CHAPTER 2

States of Matter

1. Which type of 'defect' has the presence of cations in the interstitial sites?
(a) Schottky defect (b) Vacancy defect
(c) Frenkel defect (d) Metal deficiency defect
(2018)

2. Which of the following arrangements shows the schematic alignment of magnetic moments of antiferromagnetic substance?
(a) ↑ ↓ ↓ ↓ ↓ ↑
(b) ↑ ↑ ↑ ↑ ↑ ↑
(c) ↑ ↑ ↓ ↑ ↑ ↓
(d) ↑ ↓ ↑ ↓ ↑ ↓ *(Online 2018)*

3. All of the following share the same crystal structure except
(a) RbCl (b) CsCl (c) LiCl (d) NaCl
(Online 2018)

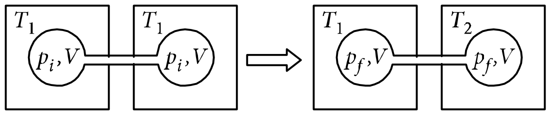
4. Assuming ideal gas behaviour, the ratio of density of ammonia to that of hydrogen chloride at same temperature and pressure is
(Atomic wt. of Cl = 35.5 u)
(a) 0.64 (b) 1.64 (c) 1.46 (d) 0.46
(Online 2018)

5. A metal crystallises in a face centred cubic structure. If the edge length of its unit cell is '*a*', the closest approach between two atoms in metallic crystal will be
(a) $\sqrt{2}a$ (b) $\frac{a}{\sqrt{2}}$ (c) $2a$ (d) $2\sqrt{2}a$
(2017)

6. Among the following, the incorrect statement is
(a) at very large volume, real gases show ideal behaviour
(b) at very low temperature, real gases show ideal behaviour
(c) at Boyle's temperature, real gases show ideal behaviour
(d) at low pressure, real gases show ideal behaviour.
(Online 2017)

7. At 300 K, the density of a certain gaseous molecule at 2 bar is double to that of dinitrogen (N_2) at 4 bar. The molar mass of gaseous molecule is
(a) 56 g mol^{-1} (b) 112 g mol^{-1}
(c) 224 g mol^{-1} (d) 28 g mol^{-1}
(Online 2017)

8. Two closed bulbs of equal volume (V) containing an ideal gas initially at pressure p_i and temperature T_1 are connected through a narrow tube of negligible volume as shown in the figure below. The temperature of one of the bulbs is then raised to T_2. The final pressure p_f is



(a) $\left(\frac{q_6 q_7}{q_6+q_7}\right)$ (b) $7\left(\frac{q_6}{q_6+q_7}\right)$
(c) $7\left(\frac{q_7}{q_6+q_7}\right)$ (d) $7\left(\frac{q_6 q_7}{q_6+q_7}\right)$ *(2016)*

9. Which of the following compounds is metallic and ferromagnetic?
(a) TiO_2 (b) CrO_2 (c) VO_2 (d) MnO_2
(2016)

10. At very high pressures, the compressibility factor of one mole of a gas is given by
(a) $1+\frac{Pb}{RT}$ (b) $\frac{Pb}{RT}$
(c) $1-\frac{Pb}{RT}$ (d) $1-\frac{b}{(VRT)}$ *(Online 2016)*

11. Which intermolecular force is most responsible in allowing xenon gas to liquefy?
(a) Instantaneous dipole-induced dipole
(b) Ion-dipole
(c) Ionic
(d) Dipole-dipole *(Online 2016)*

12. Initially, the root mean square (*rms*) velocity of N_2 molecules at certain temperature is u. If this temperature is doubled and all the nitrogen molecules dissociate into nitrogen atoms, then the new *rms* velocity will be
(a) $2u$ (b) $14u$ (c) $4u$ (d) $\frac{u}{2}$
(Online 2016)

13. Sodium metal crystallizes in a body centred cubic lattice with a unit cell edge of 4.29 Å. The radius of sodium atom is approximately
(a) 5.72 Å (b) 0.93 Å (c) 1.86 Å (d) 3.22 Å
(2015)

