24/01/2026
EVEINING

Memory Based Answers & Solutions

Time : 3 hrs. *for* M.M. : 300

JEE (Main)-2026 (Online) Phase-1

(Mathematics and Physics, Chemistry)

IMPORTANT INSTRUCTIONS:

(1) The test is of **3 hours** duration.

(2) This test paper consists of 75 questions. Each subject (PCM) has 25 questions. The maximum marks are 300.

(3) This question paper contains **Three Parts**. **Part-A** is Physics, **Part-B** is Chemistry and **Part-C** is **Mathematics**. Each part has only two sections: **Section-A** and **Section-B**.

(4) **Section - A :** Attempt all questions.

(5) **Section - B :** Attempt all questions.

(6) **Section - A (01 – 20)** contains 20 multiple choice questions which have **only one correct answer**. Each question carries **+4 marks** for correct answer and **–1 mark** for wrong answer.

(7) **Section - B (21 – 25) contains** 5 **Numerical value** based questions. The answer to each question should be rounded off to the **nearest integer**. Each question carries **+4 marks** for correct answer and **–1 mark** for wrong answer.

1. If all the letters of the word 'UDAYPUR' are arranged in all possible permutations and these permutations are listed in dictionary order, then the rank of the word 'UDAYPUR' is :

(1) 1580 (2) 1579

(3) 1582 (4) 1580

Ans. **(1)**

Sol. ADIPRUU

$A \rightarrow \frac{6!}{2!} = 360$

$D \rightarrow \frac{6!}{2!} = 360$

$P \rightarrow \frac{6!}{2!} = 360$

$R \rightarrow \frac{6!}{2!} = 360$

UA $\rightarrow$ 5! = 120

UDAP $\rightarrow$ 3! = 6

UDAR $\rightarrow$ 3! = 6

UDAU $\rightarrow$ 3! = 6

UDAYPRU $\rightarrow$ 1

UDAYPUR $\rightarrow$ 1

Total = 1580

2. Maximum value of n for which 40^n divides 60! is

(1) 10 (2) 14

(3) 20 (4) 27

Ans. **(2)**

Sol. $40^n = 2^{3n} \times 5^n$

$$E_2(60!) = \left[\frac{60}{2}\right] + \left[\frac{60}{2^2}\right] + \left[\frac{60}{2^3}\right] + \left[\frac{60}{2^4}\right] + \left[\frac{60}{2^5}\right]$$

$= 30 + 15 + 7 + 3 + 1 = 56$

$$E_5(60!) = \left[\frac{60}{5}\right] + \left[\frac{60}{5^2}\right]$$

$= 12 + 2 = 14$

$40^n = (2^3)^n \times 5^n = (2^3 \times 5)^n$

$60! = 2^{56} \times 5^{14} \ldots = 2^{14}.(2^3.5)^{14}$

$\therefore$ Maximum value of n is 14.

3. Let z = (1 + i) (1 + 2i) (1 + 3i).....(1 + ni) and $|z^2| = 44200$. Find the value of n.

(1) 5 (2) 6

(3) 8 (4) 7

Ans. **(1)**

Sol. $|z|^2 = 2^3.5^2.13.17$

$$\prod_{r=1}^{n}(1+r^2) = 2^3.5^2.13.17 = (2).(5).(2.5).(17).(2.13) = 2.5.10.17.26$$

so n = 5.

4. Let f(x) be a differentiable function satisfying the equations : $\lim_{t \to x} \frac{t^2 f(x) - x^2 f(t)}{x - t} = 3$ and f(1) = 2. Find the value of 2f(2).

(1) 20 (2) 23

(3) 25 (4) 27

Ans. **(2)**

Sol. $\lim_{t \to x} \frac{2t\, f(x) - x^2 f'(t)}{-1} = 3$

$x^2 f'(x) - 2x\, f(x) = 3$

$\frac{dy}{dx} - \frac{2y}{x} = \frac{3}{x^2}$

I.F. $= e^{-\int \frac{2}{x}dx} = e^{-2\log_e x} = 1/x^2$

$y \cdot \frac{1}{x^2} = \int \frac{3}{x^4} dx$

$\frac{y}{x^2} = -\frac{1}{x^3} + c \Rightarrow y = cx^2 - \frac{1}{x} = f(x)$

$f(1) = 2 = c - 1 \Rightarrow c = 3$

$f(x) = 3x^2 - \frac{1}{x}$

$f(2) = 12 - \frac{1}{2} \Rightarrow 2f(2) = 23$

5. If P(h, k) is a variable point on $x^2 + y^2 = 4$ & Q(2h + 1, 3k + 3) always lie on an ellipse if eccentricity of ellipse is e then $\frac{5}{e^2}$ is equal to :

(1) 9 (2) 5

(3) 3 (4) 6

Ans. **(1)**

Sol. Let P ≡ (2cos θ, 2sin θ)

∴ coordinates of Q = (4cosθ + 1, 6sinθ + 3)

∴ locus of Q is $\left(\frac{x-1}{4}\right)^2 + \left(\frac{y-3}{6}\right)^2 = 1$

$\therefore\ e^2 = 1 - \frac{16}{36} = \frac{5}{9}$

$\therefore\ \boxed{\frac{5}{e^2} = 9}$

6. Let mirror image of parabola $x^2 = 4y$ in the line x – y = 1 is $(y + a)^2 = b(x - c)$ then value of (a + b + c) is :

(1) 3 (2) 6

(3) 9 (4) 12

Ans. **(2)**

Sol. Parametric point P on $x^2 = 4y$ is $P(2t, t^2)$

∴ mirror image of P in x – y = 1 is

$$Q \equiv \left(2t - \frac{2.1.(2t - t^2 - 1)}{2}, t^2 + \frac{2.2(1).(2t - t^2 - 1)}{2}\right)$$

$Q \equiv (t^2 + 1, 2t - 1) \equiv (h, k)$

∴ locus of Q is $x = \frac{(y+1)^2}{4} + 1$ which is the required parabola.

$\therefore\ \boxed{(y+1)^2 = 4(x-1)}$

∴ a = 1, b = 4, c = 1

$\therefore\ \boxed{a + b + c = 6}$

7. Let f(x) be a differentiable function satisfying $f(x) = e^x + \int_0^1 (y + xe^x)\, f(y)dy$. Find f(0) + e (where e = napiers constant) :

(1) 2 (2) 4

(3) 6 (4) 8

Ans. **(1)**

Sol. $f(x) = e^x + \int_0^1 yf(y)dy + xe^x \int_0^1 f(y)dy$

$f(x) = e^x + A + Bxe^x$

$A = \int_0^1 yf(y)\, dy = \int_0^1 y(A + e^y + By\, e^y)\, dy$

$A = \frac{A}{2} + (0 - (-1)) + B\,(e - 1)$

$\frac{A}{2} + B\,(1 - e) = 1$

$B = \int_0^1 f(y)\, dy$

$B = \int_0^1 (e^y + A + By\, e^y)dy$

B = (e – 1) + A + B(0 – (–1))

B = e – 1 + A + B ⇒ A = 1 – e

$f(x) = e^x + A + Bxe^x$

f(0) = 1 + A = 1 – e + 1 = 2 – e

e + f(0) = 2

8. Let 4 integers a_1, a_2, a_3, a_4 are in A.P. with integral common difference ℓ such that $a_1 + a_2 + a_3 + a_4 = 48$ & $a_1a_2a_3a_4 + \ell^4 = 361$ then the greatest term in this A.P. is

(1) 24 (2) 23

(3) 27 (4) 21

Ans. **(3)**

Sol. a_1, a_2, a_3, a_4 as a –3d, a – d, a + d, a + 3d

where $\boxed{d = \frac{\ell}{2}}$

$\because\ a_1 + a_2 + a_3 + a_4 = 48 \Rightarrow 4a = 48 \Rightarrow a = 12$

& $a_1a_2a_3a_4 + \ell^4 = 361 \Rightarrow (a^2 - 9d^2)(a^2 - d^2) + 16d^4 = 361$

$\Rightarrow (144 - 9d^2)(144 - d^2) + 16d^4 = 361$

$\Rightarrow 25d^4 - 1440\, d^2 + (144)^2 = 361$

$(5d^2 - 144)^2 = 19^2$

$\therefore\ 5d^2 - 144 = 19$ or –19

$d^2 = \frac{163}{5}$ or $d^2 = \frac{125}{5} = 25$

$d = \sqrt{\frac{163}{5}}$ or d = 5

$\therefore \ \ell = 2\sqrt{\frac{163}{5}}$ or $\ell = 10$

(rejected)

