TEST CODE : 113107

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IIT-JEE

Batch - Growth (June) | Major Test - 4 (Paper-I)

Time: 3 Hours Test **Date: 2nd March 2025** **Maximum Marks: 180**

Name of the Candidate: _____Roll No._____

Centre of Examination (in Capitals):_____

Candidate's Signature: _____Invigilator's Signature:_____

Do not open this Test Booklet until you are asked to do so.

1. The candidates should not write their Roll Number anywhere else (except in the specified space) on the Test Booklet/Answer Sheet.
2. This Test Booklet consists of 54 questions.
3. This question paper is divided into three parts **PART A - MATHEMATICS, PART B - PHYSICS** and **PART C - CHEMISTRY** having 18 questions each and every **PART** has four sections.
   (i) **Section-I** contains **6** single choice questions with only one correct option.
   Marking scheme: +3 for correct answer, 0 if not attempted and –1 in all other cases.
   (ii) **Section-II** contains **6** Question Multiple Choice Option with more than one correct answer.
   Marking scheme: (+4 for correct answer, 0 if not attempted and +1 partial marking –2 in all other cases.)
   (iii) **Section-III** contains **6** Non-Negative Integer Value questions.
   Marking scheme: +4 for correct answer, 0 if not attempted and 0 in all other cases.
4. No candidate is allowed to carry any textual material, printed or written, bits of papers, mobile phone any electronic device etc., except the Identity Card inside the examination hall/room.
5. Rough work is to be done on the space provided for this purpose in the Test Booklet only.
6. On completion of the test, the candidate must hand over the Answer Sheet to the invigilator on duty in the Room/Hall. However, the candidate is allowed to take away this Test Booklet with them.
7. **For integer-based questions, the answer should be in decimals only not in fraction.**
8. **If learners fill the OMR with incorrect syntax (say 24.5. instead of 24.5), their answer will be marked wrong.**

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TEST SYLLABUS

Batch – Growth (June) | Major Test-04 (Paper I)

2nd March 2025

Mathematics: FOM-1 (Real Numbers, Complex Numbers, Even Numbers, Odd Numbers Prime Numbers, Composite Numbers, Co-Prime Numbers/ Relatively Prime Numbers, Twin Prime Numbers, LCM and HCF, Indices, Polynomial in One Variable, Degree of Polynomials, Some Special Types of Polynomials, Value and Zeros of a Polynomial, Roots of a Polynomial Equation, Remainder Theorem, Factor Theorem, Factorization, Sets, Types of Sets, Laws of Algebra of Sets (Properties of Sets), INTERVALS AS A SUBSET OF R Venn Diagram), FOM-2 (LINEAR INEQUALITIES WAVY CURVE METHOD, Rational Inequalities, Irrational Inequalities, Modulus Inequalities, Logarithmic & Exponential Inequality), Logarithm & (Function - NCERT),Sequence & Series, Compound Angle & Trignometric Eq, Quadratic Eq St. Line, Circle, Binomial Theorem, Permutation & Combination, (Probability-NCERT), Parabola, Ellipse & Hyperbola, Statistics & Complex Number & (Limits - NCERT Level)

Physics: Basic Mathematics (Except Vector),Basic Mathematics (Vector) ,Units & Dimension ,Kinematics -1D, Kinematics-2D,NLM & Friction, WEP, Circular Motion, Centre of Mass, Momentum & Collision, Rotational Motion, Gravitation, Elasticity, Thermal Expansion, Calorimetry and Heat Transfer, KTG & Thermodynamics, Fluid Mechanics, SHM & Waves

Chemistry: Mole Concept & Concentration terms - 1 (Importance of chemistry, Nature of matter ,Sig. figure, Laws of chemical combination, Avogadro law, Dalton's atomic theory, Atomic and molecular masses, Till Average/ Mean Atomic Mass),Mole Concept & Concentration terms -2(Percentage composition, Stoichiometric, calculations, Limiting reagent & Concentration, terms Equivalent Concept) Atomic Structure, Periodic Table & Periodic Properties, Chemical Bonding, Thermodynamics-1, Thermochemistry & Thermodynamics-2,Chemical Eq,Ionic Eq, Redox Reaction, Nomenclature, GOC, Isomerism & Hydrocarbon, Hydrogen & its compound & S-block & Enviromental Chemistry

Useful Data Chemistry:

Gas Constant	R	$= 8.314\,JK^{-1}mol^{-1}$
		$= 0.0821\,Lit\ atm\ K^{-1}mol^{-1}$
		$= 1.987 \approx 2\ Cal\ K^{-1}mol^{-1}$
Avogadro's Number	N_a	$= 6.023 \times 10^{23}$
Planck's Constant	h	$= 6.626 \times 10^{-34}\,Js$
		$= 6.25 \times 10^{-27}\,erg.s$
1 Faraday		$= 96500$ Coulomb
1 calorie		$= 4.2$ Joule
1 amu		$= 1.66 \times 10^{-27}\,kg$
1 eV		$= 1.6 \times 10^{-19}\,J$

Atomic No:
H = 1, D = 1, Li = 3, Na = 11, K = 19, Rb = 37, Cs = 55, F = 9, Ca = 20, He = 2, O = 8, Au = 79.

Atomic Masses:
He = 4, Mg = 24, C = 12, O = 16, N = 14, P = 31, Br = 80, Cu = 63.5, Fe = 56, Mn = 55, Pb = 207, Au = 197, Ag = 108, F = 19, H = 2, Cl = 35.5, Sn = 118.6

Useful Data Physics:

Acceleration due to gravity $g = 10\ m/s^2$

PART-A: MATHEMATICS

Only One Correct Type

1. The product of all positive real values of x satisfying the equation $x^{(16(\log_5 x)^3-68\log_5 x)} = 5^{-16}$ is _____ .

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

Ans. (A)

Sol. $x^{(16(\log_5 x)^3-68\log_5 x)} = 5^{-16}$

Taking log on both sides with base 5 , we get

$$(16(\log_5 x)^3 - 68(\log_5 x))\log_5 x = -16$$

Putting $\log_5 x = y$, we get

$$16y^4 - 68y^2 + 16 = 0$$
$$\text{or } 4y^4 - 17y^2 + 4 = 0$$

If roots are y_1, y_2, y_3 and y_4, then

$$y_1 + y_2 + y_3 + y_4 = 0$$
$$\Rightarrow \log_5 x_1 + \log_5 x_2 + \log_5 x_3 + \log_5 x_4 = 0$$
$$\Rightarrow x_1x_2x_3x_4 = 1$$

2. Let α and β be the roots of $x^2 - 6x - 2 = 0$, with $\alpha > \beta$. If $a_n = \alpha^n - \beta^n$ for $n \geq 1$, then the value of $\frac{a_{10}-2a_8}{2a_9}$ is

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

Ans. (C)

Sol. $a_n = \alpha^n - \beta^n$

Also $\alpha^2 - 6\alpha - 2 = 0$
Multiply with α^8 on both sides

$$\Rightarrow \alpha^{10} - 6\alpha^9 - 2\alpha^8 = 0$$

similarly $\beta^{10} - 6\beta^9 - 2\beta^8 = 0$

Subtracting (2) from (1) we have

$$\alpha^{10} - \beta^{10} - 6(\alpha^9 - \beta^9) = 2(\alpha^8 - \beta^8)$$
$$\Rightarrow a_{10} - 6a_9 = 2a_8$$
$$\Rightarrow \frac{a_{10} - 2a_8}{2a_9} = 3$$

3. Sum of all the solutions of $z^2 + |z| = \bar{z}^2$ is

(A) 0
(B) 1
(C) 2
(D) 3

Ans. (A)

