CLASS 12

CBSE

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Class 12 |Physics

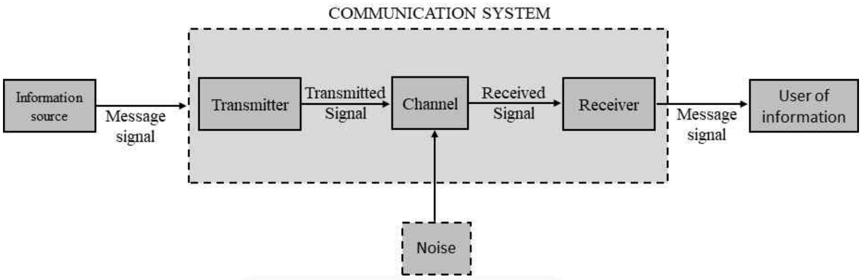
02 Communication System

01. Introduction

The act of transmission and reception of information is known as communication.

02. Elements of a Communication System

Every communication system has three essential elements, transmitter, medium and receiver.



There are two basic modes of communication: point-to-point and broadcast.

03 Basic Terminology of Communication Systems

(i) **Transducer :** Device that converts one from of energy into another.

(ii) **Signal:** Information converted in electrical from and suitable for transmission. Signals can be either *analog or digital*.

(iii) **Noise:** The unwanted singles that tend to disturb the transmission and processing of message signals

(iv) **Transmitter:** Processes the incoming message signal so as to make it suitable for transmission through a channel and subsequent reception

(v) **Receiver:** Extracts the desired message signals from the receive signals at the channel output.

(vi) **Attenuation:** It is the loss of strength a signal while propagating through a medium.

(vii) **Amplification:** The process of increasing the amplitude of a signal using an electronic circuit called the amplifier.

(viii) **Range :** Largest distance between a source and a destination up to which the signal is received with sufficient strength

(ix) **Bandwidth:** Frequency range over which an equipment operates or the portion of the spectrum occupied by the signal.

(x) **Modulation:** Original low frequency message/information signal cannot be transmitted to long distances because of obvious reasons. Therefore, at the transmitter, information contained in the low frequency message signal is superimposed on a high frequency wave, which acts as a carrier of the information

(xi) **Demodulation:** The process of extraction of information from the carrier wave at the receiver

(xii) **Repeater:** A combination of receiver and a transmitter. Communication satellite is essentially a repeater station ins space.

NOTE ☞ Undesirable effects in the course of signal transmission are
(i) **Attenuation :** decrease in signal strength due to energy loss.
(ii) **Distortion :** waveform perturbation
(iii) **Interference :** contamination by extraneous signals.
(iv) **Noise :** due to random electrical signal

03. Types of Transmission Media

Broadly, transmission media have been divided into two types

(i) **Guided transmission medium:** That communication medium of channel which is used in point to point communication between a single transmitter and receiver.

(ii) **Unguided transmission medium:** communication medium which is used, where there is no point to point contact between the transmitter and receiver.

Characteristics and quality of transmission medium depends upon

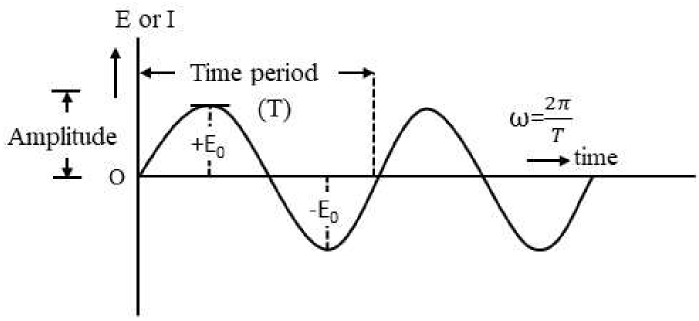
(i) Nature of transmission medium

(ii) Nature of signal

The electrical signals are of two types:

(i) **Analog signals:** An analog signal is that in which current or voltage value varies continuously with time

$$E = E_0 \sin(\omega t + \phi)$$



Examples of Analog signals are speech, music, sound produced by a vibrating tuning fork.

(ii) **Digital signals:** A digital signal is discontinuous function of time, in contrast to an analog signal, wherein current or voltage value varies continuously with time.

Examples of Digital signals are (i) letters printed in a book (ii) listing of any data (iii) output of a digital computer (iv) electronic transmission of document at a distant place via telephone

04. Propagation of Electromagnetic Waves

An antenna at the transmitter in communication using radio waves, radiates the electromagnetic waves which travel through space and reach the receiving antenna at the other end.

05. Ground Wave

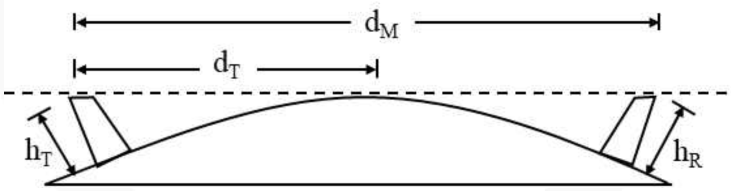
The antennas should have a size comparable to wavelength of signal. At longer wavelengths the antennas have large physical size and they are located on or very near to the ground.

06. Sky Waves

Long distance communication can be achieved by ionospheric reflection of radio waves back towards the earth. The phenomenon of bending of em waves so that they are diverted towards the earth is similar to total internal reflection.

07. Space wave

A space wave travels n a straight line from transmitting antenna to the receiving antenna. Space waves are used for line-of-sight (LOS) communication as well as satellite communication.



Where R is the radius of the earth

$d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$

where h_R is the height of receiving antenna.

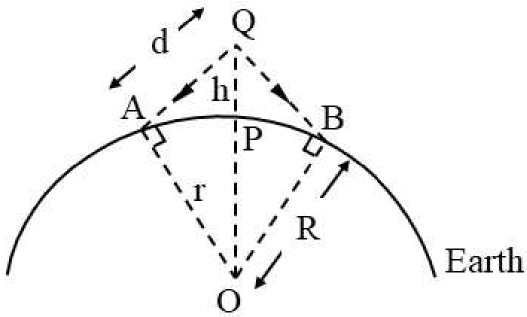
08. Determination of range

The range is determined by the height of transmitting antenna. The range *AP* or *PB* can be easily calculated by geometrical consideration. Suppose height of the tower is h and the radius of earth is r (that is OA = OB = OP = r). in the right-angled triangle OQA, we have

$$OQ^2 = QA^2 + OA^2$$
$$\because QA \simeq AP = d$$

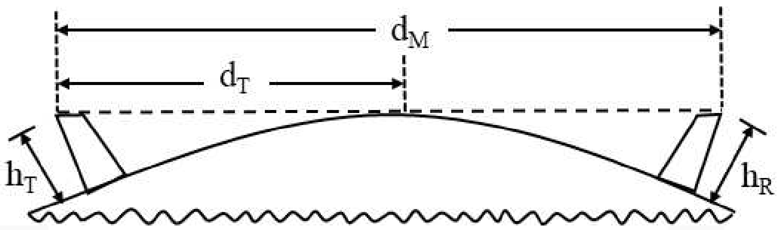
Therefore

$$(R+h)^2 = R^2+d^2$$
$$R^2+h^2+2Rh = R^2+d^2$$
$$\because\ R^2 >> h^2$$
$$\therefore\ d^2 = 2Rh$$
$$d = \sqrt{2Rh}$$



For a height of 500 m, d = 80 km

Hence maximum line-of-sight distance between two antennas will be calculated as follows



$$d_M = \sqrt{2R.h_T} + \sqrt{2R.h_R}$$

Where d_M : Maximum line-of-sight distance between two antennas

d_T : Radio horizon of transmitting antenna

h_T : Height of transmitting antenna

h_R : Height of receiving antennas

09. Modulation And its Necessity

Size of the antenna or aerial : An antenna or aerial is needed, both for transmission and reception. Each antenna should have a size comparable to the wavelength of the signals, (at least $\lambda/4$ in size) so that time variation of the signal is properly sensed by the antenna.

Effective power radiated by antenna : Theoretical studies reveal that power P radiated from a linear.

antenna of length l is proportional $(l/\lambda)^2, i.e., P \propto \left(\frac{1}{\lambda}\right)^2$

Modulation is the phenomenon of superimposing the low audio frequency baseband message or information signals (called the modulation signals) on a high frequency wave (called, the carrier wave). The resultant wave is called the modulated wave, which is transmitted.

10. Amplitude Modulation

The amplitude modulation is produced by varying the amplitude of the carrier waves in accordance with the amplitude of the modulating wave (audio signal). Let the instantaneous values of the voltage of the carrier waves and the modulating signal be represented by

$$e_c = E_c \sin \omega_c t \quad \text{...(i)}$$

and

$$e_m = E_m \sin \omega_m t \quad \text{...(ii)}$$

respectively. Here, $\omega_c = 2\pi f_c$ and $\omega_m = 2\pi f_m$ are the angular frequencies of the carrier waves and the modulating signal respectively.

The instantaneous voltage of the modulated signal is given by

$$e = (E_c + E_m \sin \omega_m t) \sin \omega_c t$$

or

$$e = E_c \left(1 + \frac{E_m}{E_c} \sin \omega_m t\right) \sin \omega_c t \quad \text{...(iii)}$$

In amplitude modulation, the degree of modulation is defined by a term called ***modulation index***, which is given by

$$m_a = \frac{E_m}{E_c} \quad \text{...(iv)}$$

The modulation index is also called ***modulation factor*** or ***depth of modulation***.

Therefore, the equation (iii) becomes

$$e = E_c (1 + m_a \sin \omega_m t) \sin \omega_c t$$

or

$$e = (E_c + m_a E_c \sin \omega_m t) \sin \omega_c t \quad \text{...(v)}$$

or

$$e = E \sin \omega_c t\,,$$

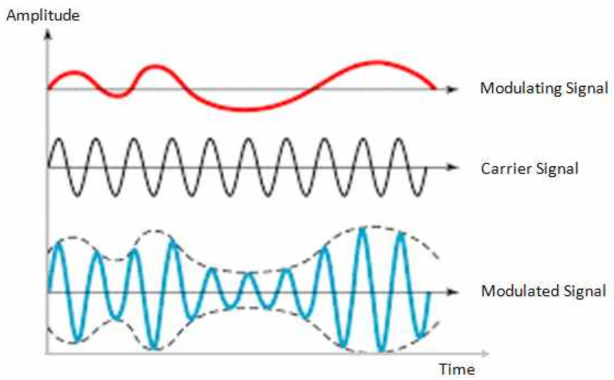
where

$$E = E_c + m_a E_c \sin \omega_m t \quad \text{...(vi)}$$

represents the amplitude of the modulated signal. It follows that the amplitude of the modulated signal varies with time in accordance with the amplitude of the modulating signal, Fig. gives the sketch of amplitude modulated signal with time. The amplitude of the modulated signal varies between $E_{\text{min}} (= E_c - E_m)$ and $E_{\text{max}} (= E_c + E_m)$. It can be easily proved that

$$m_a = \frac{E_{\text{max}} - E_{\text{min}}}{E_{\text{max}} + E_{\text{min}}} \quad \text{...(vii)}$$

It follows that the expression for instantaneous value of the voltage of the modulated signal consists of three terms. The first term represents a wave form of carrier frequency ω_c and the second term of frequency $\omega_c - \omega_m$ (slightly less than ω_c), known as ***lower sideband***. The third term represents a wave form of frequency $\omega_c + \omega_m$ (slightly greater than ω_c), called the ***upper sideband***.