$\because$ common difference is an integer

$\therefore$ largest term = 12 + 15 = 27

9. If $2(\vec{a}\times\vec{c})+3(\vec{b}\times\vec{c})=0$

where $\vec{a}=2i-5j+5k$ & $\vec{b}=i-j+3k$

and $(\vec{a}-\vec{b})\cdot\vec{c}=-97$ find $|\vec{c}\times k|^2$

(1) 218 (2) 207

(3) 165 (4) 210

Ans. **(1)**

Sol. $2(\vec{a}\times\vec{c})+3(\vec{b}\times\vec{c})=0$

$\Rightarrow (2\vec{a}+3\vec{d})\times\vec{c}=0 \Rightarrow \vec{c}=\lambda(2\vec{a}+3\vec{d})$

$\Rightarrow \vec{c}=\lambda\,(7i-13j+19k)$

Now $(\vec{a}-\vec{b})\cdot\vec{c}-=\lambda\,(7+52+38)+97\lambda=-97$

$\Rightarrow \lambda=-1$

Now $\vec{c}=-7i+13j-19k$

$\Rightarrow \vec{c}\times\vec{k}-=7j+13i \Rightarrow |\vec{c}\times\hat{k}|^2=7^2+13^2=218$

10. Evaluate :

$$\left(\frac{4}{7}+\frac{1}{3}\right)+\left(\left(\frac{4}{7}\right)^2+\left(\frac{4}{7}\right)\left(\frac{1}{3}\right)+\left(\frac{1}{3}\right)^2\right)+\left(\left(\frac{4}{7}\right)^3+\left(\frac{4}{7}\right)^2\cdot\frac{1}{3}+\left(\frac{4}{7}\right)\left(\frac{1}{3}\right)^2+\left(\frac{1}{3}\right)^3\right)+\ldots\infty$$

(1) $\frac{5}{2}$ (2) 5

(3) $\frac{7}{2}$ (4) $\frac{8}{3}$

Ans. **(1)**

Sol. Let $a=\frac{4}{7}$, $b=\frac{1}{3}$

Multiply N^r and D^r by $(a-b) = \frac{4}{7}-\frac{1}{3} = \frac{5}{21}$

$\frac{1}{a-b}[(a^2-b^2)+(a^3-b^3)+(a^4-b^4)+\ldots\infty]$

$\frac{1}{a-b}\left[\frac{a^2}{1-a}-\frac{b^2}{1-b}\right]=\frac{21}{5}\left[\frac{\frac{16}{49}}{1-\frac{4}{7}}-\frac{\frac{1}{9}}{1-\frac{1}{3}}\right]$

$=\frac{21}{5}\left[\frac{16}{21}-\frac{1}{6}\right] = \frac{21}{5}\left[\frac{96-21}{21.6}\right]$

$=\frac{75}{5.6}=\frac{15}{6}=\frac{5}{2}$

11. Let S has 5 elements and P(S) is the power set of S. Let an ordered pair (A, B) is selected at random from P(S) × P(S). If the probability that $A \cap B = \phi$ is $\frac{3^m}{2^n}$, then value of (m + n) is equal to

(1) 88 (2) 96

(3) 64 (4) 28

Ans. **(2)**

Sol. S = {a, b, c, d, e}

$P=\frac{3^{32}}{4^{32}}$ $\left(\frac{\text{fav}}{\text{total}}\right)$

$P=\frac{3^{32}}{2^{64}}=\frac{3^m}{2^n}$

m = 32, n = 64

m + n = 32 + 64 = 96

12. If domain of $f(x)=\sin^{-1}\left(\frac{1}{x^2-2x-2}\right)$ is

$(-\infty, \alpha] \cup [\beta, \gamma] \cup [\delta, \infty)$, then $(\alpha+\beta+\gamma+\delta)$ is

(1) 0 (2) 4

(3) 3 (4) 1

Ans. **(2)**

Sol. $-1\le\frac{2}{x^2-2x-2}\le 1$

$\frac{1+x^2-2x-2}{x^2-2x-2}\ge 0 \Rightarrow \frac{(x-1)^2-2}{(x-1)^2-3}\ge 0$

$\Rightarrow \frac{\left(x-1-\sqrt{2}\right)\left(x-1+\sqrt{2}\right)}{\left(x-1-\sqrt{3}\right)\left(x-1+\sqrt{3}\right)}\ge 0$

$x\in\left(-\infty,1-\sqrt{3}\right)\cup\left[1-\sqrt{2},1+\sqrt{2}\right]\cup\left(1+\sqrt{3},0\right)$ ...(1)

$1-\frac{1}{x^2-2x-2}\ge 0 \Rightarrow \frac{x^2-2x-3}{x^2-2x-2}\ge 0$

$$\Rightarrow \frac{(x+1)(x-3)}{\left(x-1+\sqrt{3}\right)\left(x-1-\sqrt{3}\right)} \geq 0$$

$$x \in (-\infty,-1] \cup \left(1-\sqrt{3},\sqrt{3}+1\right) \cup [3,\infty) \quad \ldots(1)$$

$(1) \cap (2)$

$$\Rightarrow x \in (-\infty,-1] \cup \left[1-\sqrt{2},1+\sqrt{2}\right] \cup [3,\infty)$$

$$\therefore \alpha+\beta+\gamma+\delta = 4$$

13. Let

$$f(x) = \begin{cases} b^2 \sin\left(\frac{\pi}{2}\left[\frac{\pi}{2}(\sin x+\cos x).\cos x\right]\right) & ; \quad x>0 \\ \dfrac{\sin x - \frac{\sin 2x}{2}}{x^3} & ; \quad x<0 \\ a & ; \quad x=0 \end{cases}$$

be a continuous function at x = 0 then the value of $(a^2 + b^2)$ is equal to

(where [.] denotes greatest integer function)

(1) $\frac{1}{4}$ (2) $\frac{1}{2}$

(3) $\frac{3}{4}$ (4) $\frac{5}{4}$

Ans. **(3)**

Sol. $\text{LHL} = \lim\limits_{x\to 0} \frac{\sin x - \sin x \cos x}{x^3}$

$$= \lim_{x\to 0} \frac{\sin x}{x}\frac{(1-\cos x)}{x^2} = \frac{1}{2}$$

$f(0) = a$

$$\text{RHL} = \lim_{x\to 0^+} b^2 \sin\frac{\pi}{2}\left[\frac{\pi}{2}(\sin x+\cos x)\cos x\right] = b^2$$

$$b^2 = a = \frac{1}{2}$$

$$a^2 + b^2 = \frac{1}{4}+\frac{1}{2} = \frac{3}{4}$$

14. If equation $x^4 - ax^2 + 9 = 0$ have four real & distinct roots then least possible integral value of a is

(1) 5 (2) 6

(3) 7 (4) 8

Ans. **(3)**

Sol. $x^4 - ax^2 + 9 = 0$ ...(1)

let $x^2 = t$

$t^2 - at + 9 =$ ...(2)

for roots of equation (1) to be real & distinct roots of equation (2) must be positive & distinct.

(i) $D > 0 \Rightarrow a^2 - 36 > 0 \Rightarrow a \in (-\infty, -6) \cup (6, \infty)$

(ii) $\frac{-b}{2a} > 0 \Rightarrow \frac{a}{2} > 0 \Rightarrow a > 0$

(iii) $f(0) > 0 \Rightarrow 9 > 0 \Rightarrow a \in R$

By (i) ∩ (ii) ∩ (iii)

$\therefore a \in (6, \infty)$

∴ least integral value of a is 7

15. If dataset A = {1, 2, 3, …, 19}

& dataset $B = \{ax_i + b;\ x_i \in A\}$

If mean of B is 30 & variance of B is 750, then sum of possible values of b is

(1) 30 (2) 90

(3) 20 (4) 60

Ans. **(4)**

Sol. A = {1, 2, 3, …, 19}

∴ mean of this data set $\bar{x} = 10$

$$\& \ \sigma^2 = \frac{19^2-1}{12} = 30$$

now the dataset B is $ax_i + b$

∴ new mean = a.10 + b = 30 ...(1)

& new variance = $a^2.30 = 750$

$\Rightarrow a^2 = 25 \Rightarrow a = \pm 5$

by equation (1)

if $a = 5 \Rightarrow b = -20$

if $a = -5 \Rightarrow b = 80$

∴ sum of possible values of b = 60

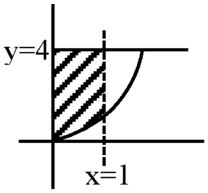
16. If f(α) is the area bounded in the first quadrant by $x = 0$, $x = 1$, $y = x^2$, $y = |\alpha x - 5| - |1 - \alpha x| + \alpha x^2$, then find f(0) + f(1)

(1) $\frac{11}{3}$ (2) $\frac{13}{3}$

(3) $\frac{17}{3}$ (4) $\frac{23}{3}$

Ans. **(4)**

Sol.

