



This booklet contains 24 printed pages.

PAPER - 1 : CHEMISTRY, MATHEMATICS & PHYSICS

Test Booklet Code

F

Do not open this Test Booklet until you are asked to do so.  
Read carefully the Instructions on the Back Cover of this Test Booklet.

Important Instructions :

1. Immediately fill in the particulars on this page of the Test Booklet with only Blue / Black Ball Point Pen provided by the Board.
2. The Answer Sheet is kept inside this Test Booklet. When you are directed to open the Test Booklet, take out the Answer Sheet and fill in the particulars carefully.
3. The test is of 3 hours duration.
4. The Test Booklet consists of 90 questions. The maximum marks are 360.
5. There are three parts in the question paper A, B, C consisting of Chemistry, Mathematics and Physics having 30 questions in each part of equal weightage. Each question is allotted 4 (four) marks for each correct response.
6. Candidates will be awarded marks as stated above in instruction No. 5 for correct response of each question.  $\frac{1}{4}$  (one fourth) marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
7. There is only one correct response for each question. Filling up more than one response in each question will be treated as wrong response and marks for wrong response will be deducted accordingly as per instruction 6 above.
8. For writing particulars/marking responses on Side-1 and Side-2 of the Answer Sheet use only Blue/Black Ball Point Pen provided by the Board.
9. No candidate is allowed to carry any textual material, printed or written, bits of papers, pager, mobile phone, any electronic device, etc. except the Admit Card inside the examination room/hall.
10. Rough work is to be done on the space provided for this purpose in the Test Booklet only. This space is given at the bottom of each page and in three pages (Pages 21 - 23) at the end of the booklet.
11. On completion of the test, the candidate must hand over the Answer Sheet to the Invigilator on duty in the Room/Hall. However, the candidates are allowed to take away this Test Booklet with them.
12. The CODE for this Booklet is F. Make sure that the CODE printed on Side-2 of the Answer Sheet and also tally the serial number of the Test Booklet and Answer Sheet are the same as that on this booklet. In case of discrepancy, the candidate should immediately report the matter to the Invigilator for replacement of both the Test Booklet and the Answer Sheet.
13. Do not fold or make any stray mark on the Answer Sheet.

Name of the Candidate (in Capital letters) : ROSELYN LORSON

Roll Number : in figures 

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: in words One crore seventy one lakhs seven thousand nine hundred thirty eight

Examination Centre Number: 

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Name of Examination Centre (in Capital letters) : SATHAYE COLLEGE

Candidate's Signature:

1. Invigilator's Signature:   
2. Invigilator's Signature:

PART A - CHEMISTRY

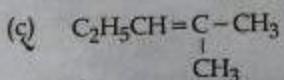
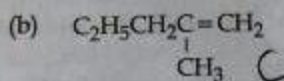
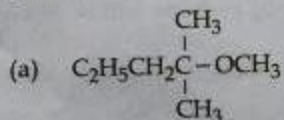
1. A stream of electrons from a heated filament was passed between two charged plates kept at a potential difference  $V$  esu. If  $e$  and  $m$  are charge and mass of an electron, respectively, then the value of  $h/\lambda$  (where  $\lambda$  is wavelength associated with electron wave) is given by :

- (1)  $2meV$
- (2)  $\sqrt{meV}$
- (3)  $\sqrt{2meV}$
- (4)  $meV$

$$E = h\nu = \frac{hc}{\lambda}$$

$$\nu = \frac{eV}{h}$$

2. 2-chloro-2-methylpentane on reaction with sodium methoxide in methanol yields :



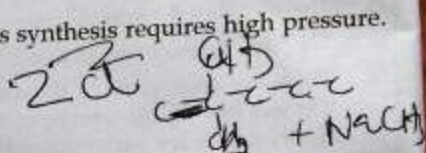
- (1) (a) and (c)
- (2) (c) only
- (3) (a) and (b)
- (4) All of these

3. Which of the following compounds is metallic and ferromagnetic ?

- (1)  $\text{CrO}_2$
- (2)  $\text{VO}_2$
- (3)  $\text{MnO}_2$
- (4)  $\text{TiO}_2$

4. Which of the following statements about low density polythene is FALSE ?

- (1) It is a poor conductor of electricity.
- (2) Its synthesis requires dioxygen or a peroxide initiator as a catalyst.
- (3) It is used in the manufacture of buckets, dust-bins etc.
- (4) Its synthesis requires high pressure.



5. For a linear plot of  $\log(x/m)$  versus  $\log p$  in a Freundlich adsorption isotherm, which of the following statements is correct? ( $k$  and  $n$  are constants)

- (1)  $1/n$  appears as the intercept.
- (2) Only  $1/n$  appears as the slope.
- (3)  $\log(1/n)$  appears as the intercept.
- (4) Both  $k$  and  $1/n$  appear in the slope term.

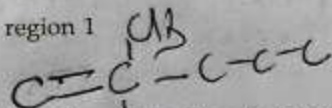
6. The heats of combustion of carbon and carbon monoxide are  $-393.5$  and  $-283.5 \text{ kJ mol}^{-1}$ , respectively. The heat of formation (in kJ) of carbon monoxide per mole is :

- (1) 676.5
- (2) -676.5
- (3) -110.5
- (4) 110.5

7. The hottest region of Bunsen flame shown in the figure below is :

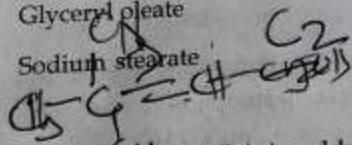


- (1) region 2  
 (2) region 3  
 (3) region 4  
 (4) region 1



8. Which of the following is an anionic detergent ?

- (1) Sodium lauryl sulphate  
 (2) Cetyltrimethyl ammonium bromide  
 (3) Glycerol oleate  
 (4) Sodium stearate



9. 18 g glucose ( $C_6H_{12}O_6$ ) is added to 178.2 g water. The vapor pressure of water (in torr) for this aqueous solution is :

- (1) 76.0  
 (2) 752.4  
 (3) 759.0  
 (4) 7.6

VP

10. The distillation technique most suited for separating glycerol from spent-lye in the soap industry is :

- (1) Fractional distillation  
 (2) Steam distillation  
 (3) Distillation under reduced pressure  
 (4) Simple distillation

SR

11. The species in which the N atom is in a state of  $sp$  hybridization is :

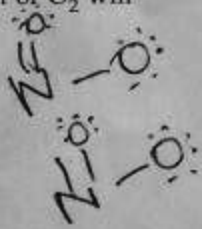
- (1)  $NO_2$   
 (2)  $NO_3^-$   
 (3)  $NO_2^-$   
 (4)  $NO_2^+$