14. Which of the following is not an assumption of the kinetic theory of gases?
(a) A gas consists of many identical particles which are in continual motion.
(b) Gas particles have negligible volume.
(c) At high pressure, gas particles are difficult to compress.
(d) Collisions of gas particles are perfectly elastic.
(Online 2015)

15. When does a gas deviate the most from its ideal behaviour?
(a) At low pressure and low temperature
(b) At low pressure and high temperature
(c) At high pressure and low temperature
(d) At high pressure and high temperature
(Online 2015)

16. If Z is a compressibility factor, van der Waals equation at low pressure can be written as
(a) $Z = 1 + \frac{Pb}{RT}$ (b) $Z = 1 + \frac{RT}{Pb}$
(c) $Z = 1 - \frac{a}{VRT}$ (d) $Z = 1 - \frac{Pb}{RT}$ *(2014)*

17. CsCl crystallises in body-centred cubic lattice. If 'a' is its edge length then which of the following expressions is correct?
(a) $r_{Cs^+} + r_{Cl^-} = \sqrt{3}a$ (b) $r_{Cs^+} + r_{Cl^-} = 3a$
(c) $r_{Cs^+} + r_{Cl^-} = \frac{3a}{2}$ (d) $r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}}{2}a$ *(2014)*

18. Experimentally it was found that a metal oxide has formula $M_{0.98}O$. Metal M, is present as M^{2+} and M^{3+} in its oxide. Fraction of the metal which exists as M^{3+} would be
(a) 5.08% (b) 7.01%
(c) 4.08% (d) 6.05% *(2013)*

19. For gaseous state, if most probable speed is denoted by C^*, average speed by $\bar{C}$ and mean square speed by C, then for a large number of molecules the ratios of these speed are
(a) $C^* : \bar{C} : C = 1 : 1.225 : 1.128$
(b) $C^* : \bar{C} : C = 1.225 : 1.128 : 1$
(c) $C^* : \bar{C} : C = 1.128 : 1 : 1.225$
(d) $C^* : \bar{C} : C = 1 : 1.128 : 1.225$ *(2013)*

20. Lithium forms body centred cubic structure. The length of the side of its unit cell is 351 pm. Atomic radius of the lithium will be
(a) 300 pm (b) 240 pm
(c) 152 pm (d) 75 pm *(2012)*

21. The compressibility factor for a real gas at high pressure is
(a) 1 (b) $1 + Pb/RT$
(c) $1 - Pb/RT$ (d) $1 + RT/Pb$ *(2012)*

22. In a face centred cubic lattice, atom A occupies the corner positions and atom B occupies the face centre positions. If one atom of B is missing from one of the face centred points, the formula of the compound is
(a) A_2B (b) AB_2
(c) A_2B_3 (d) A_2B_5 *(2011)*

23. 'a' and 'b' are van der Waals' constants for gases. Chlorine is more easily liquefied than ethane because
(a) a and b for Cl_2 > a and b for C_2H_6
(b) a and b for Cl_2 < a and b for C_2H_6
(c) a for Cl_2 < a for C_2H_6 but b for Cl_2 > b for C_2H_6
(d) a for Cl_2 > a for C_2H_6 but b for Cl_2 < b for C_2H_6
(2011)

24. The edge length of a face centred cubic cell of an ionic substance is 508 pm. If the radius of the cation is 110 pm, the radius of the anion is
(a) 144 pm (b) 288 pm
(c) 398 pm (d) 618 pm *(2010)*

25. If 10^{-4} dm^3 of water is introduced into a 1.0 dm^3 flask at 300 K, how many moles of water are in the vapour phase when equilibrium is established?
(Given : Vapour pressure of H_2O at 300 K is 3170 Pa; $R = 8.314$ J K^{-1} mol^{-1})
(a) 1.27×10^{-3} mol (b) 5.56×10^{-3} mol
(c) 1.53×10^{-2} mol (d) 4.46×10^{-2} mol *(2010)*

