Unit

1

SOLID STATE

I. Multiple Choice Questions (Type-I)

1. Which of the following conditions favours the existence of a substance in the solid state?

(i) High temperature

(ii) Low temperature

(iii) High thermal energy

(iv) Weak cohesive forces

2. Which of the following is **not** a characteristic of a crystalline solid?

(i) Definite and characteristic heat of fusion.

(ii) Isotropic nature.

(iii) A regular periodically repeated pattern of arrangement of constituent particles in the entire crystal.

(iv) A true solid

3. Which of the following is an amorphous solid?

(i) Graphite (C)

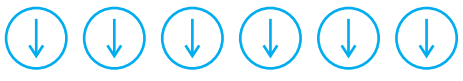
(ii) Quartz glass (SiO_2)

(iii) Chrome alum

(iv) Silicon carbide (SiC)

4. Which of the following arrangements shows schematic alignment of magnetic moments of antiferromagnetic substances?

(i) 

(ii) 

(iii) 

(iv) 

5. Which of the following is true about the value of refractive index of quartz glass?

(i) Same in all directions

(ii) Different in different directions

(iii) Cannot be measured

(iv) Always zero

6. Which of the following statement is **not** true about amorphous solids?

(i) On heating they may become crystalline at certain temperature.

(ii) They may become crystalline on keeping for long time.

(iii) Amorphous solids can be moulded by heating.

(iv) They are anisotropic in nature.

7. The sharp melting point of crystalline solids is due to _____.

(i) a regular arrangement of constituent particles observed over a short distance in the crystal lattice.

(ii) a regular arrangement of constituent particles observed over a long distance in the crystal lattice.

(iii) same arrangement of constituent particles in different directions.

(iv) different arrangement of constituent particles in different directions.

8. Iodine molecules are held in the crystals lattice by _____.

(i) london forces

(ii) dipole-dipole interactions

(iii) covalent bonds

(iv) coulombic forces

9. Which of the following is a network solid?

(i) SO_2 (Solid)

(ii) I_2

(iii) Diamond

(iv) H_2O (Ice)

10. Which of the following solids is **not** an electrical conductor?

(A) Mg (s) (B) TiO (s) (C) I_2 (s) (D) H_2O (s)

(i) (A) only

(ii) (B) Only

(iii) (C) and (D)

(iv) (B), (C) and (D)

11. Which of the following is **not** the characteristic of ionic solids?

(i) Very low value of electrical conductivity in the molten state.

(ii) Brittle nature.

(iii) Very strong forces of interactions.

(iv) Anisotropic nature.

12. Graphite is a good conductor of electricity due to the presence of _____.

(i) lone pair of electrons

(ii) free valence electrons

(iii) cations

(iv) anions

13. Which of the following oxides behaves as conductor or insulator depending upon temperature?

(i) TiO

(ii) SiO_2

(iii) TiO_3

(iv) MgO

14. Which of the following oxides shows electrical properties like metals?

(i) SiO_2

(ii) MgO

(iii) SO_2(s)

(iv) CrO_2

15. The lattice site in a pure crystal **cannot** be occupied by _____.

(i) molecule

(ii) ion

(iii) electron

(iv) atom

16. Graphite **cannot** be classified as _____.

(i) conducting solid

(ii) network solid

(iii) covalent solid

(iv) ionic solid

17. Cations are present in the interstitial sites in _____.

(i) Frenkel defect

(ii) Schottky defect

(iii) Vacancy defect

(iv) Metal deficiency defect

18. Schottky defect is observed in crystals when _____.

(i) some cations move from their lattice site to interstitial sites.

(ii) equal number of cations and anions are missing from the lattice.

(iii) some lattice sites are occupied by electrons.

(iv) some impurity is present in the lattice.