Handwritten calculation:  $3 + 4 = 7 - 1 = 6$

12. Decomposition of  $H_2O_2$  follows a first order reaction. In fifty minutes the concentration of  $H_2O_2$  decreases from 0.5 to 0.125 M in one such decomposition. When the concentration of  $H_2O_2$  reaches 0.05 M, the rate of formation of  $O_2$  will be :

- (1)  $6.93 \times 10^{-4} \text{ mol min}^{-1}$   
 (2)  $2.66 \text{ L min}^{-1}$  at STP  
 (3)  $1.34 \times 10^{-2} \text{ mol min}^{-1}$   
 (4)  $6.93 \times 10^{-2} \text{ mol min}^{-1}$



13. The pair having the same magnetic moment is :

[At.No. : Cr = 24, Mn = 25, Fe = 26, Co = 27]

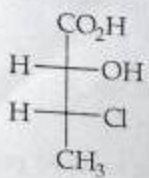
- (1)  $[Cr(H_2O)_6]^{2+}$  and  $[Fe(H_2O)_6]^{2+}$   
 (2)  $[Mn(H_2O)_6]^{2+}$  and  $[Cr(H_2O)_6]^{2+}$   
 (3)  $[CoCl_4]^{2-}$  and  $[Fe(H_2O)_6]^{2+}$   
 (4)  $[Cr(H_2O)_6]^{2+}$  and  $[CoCl_4]^{2-}$

SPACE FOR ROUGH WORK

Handwritten scribbles and numbers at the bottom left corner.

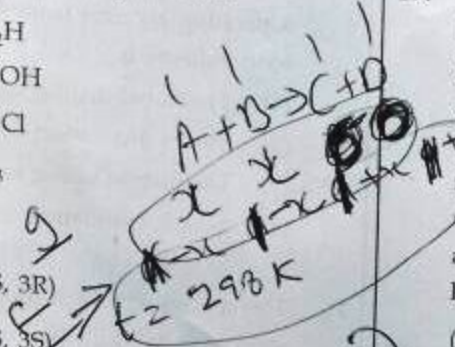
D-2 at eq → x

14. The absolute configuration of



is:

- (1) (2S, 3R)
- (2) (2S, 3S)
- (3) (2R, 3R)
- (4) (2R, 3S)



15. The equilibrium constant at 298 K for a reaction  $A + B = C + D$  is 100. If the initial concentration of all the four species were 1 M each, then equilibrium concentration of D (in mol L<sup>-1</sup>) will be: K

- (1) 0.818
- (2) 1.818
- (3) 1.182
- (4) 0.182

Handwritten solution for Q15:  $K_{eq} = 100$ . 
$$100 = \frac{[C][D]}{[A][B]}$$

16. Which one of the following ores is best concentrated by froth floatation method?

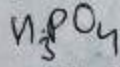
- (1) Siderite
- (2) Galena
- (3) Malachite
- (4) Magnetite

17. At 300 K and 1 atm, 15 mL of a gaseous hydrocarbon requires 375 mL air containing 20% O<sub>2</sub> by volume for complete combustion. After combustion the gases occupy 330 mL. Assuming that the water formed is in liquid form and the volumes were measured at the same temperature and pressure, the formula of the hydrocarbon is:

- (1) C<sub>3</sub>H<sub>8</sub>
- (2) C<sub>4</sub>H<sub>8</sub>
- (3) C<sub>4</sub>H<sub>10</sub>
- (4) C<sub>3</sub>H<sub>6</sub>

18. The pair in which phosphorous atoms have a formal oxidation state of +3 is:

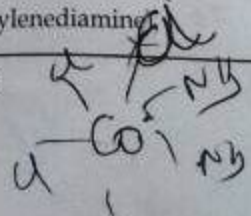
- (1) Pyrophosphorous and hypophosphoric acids
- (2) Orthophosphorous and hypophosphoric acids
- (3) Pyrophosphorous and pyrophosphoric acids
- (4) Orthophosphorous and pyrophosphorous acids



19. Which one of the following complexes shows optical isomerism?

- (1) *cis*[Co(en)<sub>2</sub>Cl<sub>2</sub>]Cl
- (2) *trans*[Co(en)<sub>2</sub>Cl<sub>2</sub>]Cl
- (3) [Co(NH<sub>3</sub>)<sub>4</sub>Cl<sub>2</sub>]Cl
- (4) [Co(NH<sub>3</sub>)<sub>3</sub>Cl<sub>3</sub>]

(en = ethylenediamine)



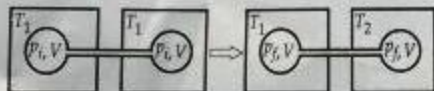
20. The reaction of zinc with dilute and concentrated nitric acid, respectively, produces :
- (1)  $\text{NO}_2$  and  $\text{NO}$   
 (2)  $\text{NO}$  and  $\text{N}_2\text{O}$   $103-99$   
 (3)  $\text{NO}_2$  and  $\text{N}_2\text{O}$   $B = 0$   
 (4)  $\text{N}_2\text{O}$  and  $\text{NO}_2$   
 $101 + 2 - 99$
21. Which one of the following statements about water is FALSE ?
- (1) Water can act both as an acid and as a base. ✓  
 (2) There is extensive intramolecular hydrogen bonding in the condensed phase. ✓  
 (3) Ice formed by heavy water sinks in normal water. ✓  
 (4) Water is oxidized to oxygen during photosynthesis. ✓  $W20$
22. The concentration of fluoride, lead, nitrate and iron in a water sample from an underground lake was found to be 1000 ppb, 40 ppb, 100 ppm and 0.2 ppm, respectively. This water is unsuitable for drinking due to high concentration of :
- (1) Lead  
 (2) Nitrate  
 (3) Iron  
 (4) Fluoride
23. The main oxides formed on combustion of Li, Na and K in excess of air are, respectively :
- (1)  $\text{LiO}_2$ ,  $\text{Na}_2\text{O}_2$  and  $\text{K}_2\text{O}$   
 (2)  $\text{Li}_2\text{O}_2$ ,  $\text{Na}_2\text{O}_2$  and  $\text{KO}_2$   
 (3)  $\text{Li}_2\text{O}$ ,  $\text{Na}_2\text{O}_2$  and  $\text{KO}_2$   
 (4)  $\text{Li}_2\text{O}$ ,  $\text{Na}_2\text{O}$  and  $\text{KO}_2$
24. Thiol group is present in :
- (1) Cystine  
 (2) Cysteine  
 (3) Methionine  
 (4) Cytosine
25. Galvanization is applying a coating of :
- (1) Cr  
 (2) Cu  
 (3) Zn  
 (4) Pb
26. Which of the following atoms has the highest first ionization energy ?
- (1) Na  
 (2) K  
 (3) Sc  
 (4) Rb

$$2 \text{NaOH} + \text{Br}_2 \rightarrow \text{NaOBr} + \text{NaBr}$$

27. In the Hofmann bromamide degradation reaction, the number of moles of NaOH and Br<sub>2</sub> used per mole of amine produced are :

- (1) Four moles of NaOH and two moles of Br<sub>2</sub>.
- (2) Two moles of NaOH and two moles of Br<sub>2</sub>.
- (3) Four moles of NaOH and one mole of Br<sub>2</sub>.
- (4) One mole of NaOH and one mole of Br<sub>2</sub>.