26. Percentages of free space in cubic close packed structure and in body centred packed structure are respectively
(a) 48% and 26% (b) 30% and 26%
(c) 26% and 32% (d) 32% and 48% *(2010)*

27. Copper crystallizes in *fcc* with a unit cell length of 361 pm. What is the radius of copper atom?
(a) 108 pm (b) 127 pm
(c) 157 pm (d) 181 pm *(2009)*

28. In a compound, atoms of element Y form *ccp* lattice and those of element X occupy 2/3rd of tetrahedral voids. The formula of the compound will be
(a) X_3Y_4 (b) X_4Y_3
(c) X_2Y_3 (d) X_2Y *(2008)*

29. Equal masses of methane and oxygen are mixed in an empty container at 25°C. The fraction of the total pressure exerted by oxygen is
(a) 1/2 (b) 2/3
(c) $\frac{1}{3} \times \frac{273}{298}$ (d) 1/3 *(2007)*

30. Total volume of atoms present in a face-centred cubic unit cell of a metal is (r is atomic radius)
(a) $\frac{20}{3}\pi r^3$ (b) $\frac{24}{3}\pi r^3$
(c) $\frac{12}{3}\pi r^3$ (d) $\frac{16}{3}\pi r^3$ *(2006)*

31. Which one of the following statements is not true about the effect of an increase in temperature on the distribution of molecular speeds in a gas?
(a) The most probable speed increases.
(b) The fraction of the molecules with the most probable speed increases.
(c) The distribution becomes broader.
(d) The area under the distribution curve remains the same as under the lower temperature.
(2005)

32. An ionic compound has a unit cell consisting of A ions at the corners of a cube and B ions on the centres of the faces of the cube. The empirical formula for this compound would be
(a) AB (b) A_2B
(c) AB_3 (d) A_3B *(2005)*

33. What type of crystal defect is indicated in the diagram below?
Na^+ Cl^- Na^+ Cl^- Na^+ Cl^-
Cl^- □ Cl^- Na^+ □ Na^+
Na^+ Cl^- □ Cl^- Na^+ Cl^-
Cl^- Na^+ Cl^- Na^+ □ Na^+
(a) Frenkel defect
(b) Schottky defect
(c) Interstitial defect
(d) Frenkel and Schottky defects *(2004)*

34. In van der Waals equation of state of the gas law, the constant b is a measure of
(a) intermolecular repulsions
(b) intermolecular attraction
(c) volume occupied by the molecules
(d) intermolecular collisions per unit volume. *(2004)*

35. As the temperature is raised from 20°C to 40°C, the average kinetic energy of neon atoms changes by a factor of which of the following?
(a) 1/2 (b) $\sqrt{313/293}$
(c) 313/293 (d) 2 *(2004)*

36. A pressure cooker reduces cooking time for food because
(a) heat is more evenly distributed in the cooking space
(b) boiling point of water involved in cooking is increased
(c) the higher pressure inside the cooker crushes the food material
(d) cooking involves chemical changes helped by a rise in temperature. *(2003)*

37. According to the kinetic theory of gases, in an ideal gas, between two successive collisions a gas molecule travels
(a) in a circular path
(b) in a wavy path
(c) in a straight line path
(d) with an accelerated velocity. *(2003)*

38. How many unit cells are present in a cube-shaped ideal crystal of NaCl of mass 1.00 g?
[Atomic masses : Na = 23, Cl = 35.5]
(a) 2.57×10^{21} (b) 5.14×10^{21}
(c) 1.28×10^{21} (d) 1.71×10^{21}
(2003)

39. Na and Mg crystallize in *bcc* and *fcc* type crystals respectively, then the number of atoms of Na and Mg present in the unit cell of their respective crystal is
(a) 4 and 2 (b) 9 and 14
(c) 14 and 9 (d) 2 and 4 *(2002)*

40. For an ideal gas, number of moles per litre in terms of its pressure P, gas constant R and temperature T is
(a) PT/R (b) PRT
(c) P/RT (d) RT/P *(2002)*

