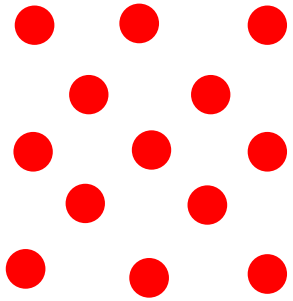
+

Component

=

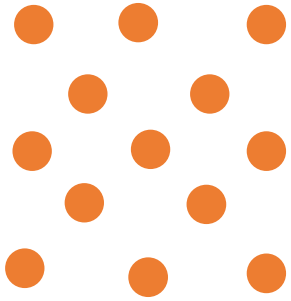
Phase

Phase mixture



+

=



What is a component?

- Chemically-independent constituents of a system

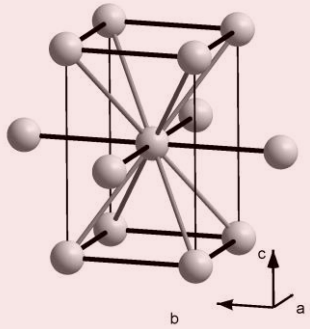
- *Copper-Tin system:* Cu and Sn are the components
- *Sugar-milk system:* Sugar and milk are the components
- *Vanilla-chocolate system:* Vanilla and cocoa are the components
- *SiO_2-Al_2O_3-MgO system:* SiO_2, Al_2O_3, MgO are the components

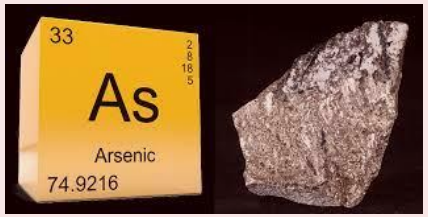
Classification of phase diagrams based on number of components:

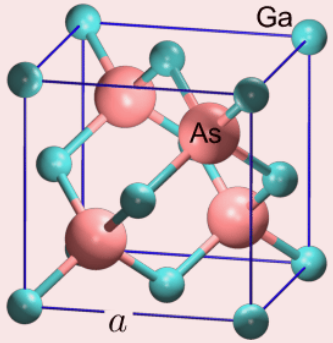
- ❑ Unary phase diagram: Water -----> H_2O
- ❑ Binary phase diagram: Cu-Ni
- ❑ Ternary phase diagram: Cu-Ni-Pt
- ❑ Quaternary phase diagram: Cu-Ni-Al-Pt
- ❑ Pseudo-binary phase diagram

How many components are present in:

