Class-12th Board

The Catalyst

for

Mathematics

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Class Notes in Handwritten Format

Updated as per latest CBSE Syllabus

100% NCERT Based Notes | Detailed Theory | CBSE PYQs

Includes Competency-Based Questions | Simplified Flowcharts and Tables

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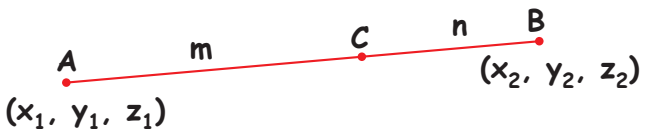
11 Three Dimensional Geometry

Distance between 2 Points in Space

$$AB = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$$

Section Formula in 3D



For internal division

$$C \equiv \left(\frac{mx_2 + nx_1}{m+n}, \frac{my_2 + ny_1}{m+n}, \frac{mz_2 + nz_1}{m+n}\right)$$

For external division

$$C \equiv \left(\frac{mx_2 - nx_1}{m-n}, \frac{my_2 - ny_1}{m-n}, \frac{mz_2 - nz_1}{m-n}\right)$$

Q.1 Prove that A(0, 2, 4), B(2, 4, 6) and C(5, 7, 9) are collinear.

Sol. $AB = \sqrt{(2-0)^2 + (4-2)^2 + (6-4)^2}$
$= \sqrt{4+4+4} = 2\sqrt{3}$

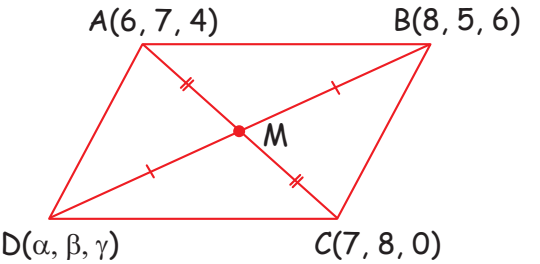
$BC = \sqrt{(5-2)^2 + (7-4)^2 + (9-6)^2}$
$= \sqrt{9+9+9} = 3\sqrt{3}$

$AC = \sqrt{(5-0)^2 + (7-2)^2 + (9-4)^2}$
$= \sqrt{25+25+25} = 5\sqrt{3}$

Clearly, AB + BC = AC. Therefore A, B, C are collinear

Q.2 There is a parallelogram ABCD with vertices A(6, 7, 4), B(8, 5, 6), C(7, 8, 0) find the coordinates of vertex D.

Sol.



[Parallelogram ke diagonals bisect karte hain iska matlab diagonals ke mid point same honge.]

M is midpoint of AC, so,

$$M = \left(\frac{6+7}{2}, \frac{7+8}{2}, \frac{4+0}{2}\right)$$

also, M is midpoint of BD,

$$M = \left(\frac{8+\alpha}{2}, \frac{5+\beta}{2}, \frac{6+\gamma}{2}\right)$$

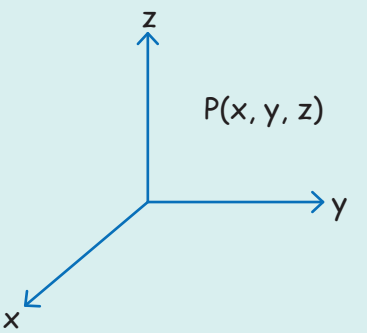
Comparing both,

$\Rightarrow 6 + 7 = 8 + \alpha, 7 + 8 = 5 + \beta, 4 + 0 = 6 + \gamma$

$\Rightarrow \alpha = 5, \beta = 10, \gamma = -2$

$\Rightarrow$ D is (5, 10, -2)

Important Baat



Any point on the x-axis (x, 0, 0)

Any point on the y-axis (0, y, 0)

Any point on the z-axis (0, 0, z)

Distance of a point P(x, y, z) from x-axis is $\sqrt{y^2+z^2}$

Distance of a point P(x, y, z) from y-axis is $\sqrt{x^2+z^2}$

Distance of a point P(x, y, z) from z-axis is $\sqrt{x^2+y^2}$

Q.3 Distance of the point (p,q,r) from y-axis is **(2023)**

(a) q (b) |q|

(c) |q| + |r| (d) $\sqrt{p^2+r^2}$

Sol. (d) Given point is (p, q, r)

The foot of perpendicular drawn from point (p, q, r) on the y-axis is (0, q, 0)

Now, distance between these two points is

$$\sqrt{(p-0)^2+(q-q)^2+(r-0)^2}=\sqrt{p^2+r^2}$$

Q.4 The length of the perpendicular drawn from the point (4, -7, 3) on the y-axis is **(2020)**

(a) 3 units (b) 4 units

(c) 5 units (d) 7 units

Sol. (c) Let P(4, -7, 3) be the given point and A be a point on y-axis s.t. PA $\perp$ to y-axis.

$\therefore$ A $\equiv$ (0, -7, 0)

Now,

$$PA \equiv \sqrt{(4-0)^2+(-7-(-7))^2+(3-0)^2}$$

$$=\sqrt{4^2+3^2}=\sqrt{16+9}=\sqrt{25}=5 \text{ units}$$

Direction Cosines & Direction Ratios of Line Passing through 2 Points

If a line passing through $A(x_1, y_1, z_1)$ & $B(x_2, y_2, z_2)$, then its DR's are

$\langle x_1 - x_2, y_1 - y_2, z_1 - z_2\rangle$

or $\langle\lambda(x_1 - x_2), \lambda(y_1 - y_2), \lambda(z_1 - z_2)\rangle$

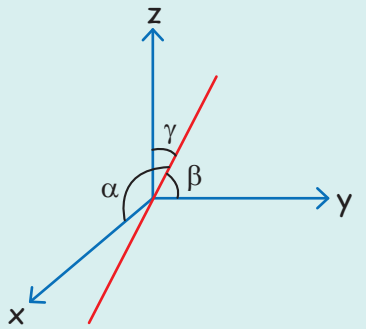
and the DC's are: $\pm\left\langle\frac{x_1-x_2}{AB}, \frac{y_1-y_2}{AB}, \frac{z_1-z_2}{AB}\right\rangle$

where AB is distance between A & B.

If a line makes an angles α, β, γ with the x, y & z axis respectively then the DC's are

$\langle\cos\alpha, \cos\beta, \cos\gamma\rangle$ or $\langle l, m, n\rangle$

Important Baat



$\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$ or $l^2 + m^2 + n^2 = 1$

or $\sin^2\alpha + \sin^2\beta + \sin^2\gamma = 2$

If DR's are $\langle a, b, c\rangle$ then DC's will be $\pm\left\langle\frac{a}{\sqrt{a^2+b^2+c^2}}, \frac{b}{\sqrt{a^2+b^2+c^2}}, \frac{c}{\sqrt{a^2+b^2+c^2}}\right\rangle$

Note: A line have 2 set of DC's i.e. $\langle\cos\alpha, \cos\beta, \cos\gamma\rangle$ or $\langle-\cos\alpha, -\cos\beta, -\cos\gamma\rangle$

A line have ∞ DR's

Q.5 If a line makes angles of 90°, 135° and 45° with the x, y and z-axes respectively, then its direction cosines are **(2023)**

(a) $\left\langle 0, -\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right\rangle$ (b) $\left\langle -\frac{1}{\sqrt{2}}, 0, \frac{1}{\sqrt{2}}\right\rangle$

(c) $\left\langle \frac{1}{\sqrt{2}}, 0, -\frac{1}{\sqrt{2}}\right\rangle$ (d) $\left\langle 0, \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right\rangle$

Sol. (a) Direction cosines are cos 90°, cos 135° and cos 45°

$\left\langle 0, -\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right\rangle$

Q.6 If a line has direction ratios 2, -1, -2, then what are its direction cosines?

Sol. DR's of line are 2, -1, -2.

DC's of line are

$$< \frac{2}{\sqrt{2^2+(-1)^2+(-2)^2}}, \frac{-1}{\sqrt{2^2+(-1)^2+(-2)^2}}, \frac{-2}{\sqrt{2^2+(-1)^2+(-2)^2}} >$$

$$\Rightarrow < \frac{2}{3}, \frac{-1}{3}, \frac{-2}{3} >$$

Q.7 Find DR's and DC's of the line $\frac{x-3}{4} = \frac{y+4}{3} = \frac{1-z}{2}$

Sol. Given line is $\frac{x-3}{4} = \frac{y-(-4)}{3} = \frac{z-1}{-2}$

DR's of the line are (4, 3, -2)

DC's of line are

$$< \frac{4}{\sqrt{4^2+3^3+2^2}}, \frac{3}{\sqrt{4^2+3^3+2^2}}, \frac{-2}{\sqrt{4^2+3^3+2^2}} >$$

$$\Rightarrow < \frac{4}{\sqrt{29}}, \frac{3}{\sqrt{29}}, \frac{-2}{\sqrt{29}} >$$

Q.8 Find the direction cosines of a line which make equal angles with the coordinate axes. **(2019)**

Sol. If a line makes α, β, γ with positive direction of x, y, z axis respectively, then DC's of line will be $\cos\alpha$, $\cos\beta$, $\cos\gamma$ or $-\cos\alpha$, $-\cos\beta$, $-\cos\gamma$.

We know that $\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$

Line makes an equal angle so, $\alpha = \beta = \gamma$

$\cos^2\alpha + \cos^2\alpha + \cos^2\alpha = 1$

$$\Rightarrow \cos^2\alpha = \frac{1}{3} \Rightarrow \cos\alpha = \pm\frac{1}{\sqrt{3}}$$

So, DC's are $\pm\frac{1}{\sqrt{3}}, \pm\frac{1}{\sqrt{3}}, \pm\frac{1}{\sqrt{3}}$

Q.9 If a line makes angles α, β and γ with the axes respectively, then $\cos 2\alpha + \cos 2\beta + \cos 2\gamma$ =

(a) -2 (b) -1

(c) 1 (d) 2

Sol. $\because \cos 2\alpha + \cos 2\beta + \cos 2\gamma = 2\cos^2\alpha - 1 + 2\cos^2\beta - 1 + 2\cos^2\gamma - 1$

$[\cos 2\theta = 2\cos^2\theta - 1]$

$\Rightarrow \cos 2\alpha + \cos 2\beta + \cos 2\gamma = 2(\cos^2\alpha + \cos^2\beta + \cos^2\gamma) - 3 = 2 \times 1 - 3 = 2 - 3 = -1$

Exercise-1

Q.1 If a line makes angle $\frac{\pi}{3}$ and $\frac{\pi}{4}$ with x-axis and y-axis respectively, then the angle made by the line with z-axis is **(NCERT)**

(a) $\frac{\pi}{2}$ (b) $\frac{\pi}{3}$

(c) $\frac{\pi}{4}$ (d) $\frac{15\pi}{12}$

Q.2 If $\left(\frac{1}{2}, \frac{1}{3}, n\right)$ are the direction cosines of a line, then the value of n is:

(a) $\frac{\sqrt{23}}{6}$ (b) $\frac{23}{6}$

(c) $\frac{2}{3}$ (d) $\frac{3}{2}$

Q.3 If the direction cosines of a line are $\left(\frac{1}{c}, \frac{1}{c}, \frac{1}{c}\right)$, then **(2023)**

(a) $0 < c < 1$ (b) $c > 2$

(c) $c > 0$ (d) $c = \pm\sqrt{3}$

Q.4 **Assertion (A):** If a line makes angles α, β, γ with positive direction of the coordinate axes then $\sin^2\alpha + \sin^2\beta + \sin^2\gamma = 2$. **(CBSE, 2023)**

Reason (R): The sum of squares of the direction cosines of a line is 1.

(a) Both Assertion (A) and Reason (R) are true, and Reason (R) is the correct explanation of Assertion (A).

(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).

(c) Assertion (A) is true, but Reason (R) is false.

(d) Assertion (A) is false, but Reason (R) is true.

