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1 Integers

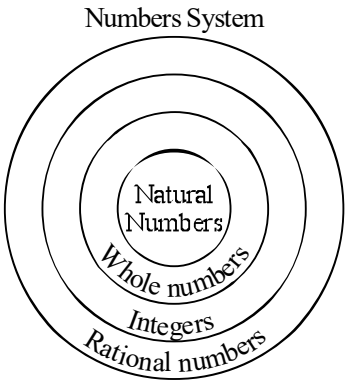
Types of Numbers

i) **Natural numbers:** Counting numbers, i.e, 1, 2, 3, 4,… are called natural numbers.

ii) **Whole numbers:** Counting numbers and 0, i.e., 0, 1, 2, 3, 4, 5,… are called whole numbers.

iii) **Integers:** All natural numbers, zero and negative of natural numbers, i.e.,… –3, –2, –1, 0, 1, 2,... Are called integers.

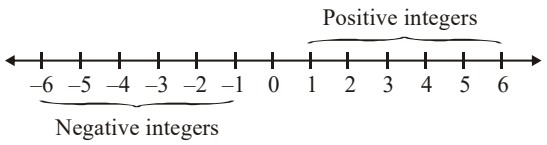
iv) **Rational numbers:** All numbers of the form $\frac{p}{q}$, where p and q are co-prime integers and $q \neq 0$ are called rational numbers.



Integers

The numbers ...–3, –2, –1, 0, 1, 2, 3, 4, … are called integers. The numbers 1, 2, 3, … i.e., natural numbers, are called positive integers and the numbers –1, –2, –3,… are called negative integers. The number 0 is simply an integer. It is neither positive nor negative.

Representation of integers on number line



Note i) All negative integers are smaller than zero and all positive integers are greater than zero.
ii) 1 is the smallest positive integer.
iii) –1 is the largest negative integer.
iv) Every positive integer is greater than every negative integer.

Operations on Integers

We are going to learn the following operations on integers:

i) Addition ii) Subtraction

iii) Multiplication iv) Division

Example 1: Find the value of (–8) – (–13).

Solution: (–8) – (– 13) = –8 + 13 = 5

Example 2: Find the value of (–8) – (–3).

Solution: (–8) – (–3) = – 8 + 3 = –5

Properties of addition and subtraction of integers:

1. **Closure property :** If '*a*' and '*b*' are integers, then (i) $a + b$ is also an integer (ii) $a – b$ is also an integer.

   Hence, closure property holds for both addition and subtraction of integers.

2. **Associative Property :** If a, b, and c are integers, then
   i) $a + (b + c) = (a + b) + c$
   ii) $a – (b – c) \neq (a – b) – c$
   Hence associative property holds for addition but not for subtraction.

3. **Commutative property :** If a and b are integers, then
   i) $a + b = b + a$
   ii) $a – b \neq b – a$
   Hence commutative property holds for addition but not for subtraction.

4. **Additive Inverse :** If 'a' is an integer, then
   (i) $a + (–a) = 0$
   (ii) $a – a = 0$
   '–a' is called additive inverse of 'a' (or) negative of 'a'

5. **Role of Zero :** If 'a' is an integer, then
   (i) $a + 0 = 0 + a = a \Rightarrow 0$ is an additive identity
   (ii) $a – 0 = a$ but $0 – a \neq a$ [as $0 – a = –a$]

Properties of Multiplication and Division of integers

1. **Closure property :** If 'a' and 'b' are integers, then
   i) $a \times b$ is an integer
   ii) $a \div b$ need not be an integer

   Example: $2 \times 3 = 6$ is an integer
   $2 \div 3 = 2/3$ is a fraction
   $\therefore$ Closure property is true for multiplication but not for division

2. **Commutative property :** If a and b are integers, then
   i) $a \times b = b \times a$
   ii) $a \div b \neq b \div a$
   Hence commutative property holds for multiplication but not for division.

3. **Associative property :** If a, b and c are integers, then
   i) $(a \times b) \times c = a \times (b \times c)$
   ii) $(a \div b) \div c \neq a \div (b \div c)$
   Hence associative property hold for multiplication but not for division.

4. **Role of 1 :** If a is an integer, then
   i) $a \times 1 = 1 \times a = a$ [1 is called multiplicative identity]
   ii) $a/1 = a$ but $1/a \neq a$

5. **Multiplicative Inverse :** If a is an integer, then 1/a is called multiplicative inverse of *a,* provided $a \neq 0$
   i) $a \times \frac{1}{a} = \frac{1}{a} \times a = 1$
   ii) $\frac{a}{a} = 1$; *i.e.* $a \div a = 1$

6. **Distributive property of multiplication over addition and subtraction:**
   If a, b, c are integers, then $a \times (b + c) = a \times b + a \times c$
   If a, b, c are integers, then $a \times (b - c) = a \times b - a \times c$

Note i) If there are odd number of negative integers in multiplication, then the result will be negative integer.
ii) If there are even number of negative integers in multiplication, then the result will be in positive integer.

SOLVED EXAMPLES

Example 3: Find the value of (–5) + (–4) + (–3) + (–2) + (–1).

Solution:
(–5) + (–4) + (–3) + (–2) + (–1)
= {(–5) + (–4)} + {(–3) + (–2)} + (–1) (Group first two and next two integers)
= {(–9) + (–5)} + (–1) (group first two integers)
= (–14) + (–1)
= –15

Example 4: Find the value of (–25) + (13) + (–49).

Solution:
(–25) + (13) + (–49) = {(–25) + (13)} + (–49) (By grouping)
= (–12) + (–49) = –61

Example 5: Find the value of (–5) – (–4) – (–3) – (–2) – (–1).

Solution:
(–5) – (–4) – (–3) – (–2) – (–1) = {(–5) – (–4)} – (–3) – (–2) – (–1) {Grouping first two}
= [(–1) – (–3)] – (–2) – (–1)
= [(+2) – (–2)] – (–1) = 4 – (–1) = 5
Aliter
(–5) – (–4) – (–3) – (–2) – (–1).
= – 5 + 4 + 3 + 2 + 1
= – 5 + (4 +3 + 2 + 1)
= 5 + 10 = 5

Example 6: Find the value of 100 – 1 – 99.

Solution: $100 - 1 - 99 = (100 - 1) - 99$ {Grouping first two}
$= 99 - 99$
$= 0$

Example 7: $(-1) \times (-2) \times (-3) \times (-4) \times (-5) \times (-6)$

$(-1) \times (-2) \times (-3) \times (-4) \times (-5) \times (-6) = +720$
2 6 24 120 720

[even number of negative integers]

Example 8: $(-15) \times (40) \times (-5) = ?$

$(-15) \times (40) \times (-5) = +3000$
600 3000

Example 9: The value of $(-100) \div 20$

Solution: $\frac{-100}{20} = \frac{-10}{2} = -5$

Note: If there are two or more of the fundamental operations +, –, × and ÷ in a numerical expression, the order of operation is

Division ⟶ **M**ultiplication ⟶ **A**ddition ⟶ **S**ubtraction

This rule is abbreviated as **DMAS**. It holds good for integers also.

Example 10: Simplify $36 \div 3 + 4 \times 3 - 4$

Solution:
$36 \div 3 + 4 \times 3 - 4 = 12 + 4 \times 3 - 4$ (division)
$= 12 + 12 - 4$ (multiplication)
$= 24 - 4$ (addition)
$= 20$ (subtraction)

Example 11: Simplify $36 \div (-3) + (-4) \times 3 - (-4)$

Solution:
$36 \div (-3) + (-4) \times 3 - (-4) = -12 + (-4) \times 3 - (-4)$ (division)
$= -12 + (-12) - (-4)$ (multiplication)
$= -24 - (-4)$ (addition)
$= -24 + 4 = -20$ (subtraction)

Use of Brackets: When brackets are present in a problem, we simplify the terms inside the brackets first.

We also sometimes use another grouping symbol '–' called **bar** or **vinculum**. The terms inside the bar are simplified before the brackets.

Note: If there are two or more fundamental operations along with brackets the order of operation in as follows:

Bracket ⟶ Division ⟶ **M**ultiplication ⟶ **A**ddition ⟶ **S**ubtraction

This is abbreviated as BODMAS

Absolute Value of an Integer

The absolute value of an integer is the numerical value of the integer without regard to its sign. The absolute value of an integer a is denoted by $|a|$ and is given by

$$|a| = \begin{cases} a, & a \geq 0 \\ -a, & a < 0 \end{cases}$$

Example 12:
$$\begin{aligned} &\big|\big|-17\big|+17\big|-34 \\ &= \big|17+17\big|-34 \\ &= 34-34=0 \end{aligned}$$

THINGS TO REMEMBER

1. The numbers ….. –4, –3, –2, –1, 0, 1, 2, 3, 4,…., etc., are integers.
2. 1, 2, 3, 4, 5,…. are positive integers and –1, –2. –3,… are negative integers.
3. 0 is an integer which is neither positive nor negative.
4. 0 is less than every positive integer and greater than every negative integer.
5. The absolute value of an integer is the numerical value of the integer without regard to its sign. The absolute value of an integer is denoted by $|a|$ and is given by
6. $$|a| = \begin{cases} a, & a \geq 0 \\ -a, & a < 0 \end{cases}$$
7. $-a$ and a are negative or additive inverse of each other.
8. Any integer when multiplied or divided by 1 results in itself and when multiplied or divided by –1 results in its negative.
9. If there are odd number of negative integers in multiplication, then the result will be negative integer.
10. If there are even number of negative integers in multiplication, then the result will be in positive integer.

TIPS

1. $(-) \times (-) = +$
2. $(+) \times (+) = +$

$\Rightarrow$ Same signs gives positive result

3. $(+) \times (-) = -$
4. $(-) \times (+) = -$

$\Rightarrow$ Opposite signs gives negative result

5. If a, b, c are integers then:
   a) $a > b \Rightarrow a \div c > b \div c$, if $c > 0$

b) $a < b \Rightarrow a \div c < b \div c$, if $c > 0$

6. If a is a non-zero integer, then $0 \div a = 0$.
7. If a is an integer, then $a \div 0$ is not meaningful.
8. $(-) \div (-) = +$ same sign gives positive results.
9. $(+) \div (+) = +$ same sign gives positive results.
10. $(-) \div (+) = -$ opposite signs gives negative results.
11. $(+) \div (-) = -$ opposite signs gives negative results.

REVISION EXERCISE

LEVEL - I

1. What will be the sign of the product if we multiply together:
   i) 8 negative integers and 1 positive integer?
   ii) 21 negative integers and 3 positive integers?
   iii) 199 negative integers and 10 positive integers?

2. Verify the following:
   i) $19 \times \{7 + (-3)\} = 19 \times 7 + 19 \times (-3)$
   ii) $(-23)\ \{(-5) + (+19)\} = (-23) \times (-5) + (-23) \times (19)$

3. Find each of the following products:
   i) $(-2) \times 36 \times (-5)$
   ii) $18 \times (-27) \times 30$ iii) $(-45) \times 55 \times (-10)$

4. Using the sign of >, <, = in the box
   i) $(-8) + (-4) \square (-8) - (-4)$
   ii) $-3 + 7 - (19) \square 15 - 8 + (-9)$

5. Find the value of:
   i) $(-3) + (-8) \div (-4) - 2 \times (-2)$
   (a) 1 (b) 2 (c) 3 (d) 4
   ii) $(-3) \times (-4) \div (-2) + (-1)$
   (a) –1 (b) –2 (c) –5 (d) –7
   iii) $(-40) \times (-1) + (-28) \div 7$
   (a) 36 (b) 30 (c) 31 (d) 32

6. Simplify each of the following:
   i) $25 - \frac{1}{2}\left\{5 + 4 - (3 + 2 - \overline{1+3})\right\}$
   (a) 18 (b) 19 (c) 20 (d) 21
   ii) $27 - \left[38 - \left\{46 - (15 - \overline{13-2})\right\}\right]$
   (a) 30 (b) 31 (c) 32 (d) 33
   iii) $36 - \left[18 - \left\{14 - (15 - 4 \div 2 \times 2)\right\}\right]$
   (a) 20 (b) 21 (c) 22 (d) 23

7. Simplify each of the following :
   i) $63 - (-3)\left\{-2 - \overline{8-3}\right\} \div 3\{5 + (-2)(-1)\}$
   (a) 62 (b) 63 (c) 64 (d) 65
   ii) $\left[29 - (-2)\left\{6 - (7-3)\right\}\right] \div \left[3 \times \left\{5 + (-3) \times (-2)\right\}\right]$
   (a) 0 (b) –1 (c) 1 (d) 2

8. (i) Simplify: $48-\left[18-\left\{16-(\overline{4-1})\right\}\right]$
   (a) 43 (b) –42 (c) 0 (d) 40

   (ii) Simplify: $\left[5+\{28-(29-7)\}\right]$
   (a) 10 (b) 11 (c) 12 (d) 13

9. Simplify each of the following :

   i) $23-\left[23-\left\{23-(23-\overline{23-23})\right\}\right]$
   (a) 0 (b) 1 (c) 2 (d) 3

   ii) $4+\frac{1}{5}\left[\left\{-10\times(25-\overline{13-3}\right\}\div(-5)\right]$
   (a) –10 (b) 8 (c) –9 (d) 10

10. Simplify:

   i) $15-(-3)\left\{4-\overline{7-3}\right\}\div\left[\{5+(-3)\times(-6)\}\right]$
   (a) –12 (b) –13 (c) 14 (d) 15

   ii) $118-\left[121\div(11\times11)-(-4)-\left\{3-\overline{9-2}\right\}\right]$
   (a) 108 (b) 109 (c) –108 (d) –109

11. Simplify: $10-\{5+(-3)+8-(-11)\}$
   (a) –11 (b) –10 (c) 1 (d) 0

12. Simplify:
   $140-2\times[3-4\{3-\overline{2\times(-8)}\}]$
   (a) 286 (b) 256 (c) 265 (d) –250

LEVEL - II

13. In a competitive exam, 3 marks are given for every correct answer and 1 mark is deduced for every incorrect answer. Raju copied some answers from Reema and answered all the questions. He scored 20 marks though he got 10 correct answers. How many incorrect answers had he attempted? What values are promoted in the question?

14. In a quiz, Rs.300 are awarded for every correct answer and a penalty of Rs.75 is put for every incorrect answer. Madhuri answered 15 questions out of which only 6 answers were correct. How much money is earned by Madhuri in the quiz? If she distributes the money earned by her to poor children in the neighbourhood, what values are being promoted?

15. A water tank has steps inside it. A monkey is sitting on the first step. The water level is at the ninth step:
   i) He jumps 3 steps down and then jumps back 2 steps up. In how many jumps will be reach the water level?
   ii) After drinking water, he wants to go back. For this, he jumps 5 steps up and then jumps back 3 steps down in every move. In how many jumps will he reach back the top of the tank?

16. A shopkeeper earns a profit of `2 by selling a pen and a loss of 50 paise per pencil and loss of 15 paise per eraser while selling pencils and erasers of old stock. On a particular day, he earns a profit of Rs.10. If he sold 10 pens and the number of pencils and erasers he sold are in the ratio 7 : 10, then find the number of pencils and erasers he sold on the day.

17. In a competition 3 marks are given for every correct answer and (–2) marks are given for every incorrect answer and no marks for not attempting any questions.
    i) Sachin scored 20 marks. If he got 12 correct answers, how many questions has he attempted incorrectly?
    ii) Mohini scores (–5) marks in this competition, though she has got 7 correct answers. How many questions she has attempted incorrectly?

18. An elevator descends into a mine at the rate of 6 m/min. If the descend starts from 10 m above the ground level, how long will it take to reach the shaft 350 m below the ground level?

19. A bookstore manager earns a profit of `20 by selling one new book and incurs a loss of `10 by selling a second hand old book. In a particular month he earns neither profit nor loss. If he sold 25 new books, how many second hand old books did he sell?

MULTIPLE CHOICE QUESTIONS

20. If X is successor of–9897, Y is a predecessor of –4859.Then X – Y is:
    (a) –5038 (b) –5032 (c) –5036 (d) –5034

21. If X = (–3) – (–8) – (+ 4), Y = (–10) – (–3) + (–4) then:
    (a) X < Y (b) X > Y (c) Y = X (d) None of these

22. If X = (–2) + (–2) …. 20 times Y = (+3) + (+3) + (+3) …. 40 times then X + Y =
    (a) 40 (b) –40 (c) 0 (d) None of these

23. If P = (–8) + (–3) + (+7)
    Q = (–9) + (+3) + (+3) + (+2) +(–9)
    R = (–6) + (–8) + (+3) + (+2) + (–9) then P + Q + R + 27 =
    (a) –1 (b) –2 (c) –4 (d) None of these

24. If $4p = -32, -2q = 16,$ then $(+10) + p + (-18) + q =$
    (a) –6 (b) –24 (c) –8 (d) –10

25. If A = (+7) + (–10)
    B = (–3) + (–8)
    C = (+9) + (–13) then arrange A, B, C in ascending order:
    (a) A, B, C (b) C, B, A (c) B, C, A (d) B, A, C

26. If (–9) – (–3) = X, (+7) – (–4) = Y, (+6) + (–2) = Z then X – Y – Z =
    (a) 25 (b) –25 (c) –21 (d) –24

27. If (–8) + (–9) = x, (+10) + (–2) = y, (+11) + (–13) = z the $x + y + z$ =
    (a) –11 (b) –12 (c) –13 (d) –10

28. Which statement is correct:
    i) sum of three negative integers is –ve
    ii) Sum of four negative integers is –ve
    iii) Sum of two positive integers is +ve
    (a) (ii) (b) (iii) (c) (i) (d) (i), (ii), (iii)

29. Absolute value of –11 is:
    (a) 10 (b) –1 (c) 11 (d) –11

30. Identify the property used in the following:
    $2 \times 13 + 8 \times 13 = (2 + 8) \times 13$
    (a) Commutative (b) Closure (c) Associative (d) Distributive

31. What will be multiplicative inverse of –8?
    (a) 8 (b) $\frac{1}{8}$ (c) $-\frac{1}{8}$ (d) 0

32. Which of the following statement is true?
    (a) $7 \div 0 = 7$ (b) $7 \div 0 = 0$ (c) $7 \div 0 = 0 \div 7$ (d) $0 \div 7 = 0$

33. Absolute value of '0' is
    (a) 0 (b) 1 (c) –1 (d) none of these

34. The value of $28945 \times 99 - (-28945)$ is
    (a) 2894500 (b) –2894500 (c) 289450 (d) 28900

35. Absolute value of – 1 is
    (a) 0 (b) 1 (c) –1 (d) none of these

MATRIX MATCH TYPE

*Question contains statements given in two columns, which have to be matched. The statements in **Column I** are labeled A, B, C and D, while the statements in **Column II** are labeled p, q, r, s and t. Any given statement in **Column I** can have correct matching with **ONE OR MORE** statements(s) in **Column II.***

36. Match the following:

Column I	**Column II**
A. (– 19) – (– 13)	(p) + 16
B. (+ 19) – (+ 13)	(q) + 32
C. (+ 19) – (– 13)	(r) + 6
D. (+ 19) – (+ 3)	(s) – 6

(a) A – s; B – r; C – q; D – p (b) A – p; B – r; C – q; D – s
(c) A – r; B – s; C – p; D – q (d) A – q; B – p; C – s; D – r

37. Match the following:

Column I	**Column II**
A. (– 7) × (–12)	(p) 70
B. (+ 7) × (–12)	(q) –96
C. (+7) × (+10)	(r) –84
D. (–8) × (+12)	(s) + 84

(a) A – p; B – s; C – q; D – r (b) A – s; B – p; C – r; D – q
(c) A – s; B – r; C – p; D – q (d) A – p; B – r; C – s; D – q

38. Match the following:

Column I	**Column II**
A. (–2) (–3) (6) (+1)	(p) 2.5
B. (–100) ÷ 25	(q) 4
C. 0.025 × 100	(r) – 4
D. 86 + (–28) + 12 + (–34)	(s) 36
(a) A – s; B – r; C – p; D – s	(b) A – s; B – p; C – r; D – q
(c) A – s; B – r; C – p; D – q	(d) A – p; B – r; C – s; D – q

39. Match the following:

Column I	**Column II**
A. (–22) + 21 + (–22) + 21 + …(40 terms)	(p) – 120
B. (–1) × (–2) × (–3) × (–4) × (–5)	(q) 7
C. (–98) ÷ (–14)	(r) 18
D. 24 – 4 ÷ 2 × 3	(s) –20
(a) A – s; B – r; C – p; D – s	(b) A – s; B – p; C – q; D – r
(c) A – s; B – r; C – p; D – q	(d) A – p; B – r; C – s; D – q

40. Match the following:

Column I	**Column II**
A. (–5) – (–48) ÷ (–16) + (–2) × 6	(p) – 7
B. $48-\left[18-\left\{16-\left(5-\overline{4-1}\right)\right\}\right]$	(q) 15
C. (–3) × (–4) ÷ (–2) + (–1)	(r) –20
D. $15-(-3)\left\{4-\overline{7-3}\right\}\div\left[3(5)\right]$	(s) 44
(a) A – r; B – s; C – p; D – q	(b) A – s; B – p; C – q; D – r
(c) A – s; B – r; C – q; D – p	(d) A – p; B – r; C – q; D – s

41. Match the following:

Column I	**Column II**
A. (–1728) ÷ 12	(p) 125
B. (–15625) ÷ (–125)	(q) –1562500
C. 15625 × (–2) + (–15625) × 98	(r) 1894600
D. 18946 × 99 + (18946)	(s) –144
(a) A – r; B – s; C – p; D – q	(b) A – s; B – p; C – q; D – r
(c) A – s; B – r; C – q; D – p	(d) A – p; B – r; C – q; D – s

42. Match the following:

Column I	**Column II**
A. –12 + 24 ÷ (5 – 3)	(p) –5
B. $222-\left[\frac{1}{3}\left\{42+\left(56-\overline{8+9}\right)\right\}+108\right]$	(q) 887000
C. – 20 + (–10) ÷ (–2) × 3	(r) 87
D. 1569 × 887 – 569 × 887	(s) 0
(a) A – r; B – s; C – p; D – q	(b) A – s; B – p; C – q; D – r
(c) A – s; B – r; C – p; D – q	(d) A – p; B – r; C – q; D – s

43. Match the following:

Column I	**Column II**
A. Successor of – 576	(p) –1
B. Predecessor of 0	(q) 0
C. [(–1) × (–1) × … (20 terms] × [(–1) + 1 + 1 (–1) + (1) + (40 terms)]	(r) –575
D. $(-1)^1 + (-1)^2 + \ldots + (-1)^{2018}$	(s) 1
(a) A – r; B – p; C – q; D – q	(b) A – s; B – p; C – q; D – r
(c) A – s; B – r; C – p; D – q	(d) A – p; B – r; C – q; D – s

44. Match the following:

Column I	**Column II**
A. (–2) + 1 + (–2) + 1 + … (20 terms)	(p) 12
B. [(1) + (–1) + (–1) + … (10 terms)] + [(–2) + (–2) + 10 terms]	(q) –2
C. – 25 ÷ 5 × 1 + 3	(r) –10
D. 16 + 10 ÷ 5 – 2 × 3	(s) – 30
(a) A – r; B – s; C – q; D – p	(b) A – s; B – p; C – q; D – r
(c) A – s; B – r; C – p; D – q	(d) A – p; B – r; C – q; D – s

45. Match the following:

Column I	**Column II**
A. Product of 8 negative integers and 2 Positive integers	(p) negative
B. Product of 2017 negative integers and 19 positive integers	(q) positive
C. 16 + 8 ÷ 4 – 2 × 3	(r) – 15
D. 25 – 5 × 6 ÷ 3	(s) 12
(a) A – q; B – p; C – s; D – r	(b) A– s; B – p; C – q; D – r
(c) A – s; B – r; C – p; D – q	(d) A – p; B – r; C – q; D – s

INTEGER TYPE

The answer to each of the questions is a single-digit integer, ranging from 0 to 9.

