# SOLUTION OF IIT-JEE 2008 (PAPER - I)

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www.momentumacademy.com, Email : momentumacademy@gmail.com

## MATHEMATICS

**Part I**

**Section - I**

**Straight Objective Type**

This section contains 6 multiply choice questions. Each question has 4 choices (A), (B), (C) and (D), out of which Only one is correct.

1. Consider the two curves

$$C_1 : y^2 = 4x$$

$$C_2 : x^2 + y^2 - 6x + 1 = 0$$

Then,

(A) $C_1$ and $C_2$ touch each other only at one point

(B) $C_1$ and $C_2$ touch each other exactly at two point

(C) $C_1$ and $C_2$ intersect (but do not touch) at exactly two point

(D) $C_1$ and $C_2$ neither intersect nor touch each other

**Ans.** **(B)**

2. The edges of a parallelopiped are of unit length and are parallel to non-coplanar unit vectors $\hat{a}, \hat{b}, \hat{c}$ such that

$$\hat{a}.\hat{b} = \hat{b}.\hat{c} = \hat{c}.\hat{a} = \frac{1}{2}$$

Then, the volume of the parallelopiped is

(A) $\frac{1}{\sqrt{2}}$ (B) $\frac{1}{2\sqrt{2}}$

(C) $\frac{\sqrt{3}}{2}$ (D) $\frac{1}{\sqrt{3}}$

**Ans.** **(A)**

3. If $0 < x < 1,$ then

$$\sqrt{1+x^2}\left[\left\{x\cos(\cot^{-1}x) + \sin(\cot^{-1}x)\right\}^2 - 1\right]^{\frac{1}{2}} =$$

(A) $\frac{x}{\sqrt{1+x^2}}$ (B) $x$

(C) $x\sqrt{1+x^2}$ (D) $\sqrt{1+x^2}$

**Ans.** **(C)**

4. Let

$$g(x) = \frac{(x-1)^n}{\log\cos^m(x-1)}; 0 < x < 2, m \text{ and } n$$

are integers, $m \neq 0, n > 0,$ and let p be the left derivative of $|x-1|$ at $x = 1$.

If $\lim_{x \to 1+} g(x) = p$, then

(A) $n = 1, m = 1$ (B) $n = 1, m = -1$

(C) $n = 2, m = 2$ (D) $n > 2, m = n$

**Ans.** **(C)**

5. Let a and b be non-zero real numbers, then, the equation

$$(ax^2 + by^2 + c)(x^2 - 5xy + 6y^2) = 0$$

represents

(A) four straight lines, when c=0 and a,b are of the same sign

(B) two straight lines and a circle, when a=b, and c is of sign opposite to that of a

(C) two straight lines and a hyperbola, when a and b, are of the same sign and c is of sign opposite to that of a

(D) a circle and an ellipse, when a and b are of the same sign and c is of sign opposite to that of a.

**Ans.** **(B)**

6. the total number of local maxima and local minima of the function

$$f(x)\begin{cases}(2+x)^3, & -3 < x \le -1 \\ x^{2/3} & -1 < x < 2\end{cases}$$

is

(A) 0 (B) 1

(C) 2 (D) 3

**Ans.** **(C)**

**Section - II**
**Multiple Correct Answers Type**

This section contains 4 multiple correct answer(s) type questions. Each question has 4 choices (A), (B), (C) and (D), out of which **ONE OR MORE** is/are correct.

7. Let $P(x_1, y_1)$ and $Q(x_2, y_2)$, $y_1 < 0, y_2 < 0$, be the end points of the latus rectum of the ellipse $x^2 + 4y^2 = 4$. The equations of parabolas with latus rectum PQ are

(A) $x^2 + 2\sqrt{3}y = 3 + \sqrt{3}$

(B) $x^2 - 2\sqrt{3}y = 3 + \sqrt{3}$

(C) $x^2 + 2\sqrt{3}y = 3 - \sqrt{3}$

(D) $x^2 - 2\sqrt{3}y = 3 - \sqrt{3}$

**Ans.** **(B,C)**

8. Let

$$S_n = \sum_{k=1}^{n} \frac{n}{n^2 + kn + k^2} \text{ and}$$

$$T_n = \sum_{k=0}^{n-1} \frac{n}{n^2 + kn + k^2}$$

for $n = 1, 2, 3, \ldots\ldots$ then,

(A) $S_n < \frac{\pi}{3\sqrt{3}}$ (B) $S_n > \frac{\pi}{3\sqrt{3}}$

(C) $T_n < \frac{\pi}{3\sqrt{3}}$ (D) $T_n > \frac{\pi}{3\sqrt{3}}$

**Ans.** **(A,D)**

9. Let $f(x)$ be a non-constant twice differentiable function defined on $(-\infty, \infty)$ such that $f(x) = f(1-x)$ and $f'\left(\frac{1}{4}\right) = 0$. Then,

(A) $f''(x)$ vanishes at least twice on $[0,1]$

(B) $f'\left(\frac{1}{2}\right) = 0$

(C) $\int_{-1/2}^{1/2} f\left(x + \frac{1}{2}\right) \sin x \, dx = 0$

(D) $\int_0^{1/2} f(t) e^{\sin \pi t} dt = \int_{1/2}^{1} f(1-t) e^{\sin xt} \, dt$

**Ans.** **(A,B,C,D)**

10. A straight line through the vertex P of a triangle PQR intersects theside QR at the point S and the circumcircle of the triangle PQR at the point T. If S is not the centre of the circumcircle, then

(A) $\frac{1}{PS} + \frac{1}{ST} < \frac{2}{\sqrt{QS \times SR}}$

(B) $\frac{1}{PS} + \frac{1}{ST} > \frac{2}{\sqrt{QS \times SR}}$

(C) $\frac{1}{PS} + \frac{1}{ST} < \frac{4}{QR}$

(D) $\frac{1}{PS} + \frac{1}{ST} < \frac{4}{QR}$

**Ans.** **(B,D)**

**Section - III**
**Reasoning Type**

This section contains 4 reasoning type questions. Each question has 4 choices (A),(B),(C) and (D), out of which **ONLY ONE** is correct.

