St. Xavier's Sr. Sec. School, Chandigarh

Class 12 **English Worksheet -1**

The Tempest By Shakespeare

Question 1.

Relationships play an important role in every scene and explore the negative and positive aspects of every relationship. Discuss this in relation to:

- Prospero and Caliban
- Prospero and Miranda
- Prospero and Ariel
- Gonzalo and the boatswain
- Gonzalo and other noblemen
- Stephano ,Trinculo and Caliban
- Miranda and Ferdinand

Points to remember while answering the question:

1. Every relationship needs to be critically evaluated.
2. Any theme it gives arise, you need to mention that.
3. Symbolic meaning if there, needs to be discussed.
4. You will quote lines from the text to support your answer.
5. Answers should be organized and according to the sequence of the play, please do not write your answers in a haphazard manner and picking events from anywhere.
6. The answer should be written in the following manner:
    - Introduction
    - Relationship
    - Supported quotes for all answers
    - Quotes should be in inverted commas and underlined
    - Critically reviewing of the relationship
    - Concluding it in a proper manner with the resultant outcome of the relationship

P.S- Please use your brains and do not copy from your friends.

Question 2

Write a original short story beginning with the following words :

I never thought that staying at home could be…….

Points to remember:

- Every story has to be original
- Story should have the following: Logical Beginning (meaning that you have to Start with the given lines and nothing else), should have a Plot, Characters, Dialogues and a Logical Ending.
- The story should not be a dream.
- It should not have an abrupt ending.
- The story should be concluded in a proper manner.

Class XII **Maths Worksheet-1**

MATRICES- Matrix is an arrangement of elements in rows and columns. Each element is denoted by a particular path a_{ij} i.e. element of ith row and jth column.

The matrix having m rows and n columns is called a Matrix of order mxn.

- A matrix having only one row and any number of columns is called **Row Matrix**
  For eg. A = [1 5 3 -7] is 1 x 4 Row Matrix
- A matrix having only one column and any number of rows is called **Column Matrix**
  For eg A = $\begin{pmatrix} 1 \\ -2 \\ 3 \end{pmatrix}$ is 3x1 Column Matrix.
- A matrix having all the elements as zero is called **Null Matrix or Zero Matrix.**
  For e.g. A = $\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$ is a 2x3 Null Matrix
- A matrix is called a **Rectangular Matrix** if number of rows and number of columns are unequal and it is called a **Square Matrix** if it has same number of rows and columns.
  For e.g. 2x2 , 3x3 …. are square matrices whereas 2x3, 4x1, 5x2 ….. are rectangular matrices.
- A square matrix with all the non diagonal elements as zero is called a **Diagonal Matrix.**
  For e.g. A = $\begin{pmatrix} 5 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -2 \end{pmatrix}$ is a Diagonal Matrix of order 3.
- A scalar matrix in which all the diagonal elements are '1' and rest all elements zero is called a **Unit Matrix or Identity Matrix**
  For e.g. A = $\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$ is Identity Matrix of order 3 written as I_3
- A square matrix is called an **Upper Triangular Matrix** if all the elements below the principal diagonal are zero and it is **Lower Triangular Matrix** if all the elements above the principal diagonal are zero.
  For e.g. A = $\begin{pmatrix} 5 & -2 & 1 \\ 0 & 1 & 2 \\ 0 & 0 & -2 \end{pmatrix}$ is Upper Triangular Matrix and B = $\begin{pmatrix} 5 & 0 & 0 \\ 7 & 1 & 0 \\ 1 & -3 & -2 \end{pmatrix}$ is Lower Triangular Matrix.

Operations on Matrices

- Two or more matrices can be *added, subtracted or equated* only if their orders are same.
- Two matrices can be multiplied only if their orders are **Compatible or Conformable.** i.e. number of columns in first matrix should be equal to number of rows in the second matrix.
  For e.g. if A = m x **n** matrix , B = **n** x p matrix then only AB is possible and resulting matrix will be of order **m x p**

Properties

- Matrix addition is commutative whereas Matrix multiplication is not Commutative.
  i.e. A + B = B + A whereas A B $\neq$ B A
- Matrix addition is associative. Also Matrix multiplication is also associative if orders of matrices are conformable.

i.e. A + (B+ C) = (A + B) + C Also A (BC) = (A B) C

- Matrix multiplication is distributive over addition.
  i.e. A (B + C) = A B + A C
- Scalar multiplication does not affect the associativity i.e.if 'k' is a scalar then k (AB) = (kA) B
- There exists an Additive Identity as well as a Multiplicative Identity
  i.e. A + O = A and A I = A where O (Null matrix) is called **Additive Identity** and I (Unit Matrix) is the **Multiplicative Identity.**

ILLUSTRATION 1

If $A = \begin{pmatrix} 1 & 2 & -3 \\ 0 & 1 & 8 \\ 3 & 3 & 0 \end{pmatrix}$ $B = \begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$, Find the product AB

Solution: A is of order 3x3 and B is of order 3 x 2 , therefore the orders are conformable.