46. If x = (–23) + 22 + (–23) + 22 + …… (40 terms) and y = 11 + (–10) + 11 + (–10) + … (20 terms), then find the value of $(y - x) \div 10$.

47. Simplify 3 – (5 – 6 ÷ 3)

48. Simplify (–2) + (–8) ÷ (–4)

49. Simplify $39 \div 3 - \left[23 - \left\{ 29 - \left(17 - \overline{9 - 3} \right) \right\} \right]$

50. Simplify $\{36 \div (-9)\} \div \{(-24) \div 6\}$

51. Simplify $[-5 - (-48) \div (-16) + (-2) \times 6] \div (-20)$

52. $\left\| -18 \right| + 18 \right| \div \left\| -16 \right| - \left| -7 \right\|$

53. $\{24 - 4 \div 2 \times 3\} \div 9$

54. $0 \div (-100)$

55. $(-1) \div (-1)$

❑❑❑

CHAPTER

5 Light

Introduction

Light is a form of energy which produces the sensation of sight. Light is electromagnetic wave which does not require any material medium for its propagation. The speed of light waves depends on the nature of the medium through which they pass.

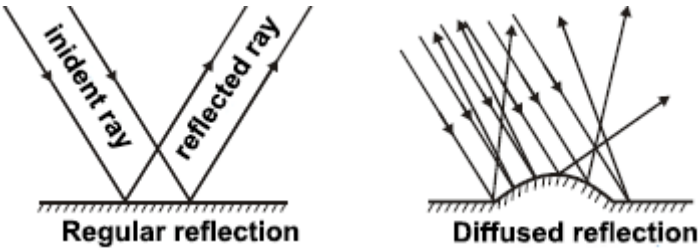
Reflection of Light

The process of bouncing back of the light to the same medium after striking the surface of another medium is called reflection.

A surface which reflects the light is called reflector. Silver metal is one of the best reflectors of light. A highly polished surface, such as a mirror, reflects most of the light falling on it.

Types of reflection: There are two types of reflection.

Regular Reflection: When a parallel beam of light falls on a smooth and highly polished surface, the reflected rays are also parallel to each other and directed in a fixed direction. Such type of reflection is called regular reflection. For example, light reflected from search light, automobile head lights, *etc.*



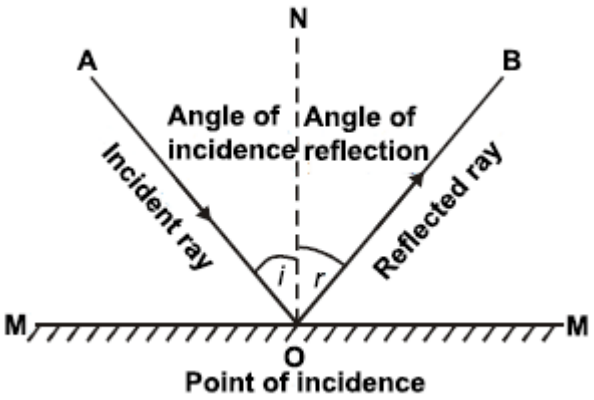
Diffused Reflection: When a parallel beam of light falls on a rough surface, then the reflected rays are not parallel but spread in all directions, such type of reflection of light is called irregular or diffused reflection. For example, light reflected from the wooden surface. We are able to see objects around us due to diffused reflection. In diffused reflection the laws of reflections are also followed.

Laws of Reflection

The reflection of light from a plane surface or from a spherical surface takes place according to two laws which are:

i) The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.

ii) The angle of incidence is equal to the angle reflection ($i.e, \angle i = \angle r$).



These laws of reflection are applicable to all types of reflecting surfaces such as plane surface, spherical surfaces or any irregular surface.

Light travels along a straight line (rectilinear propagation)

Activity 1

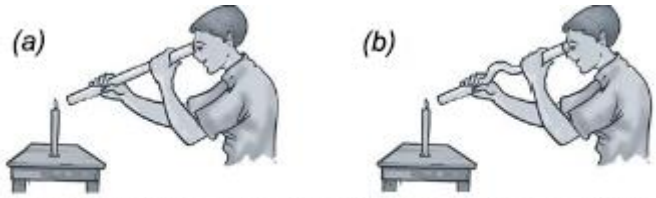


Fig. 5.1 Looking at a candle through a straight and a bent pipe

First try to see the lighted candle through a straight pipe and then through the bent pipe. You will not be able to see the candle through the bent pipe. This activity shows light travels along straight lines.

Reflection of Light

Activity 2

Place a lighted candle in front of a plane mirror. Try to see the flame of the candle in the mirror. It appears as if a similar candle is placed behind the mirror. The candle, which appears behind the mirror, is the **image** of the candle formed by the mirror. The candle itself is the **object**.

Fig. 5.2 Image of a candle in a plane mirror

In a plane mirror, the image is formed behind the mirror. It is erect, of the same size and is at the same distance from the mirror as the object is in front of it. In a plane mirror, image is laterally inverted. That is right becomes left and left becomes right.

Fig 5.3 Lateral inversion

Types of Images

There are two types of images:

i) Real image. ii) Virtual image.

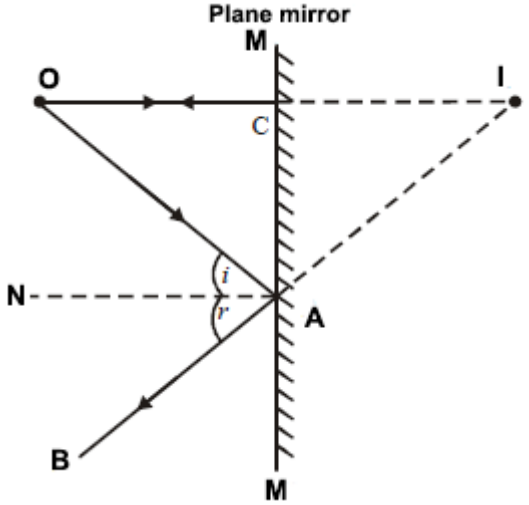
Real Image: The image which can be obtained on a screen is called real image.
Concave mirror forms real image.

Virtual Image: The image which cannot be obtained on a screen is called virtual image.
Plane mirror and convex mirror forms virtual image.

Real Image	Virtual Image
i) When light rays coming from an object actually meet at a point after reflection or refraction, then real image is formed. ii) Real image can be obtained on a screen.	i) When light rays coming from an object do not actually meet at a point but appears to meet at a point when produced backwards after reflection or refraction, then virtual image is formed. ii) Virtual image cannot be obtained on a screen.

Formation of Image by Plane Mirror

Consider a point object O placed in front of a plane mirror MM´. The mirror will form an image I of the object O. Here, two reflected rays AB and CO when produced backward, they meet at a point behind the mirror and hence form the virtual image I at that point.



Properties of Images formed by a Plane Mirror:

i) The image formed by a plane mirror is virtual and erect.

ii) The distance of the object from the mirror is equal to the distance of the image from the mirror.

iii) The size of the image is equal to the size of the object.

iv) The linear magnification produced by a plane mirror is unity.

$$i.e, m = \frac{v}{u} = \frac{h'}{h} = 1.$$

v) The image formed is laterally inverted, *i.e.,* the left side of the object appears to the right side of the image and vice-versa.

Uses of Plane Mirror:

i) Plane mirror is used as a looking glass.

ii) Plane mirror is used in solar cooker to reflect the sun light.

iii) Plane mirrors are used in periscopes usually used in submarines.

iv) Plane mirrors are used in barber's shop to see the back portion of the head.

Multiple Reflection

For an object kept in between two inclined plane mirrors, we get many images of the object. This because the light rays after reflection from one mirror fall on the other mirror.

In other words, the image formed by one mirror acts as an object for the other mirror. This continues till no more reflection on any mirror can occur.

The object and images formed by the two inclined mirrors lie on the circumference of a circle with centre at the point of intersection of the two mirrors and radius equal to the distance of object from the point of intersection.

The number of images formed depends on the angle between the two mirrors. If two mirrors make an angle θ with each other and the object is placed in between the two mirrors, the number of images formed is n or

$n - 1$ depending on $\mathrm{n} = \frac{360^{o}}{\theta^{o}}$ is odd or even

(i) If $\mathrm{n} = \frac{360^{o}}{\theta^{o}}$ is odd

(a) The number of images is n, when the object is placed asymmetrically between the mirrors.

(b) The number of images is n – 1, when the object is placed symmetrically (i.e., on the bisector of the angle) between the mirrors.

Example: If θ is 72^{o} then $\mathrm{n} = \frac{360^{o}}{72^{o}} = 5$ i.e, $\mathrm{n} = 5$ images will be formed for the object placed

Asymmetrically between the mirrors; but (n – 1) = 4 images will be formed, if the object is placed symmetrically between the mirrors because two images will now overlap.

(ii) If $\mathrm{n} = \frac{360^{o}}{\theta^{o}}$ is even, the number of images is always n - 1

Example: If the angle between two mirrors is $60^{o}, \mathrm{n} = \frac{360^{o}}{60^{o}} = 6$ the number of images is (n – 1) = 5, i.e. 5 images will be formed.

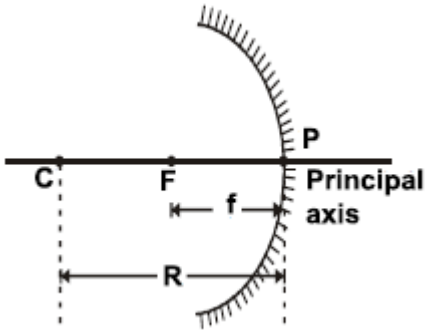
Spherical Mirrors

A spherical mirror is that mirror whose reflecting surface is the part of a hollow sphere of glass. Spherical mirrors are of two types: Concave mirror and convex mirror. A spherical mirror, whose reflecting surface is curved inwards, that is, faces towards the centre of

the sphere, is called a concave mirror. A spherical mirror whose reflecting surface is curved outwards, is called a convex mirror.

Important Terms used in Spherical Mirrors

Centre of Curvature: The centre of the hollow sphere of which the spherical mirror forms a part is called centre of curvature. It is denoted by C. The centre of curvature of a concave mirror lies in front of it but the centre of curvature of a convex mirror lies behind the mirror.



Radius of Curvature: The radius of the hollow sphere of which the spherical mirror forms a part is called radius of curvature. It is denoted by R.

Pole: The centre of the reflecting surface of a spherical mirror is called its pole. It is denoted by P.

Principal Axis: The straight line passing through the centre of curvature and the pole of a spherical mirror is called principal axis.

Aperture: The part of the spherical mirror from which the reflection of light actually takes place is called aperture of the mirror. In other words, the diameter of a spherical mirror is called its aperture.

Principal Focus: A point on the principal axis of a spherical mirror where the parallel rays of light closed to the principal axis meet or appear to meet after reflection from the mirror is called principal focus. It is denoted by the letter F.

Focal Length: The distance between the pole and the principal focus of a spherical mirror is called the focal length. It is represented by the letter f.

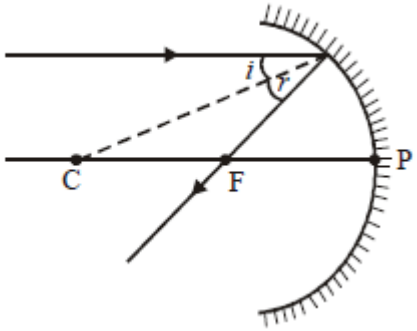
Note: For spherical mirrors of small aperture, the radius of curvature is equal to twice of its focal length *i.e.,*.

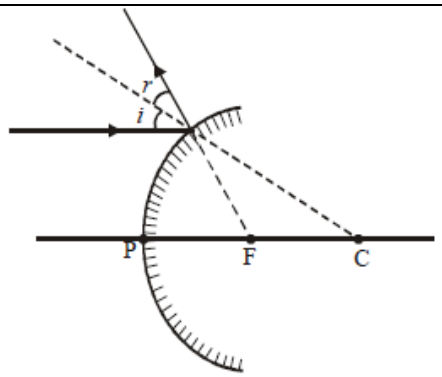
$$\mathrm{R} = 2f \qquad \text{or} \qquad f = \frac{R}{2}$$

Rules to Draw a Ray Diagram

Concave Mirror	Convex Mirror

i)





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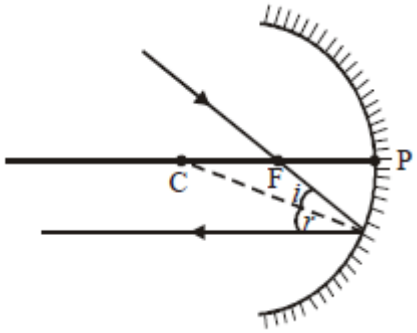

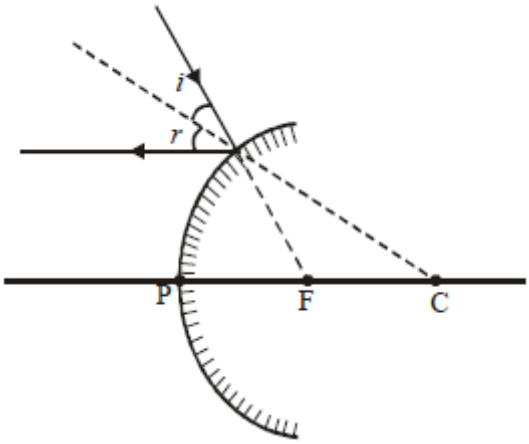

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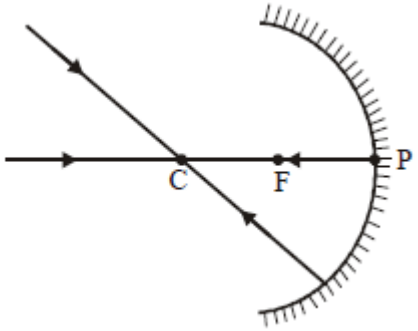

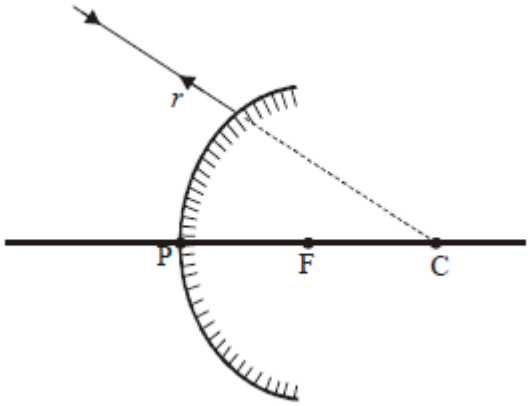

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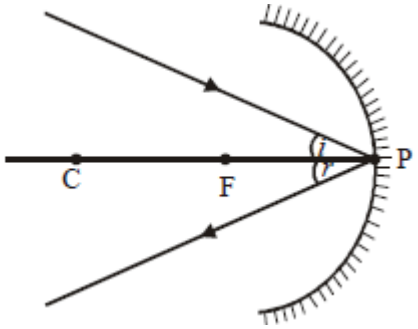
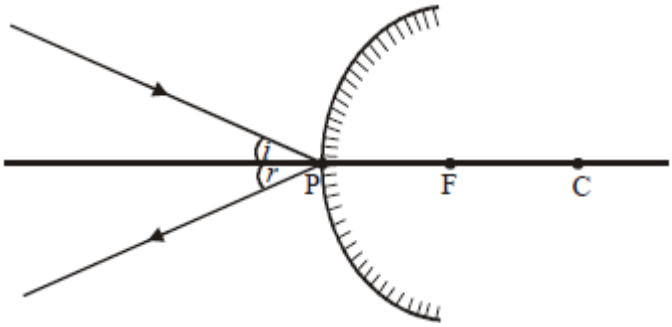




Uses of Concave Mirrors:

i) Concave mirrors are commonly used in torches, search-lights and vehicles headlights to get powerful parallel beams of light.

ii) They are often used as shaving mirrors to see a larger image of the face.

iii) The dentists use concave mirrors to see large images of the teeth of patients.

iv) Large concave mirrors are used to concentrate sunlight to produce heat in solar furnaces.

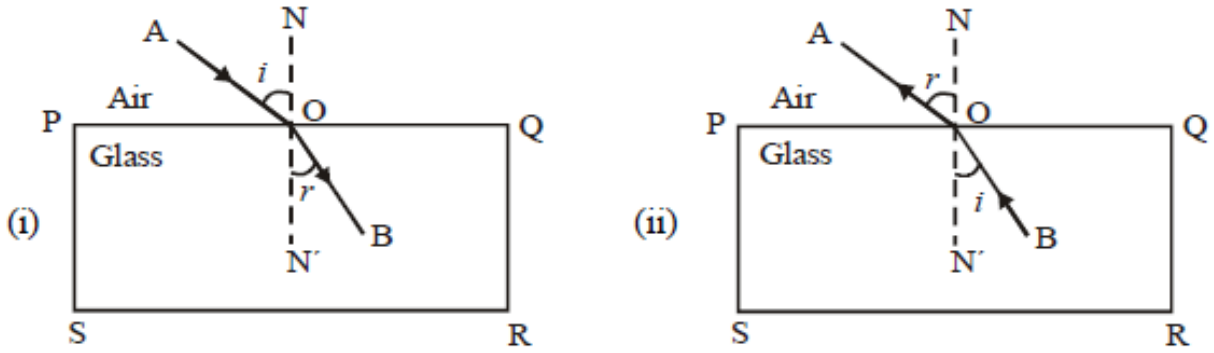
Uses of Convex Mirrors:

i) Convex mirrors are commonly used as rear-view (wing) mirrors in automobiles to see the traffic at the back side.

ii) Convex mirrors are preferred because they always give an erect, though diminished image. Also, they have a wider field of view as they are curved outwards. Thus, convex mirrors enable the driver to view much larger area than would be possible with a plane mirror and also they form erect form image for any position of the object (as compared to concave mirror).

Refraction of Light

The phenomenon of change in direction of light ray when it passes from one medium to another, is called refraction of light or the bending of light ray when it passes from one medium to another is called refraction of light.



i) When a ray of light goes from a rarer medium to a denser medium, it bends towards the normal.

ii) When a ray of light goes from a denser medium to a rarer medium, it bends away from the normal.

