Systems Forming Solid Compounds $A_xB_y$ with Congruent and Incongruent Melting Points

In some two-component systems, the participants react together to form solid compounds $A_xB_y$. On the basis of the melting point of the compounds formed, these systems can be further divided.

- Systems Forming Solid Compounds $A_xB_y$ with Congruent Melting Points

In these systems, the solid compound melts sharply at temperature $T$ with the same composition as in the initial solid. These compounds are said to possess a congruent melting point with the phase diagram as

![Phase Diagram](image)

Figure 19. The general phase diagram of systems forming compounds with congruent melting points.

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Consider two components \( A \) and \( B \) which also form a chemical compound \( AB \) by reacting with each other. Therefore, in the complete solid-state, there will be three phases named solid \( A \), solid \( B \) and solid \( AB \). Accordingly, there should also be three different freezing point curves i.e. \( OP \), \( PQR \) and \( RS \). In addition to this liquidus, there will be two solidus \( CE \) and \( DE \) as well. The significance of different parts of the above-depicted diagram is discussed below.

1. Curve \( OP \) and \( RS \): The point \( O \) and point \( S \) represent the freezing point the pure compound \( A \) and compound \( B \), respectively. When compound \( AB \) is added to component \( A \), its freezing point decreases regularly along \( OP \). Likewise, when component \( AB \) is added to component \( B \), its freezing point decreases regularly along \( SR \). In conclusion, we can say that the curve \( OP \) and \( SR \) represent the temperature-conditions at which solid \( A \) and solid \( B \) are in equilibrium with the liquid mixture. Since there are only two phases involved, and both are condensed in nature (solid and liquid), we need to use condensed or reduced phase rule here i.e. after putting \( C = 2 \) and \( P = 2 \) in equation (114), we get

\[
F' = 2 - 2 + 1 = 1
\]  

Which means that the system is univariate. In other words, only one condition is needed to define the whole system; for instance, if we define a particular composition of \( A \) and \( AB \) (or \( B \) and \( AB \)), the freezing point of the mixture is completely fixed.

2. Curve \( PQR \): When compound \( A \) is increased in compound \( AB \), its freezing point of decreases regularly along \( QP \). Likewise, when component \( B \) is added to compound \( AB \), its freezing point decreases regularly along \( QR \). In conclusion, we can say that the curve \( PQR \) represents the temperature-conditions at which compound \( AB \) is in equilibrium with the liquid mixture. Since there are only two phases involved, and both are condensed in nature (solid and liquid), we need to use condensed or reduced phase rule here i.e. after putting \( C = 2 \) and \( P = 2 \) in equation (114), we get

\[
F' = 2 - 2 + 1 = 1
\]  

However, it is also worthy to mention that at the point \( Q \) also represents the congruent melting point of compound \( AB \) because liquid and solid phases have the same compositions. Consequently, we can also conclude that the system becomes one-component system at this point because the solid as well liquid phases contain only the compound \( AB \) alone. Furthermore, the congruent melting point of compound \( AB \) may lie above or below the congruent melting points of component \( A \) and component \( B \).

3. Eutectic points \( P \) and \( R \): In order to explain that the liquid phase can have two different compositions in equilibrium with the solid phase i.e. \( x \) and \( x' \), the curve \( PQR \) is divided into two parts by the vertical line \( QQ' \). This makes the concept very simple as the left and right parts can be treated as simple eutectic systems separately. The right half of the diagram is a eutectic system with components \( B \) and \( AB \) (solidus \( CD \)); whereas left hand side is a eutectic system with components \( A \) and \( AB \) (solidus is \( EP \)). The eutectic temperature and eutectic composition for the left-hand side portion are given by point \( P \). Similarly, the eutectic temperature and eutectic composition for the right-hand side portion are given by point \( R \).
Some Typical Examples of Systems Forming Compounds with Congruent Melting Points

Some of the typical examples of two-component systems forming compounds with congruent melting points are given below for a more comprehensive analysis.