28. Two closed bulbs of equal volume (V) containing an ideal gas initially at pressure p<sub>i</sub> and temperature T<sub>1</sub> are connected through a narrow tube of negligible volume as shown in the figure below. The temperature of one of the bulbs is then raised to T<sub>2</sub>. The final pressure p<sub>f</sub> is :

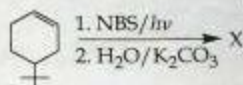


- (1)  $2p_i \left( \frac{T_1}{T_1 + T_2} \right)$
- (2)  $2p_i \left( \frac{T_2}{T_1 + T_2} \right)$
- (3)  $2p_i \left( \frac{T_1 T_2}{T_1 + T_2} \right)$
- (4)  $p_i \left( \frac{T_1 T_2}{T_1 + T_2} \right)$

29. The reaction of propene with HOCl (Cl<sub>2</sub> + H<sub>2</sub>O) proceeds through the intermediate :

- (1) CH<sub>3</sub>-CH<sup>+</sup>-CH<sub>2</sub>-Cl
- (2) CH<sub>3</sub>-CH(OH)-CH<sub>2</sub><sup>+</sup>
- (3) CH<sub>3</sub>-CHCl-CH<sub>2</sub><sup>+</sup>
- (4) CH<sub>3</sub>-CH<sup>+</sup>-CH<sub>2</sub>-OH

30. The product of the reaction given below is :



- (1)
  - (2)
  - (3)
  - (4)
- 2x - 5 = 0

$$2\left(\frac{1}{3}\right) + \frac{2}{3}$$

$$2\left(\frac{1}{3}\right) + \frac{2}{3}$$

$$2 = 2$$

PART B - MATHEMATICS

31. Two sides of a rhombus are along the lines,  $x - y + 1 = 0$  and  $7x - y - 5 = 0$ . If its diagonals intersect at  $(-1, -2)$ , then which one of the following is a vertex of this rhombus?

(1)  $(-3, -8)$  X

(2)  $(\frac{1}{3}, -\frac{8}{3})$  X

(3)  $(-\frac{10}{3}, -\frac{7}{3})$

(4)  $(-3, -9)$  X

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

32. If the 2<sup>nd</sup>, 5<sup>th</sup> and 9<sup>th</sup> terms of a non-constant A.P. are in G.P., then the common ratio of this G.P. is:

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

(2) 1

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

(4)  $\frac{8}{5}$

$$\begin{aligned} -x + y + 1 &= 0 \\ 7x - y - 5 &= 0 \end{aligned}$$

$$\begin{aligned} 6x - 6 &= 0 \\ x &= 1 \end{aligned}$$

$$\begin{aligned} -1 - y + 1 &= 0 \\ y &= 2 \end{aligned}$$

33. Let P be the point on the parabola,  $y^2 = 8x$  which is at a minimum distance from the centre C of the circle,  $x^2 + (y+6)^2 = 1$ . Then the equation of the circle, passing through C and having its centre at P is:

(1)  $x^2 + y^2 - x + 4y - 12 = 0$

(2)  $x^2 + y^2 - \frac{x}{4} + 2y - 24 = 0$

(3)  $x^2 + y^2 - 4x + 9y + 18 = 0$

(4)  $x^2 + y^2 - 4x + 8y + 12 = 0$

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

34. The system of linear equations

$$4x - y = 2y - 4$$

$$x + \lambda y - z = 0$$

$$4x - 2y = 0$$

$$\lambda x - y - z = 0$$

$$x + y - \lambda z = 0$$

$$2x - y = 0$$

$$2(-1) + (2)$$

has a non-trivial solution for:

$$-6 + \lambda$$

- (1) exactly one value of  $\lambda$ .

$$2(-3) - (-9)$$

- (2) exactly two values of  $\lambda$ .

$$= -6 + 9$$

- (3) exactly three values of  $\lambda$ .

- (4) infinitely many values of  $\lambda$ .

SPACE FOR ROUGH WORK



$$\begin{aligned} 2x &= y \\ x &= \frac{y}{2} \end{aligned}$$

$$(1) 2$$

35. If  $f(x) + 2f\left(\frac{1}{x}\right) = 3x$ ,  $x \neq 0$ , and  $S = \{x \in \mathbb{R} : f(x) = f(-x)\}$ ; then S :

- (1) contains exactly one element.
- (2) contains exactly two elements.
- (3) contains more than two elements.
- (4) is an empty set.

$$f\left(\frac{1}{x}\right) + 2f(-x) = 3x$$

36. Let  $p = \lim_{x \rightarrow 0^+} (1 + \tan^2 \sqrt{x})^{\frac{1}{2x}}$  then  $\log p$  is equal to :

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

$$(1 + \tan^2 \sqrt{x})^{\frac{1}{2x}} = (1 + \tan^2 x)^{\frac{1}{n-1}} = \ln e^{\frac{1}{n-1}}$$

37. A value of  $\theta$  for which  $\frac{2 + 3i \sin \theta}{1 - 2i \sin \theta}$  is purely imaginary, is :

- (1)  $\frac{\pi}{6}$
- (2)  $\sin^{-1}\left(\frac{\sqrt{3}}{4}\right)$
- (3)  $\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$
- (4)  $\frac{\pi}{3}$

$$\frac{2 + 3i \sin \theta}{1 - 2i \sin \theta} = i$$

$$\frac{2 + 3i \cdot \frac{\sqrt{3}}{4}}{1 - 2i \cdot \frac{\sqrt{3}}{4}}$$

38. The eccentricity of the hyperbola whose length of the latus rectum is equal to 8 and the length of its conjugate axis is equal to half of the distance between its foci is :