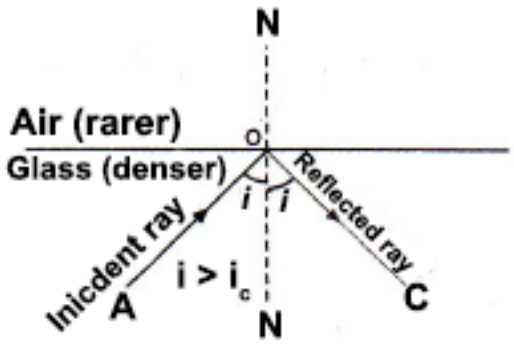
Critical Angle

We have read that when a ray of light passes from denser medium to a rarer medium, at a certain angle of incidence i_c, the angle of refraction becomes 90º, i.e., at $i = i_c$, $r = 90º$. The angle i_c is called the critical angle.

Thus critical angle is the angle of incidence in the denser medium corresponding to which the angle of refraction in the rarer medium is 90º.

Total Internal Reflection

When light travels from a rarer to a denser medium, a part of it is reflected and the rest of it is refracted at the boundary surface. Thus reflection and refraction both occur. On the other hand, when light travels from a denser to a rare medium, under certain condition (when the angle of incidence is greater than the critical angle), no part of light is refracted, but entire light is reflected back in the same medium. In figure, the light ray AO gets entirely reflected as obeying the laws of reflection and it does not suffer refraction. This phenomenon is called the total internal reflection.



Thus,

When a ray of light travelling in a denser medium, is incident at the surface of a rarer medium such that the angle of incidence is greater than the critical angle for the pair of media, the ray is totally reflected back into the denser medium. This phenomenon is called the total internal reflection.

Essential conditions for the total internal reflection.

There are following two necessary conditions for the total internal reflection:

(i) The light must travel from a denser to a rarer medium.

(ii) The angle of incidence must be greater than the critical angle for the pair of media.

Refraction by Spherical Lenses

Fig. 5.8 A magnifying glass

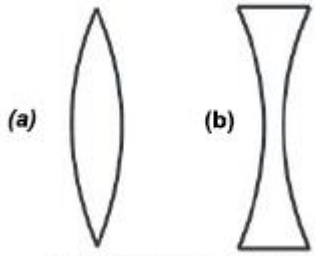


Fig. 5.9 (a) A convex lens and (b) a concave lens

A transparent material bound by two surfaces, of which one or both surfaces are spherical, forms a lens. There are two types of lenses: Convex lens and Concave lens. Convex lens is thicker at the middle as compared to the edges. It is also known as a converging lens because it converges a parallel beam of light rays.

A double concave lens is bounded by two spherical surfaces, curved inwards. It is thicker at the edges than at the middle. Such lenses are called diverging lenses. A double concave lens is simply called a concave lens.

Dispersion of light

There are seven colours in a rainbow, though it may not be easy to distinguish all of them. These are — red, orange, yellow, green, blue, indigo and violet. The prism splits sunlight into seven colours. The process of splitting of white light into seven colours is called dispersion.

A prism splits sunlight into seven colours

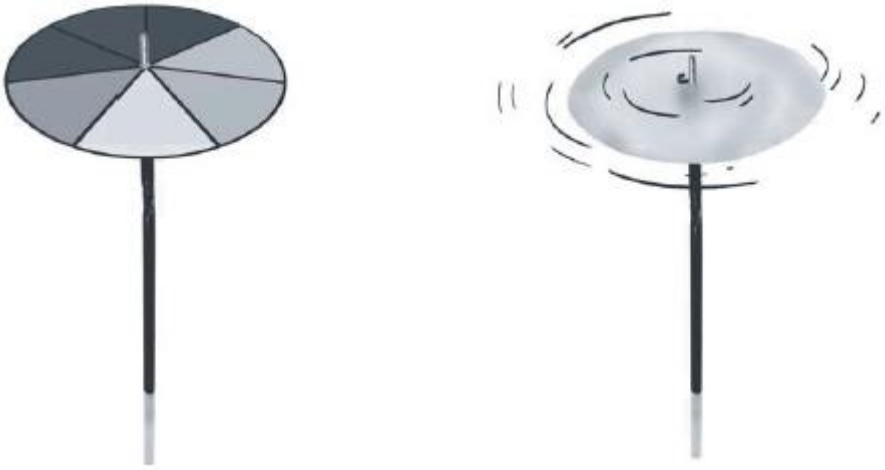
Newton's Disc

Take a circular cardboard disc of about10 cm diameter. Divide this disc into seven segments. Paint the seven rainbow colours on these segments as shown in figure. 15.11. Make a small hole at the centre of the disc.

Fix the disc loosely on the tip of a refill of a ball pen. Ensure that the disc rotates freely. Rotate the disc in the daylight. When the disc is rotated fast, the colours get mixed

together and the disappears to be whitish. Such a disc is popularly known as Newton's disc.

The Newton disc, also known as the Disappearing Colour Disc, is a well-known physics experiment with a rotating disc with segments in different colours (usually Newton's primary colours: red, orange, yellow, green, blue, indigo, and violet or ROYGBIV) appearing as white (or off-white or gray) when it spins very fast.



(a) A disc with seven colors (b) It apears white on rotationg

QUICK RECAP

1. Light is a form of energy which causes sensation of vision. It travels in straight line path.
2. If incident light after interacting with a boundary separating two media comes back into the same medium this phenomenon is called reflection.
3. Images can be either real or virtual.
4. Real image is formed by the actual intersection of light rays and it can be obtained on the screen.
5. Virtual image is formed by the apparent meeting of reflected rays from a mirror or refracted rays from lens, when produced backwards. It cannot be obtained on the screen.
6. **Laws of reflection:** There are two laws reflection.
   (i) The incident ray, the reflected ray and the normal at the point of incidence all lie in the same plane.
   (ii)The angle of incidence is equal to angle of reflection $\mathrm{i.e.}, \angle \mathrm{i} = \angle \mathrm{r}$.
7. **Spherical mirror**: There are two spherical mirrors, viz concave mirror and convex mirror.

Concave mirror: A spherical mirror whose reflecting surface is curved inwards, facing towards the centre of the sphere.

Convex mirror: A spherical mirror whose reflecting surface is curved outwards opposite to centre of sphere.

8. **Focal length of a mirror:** It is the distance between the pole and the focus of a spherical mirror. It is half of its radius of curvature. It is positive for a convex mirror and negative for a concave mirror.
9. Mirror formula $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ gives the relationship between the object distance (u),Image distance (v), and the focal length (f) of a spherical mirror.
10. The magnification of produced by a spherical mirror is the ratio of the height of the image to the height of the object, magnification (m)$= \frac{h'}{h} = -\frac{v}{u}$
11. Refraction is the phenomenon in which direction of propagation of light changes at the boundary when it passes from one medium to the other. This is because the speed of light is different in two media. Frequency, colour do not change while wavelength and velocity of light will change on undergoing refraction.

REVISION EXERCISE – LEVEL – I

Very Short Answer Questions

1. A mirror always forms virtual, erect and diminished image. Identify the mirror.
2. A prism stands in front of plane mirror and sees his image. What is the type of image formed by it?
3. Light travels in a straight line. What is this property of light known as?
4. A mirror can form real as well as virtual image. Identify the mirror?
5. A spectacular phenomenon is observed after rain when sun is shining in the sky. Name it.
6. The image formed by a lens is always virtual, erect and smaller in size for an object kept at different positions in front of it. Identify the nature of the lens
7. Fill in the blanks :

   (a) The inner surface of a steel spoon acts as a _____ mirror.

   (b) The outer surface of a flat steel plate acts as a _____ mirror.

   (c) The outer shining surface of a round bottom steel bowl acts as a _____ mirror.

(d) The inner surface of the reflector of a torch acts as a _____ mirror.

8. State whether the following statements are True or False.

(a) A concave lens can be used to produce an enlarged and erect image.

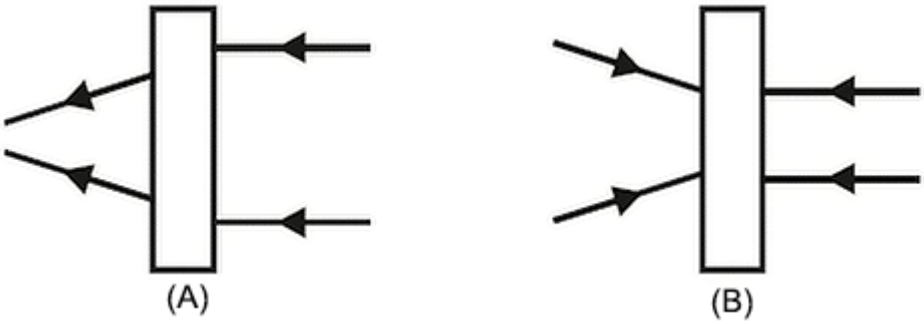
(b) A convex lens always produces a real image.

(c) The sides of an object and its image formed by a concave mirror are always interchanged.

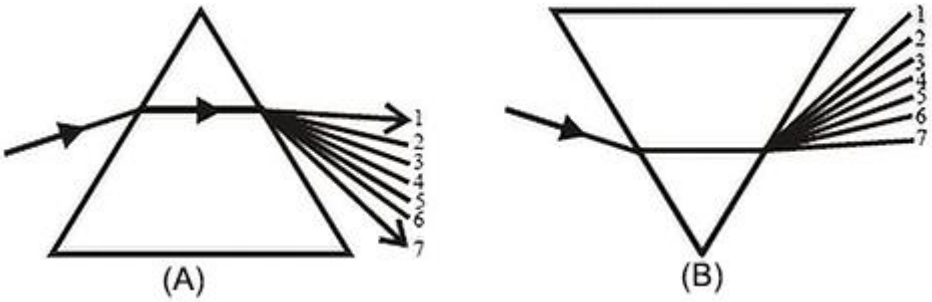
(d) An object can be seen only if it emits light.

Short Answer Questions

9. Give an example of a curved mirror.
10. Define reflection.
11. What is the type of image formed by concave lens?
12. How light make things visible to us?
13. How does light travel and what is the speed of light?
14. What type of mirror is used as a side mirror in a scooter? Why is this type of mirror chosen?
15. Observe the figures carefully and classify them as convex or concave lens



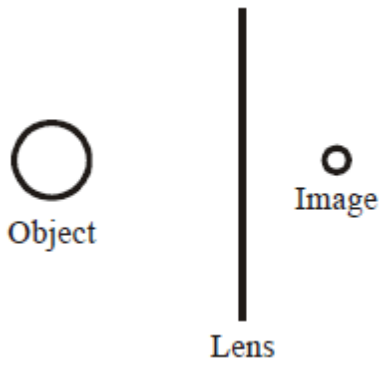
16. State the correct sequence (1-7) of colours in the spectrum formed by the prisms A and B. Shown in the following figure.



17. Two different types of lenses are placed on a sheet of newspaper. How will you identify them without touching?

Long Answer Questions

18. List the characteristics of image formed by a plane mirror.
19. Distinguish between real and virtual image.
20. Distinguish between concave and convex mirror.
21. Describe an experiment to show that a prism splits light into seven colours.
22. How far is the sun from the earth, if the light from it reaches the earth in 8 minutes? Speed of light is 300000 km/s.
23. Convex mirror is used in vehicles as rear view mirror. Why?
24. Whatever be the distance of the object from the mirror, the nature of image does not change. Identify the mirror.
25. Who am I?
    (a) I am the one who makes things visible.
    (b) I always form virtual and equal sized image.
    (c) I am the one who travels at the fastest speed.
    (d) I form real as well as virtual image.
    (e) When someone is standing in front of me, left appears right.
26. Rahul is standing at a distance of 1 m in front of a plane mirror. What will be the distance between?
    (a) His image and the mirror? (b) Rahul and his image?
27. Identify the lens:

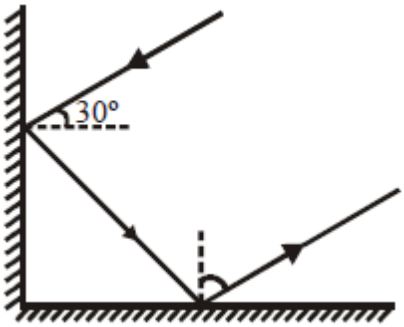


28. The distance between an object and a convex lens is changing. It is noticed that the size of the image formed on a screen is decreasing. Is the object moving in a direction towards the lens or away from it?
29. It was observed that when the distance between an object and a lens decreases, the size of the image increases. What is the nature of this lens? If you keep on decreasing the distance between the object and the lens, will you still able to obtain

the image on the screen? Explain.

LEVEL - II

1. The inner surface of a steel spoon acts as a _____mirror.
   (a) concave (b) spherical (c) convex (d) cylindrical
2. The amount of light reflected depends upon
   (a) the colour of material of the object (b) the nature of the surface
   (c) the smoothness of the surface (d) all the above
3. If there were no atmosphere, what would be the colour of the earth?
   (a) red (b) blue (c) black (d) white
4. The speed of light with the rise in the temperature of the medium.
   (a) increases (b) remains unaltered
   (c) decreases (d) drops suddenly
5. The focus of a concave mirror is _____.
   (a) real (b) virtual (c) undefined (d) at the pole
6. A converging mirror is known as _____.
   (a) convex mirror (b) plane mirror
   (c) concave mirror (d) cylindrical mirror
7. The relation between the focal length and radius of curvature of a mirror is _____.
   (a) $\frac{f}{2} + 1 = f$ (b) $R + 2 = f$ (c) $f = \frac{R}{2}$ (d) $f = 2R$
8. Radius of curvature of a concave mirror is always _____ to the mirror.
   (a) parallel (b) perpendicular (c) inclined at 60º (d) inclined at 45º
9. An image formed by a convex mirror is always _____.
   (a) virtual, erect and diminished (b) virtual, real and magnified
   (c) real, inverted and diminished (d) real, erect and magnified
10. Dentists use a _____ to focus light on the tooth of a patient.
    (a) concave mirror (b) convex mirror
    (c) plane mirror (d) cylindrical mirror
11. An object is placed 1.5 m from a plane mirror. How far is the image from the object?
    (a) 3 m (b) 1.5 m (c) 2 m (d) 1 m
12. What is the value of θ in the following diagram?



(a) 30º (b) 45º (c) 90º (d) 60º

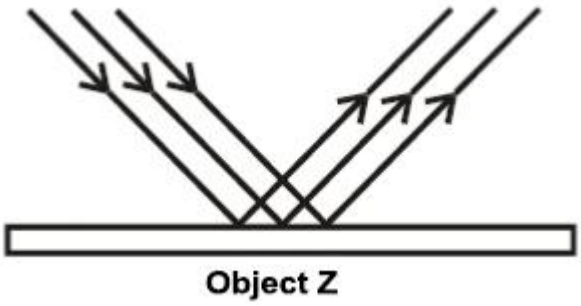
13. A ray of light is incident on a plane mirror and the angle of incidence is 25º. What is the angle of reflection?

(a) 0 (b) 50º (c) 90º (d) 25º

14. A ray of light is incident on a plane mirror and the angle of reflection is 50º. Calculate the angle between the incident ray and the reflected ray

(a) 50º (b) 25º (c) 90º (d) 100º

15. Observe the given figure.

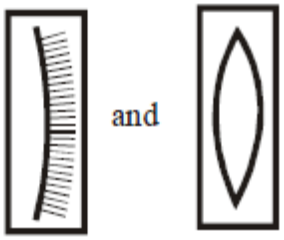


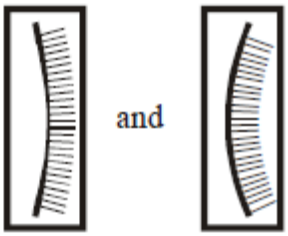
What type of surface does object Z have?

(a) Flat and Rough (b) Rough and Hard

(c) Flat and Magnetic (d) Shiny and Smooth

16. Which of the following can form a real and inverted image when objects are placed in front of them?

(a)  and

(b)  and

(c)  and 

(d)  and 

17. Which of the following reflects white light but forms no image?

(a) Plane mirror (b) Metal sheet

(c) Brick (d) Concave mirror

18. The characteristics of a particular type of mirror are given in the box.

(i) It has a flat surface. (ii) It forms an erect, virtual image of the object.

(iii) Image formed is laterally inverted. (iv) Object and image are of the same size.

Identify the mirror.

(a) Plane mirror (b) Convexo-concave mirror

(c) Convex mirror (d) Concave mirror

19. When soap bubbles are blown into the air, they appear colourful. What is this phenomenon due to?

(a) Refraction of light (b) Dispersion of light

(c) Reflection of light (d) Both (a) and (c)

20. What happens when a concave lens is placed between a candle flame and a screen?

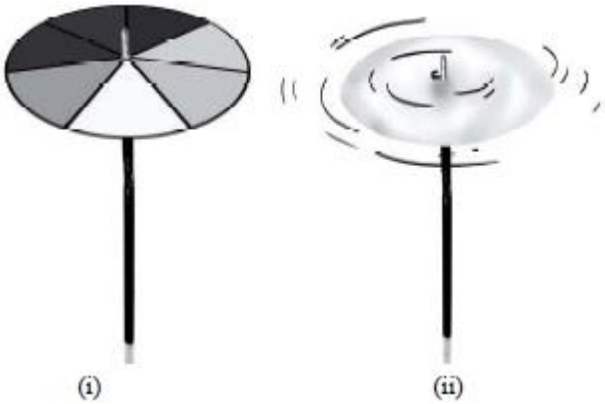
(a) A real image is formed on the screen.

(b) A virtual image is formed on the screen.

(c) A diminished image is formed on the screen.

(d) No image is formed on the screen.

21. Look at the given figures of discs.

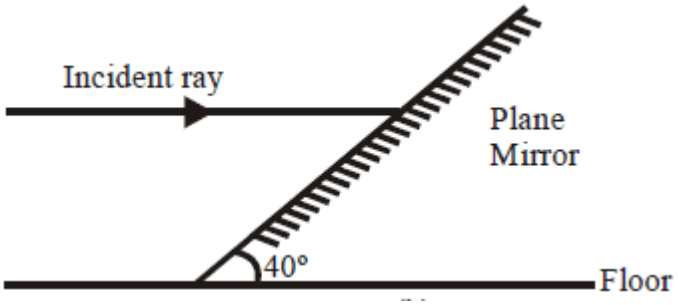


(i) (ii)

Identify the colour and the name of the disc that is formed when seven coloured disc is rotated by using a pencil at its centre?

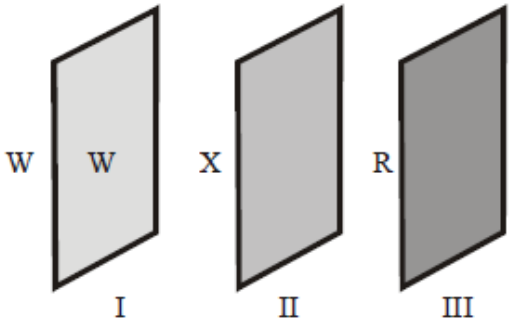
(a) Black, compact disc (b) White, Newton's disc
(c) Multicolour, brass disc (d) Orange, copper disc

22. A ray of light parallel to the floor strikes a plane mirror, which is inclined at an angle 40º as shown in figure. What is the angle of reflection?



(a) 40º (b) 80º (c) 50º (d) 90º

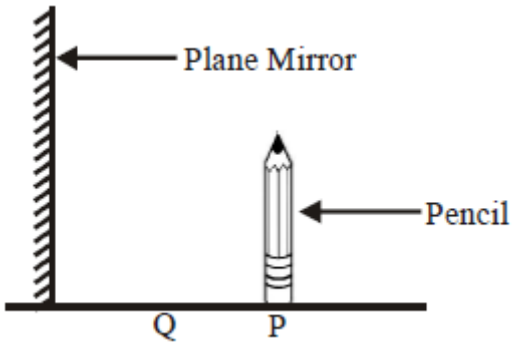
23. Reyansh placed three different types of glasses in front of letters as shown below



Which of the following observations is correct?
(a) Glass I is transparent and unclear
(b) Glass I is translucent and clear
(c) Glass I is opaque and frosted.
(d) Glass III is translucent and frosted.

24. A ray of light incident on a plane mirror at an angle of 60º is reflected. Identify the angles of incidence and reflection.
(a) 30º, 30º (b) 30º, 60º (c) 60º, 30º (d) 60º, 60º

25. A pencil placed in front of a plane mirror is shown below



The pencil is moved from position P to Q. The image formed will
(a) become smaller (b) become larger
(c) become inverted (d) remain unchanged

ADDITIONAL EXERCISE

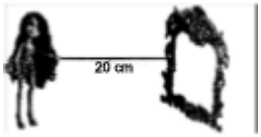
1. Match column I and column II and select the correct options from the codes given below.