41. Kinetic theory of gases proves
(a) only Boyle's law (b) only Charles' law
(c) only Avogadro's law (d) all of these. *(2002)*

42. Value of gas constant R is
(a) 0.082 L atm (b) 0.987 cal mol^{-1} K^{-1}
(c) 8.3 J mol^{-1} K^{-1} (d) 83 erg mol^{-1} K^{-1} *(2002)*

ANSWER KEY

1. (c)	**2.** (d)	**3.** (b)	**4.** (d)	**5.** (b)	**6.** (b)	**7.** (b)	**8.** (c)	**9.** (b)	**10.** (a)	**11.** (a)	**12.** (a)
13. (c)	**14.** (c)	**15.** (c)	**16.** (c)	**17.** (d)	**18.** (c)	**19.** (d)	**20.** (c)	**21.** (b)	**22.** (d)	**23.** (d)	**24.** (a)
25. (a)	**26.** (c)	**27.** (b)	**28.** (b)	**29.** (d)	**30.** (d)	**31.** (b)	**32.** (c)	**33.** (b)	**34.** (c)	**35.** (c)	**36.** (b)
37. (c)	**38.** (a)	**39.** (d)	**40.** (c)	**41.** (d)	**42.** (c)						

Explanations

1. (c) : In Frenkel defect, an ion is displaced from its regular position to an interstitial position creating a vacancy or hole.

2. (d) : In antiferromagnetic substances, the magnetic dipoles are oppositely oriented and cancel out each other's magnetic moment.

3. (b) : RbCl, LiCl and NaCl have *fcc* arrangement whereas, CsCl has *bcc* arrangement.

4. (d) : For an ideal gas, $d = \frac{PM}{RT}$

Molar mass of NH_3 = 14 + 3 = 17 g mol^{-1}

Molar mass of HCl = 1 + 35.5 = 36.5 g mol^{-1}

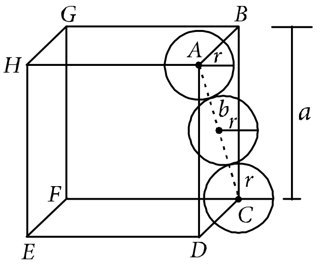
$$d_{NH_3} = \frac{P_{NH_3} M_{NH_3}}{RT_{NH_3}} \quad \text{...(i)} \qquad d_{HCl} = \frac{P_{HCl} M_{HCl}}{RT_{HCl}} \quad \text{...(ii)}$$

Dividing eqn. (i) by (ii), we get $\frac{d_{NH_3}}{d_{HCl}} = \frac{P_{NH_3} M_{NH_3}}{RT_{NH_3}} \times \frac{RT_{HCl}}{P_{HCl} M_{HCl}}$

$$= \frac{M_{NH_3}}{M_{HCl}} \qquad (\because \ T \text{ and } P \text{ are same.})$$

$$= \frac{17}{36.5} = 0.465$$

5. (b) : For *fcc*,



then $b = 4r = \sqrt{2}a$

$$a = \frac{4r}{\sqrt{2}} = 2\sqrt{2}r \Rightarrow r = \frac{a}{2\sqrt{2}}$$

Therefore, distance of closest approach $= 2r = 2 \times \frac{a}{2\sqrt{2}} = \frac{a}{\sqrt{2}}$

6. (b) : Real gases show ideal behaviour at high temperature and low pressure.

7. (b) : Density = $\frac{\text{Mass}}{\text{Volume}}$; $PV = RT$ $\left(\because V = \frac{RT}{P}\right)$

So, $d = \frac{MP}{RT}$

Now, $d_1 = x$, $P_1 = 4$, $M_1 = 28$, $d_2 = 2x$, $P_2 = 2$, $M_2 = ?$

So, $\frac{d_1}{d_2} = \frac{M_1 P_1}{RT_1} \times \frac{RT_2}{M_2 P_2} = \frac{M_1 P_1}{M_2 P_2}$ $\qquad (\because T_1 = T_2)$

$$\therefore \quad M_2 = \frac{M_1 P_1 d_2}{P_2 d_1} = \frac{2x \times 28 \times 4}{2 \times x} = 112 \text{ g mol}^{-1}$$

8. (c) : Initially, number of moles of gas in each bulb is

$$_6 = \frac{s}{o q_6} \text{ mzp } _7 = \frac{s}{o q_6}$$

After the temperature of second bulb is raised to T_2 then the number of moles of gas in both the bulbs are

$$'_6 = \frac{s}{o q_6} \text{ mzp } '_7 = \frac{s}{o q_7}$$

Now, the total number of moles of gas in both the bulbs remains same in both the cases.