1. Magnesium-zinc system (Mg-Zn):

The Mg-Zn is a typical case of solid-liquid equilibria in a two-component system that form compounds with congruent melting points. The phases involved in this case are solid Mg, solid Zn, solid MgZn$_2$, liquid mixture of three (Mg + Zn + MgZn$_2$) and vapor phase too. Now since a minor pressure disturbance will have little to no effect on the system and all the phases in two-component systems are either solid or liquids only (solid-liquid equilibria), which is the reduced or condensed phase rule i.e.

$$F' = C - P + 1$$  \(138\)

The complete phase diagram can be drawn on two dimensional paper with vertical and horizontal sides representing temperature and composition, respectively. Consider a liquid mixture of Mg and Zn at temperature $T$. Now if this liquid mixture is allowed to cool down below the freezing point of the mixture, the solid will start to separate out. Prepare a number of such mixtures but with different compositions (i.e. with different ratios of Mg and Zn). The cooling of all the mixtures is carried out in open vessels so that the pressure remains constant (atmospheric pressure). After that, the plot freezing points vs the composition is

![Phase Diagram of Mg-Zn System](image-url)

Figure 20. The phase diagram of Mg-Zn system.
The discussion on different parts (curve OQ, Curve SQ and the eutectic point) of the phase diagram of Bi-Cd system is given below.

i) Curve OP and point P: The point O represents the freezing point of the pure Zn (420°C). When Mg is added to zinc, its freezing point of decreases regularly along OP and Zn separates out simultaneously. Since there are only two phases involved, i.e. after putting $C = 2$ and $P = 2$ in equation (138), we get

$$F' = 2 - 2 + 1 = 1$$  \hspace{2cm} (139)

Which means that the system is univariate. However, after the point P is reached, the compound MgZn$_2$ is formed and also starts separating out as solid. We can say that there are three phases that coexist at point P i.e. solid Zn, solid MgZn$_2$ and melt which makes the system invariant (for $P = 3$, $F' = 0$).

ii) Curve PQ and point Q: The point Q represents the freezing point of the compound MgZn$_2$ (590°C). When Mg is added to zinc after point P, it combines with zinc to form MgZn$_2$ which keeps on separating and its freezing point increases regularly until point Q is reached (33% magnesium). Since there are only two phases involved, i.e. after putting $C = 2$ and $P = 2$ in equation (138), we get

$$F' = 2 - 2 + 1 = 1$$  \hspace{2cm} (140)

Which means that the system is univariate. Now since the liquid and solid phases have the same composition at point Q, the corresponding temperature can be called a congruent melting point of compound MgZn$_2$. Furthermore, as the number of components becomes one at point Q i.e. solid MgZn$_2$ and melt MgZn$_2$, the system becomes invariant at Q (for $P = 3$, $F' = 0$).

iii) Curve QR and point R: When Mg is further added to zinc after point Q, it goes into melt MgZn$_2$ separating out as solid, and therefore, the freezing point of MgZn$_2$ decreases regularly until point R is reached. Since there are only two phases involved along curve QR, i.e. after putting $C = 2$ and $P = 2$ in equation (138), we get the following

$$F' = 2 - 2 + 1 = 1$$  \hspace{2cm} (141)

Which means that the system is univariant. Moreover, we can also conclude here that there are three phases that coexist at point R i.e. solid Mg solid MgZn$_2$ and melt which makes the system invariant (for $P = 3$, $F' = 0$).

iv) Curve SR: When Mg is further added to zinc after point R, it starts separating out as solid, and therefore, the freezing point of Mg increases regularly until point S is reached. Since there are only two phases involved along curve SR, i.e. after putting $C = 2$ and $P = 2$ in equation (138), we get

$$F' = 2 - 2 + 1 = 1$$  \hspace{2cm} (142)

Which means that the system remains univariant along curve SR. In reverse we can also say that the freezing point of Mg decreases regularly along curve SR until point R is reached i.e. solid Mg solid MgZn$_2$ and melt which makes the system invariant (for $P = 3$, $F' = 0$).
2. Ferric chloride-water system (FeCl₃-H₂O):

The FeCl₃-H₂O is another typical case of solid-liquid equilibria in a two-component system that forms stable compounds with congruent melting point. The phases involved in this case are solid FeCl₃, ice, solid Fe₂Cl₆·12H₂O, Fe₂Cl₆·7H₂O, Fe₂Cl₆·5H₂O, Fe₂Cl₆·4H₂O, liquid mixture and vapor phase too. Now since a minor pressure disturbance will have little to no effect on the system and all the phases in two-component systems are either solid or liquids only (solid-liquid equilibria), the reduced phase rule can be used i.e.

\[ F' = C - P + 1 \]  \hspace{1cm} (143)

The complete phase diagram can be drawn on two dimensional paper with vertical and horizontal sides representing temperature and composition, respectively. The cooling of all the mixtures is carried out in open vessels so that the pressure remains constant (atmospheric pressure). After that, the plot of freezing points vs the composition is obtained.