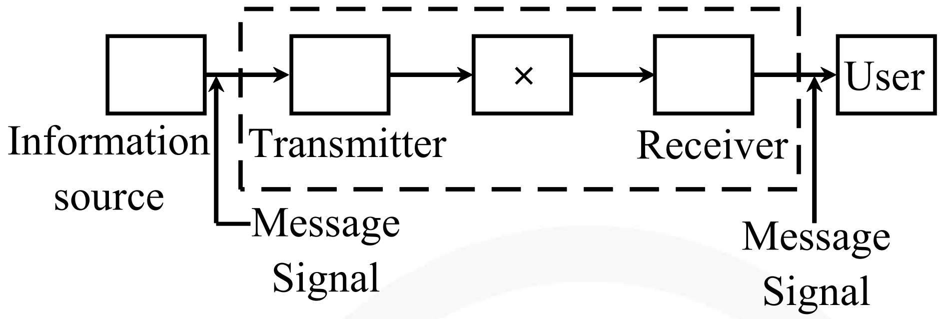
Bandwidth :
The modulated signal lies in the frequency range from $\omega_c - \omega_m$ to $\omega_c + \omega_m$ *i.e.* $2\omega_m$. It is called the bandwidth of the modulated signal.
Thus,

$$band\ width\ =\ 2\ \times\ frequency\ of\ modulating\ signal$$

CBSE Exam Pattern Exercise
Subjective Questions (1)

(Q 1 to 3) One Mark

1. The figure given below shows the block diagram of a generalised communication system. Identify the element labelled X and write its function.



2. Why are broadcast frequencies (carrier waves) sufficiently spaced in amplitude modulated wave?

3. How does the effective power radiated from a linear antenna depend on the wavelength of the signal to be transmitted?

(Q 4 to 7) Two Marks

4. Mention the function of any two of the following used in communication system.
   (i) Transducer
   (ii) Repeater
   (iii) Transmitter
   (iv) Bandpass filter

5. A message signal of frequency 10 kHz and peak voltage 10 V is used to modulate a carrier of frequency 1 MHz and peak voltage 20 V.
   Determine
   (i) the modulation index
   (ii) the side bands produced.

6.
   (i) What is line of sight communication?
   (ii) Why is it not possible to use sky wave propagation of transmission of TV signals?

7. Define the term modulation. Draw a block diagram of a simple modulator for obtaining AM signal.

(Q 8 to 10) Three Marks

8.
   (i) How is amplitude modulation achieved?
   (ii) The frequencies of two side bands in an AM wave are 640 kHz and 660 kHz, respectively. Find the frequencies of carrier and modulating signal. What is the bandwidth required for amplitude modulation?

9. Optical communication system having an operating wavelength λ (in meters) can use only x% of its source frequency as its channel bandwidth. The system is to be used for transmitting TV signals requiring a bandwidth of F hertz. How many channels can this system transmit simultaneously? Assuming all other factors to remain constant, show graphically the dependence of the number of channels that can be transmitted simultaneously on the operating wavelength of the system.

10. A signal is to be transmitted along a cable system of total length 125 km. The cable has an attenuation of 7 dB km^{-1}. Amplifiers, each having a gain of 43 dB, are placed at 6 km intervals along the cable
   (a) State what is meant by the attenuation of a signal.
   (b) Calculate (i) the total attenuation cased by the transmission of the signal along the cable, (ii) the total signal gain as a result of amplification by all of the amplifiers along the cable.
   (c) The input signal has a power of 450 mW. Use your answers in (b) to calculate the output power of the signal as it leaves the cable system.

Answer & Solution

Q1.
Labelled element X represents the channel. Its function is to transmit information from one place to another.

Q2.
To avoid mixing up of signal from different transmitters the broadcast frequencies are sufficiently spaced in amplitude modulated wave.
This can be done by modulating the signals on high frequency carrier waves, e.g. frequency band for satellite communication is 5.925-6.425 GHz.

Q3
The power radiated by a linear antenna of length L is proportional to $(L/\lambda)^2$, where λ is the signal wavelength. Since for efficient transmission, the signal should be transmitted with high power, the signal should be of small wavelength or high frequency.

Q4
(i) **Transducer :**
Any device which converts one converts pressure, temperature, etc. into varying electrical signals I.e. transducer converts physical signals into electrical signals.

(ii) **Repeater :**
It picks up the signals from the transmitter, amplifies it and transmit it to the receiver. Thus, repeater comprises up of receiver, transmitter and amplifier. Its function is to extend the range of communication.

(iii) **Transmitter :**
It comprises of message signal source, modulator and transmitting antenna. Transmitter make signals compatible for communication channel *via* modulator and antenna.

(iv) **Bandpass filter :**
A device which passes the signals with certain frequency range only.

Q5

(i) Modulation index, $\frac{E_m}{E_c} = \frac{10}{20} = 0.5$

(ii) Side band frequencies = $f_c \pm f_m$

f_m = 10 kHz $\Rightarrow$ f_c = 1 MHz = 1000 kHz

$\therefore$ Side band frequencies = 1000 $\pm$ 10

= 1010 kHz, 990 kHz

Q6

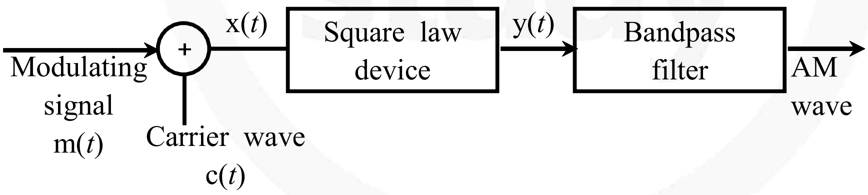
(i) Line of Sight (LOS) is a type of propagation that can transmit & receive data only where transmit & receive stations are in view of each other without any sort of obstacle between them.

Ex – FM radio, Microwave & Satellite Transmission.

(ii) The frequency of waves used for transmission of TV signals are of range 100 MHz-220 MHz. But ionosphere may be able to reflect waves back on earth of frequency up to 30 MHz. Therefore, ionosphere is unable to reflect TV waves (space waves) back on the earth.

Q7

Modulation is the process in which low frequency message signal is superimposed on high frequency carrier wave so that they can be transmitted over long distance. The block diagram for a simple modulator for obtaining AM signal is shown as below :



Q8

(i) For amplitude modulation, message signal is used to modulate amplitude of a high frequency wave in input transistor of CE amplifier.

The output voltage is carrier signal varying in amplitude in accordance with biasing modulating voltage.

(ii) Given, USB frequency = 660 kHz

and LSB frequency = 640 kHz

As USB = $f_c + f_m$ = 660 kHz

and LSB = $f_c - f_m$ = 640 kHz

$\therefore$ $2f_c$ = 660 + 640 = 1300

So, carrier frequency

f_c = 650 kHz

and $2f_m$ = 20 kHz

Bandwidth of frequencies required
= USB – LSB = 660 – 640 = 20 kHz

Q9
Here, the wavelength of signal = λ

Therefore, frequency of the signal, $v = \frac{c}{\lambda}$

Since x % of the soure frequency can be used as the bandwidth,

available bandwidth $= \frac{v \times x}{100} = \frac{cx}{\lambda \times 100}$

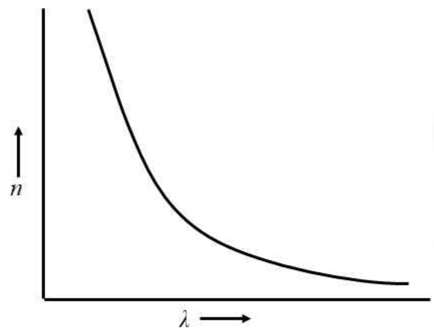
The bandwidth of the TV signal to be transmitted = F

Therefore, number of channels, the system can transmit,

$$n = \frac{\text{available bandwidth}}{\text{bandwidth of TV signal}}$$

$$= \frac{c\,x/\lambda \times 100}{F} = \frac{c\,x}{100\,\lambda\,F}$$

As n $\propto$ 1/λ, the dependence of number of channels on the operating wavelength of the system will be as shown in Fig. below.



Q10
(a) The loss of power in a signal, as it travels, is called attenuation.

(b) (i) Here, attenuation = 7 dB km^{-1}
length of the cable = 125 km
Hence, total attenuation in the cable
= 7 × 125 = **875 dB**

(ii) Since amplifiers are placed at 6 km intervals along the cable of length 125 km, it follows that in total 20 amplifiers will have to be placed.
Gain of each amplifier = 43 dB
Therefore, total signal gain = 20 × 43 = **860 dB**

(c) Here, power of the input signal,
P_1 = 450 mW = 450 × 10^{-3} W
The overall gain = 860–875 = 15 dB
If P_2 is the output power, then

gain (or loss) in signal power = $10 \log \frac{P_2}{P_1}$

or $-15 = 10 \log \frac{P_2}{450 \times 10^{-3}}$ or $\log \frac{P_1}{450 \times 10^{-3}} = -1.5$

or $\frac{P_2}{450 \times 10^{-3}} = 0.0316.$

or $P_2 = 0.0316 \times 450 \times 10^{-3} = 14 \times 10^{-3} =$ **14 mW**

CBSE Exam Pattern Exercise
Objective Questions (2)

1. Which process is used in optical fibres
   (a) T.I.R
   (b) Scattering
   (c) Reflection
   (d) Dispersion

2. An antenna behaves as a resonant circuit only when its length
   (a) equal $\frac{\lambda}{4}$
   (b) equal $\frac{\lambda}{2}$
   (c) equal $\frac{\lambda}{2}$ or its integral multiple
   (d) equal to 3λ

3. In modulation process, radio frequency wave is termed as
   (a) modulating wave
   (b) modulated wave
   (c) carrier wave
   (d) modified wave

4. A payload that is invariably found on all communication satellites is
   (a) optical telescope
   (b) camera
   (c) transponder
   (d) spectrometer

5. Attenuation in optical fibre is mainly due to
   (a) Scattering
   (b) Dispersion
   (c) Absorption and scattering
   (d) Reflection