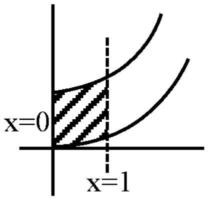


$$f(0)=\int_0^1(4-x^2)dx=\left(4x-\frac{x^3}{3}\right)_0^1=4-\frac{1}{3}=\frac{11}{3}$$

f(1) = area bounded by x = 0, x = 1, $y = x^2$,

$y = |x-5| - |x-1| + x^2$

for $x \in (0, 1)$ $y = 4 + x^2$



$$f(1)=A\int_0^1\left((4+x^2)-x^2\right)dx=4$$

$$f(0)+f(1)=\frac{11}{3}+4=\frac{23}{3}$$

17. Let $f(x)=\int\frac{(7x^{10}+9x^8)}{(1+x^2+2x^9)^2}dx$, and $f(1)=\frac{1}{4}$.

Given that $A=\begin{bmatrix}0 & 0 & 1\\ 4 & f'(1) & 1\\ \alpha^2 & \frac{1}{4} & 1\end{bmatrix}$ and B = adj(adjA), |B| = 81. Find the value of α^2 (where $\alpha \in R$)

(1) 2 (2) 4

(3) 6 (4) 8

Ans. (2)

Sol. $$f(x)=\frac{\int\left(\frac{7}{x^8}+\frac{9}{x^{10}}\right)}{\left(\frac{1}{x^9}+\frac{1}{x^7}+2\right)^2}dx$$

Put $t=\frac{1}{x^9}+\frac{1}{x^7}+2 \Rightarrow \frac{dt}{dx}=\frac{-9}{x^{10}}-\frac{7}{x^8}$

$$f(x)=\int\frac{-dt}{t^2}=\frac{1}{t}+C$$

$$f(x)=\frac{1}{\frac{1}{x^9}+\frac{1}{x^7}+2}+C$$

$$=\frac{x^9}{1+x^2+2x^9}+C$$

Given $f(1)=\frac{1}{4}=\frac{1}{4}+C \Rightarrow C=0$

$$f(x)=\frac{x^9}{1+x^2+2x^9}$$

$$f'(x)=\frac{(1+x^2+2x^9)-9x^8-x^9(2x+18x^8)}{(1+x^2+2x^9)^2}$$

$$f'(x)=\frac{36-20}{16}=1$$

$$A=\begin{pmatrix}0 & 0 & 1\\ 4 & 1 & 1\\ \alpha^2 & \frac{1}{4} & 1\end{pmatrix}$$

$|A| = |1-\alpha^2| = 3$

$1-\alpha^2 = 3, -3 \Rightarrow \alpha^2 = -2, 4$

Value of $\alpha^2 = 4$

B = adj(adjA)

$|B| = 81 = |A|^4 \Rightarrow |A| = 3$

18. Find number of solutions of the equation $\tan(x + 100°) = \tan(x + 50°) \tan x \tan(x - 50°)$ where $x \in (o, \pi)$

(1) 3 (2) 4

(3) 5 (4) 6

Ans. (2)

Sol. $$\frac{\tan(x+100°)}{\tan x}=\tan(x+50°)\tan(x-50°)$$

$$\frac{\sin(x+100°)\cos x}{\cos(x+100°)\sin x}=\frac{\sin(x+50°)\sin(x-50°)}{\cos(x+50°)\cos(x-50°)}$$

Apply C & D

$$\frac{\sin(2x+100°)}{\sin 100°}=\frac{\cos 100°}{-\cos 2x}$$

$2\sin(2x + 100°) \cos 2x + \sin 200° = 0$

$\sin(4x+100°) + \sin 100° + \sin 200° = 0$

$\sin(4x + 100°) = -2\sin 150° \sin 50°$

$\sin(4x + 100°) = -\sin 50°$

$\therefore 4x + 100° = n\pi + (-1)^n \cdot (-50°)$

$$4x=\frac{n\pi+(-)^{n+1}(50°)-100°}{4}$$

$\therefore x=\frac{130°}{4},\frac{210°}{4},\frac{490°}{4},\frac{570°}{4}$ in $(0, \pi)$

$\therefore$ no. of solutions = 4

19. Let P and Q be any two 3 × 3 matrices (where $P = [p_{ij}]_{3\times 3}$, $Q = [q_{ij}]_{3\times 3}$) such that $q_{ij} = 2^{i+j-1}p_{ij}$ where $|Q| = 2^{10}$ then find $|adj(adj(P))|$

(1) 32 (2) 8

(3) 16 (4) 64

Ans. (3)

Sol. $\begin{vmatrix} 2p_{11} & 2^2p_{12} & 2^3p_{13} \\ 2^2p_{21} & 2^3p_{22} & 2^4p_{23} \\ 2^3p_{31} & 2^4p_{32} & 2^5p_{33} \end{vmatrix} = 2^{10}$

$$2^2\cdot 2\cdot 2^3 \begin{vmatrix} p_{11} & p_{12} & p_{13} \\ 2p_{21} & 2p_{22} & 2p_{23} \\ 2^2p_{31} & 2^2p_{32} & 2^2p_{33} \end{vmatrix} = 2^{10}$$

$$2^9 \begin{vmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{vmatrix} = 2^{10} \Rightarrow |P| = 2$$

$$|\text{adj}(\text{adj}(P))| = |P|^{(n-1)^2} = |P|^4 = 2^4 = 16$$

20. Let E = $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$ be an ellipse if eccentricity of this ellipse is equal to the greatest value of the function $f(t) = \frac{-3}{4} + 2t - t^2$

& Length of latus rectum is 30

then find $a^2 + b^2$ = ?

(1) 496 (2) 250 (3) 376 (4) 175

Ans. **(1)**

Sol. $f(t) = \frac{-3}{4}+2t-t^2$

$$f(t)\Big|_{\text{maximum}} = \frac{1}{4} = e \Rightarrow e^2 = \frac{1}{16} \Rightarrow \frac{a^2-b^2}{a^2} = \frac{1}{16} \quad ..(1)$$

$$\because \frac{2b^2}{a} = 30 \Rightarrow b^2 = 15a \ldots(2)$$

By (1) & (2)

$16(a^2 - 15a) = a^2 \Rightarrow 15a^2 - 16 \times 15a = 0$

$a = 16$

$b^2 = 240$

$a^2 + b^2 = 256 + 240$

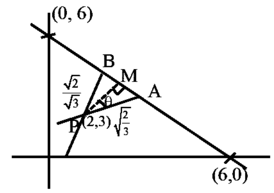
$= 496$

21. If two lines drawn from a point P(2, 3) intersecting the line x + y = 6 at a distance of $\sqrt{\frac{2}{3}}$, then angle between the lines is -

(1) $\frac{\pi}{6}$ (2) $\frac{\pi}{3}$ (3) $\frac{\pi}{12}$ (4) $\frac{5\pi}{12}$

Ans. **(2)**

Sol. $PM = \frac{1}{\sqrt{2}}$



In Δ APM -

$$\cos\theta = \frac{1}{\sqrt{2}}\cdot\sqrt{\frac{3}{2}} = \frac{\sqrt{3}}{2}$$

$$\theta = \frac{\pi}{6}$$

$$\therefore \angle APB = \frac{\pi}{3}$$

22. Let $f(x) = |\log_e x| - |x-1| + 5$

Statement 1 : f(x) is differentiable for all $x \in (0, \infty)$

Statement 2 : f(x) is increasing in $(1, \infty)$

Statement 3 : f(x) is decreasing in (0, 1)

Which of the following is correct ?

