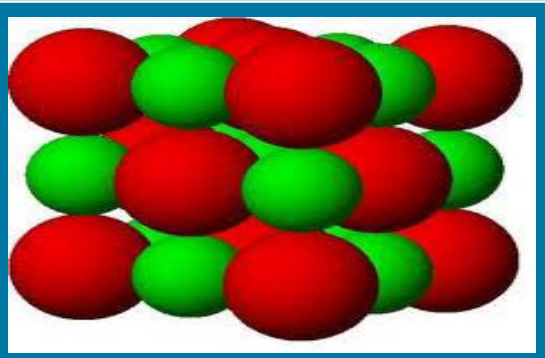
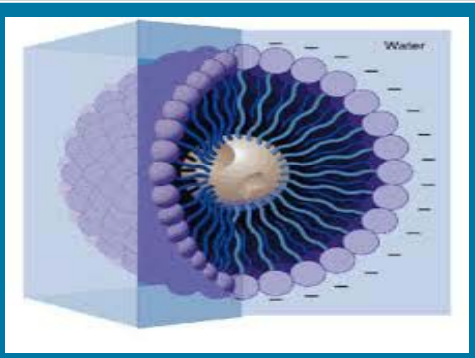
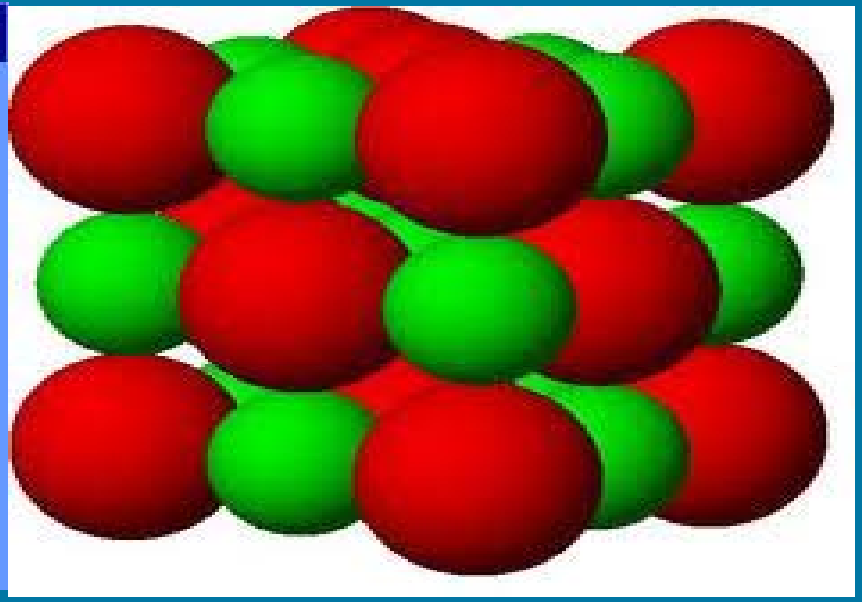
SOLIDS, COLLOIDS AND THEORY OF DILUTE SOLUTIONS







SOLIDS

TOPICS STUDIED IN SOLIDS.

1. Characteristics of solids.

Types of solids :

Crystalline and Amorphous solids

Types of crystalline solids.

a) Ionic crystals

b)Covalent (network) crystals

c) Molecular crystals

d) Metallic crystals

2. Definitions:

lattice point,

space lattice,

unit cell and

co-ordination number etc.

3. Crystal system (cubic),
   Simple ,BCC & FCC.
   Calculation of number of particles/unit cell.
   Ionic crystal :
   Radius ratio its relation to co-ordination number and geometry of crystal etc.
4. Structure of NaCl & CsCl crystal

1. Which among the following will show anisotropy?
   1. Glass
   2. Barium chloride
   3. Wood
   4. Paper.

AMORPHOUS SOLIDS

Glass

Wood

Paper

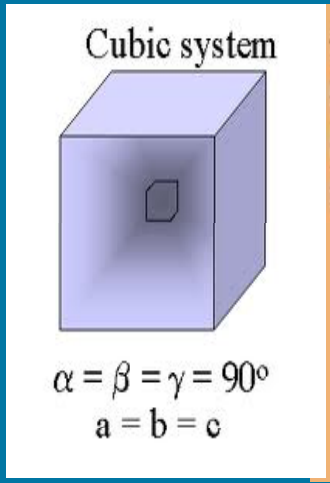
CRYSTALLINE SOLIDS

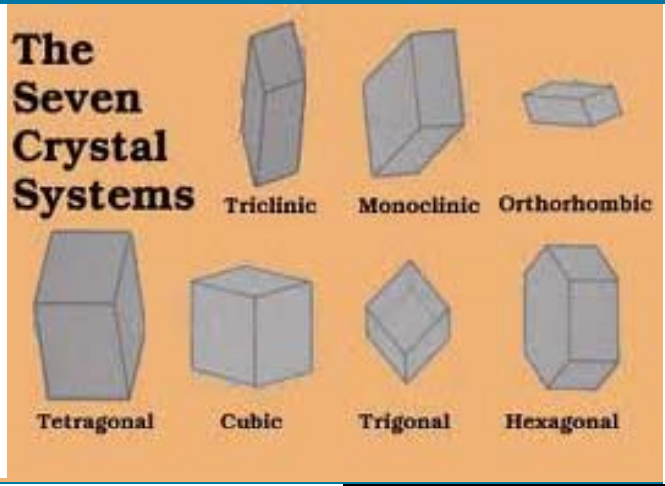
Barium Chloride

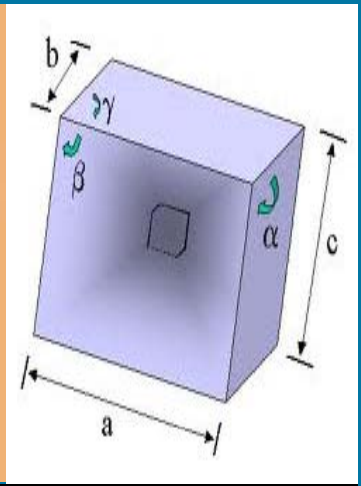
$BaCl_2$ being crystalline is Anisotropic

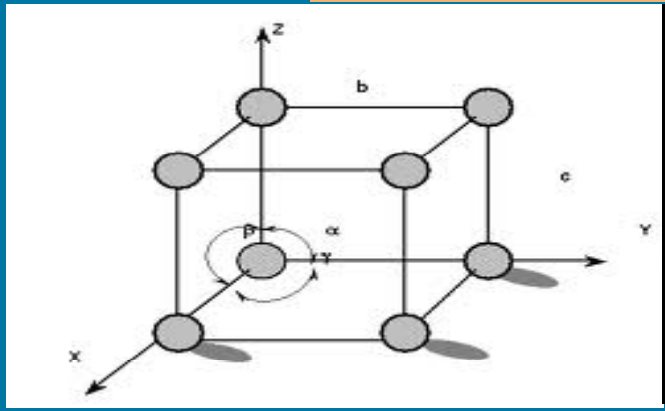
2.The most unsymmetrical crystal system is

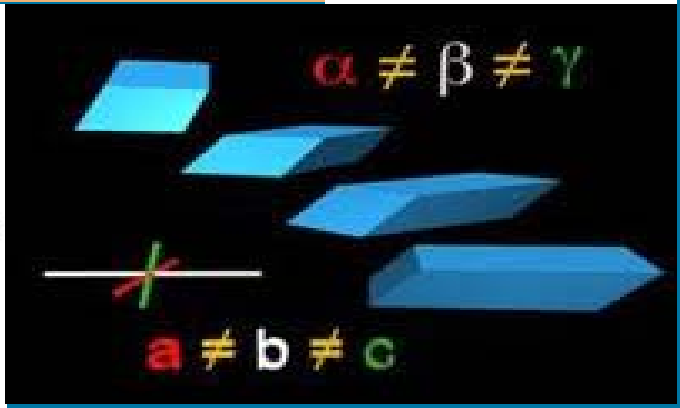
1. Cubic
2. Hexagonal
3. Triclinic
4.Orthorhombic