Answer & Solution

1. (a)
   T.I.R

2. (c)
   equal $\frac{\lambda}{2}$ or its integral multiple

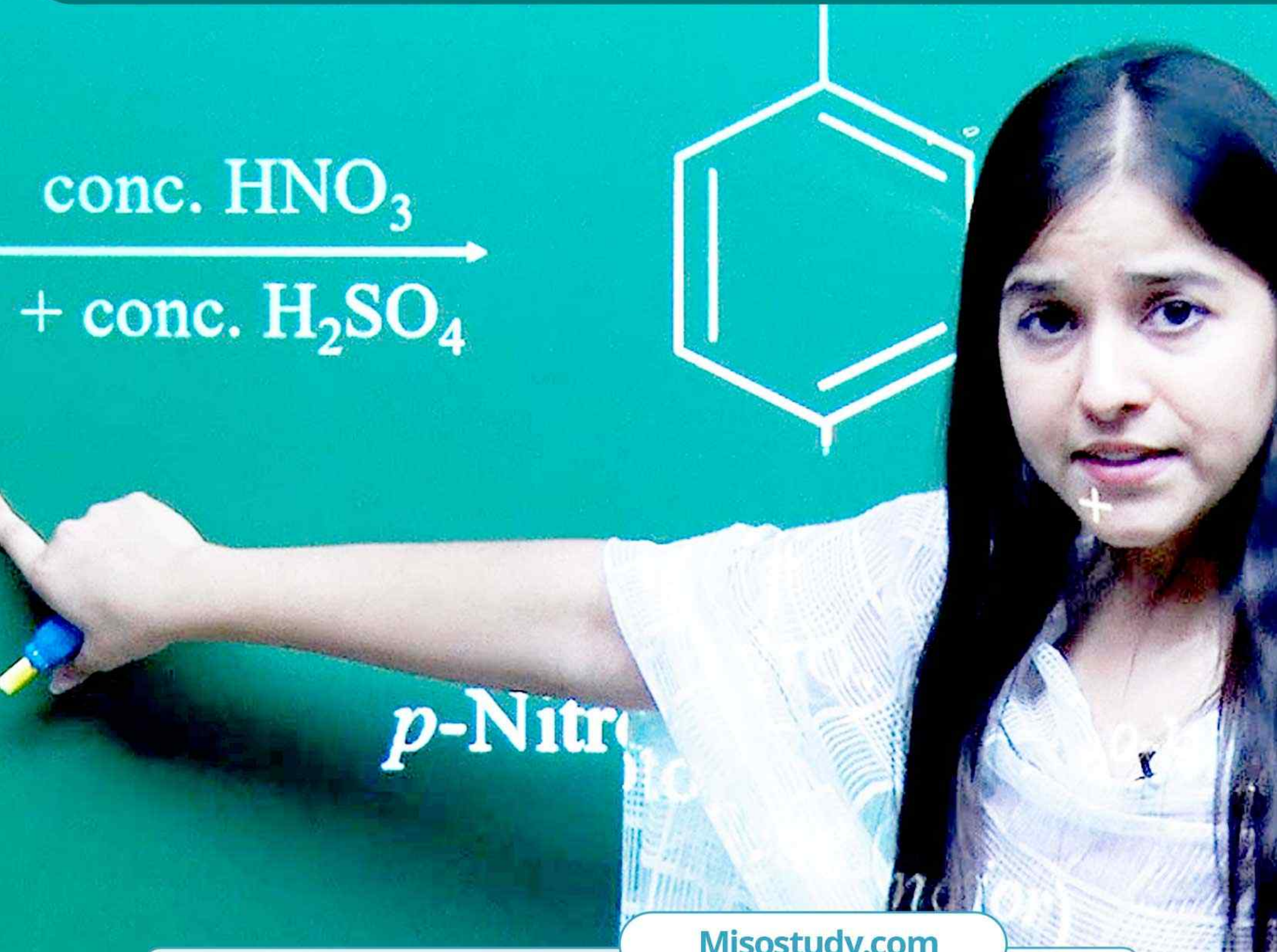
3. (c)
   carrier wave

4. (c)
   transponder

5. (c)
   Absorption and scattering

Class 12 | Chemistry

02 Solution



01. Introduction

When two or more chemically non-reacting substances are mixed and form homogeneous mixture it is called solution.

02. Types of Solution

	Solvent	Solute	Examples
1.	Gas	Gas	Mixture of gases, eg. air
2.	Gas	Liquid	Water vapour in air, mist. $CHCl_3(l)$ + $N_2(g)$
3.	Gas	Solid	Smoke, camphor (s) + $N_2(g)$
4.	Liquid	Gas	CO_2 gas dissolve in water (aerated drink), soda water.
5.	Liquid	Liquid	Mixture of miscible liquids e.g. alcohol in water.
6.	Liquid	Solid	Salt in water, sugar in water.
7.	Solid	Gas	hydrogen over palladium.
8.	Solid	Liquid	Mercury in zinc, mercury in gold i.e. all amalgams.
9.	Solid	Solid	Alloys e.g. copper in gold. zinc in copper.

03. Mass Percentage

It may be defined as the number of parts of mass of solute per hundred parts by mass of solution.

$$\% \text{ by mass } \left(\frac{w}{W}\right): = \frac{\text{Wt. of solute}}{\text{Wt. of solution}} \times 100$$

[X % by mass means 100 gm solution contains X gm solute; (100−X) gm solvent]

04. Mass-Volume Percentage (W/V %) :

It may be defined as the mass of solute present in 100 cm^3 of solution. For example, If 100 cm^3 of solution contains 5 g of sodium hydroxide, than the mass-volume percentage will be 5% NaOH solution.

$$\%\left(\frac{w}{V}\right) = \frac{\text{wt. of solute (in gm)}}{\text{volume of solution (in mL)}} \times 100$$

$$[X\%\left(\frac{w}{V}\right) \text{means 100 ml solution contains X gm solute}]$$

05. Volume Percent

It can be represented as % v/v or % volume and used to prepare such solutions in which both components are in liquids state. It is the number of parts of by volume of solute per hundred parts by volume of solution

Therefore,

$$\%\left(\frac{v}{V}\right) = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100$$

06. Parts Per Million (ppm)

This method is used for expressing the concentration of very dilute solutions such as hardness of water, air pollution etc.

$$\text{ppm of substance} = \frac{\text{Mass of solute} \times 10^6}{\text{Mass of solution}} = \frac{\text{Volume of solute} \times 10^6}{\text{Volume of solution}}$$

07. Mole Fraction:

The ratio of the number of moles of one component to the total number of all the components present in the solution, is called the mole fraction of that component.

Mole fraction of solute X_A is given by $X_A = \frac{n_A}{n_A + n_B} = \frac{n_A}{\sum n}$

Mole fraction of solvent X_B is given by $X_B = \frac{n_B}{n_A + n_B} = \frac{n_B}{\sum n}$

where n_A is moles of solute A and n_B is moles of solvent B.

For binary solution of A & B $X_A + X_B = 1$

08. Molarity (Molar Concentration) :

It is defined as the number of moles of the solute dissolved in per litre of the solution, i.e.,

$$\text{Molarity (M)} = \frac{\text{Number of moles of solute}}{\text{Volume of solution (in } l)} = \frac{w_A}{m_A \times V} = \frac{c(gm/l)}{m_A} = \frac{\% \frac{W}{W} \times d \times 10}{m_A}$$

where let w_A g of the solute of molecular mass m_A be dissolved in V litre of solution, d = density of solution in g/mL.

09. Molarity of Dilute Solution :

Before dilution		After dilution
M_1V_1	=	M_2V_2

Molarity of mixing :

Let there be three samples of solution (containing same solvent and solute) with their molarity M_1, M_2, M_3 and volumes V_1, V_2, V_3 respectively. These solutions are mixed; molarity of mixed solution may be given as:

$M_1V_1 + M_2V_2 + M_3V_3 = M_R (V_1 + V_2 + V_3)$
where, M_R = Resultant molarity
$V_1 + V_2 + V_3$ = Resultant volume after mixing

10. Some Important Point :

[Note : Molarity is dependent on volume, therefore, it depends on temperature.]

1 M	Molar solution, i.e., molarity is 1
0.5 M or M/2	Semimolar
0.1 M or M/10	Decimolar
0.01 M or M/100	Centimolar
0.001 M or M/1000	Millimolar

11. Molality (m) :

The number of moles or gram-mole of solute dissolve in 1000 gram of the solvent is called molality of the solution.

$$\text{Molality of a solution} = \frac{\text{Number of moles of solute}}{\text{Amount of solvent in kg.}} = \frac{\text{Number of moles of solute} \times 1000}{\text{Amount of solvent in grams.}}$$

12. Normality (N) :

The number of equivalents or gram equivalents of solute dissolved in one litre of the solution is known as normality (N) of the solution.

$$\text{Normality (N)} = \frac{\text{Number of gram equivalents of solute}}{\text{volume of solution in litre}} = \frac{\text{weight of solute in gram}}{\text{equivalent weight} \times \text{volume of sol}}$$

$$= \frac{\text{strength of solution in gram/litre}}{\text{Equivalent weight of solute}}$$

Equivalent weight of a substance is that weight which reacts with or displaces one gram of hydrogen, 8 grams of oxygen or 35.5 grams of chlorine.

13. Solubility of Gases

Gases dissolve in liquids in solids. For example, soda-water contains carbon dioxide dissolved in water under high pressure. Oxygen is sufficiently soluble in water to allow survival of aquatic life in lakes, rivers and oceans.
The solubility of a gas in a liquid is determined by several factors. In addition to the nature of the gas and the liquid, solubility of the gas depends on the temperature and pressure of the system. The solubility of a gas in a liquid is governed by Henry's Law which states that the solubility of a gas in a liquid is directly proportional to the pressure of the gas.

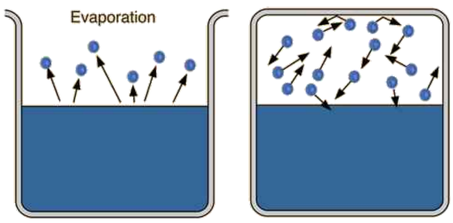
Mole fraction of the gas in a solution is proportional to the partial pressure of the gas. Or, partial pressure of the gas in solution = K_H × mole fraction of the gas in solution. Here K_H is Henry's law constant.

14. Vapour Pressure :

The Evaporation of a Liquid in a Closed Container

When a liquid is taken in a closed vessel at constant temperature, then there are two process which takes place.

(i) **evaporation**
(ii) **condensation**



In the constant evaporation from the surface particles continue to break away from the surface of the liquid.
As the gaseous particles bounce around, some of them will hit the surface of the liquid again, and will be trapped there. This is called condensation. The rate of condensation increases with time, but rate of evaporation remain constant. There will rapidly be an equilibrium set up in which the number of particles leaving the surface is exactly balanced by the number rejoining it.
This pressure at equilibrium is called the saturated vapour pressure (also known as saturation vapour pressure).

15. Effect of Temperature on Vapour Pressure

When the space above the liquid is saturated with vapour particles, you have this equilibrium occuring on the surface of the liquid :

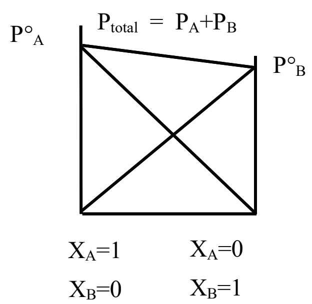
$$\text{liquid} \rightleftharpoons \text{vapour}, \quad \Delta H > 0$$

The forward change (liquid to vapour) is endothermic. It needs heat to convert the liquid into the vapour. According to Le Chatelier, increasing the temperature of a system in a dynamic equilibrium favours the endothermic change. That means increasing the temperature increase the amount of vapour present, and so increases the saturated vapour pressure.