11. Consider the system of equations

$$x - 2y + 3z = -1$$
$$-x + y - 2z = k$$
$$x - 3y + 4z = 1$$

**STATEMENT-1 :** The system of equation has no solution for $k \neq 3$

**and**

**STATEMENT-2 :** The determinant

$$\begin{vmatrix} 1 & 3 & -1 \\ -1 & -2 & k \\ 1 & 4 & 1 \end{vmatrix} \neq 0, \text{ for } k \neq 3.$$

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is **is not** a correct explanation for STATEMENT-1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is True

**Ans.** **(A)**

12. Let f and g be real valued functions defined on interval $(-1,1)$ such that $g''(x)$ is continuous, $g(0) \neq 0, g'(0) = 0, g''(0) \neq 0$ and $f(x) = g(x) \sin x$.

**STATEMENT-1 :**

$$\lim_{x\to 0}\left[g(x)\cot x - g(0)\operatorname{cosec} x\right] = f''(0)$$

**and**

**STATEMENT-2 :** $f'(0) = g(0)$

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is **is not** a correct explanation for STATEMENT-1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is True

**Ans.** **(B)**

13. Consider three planes

$$P_1 : x - y + z = 1$$
$$P_2 : x + y - z = -1$$
$$P_3 : x - 3y + 3z = 2$$

Let $L_1, L_2, L_3$ be the lines of intersection of the planes $P_2$ and $P_3$, $P_3$ and $P_1$, and $P_1$ and $P_2$, respectively.

**STATEMENT-1 :** At least two of the lines $L_1, L_2$ and $L_3$ are non-parallel.

**and**

**STATEMENT-2 :** The three planes do not have a common point.

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is **is not** a correct explanation for STATEMENT-1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is True

**Ans.** **(D)**

14. Consider the system of equations $ax + by = 0, cx + dy = 0,$ where $a, b, c, d \in \{0, 1\}$.

**STATEMENT-1 :** The probability that the system of equations has a unique solution is $\frac{3}{8}$.

**and**

**STATEMENT-2 :** The probability that the system of equations has a solution is 1.

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is **is not** a correct explanation for STATEMENT-1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is True

**Ans.** **(D)**

**Section - IV**

**linked Comprehension Type**

This section contains 3 paragraphs. Based upon each paragraph, 3 multiple choice questions have to be answered. Each question has 4 choices (A),(B), (C) and (D), out of wich **ONLY ONE** is correct.

**Paragraph for Question Nos. 15 to 17**

A circle C of radius 1 is inscribed in an equilateral triangle PQR. The points of contact of C with the sides PQ, QR, RP are D,E,F, respectively. The line PQ is given by the equation $\sqrt{3}x + y - 6 = 0$ and the point D is $\left(\frac{3\sqrt{3}}{2}, \frac{3}{2}\right)$. Further, it is given that the origin and the centre of C are on the same side of the line PQ.

15. The equation of circle C is

(A) $\left(x - 2\sqrt{3}\right)^2 + (y-1)^2 = 1$

(B) $\left(x - 2\sqrt{3}\right)^2 + (y+\frac{1}{2})^2 = 1$

(C) $\left(x - \sqrt{3}\right)^2 + (y+1)^2 = 1$

(D) $\left(x - \sqrt{3}\right)^2 + (y-1)^2 = 1$

**Ans.** **(D)**

16. Points E and F are given by

(A) $\left(\frac{\sqrt{3}}{2}, \frac{3}{2}\right), \left(\sqrt{3}, 0\right)$

(B) $\left(\frac{\sqrt{3}}{2}, \frac{1}{2}\right), \left(\sqrt{3}, 0\right)$

(C) $\left(\frac{\sqrt{3}}{2}, \frac{3}{2}\right), \left(\frac{\sqrt{3}}{2}, \frac{1}{2}\right)$

(D) $\left(\frac{3}{2}, \frac{\sqrt{3}}{2}\right), \left(\frac{\sqrt{3}}{2}, \frac{1}{2}\right)$

**Ans.** **(A)**

17. Equations of the sides QR, RP are

(A) $y=\frac{2}{\sqrt{3}}x+1,\ y=-\frac{2}{\sqrt{3}}x-1$

(B) $y=\frac{1}{\sqrt{3}}x,\ y=0$

(C) $y=\frac{\sqrt{3}}{2}x+1,\ y=-\frac{\sqrt{3}}{2}x-1$

(D) $y=\sqrt{3}x,\ y=0$

**Ans. (D)**

**Paragraph for Question Nos. 18 to 20**

Let A,B,C be three sets of complex numbers as defined below

$$A=\{z:\text{Im}\,z\geq 1\}$$
$$B=\{z:|z-2-i|=3\}$$
$$C=\{z:\text{Re}((1-i)z)=\sqrt{2}\}$$

18. The number of elements in the set $A\cap B\cap C$ is

(A) 0 (B) 1
(C) 2 (D) $\infty$

**Ans. (B)**

19. Let z be any point in $A\cap B\cap C$. Then, $|z+1-i|^2+|z-5-i|^2$ lies between

(A) 25 and 29 (B) 30 and 34
(C) 35 and 39 (D) 40 and 44

**Ans. (C)**

20. Let z be any point in $A\cap B\cap C$ and let w be any point satisfying $|w-2-i|<3$. Then , $|z|-|w|+3$ lies between

(A) -6 and 3 (B) -3 and 6
(C) -6 and 6 (D) -3 and 9

**Ans. (B)**

**Paragraph for Question Nos. 21 to 23**

Consider the functions defined implicitly by the equation $y^3-3y+x=0$ on various intervals in the real line.

If $x\in(-\infty,-2)\cup(2,\infty)$, the equation implicity defines a unique real valued differentiable function $y=f(x)$.

If $x\in(-2,2)$, the equation implicity defines a unique real valued differentiable function $y=g(x)$ satisfying $g(0)=0$.