Q.5 Direction cosines of the line $\frac{x-1}{2}=\frac{1-y}{3}=\frac{2z-1}{12}$ are:

(CBSE, 2023)

(a) $\frac{2}{7}, \frac{3}{7}, \frac{6}{7}$

(b) $\frac{2}{\sqrt{157}}, -\frac{3}{\sqrt{157}}, \frac{12}{\sqrt{157}}$

(c) $\frac{2}{7}, -\frac{3}{7}, -\frac{6}{7}$

(d) $\frac{2}{7}, -\frac{3}{7}, \frac{6}{7}$

Q.6 Direction ratios of a vector parallel to line $\frac{x-1}{2}=-y=\frac{2z+1}{6}$ are:

(a) 2, -6, 6 (b) 2, 1, 6

(c) 2, 1, 3 (d) 2, -1, 3

Equation of a Line in Space

1—point form

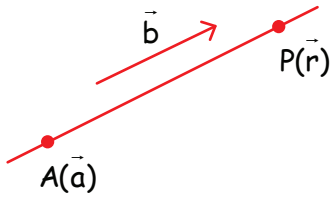
1. Vector Form of Line

The vector equation of the line is given by $\vec{r}=\vec{a}+\lambda\vec{b}$, $\lambda \in R$

Where, $\vec{r}$ = Position vector of any point of the line

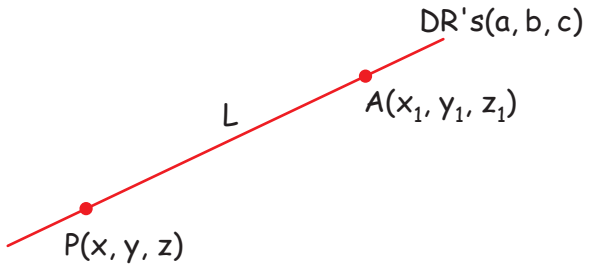
$\vec{a}$ = Position vector of a point through which line passes

$\vec{b}$ = Vector to which lines parallel



2. Cartesian Form of Line

A line L whose DR's are a, b, c and passing through the point $A(x_1, y_1, z_1)$ then the Cartesian equation of the line is $\frac{x-x_1}{a}=\frac{y-y_1}{b}=\frac{z-z_1}{c}$



Important Baat

If l, m, n are the DC's of the line, then the equation of the line is $\frac{x-x_1}{l}=\frac{y-y_1}{m}=\frac{z-z_1}{n}$

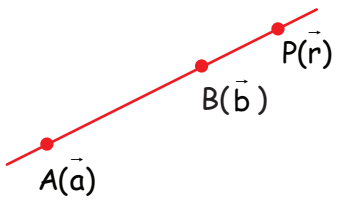
- $\frac{x-x_1}{a}=\frac{y-y_1}{b}=\frac{z-z_1}{c}=\lambda$

$\Rightarrow x = a\lambda + x_1, y = b\lambda + y_1, z = c\lambda + z_1$ be any point on the line L.

2—point form

1. Vector Form of Line

The vector equation of the line is given by $\vec{r} = \vec{a} + \lambda(\vec{b} - \vec{a})$



2. Cartesian Form of Line

If a line L passing through the point $A(x_1, y_1, z_1)$ and $B(x_2, y_2, z_2)$ then the Cartesian equation of the line is $\frac{x-x_1}{x_2-x_1}=\frac{y-y_1}{y_2-y_1}=\frac{z-z_1}{z_2-z_1}$ or

$\frac{x-x_2}{x_2-x_1}=\frac{y-y_2}{y_2-y_1}=\frac{z-z_2}{z_2-z_1}$

The DR's of line are (3, 2, -6) and (2, -12, -3) respectively.

$$\therefore \cos\theta = \frac{3\cdot 2 + 2(-12) + (-6)(-3)}{\sqrt{9+4+36}\cdot\sqrt{4+9+144}}$$

$$= \frac{6-24+18}{7\sqrt{157}} = 0$$

Hence, $\theta = \frac{\pi}{2}$ or $90°$

Q.19 Find the angle between the pair of lines given by **(NCERT)**

$\vec{r} = 3\hat{i} + 2\hat{j} - 4\hat{k} + \lambda(\hat{i} + 2\hat{j} + 2\hat{k})$

and $\vec{r} = 5\hat{i} - 2\hat{j} + \mu(3\hat{i} + 2\hat{j} + 6\hat{k})$

Sol. Here

$\vec{b}_1 = \hat{i} + 2\hat{j} + 2\hat{k}$ and $\vec{b}_2 = 3\hat{i} + 2\hat{j} + 6\hat{k}$

The angle θ between the two lines is given by

$$\cos\theta = \left|\frac{\vec{b}_1 \cdot \vec{b}_2}{|\vec{b}_1||\vec{b}_2|}\right|$$

$$= \left|\frac{(\hat{i} + 2\hat{j} + 2\hat{k})\cdot(3\hat{i} + 2\hat{j} + 6\hat{k})}{\sqrt{1+4+4}\sqrt{9+4+36}}\right|$$

$$= \left|\frac{3+4+12}{3\times 7}\right| = \frac{19}{21}$$

Hence $\theta = \cos^{-1}\left(\frac{19}{21}\right)$

Q.20 The lines $\frac{1-x}{2} = \frac{y-1}{3} = \frac{z}{1}$ and $\frac{2x-3}{2p} = \frac{y}{-1} = \frac{z-4}{7}$ are perpendicular to each other for p equal to:

(a) $-\frac{1}{2}$ (b) $\frac{1}{2}$

(c) 2 (d) 3

Sol. (c) Given line are $\frac{x-1}{-2} = \frac{y-1}{3} = \frac{z-0}{1}$ & $\frac{x-\frac{3}{2}}{P} = \frac{y-0}{-1} = \frac{z-4}{7}$.

If two lines are perpendicular then $a_1a_2 + b_1b_2 + c_1c_2 = 0$

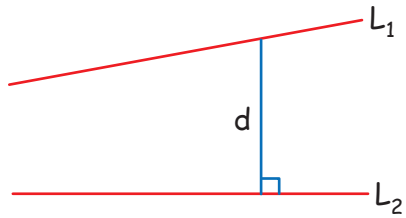
$\Rightarrow -2p - 3 + 7 = 0 \Rightarrow p = 2$

Shortest Distance between Two Skew Lines

Lines which are neither intersecting nor parallel are called skew lines and such pair of lines are non-coplanar

Vector Form: The shortest distance between two lines L_1: $\vec{r} = \vec{a}_1 + \lambda\vec{b}$ and L_2: $\vec{r} = \vec{a}_2 + \mu\vec{b}$

$$d = \left|\frac{(\vec{a}_2 - \vec{a}_1)\cdot(\vec{b}_1 \times \vec{b}_2)}{|\vec{b}_1 \times \vec{b}_2|}\right|$$



Note: If 2 lines are intersecting, then shortest distance between them is zero, i.e., $(\vec{a}_2 - \vec{a}_1)\cdot(\vec{b}_1 \times \vec{b}_2) = 0$

Cartesian form: The shortest distance between the lines $L_1 : \frac{x-x_1}{a_1} = \frac{y-y_1}{b_1} = \frac{z-z_1}{c_1}$ and $L_2 : \frac{x-x_2}{a_2} = \frac{y-y_2}{b_2} = \frac{z-z_2}{c_2}$

is $\left|\begin{vmatrix} x_2-x_1 & y_2-y_1 & z_2-z_1 \\ a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \end{vmatrix}\right| \Big/ \sqrt{(b_1c_2 - b_2c_1)^2 + (c_1a_2 - c_2a_1)^2 + (a_1b_2 - a_2b_1)^2}$.

Q.21 The lines

$\frac{x-1}{2} = \frac{y-2}{3} = \frac{z-3}{4}$ and $\frac{x-4}{5} = \frac{y-1}{2} = z$

are skew or not? **(Term-II, 2021-22)**

Sol. Given:

$$\frac{x-1}{2} = \frac{y-2}{3} = \frac{z-3}{4} \quad ...(1)$$

and $$\frac{x-4}{5} = \frac{y-1}{2} = \frac{z-0}{1} \quad ...(2)$$

SOLUTIONS

Exercise-1

1. (b) Given α, β, γ be angles made by the line with the co-ordinate axes.

$\therefore \quad \alpha = \frac{\pi}{3}, \ \beta = \frac{\pi}{4}$

$\Rightarrow \quad \cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$

$\therefore \quad \cos^2\frac{\pi}{3} + \cos^2\frac{\pi}{4} + \cos^2\gamma = 1$

$\Rightarrow \quad \frac{1}{4} + \frac{1}{2} + \cos^2\gamma = 1 \quad \Rightarrow \quad \frac{3}{4} + \cos^2\gamma = 1$

$\Rightarrow \quad \cos^2\gamma = 1 - \frac{3}{4} = \frac{1}{4}$

$\Rightarrow \quad \cos\gamma = \pm\frac{1}{2} \quad \Rightarrow \quad \gamma = \frac{\pi}{3}$

2. (a) As $\left(\frac{1}{2}, \frac{1}{3}, n\right)$ are the D.C's of a line

$\therefore \left(\frac{1}{2}\right)^2 + \left(\frac{1}{3}\right)^2 + n^2 = 1$

$\Rightarrow \frac{1}{4} + \frac{1}{9} + n^2 = 1$

$\Rightarrow n^2 = 1 - \left(\frac{1}{4} + \frac{1}{9}\right) = 1 - \left(\frac{9+4}{36}\right)$

$= 1 - \frac{13}{36} = \frac{23}{36}$

$\therefore n = \frac{\sqrt{23}}{6}$

3. (d) Since direction cosines of a line are is $\frac{1}{c}, \frac{1}{c}, \frac{1}{c}$

We know that, $l^2 + m^2 + n^2 = 1$,

Where, l, m, n are the direction cosines of a line.

$\therefore \frac{1}{c^2} + \frac{1}{c^2} + \frac{1}{c^2} = 1 \Rightarrow c^2 = 3 \Rightarrow c = \pm\sqrt{3}$

4. (a) As α, β, γ be the angles made by the line with positive direction of the co-ordinate axes.

$\therefore \cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$

$\Rightarrow 1 - \sin^2\alpha + 1 - \sin^2\beta + 1 - \sin^2\gamma = 1$

$\Rightarrow 2 = \sin^2\alpha + \sin^2\beta + \sin^2\gamma$

$\Rightarrow \sin^2\alpha + \sin^2\beta + \sin^2\gamma = 2$

Both assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of A.

5. (d) Given equation of line be

$\frac{x-1}{2} = \frac{1-y}{3} = \frac{2z-1}{12}$

$\Rightarrow \frac{x-1}{2} = \frac{y-1}{-3} = \frac{z-\frac{1}{2}}{6}$

Its direction cosines are

$\frac{2}{\sqrt{(2)^2+(-3)^2+(6)^2}}, \frac{-3}{\sqrt{(2)^2+(-3)^2+(6)^2}}, \frac{6}{\sqrt{(2)^2+(-3)^2+(6)^2}}$

i.e., $\frac{2}{7}, \frac{-3}{7}, \frac{6}{7}$

6. (d) The given line can be written as

$\frac{x-1}{2} = \frac{y}{-1} = \frac{z+\frac{1}{2}}{3}$

So, direction ratios of line parallel to given line is < 2, -1, 3>

Exercise-2

1. The given line is $5x - 3 = 15y + 7 = 3 - 10Z$

$\Rightarrow \frac{x-\frac{3}{5}}{\frac{1}{5}} = \frac{y+\frac{7}{15}}{\frac{1}{15}} = \frac{z-\frac{3}{10}}{-\frac{1}{10}}$

Co-ordiantes of the points is $\left(\frac{3}{5}, -\frac{7}{15}, \frac{3}{10}\right)$

CONCEPT MAP

To Access One Shot Revision Video Scan This QR Code

Distance between two skew lines:
Let l_1 and l_2 be two skew lines with equations

$\vec{r} = \vec{a}_1 + \lambda\vec{b}_1$

and $\vec{r} = \vec{a}_2 + \mu\vec{b}_2$

$\therefore$ Required shortest distance is

$$d = \left|\frac{(\vec{b}_1 \times \vec{b}_2).(\vec{a}_2 - \vec{a}_1)}{|\vec{b}_1 \times \vec{b}_2|}\right|$$

Cartesian form:
The shortest distance between the lines

$$l_1 : \frac{x - x_1}{a_1} = \frac{y - y_1}{b_1} = \frac{z - z_1}{c_1}$$

and $$l_2 : \frac{x - x_2}{a_2} = \frac{y - y_2}{b_2} = \frac{z - z_2}{c_2}$$

$$d = \left|\frac{\begin{vmatrix} x_2 - x_1 & y_2 - y_1 & z_2 - z_1 \\ a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \end{vmatrix}}{\sqrt{(b_1c_2 - b_2c_1)^2 + (c_1a_2 - c_2a_1)^2 + (a_1b_2 - a_2b_1)^2}}\right|$$

Distance between parallel lines:
If two lines l_1 and l_2 are parallel, then they are coplanar. Let the lines be given by