- (1)  $\frac{4}{\sqrt{3}}$
- (2)  $\frac{2}{\sqrt{3}}$
- (3)  $\sqrt{3}$
- (4)  $\frac{4}{3}$

$$\frac{1}{2a} = \frac{1}{2c} \Rightarrow a = c$$

$$2b = 2c \Rightarrow b = c$$

$$e = \frac{c}{a} = 1$$

39. If the standard deviation of the numbers 2, 3,  $a$  and 11 is 3.5, then which of the following is true ?

- (1)  $3a^2 - 32a + 84 = 0$
- (2)  $3a^2 - 34a + 91 = 0$
- (3)  $3a^2 - 23a + 44 = 0$
- (4)  $3a^2 - 26a + 35 = 0$

$$\frac{8 + 2i\sqrt{3}}{8 - 2i\sqrt{3}}$$

$$\frac{2\sqrt{3} + 3i}{\sqrt{3} - 2i}$$

SPACE FOR ROUGH WORK

$$\frac{2 + 3i\sqrt{3}}{1 - 2i\sqrt{3}}$$

$$\frac{2 + 3i}{1 - 2i}$$

$$\frac{4 + 2i}{4 - 2i}$$



40. The integral  $\int \frac{2x^{12} + 5x^9}{(x^5 + x^3 + 1)^3} dx$  is equal to:

(1)  $\frac{x^{10}}{2(x^5 + x^3 + 1)^2} + C$

(2)  $\frac{x^5}{2(x^5 + x^3 + 1)^2} + C$

(3)  $\frac{-x^{10}}{2(x^5 + x^3 + 1)^2} + C$

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

where  $C$  is an arbitrary constant.

41. If the line,  $\frac{x-3}{2} = \frac{y+2}{-1} = \frac{z+4}{3}$  lies in the plane,  $lx + my - z = 9$ , then  $l^2 + m^2$  is equal to:

(1) 18

(2) 5

(3) 2

(4) 26

42. If  $0 \leq x < 2\pi$ , then the number of real values of  $x$ , which satisfy the equation  $\cos x + \cos 2x + \cos 3x + \cos 4x = 0$ , is:

- (1) 5  
(2) 7  
(3) 9  
(4) 3

$x^2 + 1 = t$   
 $5x^2 + 3\cos^2 x = 4t$

43. The area (in sq. units) of the region  $\{(x, y) : y^2 \geq 2x \text{ and } x^2 + y^2 \leq 4x, x \geq 0, y \geq 0\}$  is:

(1)  $\pi - \frac{8}{3}$

(2)  $\pi - \frac{4\sqrt{2}}{3}$

(3)  $\frac{\pi}{2} - \frac{2\sqrt{2}}{3}$

(4)  $\pi - \frac{4}{3}$

44. Let  $\vec{a}$ ,  $\vec{b}$  and  $\vec{c}$  be three unit vectors such that  $\vec{a} \times (\vec{b} \times \vec{c}) = \frac{\sqrt{3}}{2} (\vec{b} + \vec{c})$ . If  $\vec{b}$  is not parallel to  $\vec{c}$ , then the angle between  $\vec{a}$  and  $\vec{b}$  is:

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

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

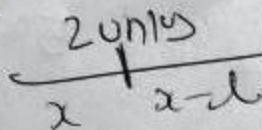
(3)  $\frac{5\pi}{6}$

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

SPACE FOR ROUGH WORK

46. A wire of length 2 units is cut into two parts which are bent respectively to form a square of side =  $x$  units and a circle of radius =  $r$  units. If the sum of the areas of the square and the circle so formed is minimum, then :

- (1)  $(4 - \pi)x = \pi r$   
 (2)  $x = 2r$   
 (3)  $2x = r$   
 (4)  $2x = (\pi + 4)r$



47. The distance of the point  $(1, -5, 9)$  from the plane  $x - y + z = 5$  measured along the line  $x = y = z$  is :

- (1)  $10\sqrt{3}$   
 (2)  $\frac{10}{\sqrt{3}}$   
 (3)  $\frac{20}{3}$   
 (4)  $3\sqrt{10}$

48. If a curve  $y = f(x)$  passes through the point  $(1, -1)$  and satisfies the differential equation,  $y(1 + xy) dx = x dy$ , then  $f\left(-\frac{1}{2}\right)$

is equal to :

- (1)  $-\frac{4}{5}$   
 (2)  $\frac{2}{5}$   
 (3)  $\frac{4}{5}$   
 (4)  $-\frac{2}{5}$

49. If the number of terms in the expansion of  $\left(1 - \frac{2}{x} + \frac{4}{x^2}\right)^{20}$ ,  $x \neq 0$ , is 28, then the sum of the coefficients of all the terms in this expansion, is :

- (1) 2187  
 (2) 243  
 (3) 729  
 (4) 64

50. Consider

$$f(x) = \tan^{-1}\left(\frac{\sqrt{1 + \sin x}}{\sqrt{1 - \sin x}}\right), x \in \left(0, \frac{\pi}{2}\right).$$

A normal to  $y = f(x)$  at  $x = \frac{\pi}{6}$  also passes through the point :

- (1)  $\left(0, \frac{2\pi}{3}\right)$   
 (2)  $\left(\frac{\pi}{6}, 0\right)$   
 (3)  $\left(\frac{\pi}{4}, 0\right)$   
 (4)  $(0, 0)$

51. For  $x \in \mathbb{R}$ ,  $f(x) = |\log 2 - \sin x|$  and  $g(x) = f(f(x))$ , then :

- (1)  $g'(0) = \cos(\log 2)$   
 (2)  $g'(0) = -\cos(\log 2)$   
 (3)  $g$  is differentiable at  $x = 0$  and  $g'(0) = -\sin(\log 2)$   
 (4)  $g$  is not differentiable at  $x = 0$

SPACE FOR ROUGH WORK

Handwritten notes:  $D = \frac{V}{L}$ ,  $t = \frac{V}{D}$

Handwritten notes:  $h$ ,  $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

51. Let two fair six-faced dice A and B be thrown simultaneously. If  $E_1$  is the event that die A shows up four,  $E_2$  is the event that die B shows up two and  $E_3$  is the event that the sum of numbers on both dice is odd, then which of the following statements is NOT true?

- (1)  $E_2$  and  $E_3$  are independent.
- (2)  $E_1$  and  $E_3$  are independent.
- (3)  $E_1, E_2$  and  $E_3$  are independent.
- (4)  $E_1$  and  $E_2$  are independent.