21. If $f(-10\sqrt{2})=2\sqrt{2}$, then $f''(-10\sqrt{2})=$

(A) $\frac{4\sqrt{2}}{7^3 3^2}$ (B) $-\frac{4\sqrt{2}}{7^3 3^2}$

(C) $\frac{4\sqrt{2}}{7^3 3}$ (D) $-\frac{4\sqrt{2}}{7^3 3}$

**Ans. (B)**

22. The area of the region bounded by the curve $y=f(x)$, the x-axis, and the lines x=a and x=b, where $-\infty<a<b<-2$, is

(A) $\int_a^b \frac{x}{3\left((f(x))^2-1\right)}dx+bf(b)-af(a)$

(B) $-\int_a^b \frac{x}{3\left((f(x))^2-1\right)}dx+bf(b)-af(a)$

(C) $\int_a^b \frac{x}{3\left((f(x))^2-1\right)}dx-bf(b)+af(a)$

(D) $-\int_a^b \frac{x}{3\left((f(x))^2-1\right)}dx-bf(b)+af(a)$

**Ans. (C)**

23. $\int_{-1}^{1} g'(x)dx=$

(A) $2g(-1)$ (B) 0
(C) $-2g(1)$ (D) $2g(1)$

**Ans. (D)**

## PHYSICS

### Section -I

**Straight Objective Type**

This section contains 6 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D), out of which **only one** is correct.

24. Two beams of red and violet colours are made to pass separately through a prism (angle of the prism is $60^o$ ). In the position of minimum deviation, the angle of refraction will be.

(A) $30^o$ for both the colours
(B) greater for the violet colour
(C) greater for the red colour
(D) equal but not $30^o$ for both the colours

**Sol.(B)** In the position of minimum deviation, the light ray passes symmetrically through the prism.

$\therefore \quad r_1 = r_2 = 30^o$ (for both colour)

$\because \quad \mu$ is larger for violet

$\therefore$ e is larger for violet

25. Which one of the following statements is **wrong** in the context of X-rays generated from a X-ray tube ?
(A) Wavelength of characteristic X-rays decreases when the atomic number of the target increase
(B) Cut-off wavelength of the continuous X-rays depends on the atomic number of the target
(C) Intensity of the characteristic X-rays depends on the electrical power given to the X-ray tube.
(D) Cut-off wavelength of the continuous X-rays depends on the energy of the electrons in the X-ray tube.

**Ans.(B)** Cut off wavelength is independent of material in the target.

26. An ideal gas is expanding such that $PT^2 =$ constant. The coefficient of volume expansion of the gas is

(A) $\frac{1}{T}$ (B) $\frac{2}{T}$ (C) $\frac{3}{T}$ (D) $\frac{4}{T}$

**Ans. (C)** $PT^2 =$ const.

$\because \quad PV = nRT \quad \Rightarrow P = \frac{nRT}{V}$

$\therefore \quad \frac{T^3}{V} = k$ (const.)

$T^3 = kV$

$\Rightarrow \quad k\Delta V = 3T^2\,\Delta T$

$\Rightarrow \quad \frac{k\Delta V}{kV} = \frac{3T^2\,\Delta T}{T^3}$

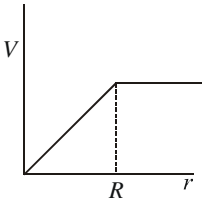
$\Rightarrow \quad \Delta V = V\left(\frac{3}{T}\right)\Delta T \qquad [\because\ \Delta V = V\gamma\Delta T]$

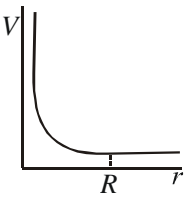
$\therefore \quad \gamma = \frac{3}{T}$

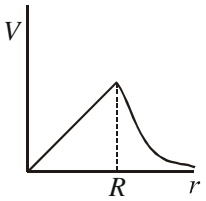
27. A spherically symmetric gravitational system of particles has a mass density

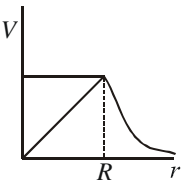
$$\rho = \begin{cases} \rho_0 \ for \ r \le R \\ 0 \ for \ r > R \end{cases}$$

Where $\rho_0$ is a constant. A test mass can undergo circular motion under the influence of the gravitational field of particles. Its speed V as a function of distance $r(0 < r < \infty)$ from the centre of the system is represented by

(A) 


(B) 

(C) 


(D) 


**Ans.(C)** The given mass distribution is identical to that of a sphere of uniform mass.
For circular motion

$$\frac{mv^2}{r} = Em \qquad \text{[E=gravitational field]}$$

$$\Rightarrow \quad V = Er$$

for

$$r < R \qquad E \propto r$$

$$\therefore \quad V \propto r$$

for $r \geq R$

$$E \propto \frac{1}{r^2}$$

$$\therefore \quad V \propto \frac{1}{r}$$

28. Students I, II and III perform an experiment for measuring the acceleration due to gravity (g) using a simple pendulum. They use different lengths of the pendulum and/or record time for different number of oscillations. The observations are shown in the table.
Least count for length = 0.1 cm
Least count for time = 0.1 s

| Student | Length of pendulum (cm) | Number of oscillations (n) | Total time for (n) oscillations (s) | Time period (s) |
|---|---|---|---|---|
| I | 64 | 8 | 128 | 16 |
| II | 64 | 4 | 64 | 16 |
| II | 20 | 4 | 36 | 9 |

If $E_I, E_{II}$ and $E_{III}$ are the percentage errors in g, i.e.

$\left(\frac{\Delta g}{g}\times 100\right)$ for students I, II and III, respectively,

(A) $E_I = 0$ (B) $E_I$ is minimum

(C) $E_I = E_{II}$ (D) $E_{II}$ is maximum

**Ans.(c)** $g = 4\pi^2 \frac{l}{T}$

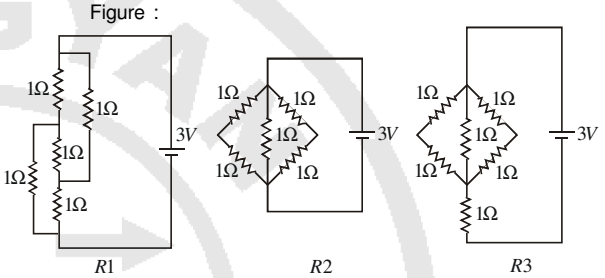
$$\frac{\Delta g}{g} = \frac{\Delta l}{l} + \frac{\Delta T}{T}$$