$n_1 + n_2 = n_1' + n_2'$

$$\frac{7 \ s}{o q_6} = \frac{s}{o q_6} + \frac{s}{o q_7} \qquad \frac{7 \ s}{o q_6} = \frac{s}{o}\left(\frac{q_7 + q_6}{q_6 q_7}\right)$$

$$= \frac{7 \ q_7}{q_6 + q_7}$$

9. (b) : CrO_2 is metallic and ferromagnetic.

10. (a) : For 1 mole of gas, $\left(P + \frac{a}{V^2}\right)(V - b) = RT$

At very high pressure, $P >> \frac{a}{V^2}$ so, $\frac{a}{V^2}$ is negligible.

$P(V - b) = RT \Rightarrow PV - Pb = RT$

$$\therefore \quad Z = 1 + \frac{Pb}{RT}$$

11. (a) : Instantaneous dipole-induced dipole forces or loosely van der Waals' forces are responsible for the liquefaction of xenon.

12. (a) : $u_{rms} = \sqrt{\frac{3RT}{M}}$

For case I, *i.e.*, at temperature T and for N_2 molecules :

$$u = \sqrt{\frac{3RT}{28}}$$

For case II, *i.e.*, at temperature $2T$ and for N atoms :

$$u' = \sqrt{\frac{3R \times 2T}{14}}$$

$$\Rightarrow \quad \frac{u}{u'} = \sqrt{\frac{1}{4}} = \frac{1}{2} \Rightarrow u' = 2u$$

13. (c) : For *bcc*, $= \frac{\sqrt{8}}{9} a = \frac{\sqrt{8}}{9} \times 937>=63=;$ Å

14. (c)

15. (c) : At high pressure and low temperature, molecules do have a volume and also exert intermolecular attractions.

16. (c) : For 1 mole of real gas, van der Waals equation will be

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

At low pressure; 'V' is large and therefore 'b' is neglected *i.e.* $(V - b) \approx V$

then, $\left(P+\frac{a}{V^2}\right)(V)=RT$ or, $PV+\frac{a}{V}=RT$

or, $PV=RT-\frac{a}{V}$ (At low pressure, $PV > RT$)

On dividing by RT on both the sides, the above equation will be,

$\frac{PV}{RT}=1-\frac{a}{VRT}$ $\left(\therefore Z=\frac{PV}{RT}\right)$ or, $Z=1-\frac{a}{VRT}$

17. (d) : In a body-centred cubic (*bcc*) lattice, oppositely charged ions touch each other along the cross-diagonal of the cube.

In case of CsCl, $2r_{Cs^+}+2r_{Cl^-}=\sqrt{3}a$ or, $r_{Cs^+}+r_{Cl^-}=\frac{\sqrt{3}}{2}a$

18. (c) : Let the fraction of metal which exists as M^{3+} be x. Then the fraction of metal as M^{2+} = $(0.98 - x)$

$\therefore$ $3x + 2(0.98 - x) = 2 \Rightarrow x + 1.96 = 2 \Rightarrow x = 0.04$

$\therefore$ % of $M^{3+}=\frac{0.04}{0.98}\times 100$ = 4.08%

19. (d) : $C^*:\bar{C}:C=\sqrt{\frac{2RT}{M}}:\sqrt{\frac{8RT}{\pi M}}:\sqrt{\frac{3RT}{M}}=\sqrt{2}:\sqrt{\frac{8}{3.14}}:\sqrt{3}$