Sol. $z^2 + |z| = \bar{z}^2$

Taking conjugate, we get

$\bar{z}^2 + |z| = z^2$

Adding (i) and (ii), we get

$\Rightarrow \quad 2|z| = 0$

$\Rightarrow \quad z = 0$

4. Let a, b, c be positive integers such that $\frac{b}{a}$ is an integer. If a, b, c are in geometric progression a and the arithmetic mean of a, b, c is $b + 2$, then the value of $\frac{a^2+a-14}{a+1}$ is

(A) 1

(B) 2

(C) 3

(D) 4

Ans. (D)

Sol. According to the question

$$\frac{b}{a} = \frac{c}{b} = \text{ (integer)}$$

$$\Rightarrow b^2 = ac \Rightarrow c = \frac{b^2}{a}$$

Also given $\frac{a+b+c}{3} = b + 2$

$$\Rightarrow a + b + c = 3b + 6$$

$$\Rightarrow a - 2b + c = 6$$

$$\Rightarrow a - 2b + \frac{b^2}{a} = 6$$

$$\Rightarrow 1 - \frac{2b}{a} + \frac{b^2}{a^2} = \frac{6}{a} \qquad (\because \text{b/a is an integer})$$

$$\Rightarrow \left(\frac{b}{a} - 1\right)^2 = \frac{6}{a}$$

$\Rightarrow a = 6$ only

$$\Rightarrow \frac{a^2+a-14}{a+1} = 4$$

5. Number of values (s) of A for which the system of equations $x^2 = y^2$ and $(x - A)^2 + y^2 = 1$ has exactly 3 solutions, is _____.

(A) 1

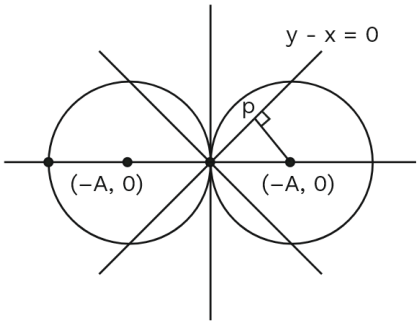
(B) 2

(C) 3

(D) 4

Ans. (B)

Sol.



$$\Rightarrow x^2 = y^2 + x$$

and $(x - A)^2 + y^2 = 1$ has centre on X-axis

For exactly three solutions,

$AP < r$

$\frac{|A|}{\sqrt{2}} < 1$

$\Rightarrow \quad |A| < \sqrt{2}$

i.e. $\quad -\sqrt{2} < A < \sqrt{2}$

$\Rightarrow$

But $A \neq 0$ as otherwise there will be four solutions.
Thus, A can take only two values.

6. If radii of director circles of $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$ and $\frac{x^2}{a^2}-\frac{y^2}{b^2}=1$ are $2r$ and r respectively and e_1 and e_2 be the eccentricities of the ellipse and the hyperbola respectively, then $4e_1^2 - e_2^2 =$ _____.

(A) 2
(B) 3
(C) 4
(D) 6

Ans. (D)

Sol. Equation of director circles of ellipse and hyperbola are respectively. and $\begin{matrix} x^2+y^2 & = a^2+b^2 \\ x^2+y^2 & = a^2-b^2 \end{matrix}$

According to the question,

$a^2 + b^2 = 4r^2$
$a^2 - b^2 = r^2$

Solving we get

$a^2 = \frac{5r^2}{2}, b^2 = \frac{3r^2}{2}$

$e_1^2 = 1 - \frac{b^2}{a^2}$

$= 1 - \frac{3r^2}{2} \times \frac{2}{5r^2}$

$= 1 - \frac{3}{5} = \frac{2}{5}$

$e_2^2 = 1 + \frac{b^2}{a^2}$

$= 1 + \frac{3}{5} = \frac{8}{5}$

So, $4e_2^2 - e_1^2 = 4 \times \frac{8}{5} - \frac{2}{5} = 6$

One or More than One Correct

7. If $(\alpha, 0)$ lies inside the quadrilateral formed by lines

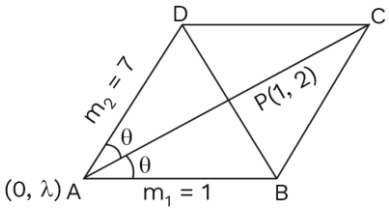
$2x + 5y = 15,$
$5x - 4y = 21,$
$3x + 5y + 17 = 0$ and
$y = x + 3$

then α can be

(A) -3
(B) 0
(C) 4
(D) 5

Ans. (B, C)

Sol.



Let point A be $(0, \lambda)$

Slope of $AP = \frac{\lambda-2}{0-1} = 2 - \lambda$

AB and AC are parallel to the lines $y = x + 2$ and $y = 7x + 3$, respectively.

So, slopes of AB and AC are 1 and 7, respectively.

From the figure,

$$\tan\theta = \frac{(2-\lambda)-1}{1+(2-\lambda)} = \frac{7-(2-\lambda)}{1+7(2-\lambda)}$$

$$\Rightarrow \quad \frac{1-\lambda}{3-\lambda} = \frac{5+\lambda}{15-7\lambda}$$

$$\Rightarrow \quad (\lambda-1)(7\lambda-15) = (5+\lambda)(3-\lambda)$$

$$\Rightarrow \quad 8\lambda^2 - 20\lambda = 0$$

$$\therefore \quad \lambda = \frac{0,5}{2}$$

$A = (0,0)$ and $\left(\frac{0,5}{2}\right)$

8. The values of a for which two curves $y = ax^2 + ax + \frac{1}{24}$ and $x = ay^2 + ay + \frac{1}{24}$ touch each other is/are

(A) $\frac{2}{3}$

(B) $\frac{1}{3}$

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

(D) $\frac{3}{2}$

Ans. (A, D)

Sol. Two curves are symmetric about $y = x$.

Hence, they touch each other on $y = x$.
So the point of contact is (α, α).
So, from any of the two equations, we get

$$\alpha = a\alpha^2 + a\alpha + \frac{1}{24}$$

or $24a\alpha^2 + 24\alpha(a-1) + 1 = 0$
This equation should have identical roots

$$\Rightarrow \quad D = 0$$

$$\Rightarrow \quad (24)^2(a-1)^2 - 4(24a) = 0$$

$$\Rightarrow \quad 6a^2 - 13a + 6 = 0$$

$$\Rightarrow \quad (2a-3)(3a-2) = 0$$

$$\Rightarrow \quad a = 3/2, 2/3$$

9. The major axis and minor axis of an ellipse are respectively $x - 2y - 5 = 0$ and $2x + y + 10 = 0$. If one end of latus rectum is $(3,4)$, then the foci are

(A) $(5,0)$

(B) $(-7,-6)$

(C) $(-11,-8)$

(D) $(11,3)$

Ans. (A, C)

Sol. Foot of perpendicular from one end of latus rectum $L(3,4)$ on major axis which is focus is given by

$$\frac{x-3}{1}=\frac{y-4}{-2}=\frac{-(3-2(4)-5)}{1^2+(-2)^2}=2$$

$$\therefore \quad S(x,y)\equiv S(5,0)$$

Now another focus is image of S in the line $2x+y+10=0$

$$\frac{x-5}{2}=\frac{y-0}{1}=\frac{-2(2(5)+0+10)}{2^2+1^2}=-8$$

$$\therefore \quad S'(x,y)\equiv S(-11,-8)$$

10. The integers from 1 to 1000 are written in order around a circle. Starting at 1 , every fifteenth numbers is marked (i.e., 1,16,31 etc.). This process is continued until a number is reached which has already been marked, then unmarked numbers are

(A) 200

(B) 400

(C) 600

(D) 800

Ans. (A, B, C, D)

Sol. In 1st round all the integers, which leaves the remainder 1 when divided by 15, will be marked. Last number of this category is 991 . Next number to be marked is $(991+15-1000)=6$ So, second round of integers which leave the remainder 6 when divided by 15 will be marked. Last number of this category is 996. Next number to be marked is $(996+15-1000)=11$ Thus, third round of integers which leave the remainder 11 when divided by 15 , will be marked. Last number of this category is 986 . Next number to be marked is $(986+15-1000)=1$; which has already been marked.