(1) All the statements are correct

(2) Statement -1 & Statement -3 are correct

(3) Statement -1 & Statement -2 are correct

(4) Statement -2 & Statement -3 are correct

Ans. **(2)**

Sol. $R f'(1) = \lim_{h\to 0^+}\frac{f(1+h)-f(1)}{h} = \lim_{h\to 0^+}\frac{|\log_e(1+h)|-|h|+5-5}{h}$

$$R f'(1) = \lim_{h\to 0^+}\frac{\log_e(1+h)-h}{h} = 0$$

$$L f'(1) = \lim_{h\to 0^+}\frac{f(1-h)-f(1)}{-h} = \lim_{h\to 0^+}\frac{|\log_e(1-h)|-|-h|+5-5}{-h}$$

$$L f'(1) = \lim_{h\to 0^+}\frac{|\log_e(1-h)|-h}{-h} = \lim_{h\to 0^+}\frac{-\log_e(1-h)-h}{-h} = 0$$

f(x) is differentiable at x = 1

$$f(x) = f(x) = \begin{cases} \log_e x - (x-1)+5 & x \ge 1 \\ -\log_e x + (x-1) + 5 & x \in (0,1] \end{cases}$$

$$f'(x) = \begin{cases} \frac{1}{x}-1 & x \ge 1 \\ -\frac{1}{x}+1 & x \in (0,1] \end{cases}$$

$$f'(x) = \begin{cases} \frac{1-x}{x} & x \ge 1 \\ \frac{x-1}{x} & x \in (0,1] \end{cases}$$

$f'(x) \le 0 \ \forall \ x \in (1,\infty) \Rightarrow f(x) \downarrow$ in $x \in (1, \infty)$

$f'(x) < 0 \ \forall \ x \in (0,1) \Rightarrow f(x) \downarrow$ in $x \in (0, 1)$

23. If shortest distance between the lines

$$\frac{x+1}{\alpha}=\frac{y-2}{-2}=\frac{z-4}{-2\alpha}$$

and $\frac{x}{\alpha}=\frac{y-1}{1}=\frac{z-1}{\alpha}$ is $\sqrt{2}$

then find sum of all possible values of α

(1) – 6 (2) 2

(3) – 8 (4) 4

Ans. (1)

Sol. $$\sqrt{2}=\frac{\begin{vmatrix}-1 & 1 & 3\\ \alpha & -2 & -2\alpha\\ \alpha & 1 & \alpha\end{vmatrix}}{\left|\begin{vmatrix}\hat{i} & \hat{j} & k\\ \alpha & -2 & -2\alpha\\ \alpha & 1 & \alpha\end{vmatrix}\right|}$$

$$=\frac{-1(0)-1(3\alpha^2)+3(3\alpha)}{\left|\hat{i}(0)-\hat{j}(3\alpha^2)+x(3\alpha)\right|}$$

$$\sqrt{2}=\frac{-3\alpha^2+9\alpha}{\sqrt{9\alpha^4+9\alpha^2}}$$

$2\,(9\alpha^4+9\alpha^2)=9\alpha^2\,(-\alpha+3)^2$

$2\,(\alpha^2+1)=\alpha^2-6\alpha+9$

$\alpha^2+6\alpha-7=0$

$(\alpha+7)\,(\alpha-1)=0 \quad\Rightarrow\quad \alpha=-7, 1$

$\therefore$ Req. sum = – 6

24. Let a function f(x) satisfies $3f(x)+2f\left(\frac{m}{19x}\right)=5x$

Where $m=\sum_{i=1}^{9} i^2$. Find f(5) + f(2).

(1) – 1 (2) 0

(3) – 5 (4) 6

Ans. (2)

Sol. $m=\frac{9\times10\times19}{6}=15\times19$

$3f(x)+2f\left(\frac{15}{x}\right)=5x$

Replace x by $\frac{15}{x}$

$3f\left(\frac{15}{x}\right)+2f(x)=\frac{75}{x}$

$9f(x)-4f(x)=15x-\frac{150}{x}$

$5f(x)=15x-\frac{150}{x}$

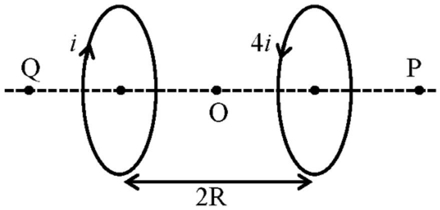
$f(x)=3x-\frac{30}{x}$

$f(5)=15-\frac{30}{5}=9$

$f(2)=6-15=-9$

$f(5)+f(2)=0$

1. Find magnetic field at midpoint O. Rings have radius R and direction of current in opposite sense.



(1) $\frac{3\mu_0 i}{4\sqrt{2}R}$ Towards P

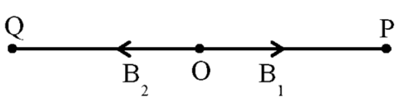
(2) $\frac{3\mu_0 i}{4\sqrt{2}R}$ Towards Q

(3) $\frac{3\mu_0 i}{2\sqrt{2}R}$ Towards P

(4) $\frac{3\mu_0 i}{2\sqrt{2}R}$ Towards Q

Ans. **(1)**

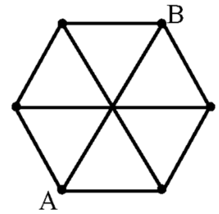
Sol. $B_{net} = B_1 - B_2$



$$= \frac{4\mu_0 i R^2}{2(R^2+R^2)^{3/2}} - \frac{\mu_0 i R^2}{2(R^2+R^2)^{3/2}}$$

$$= \frac{3\mu_0 i}{4\sqrt{2}R}$$

2. Resistance of each side is R. Find equivalent resistance between two opposite points as shown in figure.

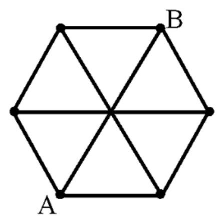


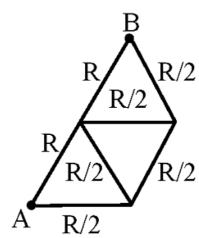
(1) $\frac{4}{5}R$ (2) $\frac{8}{5}R$

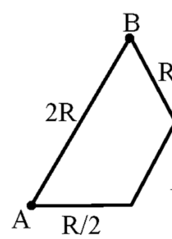
(3) $\frac{8}{10}R$ (4) $\frac{2}{5}R$

Ans. **(1)**

Sol.







$$\frac{R\times\frac{R}{2}}{\frac{3R}{2}} = \frac{R}{3}$$

$$R_{eq} = \frac{2R\times\frac{4R}{3}}{2R+\frac{4R}{3}} = \frac{8R^2}{10R} = \frac{4}{5}R$$

3. In case of meter bridge experiment balance length for 2Ω and 3Ω is ℓ and for xΩ and 3Ω is (ℓ + 10)cm. Find x.

Ans. (3)

Sol. $\frac{2}{3}=\frac{\ell}{100-\ell}$

$\ell = 40$ cm

$\frac{x}{3}=\frac{\ell+10}{90-\ell}=\frac{50}{50}$

x = 3Ω

4. 5^{th} Harmonic of closed organ pipe frequency matches with 1^{st} Harmonic of open organ pipe. Find ratio of their lengths.

(1) 5 (2) 2 (3) 5/2 (4) 2/5

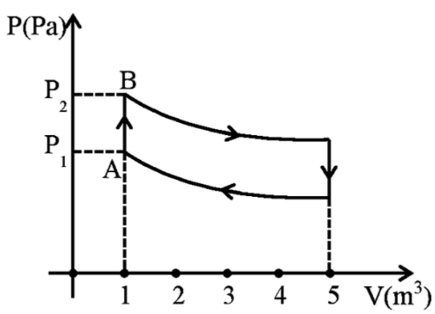
Ans. (3)

Sol. $f_{5\,closed}=f_{1\,open}$

$\frac{5v}{4L_{closed}}=\frac{v}{2L_{open}}$

$\frac{L_{closed}}{L_{open}}=\frac{5}{2}$

5. Find heat given to gas to take it from A to B. (Given : C_V = 21 S.I.units, P_2 = 30 Pa, P_1 = 21.7 Pa, R = 8.3 S.I.units, n = 10 moles)



(1) 30 J (2) 21 J (3) 42 J (4) 50 J

Ans. (2)

Sol. $Q = \Delta U + W = \Delta U = nC_V\Delta T$

$=\frac{f}{2}(P_2-P_1)V \quad ...(1)$

Here $C_V = 21 = \frac{f}{2}R$

$f=\frac{42}{R}$

So, from eq(1)

$Q=\frac{42}{R\times 2}(8.3)\times 1=21\text{ J}$

6. A cylindrical object of density 600 kg/m^3 and height 8 cm is floating in a liquid of density 900 kg/m^3. Find height of cylinder inside liquid.