![Phase diagram of FeCl₃-H₂O system.](image)

**Figure 21.** The phase diagram of FeCl₃-H₂O system.

i) Curve OP and point P: The point O represents the freezing point of the pure water (0°C). When FeCl₃ is added to water, the freezing point of water decreases regularly along OP and ice separates out simultaneously. Since there are only two phases involved along curve OP (C = 2 and P =2), the equation (143) gives

\[ F' = 2 - 2 + 1 = 1 \]  \hspace{1cm} (144)

Which means that the system is univariant along curve OP. However, after reaching the point P, the liquid phase becomes saturated with compound Fe₂Cl₆·12H₂O which also starts separating out as solid afterward. We can say that there are three phases that coexist at point P i.e. solid ice, solid Fe₂Cl₆·12H₂O and solution which
makes the system invariant (for \( P = 3, F' = 0 \)). In other words, the point P is the “eutectic point for water and FeCl\(_6\).12H\(_2\)O.

ii) Curve PQ and point Q: The point Q represents the congruent melting point of the compound FeCl\(_6\).12H\(_2\)O (37°C). When FeCl\(_3\) is added to the water after point P, it combines with water to form FeCl\(_6\).12H\(_2\)O which keeps on separating and its freezing point increases regularly until point Q is reached. Since there are only two phases involved along curve PQ, i.e., after putting \( C = 2 \) and \( P = 2 \) in equation (143), we get

\[
F' = 2 - 2 + 1 = 1
\]  

(145)

Which means that the system is univariant. Furthermore, as the number of components becomes one at point Q i.e. solid FeCl\(_6\).12H\(_2\)O and solution, the system becomes invariant at Q (for \( P = 2, F' = 0 \)).

iii) Curve QR and point R: When FeCl\(_3\) is further added to the water after point Q, the freezing point of FeCl\(_6\).12H\(_2\)O decreases regularly until point R is reached. Since there are only two phases involved along curve QR, i.e., after putting \( C = 2 \) and \( P = 2 \) in equation (143), we get

\[
F' = 2 - 2 + 1 = 1
\]  

(146)

Which means that the system is univariant. After point R, the compound FeCl\(_6\).7H\(_2\)O is formed and also starts separating out as solid. However, we can say that there are three phases that coexist at point R i.e. solid FeCl\(_6\).12H\(_2\)O, solid FeCl\(_6\).7H\(_2\)O and solution which makes the system invariant (for \( P = 3, F' = 0 \)).

iv) Curve RS and point S: The point S represents the congruent melting point of the compound FeCl\(_6\).7H\(_2\)O (37°C). When FeCl\(_3\) is added to the water after point R, it combines with water to form FeCl\(_6\).7H\(_2\)O which keeps on separating and its freezing point increases regularly until point S is reached. Since there are only two phases involved, i.e., after putting \( C = 2 \) and \( P = 2 \) in equation (143), we get

\[
F' = 2 - 2 + 1 = 1
\]  

(147)

Which means that the system is univariant. Furthermore, as the number of components becomes one at point S i.e. solid FeCl\(_6\).7H\(_2\)O and solution, the system becomes invariant at S (for \( P = 2, F' = 0 \)).

v) Curve ST and point T: When FeCl\(_3\) is further added to the water after point S, the freezing point of FeCl\(_6\).7H\(_2\)O decreases regularly until point T is reached. Since there are only two phases involved along curve ST, i.e., after putting \( C = 2 \) and \( P = 2 \) in equation (143), we get

\[
F' = 2 - 2 + 1 = 1
\]  

(148)

Which means that the system is univariant. After point T, the compound FeCl\(_6\).5H\(_2\)O is formed and also starts separating out as solid. However, we can say that there are three phases that coexist at point T i.e. solid FeCl\(_6\).7H\(_2\)O, solid FeCl\(_6\).5H\(_2\)O and solution which makes the system invariant (for \( P = 3, F' = 0 \)).

vi) Curve TU and point U: The point U represents the congruent melting point of the compound FeCl\(_6\).5H\(_2\)O (37°C). When FeCl\(_3\) is added to the water after point T, it combines with water to form FeCl\(_6\).5H\(_2\)O which
keeps on separating and its freezing point increases regularly until point U is reached. Since there are only two phases involved, i.e. after putting $C = 2$ and $P = 2$ in equation (138), we get

$$F' = 2 - 2 + 1 = 1$$  \hspace{1cm} (149)

Which means that the system is univariant. Furthermore, as the number of components becomes one at point U i.e. solid Fe$_2$Cl$_6$.5H$_2$O and solution, the system becomes invariant at U (for $P = 2$, $F' = 0$).