11. If $\sec x+\tan x=\frac{22}{7}$, then

(A) the value of $\tan\frac{x}{2}=\frac{29}{15}$

(B) the value of $\tan\frac{x}{2}=\frac{15}{29}$

(C) the value of $\operatorname{cosec}x+\cot x=\frac{29}{15}$

(D) the value of $\operatorname{cosec}x+\cot x=\frac{15}{29}$

Ans. (B, C)

Sol.

$$\sec x+\tan x=\frac{22}{7}$$

$$\Rightarrow \quad \frac{1+\sin x}{\cos x}=\frac{22}{7}$$

$$\Rightarrow \quad \frac{1+\frac{2t}{1+t^2}}{\frac{1-t^2}{1+t^2}}=\frac{22}{7}, \text{ where } t=\tan\frac{x}{2}$$

$$\Rightarrow \quad \frac{(1+t)^2}{1-t^2}=\frac{22}{7}$$

$$\Rightarrow \quad \frac{1+t}{1-t}=\frac{22}{7}$$

$$\Rightarrow \quad t=\frac{15}{29}$$

Now $\operatorname{cosec}x+\cot x$

$$= \frac{1+\cos x}{\sin x}$$
$$= \frac{2\cos^2(x/2)}{2\sin(x/2)\cos(x/2)}$$
$$= \cot\left(\frac{x}{2}\right) = \frac{29}{15}$$

12. For the expansion of $\left(x^3 + 3\cdot 2^{-\log_{\sqrt{2}}\sqrt{x^3}}\right)^5$, which of the following is/are correct?

(A) Coefficient of x^2 is non zero.

(B) Coefficient of x^2 is zero.

(C) Coefficient of x^{-3} is non zero.

(D) Ratio of coefficient of x^3 to that of x^{-3} is $1:3$.

Ans. (B, C, D)

Sol. $\left(x^3 + 3\cdot 2^{-\log_2 x^3}\right)^5 = \left(x^3 + \frac{3}{x^3}\right)^5$

General term, $T_{r+1} = {}^5C_r x^{15-3r} 3^r x^{-3r}$

For $x^2, 15-6r = 2 \Rightarrow r = \frac{13}{6}$, which is not an integer.

For $x^{-3}, 15-6r = -3 \Rightarrow r = 3 \Rightarrow$ coefficient $\neq 0$

For $x^3, 15-6r = 3 \Rightarrow r = 2 \Rightarrow$ coefficient $\neq 0$

$\therefore$ Coeff. of $x^{-3} = {}^5C_3 3^3$;

And Coeff. of $x^3 = {}^5C_2 3^2$

Ratio $= \frac{{}^5C_2 3^2}{{}^5C_3 3^3} = \frac{1}{3}$

Numerical Value (If more than two decimal, truncate/roundoff the value two decimal places).

13. The coefficients of three consecutive terms of $(1+x)^{n+5}$ are in the ratio $5:10:14$. Then $n =$ _____ .

Ans. 6

Sol. Let T_{r-1}, T_r, T_{r+1} are three consecutive terms of $(1+x)^{n+5}$

$T_{r-1} = {}^{n+5}C_{r-2}(x)^{r-2}, T_r = {}^{n+5}C_{r-1}x^{r-1}, T_{r+1} = {}^{n+5}C_r x^r,$

where, ${}^{n+5}C_{r-2} : {}^{n+5}C_{r-1} : {}^{n+5}C_r = 5:10:14.$

So

$$\frac{{}^{n+5}C_{r-2}}{5} = \frac{{}^{n+5}C_{r-1}}{10} = \frac{{}^{n+5}C_r}{14}$$

Comparing first two results we have $n - 3r = -9$

Comparing last two results we have $5n - 12r = -30$

From equation (1) and (2), $n = 6$

14. Words of length 10 are formed using the letters $A, B, C, D, E, F, G, H, I, J$. Let x be the number of such words where no letter is repeated; and let y be the number of such words where exactly one letter is repeated twice and no other letter is repeated. Then, $\frac{y}{9x} =$ _____.

Ans. 5

Sol. According to question, $x = 10!$

Now for y, we can select one letter which will be repeated twice in ${}^{10}C_1$ ways.

Remaining eight letters can be selected in ${}^9C_8$ ways.

So, $y = {}^{10}C_1 \times {}^9C_8 \times \frac{10!}{2!}$

Qt $\frac{y}{9x} = \frac{{}^{10}C_1 \times {}^9C_8}{9\times 2!} = \frac{10\times 9}{9\times 7} = 5$

15. Let $l_1, l_2, \ldots, l_{100}$ be consecutive terms of an arithmetic progression with common difference d_1, and let $w_1, w_2, \ldots, w_{100}$ be consecutive terms of another arithmetic progression with common difference

d_2, where $d_1d_2 = 10$. For each $i = 1,2,\ldots,100$, let R_i be a rectangle with length l_i, width w_i and area A_i. If $A_{51} - A_{50} = 1000$, then the value of $A_{100} - A_{90}$ is _____.

Ans. 18900

Sol.

$$d_1d_2 = 10$$
$$A_{51} - A_{50} = 1000 \Rightarrow l_{51}w_{51} - l_{50}w_{50} = 1000$$
$$\Rightarrow (l_1 + 50d_1)(w_1 + 50d_2) - (l_1 + 49d_1)(w_1 + 49d_2) = 1000.$$
$$\Rightarrow l_1d_2 + w_1d_1 = 10$$
$$\Rightarrow A_{100} - A_{90} = l_{100}w_{100} - l_{90}w_{90}$$
$$= (l_1 + 99d_1)(w_1 + 99d_2) - (l_1 + 89d_1)(w_1 + 89d_2)$$
$$= 10(l_1d_2 + w_1d_1) + (99^2 - 89^2)d_1d_2$$
$$= 10 \times 10 + 10 \times 188 \times 10$$
$$= 100(1 + 188)$$
$$= 18900$$

16. The value of $\frac{1}{\log_3 2} + \frac{2}{\log_9 4} - \frac{3}{\log_{27} 8} + 2$ is _____.

Ans. 2

Sol. $\frac{1}{\log_3 2} + \frac{2}{\log_9 4} - \frac{3}{\log_{27} 8}$

$$= \frac{\log 3}{\log 2} + \frac{2\log 9}{\log 4} - \frac{3\log 27}{\log 8}$$
$$= \frac{\log 3}{\log 2} + \frac{2(2\log 3)}{2\log 2} - \frac{3 \times 3\log 3}{3\log 2}$$
$$= \frac{\log 3}{\log 2}(1 + 2 - 3) = 0$$

17. If α and β are the roots of the equation $x^2 + 3x + 1 = 0$, then the value of $\left(\frac{\alpha}{1+\beta}\right)^2 + \left(\frac{\beta}{\alpha+1}\right)^2$ is equal to _____.