16. Raoult's Law for Volatile Solute :

For a two component solution A (volatile) and B (volatile) the vapour pressure of solution is given by.
Vapour pressure of solution = Vapour pressure of solvent in solution + Vapour pressure of solute

According to Raoult's Law partial. pressure of a component is equal to its mole fraction in solution multiplied with partial pressure in pure state
Thus $P_A = P°_A X_A$
$P°_A$ = vapour pressure in pure state of A
X_A = Mole fraction of A in solution
P_A = Partial pressure of A in solution



Total vapour pressure of solution $P = P°_A X_A + P°_B X_B$

17. Types of Solutions :

(a) **Ideal Solution :** An ideal solution may be defined as the one which obeys Raoult's law over all concentration ranges at a given temperature. The total vapour pressure of an ideal solution containing liquids A and B is given by the following equation.

$$P = P_A + P_B = P^\circ_A X_A + P^\circ_B X_B$$

Example

benzene + toluene
ethyl bromide + ethyl iodide
ethyl alcohol + methyl alcohol
chlorobenzene + bromobenzene
n-butyl chloride + n-butyl bromide

(b) **Non-ideal solutions :** Solutions which do not over Raoult's law over all concentration ranges at constant temperature are called non-ideal solutions.

18. Distinction Between Ideal & Non Ideal Solutions

S.No.	Ideal Solution	Non Ideal Solution
1.	They obey Raoult's Law	They do not obey Raoult's Law
2.	$\Delta H_{mixing} = 0 \Rightarrow$ no heat is absorbed or released during dissolution	$\Delta H_{mixing} \neq 0 \Rightarrow$ no heat is absorbed or released during dissolution
3.	$\Delta V_{mixing} = 0 \Rightarrow$ the total volume of the solution is equal to the sum of the volume of the pure liquids mixed to form the solution	$\Delta V_{mixing} \neq 0 \Rightarrow$ the total volume of the solution is not equal to the sum of the volume of the pure liquids mixed to form the solution
4.	In ideal solution $P_A = P_A{}^0 X_A$	In non ideal solution $P_A \neq P_A{}^0 X_A$
5.	Components of ideal solution can be separated in pure form by fractional distillation	Components of non ideal solution can not be separated in pure form by fractional distillation

19. Types of Non – Ideal Solutions

(I) Non ideal solutions showing positive deviation.
(II) Non ideal solutions showing negative deviation.

20. Non Ideal Solutions Showing Positive Deviation

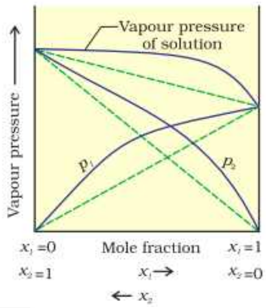
Condition for forming non-ideal solution showing positive deviation from Raoult's law. Two liquids A and B on mixing form this type of solution when

(i) A—B attractive force should be weaker than A—A and B—B attractive forces.
(ii) 'A' and 'B' have different shape, size and character.
(iii) 'A' and 'B' escape easily showing higher vapour pressure than the expected value.

Example

acetone + ethanol	acetone + CS_2	water + methanol
water + ethanol	CCl_4 + toluene	CCl_4 + $CHCl_3$
acetone + benzene	CCl_4 + CH_3OH	cyclohexane + ethanol

21. Graphical Representation of Vapour Pressure of Non-Ideal Solution Showing Positive Deviation



22. Non Ideal Solutions Showing Negative Deviation.

Condition for forming non-ideal solution showing negative deviation from Raoult's law.

Two liquids A and B on mixing from this type of solution when

(i) A—B attractive force should be greater than A—A and B—B attractive forces.

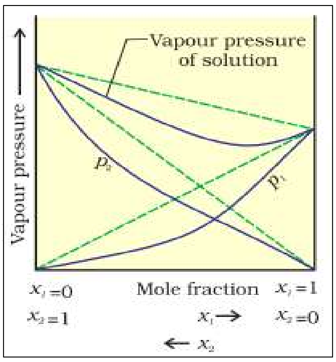
(ii) 'A' and 'B' have different shape, size and character.

(iii) Escaping tendency of both components 'A' and 'B' is lowered showing lower vapour pressure then expected ideally.

Example

acetone + aniline;	CH_3OH + CH_3COOH;
chloroform + diethyl ether,	acetic acid + pyridine;
chloroform + benzene	H_2O +HNO_3;
water + HCl	

23. Graphical Representation of Vapour of non-ideal Solution Showing Negative Deviation



24. Distinction Between Non Ideal Solutions Showing Positive Deviation & Negative Deviation

S.NO.	Showing positive deviation	Showing negative deviation
1.	$\Delta H_{mix} > 0$. (endothermic dissolution i.e. heat is absorbed)	$\Delta H_{mix} < 0$. (Exothermic dissolution i.e. heat is evolved)
2.	$\Delta V_{mix} > 0$. (Volume is increased after dissolution)	$\Delta V_{mix} > 0$. (Volume is decreased after dissolution)
3.	$p_A > p_A^oX_A$; $p_B > p_B^oX_B$, $\therefore p_A + p_B > p_A^oX_A + p_B^oX_B$	$p_A < p_A^oX_A$; $p_B < p_B^oX_B$, $\therefore p_A + p_B < p_A^oX_A + p_B^oX_B$

25. Colligative Properties

The properties of dilute solutions containing nonvolatile solute, which depends upon relative number of solute and solvent particles but do not depend upon their nature are called colligative properties.

Some of the colligative properties are
- (i) Relative lowering of vapour pressure
- (ii) Elevation in boiling point
- (iii) Depression in freezing point and
- (iv) Osmotic pressure.

26. Factor that Affect the Colligative Property

The number of solute particles in solution. To be more accurate, the colligative property depends upon the fraction of solute and solvent particles in solution.
- (1) Nature of the solvent
- (2) Independent of the nature of the solute
- (3) Extent of association and dissociation of solute particles in solution.

27. Relative Lowering of Vapour Pressure

As shown earlier the mathematical expression for relative lowering of vapour pressure is as follows

$$\frac{\Delta P}{P^o_A} = X_B = \text{mole fraction of solute}$$

$\Delta P = P^o_A - P_A$ = lowering of vapour pressure
P_A = vapour pressure of pure solvent

Molecular mass of non-volatile substance can be determined from relative lowering of vapour pressure

$$\frac{P^o_A - P}{P^o_A} = \frac{W_B/M_B}{W_A/M_A + W_B/M_B}$$

For dilute solution $W_B/M_B < W_A/M_A$ and hence W_B/M_B may be neglected in the denominator. So

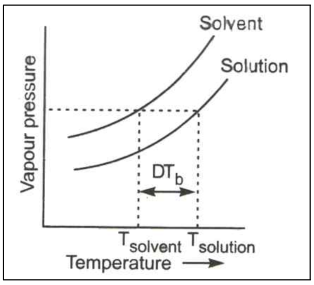
$$\frac{P^o_A - P_A}{P^o_A} = \frac{W_B/M_B}{W_A/M_A} = \frac{W_B}{W_A} \times \frac{M_A}{M_B} \text{ or } M_B = \frac{W_B/M_A}{W_A}\left(\frac{P^o_A}{P^o_A - P_A}\right)$$

28. Elevation in Boiling Point

The boiling points elevates when a non-volatile solute is added to a volatile solvent. Which occurs due to lowering of vapour pressure. The boiling point of a liquid may be defined as the temperature at which its vapour pressure becomes equal to atmospheric pressure.

So when a non-volatile solute is added to a volatile solvent results lowering of vapour pressure and consequent elevation of boiling point.
where

$\Delta T_b = T_b - T^o_b$
ΔT_b =elevation in B.P.
ΔP =lowering of V.P.
X_B =mole fraction of solute
K = elevation constant
T^o_b = boiling point of solvent
T_b =boiling point of solution



It is found that elevation of boiling point is directly proportional to the number of moles of the solute in given amount of the solvent(m).

$$\Delta T_b \propto m$$

$$\Delta T_b \propto K_b m$$

Where 'm' is the molality of solution.
Where K_b is ebullioscopic or boiling point elevation constant. When molality of the solution is equal to one. Then

$$\Delta T_b = K_b$$

Determination of K_b of solvent:

$$K_b = \frac{RT_b^2}{1000L_v}$$

where R is molar gas constant, T_b is the boiling point of the solvent on Kelvin scale and L_v the latent heat of vaporization of solvent in calories per gram.

For water $K_b = \frac{2 \times (373)^2}{1000 \times 540} = 0.515$ K-kg/mol

29. Depression in Freezing Point

The freezing point of a pure liquid is fixed. If a non-volatile solute is dissolved in a liquid the freezing point of the solution is lowered. The freezing point is that temperature at which the solvent has the same vapour pressure in two phases liquid solution and solid solvent. Since the solvent vapour pressure in solution is depressed. Its vapour pressure will become equal to that of the solid solvent at a lower temperature.

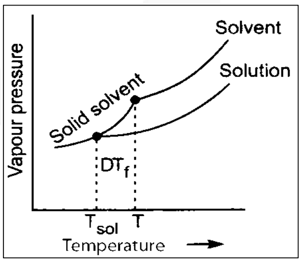
$$\Delta Tf = T^o_f - T_f$$

It is found that depression in freezing point is directly proportional to the number of moles of the solute in given amount of the solvent(m).

Hence $\Delta T_f \propto m$

$$\Delta T_f \propto K_f\, m$$

Where m = molarity of the solution.



K_f = molal depression constant
When molarity (m) of the solution is one. then

$$\Delta T_f = K_f$$

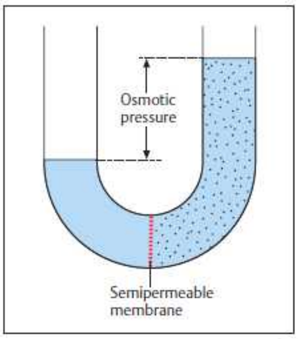
Hence molal depression constant or molal cryoscopic constant may be defined as "the depression in freezing point when one mole of non-volatile solute is dissolved per kilogram (1000 gm) of solvent" and molal depression constant is defined as "the depression in freezing point when one mole of non-volatile solute is dissolved per litre (1000 ml) of solvent."
The molecular mass of the non-volatile solute may be calculated by the use of following mathematical equation

$$M_B = \frac{K_f \times W_B \times 1000}{W_A \times \Delta T_f}$$

Where W_A = mass of solvent, W_B = mass of solute,
M_A = Molar mass of solvent, M_B = Molar mass of solute.

30. Osmotic Pressure

(i) Osmosis : Spontaneous flow of solvent molecules through a semipermeable membrane from a pure solvent to the solution (or from a dilute solution to a concentrated solution) is termed as osmosis.



(ii) Osmotic Pressure :
When a solution is separated from the pure solvent with the help of a semipermeable membrane. There occurs the flow of solvent molecules from the pure solvent to the solution side. The flow of solvent molecules from a region of higher concentration of solvent to the region of lower concentration of solvent is termed as the phenomenon of osmosis. This also happens when two solution of different concentrations are separated by s semipermeable membrane.
The excess pressure that must be applied to the solution side to prevent the passage of solvent into it through a semipermeable membrane.