$\vec{r} = \vec{a}_1 + \lambda\vec{b}$

and $\vec{r} = \vec{a}_2 + \mu\vec{b}$

The distance between the given parallel lines is

$$d = \left|\frac{\vec{b} \times (\vec{a}_2 - \vec{a}_1)}{|\vec{b}|}\right|$$

Shortest Distance Between Two Lines

THREE DIMENSIONAL GEOMETRY

Angle Between Two Lines

Let q be the acute angle between two vectors then

$$\cos\theta = \left|\frac{a_1a_2 + b_1b_2 + c_1c_2}{\sqrt{a_1^2 + b_1^2 + c_1^2}\sqrt{a_2^2 + b_2^2 + c_2^2}}\right|.$$

or $\cos\theta = \dfrac{\vec{b}_1 \cdot \vec{b}_2}{|\vec{b}_1||\vec{b}_2|}$

Two lines will be perpendicular if $a_1a_2 + b_1b_2 + c_1c_2 = 0$, or $\vec{b}_1 \cdot \vec{b}_2 = 0$

parallel if $\dfrac{a_1}{a_2} = \dfrac{b_1}{b_2} = \dfrac{c_1}{c_2}$ or $\vec{b}_1 = \lambda\vec{b}_2$

Direction Cosines and Direction Ratios

Direction ratios: Let a, b, c be proportional to the direction cosines l, m, n then a, b, c are called the direction ratios.
If the coordinates P and Q are (x_1, y_1, z_1) and (x_2, y_2, z_2) then the direction ratios of line PQ are, a = $x_2 - x_1$, b = $y_2 - y_1$ & c = $z_2 - z_1$

Direction cosines: Let a, b, g be angles which a directed line makes with the positive directions of the axes of x, y and z respectively, then cos a, cos b, cos g are called the direction cosines of the line. The direction cosines are usually denoted by (l, m, n).
Thus l = cos a, m = cos b, n = cos g.
If l, m, n be the direction cosines and a, b, c be the direction ratios of a vector, then

$$\ell = \pm\frac{a}{\sqrt{a^2 + b^2 + c^2}}, m = \pm\frac{b}{\sqrt{a^2 + b^2 + c^2}},$$

$$n = \pm\frac{c}{\sqrt{a^2 + b^2 + c^2}}$$

If l, m, n be the direction cosines of a line, then $l^2 + m^2 + n^2 = 1$.

Equation of a Line

Vector Equation of a line:
Let l be the line which passes through the point A and is parallel to a given vector $\vec{b}$. Let $\vec{r}$ be the position vector of an arbitrary point P on the line, then Vector equation is $\vec{r} = \vec{a} + \lambda\vec{b}$

Cartesian Equation of a line:
Let the coordinates of the given point A be (x_1, y_1, z_1) and the direction ratios of the line be a, b, c. Consider the coordinates of any point P be (x, y, z). Then

$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$; $\vec{A} = x_1\hat{i} + y_1\hat{j} + z_1\hat{k}$

and $\vec{B} = a\hat{i} + b\hat{j} + c\hat{k}$

Then $\dfrac{x - x_1}{a} = \dfrac{y - y_1}{b} = \dfrac{z - z_1}{c}$

This is the Cartesian equation of the line.

Class-12th Board

The Catalyst

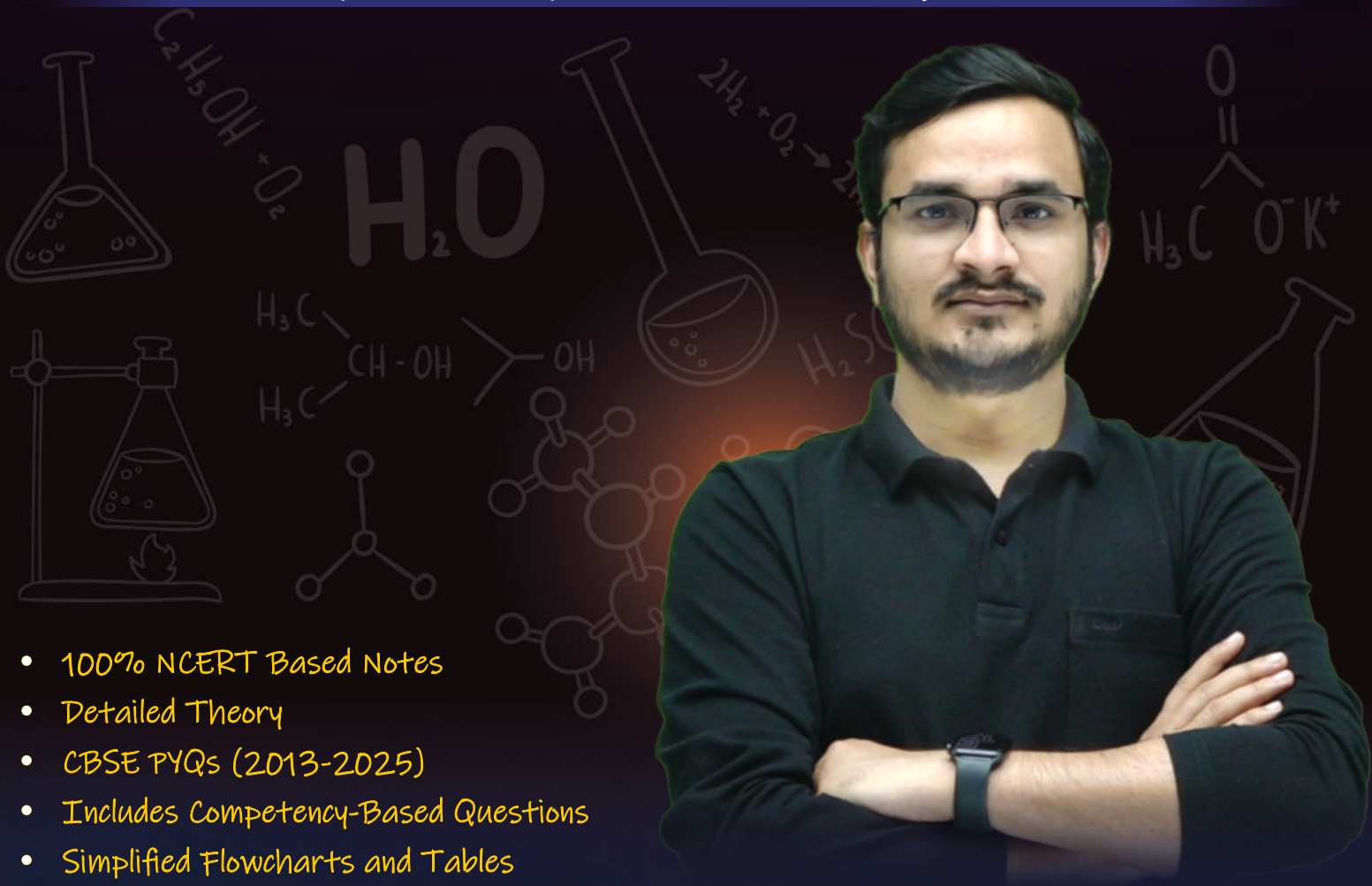
for

Chemistry

- By Om Pandey (IIT Delhi)

Class Notes in Handwritten Format

Updated as per latest CBSE Syllabus



- 100% NCERT Based Notes
- Detailed Theory
- CBSE PYQs (2013-2025)
- Includes Competency-Based Questions
- Simplified Flowcharts and Tables
- Mind Maps

Contents

1

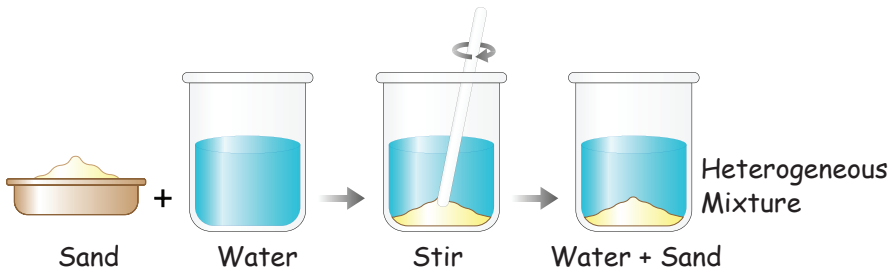
Solutions

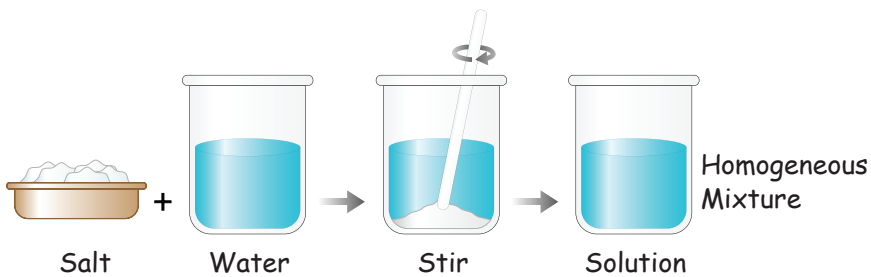
SYLLABUS

Types of solutions, expression of concentration of solutions of solids in liquids, solubility of gases in liquids, solid solutions, Raoult's law, colligative properties - relative lowering of vapour pressure, elevation of boiling point, depression of freezing point, osmotic pressure, determination of molecular masses using colligative properties, abnormal molecular mass, Van't Hoff factor.

- Solutions are homogeneous mixtures of two or more than two components.
- Homogeneous mixture means composition and properties are uniform throughout the mixture.

Example : Mixture of sugar in water is a homogeneous system. But mixture of sand in water is not homogeneous. It is called heterogeneous mixture.





Solutions

Solvent

- Component present in the largest quantity.
- Decides the physical state of solution.

Solute

- Component present in the solution other than solvent.

CLASSIFICATION

On the basis of physical states of solute and solvent			
Type of Solution	**Solute**	**Solvent**	**Common Examples**
Gaseous solutions	Gas	Gas	Mixture of oxygen and nitrogen gases
	Liquid	Gas	Chloroform mixed with nitrogen gas
	Solid	Gas	Camphor in nitrogen gas
Liquid solutions	Gas	Liquid	Oxygen dissolved in water
	Liquid	Liquid	Ethanol dissolved in water
	Solid	Liquid	Glucose dissolved in water
Solid solutions	Gas	Solid	Solution of hydrogen in palladium
	Liquid	Solid	Amalgam of mercury with sodium
	Solid	Solid	Copper dissolved in gold

CONCENTRATION TERMS

(i) Molarity : Molarity (M) is defined as number of moles of solute dissolved in 1000 ml or 1lt or $1dm^3$ of solution.

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Vol of solution in lt.}}$$ - - - (PYQ)

0.5 M KOH solution means: 0.5 moles of KOH dissolved in 1 lt or 1000 ml solution.

(ii) Molality : Molality (m) is defined as the number of moles of solute dissolved in 1kg or 1000 gm of solvent.

$$\text{Molality} = \frac{\text{Moles of solute}}{\text{Weight of solvent in kg}}$$

1.1 molal aq urea solution means: 1.1 moles of urea dissolved in 1 kg or 1000 gm of solvent.

❑ **Main advantage of molality over molarity –** - - - (PYQ)

Molality does not change with temperature whereas molarity decreases with increase in temperature.

Reason : Volume $\propto$ Temperature (If Volume of solution ↑ molarity ↓)

Q (1) Calculate the mass of urea (NH_2CONH_2) required in making 2.5 kg of 0.25 molal aqueous solution.

Sol. $\text{molality} = \frac{\text{moles of solute}}{\text{weight of solvent in kg}}$

Let the mass of urea (NH_2CONH_2) added = x gm.

Moles of urea = $\frac{x}{60}$ mol [Molecular wt of urea = 60]

Weight of solvent = weight of solution – weight of solute

= (2500 – x) gm.

$$\text{Molality} \Rightarrow 0.25 = \frac{\frac{x}{60}}{\frac{(2500-x)}{1000}}$$

On solving we get x = 36.95 gm.

HENRY'S LAW

- - - (PYQ)

Henry gave a quantitative relation between pressure and solubility of a gas in solvent.

"The solubility of a gas in a liquid is directly proportional to the partial pressure of the gas present above the surface of liquid or solution"

- The partial pressure of the gas in vapour phase (p) is proportional to the mole fraction of gas (X) in the solution.

  $p \propto X$

  $p = K_H X$ K_H = Henry's law constant

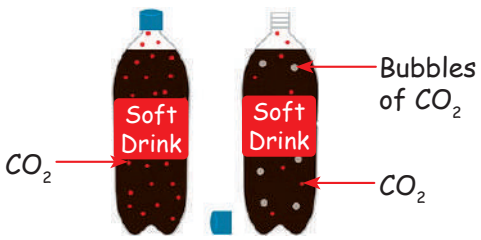
Henry's law constant (K_H):

- K_H is the function of the nature of the gas. Different gases have different K_H values at same temperature.
- Higher the value of K_H, lower is the solubility of the gas because at constant pressure, $K_H \propto \frac{1}{X}$ where X = mole fraction of gas.
- Unit of K_H = unit of pressure
- K_H is directly proportional to temperature $K_H \propto T$ and since $K_H \propto \frac{1}{X}$, So $X \propto \frac{1}{T} \Rightarrow$ Solubility of gas decreases with temperature.