**vii) Curve UV and point V:** When FeCl$_3$ is further added to the water after point U, the freezing point of Fe$_2$Cl$_6$.5H$_2$O decreases regularly until point V is reached. Since there are only two phases involved along curve UV, i.e. after putting $C = 2$ and $P = 2$ in equation (143), we get

$$F' = 2 - 2 + 1 = 1$$  \hspace{1cm} (150)

Which means that the system is univariant. After point V, the compound Fe$_2$Cl$_6$.4H$_2$O is formed and also starts separating out as solid. However, we can say that there are three phases that coexist at point V i.e. solid Fe$_2$Cl$_6$.5H$_2$O, solid Fe$_2$Cl$_6$.4H$_2$O and solution which makes the system invariant (for $P = 3$, $F' = 0$).

**viii) Curve VW and point W:** The point W represents the congruent melting point of the compound Fe$_2$Cl$_6$.4H$_2$O (37°C). When FeCl$_3$ is added to the water after point V, it combines with water to form Fe$_2$Cl$_6$.4H$_2$O which keeps on separating and its freezing point increases regularly until point W is reached. Since there are only two phases involved, i.e. after putting $C = 2$ and $P = 2$ in equation (143), we get

$$F' = 2 - 2 + 1 = 1$$  \hspace{1cm} (151)

Which means that the system is univariant. After point W, anhydrous Fe$_2$Cl$_6$ is formed and also starts separating out as solid. However, we can say that there are three phases that coexist at point Q i.e. solid Fe$_2$Cl$_6$.4H$_2$O, anhydrous Fe$_2$Cl$_6$ and solution which makes the system invariant (for $P = 3$, $F' = 0$).

**ix) Curve WX and point X:** When FeCl$_3$ is further added to the water after point W, the freezing point of Fe$_2$Cl$_6$.4H$_2$O decreases regularly until point X is reached. Since there are only two phases involved along curve WX, i.e. after putting $C = 2$ and $P = 2$ in equation (143), we get

$$F' = 2 - 2 + 1 = 1$$  \hspace{1cm} (152)

Which means that the system is univariant. After point X, anhydrous Fe$_2$Cl$_6$ is formed and also starts separating out as solid. However, we can say that there are three phases that coexist at point R i.e. solid Fe$_2$Cl$_6$.4H$_2$O, anhydrous Fe$_2$Cl$_6$ and solution which makes the system invariant (for $P = 3$, $F' = 0$).

**x) Curve XY:** The point Y represents the freezing point of the compound Fe$_2$Cl$_6$. When FeCl$_3$ is added to the water after point X, it combines with water to yield anhydrous Fe$_2$Cl$_6$ which keeps on separating and its freezing point increases regularly along XY is reached. Since there are only two phases involved along curve XY, i.e. after putting $C = 2$ and $P = 2$ in equation (143), we get

$$F' = 2 - 2 + 1 = 1$$  \hspace{1cm} (153)

Which means that the system is univariant.
Systems Forming Solid Compounds \(A_B \) with Incongruent Melting Points

In these types of systems, the two components react to give a compound which is not stable up to its melting point. When heated, the decomposition starts before the melting point is reached; and a new solid phase and a solution or melt with a different composition from the original solid are formed. Such compounds are said to undergo peritectic or transition reaction and are labeled to have congruent melting point. A typical transition can be represented as

\[ C_1 \rightleftharpoons C_2 + \text{melt or solution} \]  \hspace{1cm} (154)

Where \( C_1 \) is the compound formed by the reaction between participating components whereas \( C_2 \) represents the compound formed as a result of decomposition of \( C_1 \) below its fusion temperature.

![Diagram of systems forming compounds with incongruent melting points](image)

Figure 22. The general phase diagram of systems forming compounds with incongruent melting points.

Consider two components \( A \) and \( B \) which also form a chemical compound \( AB_2 \) by reacting with each other. The cooling of all the mixture-compositions is carried out in open vessels so that the pressure remains constant (atmospheric pressure). After that, the plot of freezing points vs the composition is obtained. The significance of different parts of the above-depicted diagram is discussed below.