(iii) Theory of Dilute Solutions :
The osmotic pressure of dilute solution was the same as the solute would have exerted if it were a gas at the same temperature as of the solution and occupied a volume equal to that of the solution. This generalization is known as Van't Hoff theory of dilute solutions. The osmotic pressure is a colligative property. So the osmotic pressure is related to the number of moles of the solute by the following relation
$\pi V = nRT$

$$\pi = \frac{n}{V} RT \qquad (\therefore \frac{n}{V} = C)$$

π = CRT

Here C = concentration of solution in miles per litre;
R = solution constant;
T = temperature in Kelvin degree;
n = number of moles of solute; and
V = volume of solution.

This equation is called Van't Hoff's equation.

31. Type of Solution :

(i) **Isotonic solution :**
The two solutions having equal osmotic pressure are termed as isotonic solution.

(ii) **Hypertonic solution :**
A solution having higher osmotic pressure than some other solution is said to be called hypertonic solution.

(iii) **Hypotonic solution :**
A solution having a lower osmotic pressure relative to some other solution is called hypotonic solution.

Semipermeable membrane :

A membrane which allows the passage of solvent molecules but not that of solute. When a solution is separated from the solvent by it is known as semipermeable membrane.
Some example of it are as follows
(a) Copper ferrocyanide $Cu_2[Fe(CN)_6]$
(b) Calcium phosphate membrane and
(c) Phenol saturated with water.

Reverse Osmosis :

If a pressure greater than the osmotic pressure is applied on the concentrated solution, the solvent starts to flow concentrated solution to dilute solution (or pure solvent). This is reverse osmosis. One of its chief uses is desalination of sea water to get pure drinking water.

32. Abnormal Molecular Masses

Vapour pressure lowering, boiling point elevation, freezing point depression and osmotic pressure are colligative properties which depend upon the fraction of solute and solvent particles in solution and not upon the chemical nature of the solute. If solute molecules dissociates in solution, there are more particles in solution and therefore, lowering of vapour pressure shows an increased effect.

$$NaCl_{(s)} \rightleftharpoons Na^{+}_{(aq)} + Cl^{-}_{(aq)}$$

If the solute molecules associates in solution, there are less particles in solution, and therefore lowering of vapour pressure shows a decreased effect.

$$nAB \rightleftharpoons (AB)_n$$
$$2C_6H_5COOH \rightleftharpoons (C_6H_5COOH)_2$$

33. Vant Hoff Factor

In 1886, Van't Hoff, Jacobs Henricus (Dutch chemist, 1859,-1911) introduced a factor 'i' known as Van't Hoff factor to express the extent to association or dissociation of a solute in solution. It can be calculated as:

$$i = \frac{\text{number of solute particles actually present in solution}}{\text{number of solute particles dissolved}}$$

$$= \frac{\text{Observed colligative property}}{\text{normal colligative property}} = \frac{\text{observed molality}}{\text{normal molality}} = \frac{\text{normal molecular weight of solute}}{\text{observed molecular weight of solute}}$$

The Van't Hoff factor for a solute can be calculated by the following modified equations:

(i) $\frac{P_A^o - P_A}{P_A^o} = iX_B$

(ii) $\Delta T_f = iK_f m$

(iii) $\Delta T_b = iK_b m$

(iv) $\pi = iCRT$

where C is molarity of the solution.

NOTE ☞ For non-electrolytes; $i = 1$
For electrolytes; $i > 1$ (If solute particles undergo Dissociation in the solution)
$i < 1$ (If solute particles undergo Association in the solution)

34. Application of Van't Hoff Factor :

(a) **Calculation of Degree of Dissociation of solute particles:**

	A_n	$\rightleftharpoons$	nA
No. of moles dissolved	1 mol		0
No. of moles after dissociation	$1 - \alpha$		$n\alpha$

Total number of moles present in solution = $(1 - \alpha) + n\alpha$

(b) Calculation of Degree of Dissociation of solute particles:

	A_n	$\rightleftharpoons$	nA
No. of moles dissolved	1 mol		0
No. of moles after dissociation	$1 - \alpha$		$n\alpha$

Total number of moles present in solution = $(1 - \alpha) + n\alpha$

$$\text{Van't Hoff factor, } \mathbf{i} = \frac{\text{Moles of solute actually present in solution}}{\text{Moles of solute dissolved}}$$

$$= \frac{(1-\alpha)+n\alpha}{1} = 1+(n-1)\alpha \quad \text{or} \quad \alpha = \frac{i-1}{n-1}$$

(c) Calculation of Degree of Association of solute particles:

Let n moles of the solute, A, associate to form $(A)_n$. If α is the degree of association.

	nA	$\rightleftharpoons$	A_n
No. of moles dissolved	1 mol		0
No. of moles after dissociation	$1 - \alpha$		α/n

Total number of moles present in solution = $(1 - \alpha) + \alpha/n$

$$i = \left[1 - \alpha\left(1 - \frac{1}{n}\right)\right] \qquad \text{Hence } \alpha = \frac{i-1}{\frac{1}{n}-1} = (i-1) \times \frac{n}{1-n}.$$

CBSE Exam Pattern Exercise
Subjective Questions (1)

(Q 1 to 2) One Mark

1. What role does the molecular interaction play in solution of alcohol and water?

2. Why do gases nearly always tend to be less soluble in liquid as the temperature is raised?

(Q 3 to 4) Two Marks

3. If the solubility product of CuS is 6×10^{-16}, calculate the maximum molarity of CuS in aqueous solution.

4. State Henry's law and mention some of its important applications.

(Q 5 to 6) Three Marks

5.
   (a) Determine the amount of $CaCl_2$ (i = 2.47) dissolved in 2.5 litre of water such that its osmotic pressure is 0.75 atm at 27°C.
   (b) Amongst the following compounds, identify which are insoluble, partially soluble and highly soluble in water (i) phenol, (ii) toluene, (iii) formic acid, (iv) ethylene glycol, (v) chloroform, (vi) pentanol

6. Calculate the mass of a non-volatile solute (molar mass 40 g mol^{-1}) which should be dissolved in 114g octane to reduce its vapour pressure to 80%.

(Q 7 to 8) Four Marks

7. 100 g of liquid A (molar mass 140 g mol^{-1}) was dissolved in 1000 g of liquid B (molar mass 180 g mol^{-1}). The vapour pressure of pure liquid B was found to be 500 torr. Calculate the vapour pressure of pure liquid A and its vapour pressure in the solution if the total vapour pressure of the solution is 475 torr.

8. The air is a mixture of a number of gases. The major components are oxygen and nitrogen with approximate proportion of 20% is to 79% by volume at 298 K. The water is in equilibrium with air at a pressure of 10 atm. At 298 K, if the Henry's law constants for oxygen and nitrogen are 3.30×10^7 mm and 6.51×10^7 mm respectively, calculate the composition of these gases in water.

(Q 9 to 10) Five Marks

9. Calculate the depression in the freezing point of water when 10 g of $CH_3CH_2CHClCOOH$ is added to 250 g of water. $K_a = 1.4 \times 10^{-3}$, K_f = 1.86 K kg mol^{-1}.

10. 19.5g of CH_2FCOOH is dissolved in 500g of water. The depression in the freezing point observed is 1.0°C. Calculate the van't hoff factor and dissociation constant of fluoroacetic acid. K_f for water is 1.86 K kg mol^{-1}.

Answer & Solution

Q1

There is strong is hydrogen bonding in alcohol molecules as well as water molecules. On mixing, the molecular interactions are weakened. Hence, their solution will show positive deviations from ideal behaviour. As a result, the solution will have higher vapour pressure and lower boiling point that of water and alcohol.

Q2

Dissolution of gas in liquid is an exothermic process (Gas + Solvent $\rightleftharpoons$ Solvent + Heat). As the temperature is increased, equilibrium shifts backward.

Q3

Maximum molarity of CuS in aqueous solution = Solubility of CuS in mol L–1

If S is the solubility of Cush in mol L^{-1}, then

$$CuS \rightleftharpoons \underset{S}{Cu^{2+}} + \underset{S}{S^{2-}} \ , \ K_{sp}=[Cu^{2+}][S^{2-}]=S\times S=S^2$$

$$\therefore \qquad S^2 = 6\times10^{-6} \text{ or } S=\sqrt{6\times10^{-16}}=\mathbf{2.45\times10^{-8}\ mol\ L^{-1}}.$$

Q4

The mass of a gas dissolved in a given volume of the liquid at constant temperature is directly proportional to the pressure of the gas present in equilibrium with the liquid.

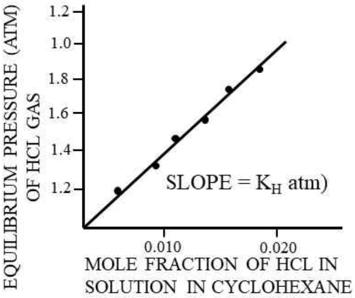
Mathematically, $m \propto P$ **or** $m = Kp$

Or

The solubility of a gas in a liquid at a particular temperature is directly proportional to the pressure of the gas in equilibrium with the liquid at that temperature.

From eqn (ii), $p_A = \frac{1}{K'}x_A$ or $P_A = K_H x_A$

The partial pressure of a gas in vapour phase (*p*) is directly proportional to the mole fraction (*x*) of the gas in the solution.



Plot of mole fraction in solution versus equilibrium pressure

Application of Henry's law:

(i) **In the production of carbonated beverages**.

(ii) **In the deep sea diving.**
bend or decompression sickness

(iii) **In the function of lungs.**

(iv) **For climbers or people living at high altitudes.**

Q5

$\pi = i\ \ CRT = i\dfrac{n}{V}RT$ or $n = n = \dfrac{\pi \times V}{i \times R \times T} = \dfrac{0.75\,atm \times 2.5\,L}{2.47 \times 0.0821\ L\ \ atm\,K^{-1}mol^{-1} \times 300\,K}$ **=0.0308 mole**

Molar mass of $CaCl_2$ = 40 + 2×35.5 = 111 g mol^{-1} ∴ Amount dissolved = 0.0308 × 111 g = **3.42g**

Q6

Reduction of vapour pressure to 80% means that if $p°$ = 100 mm, then p_s = 80 mm. Applying complete formula

$$\frac{p° - p_s}{p°} = \frac{n_2}{n_1 + n_2} = \frac{w_2 M_2}{w_1/M_1 + w_2/M_2}$$

$$\frac{100-80}{100} = \frac{w_2/40}{114/114 + w_2/40}$$ (Mol. mass of octane C_8H_{18} =114 g mol^{-1})

or $\dfrac{20}{100} = \dfrac{w_2/40}{1 + w_2/40}$ or $\dfrac{1}{5}\left(1 + \dfrac{w_2}{40}\right) = \dfrac{w_2}{40}$ or w_2 =**10g**

Note that complete formula is required because concentration of solution I greater than 5%
Complete formula can also be applied in the form

$\dfrac{p° - p_s}{p°_s} = \dfrac{w_2/M_2}{w_1/M_1}$ or $\dfrac{100-80}{80} = \dfrac{w_2/40}{114/114}$ or $\dfrac{1}{4} = \dfrac{w_2}{40}$ or w_2 =**10g**