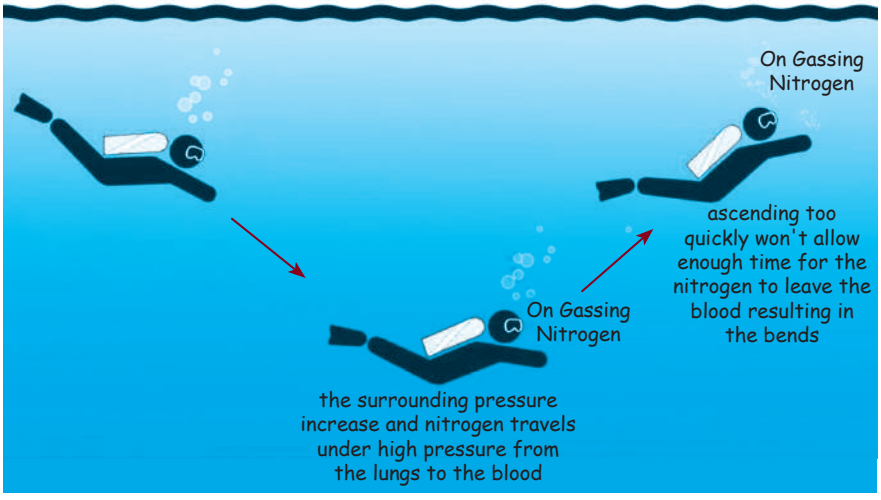
Application of Henry's law:

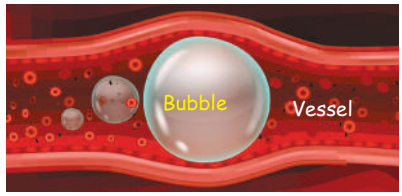
- - - (PYQ)

- To increase the solubility of CO_2 in soft drinks and soda water, the bottle is sealed under high pressure.



- Scuba divers must cope with high concentrations of dissolved gases while breathing air at high pressure under water. According to Henry's law, higher the pressure, higher will be the solubility of atmospheric gases in blood. When the diver come towards the surface of water, pressure decreases and the solubility of dissolved gases also decreases which leads to the formation of bubbles of nitrogen in the blood. This blocks capillaries and creates the medical condition known as 'bend', which is dangerous to life. To avoid the toxic effects of high concentration of nitrogen in the blood, the tanks used by scuba drives are filled with air diluted with helium (11.7% helium, 56.2% nitrogen and 32.1% oxygen).





Bends- The most common serious diving injury

- At high altitudes, the partial pressure of oxygen is low so the solubility of oxygen in the blood and tissues of people living there is also low. Low blood oxygen causes people living there or climbers to become weak and unable to think clearly, symptoms of conditions known as anoxia.

PYQ (3) The partial pressure of ethane over a saturated solution containing 6.56×10^{-2} g of ethane is 1 bar. If solution contains 5.0×10^{-2} g of ethane, then what will be partial pressure of gas?

Sol. According to Henry's law –

(*i*) $m_1 = K_H . p_1$

$$6.56 \times 10^{-2}\ g = K_H .\ 1\ bar$$

$$K_H = 6.56 \times 10^{-2}\ g\ bar$$

(*ii*) $m_2 = K_H\ p_2$

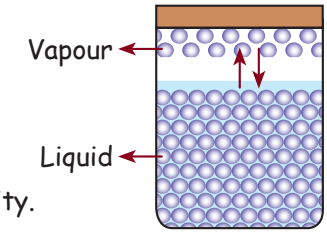
$$\text{Partial pressure of gas } (p_2) = \frac{m_2}{K_H} = \frac{5 \times 10^{-2} g}{6.56 \times 10^{-2} g / bar} = 0.762 \text{ bar.}$$

VAPOUR PRESSURE OF LIQUID SOLUTIONS

Definition: The pressure exerted by the vapours of liquid on the surface of liquid and on the walls of the container is called the vapour pressure of the pure liquid, when liquid and vapour are in equilibrium.

$$\text{liq} \rightleftharpoons \text{vap.}$$

$$K_p = \frac{P_{vap}}{P_{liq}} = P_{vap} \quad [\text{as } P_{liq} = 1]$$



As we know that K_p depends on temperature so P_{vap} is also a temperature dependent quantity.

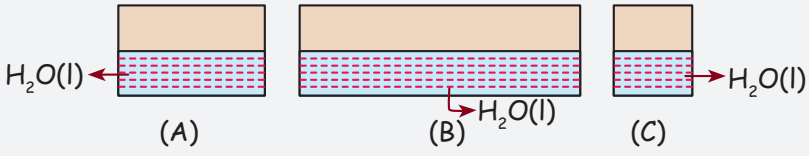
So vapour pressure of pure liquid depends on

(*i*) Nature of the liquid.

(*ii*) Temperature of the liquid.

Note: If intermolecular forces between the molecules of liquid are less, then the vapour pressure will be high, loosely held molecules escape more easily into vapour.

Q (8) Which container has more vapour pressure?



Sol. Vapour pressure depends on nature of the liquid and temperature so vapour pressure in all the containers will be same.

$$\boxed{V.P_{(A)} = V.P_{(B)} = V.P_{(C)}}$$

VAPOUR – PRESSURE OF LIQUID-LIQUID SOLUTIONS : - - - (PYQ)

Raoult's law

"For a solution of volatile liquids, the partial vapour pressure of each component of the solution is directly proportional to its mole fraction present in the solution".

Liquid A has vapour pressure = P°_A

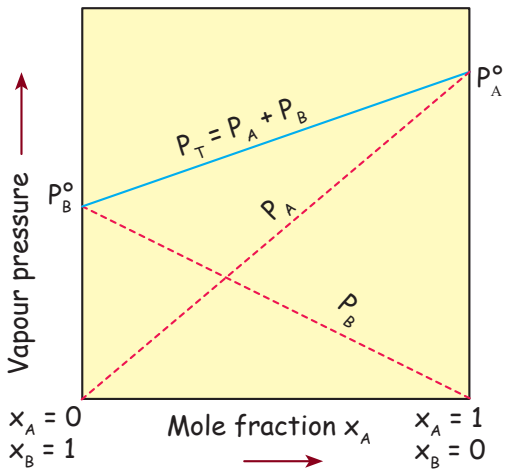
Liquid B has vapour pressure = P°_B

According the Raoult's law- $P_A \propto X_A$

$$P_A = P^\circ_A X_A \quad \ldots (i)$$

$P_B \propto X_B$

$$P_B = P^\circ_B X_B \quad \ldots (ii)$$

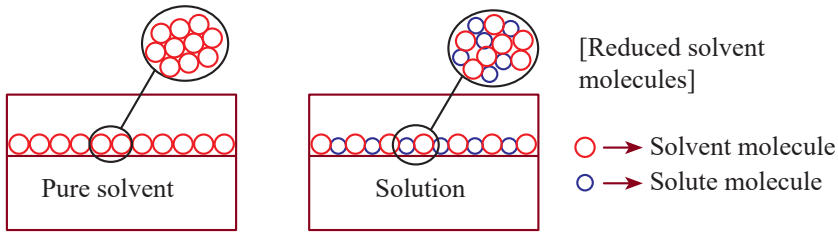


VAPOUR PRESSURE OF SOLUTIONS OF SOLIDS IN LIQUIDS

Raoult's law for the solution containing non-volatile solute and volatile solvent states that-"vapour pressure of solution at a given temperature is found to be lower than the vapour pressure of pure solvent at same temperature".

Reason:

In the solution, the surface has both solute and solvent particles, thereby the fraction of the surface covered by the solvent molecules reduced. Consequently the number of solvent molecules escaping from the surface is correspondingly reduced, then the vapour pressure is also reduced.

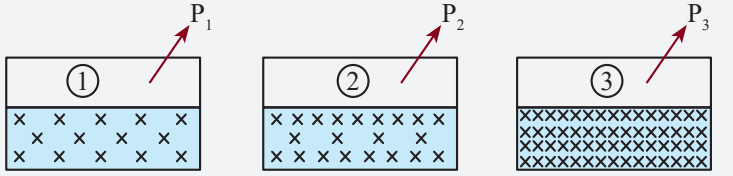


$P_T = P_A + P_B$ [A = solvent, B = solute]

$P_T = P_A$ [Solute is non-volatile, $P_B = 0$]

$P_T = P_A^\circ X_A$ [$P_A = P_A^\circ X_A$]

Q (9) Let us have three aqueous solutions of sugar at some temperature and some amount of water.



Solution having one spoon sugar | Solution having two spoons sugar | Solution having three spoons sugar

Which is the correct option?

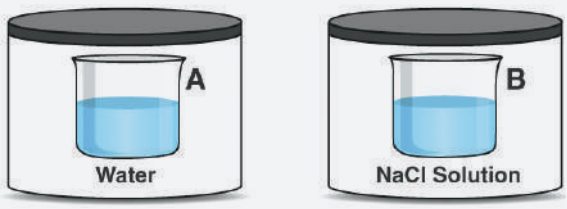
(A) $P_1 = P_2 = P_3$ (B) $P_1 > P_2 > P_3$ (C) $P_1 < P_2 < P_3$ (D) Can't predict

Sol. (B) $P = P^\circ X_{solvent}$

So more the mole fraction of solvent, more will be the vapour pressure. So for solution (1), $X_{solvent}$ is maximum. So, $P_1 > P_2 > P_3$.

Hence, option (B) is correct.

MCQ (7) Two beakers of capacity 500 mL were taken. One of these beakers, labelled "A", was filled with 400 mL water whereas the beaker labelled "B" was filled with 400 mL of 2 M solution of NaCl. At the same temperature both the beakers were placed in closed containers of same material and same capacity as shown in figure.



At a given temperature, which of the following statement is correct about the vapour pressure of pure water and that of NaCl solution.

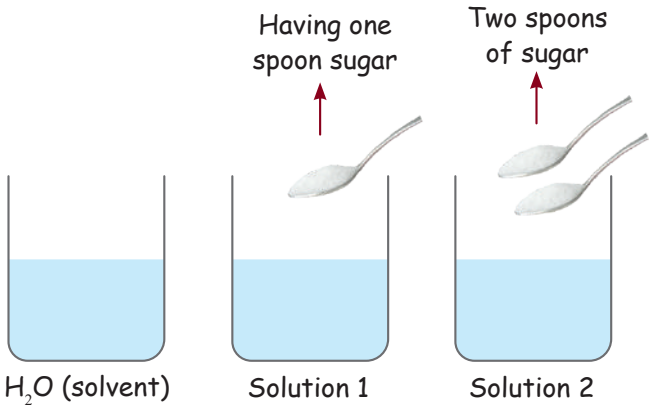
(A) vapour pressure in container (A) is more than that in container (B).

(B) vapour pressure in container (A) is less than that in container (B).

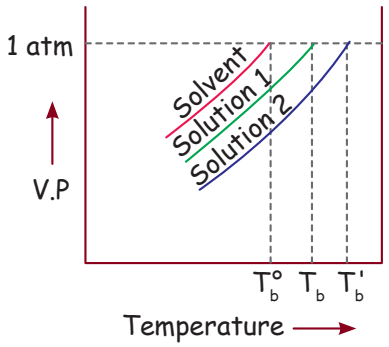
(C) vapour pressure is equal in both the containers.

(D) vapour pressure in container (B) is twice the vapour pressure in container (A).

Sol. (A) Since NaCl is a non-volatile solute, it will reduce vapour pressure of the solution. Hence, vapour pressure of pure water in container A is more than in container B.



Graphical explanation:



$T'_b > T_b > T°_b$

It is evident from the graph that on increasing the spoons of sugar, boiling point increases so increase in boiling point is a colligative property.

- For dilute solutions, $\Delta T_b \propto$ molality of solution - - - (PYQ)

$$\Delta T_b = K_b.m$$

ΔT_b = elevation in boiling point

K_b = B.P elevation constant/Molal elevation constant (Ebullioscopic constant)

m = molality of solution

- Unit of $K_b = \frac{\text{unit of temperature}}{\text{unit of molality}} = \frac{K}{\text{mol/kg}} = K\text{-kg mol}^{-1}$

Note: Ebullioscopic constant is a property of solvent only. If solvent of different solutions is same then K_b value remains same.

Example:

aq. solution of urea | aq. solution of sugar

Since both are aqueous solution, so solvent is same. Hence, K_b values for both the solutions are same.