19. Which of the following is true about the charge acquired by *p*-type semiconductors?

(i) positive

(ii) neutral

(iii) negative

(iv) depends on concentration of *p* impurity

20. To get *a n*-type semiconductor from silicon, it should be doped with a substance with valence_____.

(i) 2

(ii) 1

(iii) 3

(iv) 5

21. The total number of tetrahedral voids in the face centred unit cell is _____.

(i) 6

(ii) 8

(iii) 10

(iv) 12

22. Which of the following point defects are shown by AgBr(s) crystals?

(A) Schottky defect (B) Frenkel defect

(C) Metal excess defect (D) Metal deficiency defect

(i) (A) and (B)

(ii) (C) and (D)

(iii) (A) and (C)

(iv) (B) and (D)

23. In which pair most efficient packing is present?

(i) *hcp* and *bcc*

(ii) *hcp* and *ccp*

(iii) *bcc* and *ccp*

(iv) *bcc* and simple cubic cell

24. The percentage of empty space in a body centred cubic arrangement is _____.

(i) 74

(ii) 68

(iii) 32

(iv) 26

25. Which of the following statement is **not** true about the hexagonal close packing?

(i) The coordination number is 12.

(ii) It has 74% packing efficiency.

(iii) Tetrahedral voids of the second layer are covered by the spheres of the third layer.

(iv) In this arrangement spheres of the fourth layer are exactly aligned with those of the first layer.

26. In which of the following structures coordination number for cations and anions in the packed structure will be same?

(i) Cl^- ion form *fcc* lattice and Na^+ ions occupy all octahedral voids of the unit cell.

(ii) Ca^{2+} ions form *fcc* lattice and F^- ions occupy all the eight tetrahedral voids of the unit cell.

(iii) O^{2-} ions form *fcc* lattice and Na^+ ions occupy all the eight tetrahedral voids of the unit cell.

(iv) S^{2-} ions form *fcc* lattice and Zn^{2+} ions go into alternate tetrahedral voids of the unit cell.

27. What is the coordination number in a square close packed structure in two dimensions?

(i) 2

(ii) 3

(iii) 4

(iv) 6

28. Which kind of defects are introduced by doping?

(i) Dislocation defect

(ii) Schottky defect

(iii) Frenkel defects

(iv) Electronic defects

29. Silicon doped with electron-rich impurity forms _____.

(i) *p*-type semiconductor

(ii) *n*-type semiconductor

(iii) intrinsic semiconductor

(iv) insulator

30. Which of the following statements is **not** true?

(i) Paramagnetic substances are weakly attracted by magnetic field.

(ii) Ferromagnetic substances cannot be magnetised permanently.

(iii) The domains in antiferromagnetic substances are oppositely oriented with respect to each other.

(iv) Pairing of electrons cancels their magnetic moment in the diamagnetic substances.

31. Which of the following is **not** true about the ionic solids?

(i) Bigger ions form the close packed structure.

(ii) Smaller ions occupy either the tetrahedral or the octahedral voids depending upon their size.

(iii) Occupation of all the voids is not necessary.

(iv) The fraction of octahedral or tetrahedral voids occupied depends upon the radii of the ions occupying the voids.

32. A ferromagnetic substance becomes a permanent magnet when it is placed in a magnetic field becuase _____.

(i) all the domains get oriented in the direction of magnetic field.

(ii) all the domains get oriented in the direction opposite to the direction of magnetic field.

(iii) domains get oriented randomly.

(iv) domains are not affected by magnetic field.

33. The correct order of the packing efficiency in different types of unit cells is _____.

(i) *fcc* < *bcc* < simple cubic

(ii) *fcc* > *bcc* > simple cubic

(iii) *fcc* < *bcc* > simple cubic

(iv) *bcc* < *fcc* > simple cubic

34. Which of the following defects is also known as dislocation defect?

(i) Frenkel defect

(ii) Schottky defect

(iii) Non-stoichiometric defect

(iv) Simple interstitial defect

35. In the cubic close packing, the unit cell has _____.

(i) 4 tetrahedral voids each of which is shared by four adjacent unit cells.

(ii) 4 tetrahedral voids within the unit cell.

(iii) 8 tetrahedral voids each of the which is shared by four adjacent unit cells.

(iv) 8 tetrahedral voids within the unit cells.

36. The edge lengths of the unit cells in terms of the radius of spheres constituting *fcc*, *bcc* and simple cubic unit cell are respectively_____.