Alternatively, suppose mass of solute dissolved = w g

Moles of solute $= \dfrac{w}{40}g$

Moles of solvent (octane) $= \dfrac{114}{114} = 1\,mole$ (Mol. mass of C_8H_{18}=114g mol^{-1})

∴Mole fraction of solvent $= \dfrac{1}{1 + w/40}$

For a non-volatile solute,
Vapour pressure of solution =Mole fraction of solvent in the solution ×Vapour pressure of pure

solvent

$P_s = x_1 \times p°$

$\therefore\ 80 = \dfrac{1}{1+w/40} \times 100$ or $1 + \dfrac{w}{40} = \dfrac{100}{80}$ or $\dfrac{w}{40} = \dfrac{10}{8} - 1 = \dfrac{2}{8} = \dfrac{1}{4}$ or w = **10g**

Q7

No of moles of liquid A (solute) $= \dfrac{100\,g}{140\,g\ mol^{-1}} = \dfrac{5}{7}$ mole

No. of moles of liquid B (solvent) $= \dfrac{1000\,g}{180\ g\ mol^{-1}} = \dfrac{50}{9}$ mole

$\therefore$Mole fraction of A in the solution (x_A) $= \dfrac{5/7}{5/7+50/9} = \dfrac{5/7}{395/63} = \dfrac{5}{7} \times \dfrac{63}{395} = \dfrac{45}{395} = 0.114$

$\therefore$Mole fraction of B in the solution (x_B)=1 –0.114 = 0.886

Also, given $P_B°$=500 torr

Applying Raoult's law, $P_A = x_A\ P_A° = 0.114 \times P_A°$

$P_B = x_B\ P_B°$ = 0.886×500=443 torr

$P_{Total} = p_A + p_B$

475=0.114 $P_B°$+ 443 or $p_A° = \dfrac{475-443}{0.114}$ = **280.7 torr**

Substituting this value in eqn. (*i*), we get P_A =0.114×280.7 torr = **32 torr.**

Q8

Total pressure of air in equilibrium with water =10 atm

As sir contains 20% oxygen and 79% nitrogen by volume,

$\therefore$ Partial pressure of oxygen (p_{O_2})$= \dfrac{20}{100} \times 10$ atm = 2 atm = 2×760 mm =1520 mm

Partial pressure of oxygen (p_{N2}) $= \dfrac{79}{100} \times 10\,atm$ = 7.9 atm 7.9×760 mm = 6004 mm

$K_H(O_2)$ =3.30×10^7 mm, $K_H(N_2)$=6.51×10^{7}mm

Applying Henry's law, $Po_2 = K_H \times xo_2$ or $x_{O_2} = \dfrac{p_{O_2}}{K_H} = \dfrac{1520\ mm}{3.30 \times 10^7\ mm} = 4.61 \times 10^{-5}$

$p_{N_2} = K_H \times x_{N_2}$ or $x_{N_2} = \dfrac{P_{N_2}}{K_H} = \dfrac{6004\ mm}{6.51 \times 10^7 mm}$ = **9.22×10^{-5}.**

Q9

Molar mass of $CH_3CH_2CHClCOOH$=15+14+13+35.5+45=122.5 g mol^{-1}

10 g of $CH_3CH_2CHClCOOH = \dfrac{10}{122.5}$ mole $= 8.16 \times 10^{-2}$ mole

$\therefore$ Molality of the solution (m) $\dfrac{8.16 \times 10^{-2} mole}{250\,g} \times 1000\,g\ kg^{-1} = 0.3264$

Of *a* is the degree of dissociation of $CH_3CH_2CHClCOOH$, then

$CH_3CH_2CHClCOOH \rightleftharpoons CH_3CH_2CHClCOO^- + H^+$

Initial conc. C mol L^{-1} 0 0

At eqm. $C(1-\alpha)$ $C\alpha$ $C\alpha$

$$\therefore \quad Ka = \frac{C\alpha . C\alpha}{C(1-\alpha)} \simeq C\alpha^2 \text{ or } \alpha = \sqrt{\frac{K_a}{C}} = \sqrt{\frac{1.4\times10^{-3}}{0.3264}} = 0.065$$

To calculate van't Hoff factor:

$$CH_3CH_2CHClCOOH \rightleftharpoons CH_3CH_2CHClCOO^- + H^+$$

Initial moles 1

Moles at eqm. $1-\alpha$ α α Total $= 1+\alpha$

$$i = \frac{1+\alpha}{1} = 1+\alpha = 1+0.065 = 1.065 \; ; \; \Delta T_f = i\, K_f m = (1.065)(1.86)(0.3264) = \mathbf{0.65°.}$$

Q10

Hence, W_2=19.5g, w_1=500 g, Kf =1.86 K kg mol^{-1}, $(\Delta T_f)_{obs}$ = 1.0°

$$\therefore M2 \text{ (observed)} = \frac{100K_f w^2}{w_1 \Delta T_f} = \frac{(1000\,g\ kg^{-1})(1.86\,K\ kg\ mol^{-1})(19.5g)}{(500\,g)(1.0\,K)} = 72.54 \text{ g}$$

M_2 (calculated) for CH_2FCOOH =14+19+45=78 g mol^{-1}

$$\text{van't Hoff factor } (i) = \frac{(M_2)_{cal}}{(M_2)_{obs}} = \frac{78}{72.54} = \mathbf{1.0753.}$$

Calculation of dissociation constant. Suppose degree of dissociation at the given concentration is α.

Then $CH_2FCOOH \rightleftharpoons CH_2FCOO^- + H^+$

Initial C mol L^{-1} 0 0

At eqm. $C(1-\alpha)$ $C\alpha$ $C\alpha$, Total = $C(1+\alpha)$

$$i \quad i = \frac{C(1+\alpha)}{C} = 1+\alpha \text{ or } \alpha = i-1 = 1.0753-1 = 0.0753$$

$$K_\alpha = \frac{[CH_2FCOO^-][H^+]}{[CH_2FCOOH]} = \frac{C\alpha . C\alpha}{C(1-\alpha)} = \frac{C\alpha^2}{1-\alpha}$$

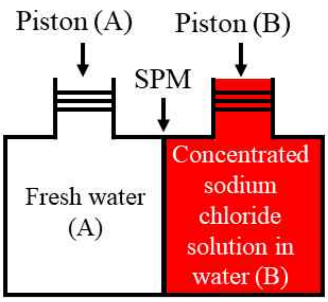
Taking volume of the solution as 500 mL,

$$C = \frac{19.5}{78} \times \frac{1}{500} \times 1000 = 0.5M \quad \therefore \quad K_a = \frac{C\alpha^2}{1-\alpha} = \frac{(0.5)(0.0753)^2}{1-0.0753} = 3.07\times10^{-3}.$$

CBSE Exam Pattern Exercise
Objective Questions (2)

1. Considering the formation, braking and strength of hydrogen bond, predict which of the following mixtures will show a positive deviation from Raoult's law ?
   (a) Methanol and acetone
   (b) Chloroform and acetone
   (c) Nitric acid and water
   (d) Phenol and aniline

2. Consider the figure and mark the correct option.
   (a) water will move form side (A) to side (B) if a pressure lower than osmotic pressure is applied on piston (B)



   (b) water will move from side (B) to side (A) if a pressure greater than osmotic pressure is applied on piston (B)
   (c) water will move from side (B) to side (A) if a pressure equal to osmotic pressure is applied on piston (B)
   (d) water will move from side (A) to side (B) if pressure equal to osmotic pressure is applied on piston (A)

3. If two liquids A and B form minimum boiling azeotrope at some specific composition, then ....
   (a) A–B interactions are stronger than those between A–A or B–B
   (b) vapour pressure of solution increases because more number of molecules of liquids A abd B can escape from the solution
   (c) vapour pressure of solution decreases because less number of molecules of only one of the liquids escape from the solution
   (d) A–B interactions are weaker than those between A–A or B–B

4. 4L of 0.02 M aqueous solution of NaCl was diluted by adding one litre of water. The molality of the resultant solution is ....
   (a) 000.4
   (b) 0.008
   (c) 0.012
   (d) 0.016

5. K_H value for Ar(g), CO_2(g), HCHO (g) and CH_4(g) are 40.39, 1.67, 1.83×10^{-5} and 0.413 respectively.
Arrange these gases in the order of their increasing solubility.
(a) HCHO < CH_4 < CO_2 < Ar
(b) HCHO < CO_2 < CH_4 < Ar
(c) Ar < CO_2 < CH_4 < HCHO
(d) Ar < CH_4 < CO_2 < HCHO

The questions given below consists of an Assertion and the Reason. Use the following key to choose the appropriate answer.
(a) If both assertion and reason are CORRECT and reason is the CORRECT explanation of the assertion.
(b) If both assertion and reason are CORRECT, but reason is NOT THE CORRECT explanation of the Assertion.
(c) If assertion is CORRECT, but the reason is INCORRECT.
(d) If both assertion and reason are INCORRECT.

6. **Assertion :** When NaCl is added to water, a depression in freezing point is observed.
Reason : The lowering of vapour pressure of a solution causes depression in the freezing point.

Answer & Solution

Q1. (a)

H — O....H—O....H—O.... .
      | | |
    CH_3 CH_3 CH_3

On adding acetone, its molecules get in between the molecules of methanol braking hydrogen bonds and reducing methanol-methanol attractions.

Q2. (b)

The process represented in the image is the reverse osmosis (R.O) which takes place when pressure more than osmotic pressure is applied to the solution.
Due to this, the solvent will flow from the solution into the pure solvent through semi permeable membrane.

Q3. (d)

Minimum boiling azeotrope is formed when actual vapour pressure in higher than expected, i.e. solution shows +ve deviation from Raoult's law which is so when A–B interactions are weaker than A–A or B–B interactions.