Ans. 18

Sol. $\alpha + \beta = -3; \alpha\beta = 1,$

Also, $\alpha^2 + 3\alpha + 1 = 0$ and $\beta^2 + 3\beta + 1 = 0$

$$y = \frac{\alpha^2}{(1+\beta)^2} + \frac{\beta^2}{(\alpha+1)^2}$$
$$= \frac{\alpha^2}{1 + 2\beta + \beta^2} + \frac{\beta^2}{1 + 2\alpha + \alpha^2}$$
$$= \left(\frac{-(3\alpha + 1)}{-\beta}\right) + \left(\frac{-(1 + 3\beta)}{-\alpha}\right)$$
$$= \frac{\alpha(1 + 3\alpha) + \beta(1 + 3\beta)}{\alpha\beta}$$
$$= 3[(\alpha + \beta)^2 - 2\alpha\beta] + (\alpha + \beta) = 18$$

18. Three couples have to be seated around a circle. Let p be the probability that no couple is together then the value of $15p$ is _____.

Ans. 4

Sol. Total number of cases $= n(S) = 5!$

Number of ways when atleast one couple is together $= {}^3C_1 \times 4! \times 2!$
Number of ways when atleast two couples are together

$= {}^3C_2 \times 3! \times 2! \times 2!$

Number of ways when atleast three couples are together

$= {}^3C_3 \times 2! \times 2! \times 2! \times 2!$

Using principle of inclusion and exclusion, required probability is:

$$p = \frac{5! - {}^3C_1(4!)\cdot(2!) + {}^3C_2(3!)\cdot(2!)\cdot(2!) - {}^3C_3(2!)\cdot(2!)\cdot(2!)\cdot(2!)}{5!}$$

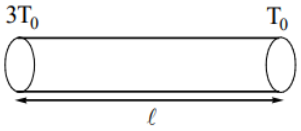
$$= \frac{120 - 144 + 72 - 16}{120} = \frac{4}{15}$$

So, $15p = 4$

PART-B: PHYSICS

Only One Correct Type

19. Two ends of a rod of uniform cross-sectional area are kept at temperatures $3T_0$ and T_0 as shown in the figure. Thermal conductivity of rod varies with its absolute temperature (T) as $k = \alpha T$, (where α is a constant). In steady state, the temperature at the mid-point of the rod is



(A) $T_0\sqrt{7}$

(B) $T_0\sqrt{5}$

(C) $T_0\sqrt{4}$

(D) $T_0\sqrt{3}$

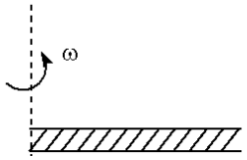
Ans. (B)

Sol. $H = -\alpha TA.\frac{dT}{dx} \Rightarrow \int_0^{\ell} H\ dx = \int_{3T_0}^{T_0} -\alpha TA\ dT$

Also $\int_0^{\ell/2} Hdx = \int_{3T_0}^{T} -\alpha TAdT$

$\therefore T = \sqrt{5}\ T_0$

20. A thin horizontal tube of inner radius 'r' and length 'l' is open at both the ends and is fully filled with a liquid of density ρ and surface tension T. If the rod is rotated about a vertical axis passing through one of the ends at a constant angular velocity ω, find maximum value of ω for which the liquid does not spill out of the tube. Assume liquid completely wets the surface of tube.



(A) $\sqrt{\frac{2T}{\rho r\ell^2}}$

(B) $\sqrt{\frac{4T}{\rho r\ell^2}}$

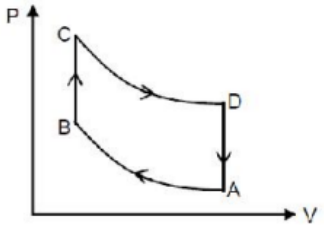
(C) $\sqrt{\frac{6T}{\rho r\ell^2}}$

(D) $\sqrt{\frac{8T}{\rho r\ell^2}}$

Ans. (D)

Sol. $T2\pi r\times 2=\left(\pi r^2\ell\rho\right)\left(\frac{\omega^2 l}{2}\right)$

21. One mole of an ideal diatomic gas of degrees of freedom 5 undergoes a cyclic process in which volume (V) of the gas changes 10 times in the process C →D (i.e., $V_D = 10\ V_C$) as shown in the figure. The processes AB & CD are adiabatic while process BC and DA are isochoric. What is the efficiency of the process in the % ? (P denotes pressure)



(A) $100-10^{8/5}$

(B) $100-10^{3/5}$

(C) $100-10^{2/5}$

(D) $100-10^{1/5}$

Ans. (A)

Sol. $\eta=1-\left|\frac{Q_{out}}{Q_{in}}\right|....(i)$

$$Q_{in}=nC_v(T_C-T_B)=\frac{5}{2}R(T_C-T_B)....(ii)$$

$$Q_{out}=nC_v(T_0-T_A)=\frac{5}{2}(T_0-T_A)R....(iii)$$

$$\Rightarrow \boldsymbol{\eta}=1-\frac{T_0-T_A}{(10)^{y-1}T_0-10^{y-1}T_A}=1-\frac{1}{10^{y-1}}=1-\frac{1}{10^{0.4}}$$

22. For an ideal gas sample with N_0 number of gas molecules, function N(V) is given by :

$$N(V)=\frac{dN}{dV}=\left(\frac{7N_0}{V_0^3}\right)V^2 \quad \text{for}\ 0<V\le V_0 \ \text{and}\ N(V)=0 \ \text{for}\ V>V_0$$

Where dN is number of gas molecules in speed range V to V + dV. Then the rms speed of the gas molecules is equal to

(A) $v_0\sqrt{\frac{7}{5}}$ (B) $v_0\sqrt{\frac{4}{5}}$ (C) $v_0\sqrt{2}$ (D) $v_0\sqrt{\frac{3}{5}}$

Ans. (A)

Sol.

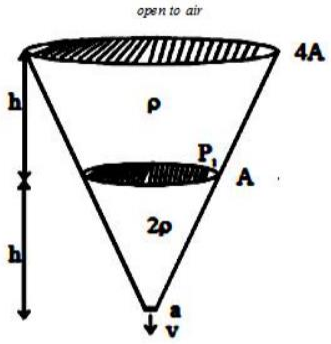
$$<V^2>=\frac{\int_0^{V_0} dNV^2}{N_0}$$

$$V_{rms}=\sqrt{<V^2>}$$

$$=\sqrt{\frac{7}{5}}v_0$$

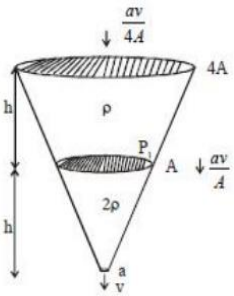
23. Two immiscible liquid are filled in conical flask as shown in figure. The area of cross section is shown, a small hole of area 'a' is made in lower end of cone. Find speed of liquid flow from hole

(A) $\sqrt{\frac{2gh}{1-\frac{17a^2}{A^2}}}$ (B) $\sqrt{\frac{gh}{1-\frac{17a^2}{A^2}}}$ (C) $\sqrt{\frac{2gh}{1-\frac{17a^2}{32A^2}}}$ (D) $\sqrt{\frac{3gh}{1-\frac{17a^2}{32A^2}}}$



Ans. (D)

Sol.