- $K_b = \frac{M_{solvent}.R\,T°_b}{\Delta H_{vap} \times 1000}$ [$T°_b$ = boiling point of solvent] [ΔH_{vap} = Heat of vaporisation solvent]

- $\Delta T_b = K_b \times$ molality

$$= K_b\left(\frac{\text{moles of solute}}{\text{wt of solvent in kg}}\right)$$

$$= K_b\left(\frac{\frac{W_{solute}}{M_{solute}}}{\frac{W_{solvent}}{1000}}\right)$$

$$M_{solute} = \frac{1000 \times W_{solute} \times K_b}{\Delta T_b \times W_{solvent}}$$

MCQ (12) The unit of ebullioscopic constant is

(A) K kg mol^{-1} or K (molality)$^{-1}$ (B) mol kg K^{-1} or K^{-1}(molality)

(C) kg mol^{-1} K^{-1} or K^{-1}(molality)$^{-1}$ (D) K mol kg^{-1} or K (molality)

Sol. (A) The unit of ebullioscopic constant is K kg mol^{-1} or K (molality)$^{-1}$.

6 Haloalkanes and Haloarenes

MOST RELEVANT BOARD LEVEL PROBLEMS

Assertion and Reason Type Questions

Direction: The following questions consist of two statements- Assertion (A) and Reason (R). Answer these questions by selecting the appropriate option given below:

(*a*) Both A and R are true, and R is the correct explanation of A.

(*b*) Both A and R are true, but R is not the correct explanation of A.

(*c*) A is true, but R is false.

(*d*) A is false, but R is true.

1. Assertion (A): The boiling points of alkyl halides decrease in the order: RI > RBr > RCl > RF

Reason (R): The boiling points of alkyl chlorides, bromides and iodides are considerably higher than that of the hydrocarbon of comparable molecular mass.

Sol. (*b*) For the same hydrocarbon part boiling point depends upon the atomic mass of halogen atom. Higher the mass of the halogen atom, higher will be the boiling point. Therefore, b.p. decreases with decrease in atomic mass of halogen atoms.

Halides are polar molecules, hence, they have greater boiling points than hydrocarbon of comparable molecular mass.

2. Assertion (A): KCN reacts with methyl chloride to give methyl isocyanide

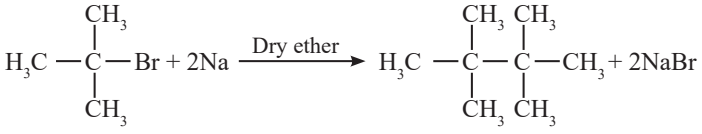
Reason (R): CN^- is an ambident nucleophile.

Sol. (*d*) KCN reacts with methyl chloride to give methyl cyanide

3. Assertion (A): tert-Butyl bromide undergoes Wurtz reaction to give 2, 2, 3, 3-tetramethylbutane.

Reason (R): In Wurtz reaction, alkyl halides react with sodium in dry ether to give hydrocarbon containing double the number of carbon atoms present in the halide.

Sol. (*a*)



4. Assertion (A): Presence of a nitro group at ortho or para position increases the reactivity of haloarenes towards nucleophilic substitution.

Reason (R): Nitro group, being an electron withdrawing group decreases the electron density over the benzene ring.

Sol. (*a*)

5. Assertion (A): Aryl iodides can be prepared by reaction of arenes with iodine in the presence of an oxidising agent.

Reason (R): Oxidising agent oxidises I_2 into HI.

Sol. (*c*)

6. Assertion (A): It is difficult to replace chlorine by –OH in chlorobenzene in comparison to that in chloroethane.

Reason (R): Chlorine-carbon (C—Cl) bond in chlorobenzene has a partial double bond character due to resonance.

Sol. (*a*)

7. Assertion (A): Hydrolysis of (–)-2-bromooctane proceeds with inversion of configuration.

Reason (R): This reaction proceeds through the formation of a carbocation.

Sol. (*c*) 2-Bromooctane $\xrightarrow{S_N2}$ inversion of configuration

8. Assertion (A): Nitration of chlorobenzene leads to the formation of m-nitrochlorobenzene

Reason (R): —NO_2 group is a m-directing group.

Sol. (*d*)

9. Assertion (A): Inversion of configuration is observed in S_N2 reaction. **(CBSE, 2024)**

Reason (R): The reaction proceeds with the formation of carbocation.

Sol (*c*)

10. Assertion (A): Chlorobenzene is resistant to electrophilic substitution reaction.

Reason (R): C-Cl bond in chlorobenzene acquires partial double bond characters due to resonance. **(CBSE, 2023)**

Sol. (*d*) Due to resonance, C-Cl bond in chlorobenzene acquires a partial double bond and the chloro group is ortho, para directing that makes it reactive towards electrophilic substitution reaction.

11. Assertion (A): Chlorobenzene is less reactive towards nucleophilic substitution reaction.

Reason (R): Nitro group in chlorobenzene increases its reactivity towards nucleophilic substitution reaction. **(CBSE, 2022 Term-I)**

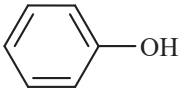
Sol. (*b*)

Short Answer Type Questions

1. Haloarenes are less reactive than haloalkanes and haloalkenes. Explain.

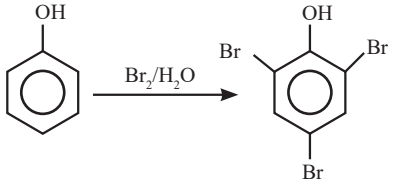
Sol. As C-X bond in aryl halide acquires a partial double bond character due to resonance while the C-X bond in alkyl halide is a pure single bond. Hence, the bond strength of haloarenes is more than that of haloalkanes. So, haloarenes are less reactive than haloalkanes towards nucleophilic substitution.

2. Which of the following compounds (a) and (b) will not react with a mixture of NaBr and H_2SO_4. Explain why?

(a) $CH_3CH_2CH_2OH$ (b) 

Sol. (*b*) As mixture of NaBr and H_2SO_4 gives Br_2 gas.

$$2NaBr + 3H_2SO_4 \rightarrow 2NaHSO_4 + SO_2 + Br_2 + 2H_2O$$



Phenol (b) reacts with Br_2 to form 2, 4, 6-tribromophenol.

But $CH_3CH_2CH_2OH$ (a) does not react with Br_2 water.

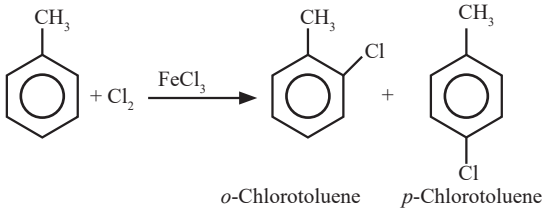
3. Which of the products will be a major product in the reaction given below? Explain.

$$CH_3CH = CH_2 + HI \rightarrow \underset{(A)}{CH_3CH_2CH_2I} + \underset{(B)}{CH_3CHICH_3}$$

Sol. In the given reaction, (B) is the major product of the reactions. According to Markownikoff's rule, H is added to the C atom with a higher number of hydrogen atoms.

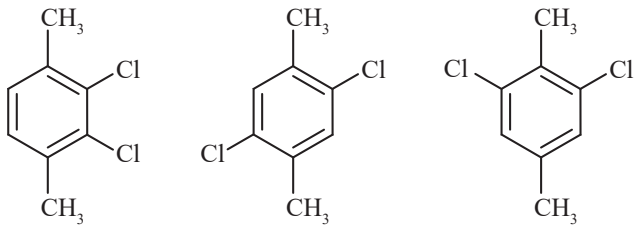
4. Write the structures and names of the compounds formed when compound 'A' with molecular formula, C_7H_8 is treated with Cl_2 in the presence of $FeCl_3$.

Sol. The compound with molecular formula C_7H_8 is toluene, $C_6H_5CH_3$. Since the $-CH_3$ group is o-, p-directing, therefore, chlorination of toluene gives o-chlorotoluene and p-chlorotoluene, in which the p-isomer predominates.



o-Chlorotoluene *p*-Chlorotoluene

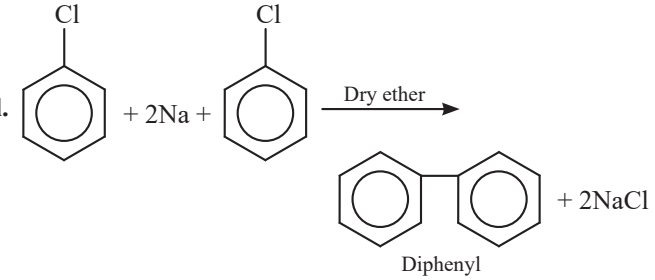
5. Which of the following compounds will have the highest melting point and why?



(I) (II) (III)

Sol. Structure II has a symmetrical structure hence, it will have the highest melting point.

6. Diphenyls are a potential threat to the environment. How are these produced from aryl halides?

Sol. 

Diphenyl

7. How can you obtain iodoethane from ethanol when no other iodine containing reagent except NaI is available in the laboratory?

Sol. $\underset{\text{Ethanol}}{C_2H_5OH} + HCl(g) \xrightarrow{ZnCl_2(anhyd)} C_2H_5Cl \xrightarrow[(Acetone)]{NaI} \underset{\text{Iodoethane}}{C_2H_5I}$

8. Cyanide ion acts as an ambident nucleophile. From which end it acts as a stronger nucleophile in aqueous medium? Give reason for your answer.

Sol. It acts as a stronger nucleophile from the carbon end because it will lead to the formation of C – C bond which is more stable (bond between two similar atoms) than C – N bond.

Long Answer Type Questions

1. Account for the following: **(CBSE, 2024)**

(*a*) Haloalkanes react with AgCN to form isocyanide as main product.

(*b*) Allyl chloride shows high reactivity towards S_N1 reaction.

(*c*) Haloarenes are extremely less reactive towards nucleophilic substitution reactions.

Sol. (*a*) $Ag - C \equiv N\overset{\odot}{:} \curvearrowright R \curvearrowleft X \longrightarrow RNC + AgX$

AgCN is mainly covalent in nature and lone pair at nitrogen is free to attack on carbon centre to form isocyanide as product.

(*b*) Allyl chloride (CH_2=CH–CH_2Cl) exhibits high reactivity towards the S_N1 reaction due to the formation of a stable allylic carbocation intermediate (CH_2=CH–$\overset{+}{C}H_2$). This intermediate is stabilized by resonance, where the positive charge is delocalized over the allyl group, making the carbocation more stable and facilitating the S_N1 reaction.

(*c*) Already given.

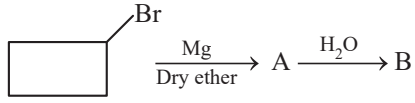
2. Answer any 3 of the following: **(CBSE, 2023)**

(*a*) Which isomer of C_5H_{10} gives a single monochloro compound C_5H_9Cl in bright sunlight?

(*b*) Arrange the following compounds in increasing order of reactivity towards S_N2 reaction: 2-Bromopentane, 1-Bromopentane, 2-Bromo-2-methylbutane

(*c*) Why p-dichlorobenzene has a higher melting point than those of ortho- and meta-isomers?

(*d*) Identify A and B in the following:



(*b*) In stage 1, it condenses vapours and returns liquid to the flask thus allowing the reaction mixture to be heated at the boiling point without any loss of the reactant.

In stage 2, it condenses vapours of the product that is distilling out.

Case-Based Type Questions

1. Nucleophilic Substitution reaction of haloalkane can be conducted according to both S_N1 and S_N2 mechanisms. S_N1 is a two step reaction while S_N2 is a single step reaction. For any haloalkane which mechanism is followed depends on factors such as structure of haloalkane, properties of leaving group, nucleophilic reagent and solvent. Influences of solvent polarity: In S_N1 reaction, the polarity of the system increases from the reactant to the transition state, because a polar solvent has a greater effect on the transition state than the reactant, thereby reducing activation energy and accelerating the reaction. In S_N2 reaction, the polarity of the system generally does not change from the reactant to the transition state and only charge dispersion occurs. At this time, polar solvent has a greater stabilizing effect on Nu than the transition state, thereby increasing activation energy and slowing down the reaction rate.

For example, the decomposition rate (S_N1) of tertiary chloro butane at 25 C in water (dielectric constant 79) is 300000 times faster than in ethanol (dielectric constant 24). The reaction rate (S_N2) of 2-Bromopropane and NaOH in ethanol containing 40% water is twice slower than in absolute ethanol. Hence the level of solvent polarity has influence on both S_N1 and S_N2 reactions, but with different results. Generally speaking weak polar solvent is favourable for S_N2 reaction, while strong polar solvent is favourable for S_N1. Generally speaking the substitution reaction of tertiary haloalkane is based on the S_N1 mechanism in solvents with a strong polarity (for example ethanol containing water).