(1) $\frac{16}{3}$cm

(2) $\frac{20}{3}$cm

(3) $\frac{5}{3}$cm

(4) $\frac{25}{3}$cm

Ans. (1)

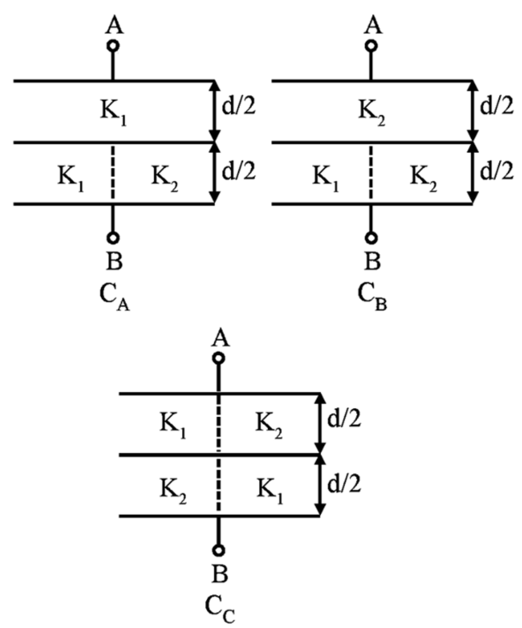
Sol. $Mg = F_b$

dAHg = ρAhg

600 × 8 cm = 900 × h

$h=\frac{16}{3}$ cm

7. Diagram shows three arrangement of di-electric in the capacitor.



Arrange the capacitors in increasing order of capacitance between A & B if $K_1 > K_2$:

(1) $C_A < C_B < C_C$

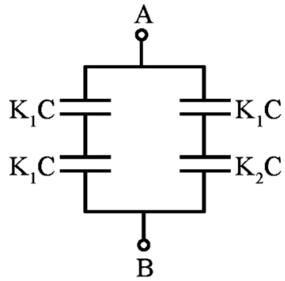
(2) $C_A < C_C < C_B$

(3) $C_B < C_C < C_A$

(4) $C_B < C_A < C_C$

Ans. (3)

Sol. For C_A :

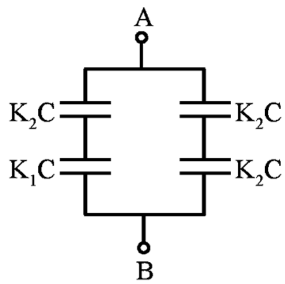


Let $\frac{\varepsilon_0 A}{d} = C$

$$\therefore\ C_A = \frac{K_1C}{2} + \frac{K_1K_2C}{K_1+K_2}$$

$$= K_1C\left[\frac{K_1+2K_2}{2(K_1+K_2)}\right]$$

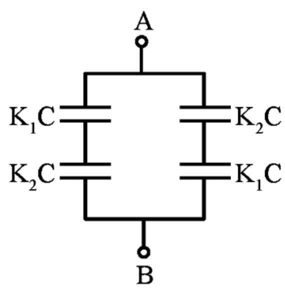
For C_B :



$$C_B = \frac{K_2C}{2} + \frac{K_1K_2C}{K_1+K_2}$$

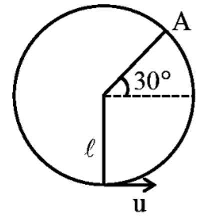
$$= K_2C\left[\frac{K_1+2K_2}{2(K_1+K_2)}\right]$$

For C_C :



$$C_C = \frac{2K_1K_2C}{(K_1+K_2)}$$

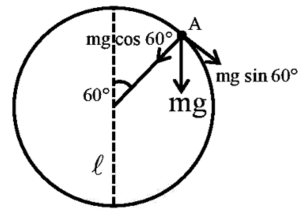
8. Find speed given to particle at lowest point so that tension in string at A point becomes zero :



(1) $\sqrt{\frac{7g\ell}{2}}$ (2) $\sqrt{3g\ell}$ (3) $\sqrt{\frac{9}{4}g\ell}$ (4) $\sqrt{\frac{g\ell}{2}}$

Ans. (1)

Sol.



$$T + mg\cos 60° = \frac{mV^2}{\ell}$$

$T = 0$

$V^2 = \frac{g\ell}{2}$ here V is the speed at point A

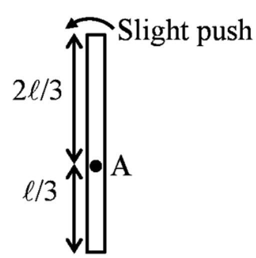
M.E.C.

$$\frac{1}{2}mu^2 = mg(\ell + \ell\cos 60°) + \frac{1}{2}mV^2$$

$$u^2 = 3g\ell + \frac{g\ell}{2}$$

$$u = \sqrt{\frac{7g\ell}{2}}$$

9. When rod becomes horizontal find it's angular velocity. It is pivoted at point A as shown :



(1) $\sqrt{\frac{3g}{\ell}}$ (2) $\sqrt{\frac{2g}{\ell}}$

(3) $\sqrt{\frac{g}{\ell}}$ (4) $\sqrt{\frac{5g}{\ell}}$

Ans. (1)

Sol. $mg\frac{\ell}{6}=\frac{1}{2}I\omega^2$

Here $I=\frac{m\ell^2}{12}+\frac{m\ell^2}{36}=\frac{m\ell^2}{9}$

$mg\frac{\ell}{6}=\frac{m\ell^2}{18}\omega^2 \Rightarrow \omega^2=\frac{3g}{\ell}$

$\omega=\sqrt{\frac{3g}{\ell}}$

10. A soap bubble of diameter 7 cm its diameter is increased to 14 cm. If change in its surface energy (15000 – x)μJ. Find x

(Given surface tension is 0.04 N/m)

(1) 208 (2) 216 (3) 432 (4) 512

Ans. **(2)**

Sol. ΔE = (change in surface area) . (surface tension)

$\Delta E = 2[(4\pi)(r_2^2 - r_1^2)](T)$

$\Delta E = 8\pi(r_2^2 - r_1^2)\,T$

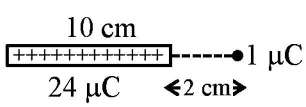
$= 8\times\frac{22}{7}\left(\frac{14^2-7^2}{10^4}\right)\times 0.04$

$= 14784\ \mu J$

$15000 - x = 14784\ \mu J$

$x = 216\ \mu J$

11. Rod has uniformly distributed charge 24 μC and length 10 cm. Find force on 1 μC particle ?



(1) 70 N

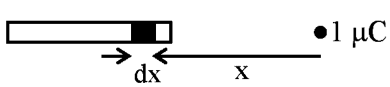
(2) 10.5 N

(3) 90 N

(4) 25 N

Ans. **(3)**

Sol.

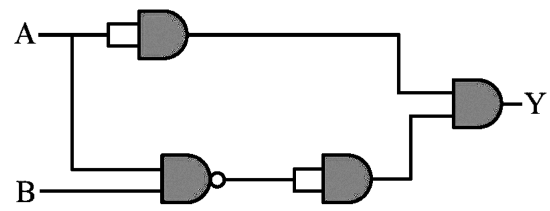


$F=\int dF=\int_{2cm}^{12cm}\frac{kq\lambda dx}{x^2}=kq\lambda\left(\frac{1}{2\times10^{-2}}-\frac{1}{12\times10^{-2}}\right)$

$F=(9\times10^9)(10^{-6})\left(\frac{24\times10^{-6}}{10^{-1}}\right)\left(\frac{5}{12}\right)\times10^2$

$= 9\times24\times\frac{5}{12}=90N$

12. Select correct truth table ?



(1)

A	B	Y
0	0	0
0	1	0
1	0	1
1	1	1

(2)

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

(3)

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

(4)

A	B	Y
0	0	0
0	1	0
1	0	1
1	1	0

Ans. **(4)**

Sol. $Y=(\overline{A.B}).A=(\bar{A}+\bar{B}).A=0+A\bar{B}$

A	B	Y
0	0	0
0	1	0
1	0	1
1	1	0

13. On a surface, if photon of λ wavelength is incident. The stopping potential is 3.2 V. If the wavelength incident is 2λ, stopping potential is 0.7V. Find λ.

(1) 4.96×10^{-7} m (2) 3.62×10^{-7} m

(3) 7.24×10^{-7} m (4) 2.48×10^{-7} m

Ans. (4)

Sol. $q.(3.2) = \frac{hc}{\lambda} - \phi$ ...(1)

$q(0.7) = \frac{hc}{2\lambda} - \phi$ ...(2)

Eq. (1) – Eq. (2)

$q.(2.5) = \frac{hc}{2\lambda}$

$2.5 = \left(\frac{hc}{e}\right)\left(\frac{1}{2\lambda}\right)$

$2.5 = \frac{12400}{2(\lambda)}$

$\lambda = \frac{12400}{5}$ Å

$\lambda = 2480$ Å

$\lambda = 2.48 \times 10^{-7}$ m

14. 300 Joule of energy is given to a gas at constant volume which increases it's temperature from 20°C to 50°C. If $R = 8.3$ SI units & $C_P = \frac{7R}{2}$ then find mass of gas :

Ans. ( )

Sol. ⇒ For Isochoric process

$Q = n\, C_V\, \Delta T$

$300 = n.\frac{5R}{2}.(50 - 20)$

$n = \left(\frac{4}{R}\right)$mole

mass of gas = $\left(\frac{4}{R}\right)$ (molecular weight)

NOTE : molecular weight of gas is unknown in question.