Q4. (d)

$M_1V_1 = M_2V_2$, $0.02 \times 4 = M_2 \times 5$ or $M_2 = 0.016$

Q5. (c)

acceleration to the henry's law

$$P_A = K_H \, x_A$$

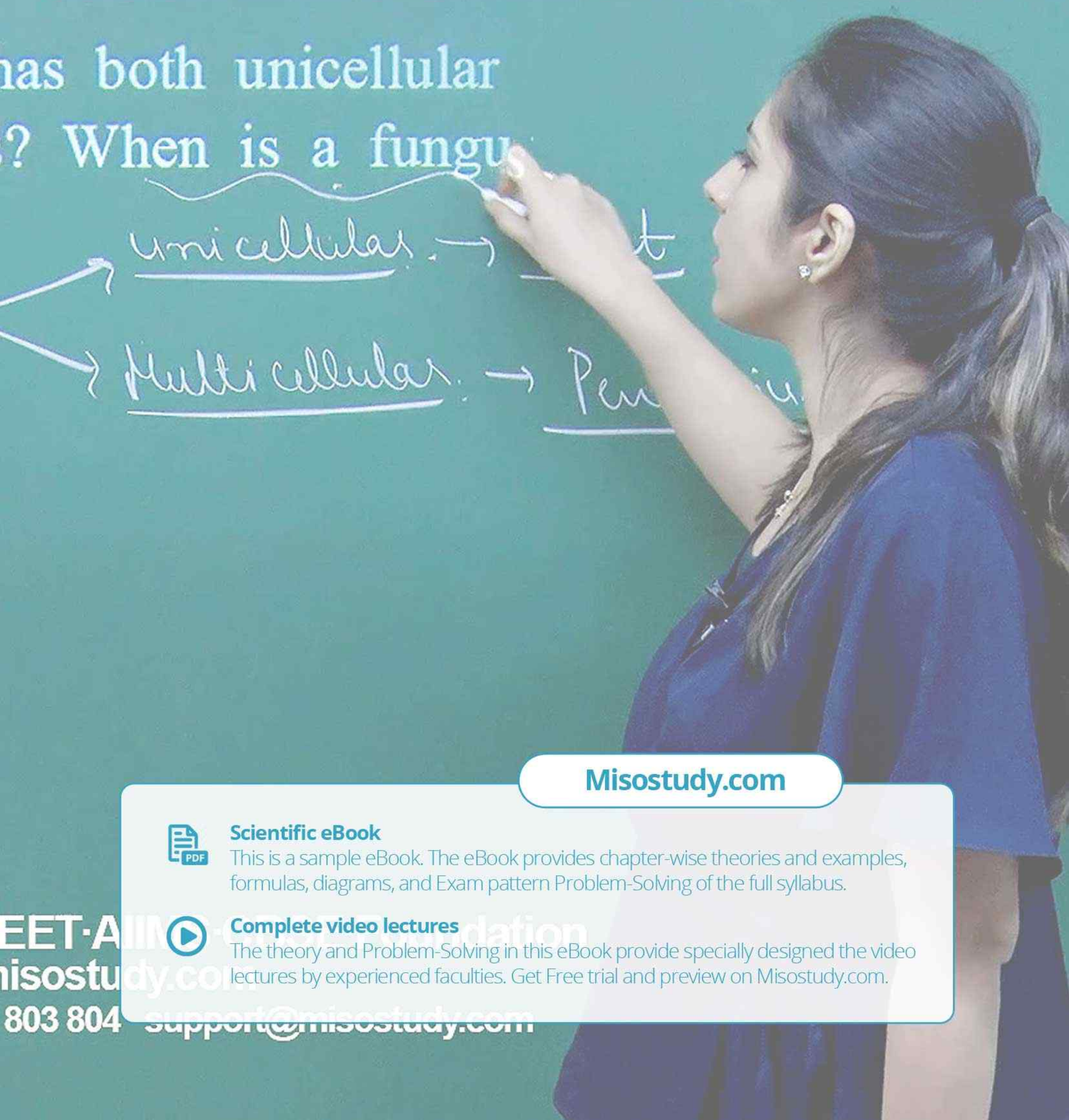
If x_A has a lower value, then K_H will increase, $\therefore$ solubility decrease.

Q6. (a)

Reason is the correct explanation of the assertion.

Class 12 |Biology

03 Reproduction in Organism



01. Introduction

A vast number of plant and animal species have existed on the earth for several thousand of years. The process in living organisms that ensures this continuity is Reproduction. Reproduction is one of the most characteristic feature of living organisms. Life will not exist on the earth if plants and animals do not reproduce to make offsprings.

02. Life span

Life span can be defined as the period from birth to the natural death of an organism. It can vary from as short as few days to as long as a number of years.

Maximum Life Span : Maximum life span is the maximum number of years survived or the greatest age reached by any member of a species. The average life span refers to the average number of years survived or age reached by the members of a population. The maximum life span of a domestic dog is about 20 years and that of a laboratory mouse is 4.5 years. The maximum life span of humans has been estimated to be about 121 years.

03. Reproduction

Reproduction is the means of self perpetuation of a race in which new, young, similar looking individuals are formed by the grown up or adult individuals. The adults which give rise to young ones are called parents.

Functions of Reproduction :

(i) It replaces the individuals dying due to senescence or ageing.

(ii) Individuals removed from population due to predation or disease are replaced through reproduction.

(iii) It introduces variations essential for adaptability and struggle for existence.

Basic Features of Reproduction :

(i) Replication of DNA.

(ii) Division of cells. It may or may not involve meiosis.

(iii) Growth due to synthesis of more protoplasm.

(iv) Formation of reproductive units.

(v) Elaboration and development of reproductive units to form new young individuals.

Types of Reproduction

Broadly speaking, there are two types of reproduction, asexual and sexual. Asexual reproduction does not involve gamete formation and fusion. It is uniparental. On the other hand, sexual reproduction consists of formation and fusion of gametes of opposite sexes. It is mostly biparental with two types o parents of different sexes but can be single/uniparental also, as in case of bisexual or hermaphrodite animals.

I. Asexual Reproduction

It is the mode of reproduction in which new individuals develop directly from specialised or unspecialised parts of a single parent without involving fusion of gametes or sex cells.
Asexual reproduction occurs in both single celled and multicelled individuals. The parent individual splits, buds or fragments to form identical daughter cells or individuals, e.g., Amoeba, Paramoecium, Euglena (acellular protists), Sycon, Hydra, Tubularia, Planaria, Ascidia (metazoans). Asexual reproduction is also called agamogenesis or agamogeny. In this mode of reproduction, somatic cells undergo mitosis during the formation of a new individual.
Therefore, it is also called somatogenic reproduction. Young ones resulting from asexual reproduction are exactly identical with the parent except in size and are called clones. Each individual of a clone is referred to as a ramet.
Asexual reproduction occurs by fission, budding and fragmentation.

(A) Fission : It is a mode of asexual reproduction in which the body of a mature individual divides into two or more similar and equal sized daughter individuals. Fission can be binary fission or multiple fission.

(a) **Binary Fission :** It is the division of the body of an individual into two equal halves, each of which functions as an independent daughter individual. In unicellular organisms, binary fission is accompanied by mitotic division of nucleus followed by cytokinesis. In metazoans. The organisms which undergo binary fission seldom die of senescence or old age because as soon as they mature, they divide into two daughters. They are, therefore, nearly immortal. Depending on the plane of division, binary fission is of the following types:

(i) **Simple Binary Fission (Irregular Binary Fission) :** Division can occur through any plane e.g., Amoeba.

(ii) **Longitudinal Binary Fission :** The plane of fission passes along the longitudinal axis of the organism, e.g., Euglena, Vorticella.

(iii) **Oblique Binary Fission :** The plane of binary fission lies at an angle to the transverse axis e.g., Ceratium, Gonyaulax.

(iv) **Transverse Binary Fission :** The plane of binary fission runs along the transverse axis of the individual, e.g., Paramoecium, diatoms, bacteria. In Paramoecium, transverse binary fission is preceeded by a mitotic division of meganucleus and mitotic division of micronucleus. In it, binary fission produces two dissimilar daughters, one proter (anterior) and the other opisthe (posterior). Both develop the deficient components and become similar.

(b) **Multiple Fission :** The nucleus divides several times by amitosis to produce many nuclei, without involving any cytokinesis. Later, each nucleus gathers a small amount of cytoplasm around it and the mother individual splits into many tiny daughter cells (e.g., Amoeba, Plasmodium, Monocystis, etc). In course of time, each of these daughter cells starts a free life and transforms into an adult individual. This kind of fission is called multiple fission.

(c) **Cyst formation :** In response to unfavourable living conditions, an Amoeba withdrawn its pseudopodia and secretes a three-layered hard covering or cyst around itself.

This phenomenon is termed as **encystation.** During favourable conditions, the encysted Amoeba divides by multiple fission and produces many minute amoubae or pseudopodiospores; the cyst wall bursts out and the spores are liberated in the surrounding medium to grow up into many Amoebae. This phenomenon is known as sporulation. Acellular protists like sporozoans (e.g., Monocystis, Plasmodium, etc.) typically exhibit sporulation in their life cycles.

(B) Budding : In budding, new individuals are formed by mitosis. Initially, a small outgrowth of the parent's body develops into a miniature individual. It then separates from the mother to lead a free life (e.g., Hydra). This type of budding is known as exogenous budding. Sometimes, the buds do not get separated from the mother individual and form a colony. For example, in Obelia, the colony consists of a number of individuals jor zooids that perform different functions. In all fresh water sponges (e.g., Spongilla) and some marine sponges (e.g., Sycon), the parent individual releases a specialized mass of cells enclosed in a common opaque envelope, called the gemmule. On germination, each gemmule gives rise to offspring and the archeocytes present in it give rise to various cells of the body of sponge as they are **totipotent**. Gemmules are thought to be **internal buds**.

(C) **Fragmentation :** The body of the parent breaks into distinct pieces, each of which can produce an offspring (e.g., Hydra, some marine worms, sea-stars).

Advantages of Asexual Reproduction :

(a) It is uniparental.
(b) It is a rapid mode of reproduction.
(c) The young ones are exact replicas of their parent.
(d) Asexual reproduction is simpler than sexual reproduction.

Disadvantages of Asexual Reproduction :

(a) As there is rapid multiplication, a large number of young ones are formed which causes overcrowding.
(b) There is no mixing of genetic material, so no new combination or variation takes place.
(c) There is no crossing over, hence hew linkages are not formed.
(d) It has no role in evolution.
(e) Adaptability to changes in environment is low due to absence of new variations.

II. Sexual Reproduction

Sexual reproduction involves formation and fusion of gametes to form the zygote which develops to form a new organism.

Characteristics :

(a) Two fusing gametes can be produced by same individual or different individuals.
(b) Offsprings produced are not identical to parents.
(c) It involves meiosis and syngamy (fusion or gametes).
(d) It is a slow, elaborate or complex process, so multiplication is not so rapid.

Phases in Life Cycle

(a) Juvenile phase
(b) Reproductive phase
(c) Senescent phase

(a) **Juvenile phase/Pre-reproductive phase :** During this phase organism will show growth so that it can attain certain maturity to perform the sexual reproduction. This phase is known as vegetative phase in plants. It is of variable durations in different organisms.
(b) **Reproductive phase :** Reproductive organs develop and mature during this phase. In the higher plants (Angiosperms). end of juvenile phase or onset of reproductive phase is easily marked. In the higher plants during this phase, there is formation of reproductive structures i.e., flowers.
(c) **Senescent phase :** It is a post-reproductive phase. It involves structural and functional deterioration of body by accumulation of waste metabolites which ultimately leads to death.

Events in Sexual Reproduction

After attainment of maturity, all sexually reproducing organisms exhibit events and processes that have remarkable fundamental similarity, even though the structures associated with sexual reproduction are indeed very different. These sequential events may be grouped into three distinct stages, namely, the pre-fertilization, fertilization and the post-fertilization events.