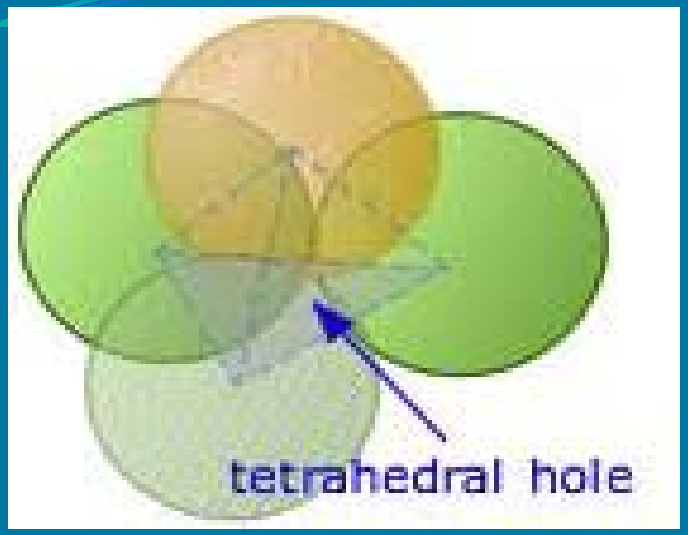


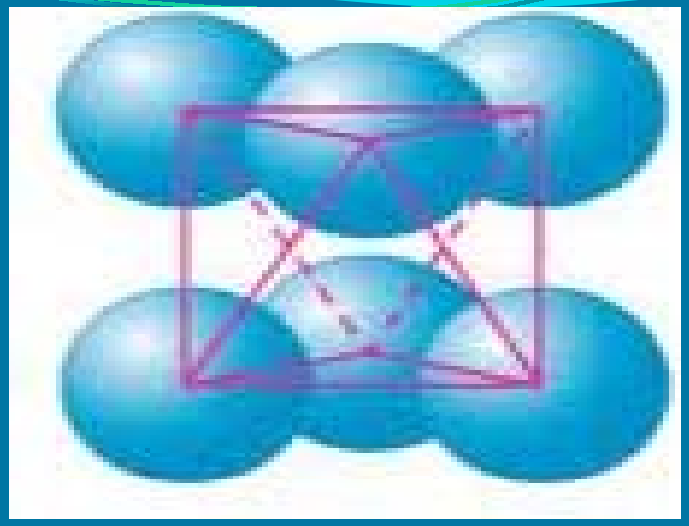
Cubic system **Triclinic crystal**

Most symmetric **Most un-symmetric**

3. The coordination number of a cat ion occupying a tetrahedral hole and octahedral hole respectively are

1. 4 and 6
2. 6 and 4
3. 8 and 4
4. 4 and 8





Tetrahedral hole:

A particle in a tetrahedral hole is surrounded by four particles. Therefore the **co-ordination is 4**

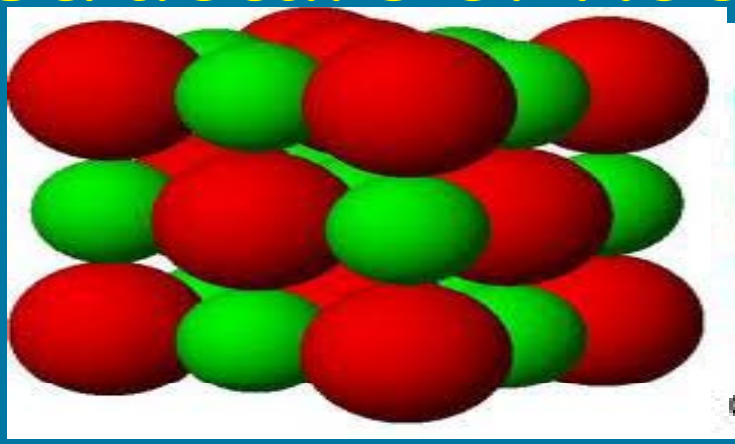
Octahedral hole:

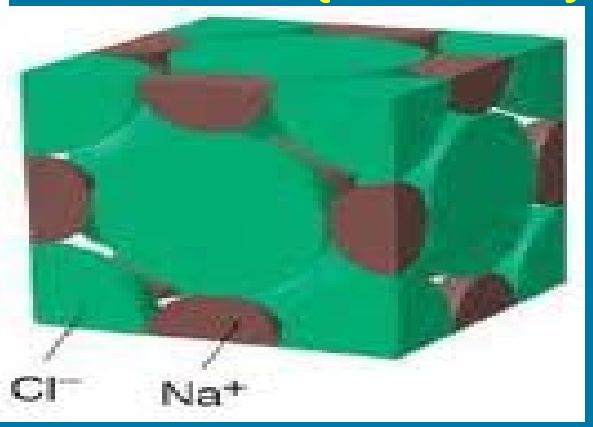
A particle in a octahedral Hole is surrounded by four particles. Therefore the **co-ordination is 6**

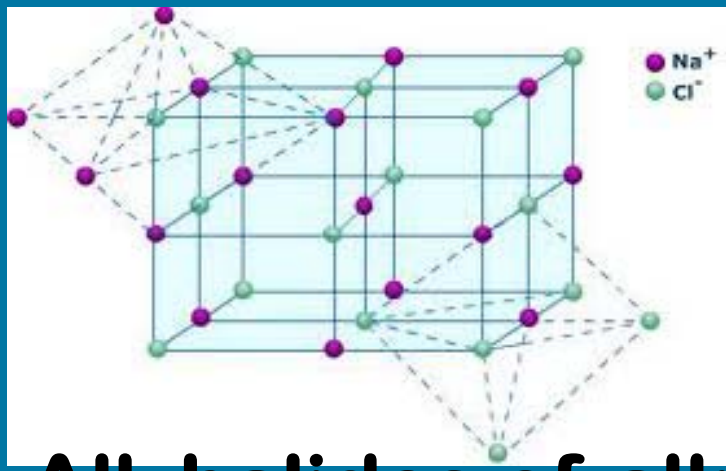
4. Which one of the following statement is incorrect about rock salt type?

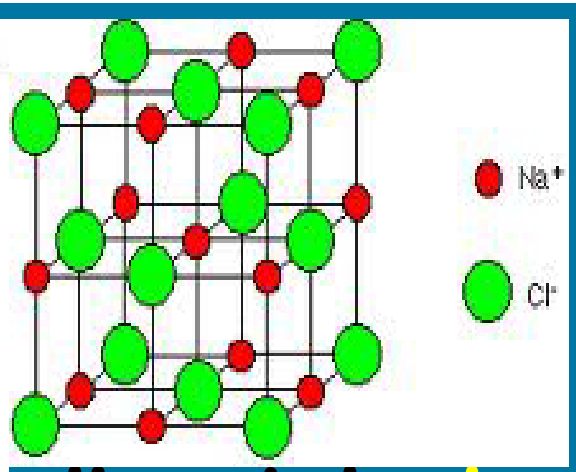
1. It has FCC arrangement
2. Na^{+} and Cl^{--} ions have coordination number of 6:6
3. A unit of NaCl consists of 4 NaCl units
4. All halides of alkali metals have rock salt type

Structure of Rock salt (NaCl)