(i) Al_2O_3-MgO
(ii) Mg-O
(iii)NaCl-H_2O
(iv)Ni-Al-O

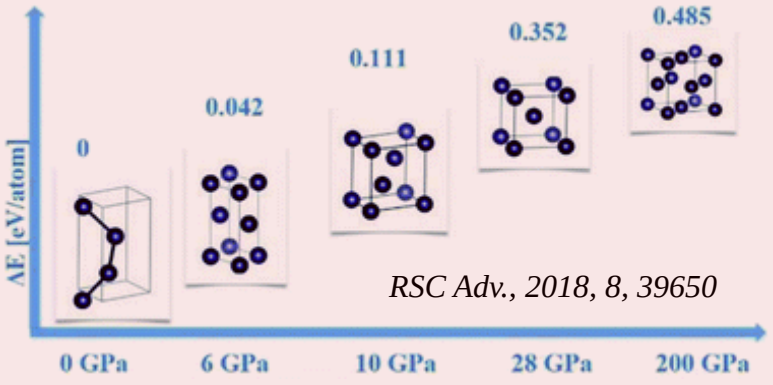






Composition

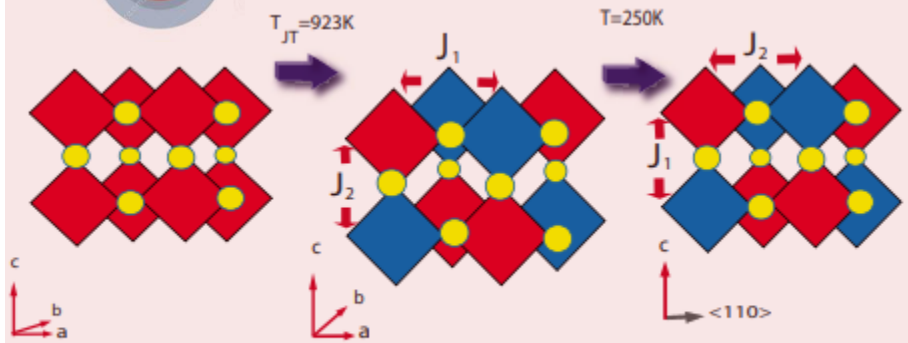
Pressure



RSC Adv., 2018, 8, 39650

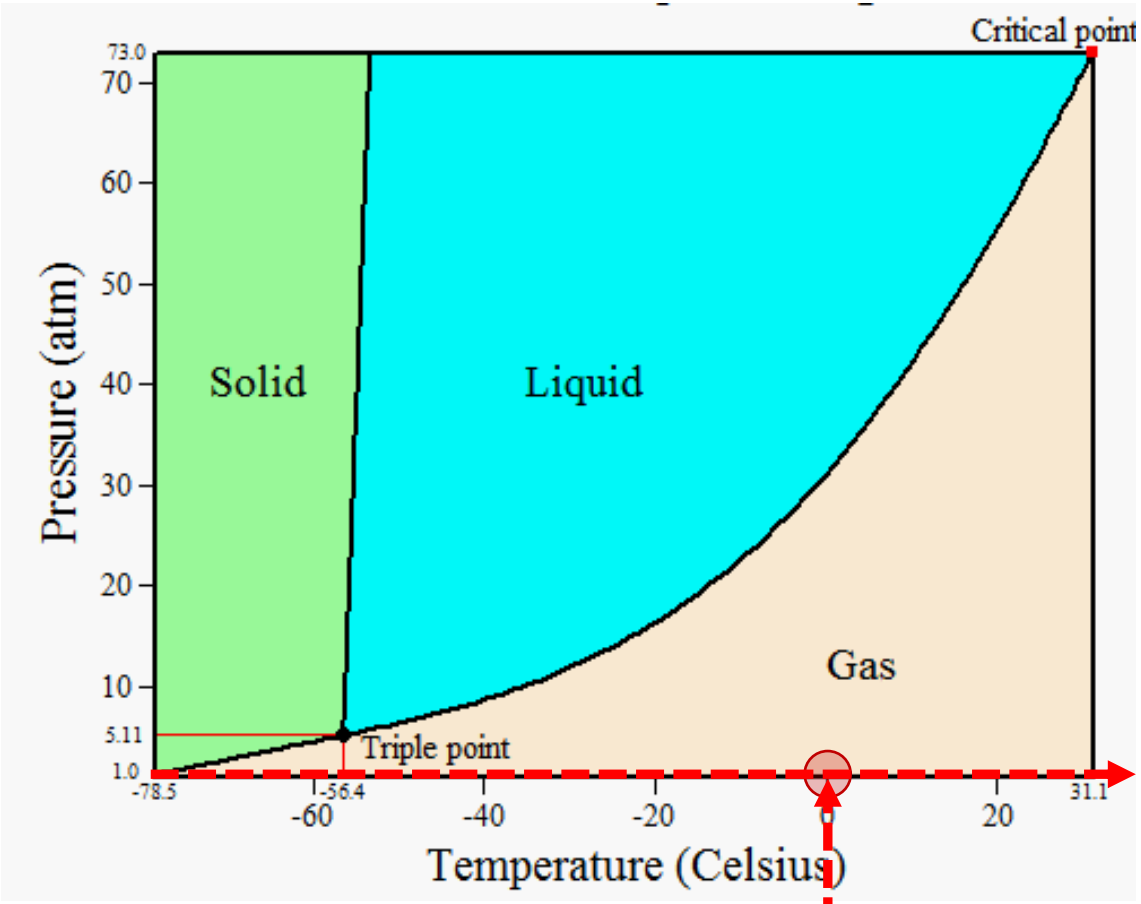
What are the factors affecting the phase formation?