In order to find the product AB ;

Step 1: Multiply first row of Matrix A with First column of Matrix B and then with second column

1x1 + 2x3 + (-3)x 5 1x2 + 2x4 + (-3)x 6

Step 2: Multiply second row of Matrix A with first column of matrix B and then with second column

0 x 1 + 1x3+ 8 x 5 0 x 2 + 1 x 4 + 8 x 6

*Step 3:*Multipliply third of Matrix A with first column of matrix B and then with second column.

3 x 1 + 3 x 3 + 0 x 5 3 x 2 + 3 x 4 + 0 x 6

Therefore the product AB = $\begin{pmatrix} -8 & -8 \\ 43 & 52 \\ 12 & 18 \end{pmatrix}$

Solve the following:

1. Find the product of $\begin{pmatrix} 3 & -1 & 3 \\ -1 & 0 & 2 \end{pmatrix} \begin{pmatrix} 2 & -3 \\ 1 & 0 \\ 3 & 1 \end{pmatrix}$ Ans: $\begin{pmatrix} 14 & -6 \\ 4 & 5 \end{pmatrix}$
2. Find the values of 'a' and 'b' for which $\begin{pmatrix} a & b \\ -a & 2b \end{pmatrix} \begin{pmatrix} 2 \\ -1 \end{pmatrix} = \begin{pmatrix} 5 \\ 4 \end{pmatrix}$ Ans: a= 1, b = -3
3. If matrix $A = \begin{pmatrix} 2 & -2 \\ -2 & 2 \end{pmatrix}$, and $A^2 = kA$, then find the value of 'k' **[Remember $A^2 = AA$]** Ans: 4
4. If $\begin{pmatrix} 2 & 3 \\ 5 & 7 \end{pmatrix} \begin{pmatrix} 1 & -3 \\ -2 & 4 \end{pmatrix} = \begin{pmatrix} -4 & 6 \\ -9 & x \end{pmatrix}$, find the value of x. Ans: 13
5. If $A = \begin{pmatrix} \cos 2\alpha & \sin 2\alpha \\ -\sin 2\alpha & \cos 2\alpha \end{pmatrix}$, then find A^2 Ans: $\begin{pmatrix} \cos 4\alpha & \sin 4\alpha \\ -\sin 4\alpha & \cos 4\alpha \end{pmatrix}$

   [**Hint:** Using $\cos^2 \alpha - \sin^2 \alpha = \cos 2\alpha$]

ILLUSTRATION 2

If f(x) = $\begin{pmatrix} \cos x & -\sin x & 0 \\ \sin x & \cos x & 0 \\ 0 & 0 & 1 \end{pmatrix}$, show that f(x) f(y) = f(x+y)

Solution : f(x) f(y) = $\begin{pmatrix} \cos x & -\sin x & 0 \\ \sin x & \cos x & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} \cos y & -\sin y & 0 \\ \sin y & \cos y & 0 \\ 0 & 0 & 1 \end{pmatrix}$

$$= \begin{pmatrix} \cos x \cos y - sinx\, siny + 0 & -\cos x\, siny - \sin x \cos y + 0 & 0+0+0 \\ \sin x \cos y + \cos x \sin y + 0 & -\sin x \sin y + \cos x \cos y + 0 & 0+0+0 \\ 0+0+0 & 0+0+0 & 0+0+1 \end{pmatrix}$$

$$= \begin{pmatrix} \cos(x+y) & -\sin(x+y) & 0 \\ \sin(x+y) & \cos(x+y) & 0 \\ 0 & 0 & 1 \end{pmatrix} = \text{f (x+y)}$$

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6. If A = $\begin{pmatrix} 3 & 2 \\ 1 & 0 \end{pmatrix}$, B = $\begin{pmatrix} 4 & 5 & 6 \\ 0 & 1 & 2 \end{pmatrix}$ and C = $\begin{pmatrix} 1 & -4 & 1 \\ -2 & 5 & -3 \\ 3 & 6 & 5 \end{pmatrix}$

   Verify that (AB) C = A (BC)

7. If A= $\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ and B = $\begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}$, show that (a A + b B) (a A – b B) = ($a^2 + b^2$) A

8. Find the value of 'k' if $A^2 = kA - 2I$ where A = $\begin{pmatrix} 3 & -2 \\ 4 & -2 \end{pmatrix}$ Ans: 1

9. If A = $\begin{pmatrix} 3 & -5 \\ -4 & 2 \end{pmatrix}$ and f(x) = $x^2 - 5x - 14$, find f(A) Ans: $\begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$

   Hint: f(A) = $A^2 - 5A - 14I$

10. Referring to Q.9. use the equation $A^2 - 5A - 14\,I = O$ to find A^3

    Solution: Multiply both sides by A ; $AA^2 - 5AA - 14AI = A\,O$ or $A^3 - 5A^2 - 14A = 0$