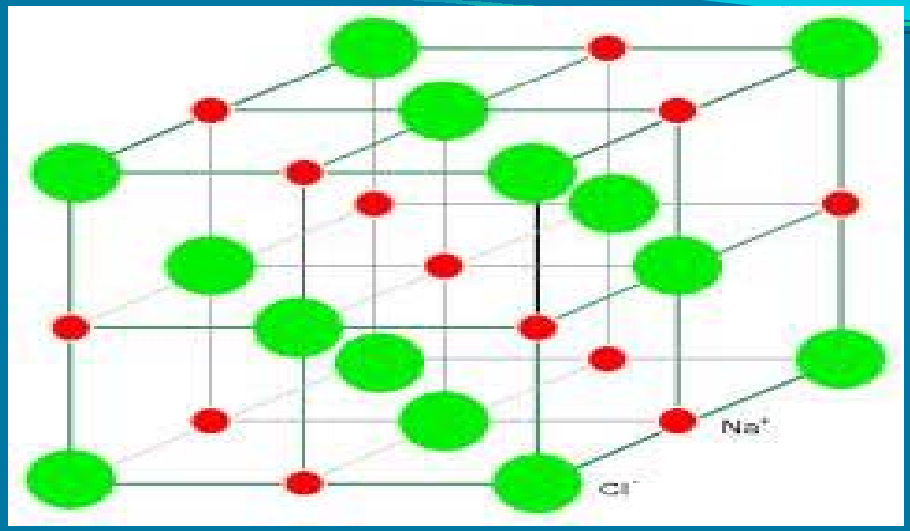




4. All halides of alkali metals <u>do not</u> have Rock salt type structure

5. How many lattice points are present in a unit cell of NaCl?

1. 9
2. 4
3. 27
4. 6



14 lattice points are occupied by Cl^-

8 are at corners

6 at the center of each face

13 lattice points are occupied by Na^+

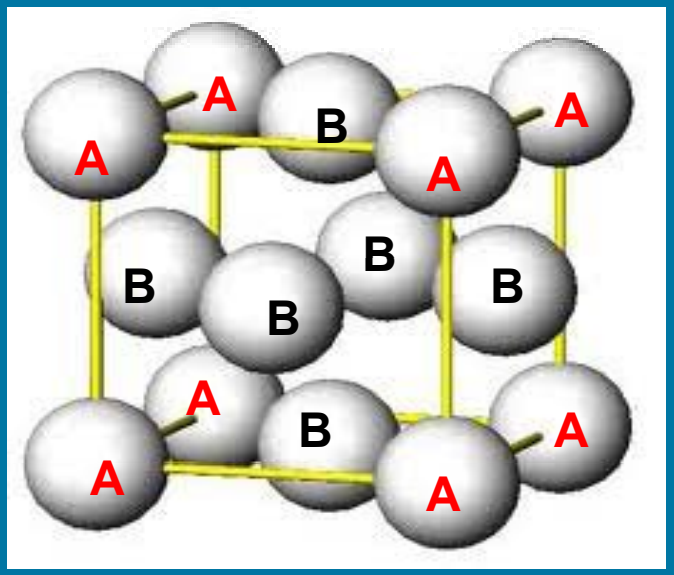
12 are at the edge

01 is at the center of the cube

The answer is 3 i.e 27

6. A substance A_xB_y crystallizes in a face centered cubic lattice in which, atoms 'A' occupy each corner of the cube and atoms 'B' occupy the centers of the each face of the cube. Identify the correct composition of the substance A_xB_y

1. AB_3 2. A_4B_3 3. A_3B_3 4. A_3B



CORNER PARTICLE = 1/8

8 CORNER PARTICLES = 8 X 1/8 =01

PARICLE AT THE CENTRE OF THE FACE= ½

6 PARTICLES ARE AT THE CENTRE OF THE FACE = 6 X ½= 03

The formula is AB_3

7. A solid X melts slightly above 273 K and is a poor conductor of heat and electricity, to which of the following categories does it belong?

1. Ionic solid
2. Covalent solid
3. Metallic solid
4. Molecular solid

Answer:

4. Molecular solid

8. The ionic radii of Rb^+ and I^- are1.46 pm and 2.16 pm respectively. The most probable type of structure exhibited by it is

1. CsCl type
2. NaCl type
3. ZnS type
4. CaF_2 type

Radius/Ratio	Preferred Coordination Number	Name
0.732	8	Cubic
0.414 to 0.732	6	Octahedral
0.225 to 0.414	4	Tetrahedral

$$\frac{r^+}{r^-} = \frac{1.46}{2.16} = 0.67$$

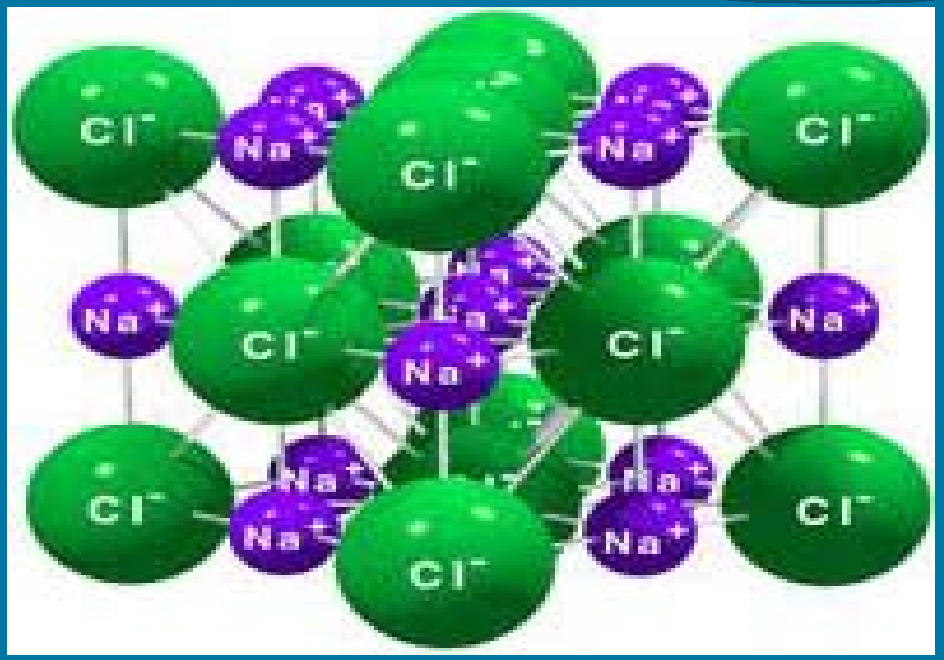
Which lies in the range of 0.414---0.732

Hence the co-ordination number is 6

The structure is NaCl type. Answer is 2

9. The positions of Cl^- ions in NaCl structure are

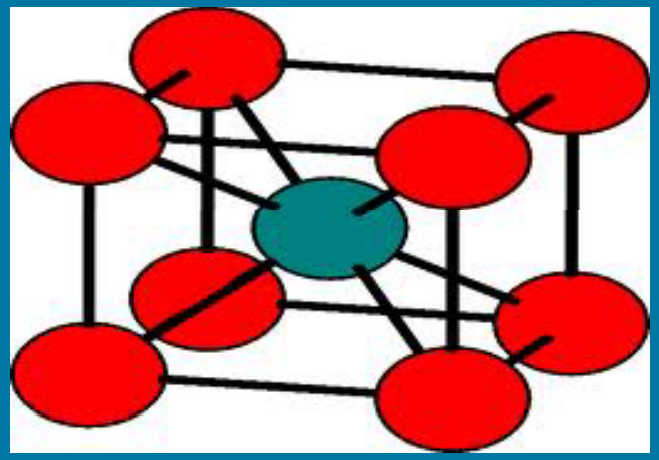
1. Corners of the cube
2. Centers of faces of the cube
3. Corners as well as centers of the faces of the cube
4. Edge centers of the cube.