15. An electron makes transition from higher energy orbit n_2 to lower energy orbit n_1 in Li^{+2} ion such that $n_1 + n_2 = 4$ & $n_2 - n_1 = 2$. Determine the wavelength of emitted photon in transition (in cm) :

(1) 1.14×10^{-6} cm (2) 3.28×10^{-6} cm

(3) 5.76×10^{-6} cm (4) 8.23×10^{-6} cm

Ans. (1)

Sol. $n_1 + n_2 = 4$

$n_2 - n_1 = 2$

$n_2 = 3;\ \ n_1 = 1$

$E_3 - E_1 = +13.6 \times 9\left(\frac{1}{1} - \frac{1}{9}\right)$eV

$= 108.8$ eV

$\lambda = \frac{12400}{108.8}$ Å ≈ 114Å $= 1.14 \times 10^{-6}$ cm

16. In a vernier callipers 50 VSD are equal to 48 MSD. 1 MSD is equal to 0.05 mm. Find least count of this vernier callipers :

(1) 0.005 mm (2) 0.004 mm

(3) 0.001 mm (4) 0.002 mm

Ans. (4)

Sol. LC = 1 MSD – 1 MSD = 1 MSD – $\frac{48}{50}$MSD

$= \frac{2}{50}\text{MSD} = \frac{2}{50} \times .05\text{mm} = 0.002\text{mm}$

17. Power of convex lens is 5D. Four students measure object and image distances as shown :

	u(in cm)	v(in cm)
A	35	37
B	30	60
C	60	30
D	25	100

(1) Students A & B are correct

(2) All are correct

(3) Student A is wrong

(4) Students C & D are wrong

Ans. (3)

Sol. $f = \frac{100}{5} = 20\text{cm}$

For student A

$\frac{1}{f} = \frac{1}{37} + \frac{1}{35} \quad \Rightarrow f \approx 18 \text{ cm}$

For student B

$\frac{1}{f} = \frac{1}{60} + \frac{1}{30} \quad \Rightarrow f = 20 \text{ cm}$

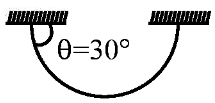
For student C

$\frac{1}{f} = \frac{1}{30} + \frac{1}{60} \quad \Rightarrow f = 20 \text{ cm}$

For student D

$\frac{1}{f} = \frac{1}{25} + \frac{1}{100} \quad \Rightarrow f = 20 \text{ cm}$

18. A flexible chain of mass m is hanging as shown. Find tension at the lowest point :

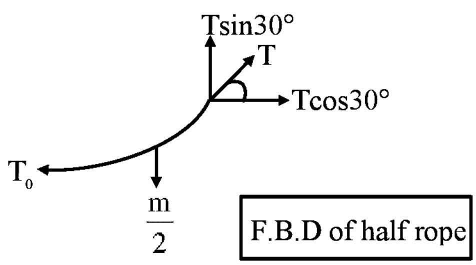


(1) $\frac{\sqrt{3}}{2}mg$ (2) $\frac{1}{2}mg$

(3) $\frac{\sqrt{2}}{3}mg$ (4) $\sqrt{2}mg$

Ans. **(1)**

Sol.



$T\sin30° = \frac{m}{2}g$

$T\cos30° = T_0$

$\tan30° = \frac{mg}{2T_0}$

$T_0 = \frac{\sqrt{3}}{2}mg$

19. In YDSE, slits separation d is 2mm, distance between slits and screen D is 10 m. Wave length of light is λ = 6000Å. If intensity of light through each slit is I_0 then find intensity at point directly in front of one of the slits

(1) $4I_0$ (2) Zero

(3) I_0 (4) $2I_0$

Ans. **(3)**

Sol. Path difference $\Delta x = d\sin\theta = d \times \frac{y}{D} = d \times \frac{d}{D}$

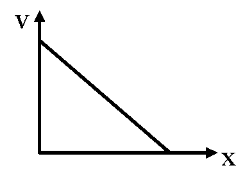
$$\Delta x = \frac{d^2}{D}$$

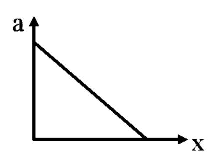
$$\Delta\phi = \frac{2\pi}{\lambda} \times \Delta x = \frac{2\pi d^2}{\lambda D}$$

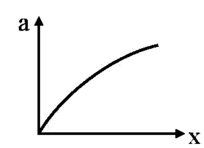
$$\Delta\phi = \frac{2\pi \times 4 \times 10^{-6}}{6 \times 10^{-7} \times 10} = \frac{4\pi}{3}$$

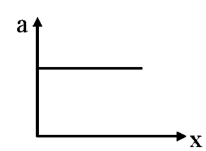
$$I = I_0 + I_0 + 2I_0 \cos\left(\frac{4\pi}{3}\right) = I_0$$

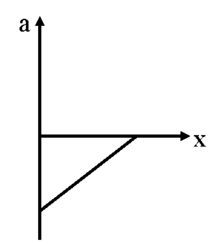
20. Velocity of particle varies with position as shown in figure. Find the correct variation of acceleration with position :



(1)


(2)


(3)


(4)


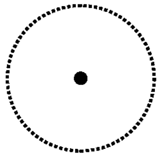
Ans. **(4)**

Sol. $v = -mx + c$

$$a = v\frac{dv}{dx} = (-mx + c)(-m)$$

$$a = m^2x - mc$$

21. The intensity at spherical surface due to a isotropic point source placed at its center is I_0. If it's volume is increased by 8 times, what will be intensity at the spherical surface :



(1) Increase by 128 times

(2) Increase by 8 times

(3) Decrease by 4 times

(4) Decrease by 8 times

Ans. **(3)**

Sol. $V \rightarrow 8V \Rightarrow R\ R \rightarrow 2R \Rightarrow A \rightarrow 4A \Rightarrow I \rightarrow \frac{I_0}{4}$

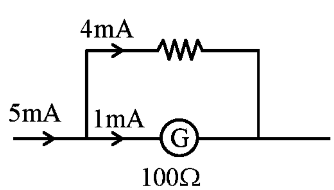
22. There is a galvanometer of resistance 100Ω and full scale current Ig = 1mA. Find shunt resistance required to increase it's range to 5mA:

(1) 25Ω (2) 0.25Ω

(3) 0.5Ω (4) 1Ω

Ans. **(1)**

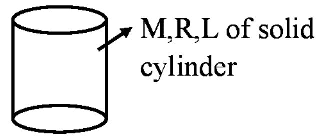
Sol.



$4 \times r_s = 1 \times G$

$r_s = \frac{G}{4} = \frac{100}{4} = 25\ \Omega$

23. A solid cylinder of radius $\frac{R}{3}$ and length $\frac{L}{2}$ is removed along the central axis. Find ratio of Initial moment of inertia and moment of inertia of removed cylinder :

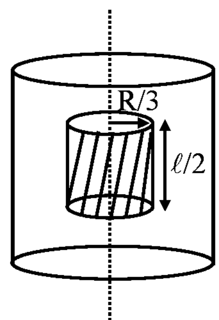


(1) 162 (2) 158

(3) 138 (4) 178

Ans. **(1)**

Sol.



Original mass (M)

The removed mass (m)

$m = \rho \times \pi \left(\frac{R}{3}\right)^2 \times \frac{L}{2}$

$= \frac{\rho.\pi R^2 L}{18} = \frac{M}{18}$

$I' = \frac{1}{2}.\frac{M}{18}.\frac{R^2}{9} = \frac{1}{324}MR^2$

$\frac{I}{I'} = \frac{\frac{1}{2}MR^2}{\frac{1}{324}MR^2} = 162$

24. For given nuclear reactions

${}_2He^3 + {}_0n^1 \rightarrow {}_2He^4 + 20\ MeV$

${}_2He^4 + {}_0n^1 \rightarrow {}_2He^5 - 0.9\ MeV$

X_3 represents stability of ${}_2He^3$, X_4 represents stability of ${}_2He^4$ and X_5 represents stability of ${}_2He^5$. compare the stabilities.