1. **Point \( O, S, Q \) and \( R \):** The point \( O \) and point \( S \) represent the freezing point the pure compound \( A \) and compound \( B \), respectively. The point \( Q \), however, is quite strange because it represents the transition temperature (incongruent melting point of \( AB_2 \)) where compound \( AB_2 \) decomposes into compound \( B \). If does not decompose at this temperature, its congruent melting point would be \( R \). In other words, we can say that the point \( R \) represents the hypothetical congruent melting point of compound \( AB_2 \).
2. Curve OP, SQ and QP: When compound B is added to component A, its freezing point decreases regularly along OP. In other words, OP is the fusion curve of compound A along which solid A is in equilibrium with melt or solution. The line SQ is the fusion curve of compound B along which solid B is in equilibrium with melt or solution. Similarly, QP is the fusion curve of compound AB₂ along which solid AB₂ is in equilibrium with melt or solution.

When a liquid mixture with composition X is allowed to cool down, it will do so by keeping its composition the same until point 1 is reached where the compound A will just start to separate out as solid. Further cooling will lead to a change in composition along the line 1P. When point P is attained, the formation of compound AB will be started; and since three phases coexist at this point (solid A, solid AB and liquid), the reduced phase rule gives

\[ F' = C - P + 1 \]

\[ F' = 2 - 3 + 1 = 0 \]  

Which means that there will be no degree of freedom at point P (P is non-variant). On the other hand, if liquid mixture with composition Y is allowed to cool down, it will do so by keeping its composition the same until point 2 is reached where the compound B will just start to separate out as solid. Further cooling will lead to a change in composition along the line 2Q. When point Q is attained, the following meritectic reaction will take place

\[ \text{Solid } B + \text{Solution} \rightleftharpoons \text{Solid } AB_2 \]  

Therefore, the formation of compound AB₂ will be started; and since three phases coexist at this point (solid B, solid AB and liquid), the point Q also become invariant. Furthermore, it is also worthy to mention that the transformation of compound B to compound AB₂ occurs at a constant temperature, and therefore, the point Q is also called a peritectic point.

Some Typical Examples of Systems Forming Compounds with Incongruent Melting Points

Some of the typical examples of two-components systems forming compounds with incongruent melting points are given below for a more comprehensive analysis.

1. Sodium chloride-water system (NaCl-H₂O):

The NaCl-H₂O is a typical case of solid-liquid equilibria in a two-component system that forms compounds with an incongruent melting point. The phases involved in this case are solid NaCl, solid NaCl₂H₂O, ice, liquid mixture, and vapour phase too. Now since a minor pressure disturbance will have little to no effect on the system and all the phases in two-component systems are either solid or liquids only (solid-liquid equilibria), which is the reduced or condensed phase rule i.e.

\[ F' = C - P + 1 \]  

The complete phase diagram can be drawn on two dimensional paper with vertical and horizontal sides representing temperature and composition, respectively. Consider a liquid mixture of water and NaCl at
temperature \( T \). Now if this liquid mixture is allowed to cool down below the freezing point of the mixture, the solid will start to separate out. Prepare a number of such mixtures but with different compositions (i.e. with different ratios of \( \text{H}_2\text{O} \) and \( \text{NaCl} \)). The cooling of all the mixtures is carried out in open vessels so that the pressure remains constant (atmospheric pressure). After that, the plot freezing points vs the composition is

![Phase diagram of NaCl-H2O system](image)

**Figure 23.** The phase diagram of \( \text{NaCl-H}_2\text{O} \) system.

i) **Point O, S and Q:** The point \( O \) and point \( S \) represent the freezing point the pure water and pure \( \text{NaCl} \), respectively. The point \( Q \), however, is quite strange because it represents the transition temperature (incongruent melting point of \( \text{NaCl.2H}_2\text{O} \)) where compound \( \text{NaCl.2H}_2\text{O} \) decomposes into pure \( \text{NaCl} \).

ii) **Curve OP, SQ and QP:** When \( \text{NaCl} \) is added to water, its freezing point decreases regularly along \( OP \). In other words, \( OP \) is the fusion curve of water along which the ice is in equilibrium with the solution. The line \( SQ \) is the fusion curve of pure \( \text{NaCl} \) along which solid \( \text{NaCl} \) is in equilibrium with the brine solution. Similarly, \( QP \) is the fusion curve of compound \( \text{NaCl.2H}_2\text{O} \) along which solid \( \text{NaCl.2H}_2\text{O} \) is in equilibrium with solution.