Temperature

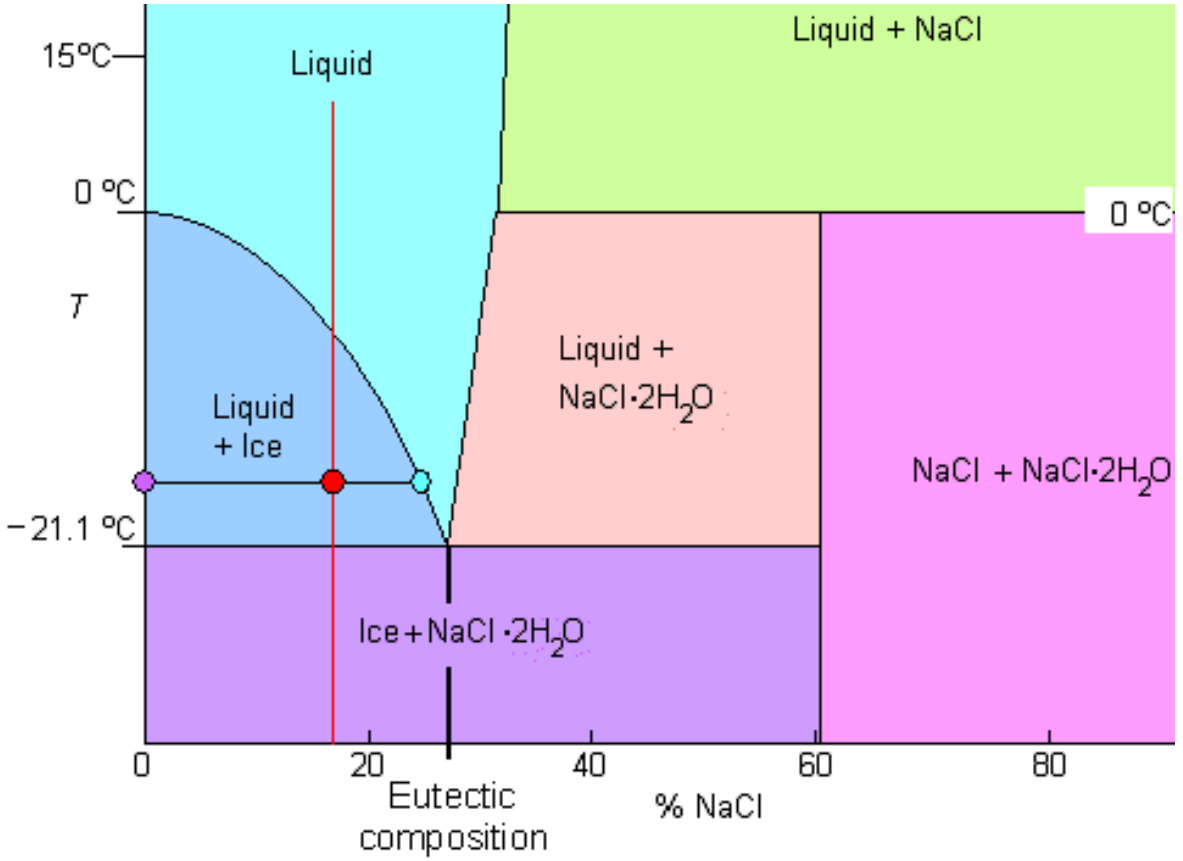


PHYSICAL REVIEW B 77, 075113 2008

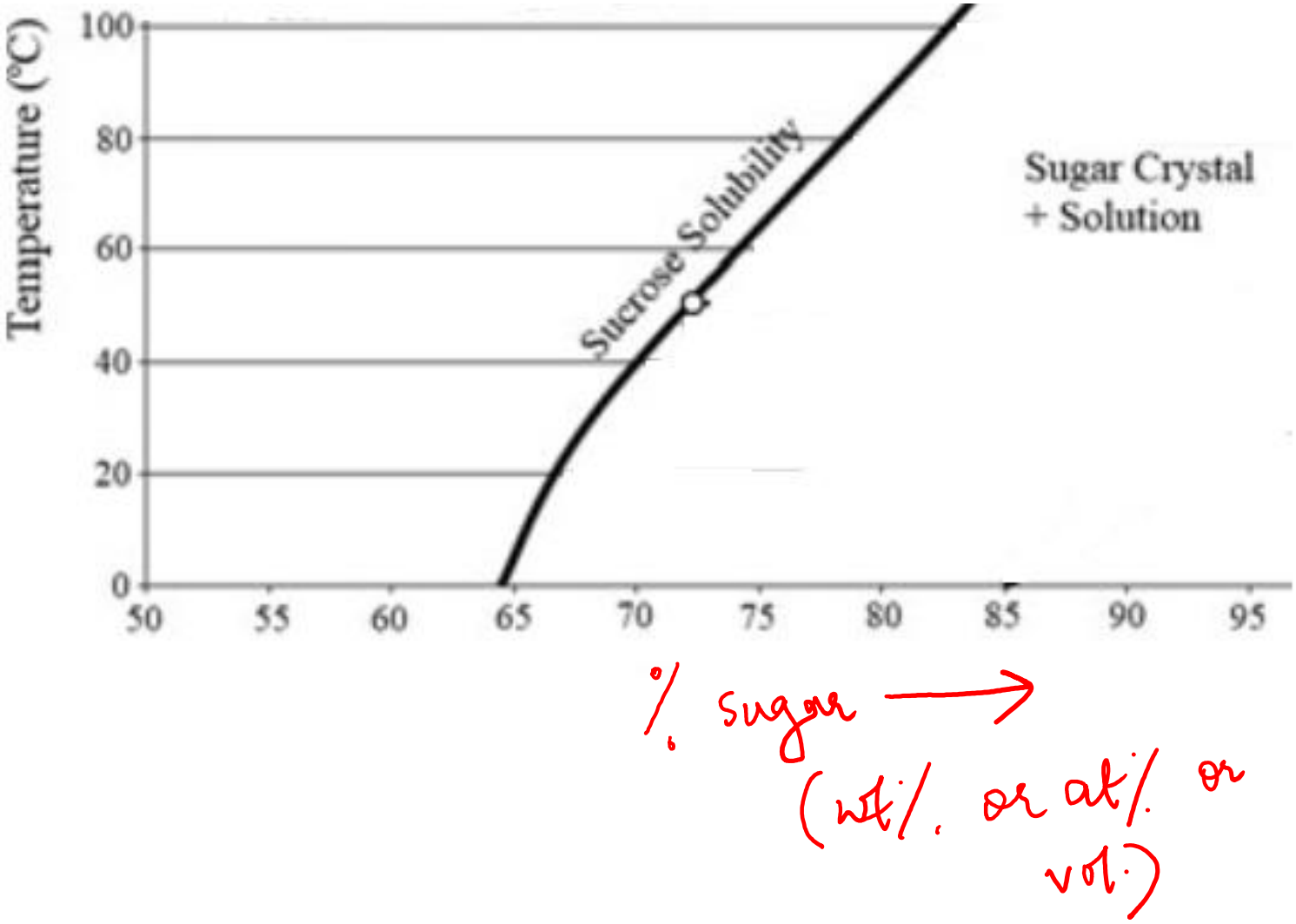
P-T diagram

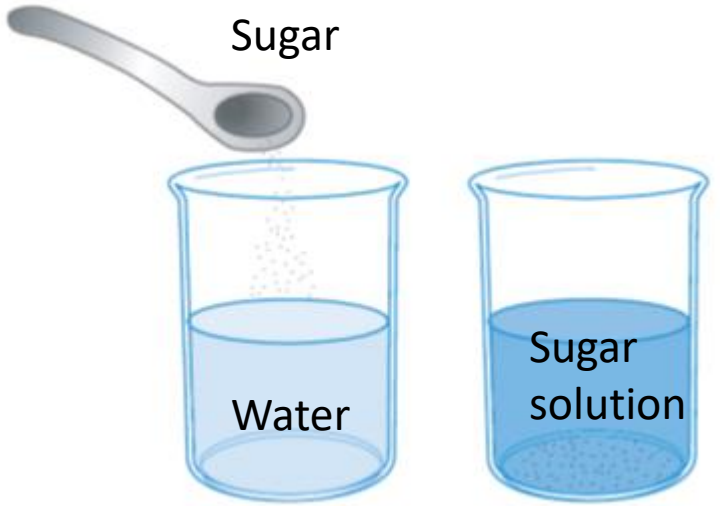


T-C diagram



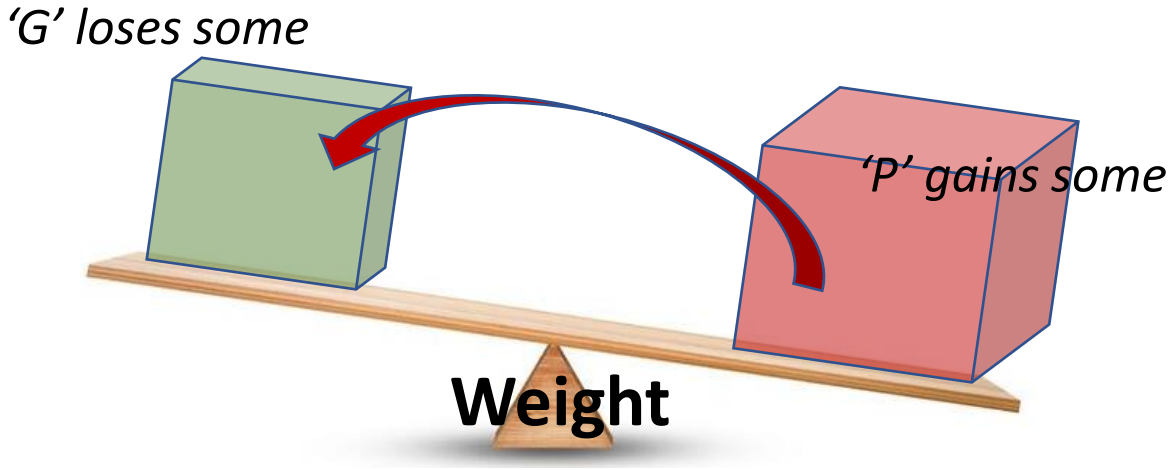
Solubility limit



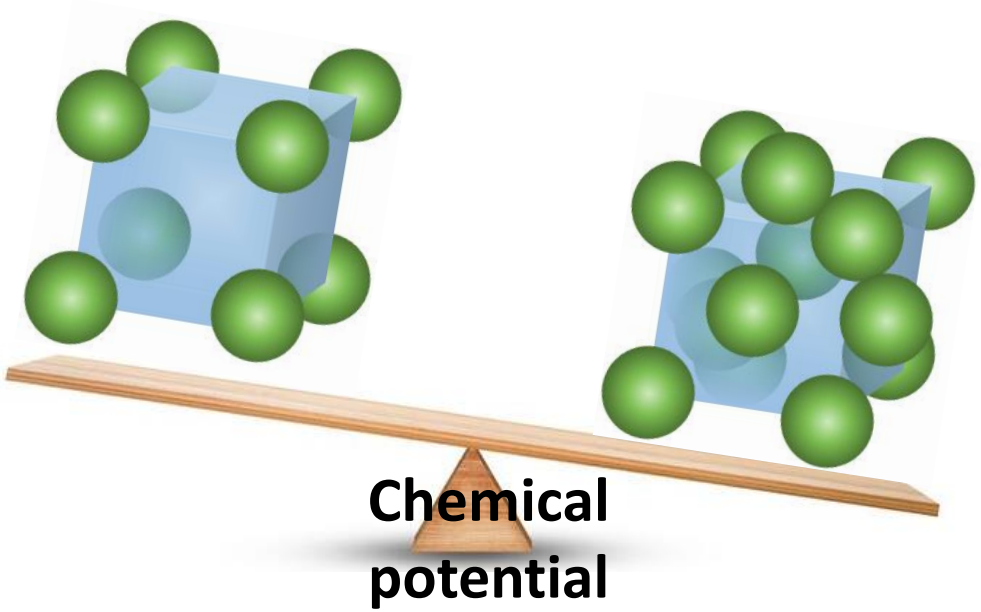


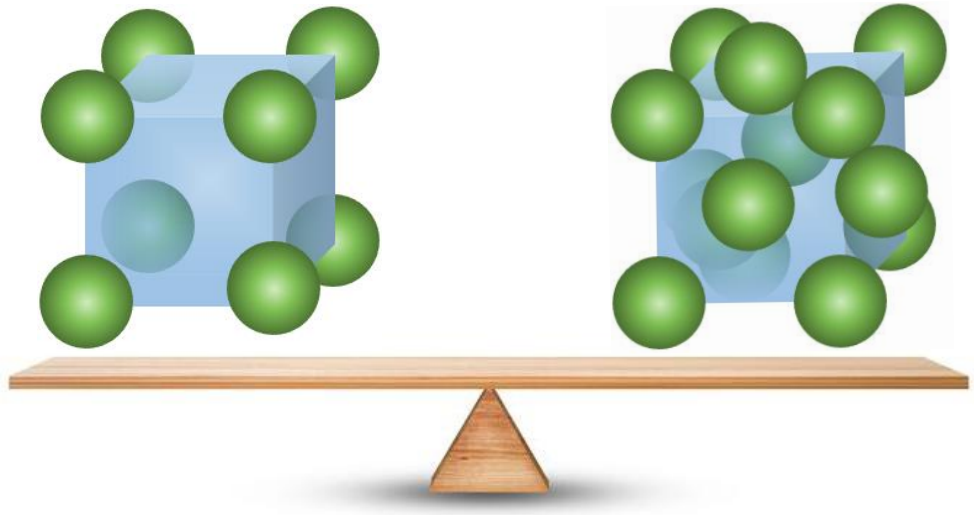
Excess sugar crystals

When will be the phases in equilibrium?



- For the phases to be in equilibrium, chemical potential (μ) of the components involved must be equal.





Chemical potential

- Represents a potential for any material to interact in a specific system.