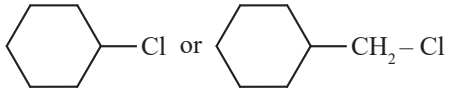
Answer the following questions: **(CBSE, 2023)**

(*a*) Why racemisation occurs in S_N1?

(*b*) Why is ethanol less polar than water?

(*c*) Which one of the following in each pair is more reactive towards S_N2 reaction?

(*i*) $CH_3 - CH_2 - I$ or $CH_3CH_2 - Cl$

(*ii*)  or

OR

(*c*) Arrange the following in the increasing order of their reactivity towards S_N1 reactions:

(*i*) 2-Bromo-2-methylbutane, 1-Bromopentane, 2-Bromopentane

(*ii*) 1-Bromo-3-methylbutane, 2-Bromo-2-methylbutane, 2-Bromo-3-methylbutane

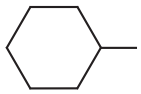
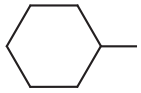
Sol. (*a*) S_N1 mechanism involves two steps.

First step involved production of the carbocation intermediate that is a planar molecule.

Second step involves nucleophilic attack that lead to the formation.

(*b*) In ethanol, hydrogen atom and alkyl groups are bonded to Oxygen, whereas in water molecule oxygen is bonded to two hydrogen atoms. The electronegativity difference between carbon (C) and oxygen (O) is smaller than that between oxygen (O) and hydrogen (H) in water. Hence, ethanol is less polar than water

(*c*) (*i*) $CH_3–CH_2–I$ is more reactive towards S_N2 as iodine is better leaving the group.

(*ii*)  Cl is secondary halide therefore undergoes S_N2 reaction slower than  $CH_2 - Cl$ which is a primary halide.

OR

(*c*) (*i*) 1-Bromopentane (1°) < 2-Bromopentane (2°) < 2-Bromo-2-methylbutane (3°)

(*ii*) 1-Bromo-3-methylbutane (1°) < 2-Bromo-3-methylbutane (2°) < 2-Bromo-2-methylbutane (3°)

2. When haloalkanes containing β-hydrogen atoms are heated with an alcoholic solution of KOH, they undergo β-elimination reactions, resulting in the formation of alkenes by eliminating hydrogen halide. These reactions are also known as dehydrohalogenation reactions and follow Saytzeff's rule, favouring the more substituted alkene as the major product. In the presence of bases, substitution and elimination reactions can compete with each other as most bases can act as nucleophiles, engaging in either substitution or elimination depending on the specific alkyl halide and reaction conditions.

(*a*) Explain why tertiary alkyl halides are more likely to undergo elimination reactions.

(*b*) What is the major product formed when a haloalkane undergoes β-elimination in the presence of an alcoholic solution of KOH?

(*c*) When an alkene is formed through β-elimination reactions of haloalkanes, which type of alkene is formed as major product and which rule governs this outcome?

Sol. (*a*) Tertiary alkyl halides are more likely to undergo elimination reactions because they form more stable product i.e., disubstituted alkene.

(*b*) The major product formed during β-elimination of a haloalkane in the presence of an alcoholic solution of KOH is an alkene.

For example:

$CH_3CH_2Br + KOH(alc.) \rightarrow H_2C = CH_2 + KBr + H_2O$

(*c*) In β-elimination reactions, the outcome is the formation of an alkene with a double bond between the α and β carbon atoms.

Saytzeff's rule governs this outcome, favouring the more substituted (more stable) alkene as the major product.

Physics Wallah Set-1

Series RP5PS/5

प्रश्न-पत्र कोड
Q.P. Code 56/5/1

रोल नं.
Roll No.

परीक्षार्थी प्रश्न-पत्र कोड को उत्तर-पुस्तिका के मुख-पृष्ठ पर अवश्य लिखें।

Candidates must write the Q.P. Code on the title page of the answer-book.

नोट

(I) कृपया जाँच कर लें कि इस प्रश्न-पत्र में मुद्रित पृष्ठ **8** हैं।

(II) कृपया जाँच कर लें कि इस प्रश्न-पत्र में **33** प्रश्न हैं।

(III) प्रश्न-पत्र में दाहिने हाथ की ओर दिए गए प्रश्न-पत्र कोड को परीक्षार्थी उत्तर-पुस्तिका के मुख-पृष्ठ पर लिखें।

(IV) **कृपया प्रश्न का उत्तर लिखना शुरू करने से पहले, उत्तर-पुस्तिका में प्रश्न का क्रमांक अवश्य लिखें।**

(V) इस प्रश्न-पत्र को पढ़ने के लिए 15 मिनट का समय दिया गया है। प्रश्न-पत्र का वितरण पूर्वाह्न में 10.15 बजे किया जाएगा। 10.15 बजे से 10.30 बजे तक परीक्षार्थी केवल प्रश्न-पत्र को पढ़ेंगे और इस अवधि के दौरान वे उत्तर-पुस्तिका पर कोई उत्तर नहीं लिखेंगे।

NOTE

(I) Please check that this question paper contains **8** printed pages.

(II) Please check that this question paper contains **33** questions.

(III) Q.P. Code given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.

(IV) **Please write down the serial number of the question in the answer-book before attempting it.**

(V) 15 minute time has been allotted to read this question paper. The question paper will be distributed at 10.15 a.m. From 10.15 a.m. to 10.30 a.m., the candidates will read the question paper only and will not write any answer on the answer-book during this period.

रसायन विज्ञान (सैद्धांतिक)
CHEMISTRY (Theory)

निर्धारित समय : 3 घण्टे *अधिकतम अंक : 70*

Time allowed : 3 hours *Maximum Marks : 70*

GENERAL INSTRUCTIONS :

Read the following instructions carefully and follow them:

*(i) This question paper contains **33 questions**. **All** questions are **compulsory**.*

*(ii) Question paper is divided into **FIVE** sections – **Section A, B, C, D and E**.*

*(iii) **Section A** – question number **1** to **16** are multiple choice type questions. Each question carries **1** mark.*

*(iv) **Section B** – question number **17** to **21** are very short answer type questions. Each question carries **2** marks.*

*(v) **Section C** – question number **22** to **28** are short answer type questions. Each question carries **3** marks.*

*(vi) **Section D** – question number **29** and **30** are case-based questions. Each question carries **4** marks.*

*(vii) **Section E** – question number **31** to **33** are long answer type questions. Each question carries **5** marks.*

*(viii) There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except section **A**.*

(ix) Kindly note that there is a separate question paper for Visually Impaired candidates.

(x) Use of calculator is NOT allowed.

SECTION - A

The following questions are multiple-choice questions with one correct answer. Each question carries 1 mark. There is no internal choice in this section.

1. Sodium chloride (NaCl), magnesium chloride ($MgCl_2$) and calcium sulphate ($CaSO_4$) are known as: **1**

(a) 1-1, 2-1, 2-2 types electrolyte respectively

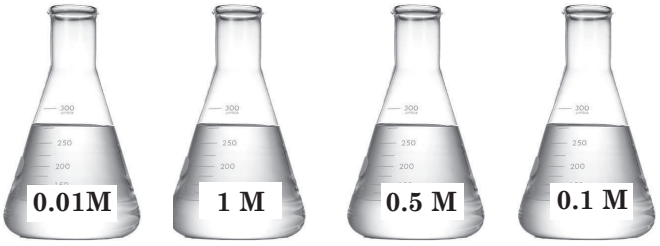
(b) Strong, weak and strong electrolytes respectively

(c) Weak, strong and strong electrolytes respectively

(d) Electrolytes with same molar conductivity

2. In a chemistry lab, Aisha is working with potassium chloride (KCl) solutions of different molar concentrations. Her task is to determine how the molar conductivity of these solutions changes with concentration.

During the experiment, she prepares four different concentrations of KCl solutions as: 0.01 M, 1 M, 0.5 M, and 0.1 M.



Can you help her figure out which concentration of KCl will have the highest value of molar conductivity?

(a) 0.01 M (b) 1 M (c) 0.5 M (d) 0.1 M

3. If a salt bridge is not used between two half cells, voltage **1**

(a) Drops to zero (b) Does not change

(c) Increases gradually (d) Increases rapidly

4. Find the order of the reaction if the rate constant (k) of reaction is 300 $L^2\ mol^{-2}\ s^{-1}$. **1**

(a) First (b) Second (c) Third (d) fourth

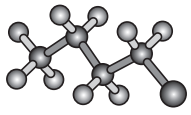
5. Acc. to Arrhenius equation, the slope of log k vs $\frac{1}{T}$ plot is **1**

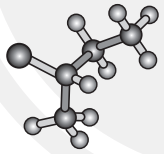
(a) $\frac{-E_a}{2.303R}$ (b) $\frac{-E_a}{6.022R}$ (c) $\frac{-E_a}{6.002RT}$ (d) $\frac{E_a}{2.303RT}$

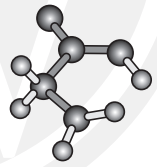
6. Which ion has maximum magnetic moment? **1**

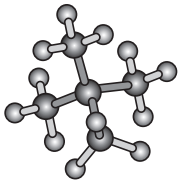
(a) V^{+3} (b) Mn^{+3} (c) Fe^{+3} (d) Cu^{+2}

7. The image below shows the ball and stick model of 4 different compounds. **1**

(i)  1-chlorobutane

(ii)  2-chlorobutane

(iii)  2-aminoethanoic acid

(iv)  2,2-dimethylpropane

How many of the above compounds is/are optically active?

(a) 1 (b) 2 (c) 3 (d) 4

8. Which among the given can differentiate between C_2H_5OH and CH_3OH? **1**

(a) HNO_3 (b) $NaOH + I_2$ (c) NH_3 (d) H_2O

9. You are a chemistry student conducting a series of reactions involving *m*-bromobenzoic acid (A) in the laboratory. You start with the *m*-bromobenzoic acid as the primary reactant. Your objective is to obtain a final product labelled **D** after a sequence of chemical reactions as shown below:

$$\boxed{A} + SOCl_2 \longrightarrow \boxed{B}$$

$$\boxed{B} + NH_3 \longrightarrow \boxed{C}$$

$$\boxed{C} + Br_2 + NaOH \longrightarrow \boxed{D}$$

EXPLANATIONS

1. (a) Depending upon the charges present on the anion and cation that are produced on dissociation of the electrolyte in solution, the type of electrolytes are called as 1 – 1, 2 –1 and 2 –2 electrolytes respectively.

$NaCl \rightarrow Na^+ + Cl^-$ (1 – 1)

$MgCl_2 \rightarrow Mg^{2+} + 2Cl^-$ (2 – 1)

$CaSO_4 \rightarrow Ca^{2+} + SO_4^{2-}$ (2 – 2) ***(1 M)***

2. (a) Molarity is inversely proportional to molar conductivity of the solution. Lower the molarity, higher will be the molar conductivity. Hence, 0.01 M KCl solution has the highest value of molar conductivity. ***(1 M)***

3. (a) The voltage drops to zero if the salt bridge is removed. ***(1 M)***

4. (c) $\text{Rate} = \frac{\text{Conc.}}{\text{time}} \times \frac{1}{(\text{Conc.})^3} = \frac{\text{mol L}^{-1}}{\text{s}} \times \frac{1}{\text{mol}^3\text{L}^{-3}}$

$\text{Rate} = \text{mol}^{-2}\text{L}^2\text{s}^{-1}$

Hence, the order of reaction is third order. ***(1 M)***

5. (a) Arrhenius equation is

$k = Ae^{-Ea/RT}$ …(i)

On taking log on both sides of eq. (i), we have

$\log k = \log A - \frac{E_a}{2.303RT}$

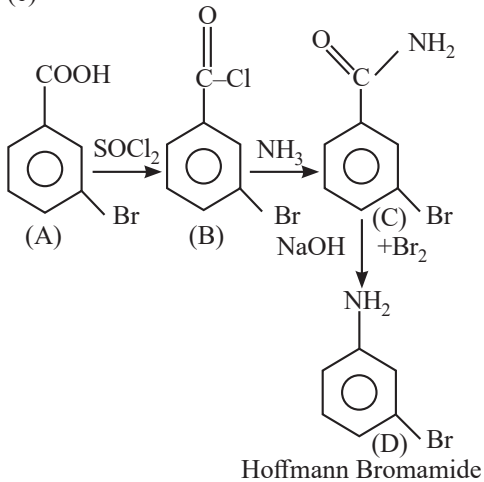
When log k will be plotted against 1/T, the slope of the reaction will be $\frac{-E_a}{2.303R}$ and intercept will be given by log A. ***(1 M)***