52. If  $A = \begin{bmatrix} 5a & -b \\ 3 & 2 \end{bmatrix}$  and  $A \text{ adj } A = A A^T$ , then  $5a + b$  is equal to:

- (1) 5
- (2) 4
- (3) 13
- (4) -1

$60$   
 $5+4$

53. The Boolean Expression  $(p \wedge \neg q) \vee q$  is equivalent to:

- (1)  $p \wedge q$
- (2)  $p \vee q$
- (3)  $p \vee \neg q$
- (4)  $\neg p \wedge q$

$p \wedge \neg q \vee q = p \vee q$   
 $3L - 3X$

54. The sum of all real values of  $x$  satisfying the equation


$$(x^2 - 5x + 5)^{\log(x^2 + 4x - 60)} = 1 \text{ is:}$$

- (1) -4
- (2) 6
- (3) 5
- (4) 3

$x^2 + 4x - 60 \log(x^2 - 5x + 5) = 1$   
 $x^2 - 5x + 5 = 1$   
 $x^2 + 4x - 60 = 0$   
 $(x+10)(x-6) = 0$   
 $x = -10, 6$   
 $12 > 5$   
 $(x+10) \times 5$

55. The centres of those circles which touch the circle,  $x^2 + y^2 - 8x - 8y - 4 = 0$ , externally and also touch the  $x$ -axis, lie on:

- (1) an ellipse which is not a circle.
- (2) a hyperbola.
- (3) a parabola.
- (4) a circle.

$x^2 - x - 5 = 0$   
 $-4 - 1$   
 $-5 + 10 - 6$   
 $10 - 6$   


56. If all the words (with or without meaning) having five letters, formed using the letters of the word SMALL and arranged as in a dictionary; then the position of the word SMALL is:

- (1) 59th
- (2) 52nd
- (3) 58th
- (4) 46th

$2L = 3X - 5 + 4$   
 $L = \frac{3X}{2}$   
 $t = 10 \times \frac{2}{2} = 10$

SPACE FOR ROUGH WORK

$\sqrt{5} = \frac{h}{L-x}$

$\frac{x}{\sqrt{5}} = \sqrt{3} L - u$   
 $2 = 3L - 3x$   
 $3(2-u)$   
 $4x = 3L$   
 $x = \frac{3L}{4}$   
 $\frac{3x}{2} = \frac{3L}{2}$   
 $\frac{2x}{2}$

57.  $\lim_{n \rightarrow \infty} \left( \frac{(n+1)(n+2)\dots 3n}{n^{2n}} \right)^{1/n}$  is equal to:

(1)  $\frac{27}{e^2}$

(2)  $\frac{9}{e^2}$

(3)  $3 \log 3 - 2$

(4)  $\frac{18}{e^4}$

Sum =  $\mu mg$

Sum =  $\mu mg$   
 $F = \mu mg$

58. If the sum of the first ten terms of the series

$$\left(1\frac{3}{5}\right)^2 + \left(2\frac{2}{5}\right)^2 + \left(3\frac{1}{5}\right)^2 + 4^2 + \left(4\frac{4}{5}\right)^2 + \dots,$$

is  $\frac{16}{5}m$ , then  $m$  is equal to:

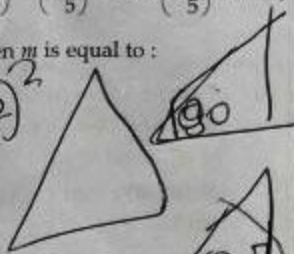
(1) 101

(2) 100

(3) 99

(4) 102

$\left(\frac{3}{5}\right)^2 + \left(\frac{4}{5}\right)^2 + \left(\frac{3}{5}\right)^2$



$N = \mu N \cos \theta - mg = 0$   
 $N = \mu N \cos \theta + mg$

59. If one of the diameters of the circle, given by the equation,  $x^2 + y^2 - 4x + 6y - 12 = 0$ , is a chord of a circle  $S$ , whose centre is at  $(-3, 2)$ , then the radius of  $S$  is:

(1)  $5\sqrt{3}$

(2) 5

(3) 10

(4)  $5\sqrt{2}$

$N = \mu N + \mu mg$   
 $N = \mu N + \mu mg$

60. A man is walking towards a vertical pillar in a straight path, at a uniform speed. At a certain point  $A$  on the path, he observes that the angle of elevation of the top of the pillar is  $30^\circ$ . After walking for 10 minutes from  $A$  in the same direction, at a point  $B$ , he observes that the angle of elevation of the top of the pillar is  $60^\circ$ . Then the time taken (in minutes) by him, from  $B$  to reach the pillar, is:

(1) 10

(2) 20

(3) 5

(4) 6



$\frac{\sqrt{3}}{2} = \frac{2}{2x_1}$   
 $x_1 = \frac{4}{\sqrt{3}} \times 2$

SPACE FOR ROUGH WORK

$F = \mu N \sin \theta =$   
 $F = \mu$

PART C - PHYSICS

ALL THE GRAPHS GIVEN ARE SCHEMATIC AND NOT DRAWN TO SCALE.

61. A uniform string of length 20 m is suspended from a rigid support. A short wave pulse is introduced at its lowest end. It starts moving up the string. The time taken to reach the support is :  
(take  $g = 10 \text{ ms}^{-2}$ )

- (1) 2 s  
(2)  $2\sqrt{2}$  s  
(3)  $\sqrt{2}$  s  
(4)  $2\pi\sqrt{2}$  s

$t = \sqrt{\frac{2L}{g \cos \theta}}$   
 $\frac{\sqrt{20 \times 2}}{10 \cos 90}$

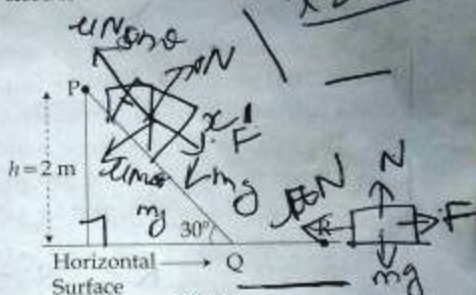
62. A person trying to lose weight by burning fat lifts a mass of 10 kg upto a height of 1 m 1000 times. Assume that the potential energy lost each time he lowers the mass is dissipated. How much fat will he use up considering the work done only when the weight is lifted up? Fat supplies  $3.8 \times 10^7 \text{ J}$  of energy per kg which is converted to mechanical energy with a 20% efficiency rate. Take  $g = 9.8 \text{ ms}^{-2}$ :

- (1)  $6.45 \times 10^{-3} \text{ kg}$   
(2)  $9.89 \times 10^{-3} \text{ kg}$   
(3)  $12.89 \times 10^{-3} \text{ kg}$   
(4)  $2.45 \times 10^{-3} \text{ kg}$

$\frac{8}{\sqrt{3}}$   
 $1.73$

63. A point particle of mass  $m$ , moves along the uniformly rough track PQR as shown in the figure. The coefficient of friction, between the particle and the rough track equals  $\mu$ . The particle is released, from rest, from the point P and it comes to rest at a point R. The energies, lost by the ball, over the parts, PQ and QR, of the track, are equal to each other, and no energy is lost when particle changes direction from PQ to QR.