(i) $2\sqrt{2}r, \frac{4r}{\sqrt{3}}, 2r$

(ii) $\frac{4r}{\sqrt{3}}, 2\sqrt{2}r, 2r$

(iii) $2r, 2\sqrt{2}r, \frac{4r}{\sqrt{3}}$

(iv) $2r, \frac{4r}{\sqrt{3}}, 2\sqrt{2}r$

37. Which of the following represents correct order of conductivity in solids?

(i) $\kappa_{\text{metals}} >> \kappa_{\text{insulators}} < \kappa_{\text{semiconductors}}$

(ii) $\kappa_{\text{metals}} << \kappa_{\text{insulators}} < \kappa_{\text{semiconductors}}$

(iii) $\kappa_{\text{metals}} \approx \kappa_{\text{semiconductors}} > \kappa_{\text{insulators}} = \text{zero}$

(iv) $\kappa_{\text{metals}} < \kappa_{\text{semiconductors}} > \kappa_{\text{insulators}} \neq \text{zero}$

II. Multiple Choice Questions (Type-II)

Note : In the following questions two or more options may be correct.

38. Which of the following is **not** true about the voids formed in 3 dimensional hexagonal close packed structure?

(i) A tetrahedral void is formed when a sphere of the second layer is present above triangular void in the first layer.

(ii) All the triangular voids are not covered by the spheres of the second layer.

(iii) Tetrahedral voids are formed when the triangular voids in the second layer lie above the triangular voids in the first layer and the triangular shapes of these voids do not overlap.

(iv) Octahedral voids are formed when the triangular voids in the second layer exactly overlap with similar voids in the first layer.

39. The value of magnetic moment is zero in the case of antiferromagnetic substances because the domains _____.

(i) get oriented in the direction of the applied magnetic field.

(ii) get oriented opposite to the direction of the applied magnetic field.

(iii) are oppositely oriented with respect to each other without the application of magnetic field.

(iv) cancel out each other's magnetic moment.

40. Which of the following statements are **not** true?

(i) Vacancy defect results in a decrease in the density of the substance.

(ii) Interstitial defects results in an increase in the density of the substance.

(iii) Impurity defect has no effect on the density of the substance.

(iv) Frankel defect results in an increase in the density of the substance.

41. Which of the following statements are true about metals?

(i) Valence band overlaps with conduction band.

(ii) The gap between valence band and conduction band is negligible.

(iii) The gap between valence band and conduction band cannot be determined.

(iv) Valence band may remain partially filled.

42. Under the influence of electric field, which of the following statements is true about the movement of electrons and holes in a *p*-type semi conductor?

(i) Electron will move towards the positvely charged plate through electron holes.

(ii) Holes will appear to be moving towards the negatively charged plate.

(iii) Both electrons and holes appear to move towards the positively charged plate.

(iv) Movement of electrons is not related to the movement of holes.

43. Which of the following statements are true about semiconductors?

(i) Silicon doped with electron rich impurity is a *p*-type semiconductor.

(ii) Silicon doped with an electron rich impurity is an *n*-type semiconductor.

(iii) Delocalised electrons increase the conductivity of doped silicon.

(iv) An electron vacancy increases the conductivity of *n*-type semiconductor.

44. An excess of potassium ions makes KCl crystals appear violet or lilac in colour since _____.

(i) some of the anionic sites are occupied by an unpaired electron.

(ii) some of the anionic sites are occupied by a pair of electrons.

(iii) there are vacancies at some anionic sites.

(iv) F-centres are created which impart colour to the crystals.

45. The number of tetrahedral voids per unit cell in NaCl crystal is _____.

(i) 4

(ii) 8

(iii) twice the number of octahedral voids.

(iv) four times the number of octahedral voids.

46. Amorphous solid can also be called _____.

(i) pseudo solids

(ii) true solids

(iii) super cooled liquids

(iv) super cooled solids

47. A perfect crystal of silicon (Fig. 1.1) is doped with some elements as given in the options. Which of these options show *n*-type semiconductors?

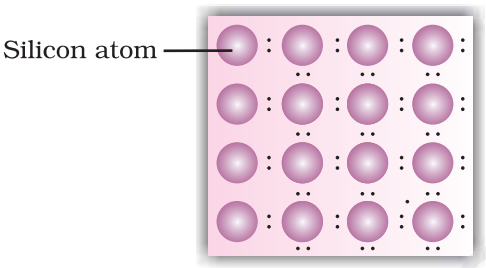
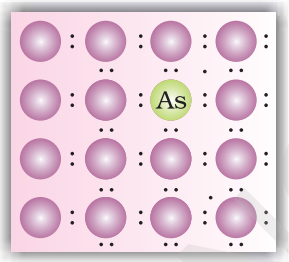
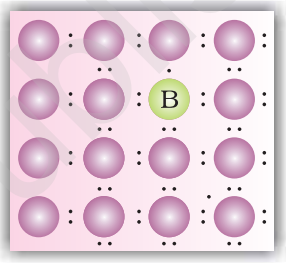