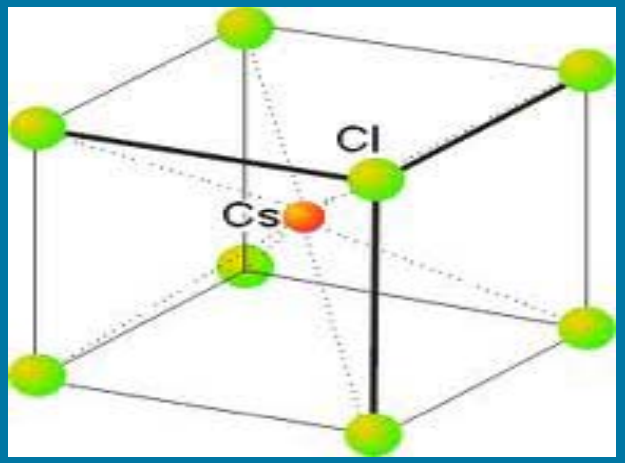


Cl^- ions are present at 8 corners and at the centre of each face.
The Na^+ ions are at the 12 edges and at the center of the cube.(It can be vice-versa also) **The answer is 3**

10.A unit cell of CsCl structure consists of

1. One CsCl unit
2. Two CsCl units
3. Three CsCl units
4. Four CsCl units.





In CsCl Cs+ ions are at centre

Chloride ions are at 8 corners

No of Cs^{+} ions per unit cell = 1 X 1 = 1

No of Cl^{--} ions per unit cell = 8 x 1/8 =1

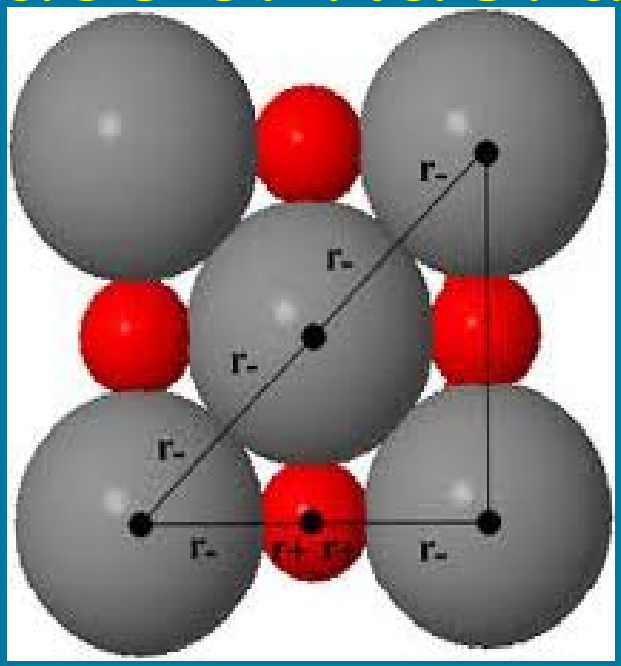
ONE CsCl unit is present per unit cell

The answer is 1

11. The distance between the Na^+ and Cl^- in NaCl crystal is 'a' pm, what is the length of the cell edge?

1. 2a pm
2. a/2 pm
3. 4a pm
4. a/4 pm

One face of NaCl unit cell

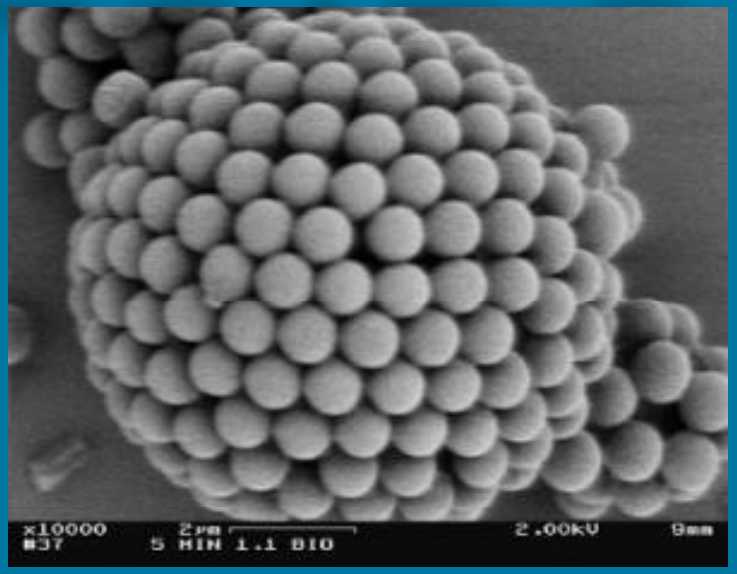


a a

The edge length = 2a

The answer is 1

COLLOIDS



Thomas Graham Colloidal particles

Colloidal system and particle size.

Types of colloidal system.

Lyophilic and Lyophobic sols, example and differences.

Preparation of sols

Bredig's arc method, Peptisation.

Purification of sols

Dialysis, Electro dialysis

Properties of colloids

Tyndall effect, Brownian movement, Electrophoresis, Origin of charge, Coagulation, Hardy and Schulz rule. Protective action of sols. Gold number.

Application of colloids

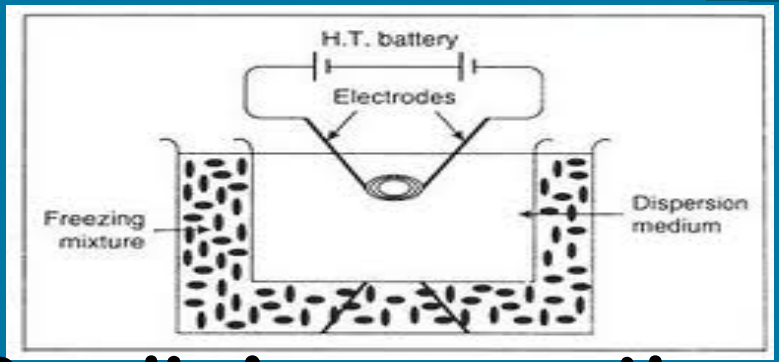
1. The stability of Lyophilic colloids is due to
   1. Charge on the particles.
   2. A thin layer of dispersion medium on their particles.
   3. The smaller size of their particles.
   4. The large size of their particles.

Answer:

2.A thin layer of dispersion medium on their particles.

2. Bredig's arc method cannot be used for the preparation of colloidal sol of

1. Copper
2. Iron
3. Silver
4. Sodium



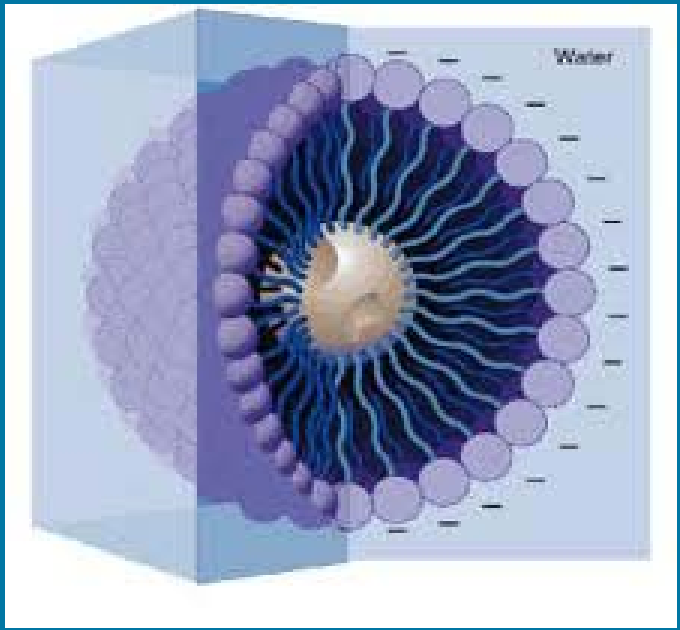
Bredig's arc method

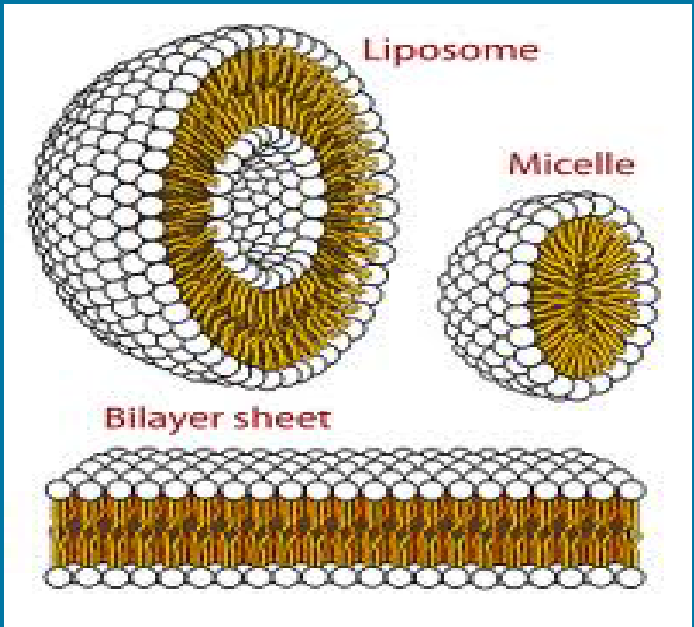
Sodium violently reacts with water liberating hydrogen gas