1st student $\frac{\Delta g}{g} = \frac{0.1}{64} + \frac{0.1}{16}$

2nd student $\frac{\Delta g}{g} = \frac{0.1}{64} + \frac{0.1}{16}$

3rd student $\frac{\Delta g}{g} = \frac{0.1}{20} + \frac{0.1}{9}$

29. Figure shows three resistor configurations R1, R2 and R3 is P1, P2 and P3, respectively, then
Figure :




(A) $P1 > P2 > P3$ (B) $P1 > P3 > P2$

(C) $P2 > P1 > P3$ (D) $P3 > P2 > P1$

**Ans.(C)** $R_1$ is balanced wheatstone bridge

$$R_1 = 1$$

$$\therefore \quad P_1 = \frac{3^2}{1} \qquad \left(\because p = \frac{V^2}{K}\right)$$

$$R_2 = 2 \| 2 \| 1 = \frac{1}{2}\Omega \qquad \therefore P_2 = \frac{3^2}{0.5}$$

$$R_3 = (2 \| 2) S\, 1 = 2\Omega \qquad \therefore P_3 = \frac{3^2}{2}$$

$$\therefore \quad P_2 > P_1 > P_3$$

**SECTION - II**
**Multiple answer objective Type**
**This section contains 3 questions numbered 10 to 12. Each question has 4 choices (a), (b), (c) and (d), out of which ONE OR MORE THAN ONE is/are correct. Mark all the correct answer/s.**

30. In a Young's double slit experiment, the separation between the two slits is d and the wavelength of the light is $\lambda$. The intensity of light falling on slit 1 is four times the intensity of light falling on slit 2. Choose the correct choice (s).

(a) If $d = \lambda$, the screen will contain only one maximum

(b) If $\lambda < d < 2\lambda$, at least one more maximum (besides the central maximum) will be observed on the screen

(c) If the intensity of light falling on slit 1 is reduced so that it becomes equal to that of slit 2, the intensities of the observed dark and bright fringes will increase.

(d) If the intensity of light falling on slit 2 is increased so that it becomes equal to that of slit 1, the intensities of the observed dark and bright fringes will increase

**Ans.(A)** $d \sin\theta = 0, \lambda, 2\lambda.....$ for maximas.

$\therefore$ If $d = \lambda$, one central fringe is formed, the next fringe will be at infinity. (Hence, A)

If $\lambda < d < 2d$, there will be two more maxima, one on either side of central maxima.

If the intensity of slit 2 is increased, the brightness of bright fringes will increase and that of dark fringe will decrease.

**31.** Two balls, having linear momenta $\vec{p}_1 = p\hat{i}$ and $\vec{p}_2 = -p\hat{i}$, undergo a collision in free space. There is no external force acting on the balls. Let $\vec{p}_1'$ and $\vec{p}_2'$ be their final momenta. The followeing option (s) is (are) NOT ALLOWED for any non zero value of $p, a_1, a_2, b_1, b_2, c_1$ and $c_2$.

(a) $\vec{p}_1' = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$, $\vec{p}_2' = a_2\hat{i} + b_2\hat{j}$

(b) $\vec{p}_1' = c_1\hat{k}$, $\vec{p}_2' = c_2\hat{k}$

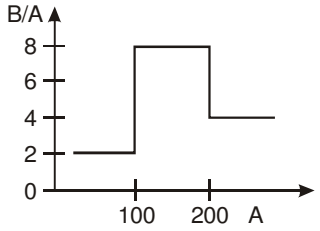
(c) $\vec{p}_1' = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$, $\vec{p}_2' = a_2\hat{i} + b_2\hat{j} - c_1\hat{k}$

(d) $\vec{p}_1' = a_1\hat{i} + b_1\hat{j}$, $\vec{p}_2' = a_2\hat{i} + b_1\hat{j}$

**Ans.** **(A,D)**

$\vec{P_1'} + \vec{P_2'} = 0$

**32.** Assume that the nuclear binding energy per nucleuon (B/A) versus mass number (A) is as shown in the figure. Use this plot to choose the correct choice(s) given below, figure :




(a) Fusion of two nuclei with mass numbers lying in the range of $1 < A < 50$ will release energy

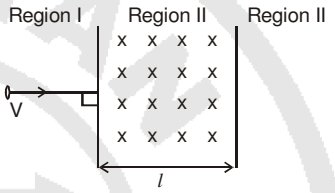
(b) Fusion of two nuclei with mass numbers lying in the range of $51 < A < 100$ will release energy

(c) Fusion of a nucleus lying in the mass range of $100 < A < 200$ will release energy when broken into two equal fragments

(d) Fission of a nucleus lying in the mass range of $200 < A < 260$ will release energy when broken into two equal fragments.

**Ans.(B,D)** For release of energy products must have BE greater then reactants.

**33.** A particle of mass m and charge q, moving with velocity V enters Region II normal to the boundary as shown in the figure. Region II has a uniform magnetic field B perpendicular to the plane of the paper. The length of the Region II is $\ell$. Choose the correct choice (s)




(a) The particle enters region III only if its velocity $V > \frac{q\ell B}{m}$

(b) The particle enters region III only if its velocity $V < \frac{q\ell B}{m}$

(c) Path length of the particle in Region II is maximum when velocity $V = \frac{q\ell B}{m}$

(d) Time spent in Region II is same for any velocity V as long as the particle returns to Region I

**Ans.(A,C,D)** particle entres III if $R > l$

$$\Rightarrow \frac{mV}{qB} > l \Rightarrow V > \frac{qBl}{m}$$

When $V = \frac{qlB}{m}$; particle discribes semicircle of largest radius.

Time period for circular motion in independent of speed.

## SECTION - III
### Assertion - Reason Type

**This section contains 2 questions numbered 13 and 14. Each question contains STATEMENT-1 (Assertion) and STATEMENT - 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which ONLY ONE is correct. Mark your responses from the following options.**

**(a) Both Assertion and Reason are true and Reason is the cor-**

**rect explanation of 'Assertion'**
**(b) Both Assertion and Reason are true and Reason is not the correct explanation of 'Assertion'**
**(c) Assertion is true but Reason is false**
**(d) Assertion is false but Reason is true**

---

**34.** **STATEMENT-1 :**
The stream of water flowing at high speed from a garden hose pipe tends to spread like a fountain when held vertically up, but tends to narrow down when held vertically down.
And
**STATEMENT-2 :**
In any steady flow of an incompressible fluid, the volume flow rate of the fluid remains constant.

**Ans.** **(A)**

**35.** **STATEMENT-1 :**
Two cylinders, one hollow (metal) and the other solid (wood) with the same mass and identical dimensions are simultaneously allowed to roll without slipping down an inclined plane from the same height. The hollow cylinder will reach the bottom of the inclined plane first.
And
**STATEMENT-2 :**
By the principle of conservation of energy, the total kinetic energies of both the cylinders are identical when they reach the bottom of the incline.