    Therefore $A^3 = 5A^2 + 14A$ **Put A^2 and A value** Ans: $\begin{pmatrix} 187 & -195 \\ -156 & 148 \end{pmatrix}$

11. If A = $\begin{pmatrix} 1 & 2 & 2 \\ 2 & 1 & 2 \\ 2 & 2 & 1 \end{pmatrix}$, verify that $A^2 - 4A - 5\,I = 0$

12. Let A and B be square matrices of same order. Does $(A+B)^2 = A^2 + B^2 + 2AB$ hold ?

    Solution: $(A+B)^2 = (A+B)(A+B) = (AA + AB + BA + BB) = A^2 + AB + BA + B^2$

    Now $A^2 + AB + BA + B^2 = A^2 + B^2 + 2AB$ only if AB = BA

    That means the given identity holds only if AB = BA or when product is commutative.

13. If A is a square matrix such that $A^2 = I$, then find $(A-I)^3 + (A+I)^3 - 7A$

    Solution: $(A-I)^3 = (A-I)(A-I)(A-I) = (AA - AI - IA + I^2)(A-I) = (A^2 - A - A + I)(A-I)$

    $= (A^2 - 2A + I)(A-I) = (A^2 A - A^2 I - 2AA + 2AI + IA - I^2)$ **[AI = A, I^2 = I]**

    $= A^3 - I - 2I + 2A + A - I = A^3 + 3A - 4I$ **[A^2 =I]**

    Similarly $(A+I)^3 = A^3 + 3A + 4I$

    Therefore, $(A-I)^3 + (A+I)^3 - 7A = A^3 + 3A - 4I + A^3 + 3A + 4I - 7A = 2A^3 - A = 2A^2A - A = A$

14. If $\begin{pmatrix} 1 & x & 1 \end{pmatrix}\begin{pmatrix} 1 & 3 & 2 \\ 2 & 5 & 1 \\ 15 & 3 & 2 \end{pmatrix}\begin{pmatrix} 1 \\ 2 \\ x \end{pmatrix} = O$, find the value of 'x'. Ans: -2,-14

Class XII Chemistry worksheet -1

HALOALKANES

Haloalkanes are alkanes in which one H-atom has been replaced with a halogen atom (X) e.g CH_3Cl, CH_3Br, C_2H_5Br, C_2H_5Cl

<u>General methods of preparation of Haloalkanes</u>:

1.From alkanes by direct halogenation

$R H + X_2 \xrightarrow{hv} RX + HX$

$CH_4 + Cl_2 \xrightarrow{hv} CH_3Cl + HCl$

$CH_3Cl + Cl_2 \xrightarrow{hv} CH_2Cl_2 + HCl$

$CH_2Cl_2 + Cl_2 \xrightarrow{hv} CHCl_3 + HCl$

$CHCl_3 + Cl_2 \xrightarrow{hv} CCl_4 + HCl$

Reactivity of alkanes is

Tertiary alkane > sec alkane > primary alkane

Reactivity of halogens : $F_2 > Cl_2 > Br_2 > I_2$

2. From alkenes using halogen acids like HCl, HB, HI

$CH_2CH_2 + HI \longrightarrow CH_3CH_2I$

Ethene Iodoethane

Order of reactivity of halogen acids: HI>HBr>HCl>HF

In case of unsymmetrical alkene, a rule known as Markownikoff's rule is followed. Acc. to which during addition of HCl, HBr, HI the negative part of adding molecule goes to that carbon of the double bond which has lesser no. of H atoms.

$RCHCH_2 + HX \longrightarrow RCHCH_3$

Unsymmetrical $\qquad$ X

Alkene $\qquad$ alkyl halide

3. From alcohols (ROH) using PCl_3, PCl_5, $SOCl_2$

$3C_2H_5OH + PCl_3 \longrightarrow 3C_2H_5Cl + H_3PO_3$

$C_2H_5OH + PCl_5 \longrightarrow C_2H_5Cl + POCl_3 + HCl$

$C_2H_5OH + SOCl_2 \xrightarrow{\text{pyridine}} C_2H_5Cl + SO_2 + HCl$

4.By halide exchange:

a) **Finkelstein reaction**: Alkyl Iodides are best prepared by this method

$aC_2H_5Br + NaI \xrightarrow{\text{acetone}} C_2H_5I + NaBr$

b) **Swarts reaction**: Fluoroalkanes are best prepared by this method

$CH_3Br + AgF \longrightarrow CH_3F + AgBr$

5. From silver salts of fatty acids: Best used for bromoalkanes and the reaction is known as **Hunsdiecker reaction**.

$CH_3COOAg + Br_2 \xrightarrow{CCl_4} CH_3Br + CO_2 + AgBr$

<u>Physical Properties of Haloalkanes</u>:

1.Lower members are gases, up to C_{18} are liquids and higher are solids.