Fig. 1.1 Pure crystal

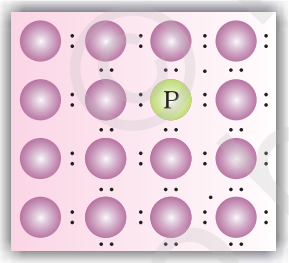
(i)



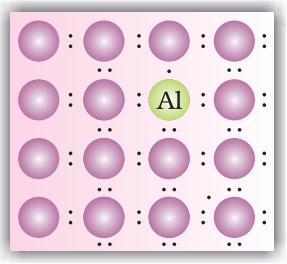
(ii)



(iii)



(iv)



48. Which of the following statements are correct?

(i) Ferrimagnetic substances lose ferrimagnetism on heating and become paramagnetic.

(ii) Ferrimagnetic substances do not lose ferrimagnetism on heating and remain ferrimagnetic.

(iii) Antiferromagnetic substances have domain structures similar to ferromagnetic substances and their magnetic moments are not cancelled by each other.

(iv) In ferromagnetic substances all the domains get oriented in the direction of magnetic field and remain as such even after removing magnetic field.

49. Which of the following features are **not** shown by quartz glass?

(i) This is a crystalline solid.

(ii) Refractive index is same in all the directions.

(iii) This has definite heat of fusion.

(iv) This is also called super cooled liquid.

50. Which of the following **cannot** be regarded as molecular solid?

(i) SiC (Silicon carbide)

(ii) AlN

(iii) Diamond

(iv) I_2

51. In which of the following arrangements octahedral voids are formed?

(i) *hcp*

(ii) *bcc*

(iii) simple cubic

(iv) *fcc*

52. Frenkel defect is also known as _____.

(i) stoichiometric defect

(ii) dislocation defect

(iii) impurity defect

(iv) non-stoichometric defect

53. Which of the following defects decrease the density?

(i) Interstitial defect

(ii) Vacancy defect

(iii) Frankel defect

(iv) Schottky defect

III. Short Answer Type

54. Why are liquids and gases categorised as fluids?

55. Why are solids incompressible?

56. Inspite of long range order in the arrangement of particles why are the crystals usually not perfect?

57. Why does table salt, NaCl, some times appear yellow in colour?

58. Why is FeO (s) not formed in stoichiometric composition?

59. Why does white ZnO (s) becomes yellow upon heating?

60. Why does the electrical conductivity of semiconductors increase with rise in temperature?

61. Explain why does conductivity of germanium crystals increase on doping with galium.

62. In a compound, nitrogen atoms (N) make cubic close packed lattice and metal atoms (M) occupy one-third of the tetrahedral voids present. Determine the formula of the compound formed by M and N?

63. Under which situations can an amorphous substance change to crystalline form?

IV. Matching Type

Note : In the following questions match the items given in Column I with the items given in Column II. In some questions more than one item of Column I and Column II may match.

64. Match the defects given in Column I with the statements in given Column II.

Column I	Column II
(i) Simple vacancy defect	(a) shown by non-ionic solids and increases density of the solid.
(ii) Simple interstitial defect	(b) shown by ionic solids and decreases density of the solid.
(iii) Frenkel defect	(c) shown by non ionic solids and density of the solid decreases
(iv) Schottky defect	(d) shown by ionic solids and density of the solid remains the same.

65. Match the type of unit cell given in Column I with the features given in Column II.

Column I	Column II
(i) Primitive cubic unit cell	(a) Each of the three perpendicular edges compulsorily have the different edge length i.e; $a \neq b \neq c$.
(ii) Body centred cubic unit cell	(b) Number of atoms per unit cell is one.
(iii) Face centred cubic unit cell	(c) Each of the three perpendicular edges compulsorily have the same edge length i.e; $a = b = c$
(iv) End centred orthorhombic unit cell	(d) In addition to the contribution from the corner atoms the number of atoms present in a unit cell is one.
	(e) In addition to the contribution from the corner atoms the number of atoms present in a unit cell is three.