$\therefore$ $C^*:\bar{C}:C$ = 1 : 1.128 : 1.225

20. (c) : a = 351 pm

For *bcc* unit cell, $a\sqrt{3}=4r$

$r=\frac{a\sqrt{3}}{4}=\frac{351\times\sqrt{3}}{4}=152$ pm

21. (b) : For real gases, $\left(P+\frac{a}{V^2}\right)(V-b)=RT$

At high pressure, $P >> a/V^2$

Thus neglecting a/V^2 gives

$P(V - b) = RT$ or $PV = RT + Pb$

or $\frac{PV}{RT}=Z=\frac{RT+Pb}{RT}$ $\Rightarrow$ $Z = 1 + Pb/RT$

22. (d) : A B

$8\times\frac{1}{8}$ $5\times\frac{1}{2}$

Formula of the compound is A_2B_5.

23. (d) :

	a (dm^3 atm mol^{-2})	b(dm^3 mol^{-1})
Cl_2	6.49	0.0562
C_2H_6	5.49	0.0638

From the above values, a for Cl_2 > a for ethane (C_2H_6)

b for ethane (C_2H_6) > b for Cl_2.

24. (a) : In *fcc* lattice,

Given, a = 508 pm, r_c = 110 pm

$\therefore$ $110 + r_a=\frac{508}{2}$ $\Rightarrow$ r_a = 144 pm

25. (a) : The volume occupied by water molecules in vapour phase is $(1 - 10^{-4})$ dm^3, *i.e.*, approximately 1 dm^3.

$PV = nRT$

$3170 \times 1 \times 10^{-3} = n_{H_2O} \times 8.314 \times 300$

$n_{H_2O}=\frac{3170\times 10^{-3}}{8.314\times 300}=1.27\times 10^{-3}$ mol

26. (c) : The packing efficiency in a *ccp* structure = 74%

$\therefore$ Percentage free space = 100 – 74 = 26%

Packing efficiency in a body centred structure = 68%

Percentage free space = 100 – 68 = 32%

27. (b) : Since Cu crystallizes in *fcc* lattice,

$\therefore$ Radius of Cu atom, $r=\frac{a}{2\sqrt{2}}$ (a = edge length)

$r=\frac{361}{2\sqrt{2}}\approx 127$ pm

28. (b) : Number of Y atoms per unit cell in *ccp* lattice (N) = 4

Number of tetrahedral voids = $2N$ = 2 × 4 = 8

Number of tetrahedral voids occupied by X = 2/3 rd of the tetrahedral void = 2/3 × 8 = 16/3

Hence the formula of the compound will be $X_{16/3}Y_4 = X_4Y_3$

29. (d) : Let the mass of methane and oxygen be m g.

Mole fraction of oxygen, $x_{O_2}=\frac{\frac{m}{32}}{\frac{m}{32}+\frac{m}{16}}=\frac{m}{32}\times\frac{32}{3m}=\frac{1}{3}$

Let the total pressure be P.

$\therefore$ Partial pressure of O_2, $p_{O_2} = P \times x_{O_2} = P \times \frac{1}{3}=\frac{1}{3}P$

30. (d) : In case of a face-centred cubic structure, since four atoms are present in a unit cell, hence volume

$V=4\left(\frac{4}{3}\pi r^3\right)=\frac{16}{3}\pi r^3$

31. (b) : Most probable velocity is defined as the speed possessed by maximum number of molecules of a gas at a given temperature. According to Maxwell's distribution curves, as temperature increases, most probable velocity increases and fraction of molecule possessing most probable velocity decreases.

32. (c) : Number of A ions per unit cell = $\frac{1}{8}\times 8=1$

Number of B ions per unit cell = $\frac{1}{2}\times 6=3$

Empirical formula = AB_3

33. (b) : When an atom or ion is missing from its normal lattice site, a lattice vacancy is created. This defect is known as Schottky defect. Here equal number of Na^+ and Cl^- ions are missing from their regular lattice position in the crystal. So it is Schottky defect.

34. (c) : van der Waals constant for volume correction b is the measure of the effective volume occupied by the gas molecules.