2.Haloalkanes have higher boiling pt. than corresponding alkanes due to their polar nature and dipole-dipole interactions between the alkyl halides. Boiling points of haloalkane dec in the order RI>RBr>RCl due to increase in the size of halogen atom. For isomeric haloalkane B.pt. dec with branching because branching of the chain makes the

molecule more compact so surface area dec and van der Waals' forces dec.

3.Solubility : Haloalkanes are polar in nature but still they are insoluble in water because they are not able to form hydrogen bonds with water molecule. They are soluble in organic solvents.

<u>Chemical Properties of Haloalkanes</u>:

1.Nucleophilc substitution reactions :Nucleophiles are electron rich species.When a nucleophile stronger than the halide ion in haloalkane approaches the C-atom of a haloalkane the halogen with its bonding pair gets displaced and a new bond is formed between the C-atom and the incoming nucleophile. It takes place by 2 mechanisms i.e S_N1 and S_N2.

S_N1 mechanism (Unimolecular nucleophilic substitution): involves 2 steps and is followed by tertiary alkyl halides.

Step 1:

$$(CH_3)_3CX \xrightarrow{\text{slow step}} (CH_3)_3C^+ + X^-$$

tertiary butyl halide

Step 2:

$$(CH_3)_3C^+ + OH^- \longrightarrow (CH_3)_3OH$$

nucleophile tertiary butyl alcohol

S_N2 mechanism (Bimolecular nucleophilic substitution): involves 1 step and is followed by primary alkyl halides.

$$CH_3Cl + OH^- \longrightarrow CH_3OH + Cl^-$$

primary alkyl halide primary alcohol

Class XII **Biology Worksheet I**

CHAPTER-Reproduction in Organisms

Life Span

The period from birth to the natural death of an organism is called its life span.
However, lifespan of different organisms is different. The life spans of organisms are not correlated with their size and body mass.

Life span of a few organisms	
1. Banana	= 25 years
2. Rice	= 3-4 months
3. Rose	= 5 to 7 years
4. Banyan	= 300 years
5. Butter fly	= 1 to 2 weeks
6. Fruit fly	= 30 days
7. Tortoise	= 100-150 years
8. Crocodile	= 60 years
9. Parrot	= 140 years
10. Crow	= 15 years
11. Elephant	= 60-90 years
12. Dog	= 20-50 years
13. Horse	= 60 years
14. Cow	= 15 years

Reproduction

It is defined as a biological process in which an organism gives rise to young one similar to itself. It is an important characteristic feature of all living organisms.
Reproduction in organism is of two main types:

1) **Asexual reproduction**
2) **Sexual reproduction**

Note:
As a result of asexual reproduction, the newly formed individual is the exact copy of its parent. The morphologically and genetically similar copy of an organism is called a clone
As a result of sexual reproduction, the new formed individual is not the exact copy of its parents. Hence it is not called clone. It is better be called as Hybrid.

Table 1.1: Differences between Asexual and Sexual Reproduction

Asexual Reproduction	Sexual Reproduction
Only one individual is used as parent.	One or two individual is/are used as parent.
No sex organs are involved.	Two types of sex organs are involved — male and female.
The individual does not produce gametes.	The individual produces gametes.
There is no meiosis.	Meiosis is essentially involved (in gamete formation).
Number of chromosomes remains unchanged throughout the reproductive process.	Number of chromosomes becomes half in gametes. It becomes again diploid when zygote is formed.
Fertilisation is absent.	Fertilisation is present which involves fusion of male and female gametes.
The newly formed individual (offspring) is genetically similar to its parent.	The newly formed individual (offspring) is genetically different from its parent.
Asexual reproduction is found only in lower and primitive animals such as protozoan, sponges and coelenterates.	Sexual reproduction is found in higher and advanced organisms.

Modes of Asexual reproduction

1) **Fission**

In this process the organism divide into two or more parts. Each part is able to produce the new individual. It is mainly of following type.

A) **Binary Fission**

In this process, the parental organism divides into two halves. Each half receives equal genetic material and is able to grow into a new individual. It may be simple, transverse binary fission.

a) Simple binary fission: When the plane of division passes through any direction it is called Simple binary fission.Eg. Amoeba