The values of the coefficient of friction  $\mu$  and the distance  $x (=QR)$ , are, respectively close to :



- (1) 0.2 and 3.5 m  
(2) 0.29 and 3.5 m  
(3) 0.29 and 6.5 m  
(4) 0.2 and 6.5 m

$x_1 = x_2$   
2 energy = work done = force  $\times$  disp



SPACE FOR ROUGH WORK

$10g x_1 = \frac{x_2}{2}$   
 $10N = \mu N \sin 30 \times 2$

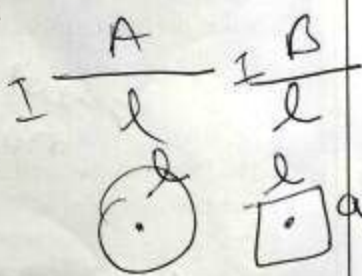
$B_A =$

$B_B =$

$R = \frac{l}{A}$

64. Two identical wires A and B, each of length  $l$ , carry the same current  $I$ . Wire A is bent into a circle of radius  $R$  and wire B is bent to form a square of side  $a$ . If  $B_A$  and  $B_B$  are the values of magnetic field at the centres of the circle and square respectively, then the ratio  $\frac{B_A}{B_B}$  is:

- (1)  $\frac{\pi^2}{16\sqrt{2}}$
- (2)  $\frac{\pi^2}{16}$
- (3)  $\frac{\pi^2}{8\sqrt{2}}$
- (4)  $\frac{\pi^2}{8}$



65. A galvanometer having a coil resistance of  $100 \Omega$  gives a full scale deflection, when a current of  $1 \text{ mA}$  is passed through it. The value of the resistance, which can convert this galvanometer into ammeter giving a full scale deflection for a current of  $10 \text{ A}$ , is:

- (1)  $2 \Omega$
- (2)  $0.1 \Omega$
- (3)  $3 \Omega$
- (4)  $0.01 \Omega$

$R = 100 \Omega$   
 $I = 1 \text{ mA} = 1 \times 10^{-3} \text{ A}$   
 $I = 10 \text{ A}$

66. An observer looks at a distant tree of height  $10 \text{ m}$  with a telescope of magnifying power of  $20$ . To the observer the tree appears:

- (1) 10 times nearer.
- (2) 20 times taller.
- (3) 20 times nearer.
- (4) 10 times taller.

67. The temperature dependence of resistances of Cu and undoped Si in the temperature range  $300\text{--}400 \text{ K}$ , is best described by:

- (1) Linear increase for Cu, exponential increase for Si.
- (2) Linear increase for Cu, exponential decrease for Si.
- (3) Linear decrease for Cu, linear decrease for Si.
- (4) Linear increase for Cu, linear increase for Si.

68. Choose the correct statement:

- (1) In amplitude modulation the frequency of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.
- (2) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.
- (3) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the frequency of the audio signal.
- (4) In amplitude modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.

SPACE FOR ROUGH WORK

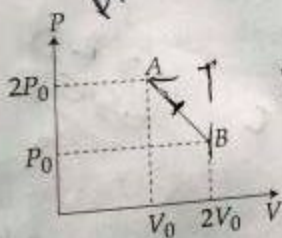
$I_2 = \frac{I_1 R_1}{R_2}$   
 $V = IR$   
 $R_2 = \frac{I_1}{I_2} \times R_1$

Half-lives of two radioactive elements A and B are 20 minutes and 40 minutes, respectively. Initially, the samples have equal number of nuclei. After 80 minutes, the ratio of decayed numbers of A and B nuclei will be :

- (1) 4 : 1  
 (2) 1 : 4  
 (3) 5 : 4  
 (4) 1 : 16

~~20/20~~  
 log

'n' moles of an ideal gas undergoes a process A → B as shown in the figure. The maximum temperature of the gas during the process will be :



- (1)  $\frac{3 P_0 V_0}{2 n R}$   
 (2)  $\frac{9 P_0 V_0}{2 n R}$   
 (3)  $\frac{9 P_0 V_0}{4 n R}$   
 (4)  $\frac{9 P_0 V_0}{4 n R}$

$PV = nRT$   
 $T \propto PV$   
 $2P_0 \times 2V_0$   
 $2P_0 + P_0$   
 $\frac{2P_0 + P_0}{2}$   
 $V_0$   
 $2V_0$

$x - y + 1 = 0$   
 $-x + y + 1 = 0$   
 $2x - 2 = 0$   
 $x = 1$

SPACE FOR ROUGH WORK

An arc lamp requires a direct current of 10 A at 80 V to function. If it is connected to a 220 V (rms), 50 Hz AC supply, the series inductor needed for it to work is close to :

- (1) 0.08 H  
 (2) 0.044 H  
 (3) 0.065 H  
 (4) 80 H

$220 \times 200 = n \times R$   
 $44000 = n \times R$

72. A pipe open at both ends has a fundamental frequency  $f$  in air. The pipe is dipped vertically in water so that half of it is in water. The fundamental frequency of the air column is now :

- (1)  $\frac{3f}{4}$   
 (2)  $\frac{2f}{3}$   
 (3)  $f$   
 (4)  $\frac{f}{2}$

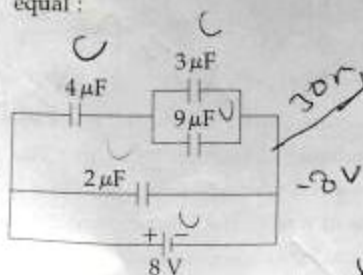
$f \sim \frac{1}{2L}$   
 $\frac{3f}{2}$   
 $\frac{2f}{3}$   
 $\frac{3P_0}{2}$   
 $\frac{3P_0}{2}$

73. The box of a pin hole camera, of length  $L$ , has a hole of radius  $a$ . It is assumed that when the hole is illuminated by a parallel beam of light of wavelength  $\lambda$  the spread of the spot (obtained on the opposite wall of the camera) is the sum of its geometrical spread and the spread due to diffraction. The spot would then have its minimum size (say  $b_{\min}$ ) when :

- (1)  $a = \sqrt{\lambda L}$  and  $b_{\min} = \left(\frac{4 \lambda L^2}{L}\right)$   
 (2)  $a = \sqrt{\lambda L}$  and  $b_{\min} = \sqrt{4 \lambda L}$   
 (3)  $a = \frac{\lambda^2}{L}$  and  $b_{\min} = \sqrt{4 \lambda L}$   
 (4)  $a = \frac{\lambda^2}{L}$  and  $b_{\min} = \left(\frac{2 \lambda^2}{L}\right)$