(1) $X_4 > X_5 > X_3$ (2) $X_4 < X_3 > X_5$

(3) $X_3 > X_4 > X_5$ (4) $X_4 > X_3 > X_5$

Ans. **(1)**

Sol. $BE_{He^4} - BE_{He^3} = 20MeV$ ...(1)

$BE_{He^5} - BE_{He^4} = -0.9MeV$ ...(2)

From eq (1) & (2)

$BE_{He^4} > BE_{He^5} > BE_{He^3}$

1. A complex $Cr(H_2O)_6.Cl_3$ show conductance similar to 1 : 2 electrolyte in aq. Solution. 9.3 g of this complex is passed through a cation exchanger then excess $AgNO_3$ is added. Find mass of AgCl precipitated in gram ?

[Molar mass of Cr = 52 g/mol.]

Ans. **(10)**

Sol. $[Cr(H_2O)_5Cl]Cl_2.H_2O + AgNO_3 \rightarrow 2AgCl$

9.3/266.5 –

= 0.0349 moles 0.0698 mole

Mass of AgCl = 0.0698 × 143.5 = 10.015 gm

2. 0.18 M HQ solution has molar conductivity $\frac{1}{30}$ times the molar conductivity of 0.02 M HZ solution. Find the value of $pK_a(HQ) - pK_a(HZ)$.

[Given that α is very less than 1]

Assume that $\lambda_m^\infty(Q^-) = \lambda_m^\infty(Z^-)$

Ans. **(2)**

Sol. $K_a(HQ) = C_1\alpha_1^2$ $\qquad \alpha_1 = \frac{\lambda_m(HQ)}{\lambda_m^\infty(HQ)}$

$K_a(HZ) = C_2\alpha_2^2$ $\qquad \alpha_2 = \frac{\lambda_m(HZ)}{\lambda_m^\infty(HZ)}$

$$\frac{K_a(HQ)}{K_a(HZ)} = \frac{C_1}{C_2}.\left(\frac{\alpha_1}{\alpha_2}\right)^2 = \frac{0.18}{0.02}.\left[\frac{\lambda_m(HQ)}{\lambda_m(HZ)}\right]^2$$

$$\frac{K_a(HQ)}{K_a(HQ)} = 9\times\left(\frac{1}{30}\right)^2 = \frac{1}{100}$$

$pK_a(HQ) - pK_a(HZ) = 2$

3. For the reaction :

$Cl_2 + KOH \rightarrow KCl + KClO + H_2O$

1 mole of Cl_2 passed into 2 litre, 2M solution of KOH. Determine the molarity of Cl^-, ClO^- and OH^- respectively.

(1) 1 M, 0.5 M, 0.5 M (2) 0.5 M, 0.5 M, 1 M

(3) 1 M, 1 M, 0.5 M (4) 0.5 M, 1 M, 0.5 M

Ans. **(2)**

Sol. $Cl_2 + 2KOH \rightarrow KCl + KClO + H_2O$

t = 0 1 mole 4 mole

t_f 0 2 mole 1 mole 1 mole

$[OH^-] = 1$ M

$[Cl^-] = \frac{1}{2}$M

$[ClO^-] = \frac{1}{2}$M

4. The half-life of radio-active isotope Zn^{65} is 245 days. Find the time after which activity of Zn sample remains 75% of its initial value ?

Ans. **(102)**

Sol. $t_{1/2} = \frac{\ell n2}{K}$

$K = \frac{\ell n 2}{245}$

$t = \frac{1}{K}\ell n\frac{a_0}{a_t}$

$t_{25\%} = \frac{1}{K}\ell n\frac{4}{3}$

$t_{25\%} = \frac{1}{\frac{\ell n2}{245}}\ell n\frac{4}{3}$

$t_{25\%} = 245\frac{\ell n\frac{4}{3}}{\ell n2} = 245\left[\frac{2\log 2 - \log 3}{\log 2}\right]$

$= 245\left[\frac{2\times 0.3010 - 0.4771}{0.3010}\right] = 101.66$ day.

5. If pure liquids A and B have a vapour pressure of 55 kPa and 15 kPa respectively. If in a solution of A and B, mole fraction of A in vapour is 0.8, then find mole fraction of A in liquid phase ?

(1) 0.813 (2) 0.5217

(3) 0.407 (4) 0.363

Ans. **(2)**

Sol. $\frac{Y_A}{Y_B} = \frac{P_A^o}{P_B^0} \cdot \frac{X_A}{X_B}$

$\frac{0.8}{0.2} = \frac{55}{15} \times \frac{X_A}{X_B}$

$\frac{X_A}{X_B} = \frac{60}{55} = \frac{12}{11}$

$X_A = \frac{12}{23} = 0.5217$

6. Two moles each of the gases P_2, Q_2 and PQ are present in a vessel at equilibrium. If 1 mole each of P_2 and Q_2 is added at equilibrium, then determine the composition (in mole) of each species at the new equilibrium ?

(1) $n_{P_2} = 0.5,\ n_{Q_2} = 0.5,\ n_{PQ} = 1$

(2) $n_{P_2} = 1.33,\ n_{Q_2} = 1.33,\ n_{PQ} = 1.67$

(3) $n_{P_2} = 2.67,\ n_{Q_2} = 2.67,\ n_{PQ} = 2.33$

(4) $n_{P_2} = 2.67,\ n_{Q_2} = 2.67,\ n_{PQ} = 2.67$

Ans. **(4)**

Sol. $P_2(g) + Q_2(g) \rightleftharpoons 2PQ(g)$

$t = t_{eq}$ 2 mole 2 mole 2 mole

$K_{eq} = \frac{2^2}{2.2} = 1$

Now 1 mole of each P_2 and Q_2 is added

So reaction will move in forward direction

$P_2(g) + Q_2(g) \rightleftharpoons 2PQ(g)$

$t = t'_{eq.}$ $3 - x$ $3 - x$ $2 + 2x$

$K_c = 1 = \frac{(2+2x)^2}{(3-x)(3-x)}$

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

$2 + 2x = 3 - x$

$x = \frac{1}{3}$

At new equilibrium :

Moles of $P_2 = \frac{8}{3} = 2.67$

Moles of $Q_2 = \frac{8}{3} = 2.67$

Moles of PQ $= \frac{8}{3} = 2.67$

7. Heat of atomisation of $CH_4(g)$ and $C_2H_6(g)$ are x kJ/mole and y kJ/mole. Find the maximum wavelength of photon required to dissociate (C–C) bond in C_2H_6 :

(1) $\frac{hcN_A}{\left[y - \frac{3x}{2}\right]}$ (2) $\frac{hcN_A}{\left[\frac{4x-6y}{4}\right]}$

(3) $\frac{hcN_A}{250\left[\frac{3x}{2} - y\right]}$ (4) $\frac{hcN_A}{500[2y-3x]}$

Ans. **(4)**

Sol. $CH_4(g) \rightarrow C(g) + 4H(g)$; $\Delta_r H = x$ kJ/mole

$C_2H_6(g) \rightarrow 2C(g) + 6H(g)$; $\Delta_r H = y$ kJ/mole

$1000x = 4 \times \varepsilon_{C-H}$

$1000y = 1 \times \varepsilon_{C-C} + 6 \times \varepsilon_{C-H}$

$\varepsilon_{C-C} = \left[y - \frac{3x}{2}\right] \times 1000 = \frac{hc}{\lambda}.N_A$

$('\lambda')$ wavelength of photon ³ $\frac{hc\ N_A}{\left[y - \frac{3x}{2}\right] \times 1000}$

8. If for Li^{2+} ion, electron is in transition between energy levels such that sum of principal quantum numbers is 4 and difference is 2 then find the wavelength (in cm) emitted for transition between these energy levels.

[Given : $R_H = 1.1 \times 10^5\ cm^{-1}$]

(1) 114×10^{-8} cm (2) 1026×10^{-8} cm

(3) 12.66×10^{-8} cm (4) 10^{-8} cm

Ans. **(1)**

Sol. $n_1 \rightarrow$ lower energy level

$n_2 \rightarrow$ higher energy level

$n_1 + n_2 = 4,\ \ n_2 = 3$

$n_2 - n_1 = 2,\ \ n_1 = 1$

Rydberg's formula :

$\frac{1}{\lambda} = R_H Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$\frac{1}{\lambda} = R_H (3)^2 \left[\frac{1}{1^2} - \frac{1}{3^2}\right]$

$\frac{1}{\lambda} = 8R_H$

$$\lambda = \frac{1}{8R_H}$$

$$\lambda = \frac{1}{8 \times 1.1 \times 10^5}$$

$$\lambda = \frac{1000}{8.8} \times 10^{-8} \text{ cm}$$

$\lambda = 113.63 \times 10^{-8}$ cm

$\lambda \simeq 114 \times 10^{-8}$ cm

9. If percentage of N_2 above a liquid solution is 80% at a total pressure of 10 atm then find the mole fraction of N_2 gas dissolved in solution.
[Given that Henry's constant for N_2 is 7.6×10^7 mm Hg].