When \( \text{NaCl} \) is added to pure water, ice will just start to separate out as solid along path \( OP \). This will lead to a change in composition along the line \( OP \). When point \( P \) is attained, the formation of compound \( \text{NaCl.2H}_2\text{O} \) will start; and since three phases coexist at \( P \) (ice, \( \text{NaCl.2H}_2\text{O} \) and liquid), the reduced phase rule

\[
F' = 2 - 3 + 1 = 0 \quad (159)
\]

Which means that there will be no degree of freedom at point \( P \) (\( P \) is non-variant). On the other hand, the curve \( SQ \) is the fusion curve of \( \text{NaCl} \). The further cooling will lead to a change in composition along the line \( SQ \). When point \( Q \) is attained, the following meritectic reaction will take place

\[
\text{Solid NaCl} + \text{Solution} \rightleftharpoons \text{Solid NaCl.2H}_2\text{O} \quad (160)
\]
Therefore, the formation of compound NaCl\(_2\)H\(_2\)O will be started; and since three phases coexist at this point (solid NaCl, solid NaCl\(_2\)H\(_2\)O and liquid), the point \(Q\) also become invariant. Furthermore, it is also worthy to mention that the transformation of compound NaCl to compound NaCl\(_2\)H\(_2\)O occurs at a constant temperature, and therefore, the point \(Q\) is also called as peritectic point.

2. Sodium sulphate-water system (Na\(_2\)SO\(_4\)-H\(_2\)O):

The Na\(_2\)SO\(_4\)-H\(_2\)O is another typical case of solid-liquid equilibria in a two-component system that forms compounds with an incongruent melting point. The phases involved in this case are solid Na\(_2\)SO\(_4\), solid Na\(_2\)SO\(_4\).10H\(_2\)O, ice, liquid mixture, and vapor phase too. Now since a minor pressure disturbance will have little to no effect on the system and all the phases in two-component systems are either solid or liquids only (solid-liquid equilibria), which is the reduced or condensed phase rule i.e.

\[ F' = C - P + 1 \]  
(161)

The complete phase diagram can be drawn on two dimensional paper with vertical and horizontal sides representing temperature and composition, respectively. Consider a liquid mixture of water and Na\(_2\)SO\(_4\) at temperature \(T\). Now if this liquid mixture is allowed to cool down below the freezing point of the mixture, the solid will start to separate out. Prepare a number of such mixtures but with different compositions (i.e. with different ratios of H\(_2\)O and Na\(_2\)SO\(_4\)). The cooling of all the mixtures is carried out in open vessels so that the pressure remains constant (atmospheric pressure). After that, the plot freezing points vs the composition is

![Phase Diagram of Na\(_2\)SO\(_4\)-H\(_2\)O System](image)

Figure 24. The phase diagram of Na\(_2\)SO\(_4\)-H\(_2\)O system.

*i) Point \(O\) and \(Q\):* The point \(O\) represents the freezing point the pure water. The point \(Q\), however, is quite strange because it represents the transition temperature (incongruent melting point of Na\(_2\)SO\(_4\).10H\(_2\)O) where compound Na\(_2\)SO\(_4\).10H\(_2\)O decomposes into pure Na\(_2\)SO\(_4\).
ii) Curve $OP$, $SQ$ and $QP$: When $\text{Na}_2\text{SO}_4$ is added to water, its freezing point decreases regularly along $OP$. In other words, $OP$ is the fusion curve of compound water along which ice is in equilibrium with the solution. The line $SQ$ is the fusion curve of pure $\text{Na}_2\text{SO}_4$ along which $\text{Na}_2\text{SO}_4$ is in equilibrium with the solution. Similarly, $QP$ is the fusion curve of compound $\text{Na}_2\text{SO}_4.10\text{H}_2\text{O}$ along which solid $\text{Na}_2\text{SO}_4.10\text{H}_2\text{O}$ is in equilibrium with the solution.

When $\text{Na}_2\text{SO}_4$ is added to water, ice will start to separate out along $OP$. This will lead to a change in composition along the line $OP$. When point $P$ is attained, the formation of compound $\text{Na}_2\text{SO}_4.10\text{H}_2\text{O}$ will be started; and since three phases coexist at $P$ (ice, $\text{Na}_2\text{SO}_4\cdot\text{H}_2\text{O}$ and solution), the reduced phase rule gives

$$F' = 2 - 3 + 1 = 0$$

(162)