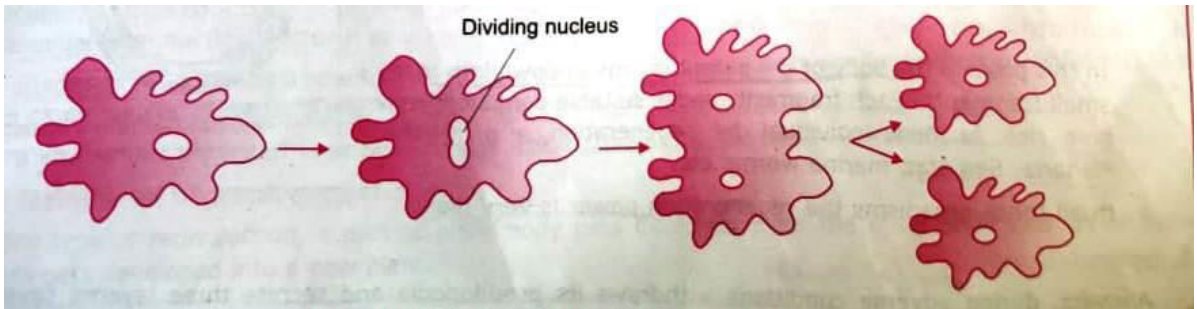


Fig. 1.1: Simple binary fission in *Amoeba*

b) Transverse binary fission: When the direction of division plane coincides with the transverse axis of the animal, it is called transverse binary fission Eg. Paramecium

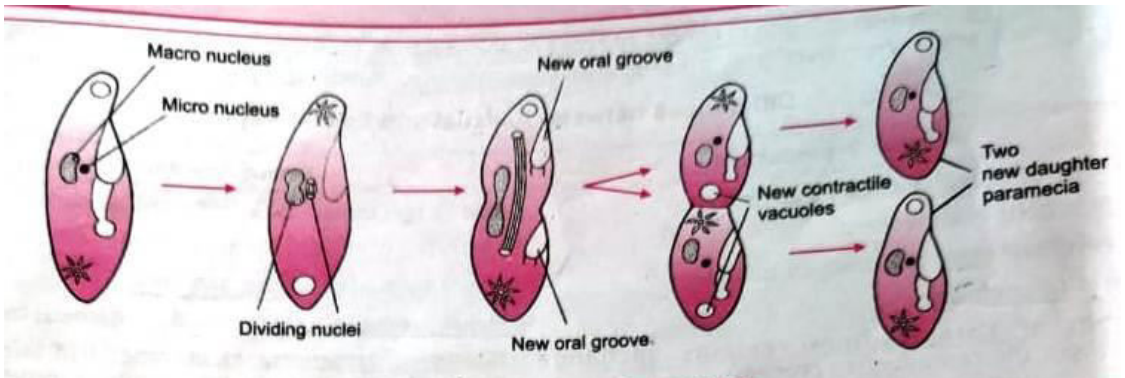


Fig. 1.2: Transverse binary fission in *Paramecium*

2) Budding

In this process the parent animal produces a small projection out form its body. This projection is called a bud. It grows in size and get separated from the parent body. It becomes a new individual.eg. Hydra, Yeast,

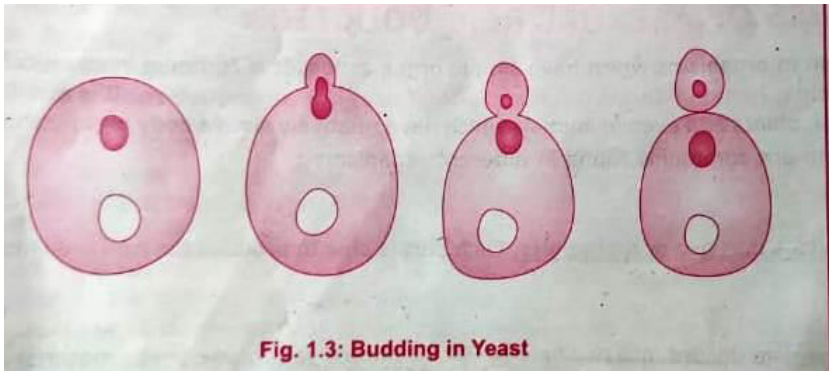


Fig. 1.3: Budding in Yeast

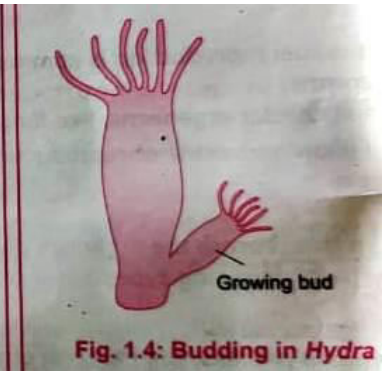


Fig. 1.4: Budding in *Hydra*

3) Gemmule Formation

In some fresh water sponges, many internal buds are developed inside the parental body during unfavorable conditions. The internal buds are called gemmules.On the return of favorable period each gemmule gives rise to new individual.

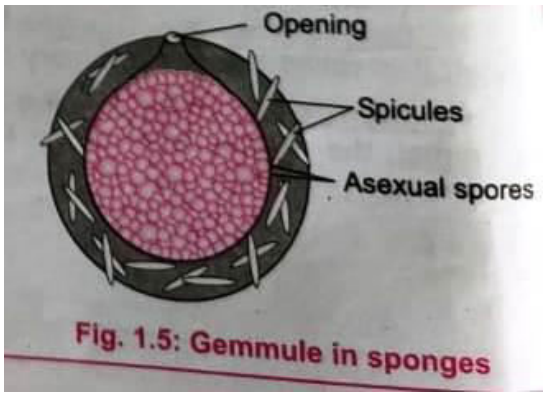


Fig. 1.5: Gemmule in sponges

4) **Fragmentation**

In this process, the body of the parent is broken down into many small fragments. Each fragment under suitable condition may give rise to new individual by regeneration.eg Planaria, Seastar, Hydra.