35. (c) : K_b = 3/2 RT

$\frac{K_{40}}{K_{20}}=\frac{T_{40}}{T_{20}}=\frac{273+40}{273+20}=\frac{313}{293}$

36. (b) : According to Gay Lussac's law, at constant pressure of a given mass of a gas is directly proportional to the absolute temperature of the gas. Hence, on increasing pressure, the temperature is also increased. Thus in pressure cooker due to increase in pressure the boiling point of water involved in cooking is also increased.

37. (c) : According to the kinetic theory of gases, gas molecules are always in rapid random motion colliding with each other and with the wall of the container and between two successive collisions a gas molecule travels in a straight line path.

38. (a) : Mass (m) = density × volume = 1.00 g

Mol. wt. (M) of NaCl = 23 + 35.5 = 58.5

Number of unit cell present in a cube shaped crystal of NaCl of mass 1.00 g = $\frac{\rho \times a^3 \times N_A}{M \times Z} = \frac{m \times N_A}{M \times Z} = \frac{1 \times 6.023 \times 10^{23}}{58.5 \times 4}$

(In NaCl each unit cell has 4 NaCl units. Hence Z = 4).

∴ Number of unit cells = $0.02573 \times 10^{23} = 2.57 \times 10^{21}$ unit cells

39. (d) : *bcc* - Points are at corners and one in the centre of the unit cell.

Number of atoms per unit cell = $8 \times \frac{1}{8} + 1 = 2$

fcc - Points are at the corners and also centre of the six faces of each cell.

Number of atoms per unit cell = $8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4$

40. (c) : From ideal gas equation, $PV = nRT$

∴ $n/V = P/RT$ (number of moles = n/V)

41. (d) : Explanation of the Gas Laws on the basis of Kinetic Molecular Model

One of the postulates of kinetic theory of gases is

Average K.E. ∝ T

or, $\frac{1}{2} mnC_{rms}^2 \propto T$ or, $\frac{1}{2} mnC_{rms}^2 = kT$

Now, $PV = \frac{1}{3} mnC_{rms}^2 = \frac{2}{3} \times \frac{1}{2} mnC_{rms}^2 = \frac{2}{3} kT$

(i) Boyle's Law :

- Constant temperature means that the average kinetic energy of the gas molecules remains constant.
- This means that the rms velocity of the molecules, C_{rms} remains unchanged.
- If the rms velocity remains unchanged, but the volume increases, this means that there will be fewer collisions with the container walls over a given time.
- Therefore, the pressure will decrease

i.e. $P \propto \frac{1}{V}$ or PV = constant.

(ii) Charles' Law :

- An increase in temperature means an increase in the average kinetic energy of the gas molecules, thus an increase in C_{rms}.
- There will be more collisions per unit time, furthermore, the momentum of each collision increases (molecules strike the wall harder).
- Therefore, there will be an increase in pressure.
- If we allow the volume to change to maintain constant pressure, the volume will increase with increasing temperature (Charles' law).

(iii) Avogadro's Law :

- It states that under similar conditions of pressure and temperature, equal volume of all gases contain equal number of molecules. Considering two gases, we have

$P_1V_1 = \frac{2}{3} kT_1$ and $P_2V_2 = \frac{2}{3} kT_2$

Since $P_1 = P_2$ and $T_1 = T_2$, therefore

$$\frac{P_1V_1}{P_2V_2} = \frac{(2/3)kT_1}{(2/3)kT_2} \Rightarrow \frac{V_1}{V_2} = \frac{n_1}{n_2}$$

- If volumes are identical, obviously $n_1 = n_2$.

42. (c) : Units of R :

(i) in L atm ⇒ 0.082 L atm mol^{-1} K^{-1}

(ii) in C.G.S. system ⇒ 8.314×10^7 erg mol^{-1} K^{-1}

(iii) in M.K.S. system ⇒ 8.314 J mol^{-1} K^{-1}

(iv) in calories ⇒ 1.987 cal mol^{-1} K^{-1}