Which means that there will be no degree of freedom at point $P$ ($P$ is non-variant). On the other hand, the curve $SQ$ is fusion curve of $\text{Na}_2\text{SO}_4$. The further cooling will lead to a change in composition along the line $SQ$. When point $Q$ is attained, the following meritectic reaction will take place

$$\text{Solid } \text{Na}_2\text{SO}_4 + \text{Solution} \rightleftharpoons \text{Solid } \text{Na}_2\text{SO}_4.10\text{H}_2\text{O}$$

(163)

Therefore, the formation of compound $\text{Na}_2\text{SO}_4.10\text{H}_2\text{O}$ will be started; and since three phases coexist at this point (solid $\text{Na}_2\text{SO}_4$, solid $\text{Na}_2\text{SO}_4.10\text{H}_2\text{O}$ and liquid), the point $Q$ also become invariant. Furthermore, it is also worthy to mention that the transformation of compound $\text{Na}_2\text{SO}_4$ to compound $\text{Na}_2\text{SO}_4.10\text{H}_2\text{O}$ occurs at a constant temperature, and therefore, the point $Q$ is also called a peritectic point.
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# Table of Contents

### CHAPTER 1 ...................................................................................................................... 11

- Quantum Mechanics – I ........................................................................................................ 11
  - Postulates of Quantum Mechanics .................................................................................... 11
  - Derivation of Schrodinger Wave Equation ........................................................................ 16
  - Max-Born Interpretation of Wave Functions ...................................................................... 21
  - The Heisenberg’s Uncertainty Principle ............................................................................ 24
  - Quantum Mechanical Operators and Their Commutation Relations ............................... 29
  - Hermitian Operators – Elementary Ideas, Quantum Mechanical Operator for Linear Momentum, Angular Momentum and Energy as Hermitian Operator .................................................. 52
  - The Average Value of the Square of Hermitian Operators .............................................. 62
  - Commuting Operators and Uncertainty Principle ($x & p; E & t$) ...................................... 63
  - Schrodinger Wave Equation for a Particle in One Dimensional Box .............................. 65
  - Evaluation of Average Position, Average Momentum and Determination of Uncertainty in Position and Momentum and Hence Heisenberg’s Uncertainty Principle .................................................. 70
  - Pictorial Representation of the Wave Equation of a Particle in One Dimensional Box and Its Influence on the Kinetic Energy of the Particle in Each Successive Quantum Level ................................. 75
  - Lowest Energy of the Particle .......................................................................................... 80
  - Problems ............................................................................................................................ 82
  - Bibliography ...................................................................................................................... 83

### CHAPTER 2 ...................................................................................................................... 84

- Thermodynamics – I ............................................................................................................. 84
  - Brief Resume of First and Second Law of Thermodynamics ............................................. 84
  - Entropy Changes in Reversible and Irreversible Processes .............................................. 87
  - Variation of Entropy with Temperature, Pressure and Volume ........................................ 92
  - Entropy Concept as a Measure of Unavailable Energy and Criteria for the Spontaneity of Reaction .................................................................................................................................................. 94
  - Free Energy, Enthalpy Functions and Their Significance, Criteria for Spontaneity of a Process... 98
  - Partial Molar Quantities (Free Energy, Volume, Heat Concept) ....................................... 104
  - Gibb’s-Duhem Equation ................................................................................................... 108
  - Problems ............................................................................................................................ 111
  - Bibliography ...................................................................................................................... 112
CHAPTER 3 .............................................................................................................................................. 113
Chemical Dynamics – I .......................................................................................................................... 113
❖ Effect of Temperature on Reaction Rates ...................................................................................... 113
❖ Rate Law for Opposing Reactions of 1st Order and 2nd Order ..................................................... 119
❖ Rate Law for Consecutive & Parallel Reactions of 1st Order Reactions ....................................... 127
❖ Collision Theory of Reaction Rates and Its Limitations ............................................................... 135
❖ Steric Factor ................................................................................................................................... 141
❖ Activated Complex Theory ........................................................................................................... 143
❖ Ionic Reactions: Single and Double Sphere Models ..................................................................... 147
❖ Influence of Solvent and Ionic Strength ........................................................................................ 152
❖ The Comparison of Collision and Activated Complex Theory ..................................................... 157
❖ Problems ........................................................................................................................................ 158
❖ Bibliography .................................................................................................................................. 159