**Ans.** **(D)**

**36.** **STATEMENT-1 :**
In a meter Bridge experiment, null point for an unknown resistance is measured. Now, the unknown resistance is put inside an enclosure maintained at a higher temperature. The null point can be obtained at the same point as before by decreasing the value of the standard resistance.
And
**STATEMENT-2 :**
Resistance of a metal increases with increase in temperature.

**Ans.** **(D)**

**37.** **STATEMENT-1 :**
An astronaut in an orbiting space station above the Earth experiences weightlessness.
And
**STATEMENT-2 :**
An object moving around the Earth under the influence of Earth's gravitational force is in a state of "free-fall".

**Ans.** **(A)**

## SECTION - IV
### Linked Comprehension Type

**This section contains 2 paragraphs . Based upon each paragraph, 3 multiple choice questions have to be answered Each question has 4 choices (A), (B), (C) and (D), out of which ONLY ONE is correct.**

**Paragraph for Question Nos. 38 to 40**

In a mixture of $H - He^+$ gas ( $He^+$ is singly ionized He atom), H atoms and $He^+$ ions are excited to their respective first excited states. Subsequently, H atoms transfer their total excitation energy to $He^+$ ions (by collisions). Assume that the Bohar model of atom is exactly valid.

38. The quantum number n of the state finally populated in $He^+$ ions is :
(a) 2 (b) 3
(c) 4 (d) 5

**Ans.(c)** Excitation energy of H atom

39. The wavelength of light emitted in the visible region by $He^+$ ions after collisions with H atom is :
(a) $6.5\times10^{-7}\,m$ (b) $5.6\times10^{-7}\,m$
(c) $4.8\times10^{-7}\,m$ (d) $4.0\times10^{-7}\,m$

**Ans.(c)** light in visible region is emitted for $4 \to 3$ transition in $He^+$

$$\Delta E = 6.04 - 3.4 = 2.64\ eV$$

$$\therefore \quad \lambda = \frac{hc}{\Delta E} = \frac{12420\ eVA^o}{2.64\ eV} = 4705A^o$$

-3.4 eV _____ n=4

-6.04 eV _____ n=3
-13.6 eV _____ n=2
-54.4 eV _____ n=1

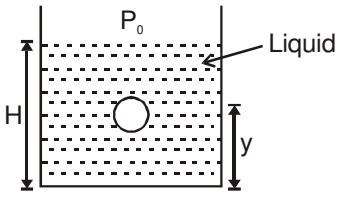
40. The ratio of the kinetic energy of the $n = 2$ electron for the H atom to that of $He^+$ ion is :
(a) 1/4 (b) 1/2
(c) 1 (d) 2

**Ans.(a)** $|E| = k$

$$\therefore \quad \frac{K_H}{K_{He}} = \frac{|E_H|}{|E_{He}|} = \frac{3.4}{13.6} = \frac{1}{4}$$

**Paragraph for Question Nos. 41 to 43**

A small spherical monoatomic ideal gas bubble $\left(\gamma = \frac{5}{3}\right)$ is trapped inside a liquid of density $\rho_\ell$ (see figure). Assume that the bubble does not exchange any heat with the liquid. The bubble contains n moles of gas. The temperature of the gas when the bubble is at the bottom is $T_0$, the height of the liquid is H and the atmospheric pressure is $P_0$ (Neglect surface tension).




41. As the bubble moves upwards, besides the buoyancy force the following forces are acting on it :
(a) Only the force of gravity

(b) The force due to gravity and the force due to the pressure of the liquid
(c) The force due to gravity, the force due to the pressure of the liquid and the force due to viscosity of the liquid
(d) The force due to gravity and the force due to viscosity of the liquid

**Ans.** **(d)**

42. When the gas bubble is at a height y from the bottom, its temperature is :

(a) $T_0\left(\frac{P_0+\rho_\ell gH}{P_0+\rho_\ell gy}\right)^{2/5}$ (b) $T_0\left(\frac{P_0+\rho_\ell g(H-y)}{P_0+\rho_\ell gH}\right)^{2/5}$

(c) $T_0\left(\frac{P_0+\rho_\ell g\,H}{P_0+\rho_\ell g\,y}\right)^{3/5}$ (d) $T_0\left(\frac{P_0+\rho_\ell g(H-y)}{P_0+\rho_\ell gH}\right)^{3/5}$

**Ans.** **(b)**

43. The buoyancy force acting on the gas bubble is (Assume R is the universal gas constant)

(a) $\rho_\ell nRgT_0\frac{(P_0+R_\ell gH)^{2/5}}{(P_0+\rho_\ell gy)^{7/5}}$

(b) $\frac{\rho_\ell nRgT_0}{(P_0+\rho_\ell gH)^{2/5}[P_0+\rho_\ell g(H-y)]^{3/5}}$

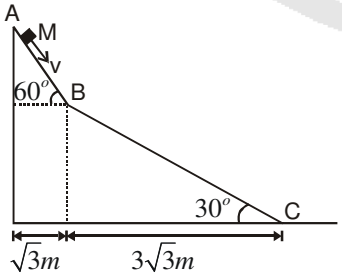
(c) $\rho_\ell nRgT_0\frac{(P_0+\rho_\ell gH)^{3/5}}{(P_0+\rho_\ell gy)^{8/5}}$

(d) $\frac{\rho_\ell nRgT_0}{(P_0+\rho_\ell gH)^{3/5}[P_0+\rho_\ell g(H-y)]^{2/5}}$

**Ans.** **(b)**

**Paragraph for Question Nos. 44 to 46**

A small block of mass M moves on a frictionless surface of an inclined plane, as shown in figure. The angle of the incline suddenly changes from $60^o$ to $30^o$ at point B. The block is initially at rest at A. Assume that collisions between the block and the incline are totally inelastic $(g=10\,m/s^2)$.