The answer is 4

3. Micelles constitute an example of

1. Multimolecular colloid
2. Macromolecular colloid
3. Associated colloid
4. None of these





Micelle is an associated colloid

The answer is 3

4. The method which does not result in sol destruction is

1. Electrophoresis
2. Addition of electrolyte
3. Diffusion through animal membrane
4. Mixing two oppositely charged sols.

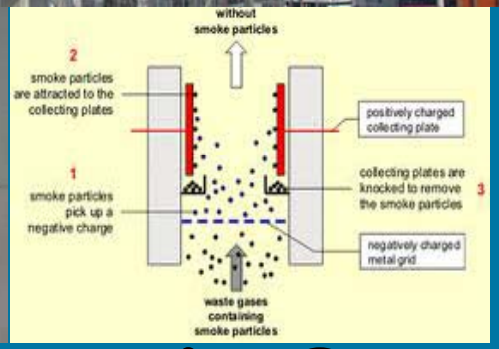
Answer:

3. Diffusion through animal membrane

5. Cottrell precipitator is a device to

1. Coagulate the particles of any sol
2. Coagulate the particles of carbon from smoke
3. Coagulate the mud particles from water
4. Coagulate the dirt particles of sewage water

SMOKE PRECIPITATION



The answer is 2

6.Which one of the following is wrong?

1.Brownian movement and Tyndall effect is shown by colloidal particles

2. Gold number is a measure of the protective power of the a lyophilic colloid

3. The colloidal solution of liquid in liquid is called gel

4. Hardy-Schulze rule is related with coagulation.

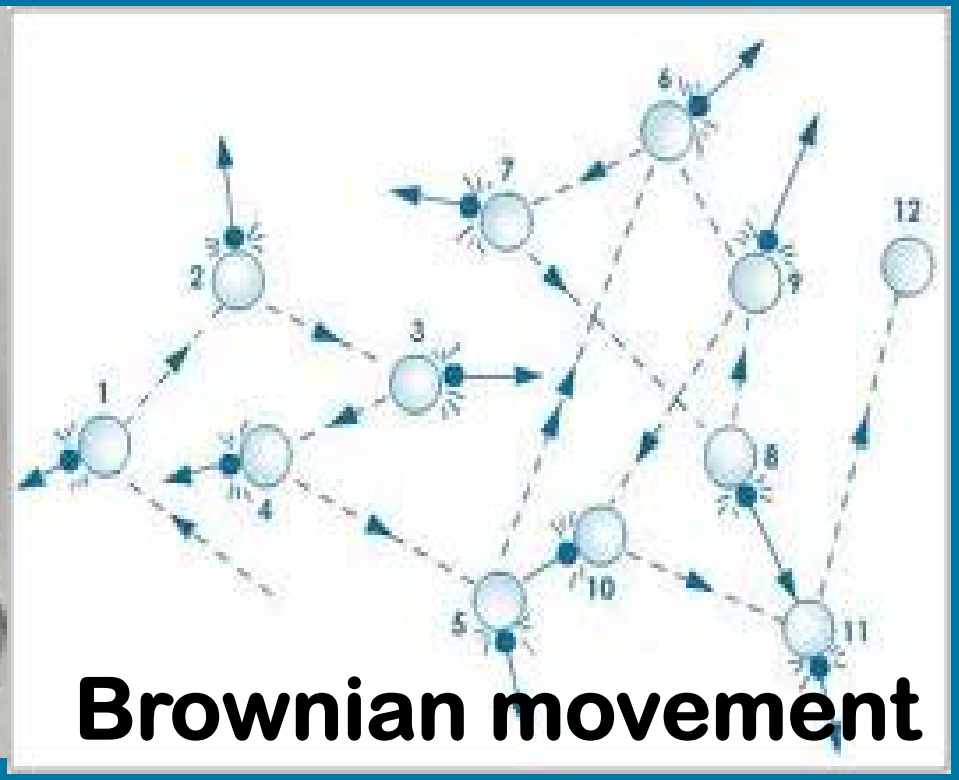
Answer:

3. The colloidal solution of liquid in liquid is called gel

7. The Brownian movement is due to

1. Temperature fluctuation within the liquid phase
2. Attraction and repulsion between charges on the colloidal particles
3. The impact of molecules of dispersion medium on the colloidal particle
4. Convective current

Robert Brown



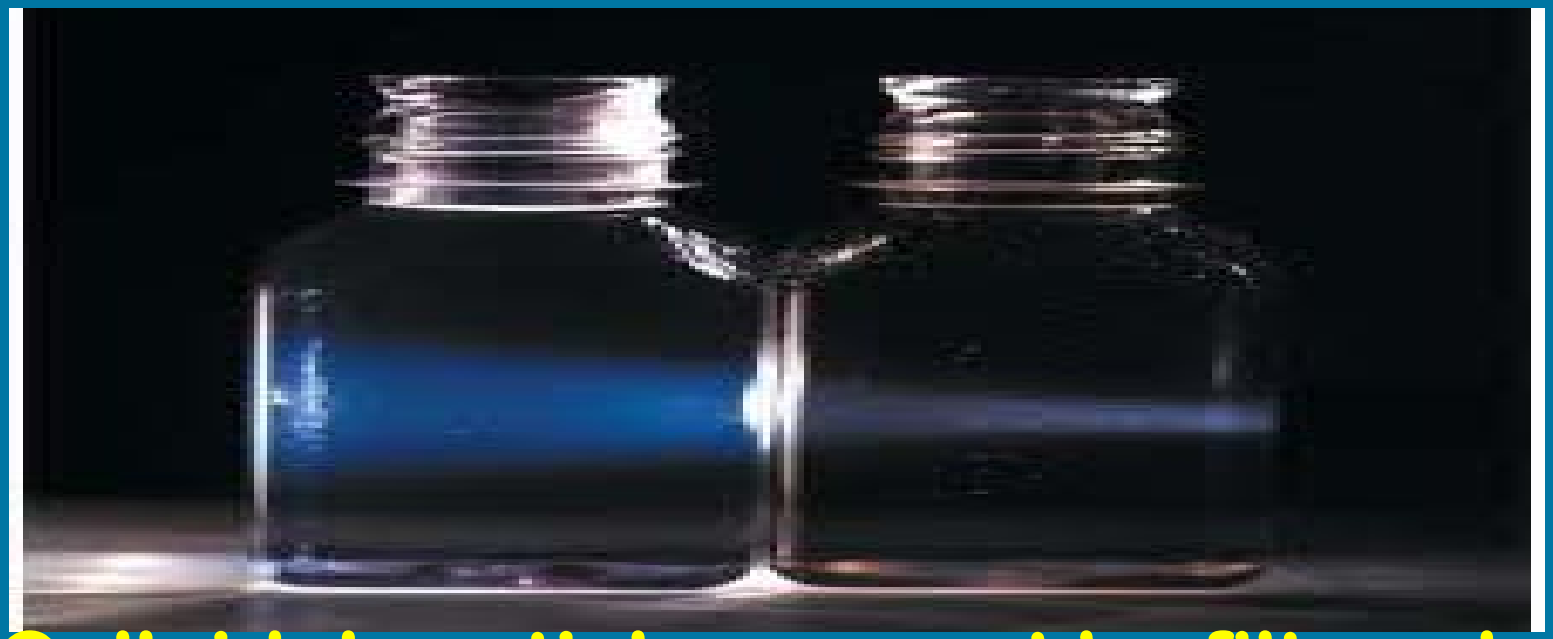
Brownian movement

The un equal collision of molecules of the dispersion medium on the colloidal particles. The answer is 3