5) **Sporulation**

Amoeba during unfavorable conditions withdraws pseudopodia and secretes three layered covering i.e.Cyst around itself this is called Encystation.
On the return of favourable period, the amoeba (Encysted) divides by multiple fission to produce many small psedupodiospores. Now the cyst bursts to release these psedupodiospores. This Process id called Sporulation.

6) **Spore Formation**

Especially in fungi, the special structures are present for asexual reproduction. These structures are as follows.

a) Zoospores :These spores are motile spores as they have flagella for locomotion. These develop into specialized structures called sporangium.eg Chlamydomonas.

b) Sporangiospores:Thes are also developed in the sporangium but these are non motile as they do not have flagella.eg Rhizopus.

c) Conidia: These are also non motile spores but these do not develop inside the sporangium.The spores develop freely on terminal portion of Hyphae called conidiophores.eg Penicillium

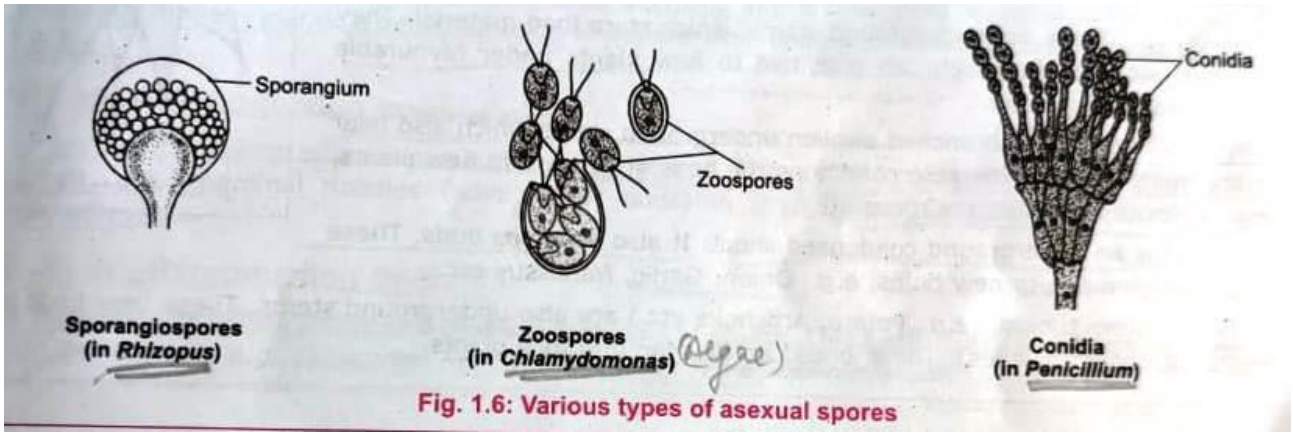


Fig. 1.6: Various types of asexual spores

Note: Learn

- Definitions of Life Span ,Clone and Hybrids.
- Differences between asexual and sexual reproduction
- Life span of all organisms
- Types of Asexual Reproduction