Column - I	**Column – II**
(a)Lateral inversion	(i)An image which cannot be caught on a screen
(b)Luminous	(ii)Objects that allow some light to pass through
(c)Translucent	(iii)Object producing light by itself
(d)Virtual	(iv)Turned around from left to right

(1) a-(i), b-(ii), c-(iii), d-(iv) (2) a-(iv), b-(iii), c-(ii), d-(i)

(3) a-(iii), b-(i), c-(iv), d-(ii) (4) a-(ii), b-(iv), c-(i), d -(iii)

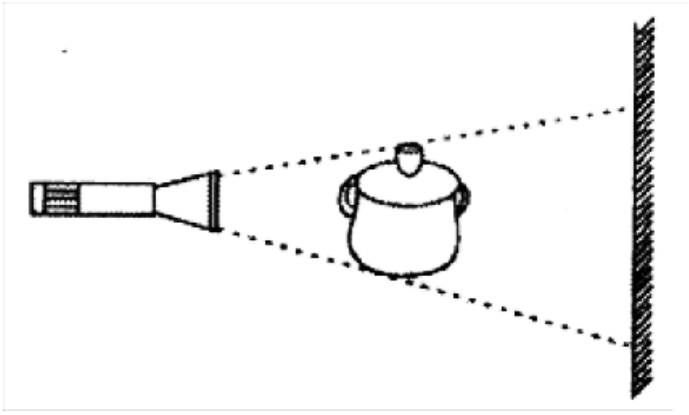
2. Miss Megha is 20 cm away from the plane mirror. If she moves few steps closer to the mirror, what will happen to the image size in the mirror?



(1)The size of image will decrease (2)The size of image will increase

(3)The size of image will be same (4)Cannot say

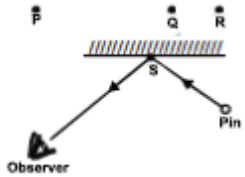
Direction (Q. No. 3&4): Read the passage carefully and answer the given questions. A man sets up the experiment as shown. The positions of the torch and object are fixed.



3. When A man switches the torch on, which one of the following shows the correct shadow formed on the screen?

(1)  (2)  (3)  (4) 

4. To cast a bigger shadow on the screen, A man should move _____.
   (1) The object closer to the torch (2) The screen closer to the object
   (3) The object away from the torch (4) The torch away from the object
5. The image formed by a slide projector on the screen is _____
   (1) Real, inverted and diminished (2) Virtual, upright and diminished
   (2) Virtual, upright and magnified (4) Real, inverted and magnified
6. In the game of basketball, the ball is bounced (with no spin) towards a player at an angle of 40 degrees to the normal. What will be the angle of reflection?
   (1) 30° (2) 45° (3) 60° (4) 40°
7. If a pin is placed in front of, and to the right of a plane mirror as shown in figure. Where is the image of the pin formed?



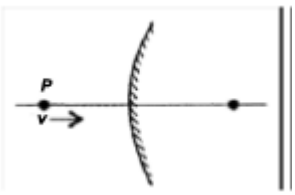
   (1) P (2) Q (3) R (4) S
8. The images of clouds and trees in water are always less bright than in reality, it is because:
   (1) Water is making the image dirty
   (2) There is an optical illusion due to which the image appears to be less bright
   (3) Only a portion of the incident light is reflected and quite a large portion goes mid water
   (4) Air above the surface of water contains a lot of moisture
9. Match the column I with column II.

Column I	**Column-II**
(a) Convex mirror	(i) used as magnifying glass
(b) Convex lens	(ii) used as side view mirror in vehicles
(c) Concave mirror	(iii) Image is erect and smaller than object
(d) Concave lens	(iv) used by dentists to see enlarged image

   (1) a-(i), b-(iii), c-(iv), d-(ii) (2) a-(iv), b-(ii), c-(iii), d-(i)
   (3) a-(ii), b-(i), c-(iv), d-(iii) (4) a-(iii), b-(iv), c-(ii), d-(i)
10. Human eye has converging lens system that produces an image at the back of the eye. If the eye views a distant object, which type of image is produced?

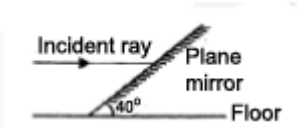
(1) Real, erect, same size
(2) Real, inverted, diminished
(3) Virtual, erect, diminished
(4) Virtual, inverted, magnified

11. A point objects P moves towards a convex mirror with a constant speed v, along its optic axis. The speed of the image :



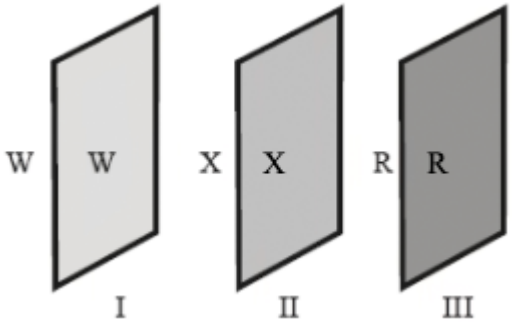
(1) Is always less than v
(2) Is always more than v
(3) Is equal to v
(4) Decreases as P comes closer to the mirror

12. A ray of light parallel to the floor strikes a plane mirror, which is inclined at an angle 40° as shown in figure. What is the angle of reflection?



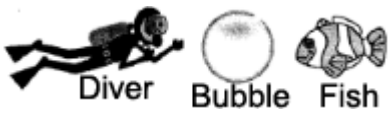
(1) 40° (2) 80° (3) 50° (4) 90°

13. Reyansh placed three different types of glasses in front of letters as shown below: Which of the following observations is correct?



(1) Glass I is transparent and unclear
(2) Glass I is translucent and clear
(3) Glass II is opaque and frosted
(4) Glass III is translucent and frosted

14. A fish sees the face of a scuba diver through a thin bubble, as shown in figure. Compared to the face the driver, the image seen by the fish will be



(1) Smaller and erect
(2) Smaller and inverted

(3) Larger and erect (4) Cannot predict

15. A camera makes use of a converging lens to produce an image. If the camera captures a distant object, then which of the following sets of characteristics of image is correct?

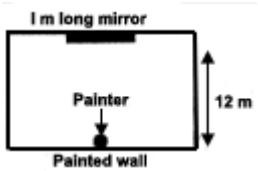
(1) Virtual, inverted, same size

(2) Real, inverted, diminished

(3) Real, upright, same size

(4) Virtual, upright, diminished

16. A painter leans his back against a painted wall while looking into a 1mlongmirror at the opposite end of a rectangular room as shown in the given figure. How much of the painted wall can he see through the given mirror?



(1) 1m (2) 2m (3) 6m (4) 12m

CHAPTER

1 Acids, Bases and Salts

Acids, bases and salts are 3 important classes of chemical compounds. Originally, the concept of acidity came from the ancient Greeks who defined “sour-tasting” substances as “acere” which was modified into Latin word for vinegar “Acetum” and then “acid”.

Acids

Some common examples of acids are Hydrochloric acid (HCl), Sulphuric acid (H_2SO_4) and Nitric acid (HNO_3). These acids are called mineral acids as they are prepared from naturally occurring compounds called minerals. Boric acid (H_3BO_3) is a substance that is sometimes used to wash the eyes. Mineral acids are stronger than household acids, so should be handled with great care as they can cause burns to skin and clothing.

Sulphuric acid (H_2SO_4) is known as the ‘king of chemicals’ and has varied uses and applications like preparation of other mineral acids, to remove the surface oxide layers on metals (pickling), in storage cell as an electrolyte, etc.

Nitric acid (HNO_3) is used for manufacture of fertilizers, plastics, dyes, etc.

Hydrochloric acid (HCl) is also used to clean brick and tile and in manufacture of sugar and glue.

Lemon, grape fruit and amla taste sour due to presence of citric acid and ascorbic acid (vitamin C).

Vinegar contains 5% acetic acid in water and glacial acetic acid 98 - 100% acetic acid (CH_3COOH).Tomato contains oxalic acid, tamarind contains tartaric acid, Yoghurt (dahi) contains lactic acid and fizzy drinks contains carbonic acid.

Classification of Acids:

1. **On the basis of source:**

a) **Organic acid:** Acids obtained from plants and animals are called organic acids, e.g., citric acid (oranges and lemons), acetic acid (vinegar), oleic acid (olive oil), etc.

b) M**ineral Acids:** Acids obtained from minerals are called mineral or inorganic acids. They do not contain carbon e.g., H_2SO_4, HCl, HNO_3, etc.

2. On the basis of presence of oxygen

a) **Oxy-acids:** Acids having oxygen in their composition. e.g. Sulphuric acid H_2SO_4, Oxalic acid ($H_2C_2O_4$), Nitric acid HNO_3, acetic acid (CH_3COOH).

b) **Hydroacids:** Acids, that contain hydrogen together with other elements and not any oxygen in their composition are called hydroacids. E.g., HCl, Hydroiodic acid (HI), Hydrobromic acid (HBr).

3. On the basis of strength of acids:

Almost all acids dissociate in water and produce hydrogen ion. The strength of acid depends on the hydrogen ions present in a solution. The strength increases with increase in the number of H^+ ions.

a) **Strong acid:** Acid that dissociates almost or completely in water is a strong acid. E.g. HCl, H_2SO_4, HNO_3, etc.

b) **Weak acid:** Acid that dissociates negligibly or almost incompletely in water is a weak acid. E.g. Acetic acid, formic acid, carbonic acid, etc.

4. On the basis of concentration of acid:

Amount of acid dissolved in water is called concentration of acid in water.

a) **Concentrated acid:** Relatively high amount or percentage of acid is dissolved in water (~90%). E.g., concentrated HCl, concentrated HNO_3, concentrated H_2SO_4, concentrated CH_3COOH, etc.

b) **Dilute acid:** Relatively low percentage (~10%) of acid is dissolved in water (aqueous solution). E.g., dilute HCl, dilute H_2SO_4, dilute HNO_3.

5. On the basis of basicity of acid:

Basicity is the number of hydrogen ions (H^+) that can be donated by an acid.

a) **Monobasic acid:** Acids having only 1 hydrogen ion (H^+). E.g., HCl, HI (hydroiodic acid), HNO_3, CH_3COOH (acetic acid), HBr (hydrobromic acid), HOCl (hydrochlorous acid), HCOOH (formic acid).

b) **Dibasic acid:** Acids having two hydrogen ions (H^+) to donate e.g., H_2SO_4, H_2SO_3 (sulphurous acid), H_2CO_3 (carbonic acid), $(COOH)_2$ – oxalic acid.

c) **Tribasic acid:** Acids having three hydrogen ions H^+ to donate e.g., H_3PO_4 (phosphoric acid).

Properties of Acids:

1. They have a sour taste.
2. Change of colour with indicator.

Indicator	Change in colour	
	From	To
Litmus	Blue	Red
Turmaric	Yellow	No change
Methyl Orange	Orange/Yellow	Pink / Red
Phenolphthalein	Colourless	No change

3. Corrosive action: Mainly all acids including sulphuric acid (H_2SO_4) and nitric acid (HNO_3) have high corrosive effect on surface. Acids corrode most metals i.e. chemically act on them, forming new compounds called salts. That is why sour things (e.g. pickles and vinegar) are not kept in metal pots. Hydrogen is produced when acids react with most of common metals.

Metal + Acid ⟶ Salt + Water

$$\underset{\text{(Zinc)}}{Zn} + \underset{\text{(Sulphuric acid)}}{H_2SO_4} \longrightarrow \underset{\text{(Zinc sulphate)}}{ZnSO_4} + \underset{\text{(Hydrogen gas)}}{H_2}$$

$$\underset{\text{(Iron)}}{Fe} + \underset{\text{(Sulphuric acid)}}{H_2SO_4} \longrightarrow \underset{\text{(Iron (II)sulphate)}}{FeSO_4} + \underset{\text{(Hydrogen gas)}}{H_2}$$

4. Actions with basic oxides.

Basic oxide + Acid → Salt + H_2O

$$\underset{\text{(Sodium oxide)}}{Na_2o} + \underset{\text{(Hydrochloric acid)}}{2HCl} \longrightarrow \underset{\text{(Sodium Chloride)}}{2NaCl} + H_2O$$

5. Action with basic hydroxide

Metal hydroxide + Acid → Salt + H_2O

$$\underset{\text{(Potassium hydroxide)}}{2KOH} + \underset{\text{(Carbonic acid)}}{H_2Co_3} \longrightarrow \underset{\text{(Potassium carbonate)}}{K_2CO_3} + H_2O$$

6. Action with carbonate and hydrogen carbonates or bicarbonates.

$$\text{Bicarbonate / Carbonate} + \text{Acid} \rightarrow \text{Salt} + \underset{\text{(effervescence)}}{CO_2} + H_2O$$

Note: If you drop some strong vinegar or bathroom acid on a marble floor, effervescence is observed. This is because marble is $CaCO_3$ - calcium carbonate, that reacts with acids and releases CO_2. Similarly, the reason why marble monuments (like Taj Mahal) are affected by acid rain.

$$\underset{\text{(Calcium Carbonate)}}{CaCO_3} + H_2SO_4 \longrightarrow \underset{\text{(Calcium sulphate)}}{CaSO_4} + H_2O + \underset{\text{(Carbon dioxide)}}{CO_2}$$

How acids are formed?

Acids are formed in small amounts in nature. When required in large quantities, they are prepared by artificial methods.

Acids are generally made by dissolving oxides of non-metals (e.g. carbon, sulphur and nitrogen) in water. These oxides are called **acidic** because when dissolved in water they form acids.

Hydrochloric acid (HCl) is a solution of hydrogen chloride (HCl) gas in water. The HCl gas can be prepared by various methods (e.g., by the reaction between hydrogen and chlorine in the presence of sunlight), and dissolved in water to obtain hydrochloric acid.

$$\underset{\text{(Carbon dioxide)}}{CO_2} + H_2O \longrightarrow \underset{\text{(Carbonic acid)}}{H_2CO_3}$$

$$\underset{\text{(Sulphur dioxide)}}{SO_3} + H_2O \longrightarrow \underset{\text{(Sulphuric acid)}}{H_2SO_4}$$

$$\underset{\text{(Nitrogen dioxide)}}{3NO_2} + H_2O \longrightarrow \underset{\text{(Nitrite acid)}}{2HNO_3} + \underset{\text{(Nitric oxided)}}{NO}$$

Acidic substances in air:

i) **Carbon dioxide:** CO_2 is formed by the respiration of plants and animals, and also by the burning of fuels like wood, coal, petrol, kerosene, diesel, natural gas and LPG (liquefied petroleum gas). Coal contains mainly carbon, and other fuels contain carbon compounds which give CO_2 on burning. Thus, large amounts of CO_2 are discharged into the air.

$$\underset{\text{Coal}}{C} + O_2 \xrightarrow{\text{burn}} CO_2$$

$$\underset{\text{Natural gas}}{CH_4} + 2O_2 \xrightarrow{\text{burn}} CO_2 + \underset{\text{Steam}}{2H_2O}$$

ii) **Oxides of sulphur:** Sulphur dioxide (SO_2) is mainly formed when sulphur and sulphur containing minerals and fuels (e.g. coal) are burnt. A part of the SO_2 then slowly gets converted into sulphur trioxide (SO_3) in the air under various conditions.

$$S + O_2 \xrightarrow{\text{burn}} \underset{\text{(Sulphur dioxide)}}{SO_2}$$

$$2SO_2 + O_2 \xrightarrow{\text{burn}} \underset{\text{(Sulphur Trioxide)}}{2SO_3}$$

iii) **Oxides of nitrogen:** Nitric oxide (NO) is formed by the direct reaction between N_2 and O_2 in the sky when there is lightning. The NO formed immediately reacts with O_2 of the air to form NO_2 (nitrogen dioxide).

$$N_2 + O_2 \xrightarrow{\text{lightning}} \underset{\text{(Nitric oxided)}}{2NO}$$

$$2NO + O_2 \longrightarrow \underset{\text{(Nitrogen dioxide)}}{2NO_2}$$

iv) **Acid rain:** Except CO_2, the acidic gases present in the atmosphere are fairly soluble in water. So they are brought down by rain. Thus, the first shower is slightly acidic. After that, the rain becomes almost neutral. Rain with a high acid content is called acid rain. A part of the acid present in acid rain is neutralized by the bases present in the soil. But the excess acid makes the soil acidic and unfit for cultivation. It also makes water bodies like ponds, lakes and rivers acidic. This adversely affects aquatic life. Acid rain corrodes statues and monuments made of metals, marble and cement.

Uses of Acids

Mineral acids	**Uses**
Hydrochloric acid	1. As a bathroom cleaner
	2. In the tanning of leather
	3. In the dyeing and textile industries
Nitric acid	1. In the manufacture of fertilisers
	2. In the manufacture of explosives, dyes and drugs

Sulphuric acid	1. In lead storage batteries
	2. In the manufacture of hydrochloric acid, fertilisers, drugs, detergents and explosives.

Natural acids (Organic Acids)	**Uses**
Ascorbic acid	Vitamin C
Citric acid	Flavouring agent and food preservative
Acetic acid	Flavouring agent (vinegar) and food preservative
Tartaric acid	Souring agent, and in baking powder

Bases

Bases are compounds which taste bitter, example milk of magnesia. Ammonium hydroxide or ammonia water is very irritating to the nose and the eyes. This substance called a hydroxide, or a base, often used in home for cleaning and have wide industrial applications. Ammonia is used in preparation of nitric acid and ammonium chloride. Sodium hydroxide is used in manufacture of soap, rayon and paper, Calcium hydroxide, commonly known as **slaked lime** is used in the preparation of plaster and mortar. Water solutions of calcium hydroxide, called **lime water**, can be used in the lab to test for CO_2.

Similar to acids, bases also dissociate in water, but they produce hydroxyl ion (OH^-). A base may be an oxide or a hydroxide of a metal.

Example: Ammonium hydroxide (NH_4OH)

$$\underset{}{NH_4OH_{(aq)}} \longrightarrow \underset{\text{Ammonium ion}}{NH^+_{4(aq)}} + \underset{\text{Hydroxyl ion}}{OH^-_{(aq)}}$$

Alkali are bases that dissociate in water to yield hydroxyl ion (OH^-) as the only negative ion.

Example: Sodium hydroxide (NaOH)

Potassium hydroxide (KOH)

Calcium hydroxide $Ca(OH)_2$

Classification of Base:

1. **On the basis of strength:** Strength of a base depends on the hydroxyl ion (OH^-) concentration.
   a) **Strong base:** Almost or complete dissociation of a base in water. E.g., NaOH, KOH, $Ca(OH)_2$,

   Example: $NaOH(aq) \rightarrow Na^+ + OH^-$

   b) **Weak base:** Partial dissociation of a base in water.

   Example: NH_4OH, $Mg(OH)_2$ (Magnesium hydroxide)

$$NH_4OH_{(aq)} \longrightarrow NH_{4(aq)}^+ + OH_{(aq)}^-$$

2. On the basis of concentration:

a) **Concentrated base:** Relatively high amount or percentage of base in aqueous solution.

b) **Dilute base:** Relatively low amounts or percentage of base dissolved in aqueous solution.

3. On the basis of acidity:

a) **Monoacidic base:** Base having only 1 hydroxyl ion (OH^-).

Example: NaOH, KOH, LiOH (Lithium hydroxide), NH_4OH

$$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

b) **Diacidic base**: Base having 2 hydroxyl ions (OH^-).

Example: Iron (II) hydroxide $Fe(OH)_2$, Magnesium hydroxide $Mg(OH)_2$,

Zinc hydroxide $Zn(OH)_2$, Lead hydroxide $Pb(OH)_2$.

$$Ca(OH)_{2(aq)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + 2H_2O_{(l)}$$

c) **Triacidic base:** Base having 3 hydroxyl ions (OH^-)

Example: Aluminium hydroxide $Al(OH)_3$.

$$Al(OH)_{3(aq)} + 3HCl_{(aq)} \longrightarrow \underset{\text{(Aluminium chloride)}}{AlCl_{3(aq)}} + 3H_2O_{(l)}$$

Properties of Bases:

i) They are bitter in taste.

ii) They turn red litmus blue.

iii) They are soapy and slippery to touch.

iv) Some bases are good conductors of electricity e.g., NaOH and KOH are used as electrolyte.

v) Caustic alkalis (base that burn skin) like NaOH and KOH are commonly called caustic soda and caustic potash respectively. These corrode glass and some metals like aluminium, zinc, tin and lead. Also they corrode organic tissues like skin completely.

How are bases formed?

Bases are generally formed in the following ways:

1. By the direct combination of a metal with oxygen.

$$2Mg + O_2 \xrightarrow{heat} \underset{\text{magnesium oxide}}{2MgO}$$

2. By the action of water or steam on some metals.

$$2Na + 2H_2O \xrightarrow{heat} \underset{\text{Sodium hydroxide}}{2NaOH} + H_2$$

$$Mg + \underset{\text{Steam}}{H_2} \xrightarrow{heat} \underset{\text{magnesium oxide}}{MgO} + H_2$$

3. By the action of heat on some metal carbonates.

$$\underset{\substack{\text{calcium carbonate}\\(\text{lime stone})}}{CaCO_3} \xrightarrow{heat} \underset{\substack{\text{calcium oxide}\\(\text{quick lime})}}{CaO} + CO_2$$

Uses of bases:

Bases are used for various purposes.

1. They are used for neutralising acids and acidic substances. For example, when you have hyperacidity, the doctor gives you an antacid. The antacid is generally a base, e.g., Magnesium hydroxide [$Mg(OH)_2$], which neutralises the acid.

2. Ammonia is used for manufacturing nitrogenous fertilisers like urea, Ammonium sulphate and Ammonium nitrate.

3. Caustic alkalis (NaOH and KOH) are used in making soap from oils and fats.

4. Lime [$Ca(OH)_2$], is used as whitewash.

5. Coloured oxides of metals like Iron, Cobalt, Chromium and Copper are used for making coloured glass.

6. Metal oxides like Magnesium oxide (MgO), Calcium oxide (CaO) and Aluminium oxide (Al_2O_3) melt only at very high temperatures. So they are used for making refractory bricks. Refractory bricks can with stand high temperatures.