CHAPTER 4 .............................................................................................................................................. 160
Electrochemistry – I: Ion-Ion Interactions .......................................................................................... 160
❖ The Debye-Huckel Theory of Ion-Ion Interactions ....................................................................... 160
❖ Potential and Excess Charge Density as a Function of Distance from the Central Ion ................. 168
❖ Debye-Huckel Reciprocal Length ................................................................................................. 173
❖ Ionic Cloud and Its Contribution to the Total Potential ............................................................... 176
❖ Debye-Huckel Limiting Law of Activity Coefficients and Its Limitations ................................... 178
❖ Ion-Size Effect on Potential ........................................................................................................... 185
❖ Ion-Size Parameter and the Theoretical Mean - Activity Coefficient in the Case of Ionic Clouds with Finite-Sized Ions ........................................................................................................... 187
❖ Debye-Huckel-Onsager Treatment for Aqueous Solutions and Its Limitations ............................ 190
❖ Debye-Huckel-Onsager Theory for Non-Aqueous Solutions ........................................................ 195
❖ The Solvent Effect on the Mobility at Infinite Dilution ................................................................ 196
❖ Equivalent Conductivity ($\Lambda$) vs Concentration $C^{1/2}$ as a Function of the Solvent .......... 198
❖ Effect of Ion Association Upon Conductivity (Debye-Huckel-Bjerrum Equation) ...................... 200
❖ Problems ........................................................................................................................................ 209
❖ Bibliography .................................................................................................................................. 210

CHAPTER 5 .............................................................................................................................................. 211
Quantum Mechanics – II .................................................................................................................... 211
❖ Schrodinger Wave Equation for a Particle in a Three Dimensional Box ..................................... 211
The Concept of Degeneracy Among Energy Levels for a Particle in Three Dimensional Box .... 215
Schrodinger Wave Equation for a Linear Harmonic Oscillator & Its Solution by Polynomial Method ..............................................................217
Zero Point Energy of a Particle Possessing Harmonic Motion and Its Consequence ........... 229
Schrodinger Wave Equation for Three Dimensional Rigid Rotator .............................................. 231
Energy of Rigid Rotator ................................................................................................................ 241
Space Quantization........................................................................................................................ 243
Schrodinger Wave Equation for Hydrogen Atom: Separation of Variable in Polar Spherical Coordinates and Its Solution ......................................................................................................... 247
Principal, Azimuthal and Magnetic Quantum Numbers and the Magnitude of Their Values...... 268
Probability Distribution Function .................................................................................................. 276
Radial Distribution Function ......................................................................................................... 278
Shape of Atomic Orbitals (s, p & d) .............................................................................................. 281
Problems ........................................................................................................................................ 287
Bibliography .................................................................................................................................. 288

CHAPTER 6 .............................................................................................................................................. 289

Thermodynamics – II .......................................................................................................................... 289
Clausius-Clapeyron Equation ........................................................................................................ 289
Law of Mass Action and Its Thermodynamic Derivation .............................................................. 293
Phase Diagram for Two Completely Miscible Components Systems ........................................ 304
Eutectic Systems (Calculation of Eutectic Point) ........................................................................ 311
Systems Forming Solid Compounds AₓBᵧ with Congruent and Incongruent Melting Points ...... 321
Phase Diagram and Thermodynamic Treatment of Solid Solutions .............................................. 332
Problems ........................................................................................................................................ 342
Bibliography .................................................................................................................................. 343

CHAPTER 7 .............................................................................................................................................. 344

Chemical Dynamics – II ...................................................................................................................... 344
Chain Reactions: Hydrogen-Bromine Reaction, Pyrolysis of Acetaldehyde, Decomposition of Ethane ........................................................................................................................................... 344
Photochemical Reactions (Hydrogen-Bromine & Hydrogen-Chlorine Reactions) ....................... 352
General Treatment of Chain Reactions (Ortho-Para Hydrogen Conversion and Hydrogen-Bromine Reactions) ...................................................................................................................................... 358
CHAPTER 8

Electrochemistry – II: Ion Transport in Solutions

- Ionic Movement Under the Influence of an Electric Field
- Mobility of Ions
- Ionic Drift Velocity and Its Relation with Current Density
- Einstein Relation Between the Absolute Mobility and Diffusion Coefficient
- The Stokes-Einstein Relation
- The Nernst-Einstein Equation
- Walden’s Rule
- The Rate-Process Approach to Ionic Migration
- The Rate-Process Equation for Equivalent Conductivity
- Total Driving Force for Ionic Transport: Nernst-Planck Flux Equation
- Ionic Drift and Diffusion Potential
- The Onsager Phenomenological Equations
- The Basic Equation for the Diffusion
- Planck-Henderson Equation for the Diffusion Potential
- Problems
- Bibliography

INDEX
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