$\frac{2}{3} - y + 1 = 0$   
 $y = \frac{2}{3} + 1 = \frac{2+3}{3} = \frac{5}{3}$

74. A combination of capacitors is set up as shown in the figure. The magnitude of the electric field, due to a point charge  $Q$  (having a charge equal to the sum of the charges on the  $4 \mu\text{F}$  and  $9 \mu\text{F}$  capacitors), at a point distant  $30 \text{ m}$  from it, would equal :



- (1)  $360 \text{ N/C}$   
 (2)  $420 \text{ N/C}$   
 (3)  $480 \text{ N/C}$   
 (4)  $240 \text{ N/C}$

75. Arrange the following electromagnetic radiations per quantum in the order of increasing energy :

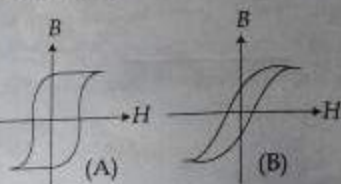
A : Blue light    B : Yellow light

C : X-ray    D : Radiowave

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

Handwritten notes for Q75:  
 $v = \lambda \nu$   
 $c = \lambda \nu$   
 $\frac{c}{\lambda} = \frac{c}{\lambda} \Rightarrow \lambda \propto \frac{1}{\nu}$   
 $A < B < C$

76. Hysteresis loops for two magnetic materials A and B are given below :



These materials are used to make magnets for electric generators, transformer core and electromagnet core. Then it is proper to use :

- (1) A for electromagnets and B for electric generators.  
 (2) A for transformers and B for electric generators.  
 (3) B for electromagnets and transformers.  
 (4) A for electric generators and transformers.

Handwritten notes for Q76:  
 $\frac{65}{100} \times 100$   
 $\frac{65}{100} \times 100$

77. A pendulum clock loses  $12 \text{ s}$  a day if the temperature is  $40^\circ\text{C}$  and gains  $4 \text{ s}$  a day if the temperature is  $20^\circ\text{C}$ . The temperature at which the clock will show correct time, and the co-efficient of linear expansion ( $\alpha$ ) of the metal of the pendulum shaft are respectively :

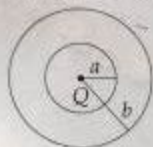
- (1)  $60^\circ\text{C}$ ;  $\alpha = 1.85 \times 10^{-4}/^\circ\text{C}$   
 (2)  $30^\circ\text{C}$ ;  $\alpha = 1.85 \times 10^{-3}/^\circ\text{C}$   
 (3)  $55^\circ\text{C}$ ;  $\alpha = 1.85 \times 10^{-2}/^\circ\text{C}$   
 (4)  $25^\circ\text{C}$ ;  $\alpha = 1.85 \times 10^{-5}/^\circ\text{C}$

Handwritten notes for Q77:  
 $100 \times \frac{T - 20}{100} = -12$   
 $100 \times \frac{T - 40}{100} = 4$

Handwritten calculation at the bottom of the page:  
 $(9 \times 10^9) \left( 4 + \left( \frac{1}{3} + \frac{1}{9} \right) + 2 \right) \times \left( \frac{1}{5} + \frac{1}{9} \right) \times 10^{-20}$



78. The region between two concentric spheres of radii 'a' and 'b', respectively (see figure), has volume charge density  $\rho = \frac{A}{r}$ , where A is a constant and r is the distance from the centre. At the centre of the spheres is a point charge Q. The value of A such that the electric field in the region between the spheres will be constant, is :

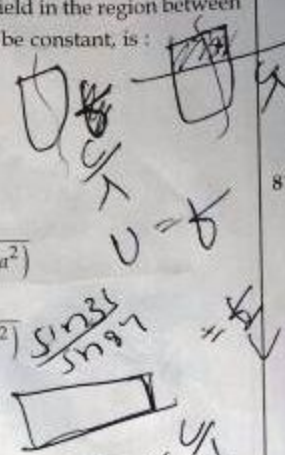


(1)  $\frac{Q}{2\pi(b^2 - a^2)}$

(2)  $\frac{2Q}{\pi(a^2 - b^2)}$

(3)  $\frac{2Q}{\pi a^2}$

(4)  $\frac{Q}{2\pi a^2}$



$n_2 = \frac{c}{v} = \frac{3 \times 10^8}{2 \times 10^8} = 1.5$

79. In an experiment for determination of refractive index of glass of a prism by  $i - \delta$  plot, it was found that a ray incident at angle  $35^\circ$ , suffers a deviation of  $40^\circ$  and that it emerges at angle  $79^\circ$ . In that case which of the following is closest to the maximum possible value of the refractive index ?

(1) 1.6

(2) 1.7

(3) 1.8

(4) 1.9

$n_c = \frac{1.5}{1.5} = 1$   
 $v = \frac{c}{\lambda} = \frac{3 \times 10^8}{500 \times 10^{-9}} = 6 \times 10^{14}$

80. A student measures the time period of 100 oscillations of a simple pendulum four times. The data set is 90 s, 91 s, 95 s and 92 s. If the minimum division in the measuring clock is 1 s, then the reported mean time should be :

(1)  $92 \pm 5.0$  s

(2)  $92 \pm 1.8$  s

(3)  $92 \pm 3$  s

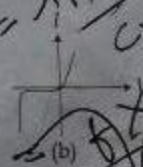
(4)  $92 \pm 2$  s

$\frac{100}{4} = 25$   
 $\frac{90 + 91 + 95 + 92}{4} = 92$   
 $\Delta t = 5$   
 $\Delta t = 1.8$   
 $\Delta t = 3$   
 $\Delta t = 2$

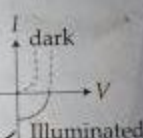
81. Identify the semiconductor devices whose characteristics are given below, in the order (a), (b), (c), (d) :



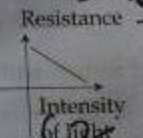
(a)



(b)



(c)



(d)

- (1) Zener diode, Simple diode, Light dependent resistance, Solar cell  
 (2) Solar cell, Light dependent resistance, Zener diode, Simple diode  
 (3) Zener diode, Solar cell, Simple diode, Light dependent resistance  
 (4) Simple diode, Zener diode, Solar cell, Light dependent resistance

SPACE FOR ROUGH WORK

Handwritten rough work including:  
 $c = \frac{v}{\lambda} = \frac{3 \times 10^8}{500 \times 10^{-9}} = 6 \times 10^{14}$   
 $\omega = 2\pi \nu = 2\pi \times 6 \times 10^{14} = 12\pi \times 10^{14}$   
 $\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{6 \times 10^{14}} = 500 \times 10^{-9}$   
 $\nu = \frac{c}{\lambda} = \frac{3 \times 10^8}{500 \times 10^{-9}} = 6 \times 10^{14}$   
 $\omega = 2\pi \nu = 12\pi \times 10^{14}$   
 $\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{6 \times 10^{14}} = 500 \times 10^{-9}$