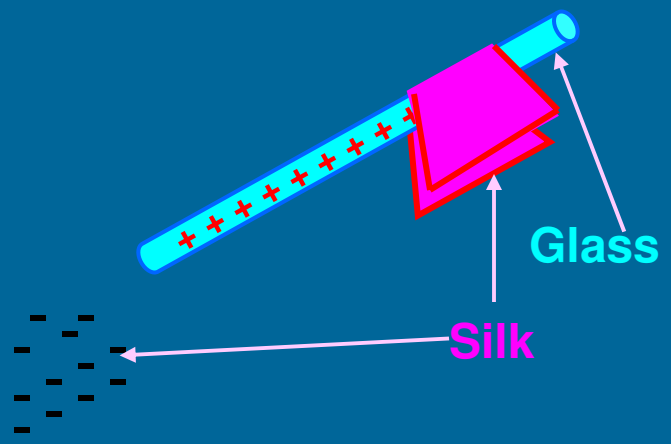
ELECTROSTATICS - I

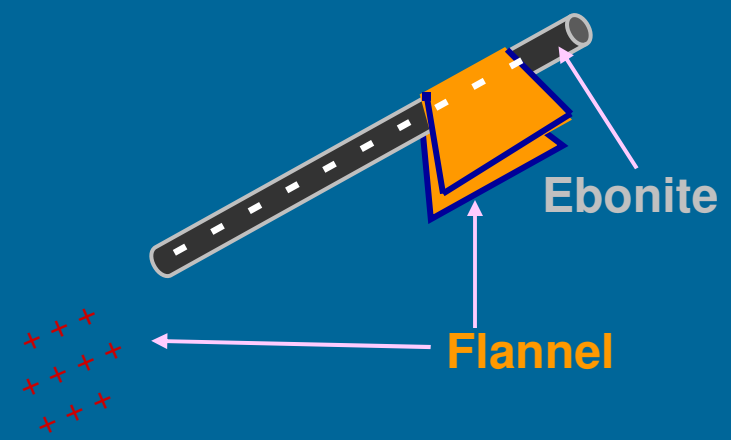
– Electrostatic Force

1. Frictional Electricity
2. Properties of Electric Charges
3. Coulomb's Law
4. Coulomb's Law in Vector Form
5. Units of Charge
6. Relative Permittivity or Dielectric Constant
7. Continuous Charge Distribution
   - i) Linear Charge Density
   - ii) Surface Charge Density
   - iii) Volume Charge Density

Frictional Electricity:

Frictional electricity is the electricity produced by rubbing two suitable bodies and transfer of electrons from one body to other.





Electrons in glass are loosely bound in it than the electrons in silk. So, when glass and silk are rubbed together, the comparatively loosely bound electrons from glass get transferred to silk.

As a result, glass becomes positively charged and silk becomes negatively charged.

Electrons in fur are loosely bound in it than the electrons in ebonite. So, when ebonite and fur are rubbed together, the comparatively loosely bound electrons from fur get transferred to ebonite.

As a result, ebonite becomes negatively charged and fur becomes positively charged.

It is very important to note that the electrification of the body (whether positive or negative) is due to transfer of electrons from one body to another.

i.e. If the electrons are transferred from a body, then the deficiency of electrons makes the body positive.

If the electrons are gained by a body, then the excess of electrons makes the body negative.

If the two bodies from the following list are rubbed, then the body appearing early in the list is positively charges whereas the latter is negatively charged.

Fur, Glass, Silk, Human body, Cotton, Wood, Sealing wax, Amber, Resin, Sulphur, Rubber, Ebonite.

Column I (+ve Charge)	Column II (-ve Charge)
Glass	Silk
Wool, Flannel	Amber, Ebonite, Rubber, Plastic
Ebonite	Polythene
Dry hair	Comb

Properties of Charges:

1. There exists only two types of charges, namely positive and negative.
2. Like charges repel and unlike charges attract each other.
3. Charge is a scalar quantity.
4. Charge is additive in nature. eg. +2 C + 5 C – 3 C = +4 C
5. Charge is quantized.

   i.e. Electric charge exists in discrete packets rather than in continuous amount.

   It can be expressed in integral multiples fundamental electronic charge ($e = 1.6 \times 10^{-19}$ C)

   $q = \pm ne$ where n = 1, 2, 3, ...

6. Charge is conserved.

   i.e. The algebraic sum of positive and negative charges in an isolated system remains constant.

   eg. When a glass rod is rubbed with silk, negative charge appears on the silk and an equal amount of positive charge appear on the glass rod. The net charge on the glass-silk system remains zero before and after rubbing.

   It does not change with velocity also.

Note: Recently, the existence of quarks of charge ⅓ e and ⅔ e has been postulated. If the quarks are detected in any experiment with concrete practical evidence, then the minimum value of 'quantum of charge' will be either ⅓ e or ⅔ e. However, the law of quantization will hold good.

Coulomb's Law – Force between two point electric charges:

The electrostatic force of interaction (attraction or repulsion) between two point electric charges is directly proportional to the product of the charges, inversely proportional to the square of the distance between them and acts along the line joining the two charges.

Strictly speaking, Coulomb's law applies to stationary point charges.

$F \alpha q_1 q_2$

$F \alpha 1 / r^2$

or $F \alpha \dfrac{q_1 q_2}{r^2}$ or $F = k \dfrac{q_1 q_2}{r^2}$

where k is a positive constant of proportionality called electrostatic force constant or Coulomb constant.

In vacuum, $k = \dfrac{1}{4\pi\varepsilon_0}$ where ε_0 is the permittivity of free space

In medium, $k = \frac{1}{4\pi\varepsilon}$ where ε is the absolute electric permittivity of the dielectric medium