8. A liquid which markedly scatters a beam of light(visible in a dark room)but leaves no residue when passed through a filter paper is best described as

1. A suspension 2. A true solution
3. Lyophilic sol 4. Lyophobic sol

TYNDALL EFFECT



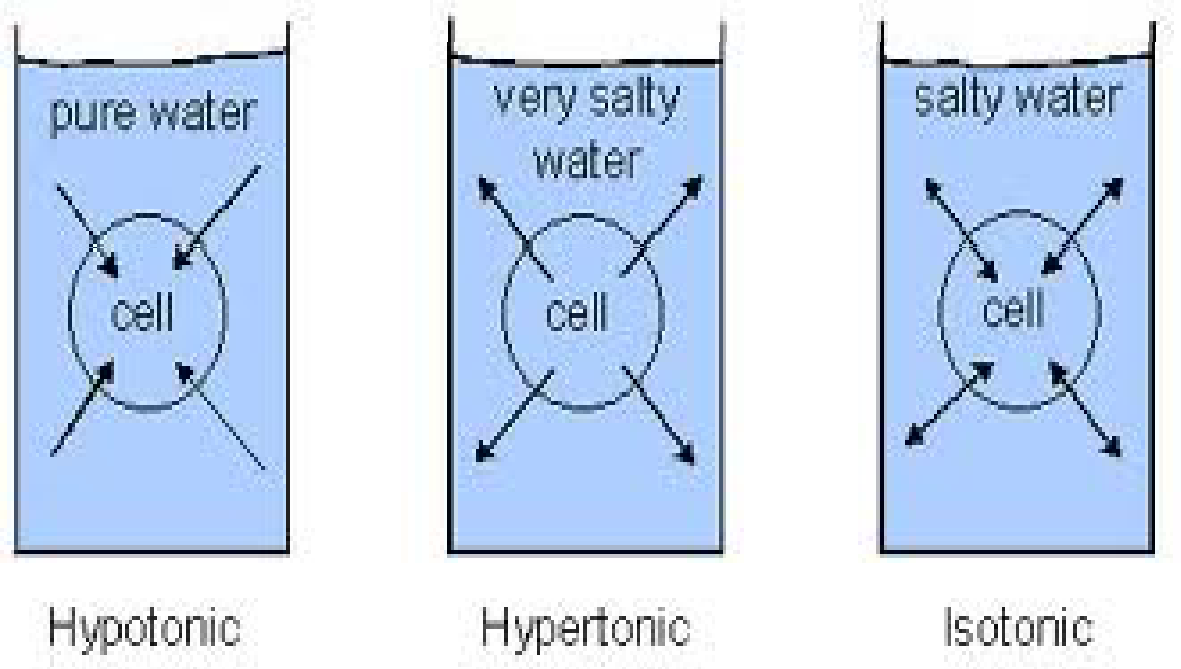
Colloidal particles cannot be filtered by using filter paper. They can only be filtered by using animal membrane.

The answer is 4

9. Swimming for a long time in salt water makes the skin of one's finger tips wrinkled. Which one of the following properties is responsible for this observation?

1. Osmosis
2. Dialysis
3. Electrodialysis
4. Coagulation

Osmosis



The answer is 1

10. The colour of the colloidal particles of gold obtained by different methods differ because of

1. Variable valency of gold
2. Different concentration of gold particles
3. Different types of impurities
4. Different diameters of colloidal particles

As the size of the colloidal particles of gold changes, the colour of the colloidal solution also changes.

The answer is 4

11. Which of the following is most effective in causing the coagulation of ferric hydroxide sol?

1. KCl
2. KNO_3
3. K_2SO_4
4. $K_3[Fe(CN_6)]$

According to Hardy –Schulze rule

"The ion having charge opposite to the colloidal particle is called Active ion" and it is responsible for the coagulation.

"The coagulating power of the active ion is directly proportional to the charge on the active ion".

$Fe(OH)_3$ is a positively charged colloid.
Therefore negative ion can cause coagulation. Among
Cl^{--} NO_3^{--} $(SO_4)^{2--}$ $[Fe(CN)_6]^{3-}$
$[Fe(CN)_6]^{3--}$ has the highest valency.
Therefore it is most effective in causing coagulation

The answer is 4

12. The coagulation of 100ml of colloidal solution of gold is completely prevented by addition of 0.25 g of a substance "X" to it before adding 1 ml 10%NaCl solution. The Gold number of X is

1. 0.25
2. 25
3. 250
4. 2.5

250 mg (0.25g)of X is present in 100ml

By the definition of Gold Number:

Gold number of X is that amount of it in mg which is present in 10 ml of the standard gold sol.

Hence in 10 ml the amount of X present is 25 mg which is the gold number of X

Answer is 2

13.Alum helps in purifying water by

1. Forming silicon complexes with clay particles
2. Sulphate part which combines with dirt and removes it
3. Aluminium which coagulates the clay particles
4. Making the clay water soluble.

Answer:

3. Aluminium which coagulates the clay particles

THEORY OF DILUTE SOLUTIONS

Solution of liquid in liquid:

Vapour pressure of solvent, vapour pressure of Solution. Raoult's law of liquid mixture, Ideal & Non-ideal solutions with positive & negative deviations. Differences and examples.

Solution of non-volatile solute in a solvent

Colligative property-

Relative lowering of vapour pressure, elevation in B.P, depression in F.P, and osmotic pressure.

Raoult's law for RLVP.

Determination of molecular mass by lowering of vapour pressure. problems

Ostwald and Walker's dynamic method for measurement of lowering of vapour pressure.

Numerical problems

Osmotic pressure:

Van't Hoff's theory of dilute solutions

Laws of osmotic pressure-

Van't Hoff Boyle's law

Van't Hoff Charle's law,

Combined solution equation etc.

1.For an aqueous solution of the same solute

1.1M = 1m 2. 1M > 1m

3.1M< 1m 4. 1M = ½ m

1M aqueous solution means 1 mole of the solute in 1000ml of the solution, which includes solute also.

Hence solvent present is less than 1000ml(1000g).

Therefore complete 1000ml of the solvent will contain more than l mole of the solute

Therefore the 1M > 1m

The answer is 2.

2.Which of the following modes of expressing the concentration is independent of temperature?