(1) 10^{-4} (2) 8×10^{-5}
(3) 10^{-7} (4) 10^{-6}

Ans. (2)

Sol. $P_{N_2} = K_H.X_{N_2}$

$P_{N_2} = 0.8 \times 10 = 8$ atm

$8 \times 760 = 7.6 \times 10^7 \times X_{N_2}$

$$X_{N_2} = \frac{8 \times 760}{7.6 \times 10^7}$$

$X_{N_2} = 8 \times 10^{-5}$.

10. An organic compound contains 'C', 'H' and 'O'. 0.25 gm of organic compound. On combustion produces $CO_2(g)$ and $H_2O(\ell)$. When residual gases passes through potash solution, it's mass increases by 0.18 g and when passed through anhydrous $CaCl_2$, the increase in mass of $CaCl_2$ is 0.15 g. Find mass % of oxygen in the organic compound.

Ans. (73)

Sol.

	$C_xH_yO_z + O_2 \rightarrow$	CO_2	+ H_2O
t = 0	0.25 gm		
t_{eq}	–	0.18 gm	0.15 gm

Mass of 'C' = $\frac{0.18}{44} \times 12 = 0.049 \simeq 0.05$ gm

Mass of 'H' = $\frac{0.15}{18} \times 2 = 0.016 \simeq 0.017$ gm.

Mass of 'O' = 0.25 – 0.05 – 0.017 = 0.1833 gm

Mass % of 'O' = $\frac{0.1833}{0.25} \times 100 = 73.32\%$.

11. Correct order of 2[nd] ionisation energy is :

(1) O < C < N < F (2) C < N < O < F
(3) C < N < F < O (4) C < O < N < F

Ans. (3)

Sol. $O \rightarrow O^+ (2p^3)$

$N \rightarrow N^+ (2p^2)$

$C \rightarrow C^+ (2p^1)$

$F \rightarrow F^- (2p^4)$

Left to right IE increases but IE of $2p^3 > 2p^4$

12. Among the following species O_2^+, N_2^-, N_2^{2-} and O_2^- which have same bond order as well as paramagnetic in nature.

(1) N_2^-, N_2^{2-} (2) O_2^+, N_2^-
(3) O_2^+, O_2^- (4) O_2^-, N_2^-

Ans. (2)

Sol.

Species	B.O.	n_e
O_2^+	2.5	1
N_2^-	2.5	1
N_2^{2-}	2	2
O_2^-	1.5	1

13. Consider the following complexes :

(A) $[Co(CN)_6]^{3-}$ (B) $[Co(NH_3)_5H_2O]^{3+}$
(C) $[Co(H_2O)_6]^{3+}$ (D) $[CoF_6]^{3-}$

The wavelength absorbed by the above complexes are in the order of :

(1) A > B > C > D (2) A < B < C < D
(3) B < A < C < D (4) C > A > B > D

Ans. (2)

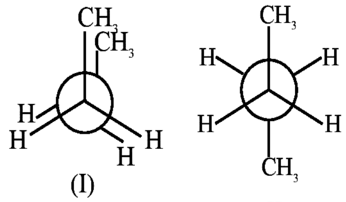
Sol. Ligand strength : $CN^- > NH_3 > H_2O > F^-$

14. Element 'X' is the lightest element of group 7 of periodic table which forms oxo-anion in +6 oxidation state. The colour of potassium salt of the oxo-anion is :

(1) Green (2) Orange
(3) Yellow (4) Brown

Ans. (1)

Sol. K_2MnO_4 (Green in colour)

18. 

(I) (II)

Statement-I : II[nd] is more stable than I[st]

Statement-II : As dihedral angle increases stability decreases.

(1) Statement-1 is incorrect but Statement-2 is correct

(2) Statement-1 is correct but Statement-2 is incorrect

(3) Both statements are correct.

(4) Both statements are incorrect.

Ans. (2)

Sol. II[nd] compound is more stable because it has less steric and Torsional strain and statement II is incorrect.

19. **Statement-I :** RMgX react with CO_2 followed by acidification form product, which reacts with NH_3/Δ then reacts with NaOCl form product which further reacts with $CHCl_3$/NaOH and final product is $R-N\overset{\rightarrow}{=}C$.

Statement-II : $R-N\overset{\rightarrow}{=}C$ on hydrolysis gives RCOOH.

Which amongs the following statement is correct.

(1) Statement-I and Statement-II both are correct

(2) Statement-I is incorrect Statement-II is correct

(3) Statement-I is correct Statement-II is incorrect

(4) Statement-I and Statement-II both incorrect

Ans. (3)

Sol. **Statement-I**

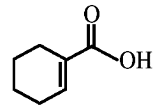
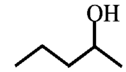
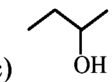
$$RMgX \xrightarrow[\substack{(ii)H^{\oplus} \\ (iii)NH_3/\Delta}]{(i)CO_2} R-CONH_2 \xrightarrow{NaOCl} R-NH_2$$

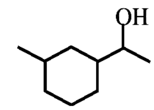
$$\xrightarrow[NaOH]{CHCl_3} R-N\overset{\rightarrow}{=}C \text{ (Alkyl isocyanide)}$$

Statement-II

$$R-N\overset{\rightarrow}{=}C \xrightarrow{H_3O^{\oplus}} R\text{–}NH_2 + HCOOH$$

20. How many molecules are secondary alcohol?

(a)  (b)  (c) 

(d)  (e) 

(1) 2 (2) 3

(3) 4 (4) 5

Ans. (2)

Sol. –OH group attached to secondary carbon is secondary alcohol

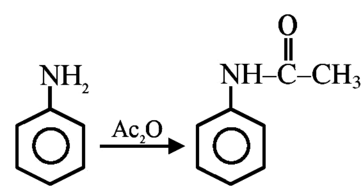
So compound b, c, e are secondary alcohol

21. Aniline (9.3 gm) on reaction with acetic anhydride forms 'X' (11 gm), find the percentage yield of the reaction :

(1) 80 (2) 90

(3) 81.48 (4) 93.2

Ans. (3)

Sol. 

9.3 gm 11 gm

$n = \frac{9.3}{93} = 0.1 \qquad n = \frac{11}{135} = 0.08148$

$\% \text{ yield} = \frac{0.08148}{0.1} \times 100 = 81.48\%$

22. How many tri peptides are possible when following three amino acid make tri peptide.

(No amino acid should repeat twice)

(A) Glycine (B) Alanine (C) Valine

(1) 4 (2) 6

(3) 8 (4) 9

Ans. (2)

Sol. Gly ala val

Gly val ala

Val gly ala

Val ala gly

Ala val gly

Ala gly val

Total tri peptides = 6

15. In general tests of Ba^{2+} and Ca^{2+} give the respective test as :

(1) Chromate , Sulphate

(2) Sulphite , Sulphate

(3) Hydroxide, Carbonate

(4) Carbonate, Carbonate

Ans. **(4)**

Sol. Group reagent is $(NH_4)_2CO_3$ in presence of NH_4OH and NH_4Cl. Precipitate formed is $BaCO_3$ (white) and $CaCO_3$ (white).

16. Select incorrect option :

(1) Carbon can have negative oxidation state in its compounds.

(2) CO_2 is most acidic oxide among oxides of group-14 elements.

(3) Maximum covalency of carbon is four.

(4) Carbon has least catenation property in group 14.

Ans. **(4)**

Sol. Carbon has highest catenation property in group 14.

17. **Statement-I :** Two different aldehyde on cross aldol condensation always give four product :

Statement-II : Among benzaldehyde and acetophenone only acetophenone reacts with semicarbazide.

(1) Statement-I and Statement-II both are correct

(2) Statement-I is incorrect Statement-II is correct

(3) Statement-I is correct Statement-II is incorrect

(4) Statement-I and Statement-II both incorrect

Ans. **(3)**

Sol. **Statement-I**

If both aldehydes have αH, then only on cross aldol condensation give four products if only one have αH then three products will form.

Statement-II

Benzaldehyde and Acetophenone both react with semicarbazide and form semicarbazone