66. Match the types of defect given in Column I with the statement given in Column II.

	Column I		Column II
(i)	Impurity defect	(a)	NaCl with anionic sites called F-centres
(ii)	Metal excess defect	(b)	FeO with Fe^{3+}
(iii)	Metal deficiency defect	(c)	NaCl with Sr^{2+} and some cationic sites vacant

67. Match the items given in Column I with the items given in Column II.

	Column I		Column II
(i)	Mg in solid state	(a)	*p*-Type semiconductor
(ii)	$MgCl_2$ in molten state	(b)	*n*-Type semiconductor
(iii)	Silicon with phosphorus	(c)	Electrolytic conductors
(iv)	Germanium with boron	(d)	Electronic conductors

68. Match the type of packing given in Column I with the items given in Column II.

	Column I		Column II
(i)	Square close packing in two dimensions	(a)	Triangular voids
(ii)	Hexagonal close packing in two dimensions	(b)	Pattern of spheres is repeated in every fourth layer
(iii)	Hexagonal close packing in three dimensions	(c)	Coordination number 4
(iv)	Cubic close packing in three dimensions	(d)	Pattern of sphere is repeated in alternate layers

V. Assertion and Reason Type

Note : In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(i) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(ii) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(iii) Assertion is correct statement but reason is wrong statement.
(iv) Assertion is wrong statement but reason is correct statement.

69. **Assertion** : The total number of atoms present in a simple cubic unit cell is one.
Reason : Simple cubic unit cell has atoms at its corners, each of which is shared between eight adjacent unit cells.

70. **Assertion** : Graphite is a good conductor of electricity however diamond belongs to the category of insulators.
Reason : Graphite is soft in nature on the other hand diamond is very hard and brittle.

71. **Assertion** : Total number of octahedral voids present in unit cell of cubic close packing including the one that is present at the body centre, is four.
Reason : Besides the body centre there is one octahedral void present at the centre of each of the six faces of the unit cell and each of which is shared between two adjacent unit cells.

72. **Assertion** : The packing efficiency is maximum for the *fcc* structure.
Reason : The cordination number is 12 in *fcc* structures.

73. **Assertion** : Semiconductors are solids with conductivities in the intermediate range from $10^{-6} - 10^{4}$ $ohm^{-1}m^{-1}$.
Reason : Intermediate conductivity in semiconductor is due to partially filled valence band.

VI. Long Answer Type

74. With the help of a labelled diagram show that there are four octahedral voids per unit cell in a cubic close packed structure.

75. Show that in a cubic close packed structure, eight tetrahedral voids are present per unit cell.

76. How does the doping increase the conductivity of semiconductors?

77. A sample of ferrous oxide has actual formula $Fe_{0.93}O_{1.00}$. In this sample what fraction of metal ions are Fe^{2+} ions? What type of nonstoichiometric defect is present in this sample?

ANSWERS

I. Multiple Choice Questions (Type-I)

1. (ii)	2. (ii)	3. (ii)	4. (iv)	5. (i)	6. (iv)
7. (ii)	8. (i)	9. (iii)	10. (iii)	11. (i)	12. (ii)
13. (iii)	14. (iv)	15. (iii)	16. (iv)	17. (i)	18. (ii)
19. (ii)	20. (iv)	21. (ii)	22. (i)	23. (ii)	24. (iii)
25. (iv)	26. (i)	27. (iii)	28. (iv)	29. (ii)	30. (ii)
31. (iv)	32. (i)	33. (ii)	34. (i)	35. (iv)	36. (i)
37. (i)					

II. Multiple Choice Questions (Type-II)

38. (iii), (iv)	39. (iii), (iv)	40. (iii), (iv)	41. (i), (ii), (iv)
42. (i), (ii)	43. (ii), (iii)	44. (i), (iv)	45. (ii), (iii)
46. (i), (iii)	47. (i), (iii)	48. (i), (iv)	49. (i), (iii)
50. (i), (ii), (iii)	51. (i), (iv)	52. (i), (ii)	53. (ii), (iv)

III. Short Answer Type

54. The liquids and gases have a property to flow i.e. the molecules can move past and tumble over one another freely. Hence, they have been categorised as fluids.

55. The distance between the constituent particles (atoms, ions, molecules etc.) is very less in solids. On bringing them still closer repulsion will start between electron clouds of these particles. Hence, they cannot be brought further close to each other.