$$P_0 + \frac{1}{2}2\rho v^2 = P_1 + 2\rho gh + \frac{1}{2}(2\rho)\left(\frac{av}{A}\right)^2$$

$$P_0 + \frac{1}{2}\rho\left(\frac{av}{4A}\right)^2 + \rho gh = P_1 + O + \frac{1}{2}\rho\left(\frac{av}{A}\right)^2$$

$$\Rightarrow \rho v^2 - \frac{\rho}{32}\frac{a^2v^2}{A^2} + \rho gh = 2\rho gh + \rho\frac{a^2v^2}{A^2} - \frac{\rho}{2}\frac{a^2v^2}{A^2}$$

$$v^2\left[1 - \frac{a^2}{32A^2} - \frac{a^2}{A^2}.v^2 + \frac{a^2v^2}{2A^2}\right] = gh$$

$$v = \sqrt{\frac{3gh}{1-\frac{17a^2}{32A^2}}}$$

24. A particle of mass 2 kg moving horizontally with a speed of 2 m/s perpendicularly to a uniform rod of mass 10 kg & length 4 m lying on a smooth horizontal surface. Particle strikes the rod perpendicularly at a distance of 1 m from its center and comes to rest after the collision. The coefficient of restitution between the particle & the rod is

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

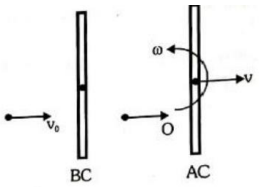
(B) $\frac{7}{15}$

(C) $\frac{7}{20}$

(D) $\frac{3}{7}$

Ans. (C)

Sol. Apply linear momentum conservation & angular momentum conservation



$$mv_0 = Mv$$

$$mv_0 \times 1 = \frac{ML^2}{12} \times \omega$$

$$e = \frac{v + \omega \times 1 - 0}{v_0} = \frac{7}{20}$$

One or More than One Correct

25. An enemy fighter jet is flying at a constant height of 250m with a velocity of 500m/s. The fighter jet passes over an anti-aircraft gun that can fire at any time and in any direction with a speed of 100 m/s. Determine the time interval during which the fighter jet is in danger of being hit by the gun bullets.

(A) The fighter jet is in danger zone for a period of $4\sqrt{2}$ sec.

(B) The fighter jet is in safe zone for a period of $4\sqrt{2}$

(C) The fighter jet can travel $2000\sqrt{2}$ m while in danger zone

(D) The fighter jet is in danger zone for a period of $2\sqrt{2}$ sec

Ans. (D)

Sol.

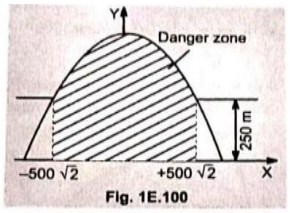


Fig. 1E.100

For a given value of x, maximum y can be determined from

$$\frac{dy}{d(\tan\theta)} = x - \frac{\frac{1}{2}gx^2}{u^2}(2\tan\theta) = 0$$

or $$\tan\theta = \frac{u^2}{gx}$$

On substituting the expression for $\tan\theta$ in eqn. (1), we get

$$y_{max.} = x\frac{u^2}{gx} - \frac{\frac{1}{2}gx^2}{u^2}\left[1 + \frac{u^4}{g^2x^2}\right]$$

or $$y_{max.} = \frac{u^2}{2g} - \frac{\frac{1}{2}gx^2}{u^2}$$

The shell can hit an area defined by

$$y \le \frac{u^2}{2g} - \frac{\frac{1}{2}gx^2}{u^2}$$

On substituting numerical values, $y = 250$ m, $u = 100$ m/s, $g = 10$ m/s^2, we get

$$\frac{x^2}{2000} \le 250$$

or $$-500\sqrt{2} \le x \le 500\sqrt{2}$$

The fighter jet, can travel $1000\sqrt{2}$ m while it can be hit.

So the plane is in danger for a period of $\frac{1000\sqrt{2}}{500} = 2\sqrt{2}$ sec.

26. Consider a Vernier callipers in which each 1cm on the main scale is divided into 8 equal divisions and a screw gauge with 100 divisions on its circular scale. In the Vernier callipers, 5 divisions of the Vernier scale coincide with 4 divisions on the main scale and in the screw gauge, one complete rotation of the circular scale moves it by two divisions on the linear scale. Then

(A) If the pitch of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.01mm.

(B) If the pitch of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.005mm.

(C) If the least count of the linear scale of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.01mm.

(D) If the least count of the linear scale of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.005mm

Ans. (B),(C)

Sol. For vernier callipers

1 main scale division $= \frac{1}{8}$cm

1 vernier scale division $= \frac{1}{10}$cm

So least count $= \frac{1}{40}$cm

For screw gauge.

pitch $(p) = 2$ main scale division

So least count= $\frac{p}{100}$ So options (B) &(C) are correct

27. Let V , V_{rms} and V_p respectively denote the mean speed, the root-mean-square speed , and the most probable speed of the molecules in an ideal monoatomic gas at absolute temperature T. The mass of molecule is m then

(A) No molecule can have a speed greater than V_{rms}

(B) No molecule can have speed of less than V_{rms} / 2

(C) $V_p < V$

(D) The average kinetic energy of a molecule is $\frac{3}{4}mV_p^2$

Ans. (C),(D)

Sol. $V_{rms} = \sqrt{\frac{3RT}{M}}; \overline{V} = \sqrt{\frac{8RT}{\pi M}}; V_p = \sqrt{\frac{2RT}{M}}$

28. Two particles projected from the same point with same speed u at angles of projection α and β strike the horizontal ground at the same point. If h_1 and h_2 are the maximum heights attained by projectiles, R be the range for both and t_1 and t_2 be their time of flights respectively then

(A) $\alpha + \beta = \pi / 2$

(B) $R = 4\sqrt{h_1 h_2}$

(C) $\tan\alpha = \frac{t_1}{t_2}$

(D) $\tan\alpha = \sqrt{\frac{h_1}{h_2}}$

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

Sol: Conceptual

29. Two strings of same material are joined to form a large string and is stretched between rigid supports. The diameter of the second string is twice that of the first. It is observed that the whole string was oscillating in 4 loops with a node at the joint. The possible lengths of the second string if the length of first string is 90cm are

(A) 15cm

(B) 45cm

(C) 84cm

(D) 135cm

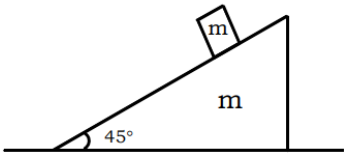
Ans. (A), (B), (D)

Sol. 1) String – 1 →one loop ; string – 2 →3 loops

2) String – 1 →2 loops ; string – 2 →2 loops

3) String – 1 →3 loops ; string – 2 →one loop

30. A block of mass m is placed on a wedge of same mass m as shown. All the surfaces are smooth. Mark the correct statements for the situation just after the system is released from rest



(A) The acceleration of block makes an angle greater than 45^0 with horizontal

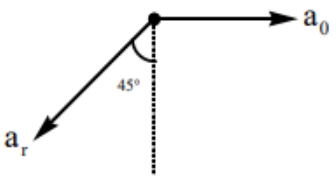
(B) The acceleration of block with respect to wedge makes an angle 45^0 with horizontal

(C) The normal force between wedge and ground is less than $\frac{3mg}{2}$

(D) The normal force between wedge and the block is less than $\frac{mg}{\sqrt{2}}$

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

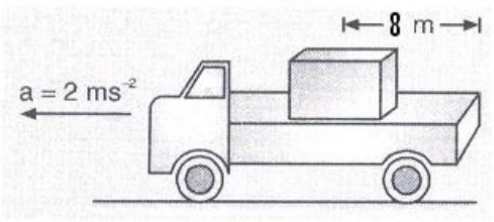
Sol. a_0 = acceleration of wedge; a_r = acceleration of block relative to wedge; a = acceleration of block lies between a_r and a_0



Relative to wedge the equation of motion of block in the direction perpendicular to plane of wedge is $mg\cos 45 = ma_0 \sin 45 + N \Rightarrow N < \frac{mg}{\sqrt{2}}$

Numerical Value (If more than two decimal, truncate/roundoff the value two decimal places).