Salts

Acids and bases react with each other to neutralise the effect of one another forming salt and water. This reaction is called as **neutralisation reaction.**

Example:

$$\underset{\text{(Base)}}{Na_2O} + \underset{\text{(acid)}}{2HCl} \longrightarrow \underset{\text{(salt)}}{2NaCl} + \underset{\text{(water)}}{H_2O}$$

$$\underset{\text{(Calcium oxide)}}{CaO} + \underset{\text{(Hydrochloric acid)}}{2HCl} \longrightarrow \underset{\text{(Calcium chloride)}}{CaCl_2} + \underset{\text{(water)}}{H_2O}$$

$$\underset{\text{(Sodium hydroxide)}}{2NaOH} + \underset{\text{(Sulphuric acid)}}{H_2SO_4} \longrightarrow \underset{\text{(Sodium sulphate)}}{Na_2SO_4} + 2\underset{\text{(water)}}{H_2O}$$

$$\underset{\text{(Ammonium hydroxide)}}{NH_4OH} + \underset{\text{(Hydrochloric acid)}}{HCl} \longrightarrow \underset{\text{(Ammonium chloride)}}{NH_4Cl} + \underset{\text{(water)}}{H_2O}$$

Also, salts can be formed by:

i) Direct combination of elements.

$$2Na + Cl_2 \xrightarrow{\text{heat}} \underset{\text{(Sodium chloride)}}{2NaCl}$$

$$Mg + Cl_2 \xrightarrow{\text{heat}} \underset{\text{(Magnesium chloride)}}{MgCl_2}$$

ii) By action of an acid on a metal.

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

$$Zn + H_2SO_4 \longrightarrow \underset{\text{(zinc sulphate)}}{ZnSO_4} + H_2$$

Salts found in nature

Salts are found in abundance in the earth's crust. A large number of them dissolve in rainwater and are discharged into lakes, rivers and ultimately into the sea. Salts such as chlorides, bromides, iodides and sulphates of sodium, potassium, magnesium and calcium are obtained from sea water.

Salts commonly found in soil and rocks

Salt	**Occurrence**
Sodium chloride	Rocks of common salts (common salt derived from this source is called rock salt)
Sodium carbonate	Soils of some areas (such soil is called sajji mitti in Hindi and is used in place of washing soda)
Sodium nitrate	Chile saltpetre — huge deposits are found in Chile (South America)
Potassium nitrate	Nitre — a white, woolly crust on the soil
Calcium carbonate (limestone)	All soils and limestone rocks
Calcium phosphate	All soils and phosphate rocks
Metal silicates	All soils, mica and china clay

Uses of Salts:

Salts are used for various purposes. The common uses are mentioned in table.

Salt	**Use**
Sodium chloride	As a flavouring agent in food and in the manufacture of hydrochloric acid
Sodium iodate	A supplement to common salt (iodine in food prevents the disease goitre)
Sodium carbonate	As washing soda and to make glass
Sodium benzoate	As a good preservative

Potassium nitrate	As a fertiliser, and in gunpowder and match sticks
Ammonium sulphate	As a fertiliser
Calcium carbonate (limestone)	In the cement industry and the extraction of metals
Calcium sulphate	1. As plaster of Paris ($2CaSO_4.H_2O$): When a broken limb is set in a cast made of a paste of Plaster of Paris in water, movement is restricted. This helps the bone to heal. Plaster of Paris is also used in making moulds and statues. 2. In the cement industry (in the form of gypsum, $CaSO_4.2H_2O$)
Calcium phosphate	In the manufacture of fertilisers
Bleaching powder	As a disinfectant and a bleaching agent
Alum (potassium aluminium sulphate)	1. In the purification of water (the muddy substance settles down upon treatment with alum) 2. In the dyeing industry

Test for Acidic and Basic Substances

One of the ways of finding out whether a substance is acidic or basic, is to use something known as an acid- base indicator.

Acid-Base Indicator

An acid base indicator is a substance that gives different colors in acidic and basic media.

Indicator	**Colour in Acid**	**Colour in Base**
Colour in Base	Blue to Red	Red to Blue
Phenolphthalein	Colourless	Magenta Pink
Turmeric	Yellow	Reddish brown
China Rose	Red	Green
Methyl Orange	Red	Yellow
Red Cabbage Juice	Red	Green

Some Important Chemicals:

Bleaching Powder ($CaOCl_2$)

Preparation: In Hasen-Clever Plant

$$Ca(OH)_2 + Cl_2 \longrightarrow CaOCl_2 + H_2O$$

Properties:

1. It is yellowish white solid having chlorine like smell.
2. Bleaching powder decomposes to form O_2

$$2CaOCl_2 \xrightarrow{CoCl_2} 2CaCl_2 + O_2$$

3. When reacted with H_2O liberates Cl_2.

$$CaOCl_2 + H_2O \longrightarrow Ca(OH)_2 + Cl_2$$

4. Bleaching powder is decomposed to Cl_2 by dilute H_2SO_4.

$$CaOCl_2 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + Cl_2$$

5. It reacts with carbon dioxide to form calcium carbonate and Cl_2.

$$CaOCl_2 + CO_2 \longrightarrow CaCO_3 + Cl_2$$

6. The chlorine liberated in above reaction can be used to oxidise I^- to I_2 there by liberating I_2. This I_2 can be estimated by $Na_2S_2O_3$ thus we can measure the available chlorine in bleaching powder.

$$2KI + Cl_2 \longrightarrow 2KCl + I_2$$

Uses:

Bleaching powder is used for the disinfection of drinking water or swimming pool water. For use in outdoor swimming pools, it can be used as a sanitizer in combination with a cyanuric acid stabilizer. The stabilizer will reduce the loss of chlorine because of UV radiation. Calcium does make the water 'hard' and tends to clog up some filters, for this reason Sodium hypochlorite is preferred. Bleaching powder is also used for bleaching cotton and linen and used in the manufacture of chloroform.

Sodium Hydroxide (NaOH)

Preparation

1. Soda lime process, Causticisation process or Gossage process.

$$Na_2CO_3 + Ca(OH)_2 \xrightarrow{80-90^oC} 2NaOH + CaCO_3$$

2. Castner kellner process - Electrolytic process.

Electrolyte ⟶ Brine (NaCl Solution in water)

Anode ⟶ Graphite.

Cathode ⟶ Iron rods and Mercury acts as intermediate cathode by induction.

Reaction $NaCl \longrightarrow Na^+ + Cl^-$

At anode – $Cl^- \longrightarrow Cl + e$

$Cl + Cl \longrightarrow Cl_2$

At cathode – $Na^+ + e^- + Hg \longrightarrow Na - Hg$

$2Na - Hg + 2H_2O \longrightarrow 2NaOH + H_2 + 2Hg$

(sodium amalgam)

Properties

1. White hygroscopic solid.
2. Sodium hydroxide decomposes on heating to form sodium, hydrogen and oxygen.

$$2NaOH \xrightarrow{1300^0} 2Na + H_2 + O_2$$

3. It reacts with acids to form salt and water.
   a) $NaOH + HCl \longrightarrow NaCl + H_2O$
   b) $2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$

4. It reacts with acidic oxides to form salt and water.
   a) $2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$
   (Sodium carbonate)
   b) $2NaOH + SO_2 \longrightarrow Na_2SO_3 + H_2O$
   (Sodium sulphite)
   c) $2NaOH + SiO_2 \longrightarrow Na_2SiO_3 + H_2O$

5. Metals like Zn, Al, Sn, Pb etc. displace hydrogen from sodium hydroxide. Even silicon displaces hydrogen from NaOH.
   a) $Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2$
   (Sodium zincate)

b) $2Al + 2NaOH + 2H_2O \longrightarrow 2Na AlO_2 + 3H_2$

(Sodium meta-aluminate)

c) $2Al + 6NaOH \longrightarrow 2Na_3AlO_3 + 3H_2$

(Sodium aluminate)

d) $Si + 2NaOH + H_2O \longrightarrow Na_2SiO_3 + 2H_2$

(Sodium silicate)

6) Non metals like P, S, Cl_2, Br_2 disproportionate in sodium hydroxide.

a) $4S + 6NaOH \longrightarrow 2Na_2S + Na_2S_2O_3 + 3H_2O$

(Sodium thiosulphate)

b) $4P + 3NaOH + 3H_2O \longrightarrow 3NaH_2PO_2 + PH_3$

(Sodium hypophosphite)

c) $Cl_2 + 2NaOH \longrightarrow NaCl + NaClO + H_2O$

(cold and dilute) (Sodium hypochloride)

d) $3Cl_2 + 6NaOH \longrightarrow 5\ NaCl + NaClO_3 + 3H_2O$

(hot and conc.) (Sodium chlorate)

7) It precipitates Fe^{3+}, Cu^{2+}, Cd^{2+}, etc., as metal hydroxides.

a) $FeCl_3 + 3NaOH \longrightarrow Fe(OH)_3 \downarrow + 3NaCl$

(Brown)

b) $CuSO_4 + 2NaOH \longrightarrow Cu(OH)_2 \downarrow + Na_2SO_4$

(Green)

c) $CdCl_2 + 2NaOH \longrightarrow Cd(OH)_2 \downarrow + 2NaCl$

8) Metallic salts of Al^{3+} and Zn^{2+} are precipitated as $Al(OH)_3$ and $Zn(OH)_2$ but in excess of NaOH these precipitation dissolve to form aluminates and zincates respectively.

a) $AlCl_3 + 3NaOH \longrightarrow Al(OH)_3 \downarrow + 3NaCl$

$Al(OH)_3 + NaOH \longrightarrow NaAlO_2 + 2H_2O$

b) $Zn SO_4 + 2NaOH \longrightarrow Zn(OH)_2 + Na_2SO_4$

$Zn(OH)_2 + 2NaOH \longrightarrow Na_2ZnO_2 + H_2O$

Uses: Used as strong base in chemical industry. Also used in detection of elements in chemical analysis, soap making and in making of biodiesel as catalyst.

Plaster of Paris

Quick-setting gypsum plaster consisting of a fine, white powder, calcium sulphate hemihydrate, which hardensgypsum, to 120°–180° C (248°–356° F). With an additive to retard the set, it is called wall, or hard-wall, plaster.

$$\underset{\text{Gypsum}}{CaSO_4 2H_2O} \xrightarrow{\Delta} \underset{\text{Plaster of Paris}}{CaSO_4 \frac{1}{2} H_2O} + 1\frac{1}{2} H_2O$$

Uses: Used since ancient times, Plaster of Paris is so called because Gypsum was earlier used near Paris to make plaster and cement. Plaster of Paris is also used to precast and hold parts of ornamental plasterwork placed on ceilings and cornices and is used in medicine to make plaster casts to immobilize broken bones while they heal. Some modern sculptors work directly in plaster of Paris. The speed at which the plaster sets gives the work a sense of immediacy and enables the sculptor to achieve the original idea quickly.

Water of crystallization

Water chemically bonded to a salt in its crystalline state is called water of crystallization. For example, in copper (II) sulphate, there are five moles of water per mole of copper sulphate: hence its formula is $CuSO_4.5H_2O$. This water is responsible for the color and shape of the crystalline form. When the crystals are heated gently, the water is driven off as steam and a white powder of the anhydrous salt is formed.

$$CuSO_4.5H_2O(s) \xrightarrow{\Delta} CuSO_4(s) + 5H_2O(g)$$

Baking Soda

Sodium bicarbonate is the chemical compound with the formula $NaHCO_3$. Because it has long been known and is widely used, the salt has many other names including sodium hydrogen carbonate, sodium bicarbonate, baking soda, bread soda, cooking soda, bicarb soda, saleratus or bicarbonate of soda. It is soluble in water. Sodium bicarbonate is a white solid that is crystalline but often appears as a fine powder. It has a slight alkaline taste resembling that of sodium carbonate. It is a component of the mineral

natron and is found dissolved in many mineral springs. The natural mineral form is known as nahcolite. It is also produced artificially bypassing CO_2 through aqueous sodium carbonate solution.

$$Na_2CO_3 + H_2O + CO_2 \longrightarrow 2NaHCO_3$$

Uses: It is primarily used in cooking. Also used as antacid in medicines and as an absorbent for moisture and odour. In toothpaste it is used as whitener.

Washing Soda

Sodium carbonate (also known as washing soda or soda ash), Na_2CO_3, is a sodium salt of carbonic acid. It most commonly occurs as a crystalline heptahydrate which readily effloresces to form a white powder, the monohydrate. It has a cooling alkaline taste, and can be extracted from the ashes of many plants. It is synthetically produced in large quantities from table salt in a process known as the Solvay process.

Solvay's ammonia process: In this process Brine (NaCl) solutions is saturated with ammonia and carbon dioxide to get the precipitate of $NaHCO_3$ which on heating gives Na_2CO_3. The various reactions taking place are given below:

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

$$H_2CO_3 \longrightarrow H^+ + HCO_3^-$$

$$NH_3 + H^+ \longrightarrow NH_4^+$$

$$NH_4^+ HCO_3^- + NaCl \longrightarrow NaHCO_3 + NH_4Cl$$

$$2NaHCO_3 \xrightarrow{250°C} Na_2CO_3 + H_2O + CO_2 \text{ (recycled)}$$

$$2NH_4Cl + CaO \longrightarrow CaCl_2 + H_2O + 2NH_3 \text{ (recycled)}$$

Uses: Sodium carbonate: most important use is in the chemical make-up of glass. In chemistry, sodium carbonate is often used as an electrolyte. Domestically it is used as a water softener during laundry. It competes with the ions of magnesium and calcium in hard water and prevents them from bonding with the detergent being used. It effectively removes oil, grease, and alcohol stains. Sodium Carbonate is also used as a descaling agent in boilers such as found in coffee pots, espresso machines, etc. Sodium carbonate is widely used in photographic processes as a pH regulator to maintain stable alkaline conditions necessary for the action of the majority of developing agents.

It is also used for making fusion mixture (Na_2CO_3 + K_2CO_3) and black ash (Na_2CO_3 + CaS).

DEFINITIONS

1. **Acids:** Substacnes which are sour in taste and turn blue litmus paper red are called acids.
2. **Bases:** Substnaces which are bitter in taste, soapy in touch and turn red litmus paper blue are called bases.
3. **Indicators:** Solutions which give different colours with acidic or basic medium are called indicators
4. **Neutralisation Reaction:** The reaction of an acid with base to form salt and water is called neutralisation reaction.
5. **Indigestion:** When our stomach secretes lot of acid (hydrochloric acid), it causes indigestion in stomach.

TIPS FOR COMPETITION

Acids and Bases

1. Different scientists gave different definitions for acids and bases from time to time.

i) **Arrhenius Theory :** Arrhenius defined acids as those compounds which give hydrogen ions [H^+] in aqueous solution, and bases as those compounds which give hydroxide ions [OH^-] in solutions,.e.g.

$$H_2SO_4(aq) \Longleftrightarrow 2H^+(aq) + SO_4^{2-}(aq)$$

The strength of an acid or base depends upon its tendency to furnish H^+ or OH^- ions in solution.

This definition can be applied only for those reactions which take place in aqueous solutions. Further this theory does not include substances that do not contain H^+ and OH^- ions but still can neutralize acids and bases.

Basicity or protonicity of acids: It is the number of H^+ ions furnished by a molecule of an acid.

Monobasic acid: An acid furnishing one H^+ ions, e.g., HCl, HNO_3 etc.

Dibasic acid: An acid furnishing two H^+ ions, e.g., H_2SO_4, H_2CO_3 etc.

Tribasic acid: An acid furnishing three H^+ ions, e.g., H_3PO_4 etc.

Acidity or Hydroxicity of base: It may be defined as the number of OH^- ions furnished by a molecule of a base.

Monoacidic base: NaOH, KOH.

Diacidic base: $Ca(OH)_2$, $Ba(OH)_2$.

ii) Bronsted Lowry Theory : According to this theory acids are defined as those substances which give up proton and bases are substances which accept proton,.e.g.

$$\underset{A_1}{HCl} + \underset{B_2}{H_2O} \longrightarrow \underset{A_2}{H_3O^+} + \underset{B_1}{Cl^-}$$ Equation ...1 (HCl is acid)

$$\underset{B_1}{NH_3} + \underset{A_2}{H_2O} \longrightarrow \underset{A_1}{NH_4^+} + \underset{B_2}{OH^-}$$ Equation ...2 (NH_3 is base)

From the above observations we may conclude that every acid has a conjugate base and every base has a conjugate acid.

In above equation 1, the conjugate base of acid HCl is Cl^- and the conjugate acid of water is H_3O^+ (hydronium ion)

In the above equation 2, the conjugate acid of base NH_3 is NH_4^+ and the conjugate base of H_2O is OH^-.

Thus according to this theory the following conclusions can be drawn:

a) A substance can act as an acid/base when another substance capable of accepting a proton and capable of donating a proton exists.
b) In aqueous solutions H^+ ions exist as hydrated ions or H_3O^+ (H^+. H_2O) ions.
c) Even ions may act as acid or base.
d) Water, can act both as an acid or base because it can give off a proton as well as can accept a proton.

$$\underset{B_1}{H_2O} + \underset{A_1}{H_2O} \longrightarrow \underset{A_1}{H_3O^+} + \underset{B_2}{OH^-}$$ (B_1 is acid and A_1 is base)

e) The strength of acids (or bases) depends on the medium which acts as base (or acids)

$$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$$

$$HCl + NH_3 \longrightarrow NH_4^+ + Cl^-$$

$$HCl + Benzene \longrightarrow No\ reaction$$

Acidic nature of HCl is greatest in ammonia and least in benzene.

Salt

A substance which ionizes in water to produce ions other than H^+ and OH^- is called a salt.

Types of Salts

Neutral Salts: Those salts whose aqueous solutions neither turn blue litmus red nor red litmus blue are called neutral salts. These are prepared by the neutralization of strong acid and strong base, e.g. NaCl, K_2SO_4, KNO_3, etc.

Acidic Salts: Those salts whose aqueous solutions turn blue litmus red are called Acidic salts. These are prepared by neutralization of strong acid with weak base, e.g., NH_4NO_3, NH_4Cl.

Basic Salts: Those salts whose aqueous solutions turn red litmus blue are called basic salts. These are formed by the neutralization of strong bases with weak acids, e.g., Na_2CO_3, CH_3COONa.

Mixed salts: Salts formed by the neutralization of one acid by two bases or one base by two acids are called mixed salts, e.g., $CaOCl_2$

Double Salts: A compound of two salts whose aqueous solution shows the tests for all constituent ions is called double salt e.g.

Mohr's Salt $FeSO_4.(NH_4)_2SO_4.6H_2O$.

Potash Alum $K_2SO_4.Al_2(SO_4)_3.24H_2O$.

Complex Salts: A compound whose solutions does not give tests for the constituent ions is called a complex salt, e.g.