A. Pre-fertilization Events

These are events in sexual reproduction which occur prior to the process of fertilization. The two main pre-fertilization events are **gametogenesis** and **gamete transfer.**

(a) **Gametogenesis :** It refers to the process of formation of gametes – male and female.
Categories of Gametes :

(i) **Isogametes :** When the fusing gametes are morphologically similar they are known as isogametes or homogametes. They are produced in some algae and fungi.
- Algae : Cladophora, Chlamydomonas debaryana, Ulothrix
- Fungi : Synchytrium, Rhizopus

(ii) **Heterogametes :** When the fusing gametes are morphologically distinct types, they are known as heterogametes. It is the feature of majority of sexually reproducing organisms. e.g.
(a) Algae : Fucus, Volvox, Chara
(b) All Bryophytes, Pteridophytes, Gymnosperms and Angiosperms.
In such organisms, male gamete is called antherozoid or sperm and the female gamete is called egg or ovum

Cell Division During Gamete Formation : Gametes are always haploid i.e., they possess only one set of chromosomes or genome though the parent body producing gametes may be either haploid or diploid. As gametes are always haploid so surely in haploid parent, gametes are produced by mitotic division. In plants belonging to group pteridophytes, gymnosperms and angiosperms and animals the parental body is diploid. Here reductional division occurs before or at the time of gamete formation. The cells which undergo meiosis ar called meiocyte. If meiocyte is indulged in gamete formation, then it is called gamete mother cell. In haploid organisms, gametes are produced through mitosis but you must not think that meiosis never occurs in life cycle of haploid organisms.
This could be made clear from what you have learnt in previous classes. In these organisms like haploid algae and some fungi, meiosis occurs in zygote or zygospore which is called zygotic meiosis.

04. Sexuality in Organisms :

Lower Organisms : In most of the lower sexually reproducing organisms, two fusing gametes are morphologically similar. If these gametes belong to the same parent then such organisms are called homothallic, e.g., fungi (Mucor mucedo). When these gametes belong to different parents then these organisms are called heterothallic.

Higher Organisms : In higher plants there are well-developed sex organs and there is clear distinction between male and female sex organs. Angiosperms possess flowers as reproductive structures. The male sex organ is called stamen and female sex organ is carpel or pistil. If male and female sex organs occur in the same flower then these plants are called bisexual, e.g., China rose. If flowers possess only stamen or carpel then these plants are called unisexual. When male flower (staminate) and female flower (pistillate) are present on same plant body such plants are monoecious, e.g., cucurbits, coconut and maize. However, if they are present on separate plant body then these plants are known as dioecious, e.g., date palm and papaya.

05. Gamete Transfer :

After the formation of male and female gametes, compatible gametes must be physically brought together to facilitate fusion (fertilisation or syngamy). In few fungi and algae, both types of gametes are motile. But in majority of organisms male gamete is motile and the female gamete is non-motile. So there is a need of a medium through which the male gametes move.
In seed plants both male and female gametes are non-motile. Here pollen grains are the carrier of male gametes and ovule has the egg. As the male gamete is non-motile so it cannot swim through water medium to reach female gamete rather pollen tube serve this purpose. For this pollen grain produced in anther (♂ part) are transferred to the stigma of female organ i.e., carpel through the process of pollination.

Pollination is of two type i.e., self pollination and cross pollination. Self pollination is the transfer of the pollen grains from anther of a flower to the stigma of same flower or different flower of the same plant. Cross pollination is transfer of the pollen grain from anther of one flower to the stigma of different flower of other plant.

06. Fertilization

The most vital event of sexual reproduction is the fusion of gametes. This process is called syngamy or fertilization which results in the formation of a diploid zygote.

(a) **External fertilization :** Syngamy occurs outside the body of organism in external medium (water). It is shown by majority of aquatic organisms like most of algae, fishes as well as amphibians.

(b) **Internal fertilization :** Syngamy occurs inside the body of organisms. It is present in majority of plants like bryophytes, pteridophytes, gymnosperms and angiosperms. It occurs in few algae like spirogyra. In all these organisms egg is formed inside the female body where syngamy occurs.

07. Post-Fertilization Events

Events in sexual reproduction after the formation of zygote are called post-fertilization events.
Zygote : It is the first cell of the new generation in all sexually reproducing organisms. Zygote is always diploid. It is formed in the external aquatic medium in those organisms which perform external fertilization. Zygote is produced inside the body in cases where fertilization in internal.
In many algae and fungi, the zygote secretes a thick wall that is resistant to desiccation and damage, which help organisms to tide over unfavourable conditions. During unfavourable conditions it undergoes a period of rest until a swing back to sustainability occurs.
Embryogenesis : Embryogenesis is the process of development of embryo from zygote. Embryo is a multicellular stage in the life cycle of a plant or animal prior to formation of an independent individual. In embryogenesis, the zygote undergoes repeated cell divisions through mitosis. Cell differentiation occurs at specific locations resulting in production of different tissues, organs and organ systems. Development of different external and internal structures is called morphogenesis. Embryo formation is present in all plant groups, except algae. In flowering plants, zygote develops into embryo. The food for development of embryo comes from a special tissue known as endosperm. Ultimately, the fertilized ovule matures into a seed. Inside the mature seed is the progenitor of the next generation, the embryo. A number of seeds develop in an ovary depending upon the number of ovules. Meanwhile, wall of the ovary also proliferates. It produces pericarp or fruit wall. The pericarp can be dry or fleshy. The ripened ovary with pericarp and seeds is called fruit.

Differences between Asexual and Sexual Reproduction	
Asexual Reproduction	**Sexual Reproduction**
i. New individuals are formed from a single parent.	i. Commonly two parents are involved in the formation of new individuals through sexual reproduction.
ii. Asexual reproduction does not require the production of sex organs.	ii. Formation of sex organs is a pre-requisite for sexual reproduction.
iii. It does not involve meiosis. All divisions are mitotic.	iii. Sexual reproduction involves meiosis at one or the other stage. In higher plants, it occurs at the time of spore formation or sporogenesis.
iv. Asexual reproduction does not involve fusion of cells or gametes.	iv. It involves fusion of gametes.
v. New individual develops from one cell or a part of one parent.	v. New individual develops from zygote i.e., fusion product of two gametes.
vi. New individuals are genetically similar to the parents.	vi. Offspring or new individuals are genetically different from either of the two parents.
vii. It does not introduce variability. Hence, asexual reproduction has no evolutionary importance.	vii. It introduces variability and is, hence of evolutionary importance.
viii. It is quick method of multiplication.	viii. Sexual reproduction is a slower method of multiplication.
ix. It is simple process.	ix. It is elaborate or complex process.

CBSE Exam Pattern Exercise
Subjective Questions (1)

(Q 1 to 3) One Mark

1. Write the name of the organism that is referred to as 'Terror of Bengal'.

2. Give one example each of a fungus which reproduces by
   (i) budding (ii) conidia

3. Name an organisms, where cell division is itself a mode of reproduction.

(Q 4 to 6) Two Marks

4. Name an alga that reproduces asexually through zoospores. Why are these reproductive units so called?

5. Offsprings produced by asexual reproduction are called clones. Justify

6. Unicellular organisms are immortal, whereas multicellular organisms are not. justify.
   (i) Name the organism that reproduce. through the following reproductive structures:
      (a) Conidia (b) Zoospores
   (ii) Mention similarity and one difference between these two reproductive units.

(Q 7 to 8) Three Marks

7. Which one of the following statements is true for years?
   (i) The cell divides by binary fission. One of them develops into a bud.
   (ii) The cell divides unequally. The smaller cell develops into a bud.
   (iii) The cell produces conidia, Which develop into a bud.

8. Coconut palm is monoecious, while date palm is dioecious. Why are they so called?

(Q 9 to 10) Five Marks

9.
   (i) List the three states the annual and biennial angiosperms have to pass through during their life cycle.
   (ii) List and describe any two vegetative propagules in flowering plants.

10. Differentiate between an annual and biennial plant. Provide one example of each.

Answer & Solution

Q1
Water hyacinth is referred to as the 'Terror of Bengal'

Q2
Fungus that reproduces by
(i) budding–Yest
(ii) conidia–*penicillium*

Q3
In unicellular organisms like *Amoeba*, bacteria, etc, cell division itself is a mode of reproduction

Q4
Chlamydomonas in an alga that reproduces asexually through zoospores. Due to mobility (motile), these reproductive units are referred to as zoospores.

Q5
Offsprings produced by asexual reproduction are called clones. because
(i) they are morphologically similar to their parent.
(ii) they have same genetic composition as their parent.

Q6
Unicellular organism are considered immortal mainly because, in them the parent body as a whole

constitutes the reproductive unit and after reproductive continues to live as daughter cells. The multicellular organisms produce their reproductive structures in speacialised organs and their whole body dies due to ageing and senescence.

Q7
Statement (ii) is true for yest. The cell division unequally. The smaller cell develops into a bud.

Q8
Papaya and date palm plants are said to be dioecious because male and female flowers are borne on separate plants. whereas cucurbits and coconut palms are monoecious because male and female flowers are borne on the same plant.

Q9
Water hyacinth is referred to as the Terror of Bengal'

Q10

Annual plants	Biennial plants
These plants complete their life cycle in one year.	These plants complete their life cycle in two years.
The vegetative and reproductive phases occur within a year only.	Flowering occurs during second year, after a year of vegetative growth.
Since, these plants require less time, they	Due to more required time in growing, these plants are of high maintenance type.
E.g cereals, legumes, marigold, gerberas, etc.	E.g trees, shrubs and some grasses, poppy foxglove, etc

CBSE Exam Pattern Exercise
Objective Questions (2)

1. Stock and scion are used in
   (a) cutting
   (b) grafting
   (c) layering
   (d) micropropagation

2. In ginger, vegetative propagation occurs through.
   (a) rhizome
   (b) offsets
   (c) bulbils
   (d) runners

3. Which of the following pairs is not correctly match?

Mode of reproduction		Example
(a) Offset	—	Water hyacinth
(b) Rhizome	—	Banana
(c) Binary	—	Sargassum
(d) Conidia	—	Penicillium

4. Which of the following processes ensures the continuity of life on earth?
   (a) Reproduction
   (b) Respiration
   (c) Digestion
   (d) Growth and development

5. Budding is found in
   (a) Sycon
   (b) Hydra
   (c) Fasciola
   (d) Obelia

Answer & Solution

Q1. (b)
Stock and scion are used in grafting. Grafting is a horticulture technique wherein tissues from one plant are inserted into those of another, so that the two sets of vascular tissues join together.
This technique is mist commonly used in asexual propagation of commercially grown plants. In this technique, one plant is selected for its roots and is called the **stock** or **root stock.**
The other plant is selected for its stems, leaves, flowers or fruits and is called the **Scion.** The scion and stock contains the desired genes to be duplicated in future production by the stock and scion plant.

Q2. (a)
In ginger, vegetative propagation occurs through rhizome. Rhizomes are stems which grow horizontally under the ground.
In ginger, the underground stems are swollen with food reserves. The terminal bud grows upward to produce the flowering shoot and the lateral buds grow out to form new plant.

Q3. (c)
The plant body of Sargassum is a diploid sporophyte. It does not multiply asexually by means of spores instead, it the only known method of vegetative means, i.e. fragmentation, which is the only known method of vegetative reproduction in the free-floating species of Sargassum.

Q4. (a)
Reproduction is the process of formation of new individuals of a species fromt the pre-existing one. It is meant for perpetuation of a species because the older individuals of each species undergo senescence and die.

Q5. (b)
Hydra reproduces asexually by exogenous budding, a type of vegetative propagation and sexually by formation of gametes. Hydra reproduces by budding, when plenty of food is available.