31. The rear side of a truck is open and a box of 40 kg mass is placed 8 m away from the open end as shown in figure. The coefficient of friction between the box and the surface below it is $\mu = 0.1$. On a straight road, the truck starts from rest and moves with acceleration 2 ms^{-2}. Find the time when box falls off the truck in seconds. Take g = 10 ms^{-2}.

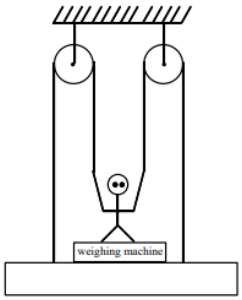


Ans. 4.00

Sol. $a_{b/t} = a_b - a_t \quad \Rightarrow a_{b/t} = \mu g - a_t = -1$

$$S_{b/t} = \frac{1}{2} a_{b/t} t^2 \quad \Rightarrow t = \sqrt{\frac{2 \times 8}{1}} = 4$$

32. A man of mass 75 kg uses two pulleys to raise himself with an acceleration 2 m/s^2 as shown in figure. Man stands on a light weighing machine fitted on horizontal platform of mass 25 kg. Reading of weighting machine is _____ N. ($g = 10 m/s^2$)

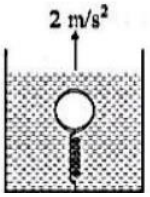


Ans. 300.00

Sol. If T is the tension in the string, then: $4T - (M_1 + M_2)g = (M_1 + M_3)a \quad \Rightarrow T = 300N$

Also, $2T + N - M_1 g = M_1 a \quad \Rightarrow N = 300\ N$

33. A ball of mass 10 kg and density 1 gm/cm^3 is attached to the base of a container having a liquid of density 1.1 gm/cm^3, with the help of a spring as shown in the figure. The container is going up with an acceleration 2 m/s^2. If the spring constant of the spring is 200 N/m, the elongation (in cm) in the spring is _____. (Take $g = 10 m/s^2$)



Ans. 6.00

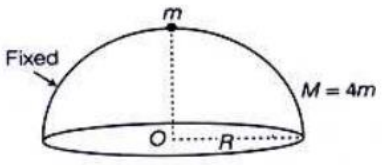
Sol. In the frame of the container:

Gravitational force on the ball: $m(g+a)=10(g+a)$

Buoyancy Force on the ball: $\rho_L V(g+a)=\rho_L\frac{m}{\rho_s}(g+a)=11(g+2)$

$F_s=kx=F_b-mg=(g+a)=12 \qquad \Rightarrow x=12/k=0.06$

34. A small particle of mass m starts sliding down from rest along the smooth surface of a fixed uniform hollow hemisphere of mass (M = 4m). The distance of centre of mass of (particle + hemisphere) system from centre O of hemisphere, when the particle separates from the surface of hemisphere is $\frac{\sqrt{x}}{15}R$. Find the value of x



Ans. 69.00

Sol. Let the particle is separated when it is at the position θ (see figure)

$Now,$

$\Rightarrow mg\cos\theta=\frac{mv^2}{R}$....(i)

$v^2=Rg\cos\theta$

$h=R(1-\cos\theta)$

Decrease in PE=increase in KE $\Rightarrow mgR(1-\cos\theta)=\frac{1}{2}mv^2$ ....(ii)

From Eqs.(i) and (ii), we get $\cos\theta=\frac{2}{3}$

So, Coordinates of particle, $m=(x_1,y_1)=\left(\frac{\sqrt{5}}{3}R,\frac{2}{3}R\right)$

Coordinates of COM of hemisphere $=(x_2,y_2)=\left(0,\frac{R}{2}\right)$

∴x- Coordinate of COM of (particle + hemisphere) is

$$X_{COM}=\frac{m\left(\frac{\sqrt{5}}{3}R\right)+4m(0)}{m+4m}=\frac{R}{3\sqrt{5}}$$

y- Coordinate of COM of (particle + hemisphere) is

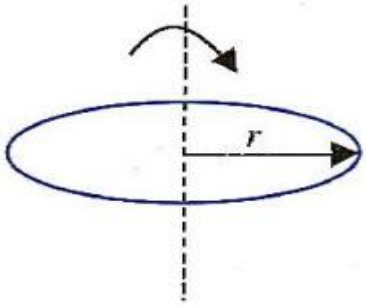
$$Y_{COM}=\frac{m\left(\frac{2}{3}R\right)+4m\left(\frac{1}{2}R\right)}{m+4m}=\frac{8R}{15}$$

Coordinate of point O= (0, 0)

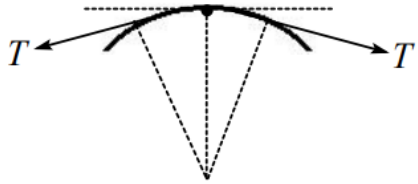
$$\therefore \text{ Required distance }=\sqrt{\left(0-\frac{R}{3\sqrt{5}}\right)^2+\left(0-\frac{8R}{15}\right)^2}=\frac{\sqrt{69}}{15}R$$

$\Rightarrow x=0.553$

35. A uniform ring of radius r made of wire of density ρ is rotated about a stationary vertical axis passing through its centre and perpendicular to the plane of the ring as shown in the figure. Determine the minimum angular velocity (in rad/s) of ring at which the ring breaks. The wire breaks at tensile stress σ . Ignore gravity. Take σ/ρ=4 and r = 1 m.



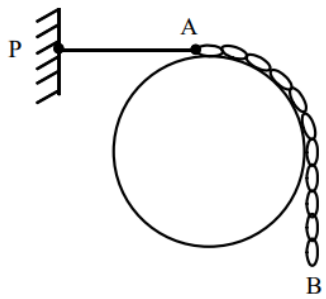
Ans. 2.00



Sol. $T = \rho A r^2 \omega^2$

$$\sigma = \frac{T}{A} = \rho r^2 \omega^2$$

36. A uniform flexible chain of length 1.5m, rests on a fixed smooth sphere of radius R=$\frac{2}{\pi}$m, such that one end A, of chain is at top of the sphere while the other end B is hanging freely. Chain is held stationary by a horizontal thread PA as shown. The acceleration of chain just after thread is burnt is (g = 10 m/s^2) $\frac{10(\pi+4)}{K\pi}$ m/s^2 where K = _____

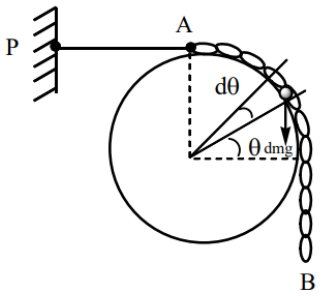


Ans. 3.00

Sol. Summing the tangential component of forces

$$F_t = \int dmg\cos\theta = \int \lambda Rg\cos\theta d\theta$$

$$= \lambda Rg\left[\sin\theta\right]_0^{\pi/2} = \lambda Rg$$



$$F_{net} = \left(\ell_0 - \frac{\pi R}{2}\right)\lambda g + \lambda R g$$

$$a = \frac{\left(\ell_0 - \frac{\pi R}{2}\right)\lambda g + \lambda R g}{\ell_0 \lambda}$$

$$= \frac{g}{\lambda_0}\left[R + \ell_o - \frac{\pi R}{2}\right]$$

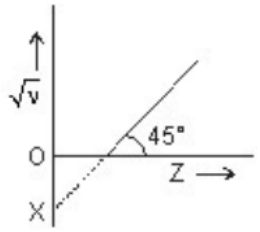
$$= \frac{10}{1.5}\left[\frac{2}{\pi} + \frac{1}{2}\right]$$

$$= \frac{10}{3}\left[\frac{4}{\pi} + 1\right]$$

PART-C: CHEMISTRY

Only One Correct Type

37. In the graph between $\sqrt{v}$ and z for the Moseley's equation, $\sqrt{v} = a(Z - b)$, the intercept OX is -1 on $\sqrt{v}$ axis. What is the frequency v when atomic number Z is 57 ?