56. Crystals have long range repeated pattern of arrangement of constitutent particles but in the process of crystallisation some deviations from the ideal arrangement (i.e. defects) may be introduced, therefore, crystals are usually not perfect.

57. Yellow colour in sodium chloride is due to metal excess defect due to which unpaired electrons occupy anionic sites. These sites are called F-centres. These electrons absorb energy from the visible region for the excitation which makes crystal appear yellow.

58. In the crystals of FeO, some of the Fe^{2+} cations are replaced by Fe^{3+} ions. Three Fe^{2+} ions are replaced by two Fe^{3+} ions to make up for the loss of positive charge. Eventually there would be less amount of metal as compared to stoichiometric proportion.

59. On heating ZnO loses oxygen according to the following reaction.

$$ZnO \xrightarrow{\text{heating}} Zn^{2+} + \frac{1}{2}O_2 + 2e^-$$

Zn^{2+} ions and electrons move to interstitial sites and F-centres are created which impart yellow colour to ZnO(s).

60. The gap between conduction band and valence band is small in semiconductors (Fig. 1.1), therefore, electrons from the valence band can jump to the conduction band on increasing temperature. Thus they become more conducting as the temperature increases.

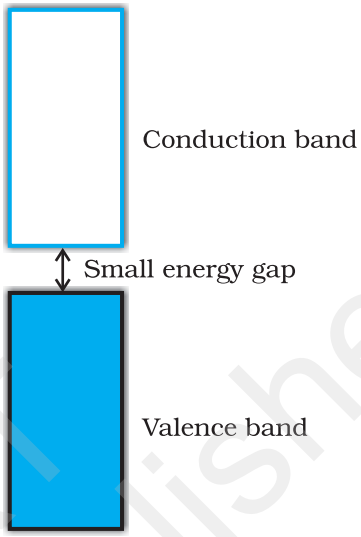


Fig. 1.2 : Semi conductor

61. On doping germanium with galium some of the positions of lattice of germanium are occupied by galium. Galium atom has only three valence electrons. Therefore, fourth valency of nearby germanium atom is not satisfied. The place remains vacant. This place is deficient of electrons and is therefore called electron hole or electron vacancy. Electron from neighbouring atom comes and fills the gap, thereby creating a hole in its original position. Under the influence of electric field electrons move towards positively charged plates through these holes and conduct electricity. The holes appear to move towards negatively charged plates.

62. M_2N_3

63. See page no. 3 of NCERT textbook for Class XII.

IV. Matching Type

64. (i) → (c) (ii) → (a) (iii) → (d) (iv) → (b)

65. (i) → (b), (c) (ii) → (c), (d) (iii) → (c), (e) (iv) → (a), (d)

66. (i) → (c) (ii) → (a) (iii) → (b)

67. (i) → (d) (ii) → (c) (iii) → (b) (iv) → (a)

68. (i) → (c) (ii) → (a) (iii) → (d) (iv) → (b)

V. Assertion and Reason Type

69. (i) 70. (ii) 71. (iii) 72. (ii) 73. (iii)

VI. Long Answer Type

74. [**Hint :** Draw structure and discuss]

75. [**Hint :**Draw structure and discuss]

76. See page no. 26 of NCERT textbook for Class XII.

77. Let the formula of sample be

$(Fe^{2+})_x (Fe^{3+})_y O$.

On looking at the given formula of the compound

$x + y = 0.93$ ... (1)

Total positive charge on ferrous and ferric ions should balance the two units of negative charge on oxygen. Therefore,

$2x + 3y = 2$ ... (2)

$\Rightarrow \quad x + \frac{3}{2}y = 1$ ... (3)

On subtracting equation (1) from equation (3) we have

$$\frac{3}{2}y - y = 1 - 0.93$$

$$\Rightarrow \quad \frac{1}{2}y = 0.07$$

$$\Rightarrow \quad y = 0.14$$

On putting the value of y in equation (1) we get,

$x + 0.14 = 0.93$

$\Rightarrow \quad x = 0.93 - 0.14$

$x = 0.79$

Fraction of Fe^{2+} ions present in the sample = $\frac{0.79}{0.93} = 0.81$

Metal deficiency defect is present in the sample because iron is less in amount than that required for stoichiometric composition.