6. (c) Among the given options, Fe^{+3} has maximum magnetic moment because it has maximum number of unpaired electrons in +3 oxidation state. ***(1 M)***

7. (a) Only 2-chlorobutane is optically active due to its chiral carbon, while the other compounds lack chirality. ***(1 M)***

8. (b) $C_2H_5OH + 4I_2 + 6NaOH \longrightarrow \underset{\text{Iodoform (yellow ppt)}}{CHI_3} + HCOONa + 5NaI + 5H_2O$ ***(1 M)***

9. (c)



Hoffmann Bromamide synthesis ***(1 M)***

10. (b) Gattermann reaction ***(1 M)***

11. (a) Guanine is a heterocyclic nitrogenous purine base which present in nucleic acids. ***(1 M)***

12. (b) A mixture of amylose and amylopectin is called starch. ***(1 M)***

13. (a) For weak electrolytes, degree of dissociation increasing with dilution. ***(1 M)***

14. (b) Zr, Hf lies in the same group of periodic table and their separation is difficult. ***(1 M)***

15. (d) α-Hydrogen in carbonyl compound is more acidic and anion formed by the loss of α-hydrogen is resonance stabilised. ***(1 M)***

16. (b) N,N-diethylbenzene sulphonamide is insoluble in alkali due to lack of acidic hydrogen. Sulphonyl group attached to nitrogen is electron-withdrawing group. ***(1 M)***

17. (a) Since the formation of intermediate is slow, the first step is the slowest step. ***(½ M)***

Hence the rate will depend on the first step. Therefore, $\text{Rate} = k[H_2O_2][I^-]$ ***(½ M)***

(b) If the concentration of peroxide is doubled, the rate of the reaction also doubles. ***(1 M)***

18. (a) In S_N2 (substitution nucleophilic bimolecular) reactions, aprotic polar solvents are typically employed. ***(1 M)***

(b) Polar protic solvents stabilise the carbocation intermediate formed in S_N1 reactions through solvation, increasing the reaction rate and facilitating the formation of the product. ***(1 M)***

19. (a) No, ethers cannot undergo hydrogen bonding. In ethers, the oxygen atom is bonded to two alkyl or aryl groups, and it does not have any hydrogen atom directly bonded to it. As a result, there are no hydrogen atoms available in ethers to participate in hydrogen bonding with other ether molecules or other hydrogen bond-donating compounds. Therefore, ethers do not exhibit hydrogen bonding. ***(1 M)***

(b) $\underset{\text{But-2-enol}}{CH_3–CH=CH–CH_2–OH} \xrightarrow{PCC} \underset{\text{But-2-enal}}{CH_3–CH=CH–CHO}$ ***(1 M)***

OR

The increasing order of boiling points is: CH_3-CH_2-CH_2-CH_3 (butane) < CH_3-CH_2-CH_2-CHO (butanal) < CH_3-CH_2-CH_2-CH_2-OH (1-butanol).

The increasing order of boiling points is determined by the strength of intermolecular forces. Due to H-bonding 1-butanol has the highest boiling point & only weak van der Waals forces between molecules, leading to a lower boiling point. So, butane has the lowest boiling point. ***(2 M)***

20. (a) Clemmensen reduction is a chemical reaction that turns compounds like ketones into simple hydrocarbons using zinc and hydrochloric acid.

Class-12th Board

The Catalyst for Physics

BY- Gagan Sir & Rajwant Sir

Class Notes in Handwritten Format

Updated as per latest CBSE Syllabus

100% NCERT Based Notes | Detailed Theory | CBSE PYQs

Includes Competency-Based Questions | Simplified Flowcharts and Tables

Contents

01

Electric Charges and Fields

SYLLABUS

Electric charges, Conservation of charge, Coulomb's law-force between two-point charges, forces between multiple charges; superposition principle and continuous charge distribution.

Electric field, electric field due to a point charge, electric field lines, electric dipole, electric field due to a dipole, torque on a dipole in uniform electric field.

Electric flux, statement of Gauss's theorem and its applications to find field due to infinitely long straight wire, uniformly charged infinite plane sheet and uniformly charged thin spherical shell (field inside and outside).

1. INTRODUCTION

Before Starting This Chapter, Just Give A Thought to the Following Points:

(i) Have you ever seen a spark or hear a cracking sound when you takes off your clothes?

(ii) Have you ever rubbed a balloon on your head and made your hair stand up?

(iii) Have you ever got a shock while opening the door of a car?

If yes then this chapter will bring a lot of interest to you.

Ans to all the above phenomenon is static charge which means charge at rest & we will be discussing about the static charge in detail in this chapter.

2. CHARGE AND ITS PROPERTIES

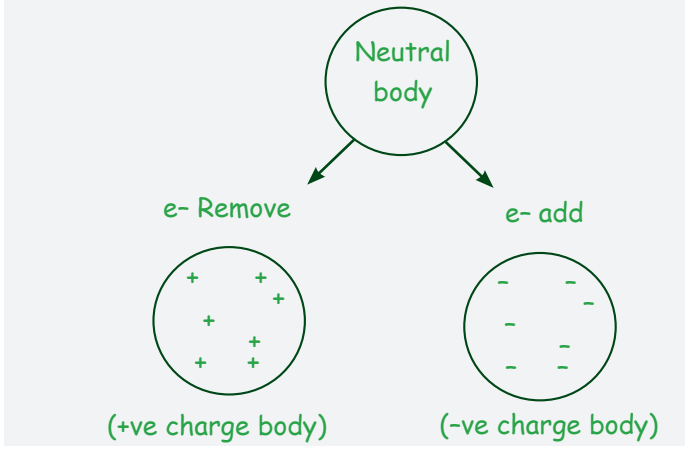
CHARGE

Charge is an intrinsic property of matter due to which it experiences or exerts electric & magnetic effects

Intrinsic: Independent of external factor

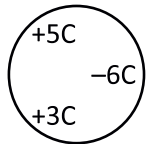
1. How does a body attain any Charge?

Ans. By transfer of e- from One body to another. (Body with equal number of positive and negative charges is neutral).



PROPERTIES OF CHARGE

1. **Additive Nature of Charge:** Total Charge on a body is algebraic sum of all the charges present on the body.



Total Charge one body = +5C – 6C + 3C = +2C

2. **Quantization of Charge:** The electric charge on a body is always integral multiple of e (charge of 1 electron).

$$Q = \pm ne$$

$n = 0, 1, 2, 3, 4, \ldots\ldots \infty$

$e = 1.6 \times 10^{-19}\ C$

- ❑ This is because a body gets positive charge when it loses some e- and it gets negative charge when it gains some e- & it is quite obvious that loosing or gaining of electron will always be in integer.
- ❑ Gaining or loosing of half electron will make no sense.

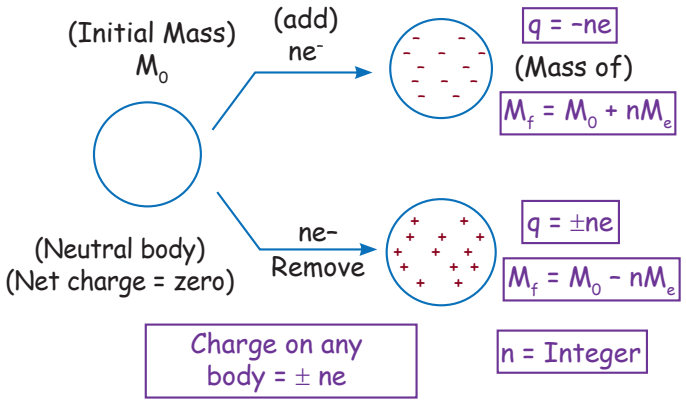
3. **Charge is Conserved:** Charge can neither be created nor be destroyed. It can only be transferred from one body to another body.

4. **Charge is Invariable:** Charge of a body does not depend on its state of Rest or Motion, also it is independent of the location.

   For Example: Charge of an e- is 1.6×10^{-19} C whether it is in rest or it is moving with speed of light. Whether, it is on earth or it is on moon.

5. **Charge is transferable:** Charge can be transfered to a body).

6. **Charge is always associated with mass:** A charged body will always have mass.



7. **Interaction of charges:**

⇒ Like charges Repel each other.
⇒ Unlike charges attract each other.

8. **Accelerated charge radiates energy**

v = 0 (i.e. at rest) ⊕ Q * produces $\vec{E}$ only (electric field) (Electrostats)	v = constant ⊕ → (Current) Q produces both $\vec{E}$ and $\vec{B}$ (magnetic field) but no radiation	v ≠ constant (i.e. time varying). ⊕ → Q produces both $\vec{E}$, $\vec{B}$ and radiates energy (EM Wave)
⊕ ⊖ Rest Produces Electric field.	⊕→ v = constant ←⊖ develops current ↓ (Magnetic field) + (electric field)	⊕→ accelerated EM Radiations

9. **Unit of charge** = Coulomb.

   Charge on electron is $-e = -1.6 \times 10^{-19}$

   Charge on proton is $+e = 1.6 \times 10^{-19}$

   SI unit of charge is coulomb (C) & CGS unit of charge is electrostatic unit (esu) or stat Coulomb (stat C)

   $1C = 3 \times 10^9$ esu

2. An object has charge of 1 C and gains 5.0×10^{18} electrons. The net charge on the object becomes- **(CBSE, 2022)**

(A) −0.80 C (B) +0.80 C
(C) +1.80 C (D) +0.20 C

Ans. (D) Initial charge = 1 C
Charge Added = $-(1.6 \times 10^{-19} \times 5 \times 10^{+18}) = -0.8$ C
Final charge = (1 − 0.8)C = 0.2 C
option (d) is correct answer.

3. Name any two basic properties of electric charges.

Ans. **Quantization of Charge:** Electric charge exists in discrete packets rather than being continuous.
Conservation of Charge: The total electric charge in an isolated system remains constant over time.

4. If 10^9 electrons move out of a body to another body every second, how much time is required to get a total charge of 1 C on the other body?

Ans. In one second 10^9 electrons move out of the body. Therefore the charge given out in one second is $1.6 \times 10^{-19} \times 10^9 C = 1.6 \times 10^{-10}$ C.
The time required to accumulate a charge of 1 C can then be estimated to be

$$\frac{1C}{1.6\times10^{-10}C/s} = 6.25\times10^9 s = 198 \text{ years}$$

5. How much positive and negative charge is there in a cup of water? **(NCERT Intext)**

Ans. Let us assume that the mass of one cup of water is 250 g. The molecular mass of water is 18 g. Thus, one mole (= 6.02×10^{23} molecules) of water is 18 g. Therefore the number of molecules in one cup of water is $(250/18) \times 6.02 \times 10^{23}$.

Each molecule of water contains two hydrogen atoms and one oxygen atom, i.e., 10 electrons and 10 protons. Hence the total positive and total negative charge has the same magnitude. It is equal to $(250/18) \times 6.02 \times 10^{23} \times 10 \times 1.6 \times 10^{-19}$ C $= 1.34 \times 10^{7}$ C.

6. How many electrons should be removed from a metal sphere to give it a positive charge of 1×10^{-7}C?

(A) 6.25×10^{-11}
(B) 6.25×10^{-12}
(C) 6.25×10^{11}
(D) 6.25×10^{14}

Ans. (C) According to quantisation of charge

$$q = ne$$

$$\therefore n = \frac{1 \times 10^{-7}}{1.6 \times 10^{-19}} = 6.25 \times 10^{11}$$

3. METHOD OF PRODUCING CHARGES

(A) CHARHING BY FRICTION:

When two objects are rubbed together, the friction between them leads to the transfer of electrons from one object to another. Consequently, both acquire an electrical charge. The object that loses electrons becomes positively charge, and the object which gained electrons becomes negatively charged.

When the following pair will rub against each other then the charge attained by the bodies is given as:

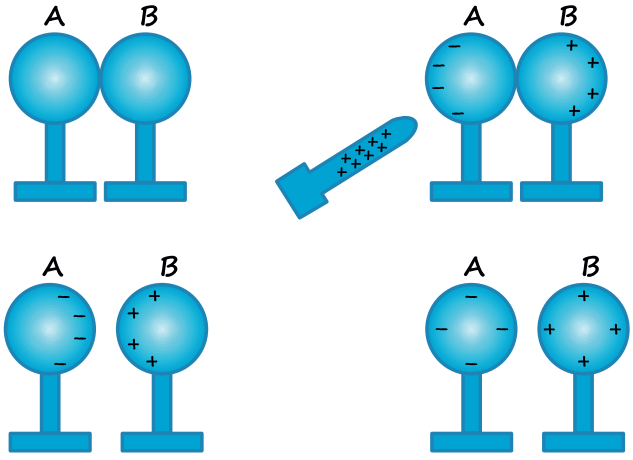
Positively Charged	Negatively Charged
Glass	Silk
Hair	Comb
Wool	Rubber
Cat skin	Ebonite Rod

(B) CHARGING BY INDUCTION

Induction is a process of charging a body without any physical contact between charged body and uncharged body.