1.Normality
2.Molarity
3.Molality
4.Formality

Answer:

3.Molality

3. The vapour pressure of a liquid in a closed container depends upon

1. Amount of liquid
2. Surface area of the liquid
3. Temperature
4. Shape of the container.

Answer:

3. Temperature

4. A non-ideal solution was prepared by mixing 30 ml of chloroform and 50 ml of acetone .

The volume of mixture will be

1.= 80ml

2.≥ 80ml

3.> 80ml

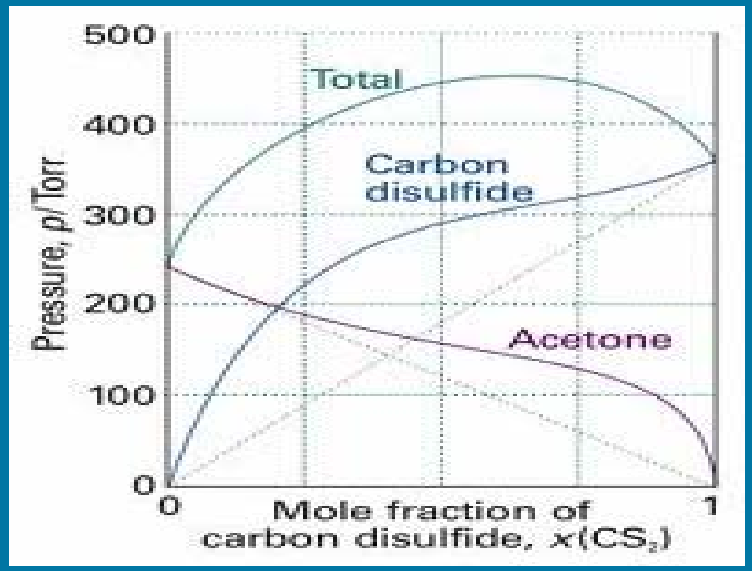
4.< 80ml

Answer:

4.< 80ml

5. Which of the following pair shows positive deviation from Raoult's law?

1. H_2O & HNO_3
2. CH_3COCH_3 & $CHCl_3$
3. H_2O & HCl
4. CS_2 & CH_3COCH_3



CS_2 and CH_3COCH_3 is the only process which is endothermic i,e, ΔH_{mix} = +ve

The answer is 4

6. Two solutions of KNO_3 and CH_3COOH are prepared separately. Molarity of both is 0.1M and osmotic pressure are P_1 & P_2 respectively. The correct relation ship between the osmotic pressure is

1. $P_1 = P_2$
2. $P_1 > P_2$
3. $P_2 > P_1$
4. $P_1 / P_1 + P_2 + P_2 / P_1 + P_2$

KNO_3 is strong electrolyte,
It dissociates completely in aqueous solution. The effective number of particles in the solution is 0.2M.
CH_3COOH is weak electrolyte.
It dissociates partially in aqueous solution. The effective number of particles in the solution
is very much less than 0.2M

The answer is 2 ($P_1 > P_2$)

7.When mercuric iodide is added to the aqueous solution of potassium iodide ,the

1.Freezing point is raised

2. Freezing point is lowered

3.Freezing point does not change

4. Boiling point does not change

$$2KI + HgI_2 \rightarrow K_2HgI_4$$

As a result of this reaction, no. of ions decrease. So the lowering in Freezing Point is less

or

The actual Freezing Point is more

The answer is 1

8. A liquid is in equilibrium with its vapours at its boiling point. On average the molecules in the two phases have equal

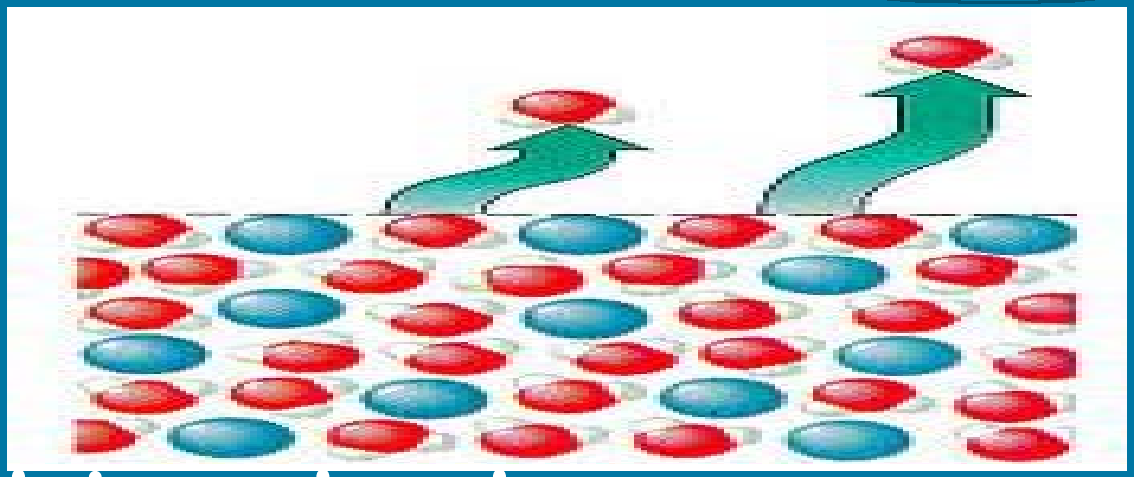
1. Intermolecular forces
2. Potential energy
3. Total energy
4. Kinetic energy

Answer:

4. Kinetic energy

9. The lowering of vapour pressure of the solvent takes place on dissolving a non- volatile solute because

1. The density increases
2. The surface tension increases
3. The viscosity increases
4. The molecules of the solvent on the surface are replaced by the molecules of the solute.



Solute molecules occupy some of the surface positions, being non-volatile it will not vapourise, and will not allow the solvent molecules to vapourise from that position. Therefore the vapour pressure decreases

The answer is 4.

10.A 0.6 % solution of urea (mol Mass=60) would be isotonic with

1. 0.1 M glucose
2. 0.1 M KCl
3. 0.6% glucose solution
4. 0.6% KCl solution.

When two solutions have same molar concentration, Then they will have same osmotic pressure. Such solutions are called ISOTONIC solutions.

0.6% urea = 0.6g in 100ml

= 6g in 1000ml

= 6/60=0.1 mole in 1000ml

0.6% urea = 0.1M

(Both urea and glucose are non-electrolytes)

It is isotonic with 0.1M glucose.

The answer is 1

11. what is the molality of a certain solute in a solvent if there is a freezing point depression of 0.184^0 and if the $K_f = 18.4$?

1. 0.01
2. 1
3. 0.001
4. 100.

We Know that:

$$\Delta T_f = K_f\, m$$

$$m = \Delta T_f / K_f$$

$$= 0.184/18.4$$

$$= 1 \times 10^{-2}$$

$$= 0.01$$

The answer is 1

12.Which of the following will have highest freezing point?

1.0.1 M NaCl solution
2.0.1 M sugar solution
3. 0.1 M $BaCl_2$ solution
4. 0.1 M $FeCl_3$ solution

1. 0.1 M NaCl solution = 0.1 x2 = 0.2M particles
2. 0.1 M sugar solution =0.1 x 1= 0.1 M particles
3. 0.1 M $BaCl_2$ solution = 0.1 x 3=0.3 M particles
4. 0.1 M $FeCl_3$ solution = 0.1 x 4 = 0.4M particles

Since least no of particles are present in 0.1 M sugar solution.
It will have lowest depression in F P

Hence has highest F P

13. An aqueous solution containing 1 g of urea boils at 100.25^0C. The aqueous solution containing 3g of glucose in the same volume will boil at

1. 100.75^0C
2. 100.5^0C
3. 100^0C
4. 100.25^0C

Mol mass of urea(NH_2CONH_2) = 60

Therefore 1g of urea = 1/60mole

Mol mass of glucose($C_6H_{12}O_6$) = 180

Therefore 3g of glucose = 3/180=1/60

Since the **no of moles are same** & they are present in the same volume of same solvent. The molar concentration is also same. Both will boil at same temperature .

Answer is 4 (100.25^{0}C)

14. If all the following four compounds are sold at the same price. Which would be the cheapest for preparing antifreeze solution for a car radiator.

1. C_2H_5OH
2. CH_3OH
3. $C_2H_4(OH)_2$
4. $C_3H_5(OH)_3$

Answer:

2. CH_3OH

15. The vapour pressure of pure benzene and toluene are 160 & 60 mm of Hg respectively. The mole fraction of toluene in vapour phase in contact with equi molar solution of benzene and toluene is equal to.

1. 0.50 2. 0.6
3. 0.27 4. 0.73.