44. The speed of the block at point B immediately after it strikes the second incline is :

(a) $\sqrt{60}\,m/s$ (b) $\sqrt{45}\,m/s$

(c) $\sqrt{30}\,m/s$ (d) $\sqrt{15}\,m/s$

**Ans.** **(b)**

45. The speed of the block at point C, immediately before it leaves the second incline is :

(a) $\sqrt{120}\,m/s$ (b) $\sqrt{105}\,m/s$

(c) $\sqrt{90}\,m/s$ (d) $\sqrt{75}\,m/s$

**Ans.** **(b)**

46. If collision between the block and the incline is completely elastic, then the vertical (upward) component of the velocity of the block at point B, immediately after it strikes the second incline is

(a) $\sqrt{30}\,m/s$ (b) $\sqrt{15}\,m/s$

(c) 0 (d) $-\sqrt{15}\,m/s$

**Ans.** **(c)**

## CHEMISTRY

### SECTION - I
### Straight Objective Type

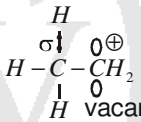
This section contains 6 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** is correct.

47. Hyperconjugation involves overlap of the following orbitals

(a) $\sigma-\sigma$ *(b) $\sigma-p$

(c) $p-p$ (d) $\pi-\pi$

**Sol.(b)**




$\therefore$ overlapping takes place of $\sigma-p$ orbital

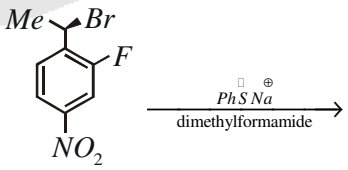
48. Aqueous solution of $Na_2S_2O_3$ on reaction with $Cl_2$ gives

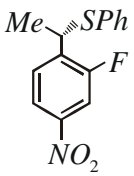
(a) $Na_2S_4O_6$ *(b) $NaHSO_4$

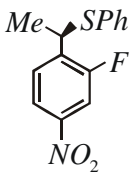
(c) $NaCl$ (d) $NaOH$

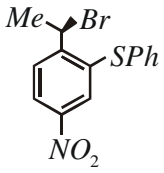
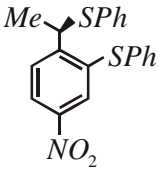
**Sol.(b)** $Na_2\overset{+2}{S}_2O_3+Cl_2\longrightarrow NaHSO_4$

49. The major product of the following reaction is




*(a) 


(b) 

(c)  (d) 

**Sol.(a)** ∵ solvent is dimethyl formamide (aprotic solvent) therefore reaction goes through $S_N^2$ path & product is inverted product. (waldeninversion)

50. Under the same reaction conditions, initial concentration of $1.386\,mol\,dm^{-3}$ of a substance becomes half in 40 seconds and 20 seconds through first order and zero order kinetics, respectively. Ratio $\left(\frac{k_1}{k_0}\right)$ of the rate constants for first order $(k_1)$ and zero order $(k_0)$ of the reactions is

*(a) $0.5\,mol^{-1}dm^3$ (b) $1.0\,mol\,dm^{-3}$

(c) $1.5\,mol\,dm^{-3}$ (d) $2.0\,mol^{-1}\,dm^3$

**Sol. (a)** $a = 1.386\ mol/L\ \ (t_{1/2}) = 40\sec$

$$a - x = 0.693$$

$$K_1 = \frac{2.303}{40}\log\frac{1.386}{0.693} = \frac{2.303\times 0.3010}{40}$$

$$K_0 = \frac{0.693}{20}$$

$$\frac{K_1}{K_0} = \frac{2.3030\times 0.3010}{\frac{40}{0.693}{20}} = \frac{2.3030\times 0.3010}{40}\times\frac{20}{0.693}$$

$$= \frac{2.3030\times 0.3010}{1.386}$$

51. Native silver metal forms a water soluble complex with a dilute aqueous solution of $NaCN$ in the presence of

(a) nitrogen *(b) oxygen

(c) carbon dioxide (d) argon

**Sol.(b)** $Ag^o + NaCN \xrightarrow{O_2} Na[\overset{+1}{A}g(CN)_2]$

52. 2.5 mL of $\frac{2}{5}M$ weak monoacidic base $(K_b = 1\times10^{-12}\,at\,25°C)$ is titrated with $\frac{2}{15}M\ HCl$ in water at 25°C. The concentration of $H^+$ at equivalence point is $(K_w = 1\times10^{-14}\,at\ 25°C)$.

(a) $3.7\times10^{-13}M$ (b) $3.2\times10^{-7}M$

*(c) $3.2\times10^{-2}M$ (d) $2.7\times10^{-2}M$

**Sol.(c)**

$$\underset{t=0}{NH_4OH} + \underset{2.5\times\frac{2}{5}}{HCl} \rightarrow \underset{7.5\times\frac{2}{15}}{NH_4Cl} + \underset{O}{H_2O}$$

$$\underset{t=t}{\quad} \quad \underset{0}{\quad} \quad \underset{0}{\quad} \quad \underset{1m\cdot mol/10ml}{\quad} \quad \underset{1m\cdot mol/10ml}{\quad}$$

(Salthydrolysis)

because the above case is salt hydrolysis there fore we can apply following formula

$$pH = 7 - \frac{1}{2}pK_b - \frac{1}{2}\log C$$

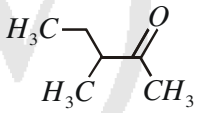
therefore $pH = 7 - 6 + \frac{1}{2}$

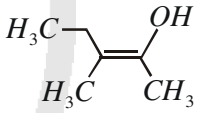
or $pH = 1.5$ or (H+) = $3.7\times10^{-2}$

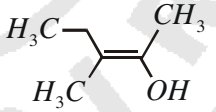
## SECTION - II
### Multiple Correct Answers Type

This section contains 4 multiple correct answer(s) type questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONE OR MORE** is/are correct.