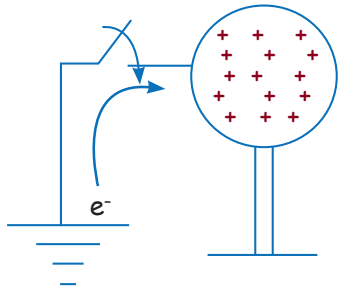
Let's grasp the concept of charging by induction with an illustration:

- Consider two metallic spheres, A and B, placed on insulating stands, and bring them close together.
- Next, position a positively charged rod near the left side of sphere A, without making physical contact.
- The positive charge on the rod attracts the electrons in sphere A, resulting in an excess of negative charge on the left side of A. Simultaneously, there will be positive charge at end B because e^- of those atoms are attracted by Rod & has moved to side A.
- Consequently, if we separate both the spheres and Remove the rod both spheres get charged. Both spheres become charged by the end of this process. This phenomenon is termed charging by induction.

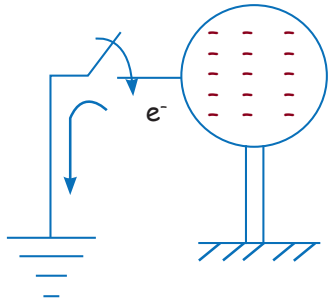


We can use Earthing also to charge a body. Lets understand what is Earthing it is process of connecting a body to Earth by a wire due to which potential of body becomes zero.

If we Earth a positive and Negative charge.



Electron move from Earth to body



e^- move from body to earth.

1 Electric Charges and Fields

MOST RELEVANT BOARD LEVEL PROBLEMS

Multiple Choice Questions (MCQ)

1. Two charged particles having each charge $2 \times 10^{-8} C$ each are joined by an insulating string of length 1m and the system is kept on a frictionless horizontal table, what is the tension in the string?

(*a*) $3.6 \times 10^{-6}\ N$ (*b*) $3.4 \times 10^{-6}\ N$

(*c*) $4 \times 10^{-7}\ N$ (*d*) $4 \times 10^{-4}\ N$

Sol. (*a*) $q_1 = q_2 = 2 \times 10^{-8}$C, $r = 1$ m

Tension in the string is equal to the force between the two charges.

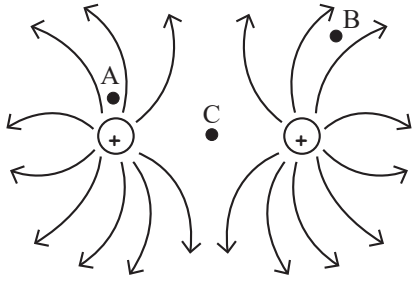
According to coulomb's law

$$F = \frac{k q_1 q_2}{r^2} = \frac{9 \times 10^9 \times (2 \times 10^{-8})^2}{(1)^2}$$

$= 3.6 \times 10^{-6}$ N.

2. Electric field lines are pictorial representations of electric fields due to static charges on the plane of a paper.

(CBSE CFPQ, 2023)



Study the given electric field representation and identify one INCORRECT qualitative impression given by this representation.

(*a*) The electric field at point *A* is stronger than at point *B*.

(*b*) The electric field distribution is two-dimensional.

(*c*) The electric field at point *C* is zero.

(*d*) The electric field always points away from a positive charge.

Sol. (*b*) The electric field distribution is not two-dimensional.

It exist in 3D space around change.

3. Amount of work done in moving an electric charge Q_1 once round a circle of radius R with a charge Q_2 at the center of the circle is

(*a*) $\frac{Q_1 Q_2}{4\pi\varepsilon_o R}$ (*b*) ∞

(*c*) $\frac{Q_1 Q_2}{4\pi\varepsilon_o R^2}$ (*d*) Zero

Sol. (*d*) Electrostatic force is a conservative force so work done in carrying an electric charge Q, once around a circle is zero.

4. An electric dipole has a dipole moment of 3×10^{-9} C m and is positioned in a uniform electric field. If the electric field strength is 2×10^3 N/C and the dipole is initially in an unstable equilibrium, how much work is required to move it to a stable equilibrium?

(*a*) Zero (*b*) 1.2×10^{-5} J

(*c*) 2.4×10^{-5} J (*d*) -1.2×10^{-5} J

Sol. (*d*) -1.2×10^{-5}J

The work done is rotating an electric dipole from an unstable equilibrium to a stable equilibrium in a uniform electric field is given by the formula:

Work done (W) = PE $\cos(\theta_1 - \theta_2)$

where,

Dipole moment (P) = 3×10^{-9} cm

Electric field (E) = 2×10^3 N/C

θ_1 is the angle at unstable equilibrium, which is 180.

θ_2 is the angle at stable equilibrium which is 0.

Plugging in these values,

Work Done (W) = PE $(\cos\theta_1 - \cos\theta_2)$N/C

Work Done (W) = $3 \times 10^{-9} \times 2 \times 10^3$ (cos 180° – cosθ°)

$= 3 \times 10^{-9} \times 2 \times 10^3$ [(–1) – (1)]

$= 6 \times 10^{-6}$ [(–1) – (1)] = -1.2×10^{-5}T

So, the work done is rotating the dipole to a position of stable equilibrium is -1.2×10^{-5} J

Physics Wallah Set-1

Series SR5QP/5

प्रश्न-पत्र कोड
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परीक्षार्थी प्रश्न-पत्र कोड को उत्तर-पुस्तिका के मुख-पृष्ठ पर अवश्य लिखें।
Candidates must write the Q.P. Code on the title page of the answer-book.

नोट

(I) कृपया जाँच कर लें कि इस प्रश्न-पत्र में मुद्रित पृष्ठ **8** हैं।

(II) कृपया जाँच कर लें कि इस प्रश्न-पत्र में **33** प्रश्न हैं।

(III) प्रश्न-पत्र में दाहिने हाथ की ओर दिए गए प्रश्न-पत्र कोड को परीक्षार्थी उत्तर-पुस्तिका के मुख-पृष्ठ पर लिखें।

(IV) **कृपया प्रश्न का उत्तर लिखना शुरू करने से पहले, उत्तर-पुस्तिका में प्रश्न का क्रमांक अवश्य लिखें।**

(V) इस प्रश्न-पत्र को पढ़ने के लिए 15 मिनट का समय दिया गया है। प्रश्न-पत्र का वितरण पूर्वाह्न में 10.15 बजे किया जाएगा। 10.15 बजे से 10.30 बजे तक परीक्षार्थी केवल प्रश्न-पत्र को पढ़ेंगे और इस अवधि के दौरान वे उत्तर-पुस्तिका पर कोई उत्तर नहीं लिखेंगे।

NOTE

(I) Please check that this question paper contains **8** printed pages.

(II) Please check that this question paper contains **33** questions.

(III) Q.P. Code given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.

(IV) **Please write down the serial number of the question in the answer-book before attempting it.**

(V) 15 minute time has been allotted to read this question paper. The question paper will be distributed at 10.15 a.m. From 10.15 a.m. to 10.30 a.m., the candidates will read the question paper only and will not write any answer on the answer-book during this period.

भौतिक विज्ञान (सैद्धांतिक)
PHYSICS (Theory)

*निर्धारित समय : **3** घण्टे* | *अधिकतम अंक : **70***

*Time allowed : **3** hours* | *Maximum Marks : **70***

The dielectric material between the two plates is made of a soft material and is compressible. The combination of the two plates and the dielectric between them constitutes a capacitor.

Each key on the keyboard when pressed is recognized due to which one of the following factors?

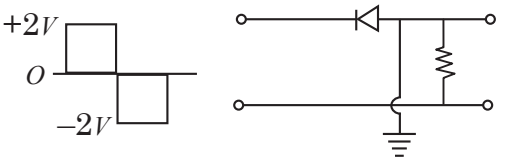
(a) The pressing of the key increases the capacitance of the capacitor below the key due to a decrease in separation between the plates.

(b) The decrease in the thickness of the soft dielectric layer decreases the capacitance of the capacitor below the key.

(c) The momentary decrease in the space between the plates of the capacitor is detected as a mechanical sound signal of a specific frequency.

(d) all of the above

2. A ideal diode and a resistor are connected to an ac source as shown.



Input Output

The input voltage is a square wave as shown above. What will be output across the resistor?

(a) Only +2 V (b) Only –2 V (c) Either 0 V or +2 V (d) Either 0 V or -2 V

3. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon the **1**

(a) rate at which current change in the two coils

(b) relative position and orientation of the coils

(c) rate at which voltage induced across two coils

(d) currents in the two coils

4. An electron is released from rest in a region of uniform electric and magnetic fields acting parallel to each other. The electron will **1**

(a) move in a straight line. (b) move in a circle.

(c) remain stationary. (d) move in a helical path.

5. Read the following statements carefully:

I. Steel has high retentivity, high coercivity, and high permeability.

II. Soft iron has higher permeability, lower retentivity, and lower hysteresis loss compared to steel.

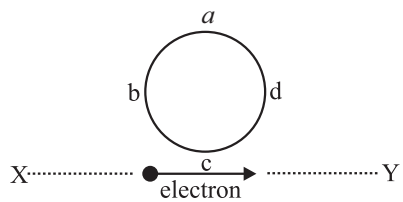
III. Amorphous metals are non-crystalline solids of very high resistivity and allow very less hysteresis losses (example: an alloy of Fe, Ni, Co and glass). Their B-H (net field Vs. magnetizing field) curve is very narrow.

Based on the above material-specific properties, identify which materials are MOST suitable for the given electrical applications. **1**

I. Steel	A. Transformer core
II. Soft iron	B. Permanent magnets
III. Amorphous metals	C. Electromagnet

(a) I-A, B : II-B, C : III-C, A
(b) I-B : II-C : III-A
(c) I-B : II-C, A : III- A, B
(d) I-A : II-C : III-B

6. An electron moves on a straight line path XY as shown. The abcd is a coil adjacent to the path of electron. What will be the direction of current, if any, induced in the coil? **1**



(a) No current induced
(b) abcd
(c) adcd
(d) The current will reverse its direction as the electron goes past the coil

7. Which of the following is not a property of a semiconductor diode? **1**
(a) It allows current to flow in one direction only.
(b) It has a high resistance in the reverse direction.
(c) It emits light when a current flows through it.
(d) It converts AC to DC.

8. An magnetic field $\vec{B}$ and electric field $\vec{E}$ exist in region. The field are not perpendicular to each other, then **1**
(a) No electromagnetic wave is passing through the region
(b) Data insufficient
(c) An electromagnetic wave may be passing through the region
(d) An electromagnetic wave is certainly passing through the region

9. Plano-concave lens having focal length –10 cm, then its focal length when its plane surface is polished is (n = 3/2) **1**
(a) 40 cm
(b) – 10 cm
(c) 5 cm
(d) None of these

10. Interference was observed in interference chamber where air was present, now the chamber is evacuated, and if the same light is used, a careful observer will see **1**
(a) No interference
(b) Interference with brighter bands
(c) Interference with dark bands
(d) Interference with larger width

11. Find average life time of radium if half life is 2000 years. **1**
(a) 1550 year
(b) 4000 year
(c) 3000 year
(d) 2886 year

12. The energy of an electron in an excited hydrogen atom is –3.4 eV. Calculate the angular momentum of the electron according to Bohr's theory. ($h = 6.6 \times 10^{-34}$ J-s) **1**
(a) 3×10^{-32} J-s
(b) 2.1×10^{-34} J-s
(c) 4×10^{-34} J-s
(d) None of these

About the Author

Mr. Om Pandey

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With over 9 years of teaching experience, Mr. Om Pandey is a renowned name in the field of Chemistry. A remarkable academic achiever, he secured an outstanding **AIR 100 in IIT JAM** and **AIR 13 & 49 in JRF,** reflecting his exceptional proficiency and deep-rooted expertise in Chemistry.

Currently teaching at **Physics Wallah**, Mr. Pandey has transformed the way students learn and understand Chemistry. His passion for teaching and commitment to excellence have guided thousands of students, shaping the careers of top engineers from IITs, NITs, and IIITs, as well as future doctors. His unique teaching style, coupled with his ability to simplify complex concepts, has earned him immense respect among students and peers alike.

One of his key philosophies in teaching is reflected in his popular saying, "PYARE ❤ Chemistry samjhi ja sakti hai, bas TEACHER ke explanation me dum hona chahiye." This belief drives his dedication to ensuring every student finds Chemistry both understandable and enjoyable.

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