$K_4[Fe(CN)_6]$ Potassium ferrocyanide

$Li(AlH_4)$ Lithium Aluminum hydride

pH : pH scale is used to measure the strengths of acidic and alkaline solutions. It may be defined in number of ways.

pH is defined as the negative logarithm of $[H^+]$ ion concentrations.

$$\mathrm{pH} = -\log[\mathrm{H}^+] = \log\frac{1}{[\mathrm{H}^+]}$$

pOH: The solution with less than 7 pH are acidic, the solutions with pH value more than 7 are alkaline and solution with pH value equal to 7 are neutral. It may be defined as the negative logarithms of hydroxyl ions concentration:

$$\mathrm{pOH} = -\log(\mathrm{OH}^-) = \log\frac{1}{[\mathrm{OH}^-]}$$

Ionic product of water:

$$[H^+]\,[OH^-] = 10^{-14} = K_w$$

$$-\log[H^+] \ (+) \ -\log[OH^-] = 14 = PK_w$$

$$\Longrightarrow pH + pOH = pK_w = 14.$$

SOME IMPORTANT ACIDS, BASES AND SALTS

Name of Acids	Formula of Acids
Hydrochloric acid	HCl
Sulphuric acid	H_2SO_4
Nitric acid	HNO_3
Carbonic acid	H_2CO_3
Phosphoric acid	H_3PO_4
Boric acid	H_3BO_3
Oxalic acid	$H_2C_2O_4$
Acetic acid	CH_3COOH
Lactic acid	$CH_3CH(OH)COOH$

Name of Base	Formula of Base
Sodium hydroxide	NaOH
Calcium hydroxide	$Ca(OH)_2$
Magnesium hydroxide	$Mg(OH)_2$
Potassium hydroxide	KOH
Barium hydroxide	$Ba(OH)_2$
Name of Salts	**Formula of Salt**
Sodium chloride	NaCl
Sodium carbonate	Na_2CO_3
Sodiuim bicarbonate	$NaHCO_3$
Calciuim carbonate	$CaCO_3$
Ammonium chloride	NH_4Cl
Sodium sulphate	Na_2SO_4
Potassium sulphate	K_2SO_4
Magnesium chloride	$MgCl_2$

REVISION EXERCISE LEVEL - I

State the following as True or False:

1. The pH of neutral water at 90ºC is 7.
2. Organic acids are weak acids generally.
3. The blood is slightly alkaline

Fill in the blanks:

4. Washing soda solution has pH _____ than 7.
5. When equal amounts of strong acid and base are mixed, the solution will be _____.
6. Famous “Dandi March” is related to chemical compound _____.
7. Sodium bicarbonate is also called _____.
8. HSO_4^- is a conjugate acid of _____.
9. Match the following

i) HCl	a) in storage batteries
ii) H_2SO_4	b) found in yoghurt
iii) Ascorbic acid	c) in vinegar
iv) Lactic acid	d) as bathroom acid
v) Acetic acid	e) vitamin C

10. H_3PO_2 is a

(A) monobasic acid (B) dibasic acid
(C) tribasic acid (D) tetrabasic acid

11. $AlCl_3$ is

(A) Arrhenius acid (B) Bronsted acid
(C) Bronsted base (D) None of these

12. Aqueous solution of C_6H_5COONa is

(A) Acidic (B) Basic (C) Neutral (D) Amphoteric

13. Bleaching powder acts as

(A) oxidising agent (B) reducing agent
(C) both of these (D) none of these

14. Soaps are sodium salts of

(A) carbonic acid (B) benzoic acid
(C) lower fatty acids (D) higher fatty acids

15. Which of the following is a weak electrolyte?

(A) NH_4Cl (B) NH_4OH (C) NaOH (D) HCl

16. The reaction of water with ammonia is given by the following equation

$H_2O + NH_3 \longrightarrow NH_4^+ + OH^-$

In this reaction water behaves as -

(A) neutral (B) base (C) acid (D) both B & C

17. The compound that is not a Lewis acid is

(A) BF_3 (B) $BaCl_2$ (C) $AlCl_3$ (D) $SnCl_4$

18. Which of the following will not change red litmus blue?

(A) $B(OH)_3$ (B) NaOH (C) $Ca(OH)_2$ (D) $Ba(OH)_2$

19. Hydrochloric acid can be neutralised by

(A) Nitric acid (B) Sulphuric acid

(C) Citric acid (D) Sodium hydroxide

20. A soap solution is

(A) Acidic (B) Alkaline (C) Neutral (D) All of these

21. In a neutralisation reaction, an acid reacts with a base to give

(A) another acid (B) another base

(C) salt and water (D) Oxide and water

22. What is the common name for sodium bicarbonate?

(A) Baking powder (B) Blue vitriol

(C) Caustic soda (D) Alum

LEVEL - II

1. On passing excess of CO_2 gas in an aqueous solution of calcium carbonate, milkiness of the solution

(A) Persists (B) Pades (C) Deepens (D) Disappears

2. Which of the following properties are not shown by dilute HCl?

(A) It turns blue litmus red

(B) It turns red litmus blue

(C) It reacts with zinc and a gas is evolved

(D) It reacts with solid sodium carbonate to give brisk effervescence.

3. Metallic oxides are _____ in nature, but non-metallic oxides are _____ in nature.

The information in which alternative completes the given statement?

(A) Neutral, acidic (B) Acidic, basic (C) Basic, neutral (D) Basic, acidic

4. When a drop of unknown solution X is placed on a strip of pH paper, a deep red colour is produced. This sample is which one of the following?
   (A) NaOH (B) HCl (C) Water (D) CH_3COOH
5. Solid sodium bicarbonate was placed on a strip of pH paper. The colour of the strip is:
   (A) turned red (B) did not change
   (C) turned green and slightly yellow (D) turned pink
6. Four drops of red litmus solution were added to each of the following samples which one has turned red litmus blue?
   (A) Alcohol (B) Distiled water
   (C) Sodium hydroxide solution (D) HCl
7. Which of the following natural sources contains oxalic acid?
   (A) Lemon (B) Orange (C) Tomato (D) Tamarind
8. The acid found in an outstanding is:
   (A) Acetic acid (B) Citric acid
   (C) Tartaric acid (D) Methanoic acid
9. Which of the following salts has minimum pH value?
   (A) $(NH_4)_2SO_4$ (B) $NaHCO_3$ (C) H_2SO_4 (D) NaCl
10. What are the products obtained when potassium sulphate reacts with barium iodide in an aqueous medium?
    (a) KI and $BaSO_4$ (B) KI, Ba and SO_2
    (C) K, I_2 and $BaSO_3$ (D) K, Ba, I_2 and SO_2
11. Which of the following salts is base in nature?
    (A) NH_4NO_3 (B) Na_2CO_3 (C) Na_2SO_4 (D) NaCl
12. Which one of the following is required to identify the gas evolved when dilute hydrochloric acid reacts with zinc metal?
    (A) Blue litmus paper (B) Red litmus paper
    (C) A burning silver (D) Lime water
13. Zinc reacts with an acid as well as with a base to liberate hydrogen on the basis of this what should be the behaviour of the zinc metal?
    (A) Basic (B) Acidic (C) Amphoteric (D) Neutral
14. If an unknown solution turns blue litmus red, then the pH of the solution is

more likely to be

(A) 12 (B) 10 (C) 7 (D) 4

ADDITIONAL EXERCISE

1. Limewater is -

   (A) dilute solution of $Ca(OH)_2$ (B) $Mg(OH)_2$ solution

   (C) NaOH solution (D) KOH solution

2. Which of the following is a base and not analkali?

   (A) NaOH (B) KOH (C) $Fe(OH)_3$ (D) None of these

3. Nature of aqueous solution of Ammonia is -

   (A) acidic (B) basic (C) neutral (D) None of these

4. Neutralization reaction is an example of -

   (A) Exothermic reaction (B) Endothermic reaction

   (C) Oxidation (D) None of these

5. An indicator that turns reddish brown when dissolved in soap solution is -

   (A) litmus (B) china rose

   (C) turmeric powder (D) None of these

6. Which of the following is not an indicator?

   (A) Methyl orange (B) Litmus (C) China rose (D) Sunflower

7. Which of the following is a strong acid?

   (A) Acetic acid (B) Citric acid (C) Nitric acid (D) Tartaric acid

8. Acetic acid is used -

   (A) as soda water (B) for preparing soaps

   (C) in flavouring food items (D) to manufacture detergents

9. The acid present in lemon is -

   (A) citric acid (C) acetic acid

   (B) oxalic acid (D) hydrochloric acid

10. ..... is known as ascorbic acid which is present in citrus fruits.

    (A) Vitamin D (B) Vitamin C (C) Vitamin A (D) Vitamin K

11. When a drop of phenolphthalein is introduced in limewater, the solution turns.

    (A) blue (B) red (C) milky (D) pink

12. Acids are ---------- in taste while bases are ---------- in taste.

    (A) sweet, salty (B) sweet, sour (C) sour, salty (D) sour, bitter

13. A base which dissolves in water is called -

(A) a soluble base (B) an alkali (C) an acid (D) an oxide

14. Choose the correct statement (s)

(i) Most of the acids are water soluble.

(ii) Acids react with metallic oxides and hydroxides form metallic salt and water only.

(iii) Acids react with metallic carbonates to form metallic salt and hydrogen gas and water.

(iv) Acetic acid is used as a food preservative.

(A) (i)&(ii) only (B) (iii)&(iv) (C) (i), (ii)&(iv) (D) All the above

15. Match the following compounds with their use:

(i) Caustic soda	(a) Bleaching powder
(ii) Phosphoric acid	(b) Dyeing industry
(iii) Calcium hydroxide	(c) Manufacture of medicine
(iv) Hydrochloric acid	(d) Manufacture of phosphatic fertilizers

(A) (i)-(b), (ii)-(d),(iii)-(a),(iv)-(c) (B) (i)-(c), (ii)-(a), (iii)-(d),(iv)-(b)

(C) (i)-(c),(ii)-(d),(iii)-(a),(iv)-(b) (D) (i)-(b),(ii)-(a),(iii)-(d),(iv)-(c)

16. Acidic soil which is not good for healthy growth of plants , is neutralized by

(A) potassium hydroxide (KOH) (B) calcium oxide (CaO)

(C) sodium hydroxide (NaOH) (D) magnesium hydroxide ($Mg(OH)_2$)

17. The acid present in our stomach which helps in digestion of food -

(A) sulphuric acid (H_2SO_4) (B) nitric acid (HNO_3)

(C) hydrochloric acid (HCl) (D) phosphoric acid (H_3PO_4)

18. When turmeric stain on white clothes is washed with soap it turns red in color because -

(A) soap solution is acidic (B) soap solution is neutral

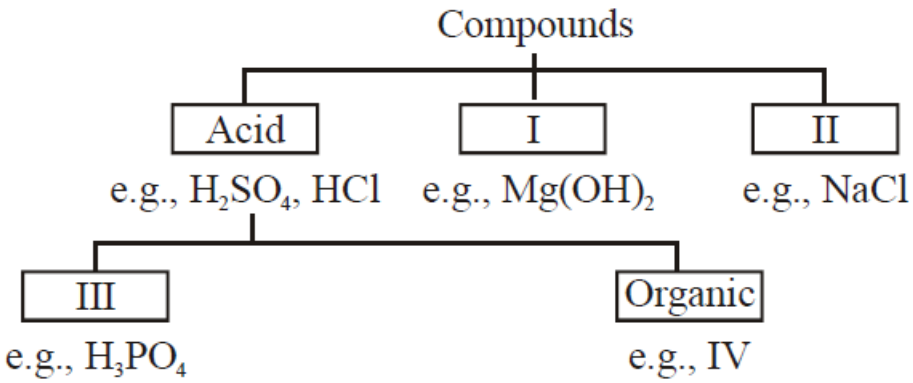
(C) soap solution is basic (D) both (A) and (B)

19. When magnesium oxide (MgO) react with water to form magnesium hydroxide [$Mg(OH)_2$], a base, it turns _____ litmus to _____ .

(A) blue, red (B) blue, colourless

(C) red, blue (D) colourless, blue

20. Observe the given flowchart carefully and mark the option that best represents I,II, III and IV



	I	II	III	IV
(A)	Mineral	Base	Salt	Acetic acid
(B)	Mineral	Salt	Base	Acetic acid
(C)	Salt	Base	Acetic acid	Mineral
(D)	Base	Salt	Mineral	Acetic acid

21. Rishi burnt a magnesium ribbon, and it burnt with a dazzling white flame. A powder yash was formed. He collected the ash and dissolved it in water. The product formed and nature of the product could be _____.

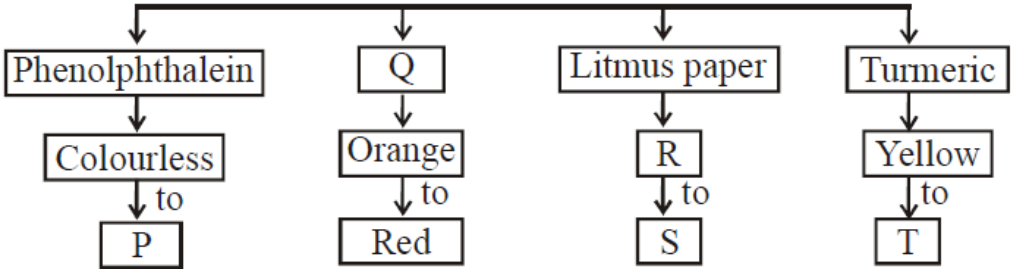
(A) MgO, acidic (B) MgO, basic

(C) $Mg(OH)_2$, basic (D) $Mg(OH)_2$, acidic

22. In summers, if milk is not refrigerated, it becomes sour. Which of the following is added by milkmen to fresh milk to prevent the milk from spoiling?

(A) Caustic soda (B) Potash alum (C) Baking soda (D) Limewater

23. When acids are added to different indicators, some colour changes occur. These colour changes are listed below.



identify P,Q, R, S and T respectively.

	P	Q	R	S	T
(A)	Colourless	Methyl orange	Blue	Red	Yellow
(B)	Colourless	China rose	Blue	Red	Yellow
(C)	Pink	Methyl orange	Blue	Red	Reddish-brown
(D)	Pink	China rose	Red	Blue	Reddish-brown

CHAPTER

5 Reproduction in Plants

A characteristic feature of all living organisms is that they give birth to young ones of their own kind. What would happen if new generations of species were not produced from their parents? The earth would turn out to be barren place with no life. Since the life span of an organism is limited, they have devised ways and means to multiply their number. *The ability of all living organisms to produce new individuals of their own kind is called* ***reproduction***. However, reproduction is not essential for an organism's survival, but it ensures that the organisms leave behind more individuals of its own kind, so that the species does not perish from earth.

There are different types of plants growing around us in park, school, garden and in our neighborhood. Many of these plants bear flowers and fruits. Such plant body consists of two main parts:

i) **Vegetative Part:** These are concerned with nutrition and growth. They comprise of the roots, stems and leaves.

ii) **Reproductive Part:** This is essentially concerned with reproduction of the plant. It comprises of the flower. A plant may have both male and female parts borne on the same flower or they may be borne by different flowers.

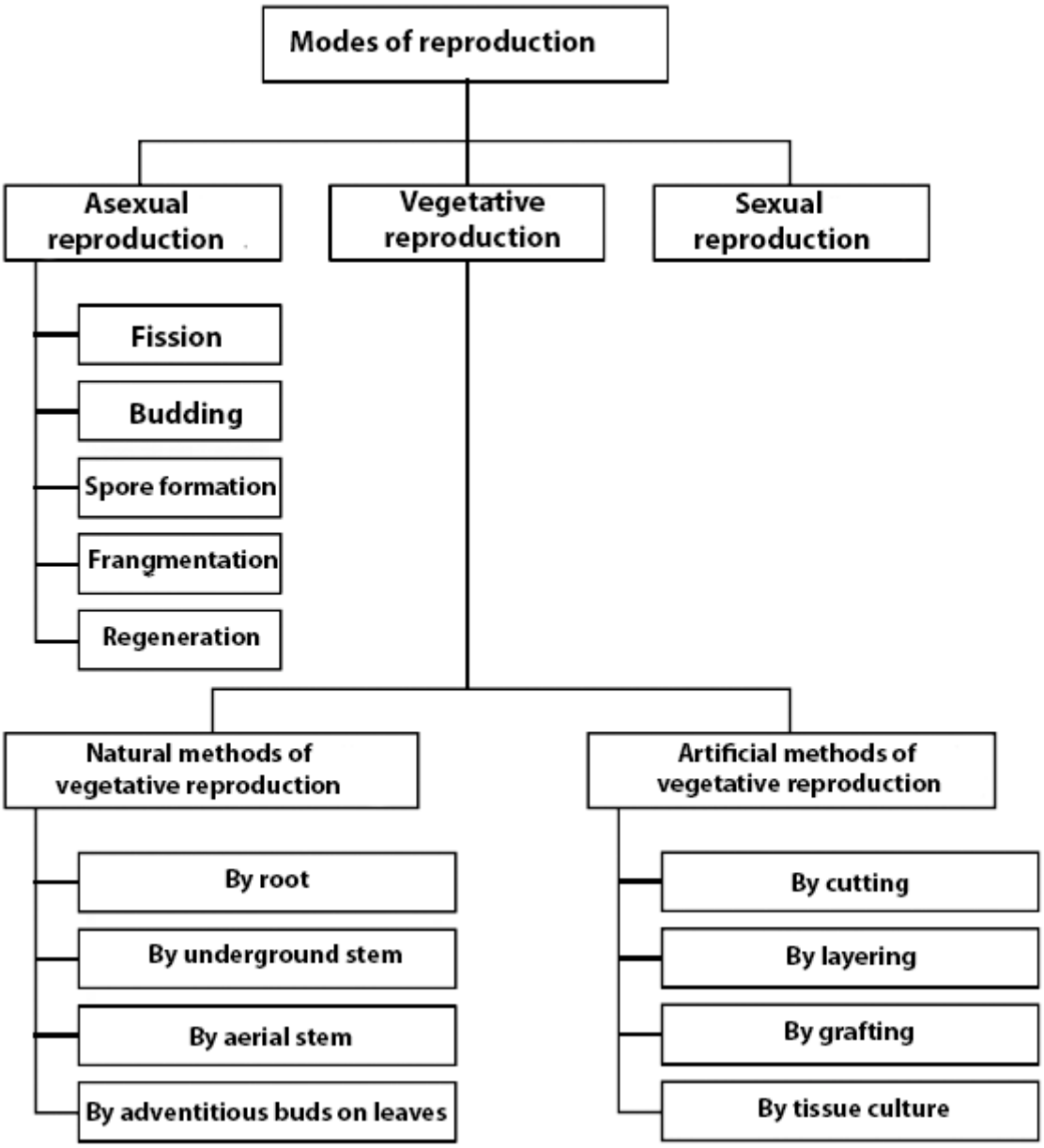
MODES OF REPRODUCTION

The three most common methods of reproduction among living organisms are:

1. Asexual reproduction.
2. Vegetative Propagation.
3. Sexual reproduction.

Asexual Reproduction

This type of reproduction involves the production of a new organism by a single parent. It occurs when there is plenty of food available and conditions are suitable for growth. Asexual reproduction is common in unicellular



a) Fission b) Budding c) Sporulation

d) Fragmentation e) Regeneration

a) **Fission:** Fission means division of cell into two parts. During fission, two daughter cells of equal size are formed from one parent. This is the simplest and most common method of reproduction seen in unicellular organisms such as *Amoeba*, *Paramoecium*, *Euglena* and bacteria. It can be of 2 types:

i) ***Binary fission:*** In binary fission, the fully grown parent cell splits into two halves to produce two daughter cells. Binary fission takes place when food is abundant. In Amoeba (Fig. 1) a unicellular organisms that lives in ponds and puddles, first the

nucleus divides into two equal nuclei and then the cytoplasm divides. This results in two daughter *Amoeba* which grow to attain full size and split again.

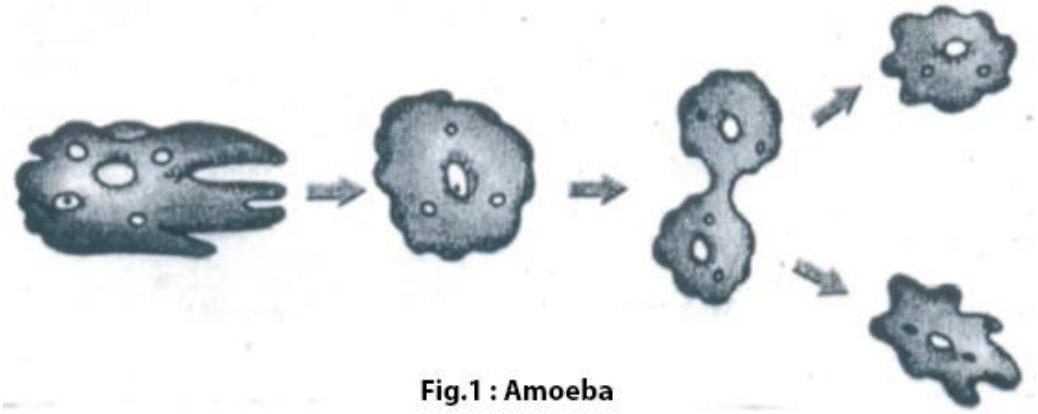
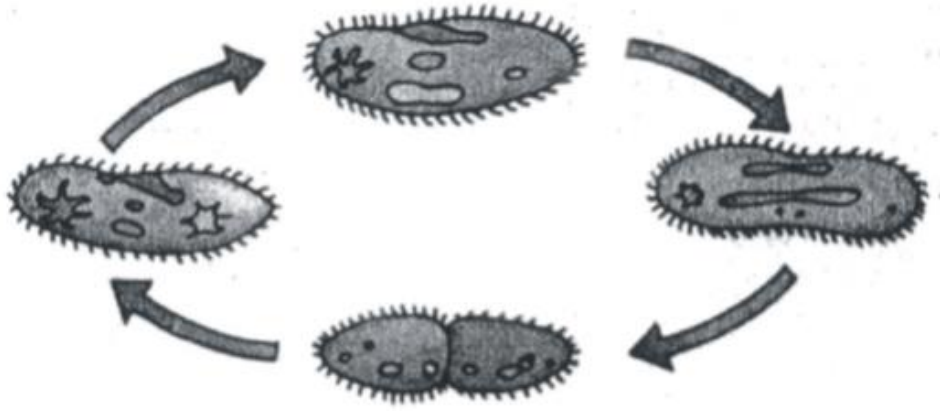


Fig.1 : Amoeba

The binary fission may be longitudinal or transverse. *Paramoecium* (Fig. 2) shows transverse binary fission. The parent cell or individual no longer exists after binary fission is complete.



B. Paramecium

Fig.2 Binary fission

ii) ***Multiple fission:*** During unfavorable conditions like lack of water, excessive heat or high temperature, a thick protective wall develops around the ***Plasmodium*** cell, called the cyst (Fig. 3). The ***Plasmodium*** splits many times within the cyst to form many small **daughter cells**. This is called multiple fission. When the cyst finally breaks, several daughter cells are released at once.