53. The correct statement(s) concerning the structures E, F and G is (are)


(E)


(F)


(G)

(a) E, F and G are resonance structures

*(b) E, F and E, G are tautomers

*(c) F and G are geometrical isomers

*(d) F and G are diastereomers

**Sol.** (b), (c)and (d) only correct

(E), (F) and (E) (G) are tautomers ∵ H-shift from $\propto -c-atom$ to oxygen & then oxygen to c-atom (F) & (G) are also geometrical isomers

54. A solution of colourless salt H on boiling with excess $NaOH$ produces a non-flammable gas. The gas evolution ceases after sometime. Upon addition of $Zn$ dust to the same solution, the gas evolution restarts. The colourless salt(s) H is (are)

*(a) $NH_4NO_3$ *(b) $NH_4NO_2$

(c) $NH_4Cl$ (d) $(NH_4)_2SO_4$

**Sol.(a,b)**

$$NH_4NO_3 / NH_4NO_2 + NaOH \longrightarrow NH_3$$

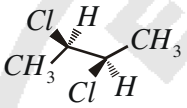
$$NH_3 + H_2O \longrightarrow NH_4OH$$

$$2NH_4OH + Zn \longrightarrow Zn(OH)_2 + 2NH_3$$

55. A gasdescribed by van der Waals equation
*(a) behaves similar to an ideal gas in the limit of large molar volumes
(b) behaves similar to an ideal gas in he limit of large pressures
*(c) is characterised by van der Waals coefficients that are dependent on the identity of the gas but are independent of the temperature
*(d) has the pressure that is lower than the pressure exerted by the same gas behaving ideally

**Sol. (a,c,d)**
At large pressure it does not behave as an ideal gas:

56. The correct statement(s) about the compound given below is (are)



(a) The compound is optically active
(b) The compound possesses centre of symmetry
*(c) The compound possesses plane of symmetry
*(d) The compound possesses axis of symmetry

**SECTION - III**
**Reasoning Type**

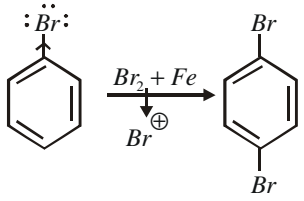
This section contains 4 reasoning type questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** is correct.

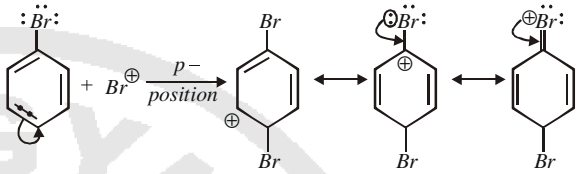
57. **Statement - 1** :
The plot of atomic number $(y-axis)$ versus number of neutrons $(x-axis)$ for stable nuclei shows a curvature towards $x-axis$ from the line of $45°$ slope as the atomic number is increased.
**and** **Statement - 2** :
Proton-proton electrostatic repulsions begin to overcome attractive forces involving protons and neutrons in heavier nuclides.
(a) Statement - 1 is Ture, Statement - 2 is True; Statement - 2 is a correct explanation for Statement -1.
(b) Statement - 1 is True, Statement - 2 is True; Statement - 2 is NOT a correct explanation for Statement - 1.
(c) Statement - 1 is True, Statement - 2 is False.
(d) Statement - 1 is False, Statement - 2 is True.

**Ans : (a)**

58. **Statement - 1** :
Bromobenzene upon reaction with $Br_2 / Fe$ gives 1, 4-dibromobenzene as the major product.
**and** **Statement - 2** :
In bromobenzene, the inductive effect of the bromo group is more dominant than the mesomeric effect in directing the incoming electrophile.
(a) Statement - 1 is Ture, Statement - 2 is True; Statement - 2 is a correct explanation for Statement -1.
(b) Statement - 1 is True, Statement - 2 is True; Statement - 2 is NOT a correct explanation for Statement - 1.
(c) Statement - 1 is True, Statement - 2 is False.
(d) Statement - 1 is False, Statement - 2 is True.

**Sol.(c)**





one of the resonating structure of above is most stable due to conjugation of lone pair of bromine with vacant orbital of C in benzene ring.

59. **Statement - 1** :
$Pb^{4+}$ compounds are stronger oxidizing agents than $Sn^{4+}$ compounds.
**and** **Statement - 2** :
The higher oxidation states for the group 14 elements are more stable for the heavier members of the group due to 'inert pair effect'.
(a) Statement - 1 is Ture, Statement - 2 is True; Statement - 2 is a correct explanation for Statement -1.
(b) Statement - 1 is True, Statement - 2 is True; Statement - 2 is NOT a correct explanation for Statement - 1.
(c) Statement - 1 is True, Statement - 2 is False.
(d) Statement - 1 is False, Statement - 2 is True.

**Sol.(c)** Top of bottom in a group of p-block inert pair effect increases.

60. **Statement - 1** :
For every chemical reaction at equilibrium, standard Gibbs energy of reaction is zero.
**and** **Statement - 2** :
At constant temperature and pressure, chemical reactions are spontaneous in the direction of decreasing Gibbs energy.
(a) Statement - 1 is Ture, Statement - 2 is True; Statement - 2 is a correct explanation for Statement -1.
(b) Statement - 1 is True, Statement - 2 is True; Statement - 2 is NOT a correct explanation for Statement - 1.
(c) Statement - 1 is True, Statement - 2 is False.
(d) Statement - 1 is False, Statement - 2 is True.

**Ans : (d)**

**SECTION - IV**
**Linked Comprehension Type**

This section contains 3 paragraphs. Based upon each paragraph, 3 multiple choice questions have to be answered. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** is correct.

**Paragraph for Question Nos. 61 to 63.**
In the following raction sequence, products I, J and L are

formed. K represents a reagent.

$$Hex-3-ynal \xrightarrow[2.PBr_3]{1.NaBH_4} I \xrightarrow[3.H_3O^+]{1.Mg/ether\ 2.CO_2} J \xrightarrow{K} Me\text{-}C\equiv C\text{-}CH_2\text{-}CH_2\text{-}C(=O)\text{-}Cl \xrightarrow[Pd/BaSO_4\ quinoline]{H_2} L$$

61. The structure of the product I is

(a) $Me\text{-}CH=CH\text{-}CH_2\text{-}Br$ (b) $Me\text{-}CH_2\text{-}CH=CH\text{-}Br$

(c) $Me\text{-}CH=CH\text{-}CH=CH\text{-}Br$ *(d) $Me\text{-}C\equiv C\text{-}CH_2\text{-}Br$