- Change in energy in a system with the change in the number of atoms of a given material.

- High chemical potential: Donate the atoms
- Low chemical potential: Accept the atoms

- If $\alpha, \beta, \gamma, \ldots\ldots, P$ are the phases in equilibrium for a given binary A-B system, then:

$$\mu_A^{\alpha} = \mu_A^{\beta} = \mu_A^{\gamma} = \ \ldots\ldots\ldots = \mu_A^{P}$$

$$\mu_B^{\alpha} = \mu_B^{\beta} = \mu_B^{\gamma} = \ \ldots\ldots\ldots = \mu_B^{P}$$

Gibb's Phase Rule

- Total number of phases = P $\quad P_1 \quad P_2 \quad P_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad P_P$
- Total number of components = C $\quad C_1 \quad C_2 \quad C_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad C_C$

$$\sum_{i}^{n} C = 1$$

- Independent concentration variables for one phase = C-1
- Other two independent variables = Temperature (T) and Pressure (P) = 2
- Independent concentration variables for P phases = P(C-1) + 2

- Total number of variables = P(C-1) + 2

  - Phases present in a system can be in equilibrium when the chemical potential (μ) of each of the component is the same in all phases

$$\mu_A^{\alpha} = \mu_A^{\beta} = \mu_A^{\gamma} = \ \ldots\ldots\ldots = \mu_A^{P}$$

$$\mu_B^{\alpha} = \mu_B^{\beta} = \mu_B^{\gamma} = \ \ldots\ldots\ldots = \mu_B^{P}$$

- Total number of equilibria for ‘C’ components = C (P-1)

- Total degree of freedom = Total number of variables – Total number of equilibria

Total degree of freedom = P(C-1) + 2 – C (P-1) = PC - P + 2 – CP + C = C - P + 2

Gibbs Phase Rule

- Gives information about the conditions of phase equilibrium in different systems.

$$F = C - P + 2$$

- F: Degree of freedom
- C: No. of components
- P: No. of phases
- 2: Variables *(T, P)*