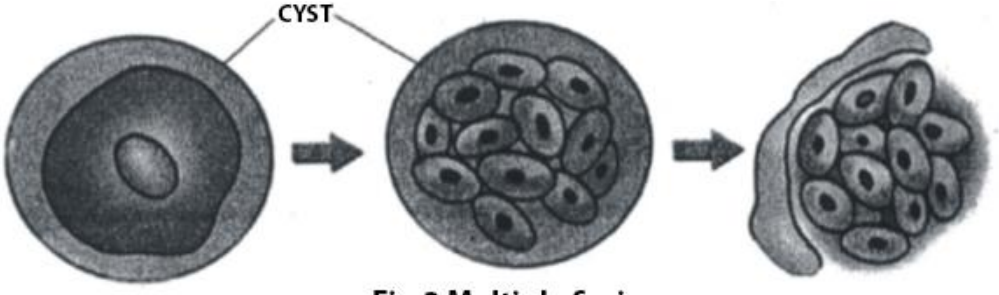


Fig.3 Multiple fission

b) **Budding:** Budding is another method of asexual reproduction in which a small bulb like outgrowth appears on the body of the organism called the bud. It grows and may break away from the parent to form a miniature organism. Yeast, corals, sponges and *Hydra* reproduce by budding (Fig. 4).

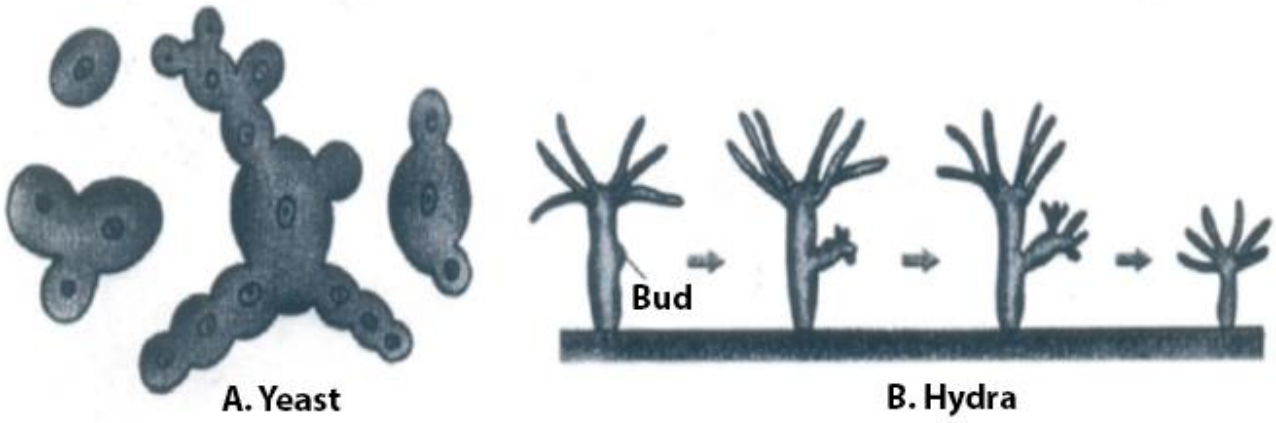


Fig.4 Budding

In yeast, a unicellular organisms, a little cytoplasm accumulates at one end of the cell. The nucleus of the parent cell divides into two and one is sent into the bud. Bud formation occurs very rapidly in yeast cells, to form a chain of yeast cells under favorable conditions. All these chains of buds don't detach from the parent individual. So a sort of colony is formed.

In *Hydra*, a multi cellular organisms a bud appears on the body wall which grows into a full Hydra in a day or two, develops tentacles and mouth and detaches from the parent body.

In corals and sponges, buds don't separate out but remain attached to the parent organism. They grow to full size and reproduce again and again, producing a colony.

c) **Spore Formation:** During unfavorable conditions many fungi (mushrooms), ferns, mosses and bacteria such as yeast, *rhizopus* and *mucor*, reproduce through spore formation. A spore is a tiny spherical unicellular body protected by a hard and thick wall (Fig. 5). Spores are microscopic structures. These spores help in overcoming conditions unfavorable for reproduction, in

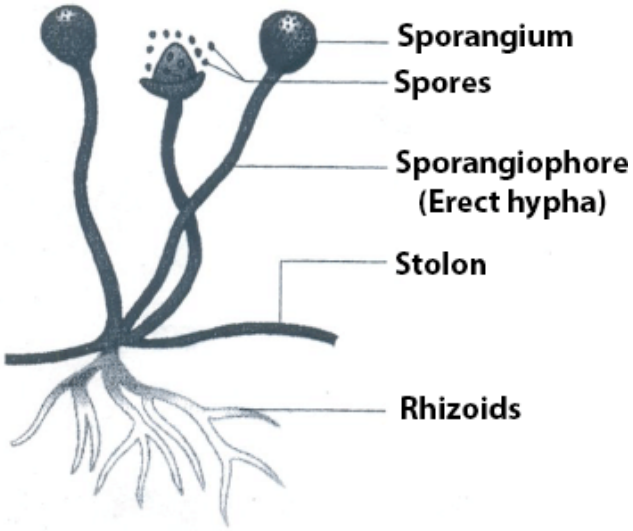


Fig.5 Spores in sporangium of rhizopus

which the plants can survive eg. Lack of food and external temperature conditions by forming spores.

The resistant spores of various organisms, e.g. the bread mould (fungi) float in the air and settle on uncovered bread or any other suitable food. It germinates and grows under favorable conditions like nutritions, temperature, moisture, etc. to produce hyphae.
Hyphae penetrate the bread, as can be seen as white thread like structure on the bread during rainy season. Some hyphae are erect and possess the swelling at their tips, called sporangium. The spores are produced by multiple fission inside the sporangium.
The white powder like substance that grows on leather goods and shoes during the rainy season are also fungi whose spores germinate to produce new colonies on leather given favourable conditions of temperature and moisture.
In case of mosses and ferns, spores are produced inside the special structure called capsules.

d) **Fragmentation**

There are several filamentous organisms like *Spirogyra* and flatworm (*Planaria*) that increases their population by fragmenting their filaments. The organisms breaks up into two or more fragments after maturation, and each fragment starts growing into a new individual (Fig. 6).

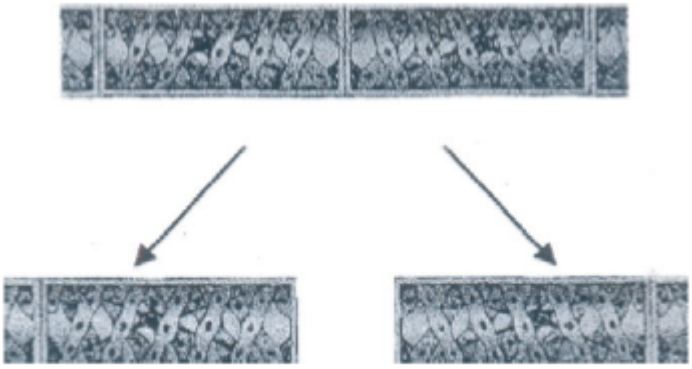
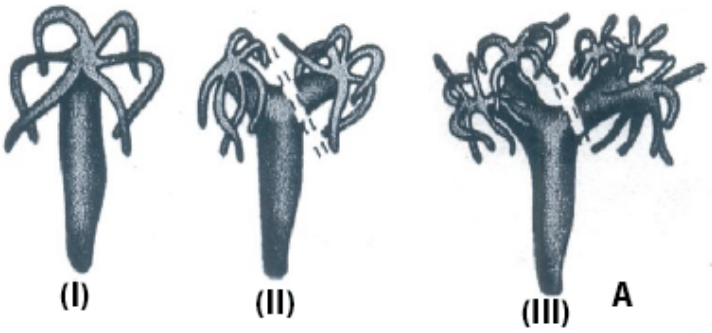


Fig.6 Fragmentation in spirogyra

e) **Regeneration:** The ability of certain plants and animals to re-develop, a lost limb or body part, is called 'regeneration', e.g. *Amoeba* and *Paramoecium* can regenerate lost parts. In fact, if an ***Amoeba*** is cut or crushed into many small pieces, with a portion of nucleus in every piece, each piece can develop into a full *Amoeba*.



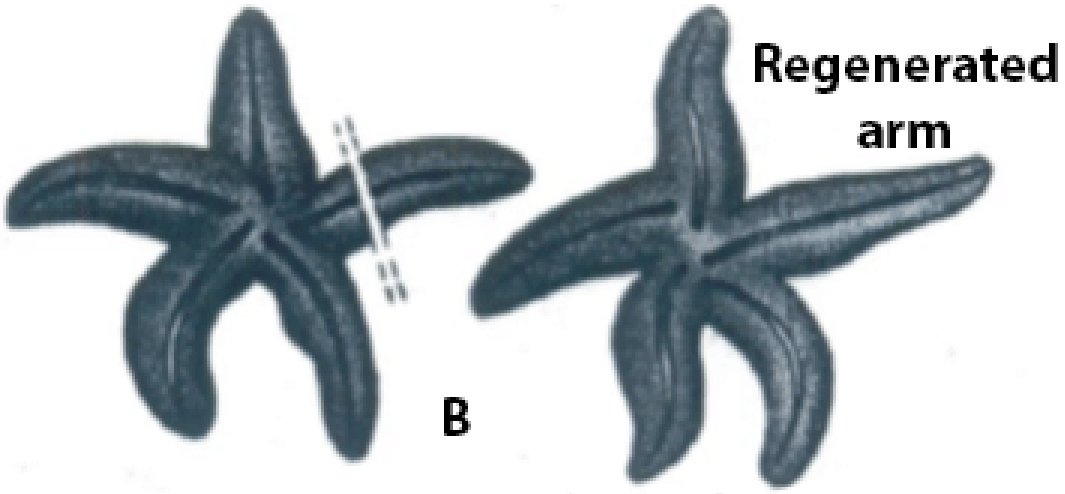


Fig.7 Regeneration (A) Hydra (B) star fish

Regeneration is more common in plants than in animals. If a Hydra (Fig. 7A), earthworm or Planaria is cut into pieces, each piece can develop into small Hydra, earthworm or Planaria. A starfish (Fig. 7B) if caught by the enemy, loses its arms and escapes. Later on, it can develop or regenerate that arm. Similarly, a wall lizard can regenerate its lost tail. A grasshopper can grow a new leg in place of broken one. The power of regeneration is restricted only up to healing of wounds etc., in man. Humans are not able to regenerate a lost part naturally.

Vegetative Propagation

Like spores, higher plants can also survive unfavorable conditions. Under such conditions, the aerial parts of a plant usually die but the underground parts like root or stem remain dormant or inactive. When conditions are favorable again, these dormant parts grow again to produce a new plant. Similar is the case with sweet potato, potato etc., which do not produce any seeds. Thus, when new plants are produced from parts of the parent plant such as the root, stem or leaves, without the help of any reproductive organs, it is known as vegetative reproduction. Different methods are used in horticulture for fruit yielding and ornamental plant, like, cutting (stem), e.g. layering in sugar cane and grafting in mango, roses, etc.:

a) **Vegetative Propagation by stem:** Some plants send out a side branch from the main plant, and a root grows down into the soil. The stem grows in length and creeps along the ground (runners) and forms roots at intervals, thus forming new plants (Fig.8). When

the new plant has grown enough, the link between the old and the new plant withers away, e.g. some species of grass and strawberry.

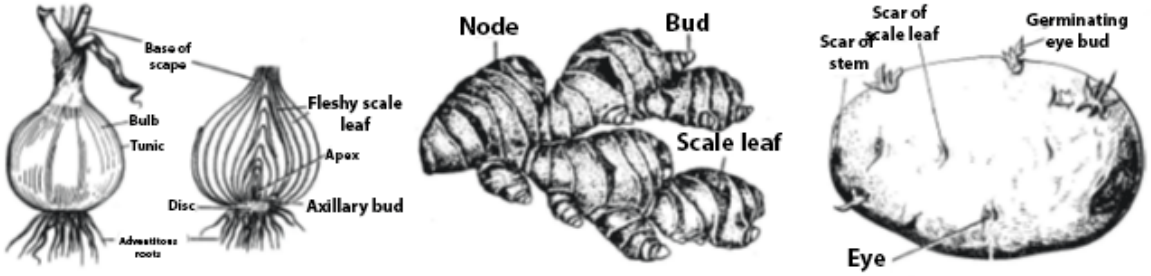


Fig.8 Vegetative propagation by underground ste,

Some plants reproduce vegetatively beneath the soil, e.g., onion, potato, ginger, etc., modified underground stems also store food. Underground stems are capable of producing several new plants from their buds and thus help the plant to multiply. Tuber, bulb, corm, rhizome are the different modifications of an underground stem. (Fig. 8):

i) ***Tuber:*** Seeds of potato are not viable. The tubers have 'eyes' present on the them. The 'eye' is made up of a bud and scale leaves. When sown, each eye is capable of developing the root, stem and leaves.

ii) ***Bulb:*** Bulbs are actually swollen large underground buds covered with scale leaves. It is a shoot modification that has a very short stem and apical and axillary buds. It stores food for the growth of new leaves and flowers. For example, onion, lily, tulip, garlic etc.

iii) ***Rhizome:*** It is horizontally growing underground stem, swollen with stored food. A rhizome bears distinct nodes, internodes, scaly leaves and adventitious roots. It has buds on its surface from which grow new plants. Ginger and turmeric are examples (Fig.9).

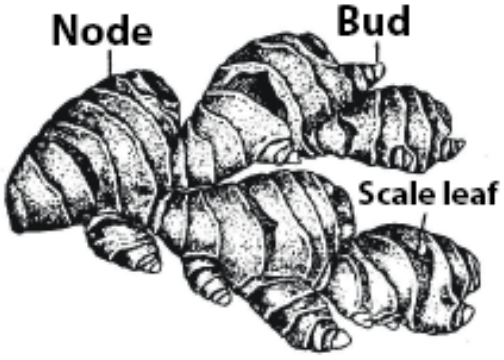


Fig.9 Rhizome of ginger

iv) ***Corm:*** It is vertically growing underground stem, swollen with stored food. Some plants like *Crocus*, *Gladiolus*, etc., consist of a short swollen solid fleshy underground stem (Fig. 10). Daughter corms develop from the sides of the parent corm, which later break off to form new plants.

Fig.10 The corm

b) **Vegetative Propagation by Root:** Some plants like Dahlia and sweet potato have roots that help in vegetative propagation (Fig.11). If roots tubes of sweet potato is cut into pieces and sown in well prepared soil, a new plant can be produced


Fig.11 Sweet potato

c) **Vegetative Propagation by Leaves:** In *Bryophyllum* and *Begonia*, new plants are produced from leaves, which have buds on the notches in their margins (Fig.12). These buds after falling on the ground or coming in contact with the soil, grow into new plant. Thus a new plant with proper root and shoot system can grow from a bud.

Fig.12 Buds of bryophyllum

d) **Vegetative propagation using artificial methods:** Vegetative propagation is a simple, fast and less expensive method of plant propagations. It is, therefore, commonly

used in horticulture and agriculture. The techniques used are stem cutting, layering, grafting and tissues culture:

i) ***Cutting:*** In this method, cutting of a healthy young branch of a plant having leaf buds is planted in the moist soil. Cutting develops roots and grows into a new plant. This method is to propagate plants like chameli, *Bougainvillea*, rose and sugarcane (Fig.13).

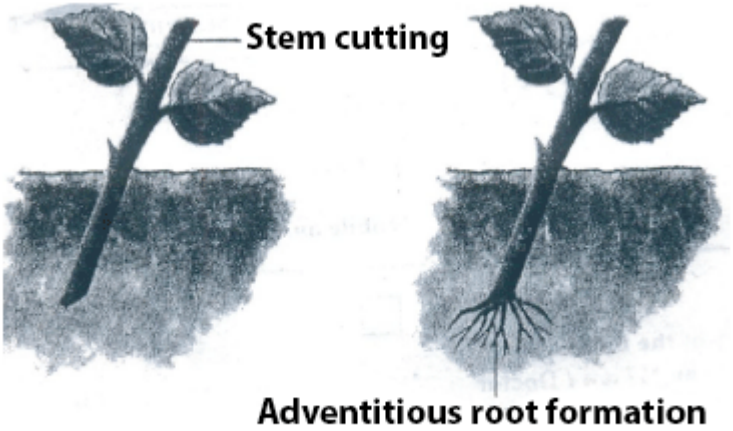


Fig.13 Vegetative propagation in orse by stem cutting

ii) ***Layering:*** In this process a young branch is bent towards the ground and covered with moist soil forming a layer. After some time, roots develop from the covered part. The branch is then cut off from the parent plant and allowed to grow into a new plant. This method is commonly used by gardeners to develop plants like jasmine, vines rose and Bougainvillea (Fig.14).

Fig.14 Layering in jasmine

iii) **Grafting:** This is a common method used in horticulture to develop new varieties of ornamental plants and fruit trees:

- In this method a bud or cutting with buds of one plant, called the scion, is kept over the cut stem of another plant, called the stock.
- The scion and the stock are then firmly tied together.
- The care is to be taken that stock has an extensive root system under the soil.

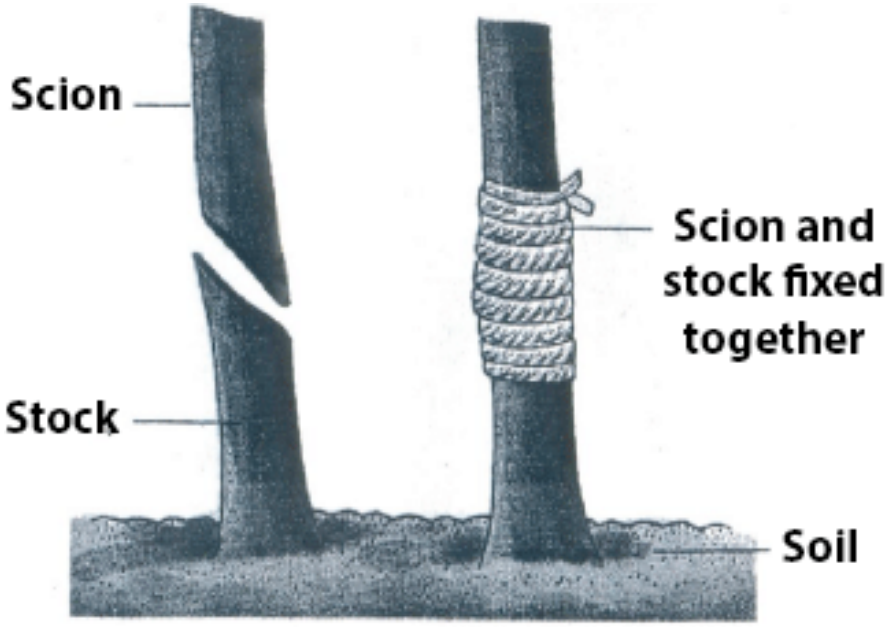


Fig.15 Vegetative propagation through grafting in plant

- After sometimes, the tissue, of the stock and scion join together to form one plant. The stock supplies the essential nutrients to the scion (Fig. 15).

This is the technique of combining the features of two plants. For example a high yielding variety may be grafted to a disease resistant variety to have characteristics of both the plants. Many new varieties of mangoes available in the market are developed by this method.

iv) **Tissue Culture:** It is a modern method of vegetative propagation of plants like *Chrysanthemum*, orchids, *Asparagus*, etc. In this method cells from the growing tip of a plant are taken. They are placed in a nutrient medium contains hormones that make the cells divide and form group of cells. These small groups of cells grow roots. The plantlet is then shifted to another medium that contains hormones suitable for growing roots. Finally the small plants are then grown in pots of soil (Fig. 16) When the plants are big enough, they are transplanted in the fields. By this technique a very large number of plants can be produced from just one parent plant. Tissue culture is being used very successfully in getting high yielding dwarf and disease resistant varieties of paddy.

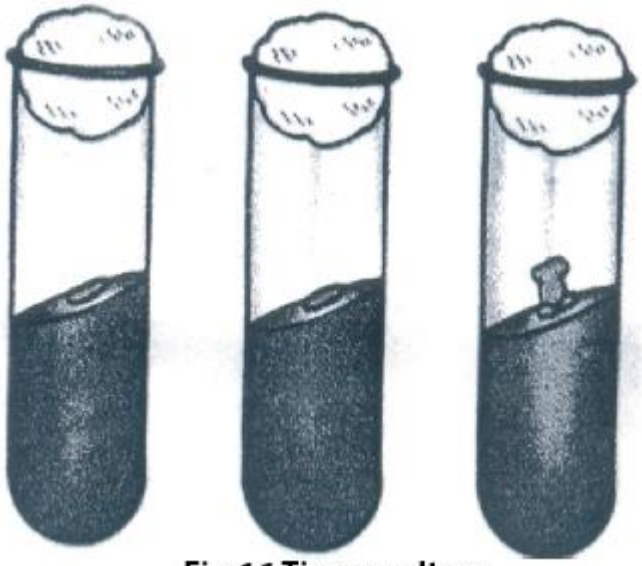


Fig.16 Tissue culture

Advantages of Vegetative Propagation

1. It is a sure and quick method of multiplying a plant.
2. Plants grown this way require less time to mature and bear fruits than those grown from the seeds.
3. It helps in rapid spread of the plant over an area.
4. The new plants produced by this method are exactly like the parent plant.
5. Through grafting, plants with desirable qualities of two varieties can be combined.
6. Plants developed by vegetative propagation usually need less attention than plants grown from seeds.
7. The survival rate of plants is almost 100% in vegetative propagation while it is hardly 1% through the formation of seeds.