The dielectric constant or relative permittivity or specific inductive capacity or dielectric coefficient is given by

$$K = \varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$$

$\therefore$ In vacuum, $F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$

In medium, $F = \frac{1}{4\pi\varepsilon_0\varepsilon_r} \frac{q_1 q_2}{r^2}$

$$\varepsilon_0 = 8.8542 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$$

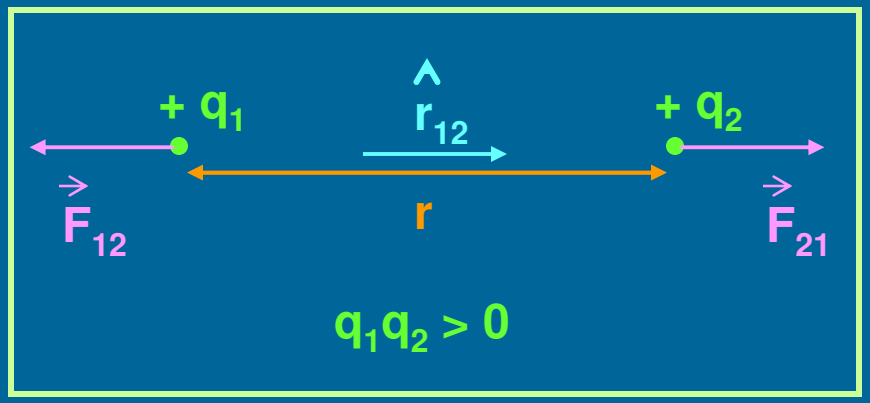
$\frac{1}{4\pi\varepsilon_0} = 8.9875 \times 10^9\ N\ m^2\ C^{-2}$ or $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ N\ m^2\ C^{-2}$

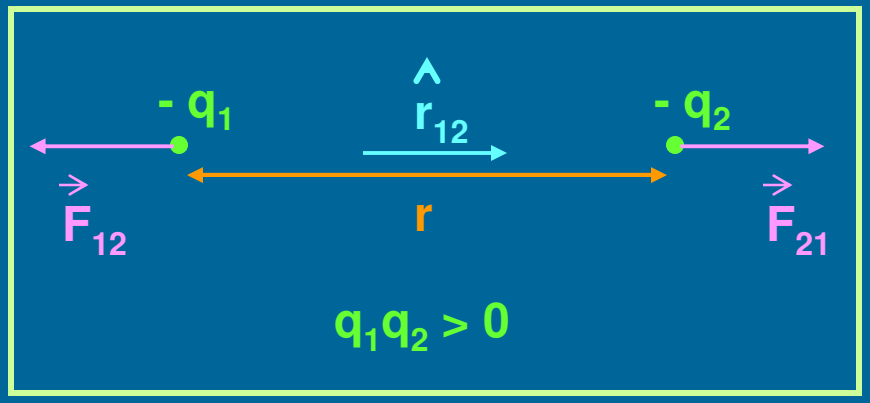
Coulomb's Law in Vector Form:

In vacuum, for $q_1 q_2 > 0$,

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \hat{r}_{21}$$

$$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \hat{r}_{12}$$



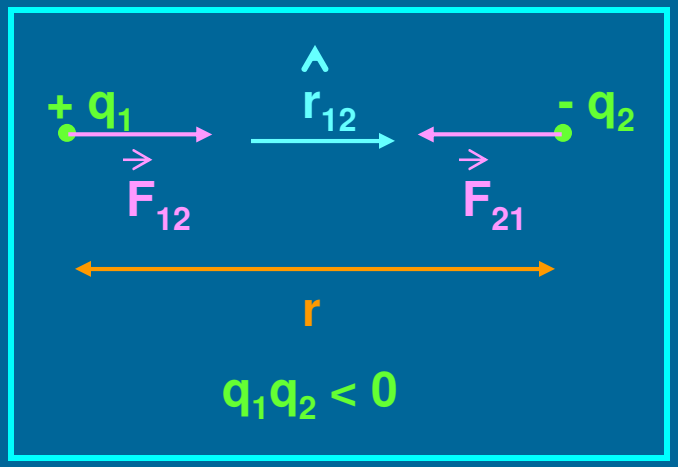


In vacuum, for $q_1 q_2 < 0$,

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \hat{r}_{12} \quad \& \quad \vec{F}_{21} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \hat{r}_{21}$$

$$\therefore \quad \boxed{\vec{F}_{12} = -\vec{F}_{21}}$$

(in all the cases)



$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^3} \vec{r}_{12} \quad \& \quad \vec{F}_{21} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^3} \vec{r}_{21}$$

Note: The cube term of the distance is simply because of vector form.

Otherwise the law is 'Inverse Square Law' only.

Units of Charge:

In SI system, the unit of charge is coulomb (C).

One coulomb of charge is that charge which when placed at rest in vacuum at a distance of one metre from an equal and similar stationary charge repels it and is repelled by it with a force of 9×10^9 newton.

In cgs electrostatic system, the unit of charge is 'statcoulomb' or 'esu of charge'.

In cgs electrostatic system, $k = 1 / K$ where K is 'dielectric constant'.

For vacuum, $K = 1$.

$$\therefore \quad F = \frac{q_1 q_2}{r^2}$$

If $q_1 = q_2 = q$ (say), $r = 1$ cm and $F = 1$ dyne, then $q = \pm 1$ statcoulomb.

In cgs electromagnetic system, the unit of charge is 'abcoulomb' or 'emu of charge'.