62. The structures of compounds J and K, respectively, are

*(a) $Me\text{-}C\equiv C\text{-}COOH$ and $SOCl_2$

(b) $Me\text{-}CH=CH\text{-}C(=O)\text{-}OH$ and $SO_2Cl_2$

(c) $Me\text{-}CH=CH\text{-}COOH$ and $SOCl_2$

(d) $Me\text{-}C\equiv C\text{-}COOH$ and $CH_3SO_2Cl$

63. The structure of product $L$ is

(a) $Me\text{-}C\equiv C\text{-}CHO$

(b) $Me\text{-}CH=CH\text{-}CHO$

*(c) $Me\text{-}CH=CH\text{-}CH=O$

(d) $Me\text{-}CH=CH\text{-}CHO$

**Sol. 61 (d)**

$$H_3C-H_2-C\equiv C-CH_2-C-H$$

$\downarrow NaBH_4$ (only redces carbonyl compounds & acid chloride)

$$H_3C-CH_2-C\equiv C-CH_2-CH_2-OH \xrightarrow{PBr_3}$$

$$CH_3-CH_2-C\equiv C-CH_2-CH_2-Br$$

$(I)$

**Sol.62 (a)**

$$CH_3-CH_2-C\equiv C-CH_2-CH_2-Br \xrightarrow{Mg/ether}$$

$$CH_3-CH_2-C\equiv C-CH_2-CH_2-MgBr$$

$\downarrow (1)\ CO_2$

$\downarrow (2)\ H_3O^{\oplus}$

$$CH_3-CH_2-C\equiv C-CH_2-CH_2-C(=O)-OH$$

(J)

**Sol. 63 (c)**

$$CH_3-CH_2-C\equiv C-CH_2-CH_2-C(=O)-OH$$

$(J)$

$$\xrightarrow{SOCl_2} CH_3-CH_2C\equiv C-CH_2-CH_2-C(=O)-Cl$$

Rosenmund Reaction $\xleftarrow[H_2]{Pd/BaSO_4}$

$$CH_3\text{-}\ CH_2C=C\text{-}\ CH_2\text{-}\ CH_2\text{-}\ C(=O)\text{-}\ H$$

**Paragraph for Question Nos. 64 to 66**

Properties such as boiling point, freezing point and vapour pressure of a pure solvent change when solute molecules are added to get homogeneous solution. These are called colligative properties. Applications of colligative properties are very useful in day-to-day life. One of its examples is the use of ethylene glycol and water mixture as anti-freezing liquid in the radiator of automobiles.

A solution M is prepared by mixing ethanol and water. The mole fraction of ethanol in the mixture is 0.9.

Given : Freezing point depression constant of water $\left(K_f^{water}\right)=1.86K\ kg\ mol^{-1}$.

Freezing point depression constant of ethanol $\left(K_f^{ethanol}\right)=2.0K\ kg\ mol^{-1}$

Boiling point elevation constant of water $\left(K_b^{water}\right)=0.52K\ kg\ mol^{-1}$

Boiling point elevation constant of ethanol $\left(K_b^{ethanol}\right)=1.2K\ kg\ mol^{-1}$

Standard freezing point of water = 273 K
Standard freezing point of ethanol = 155.7 K
Standard boiling point of water = 373 K
Standard boiling point of ethanol = 351.5 K
Vapour pressure of pure water = 32.8 mm Hg
Vapour pressure of pure ethanol = 40 mm Hg

Molecular weight of water = 18 g $mol^{-1}$

Molecular weight of ethanol = 46 g $mol^{-1}$

In answering the following questions, consider the solutions to be ideal dilute solutions and solutes to be non-volatile and non-dissociative.

64. The freezing point of the soltuion M is
(a) 268.7 K (b) 268.5 K
(c) 234.2 K *(d) 150.9 K

65. The vapour pressure of the solution M is
(a) 39.3 mm Hg *(b) 36.0 mm Hg
(c) 29.5 mm Hg (d) 28.8 mm Hg

66. Water is added to the solution M such that the mole fraction of water in the solution becomes 0.9. The boiling point of this solution is
(a) 380.4 K *(b) 376.2 K
(c) 375.5 K (d) 354.7 K

**64 (d)** Freezing point solution M

$$\Delta T_f = K_f \times m(molality)$$

$$= 2\times\frac{0.1\times1000}{0.9\times46}$$

$$= \frac{2\times1000}{46\times9}$$

$$= 1.83$$

there fore freezing point = 155.7-1.83
= 150.86
= 150.9

**65. (b)** Given $X_{CH_3CH_2OH} = 0.9$, $X_{H_2o} = 0.1$

$$P^0_{H_2O} = 32.8mmHg \quad P^0_{CH_3CH_2OH} = 40mm$$

$$P_T = 0.9\times40 + 0.1\times32.8mmHg$$

$$= 36 \ mmHg$$

**66. (b)** $$(\Delta)_{T_b} = 0.52\times\frac{0.1\times1000}{0.9\times18} = 3.20$$

$$B.P = 373 + 3.20 = 376.20$$

**Paragraph for Question Nos. 67 to 69**

There are some deposits of nitrates and phosphates in earth's crust. Nitrates are more soluble in water. Nitrates are difficult to reduce under the laboratory conditions but microbes do it easily. Ammonia forms large number of complexes with transition metal ions. Hybridization easily explains the ease of sigma donation capability of $NH_3$ and $PH_3$. Phosphine is a flammable gas and is prepared from white phosphorous.

67. Among the follwoing, the correct statements is
(a) Phosphates have no biological significane in humans
(b) Between nitrates and phosphates, phosphates are less abundant in earth's crust
*(c) Between nitrates and phosphates, nitrates are less abundant in earth's crust
(d) Oxidation of nitrates is possible in soil

68. Among the following, the correct statements is
(a) Between $NH_3$ and $PH_3$, $NH_3$ is a better electron beacause the lone pair of electrons occupies spherical 's' orbital and is less directional
(b) Between $NH_3$ and $PH_3$, $PH_3$ is a better electron donor because the lone pair of electrons occupies $sp^3$ orbital and is more directional
*(c) Between $NH_3$ and $PH_3$, $NH_3$ is a better electron donor because the lone pair of electrons occupies $sp^3$ orbital and is more directional
(d) Between $NH_3$ and $PH_3$, $PH_3$ is a better electron donor because the lone pair of electrons occupies spherical 's' orbital and is less directional

69. White phosphorus on reaction with $NaOH$ gives $PH_3$ as one of the products. This is a
(a) dimerization reaction
*(b) disproportionation reaction
(c) condensation reaction
(d) precipitation reaction

**Solution from 67 to 69**

**67.(c)** Nitrales are more soluble and hence less abundant.

**68.(c)** $NH_3$ is a better electron donor and Hybridisation of $N$ is $sp^3$

**69.(b)** $$P_4 + NaOH \longrightarrow PH_3 + NaH_2PO_2$$