Disadvantages of Vegetative Propagation

1. It leads to overcrowding.
2. There is no mechanism of dispersal.
3. The plants may show degeneration due to the absence of sexual stimulus.
4. Plants so propagated are not so efficiently protected as the seeds are. They decay easily.
5. Due to lack of genetic variation, the adaptability of plants to the environment is limited. Plants gradually lose vigour and become prone to diseases.

Sexual Reproduction

Most flowering plants are **hermaphrodites** i.e., both male and female gametes or sex cells are present in the same flower. Thus flower are the reproductive organ in plants. Flowers of plants like china rose, *Calotropis* and banyan contain both male and female gamete. Plants use various methods to ensure fertilization and sexual reproduction. For

example, moss grows in damp places because it needs water for the sperms to swim to the eggs to fertilize them.

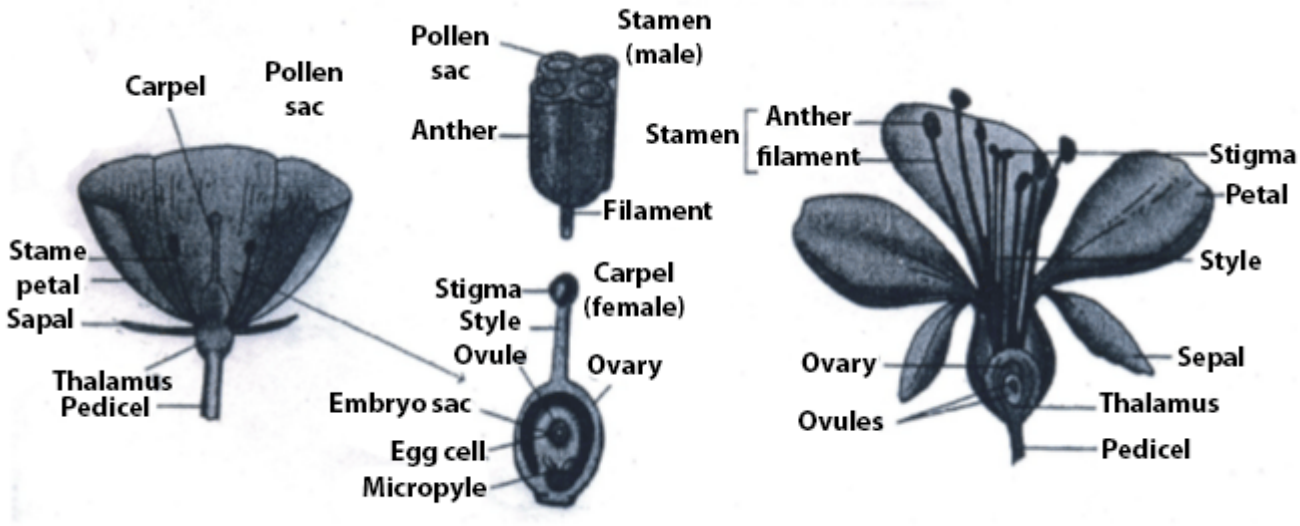


Fig.17 The structure of a typical flower

a) **Flower:** It is the reproductive organ of a plant. A flower is attached to the plant by stalk. There are many kinds of flowers but the main function of the flower is sexual reproduction and to produce seed which, on getting favorable conditions, produce new plants. Certain common features are present in all flowers. A flower that contain both male and female parts is known as **complete flower**. Thus, a complete flower contains **sepals, petals, androecium or stamen and gynoecium or carpel or pistil**. The androecium or stamen produces the male gametes while the gynoecium or pistil produces the female gamete (Fig. 17). Some flowers like corm and papaya contain either male or female reproductive organs and can produce only one type of gamete are called incomplete flowers.

There are four main parts of the flower

1. Sepals 2. Petals 3. Stamen 4. Pistil

Sepals: The sepals are green in colour and protect the flower in bud condition.

Petals: The petals are large and variously coloured to attract insect for pollination.

Stamen: It is the male reproductive part and consists of two parts the long narrow salts like filaments and the upper, broader knob like anther. The anther lobes consist of pollen sacs that contain, millions of pollen grains, which are yellow in colour. The male gametes are produced inside the pollen grains.

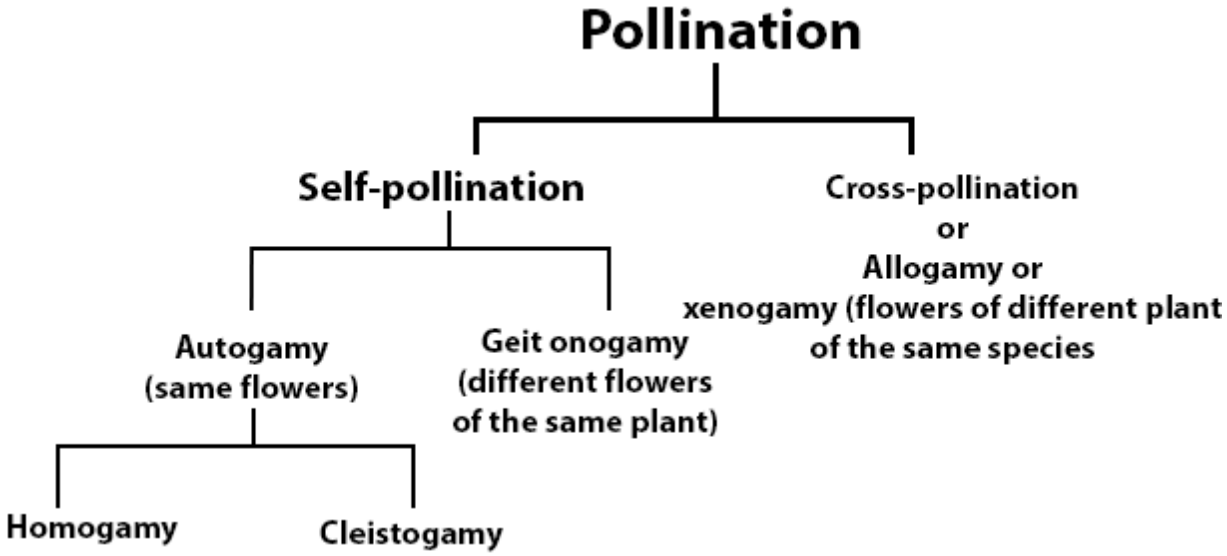
Pistil: It is the female reproductive part and consist of a swollen stigma at the top, a slender tube like style and a swollen ovary at the bottom. Inside the ovary, the ovules

contain a little bag called the embryo sac. The unripe seeds or eggs are present inside this sac.

b) **Pollination:** When the anther is mature, it splits open and sheds the pollen grains. They are dispersed by various agencies such as wind and water, so that they can be transferred to the stigma of another flower of the same species or of the same flower. The pollen grains have to be deposited on to the stigma to fertilize the egg in the ovary. Thus, the transfer of pollen from anther to stigma is called **pollination**. Pollination takes place through wind, water and insects.

Pollination: It is the transference of pollen grain from the anthers to the stigmas. Pollination is of two types:

- **Self pollination**
- **Cross pollination**



Agents for Cross Pollination

- **Anemophily:** Pollination is carried out by wind in those plants where the flowers are inconspicuous and not showy, nor do they emit any scent or produce nectar for attracting insects. Stigmas are long and often feathery. Anemophily is common in cereals, grasses, palms, etc.
- **Hydrophily:** Pollination is carried out by water. It is observed in aquatic plants, e.g., *Hydrilla, Elodea, Vallisneria.*
- **Zoophily:** Pollination is carried out by animals. Various types of zoophily are as follows :

→ **Entomophily:** Flowers are characteristically large and brightly coloured to attract insects. Pollen grains are sticky with rough surfaces. E.g., *Salvia, Ficus,* Orchids, Aroids, etc., are pollinated by insects. Common insect pollinators are bees, wasps, moths, butterflies, etc.

→ **Ornithophily:** It involves pollination by birds, e.g., bottle brush, coral tree, red silk cotton tree. The flowers are rich in nectar.

→ **Chiropterophily:** It involves pollination by bats. Flowers are large-sized and produce abundance of nectar, e.g., *Kigelia pinnata* (sausage tree), *Anthocephalus cadamba*.

→ **Malacophily:** It is pollination by snails e.g., aroids

- **Myrmecophily:** It involves pollination by ants. e.g., members of mimoceae family.

Advantages of self-pollination:

1. Flowers need not be large or conspicuous.
2. Scent and nectar are generally not produced by flowers to attract insect
3. Small quantity of pollen is sufficient.
4. Parental characters are preserved from generation to generation.
5. It is a definite method of seed formation.

Disadvantage of self-pollination:

1. Weak characteristics of the species are passed from one generation to the other.
2. The plant doesn't improve genetically.
3. Continued self-pollination may decrease vigour of the future generations of the species.

Advantages of cross-pollination:

1. New and better adapted verities are produced continuously.
2. More vigorous off springs are produced.

Disadvantages of cross-pollination:

1. The process takes a lot out of the plant as the flowers have to be large, showy with bright petals and nectar to attract insects for ensuring pollination. This costs the plant a heavy amount of food and energy to produce.
2. Large quantity of pollens are produced and wastage is substantial.
3. Pollination dependents on pollinating agents or medium like water, air, insects, bats, birds animals, etc.
4. Pollination is an uncertainty; it is not definite

Table 1: Differences between self-pollination and cross-pollination

	Self-pollination	Cross-pollination
1.	It is the migration of pollen grains from anther to the stigma of the same flower or different flower of the same plant.	It is the migration of pollen grains from anther to the stigma of another flower of another plant.

2.	Self-pollination always occurs through touch or wind.	Cross-pollination always occurs through an external agent e.g., air, wind, insects, etc.
3.	Both anthers and stigmas mature at the same time.	The anthers and stigmas mature at different times.
4.	It can occur in closed flowers.	It occurs only when the flowers are open.
5.	Race is almost constant i.e., homozygous.	The race is changing i.e., heterozygous.
6.	It gives rise to pure lines.	It gives rise to offspring having variations.
7.	It preserves the parental characters.	It does not preserve the parental characters.
8.	Yield of plant falls off with time.	Yield of plant does not fall off with time.
9.	Origin of new species is not possible.	It produces new race and varieties.
10.	For example – pea, wheat, rice, etc.	For example – jasmine, palm, coconut, maize, *Zostera*, etc.

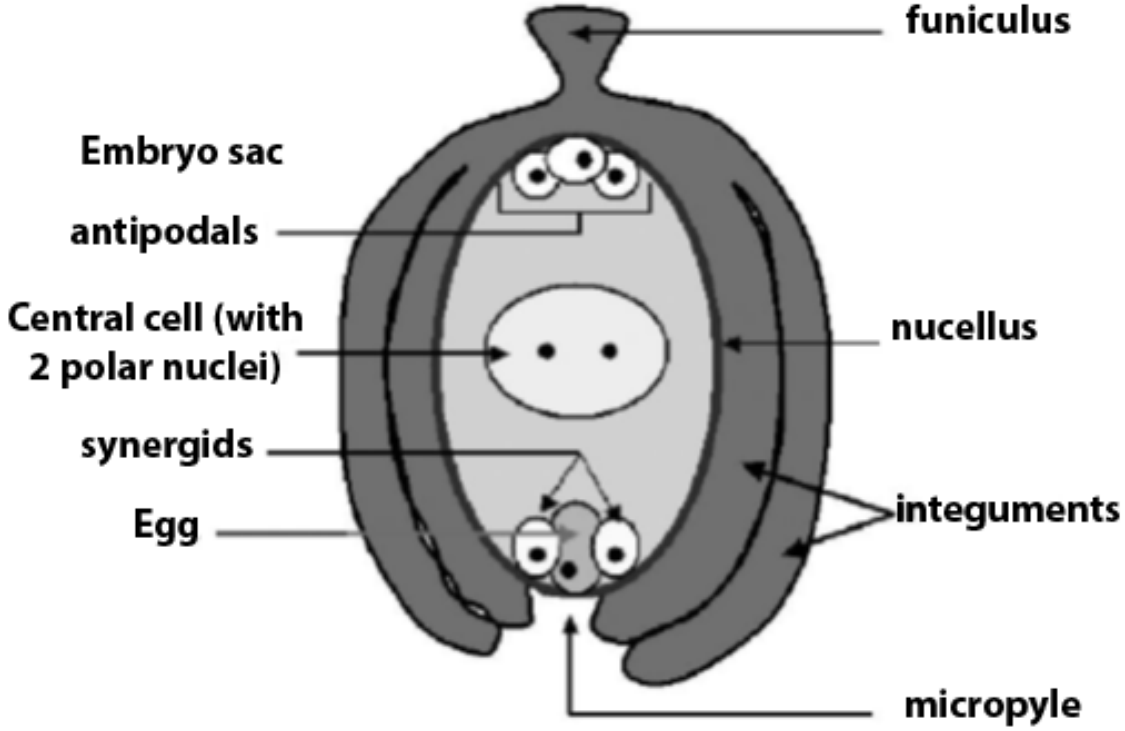
Table 2: Differences between wind pollinated and insect pollinated flower.

	Insect pollinated flower	Wind pollinated flower
1.	Flowers are large or may be in clusters.	Flowers are small.
2.	Flowers are showy and attractive, with brightly coloured petals.	Flowers are not brightly coloured.
3.	Flowers emit scent for inviting insects.	Flowers do not emit scent.
4.	They produce nectar, which is food for several insects.	They do not produce nectar.
5.	Their pollens are sticky or spiny.	Pollens are neither sticky nor spiny.
6.	Pollens are produced in small quantity.	Large quantity of pollen is produced, since wastage is substantial.
7.	Their stamens are usually small and within the flower petals.	Stamens are long and protruding to release pollens in air.
8.	Stigma is short and sticky.	Stigma is long and exposed to the air.
9.	For example – jasmine, *Rafflesia*, *Bougainvillea*, etc.	For example – coconut palm, date palm, maize, *Cannabis*, etc.

FERTILIZATION

- **Fertilization:** The fusion of male and female gametes is known as fertilization. A pollen grain falls on the stigma of the carpel, it grows a pollen tube downwards into the style. This pollen tube (which contains two male gametes) reaches the ovary where ovules are present. The male gametes coming through the pollen tube can

enter into the **embryo sac** of ovule through a tiny opening called **micropyle**. The mature embryo sac contains eight nuclei, four at its each end.



Ovule showing Embryo sac

Initial growth of the pollen tube takes place on expenditure of food present in the pollen grain. For further growth the pollen tube obtains its nourishment from the interior of stigma and style.

The pollen tube enters the ovule, either through its micropyle (porogamy) chalaza (chalazogamy) or integuments (mesogamy). The most common of these is porogamy.

- **Double Fertilization:** The pollen tube releases two male gametes into the embryo sac, one of which fuses with the female gamete (or egg) to or a zygote. This phenomenon is known as **syngamy**. The other male gamete fuses with two polar nuclei to form on endosperm nucleus. This phenomenon is known as **triple fusion**. The zygote grows into an embryo whereas the endosperm nucleus grows into endosperm which is the *food storage tissue of seed*.

Significance of Double Fertilization

Double fertilization ensures that the nutritive tissue is formed only when the formation of embryo has taken place by fertilization of the oosphere or egg.

Fruit

The fruit is a ripened ovary. They may or may not contain seeds. At times, the fruit develops even without fertilization. This is called **parthenocarpy**. Fruits are two types:

True fruits: True fruit is the fruit that is formed from the fertilized ovary. e.g., Mango, Peach, Lemon, Watermelon and Kiwifruit.

False fruits (Accessory fruit): It is the fruit that is formed the floral parts other than ovary. e.g., Cashewnut, Apple, Pear, Cucumber and Pineapple.

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REVISION EXERCISE - LEVEL - I

1. The process by which plants give rise to new plants without seeds is called :
   (a) Sexual (b) Asexual reproduction
   (c) Vegetative Propagation (d) Budding
2. Reproduction through the vegetative parts of a plant is known as :
   (a) Sexual Reproduction (b) Vegetative Propagation
   (c) Asexual reproduction (d) Pollination
3. Male reproductive part of a plant is :
   (a) Pores (b) Stamen (c) Pistil (d) Fusion
4. The flowers which contain either only the pistil or only the stamens are called :
   (a) Unisexual flowers (b) Asexual flowers
   (c) Sexual flowers (d) None of these
5. The cell which results after fusion of the gametes is called :
   (a) Spore (b) Zygote (c) Embryo (d) Pistil
6. The female reproductive part of a plant is :
   (a) Pistil (b) Bud (c) Stamen (d) Spore
7. The process of fusion of the male and female gametes is called :
   (a) Fertilisation (b) Reproduction (c) Pollination (d) Seed formation
8. Mature ovary forms the :
   (a) Seed (b) Pistil (c) Stamen (d) Fruit
9. Fill in the blank:
   (i) Production of new individuals from the vegetative part of parent is called _____ _____.

(ii) Asexual reproduction in spirogyra is an example of _____.

(iii) Fungi reproduce by _____ formation.

(iv) The fusion of male and female gamete is termed as _____.

10. State which of the following statement is true or false.

(i) A flower that contain both male and female part is incomplete flower.

(ii) The fruit is ripened ovary.

(iii) Pistil is the female reproductive part of plant.

(iv) The production of new individuals from their parents is known as respiration

(v) In sexual reproduction, only one parent is involved.

LEVEL – II

1. Which of the following produces spores:

(a) Rose (b) Potato (c) Bread mould (d) Ginger

2. *Bryophyllum* can reproduce by its :

(a) Stem (b) Roots (c) Leaves (d) Flower

3. Plants are mainly carried by two means and those are:

(a) insects and birds (b) wind and birds

(c) insects and wind (d) Grazing animals and insects.

4. Hydra reproduces by:

(a) spores (b) fusion of gametes

(c) budding (d) all of these

5. Which of the following plant gives rise to new plant by roots?

(a) Sweet potato (b) Ginger (c) Rose (d) Orchids

6. Which one of the following is ***not*** a method of vegetative propagation?

(a) Cutting (b) Grafting (c) Fragmentation (d) All of these

7. The small bulb like projection coming out of yeast is known as _____.

(a) fragmentation (b) spore (c) bud (d) seed

8. What is true about pollen of a flowering plant?

(a) It holds the embryo

(b) It is brightly coloured to attract insects

(c) It is produced by the pistil

(d) All of these

9. Which one of the following option correctly defines pollination?

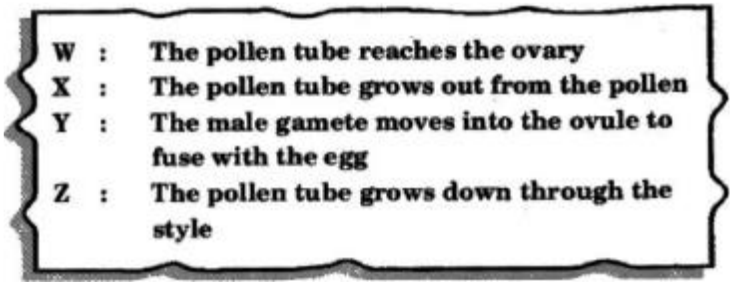
(a) Shedding of pollen from anthers

(b) Similar to fertilization of animals

(c) Transfer of pollen from anthers to stigma

(d) Transfer of pollen from anthers to ovule

10. The information in the given box: describes the process of fertilisation, but not in correct sequence.



Identify the correct sequence that takes place during the process of fertilization.

(a) WXYZ (b) XZWY (c) YWZX (d) WZXY

ADDITIONAL EXERCISE

1. Vegetative propagation in potato takes place by

(A) leaves (B) stem (C) root (D) seed

2. In which of the following plants buds are present on the margins of leaves?

(A) Bryophyllum (B) Touch me not (C) Chandan (D) Coriander

3. In yeasts reproduction occurs by

(A) fragmentation (B) binary fission

(C) budding (D) spore formation

4. A spore

(A) is a sexual reproductive body

(B) is covered by a hard protective coat

(C) germinates and develops into a new individual

(D) all of these

5. Which one of the following is not a part of a pistil?

(A) Filament (B) Ovary (C) Style (D) Stigma

6. Pollination is the movement of pollen grains from

(A) anther to ovary (B) anther to egg

(C) anther to stigma (D) none of these

7. The fusion of male and female gametes is called

(A) pollination (B) fertilisation (C) ovulation (D) gametogenesis

8. The cell which results after fusion of male gamete and female gamete is called

(A) egg (B) ovule (C) zygote (D) all of these

9. Process of fertilisation in plants occurs
   (A) inside the ovary (B) inside the anther
   (C) on the stigma (D) outside the ovary
10. Which of the following is a winged seed?
   (A) Drumstick (B) Xanthium (C) Aak (D) Castor
11. Dispersal of seeds in coconut is aided by
   (A) wind (B) water
   (C) insects (D) by burning of fruit
12. Which of the following is dispersed by sticking on the body of animals?
   (A) Xanthium (B) Maple (C) Balsam (D) All of these
13. Which of the following show vegetative reproduction?
   (A) Wheat (B) Sugarcane (C) Sunflower (D) Rice