Equimolar solution $X_B + X_T = 1$

or $X_B = X_T = 0.5$

WKT: $P_B = P^0_B \times X_B = 160 \times 0.5 = 80$

$P_T = P^0_T \times X_T = 60 \times 0.5 = 30$

Therefore

The total vapour pressure= 80+ 30 =110

The partial vapour pressure

of toluene $= P_T = 30/110 = 0.27$

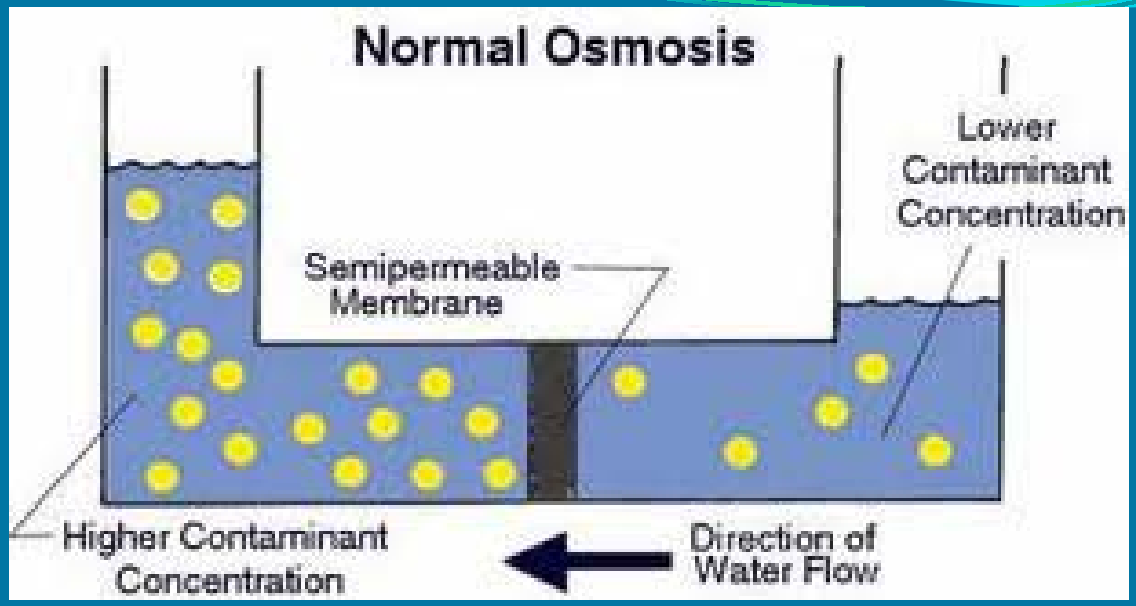
Since vapour pressure is

proportional to mole fraction

The answer is 3 (0.27)

16. The phenomenon of osmosis is the movement of

1. The solvent molecules from lower solution concentration to higher
2. Solvent molecules from higher solution concentration to lower
3. The solute molecules from lower solution concentration to higher
4. Solute molecules from higher solution concentration to lower



Osmosis is the spontaneous flow of the solvent molecules through a semi permeable membrane from pure solvent to a solution Or from dilute to concentrated solution

The answer is 1

17. The vapour pressure of a solvent decreases by 10 mm of Hg. When a non- volatile solute was added to the solvent , the mole fraction of the solute in the solution is 0.2. What should be the mole fraction of the solvent if the decrease in the vapour pressure is to be 20 mm of Hg.

1. 0.8 2. 0.6 3. 0.75 4. 0.90

From Raoult's law: $\frac{P^0 - P}{P^0} = X_B$

Therefore $P^0 = \frac{P^0 - P}{X_B}$

$= \frac{10}{0.2}$

$P^0 = 50$

To calculate the mole fraction:

From Raoult's law: $\frac{P^0 - P}{P^0} = X_B$

$\frac{20}{50} = 0.4$

We know that:

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

Therefore

$$X_{solvent} = 1 - X_{solute}$$

$$= 1 - 0.4$$

$$X_{solvent} = 0.6$$

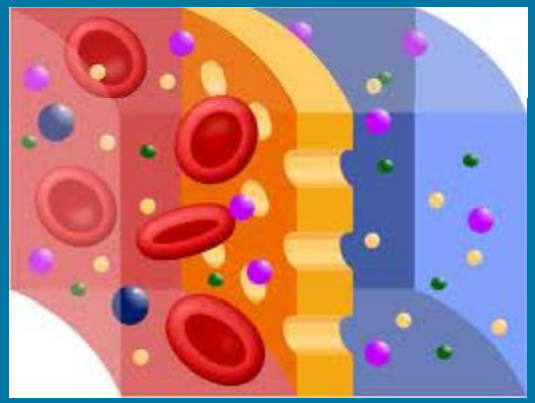
The answer is 2 (0.6)

18. When the following solutions are separated by a membrane made of gelatinous ppt of cupric ferrocyanide in which case there is flow of solvent?

1. 1M Sucrose & 1M glucose
2. 1M NaCl & 2 M Urea
3. 0.05 M $K_4Fe[(CN)_6]$ & 0.1 M $MgCl_2$
4. 0.001 M $CaCl_2$ & 0.0015 M NaCl.

Semipermiable membrane

1M Sucrose = 1x1ions =1M
1M glucose = 1 x1ions =1M



1M NaCl = 1 X 2 ions =2M
2 M Urea = 2X 1ions =2M

ANS: 0.05 M $K_4Fe[(CN)_6]$ = 0.05 X 5 = 0.25M
0.10 M $MgCl_2$ = 0.1x 3 ions = 0.3M

0.001 M $CaCl_2$ = 0.001X 3 ions = 0.003
0.0015 M NaCl = 0.0015 X2 ions =0.003M

SOME EXTRA QUESTIONS

1. The packing fraction for a body centered cubic crystal is

1. 0.42
2. 0.52
3. 0.68
4. 0.72

$$P.F = \frac{\text{Volume of the spherical atom}}{\text{Volume of the cube}}$$

Volume of the sp. Atom = $(4/3)\ \pi r^3$

Volume of the cube = a^3

(a is the edge cubic crystal in pm)

FOR SIMPLE CUBE r = a/2

The P F = π/6 = 0.52

For B C C = 0.68 $r = \frac{\sqrt{3}\,a}{4}$

$$\text{The P.F} = \frac{\sqrt{3}\pi}{8} = 0.68$$

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

For F C C

$$\text{The P.F} = \frac{\sqrt{2}\pi}{6} = 0.74$$

The answer is 3

2. Which of the following is wrong?

1. Sulphur sol is an example of macro molecular colloid
2. Bleading due to a cut can be stopped by coagulation of negatively charged blood particles by ferric ions
3. AgI is used for producing artificial rain because AgI has similar crystal structure to ice.
4. Alums purify muddy water by coagulation.

Answer:

1. Sulphur sol is an example of macro molecular colloid

3. An azeotropic solution of two liquids has boiling point lower than either of the two liquids when it

1. Shows a negative deviation from Raoult's law
2. Shows a positive deviation from Raoult's law
3. Shows no deviation from Raoult's law
4. Is saturated.

Azeotropic mixture with minimum BP

It is formed by that composition of non-ideal solution showing positive deviation for which the vapour pressure is maximum

Azeotropic mixture with maximum BP

It is a non-ideal solution showing negative deviation for which the vapour pressure is minimum

Therefore the answer is 2

4.Which statement is wrong regarding osmotic pressure(p), volume (v) and temperature(T)?

1.P ά V if T is constant

2.P ά T, if V is constant

3.PV is constant , if T is constant

4.P ά 1/V , if T is constant

Van't Hoff Boyle law:

P ά C at constant T

If V liters of solution contain n moles of solute then

C=n/V or n ά 1/V

Hence P ά 1/V at constant T

or PV= constant

Van't Hoff Charle's law:

P ά T at constant C

The answer is 1