82. Radiation of wavelength  $\lambda$ , is incident on a photocell. The fastest emitted electron has speed  $v$ . If the wavelength is changed to  $\frac{3\lambda}{4}$ , the speed of the fastest emitted electron will be :

(1)  $< v\left(\frac{4}{3}\right)^{\frac{1}{2}}$

(2)  $= v\left(\frac{4}{3}\right)^{\frac{1}{2}}$

(3)  $= v\left(\frac{3}{4}\right)^{\frac{1}{2}}$

83. A particle performs simple harmonic motion with amplitude  $A$ . Its speed is trebled at the instant that it is at a distance  $\frac{2A}{3}$  from equilibrium position. The new amplitude of the motion is :

(1)  $\frac{3A}{4}$

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

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

(4)  $\frac{A}{3}\sqrt{41}$

84. A particle of mass  $m$  is moving along the side of a square of side 'a', with a uniform speed  $v$  in the  $x$ - $y$  plane as shown in the figure :



Which of the following statements is false for the angular momentum  $\vec{L}$  about the origin ?

(1)  $\vec{L} = mv \left[ \frac{R}{\sqrt{2}} - a \right] \hat{k}$  when the particle is moving from C to D.

(2)  $\vec{L} = mv \left[ \frac{R}{\sqrt{2}} + a \right] \hat{k}$  when the particle is moving from B to C.

(3)  $\vec{L} = \frac{mv}{\sqrt{2}} R \hat{k}$  when the particle is moving from D to A.

(4)  $\vec{L} = -\frac{mv}{\sqrt{2}} R \hat{k}$  when the particle is moving from A to B.

Handwritten rough work including calculations:  $25 + 60 = 320$ ,  $25 = 18$ ,  $-12 = 40 - t$ ,  $4 = 20 - t$ ,  $20 - t$ .

85. An ideal gas undergoes a quasi static, reversible process in which its molar heat capacity  $C$  remains constant. If during this process the relation of pressure  $P$  and volume  $V$  is given by  $PV^n = \text{constant}$ , then  $n$  is given by (Here  $C_p$  and  $C_v$  are molar specific heat at constant pressure and constant volume, respectively):

$P dV$

(1)  $n = \frac{C - C_p}{C - C_v}$

(2)  $n = \frac{C_p - C}{C - C_v}$

(3)  $n = \frac{C - C_v}{C - C_p}$

(4)  $n = \frac{C_p}{C_v}$

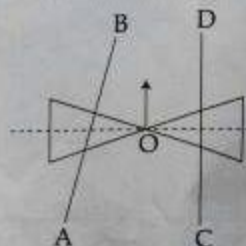
$n \log PV = K$   
 $n = \frac{C - C_p}{C - C_v}$   
 $n = \frac{C_p - C}{C - C_v}$   
 $n = \frac{C - C_v}{C - C_p}$   
 $n = \frac{C_p}{C_v}$

86. A screw gauge with a pitch of 0.5 mm and a circular scale with 50 divisions is used to measure the thickness of a thin sheet of Aluminium. Before starting the measurement, it is found that when the two jaws of the screw gauge are brought in contact, the 45<sup>th</sup> division coincides with the main scale line and that the zero of the main scale is barely visible. What is the thickness of the sheet if the main scale reading is 0.5 mm and the 25<sup>th</sup> division coincides with the main scale line?

- (1) 0.80 mm
- (2) 0.70 mm
- (3) 0.50 mm
- (4) 0.75 mm

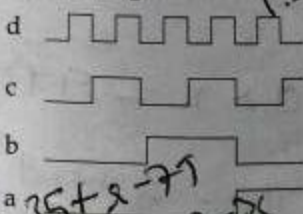
$\delta = (45 + x) - A$   
 $2t - 60 = -8$   
 $2t = 52$

87. A roller is made by joining together two cones at their vertices  $O$ . It is kept on two rails  $AB$  and  $CD$  which are placed asymmetrically (see figure), with its axis perpendicular to  $CD$  and its centre  $O$  at the centre of line joining  $AB$  and  $CD$  (see figure). It is given a light push so that it starts rolling with its centre  $O$  moving parallel to  $CD$  in the direction shown. As it moves, the roller will tend to:



- (1) turn right.
- (2) go straight.
- (3) turn left and right alternately.
- (4) turn left.

88. If  $a, b, c, d$  are inputs to a gate and  $x$  is its output, then, as per the following time graph, the gate is:



- (1) AND
- (2) OR
- (3) NAND
- (4) NOT

$T = \frac{2T}{2T}$   
 $2 \times 3 \times 4$   
 $6 \times 2 = 12$   
 $40 = 35 + 2 - 7$   
 $2x = 79 + 90 - 5$   
 $2x = 174$   
 $x = 87$   
 $-8 = 60 - 20$   
 $-2t = -52$   
 $t = 26$

SPACE FOR ROUGH WORK

$-12 = t - 90$   
 $t = 78$   
 $40 - 5$   
 $35 = 20 + 15$   
 $4 = 20 - 16$

89. For a common emitter configuration, if  $\alpha$  and  $\beta$  have their usual meanings, the incorrect relationship between  $\alpha$  and  $\beta$  is:

(1)  $\alpha = \frac{\beta}{1 - \beta}$

(2)  $\alpha = \frac{\beta}{1 + \beta}$

(3)  $\alpha = \frac{\beta^2}{1 + \beta^2}$

(4)  $\frac{1}{\alpha} = \frac{1}{\beta} + 1$

90. A satellite is revolving in a circular orbit at a height  $h$  from the earth's surface (radius of earth  $R$ ;  $h \ll R$ ). The minimum increase in its orbital velocity required, so that the satellite could escape from the earth's gravitational field, is close to: (Neglect the effect of atmosphere.)

(1)  $\sqrt{gR}$

(2)  $\sqrt{gR/2}$

(3)  $\sqrt{gR} (\sqrt{2} - 1)$

(4)  $\sqrt{2gR}$

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SPACE FOR ROUGH WORK

$t_2 = a + d = \frac{4}{g}$

$t_5 = a + 4d$

$t_9 = a + 8d$

$\frac{4d}{d}$   
 $d$   
 $4d$   
 $8d$

$9 + d \times x = 9 + 4d$

$x = \frac{9 + 4d}{9 + d}$

$= \frac{4 \left( \frac{9 + d}{4} \right)}{9 + d}$