1. 

(A) 2296 Hz
(B) 2684 Hz
(C) 2809 Hz
(D) 3136 Hz

Ans. (D)

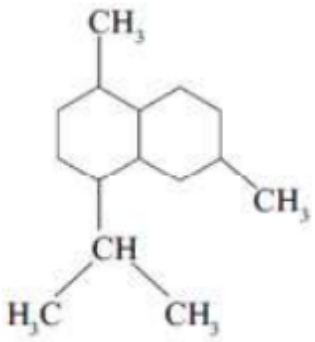
Sol. Slope $= a = \tan 45^\circ = 1$

Intercept, $OX = -ab = -1; b = 1$

$\sqrt{v} = 57 - 1 = 56$

$v = 3136$ Hz

38. How many products (structural isomers only) are formed by monochlorination of



(A) 13

(B) 12
(C) 15
(D) 14

Ans. (D)

Sol. There are 14 available sites.

39. The major product formed in the reaction of 1,3 -butadiene with bromine at $50^{\circ}C$ is
(A) $BrCH_2CH(Br)CH = CH_2$
(B) $CH = CH - CH_2CH_2Br$
(C) $CH_2 = C(Br) - C(Br) = CH_2$
(D) $BrCH_2CH = CHCH_2Br$

Ans. (D)

Sol. Thermodynamically controlled product will be formed.
1, 4 addition will take place.

40. Give the correct order of initials T (true) or F (false) for following statements.
(I) Top positions of Lother-Mayer's atomic volume curve are occupied by Alkali metals.
(II) Number of elements presents in the fifth period of the periodic table are 32.
(III) 2^{nd} I.P. of Mg is less than the 2^{nd} I.P. of Na .(IV) A p-orbital can take maximum of six electrons.
(A) TFTF
(B) TFFT
(C) FFTF
(D) TTFF

Ans. (A)

Sol.

(II)	5s	4d	5p
Orbital	1	5	3

Total orbitals = 9
$\therefore$ Total element = 18

(III) $Mg^+ \longrightarrow 1s^2\ 2s^2\ 2p^6\ 3s^1$
$Na^+ \longrightarrow 1s^2\ 2s^2\ 2p^6$
$\therefore$ Na^+ attained inert gas configuration
$\therefore$ IE_2 of Na is greater than Mg.
(IV) p-orbital can have 2 electrons but p-subshell can have 6 electrons.

41. What should be the atomic number of the next inert gas if discovered in future?
(A) 115
(B) 119
(C) 118
(D) 121

Ans. (C)

Sol. The next halogen will have 7 $s^2 7p^5$ outer configuration. Since, the filling of 7 p -orbitals will begin after 5 f and 6 d -orbitals, thus the atomic number of the new halogen will be 112 (up to the filling of 6 d -orbitals) plus 5, i.e., 117.

42. Angular momentum of electron in Bohr's model is directly proportional to (r = radius of Bohr orbit)
(A) r
(B) r^2

(C) $r^{\frac{1}{2}}$

(D) None of these.

Ans. (C)

Sol. Angular momentum = $mvr = \frac{nh}{2\pi}$ (Bohr's Model)

$= K \cdot r^{1/2} \left(r = \frac{r_0 n^2}{Z} \right), n = r^{1/2}$

One or More than One Correct

43. Consider the group 17 elements and identify the correct statement(s)

(A) The energy required for π^* to σ^* electronic transition for F is greater than that for Cl

(B) σ_{3p_z} orbital of Cl is lower in energy as compared to σ_{4p_z} of Br

(C) Energy gap between σ_{3p_2} and π_{3p_x} of Cl is lesser than that of σ_{4p_z} and π_{4p_x} of Br

(D) I_2 is most intensely coloured (among group-17 elements) because it absorbs energy of maximum frequency from the white light for HOMO-LUMO electronic transition

Ans. (A, B)

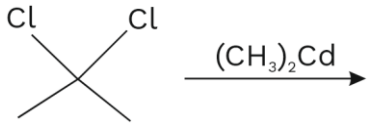
Sol. In Group-17 elements on moving down the group gap between HOMO-LUMO (π^* to σ^*) decreases.

44. Which reactions can produce propanone as major product?

(A) $H_3C - C \equiv CH \xrightarrow[(ii)\,H_2O_2/OH^-]{(i)\,BH_3-THF}$

(B) $H_3C - C \equiv N \xrightarrow[(ii)\,H^+/H_2O]{(i)\,MeMgX}$

(C) $H_3C - \underset{\underset{O}{\|}}{C} - Cl \xrightarrow{(CH_3)_2Cd}$

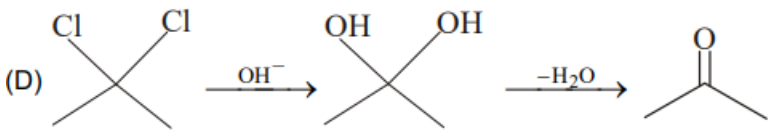
(D) 

Ans. (B, C, D)

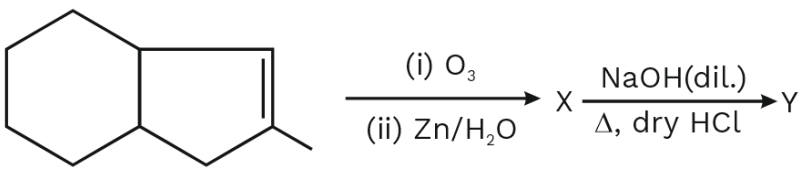
Sol.

(B) $H_3C-C\equiv N \xrightarrow{(i)MeMgX} CH_3-\underset{\underset{\ominus}{N}MgX}{\overset{Me}{\underset{|}{C}}}=\square \xrightarrow{(ii)H^+/H_2O} CH_3-\overset{CH_3}{\underset{|}{C}}=O$

(C) $H_3C-\underset{\underset{O}{\|}}{C}-Cl \xrightarrow{(CH_3)_2Cd} CH_3-\underset{\underset{O}{\|}}{C}-CH_3$

(D) 

45. Consider the following reaction, in which reductive ozonolysis takes place, and then the reaction product (X) is heated in presence of dil NaOH as shown below:



Which of following is not correct?

(A) X has 2 chiral centres but it is meso

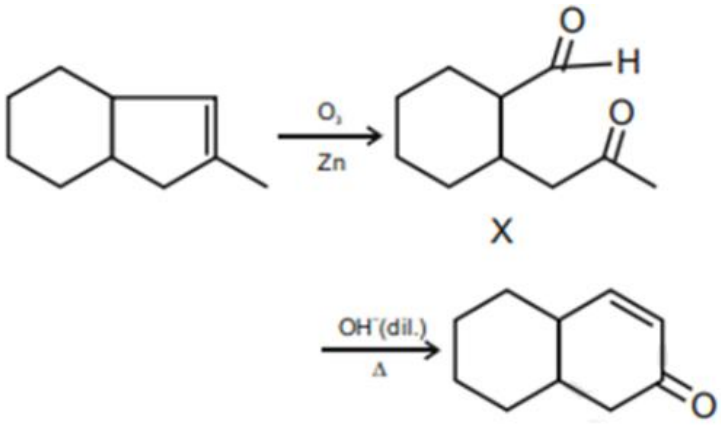
(B) Y has 2 six membered rings

(C) Y is an α,β-unsaturated ketone

(D) For the formation of Y , dehydration occurs

Ans. (A)

Sol. Ozonolysis followed by Aldol condensation



46. The enthalpy and entropy of trimerization of gas A in gas phase $[3\ \mathrm{A(\ g)} \rightleftharpoons \mathrm{A_3(\ g)}]$ are $-100\ \mathrm{kJ/mol}$ and $-400\ \mathrm{J/\ K\ mol}$ respectively. The enthalpy of vapourisation for liquids A and A_3 are respectively $25\ \mathrm{kJ/mol}$ and $50\ \mathrm{kJ/mol}$ respectively. If the boiling points of A and $\mathrm{A_3}$ are 300 K and 400 K respectively, then select correct statement(s):

(A) Enthalpy for trimerization of liquid is $-\frac{75\ \mathrm{kJ}}{\mathrm{mol}}$

(B) Enthalpy for trimerization of liquid is $-\frac{125\ \mathrm{kJ}}{\mathrm{mol}}$

(C) Entropy for trimerization of liquid is $-\frac{775\ \mathrm{J}}{\mathrm{K}}.\mathrm{mol}$

(D) ΔG for trimerization of liquid at 300 K is $7.5\ \mathrm{kJ/mol}$

Ans. (A, D)

Sol.

$3A(l) \rightleftharpoons A_3(l)$ at 300 K.

$3A(l) \longrightarrow A_3(l)$

$3A(g) \longrightarrow A_3(g)$

Enthalpy for trimerization of liquid

$\Delta H = -100 \times 10^3 + 3 \times 25 \times 10^3 - 50 \times 10^3$

$\Delta H = -75 \times 10^3$ J/mol

$$\Delta S = -400 + \frac{3\times25\times10^3}{300} - \frac{50\times10^3}{400}$$

$= -400 - 125 + 250 = -275$ J / K.mole

$\Delta G = -75 \times 10^3 + 300 \times 275$

$= 7500$ J or 7.5 kJ / mol

47. Select the correct statement(s).

(A) For mechanical equilibrium, pressure is constant.

(B) For thermal equilibrium, temperature is constant.

(C) For chemical equilibrium, $\left(\frac{\partial G}{\partial n}\right)_{P,T}$ is constant.

(D) For all types of equilibrium, pressure & temperature is variable.

Ans. (A, B, C)

Sol. (A) Mechanical Equilibrium

(B) Thermal Equilibrium

(C) Chemical Equilibrium

48. Select the correct option(s):

(A) $q = nC_v dT$ is applicable to all substances during heating / cooling at constant ' v '.

(B) $q = nC_v dT$ is applicable to ideal gas during heating / cooling at constant ' v ' only.

(C) $dU = nC_v dT$ is applicable for real gas at constant ' v '

(D) pressure is extensive property

Ans. (A, B, C)

Sol.

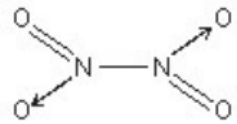
Numerical Value

49. Among N_2O, N_2O_4, NO in solid state, $H_2S_2O_3, P_4, O_3, B_2H_6$, and $H_2S_2O_6$, the total number of molecules containing covalent bond between two atoms of the same kind is

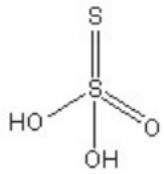
Ans. 7

Sol.

N_2O_4

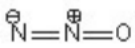


$H_2S_2O_3$

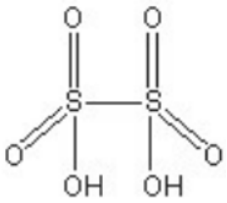


P_4

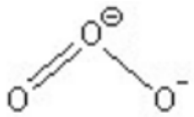
N_2O



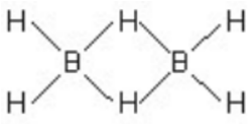
$H_2S_2O_6$



O_3



B_2H_6



NO(s)

O – N – N – O (symmetrical dimer)

50. $XeF_4 + H_2O \rightarrow Xe + HF + O_2 + A$

$XeF_6 + SiO_2(1eq) \rightarrow B + SiF_4$

The sum of number of lone pair(s) of electron present on the whole molecule of A and B is

Ans. 22

Sol. $3XeF_4 + 6H_2O \rightarrow 2Xe + XeO_3 + 12HF + \frac{3}{2}O_2$

$2XeF_6 + SiO_2 \rightarrow XeOF_4(\ B) + SiF_4$

A contains 7 lone pairs
B contains 15 lone pairs

51. The number of nodal planes in a p_x orbital is:

Ans. 1

Sol. For P_x, P_y & P_z only one nodal plane exists.

52. The number of electrons present in Co^{2+} having azimuthal quantum number l = 1 is:

Ans. 12

Sol. $_{27}Co^{2+}: 1\ s^2\ 2\ s^2 2p^6 3\ s^2 3p^6 3\ d^7$

Number of electron with $(\ell = 1) =$ number of electrons present in p-subshells.

$= 6 + 6 = 12$

53. At high temperatures, the compound S_4N_4 decomposes completely into N_2 and sulphur vapours. If all measurements are made under the same conditions of temperature and pressure, it is found that for each volume of S_4 N_4 decomposed 2.5 volumes of gaseous products are formed. What is the x in molecular formula of sulphur?

Ans. 8

Sol.

Reaction	N_4S_4	$\xrightarrow{\text{High temp.}}$	$2N_2 + \text{sulphur vapours}$
	1 Vol		2.5 Vol $(2 + 0.5)$
	1 molecule		2.5 molecules

2.5 molecules of N_2 + sulphur vapours = 4 atoms of nitrogen + 0.5 molecule of sulphur vapour. Hence the formula S_4N_4 indicates that :

0.5 molecule of sulphur contains S-atoms = 4

1 molecule of sulphur contains S-atoms $= \dfrac{4}{0.5} = 8$

$\therefore$ Formula of sulphur $= S_8$

54. 15 ml of gaseous hydrocarbon required for complete combustion 357 ml of air (21% of O_2 by volume and the gaseous products occupied 327 ml (all volumes being measured at S.T.P.). What will be x if hydrocarbon is C_xH_y.

Ans. 3

Sol.

C_3H_8

Let C_xH_y be the hydrocarbon

$$C_xH_y + \left(x+\frac{y}{4}\right) O_2 \rightarrow xCO_2 + \frac{y}{2} H_2O$$

1 Vol. $\left(x+\frac{y}{4}\right)$ Vol. x Vol.

From equation, the contraction

$= 1 + (x + y/4) - (x + 0) = 1 + y/4$

for 15 ml gas, contraction =

$15\,(1 + y/4) = (15 + 357) - (327) = 45$

$y = 8$

The gaseous products after contraction = 327

This includes vol. of CO_2 plus volume of N_2 in the air (O_2 is completely used up). So calculate the volume of N_2 in the air.

Vol. of $O_2 = 0.21 \times 357 = 75$ ml

Vol. of $N_2 = 357 - 75 = 282$ ml

Now, Vol. of N_2 + Vol. of $CO_2 = 327$ ml

Vol. of $CO_2 = 327 - 282 = 45$ ml

The volume of CO_2 produced = 15 x

$15\,x = 45$

$x = 3$

Hence the hydrocarbon is C_3H_8

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