

# SOLVED PAPER

# AIEEE - 2009

No. of Questions : 90

Time : 3 hrs.

Max. Marks : 432

**Part A : Chemistry (144 marks)** : Question No. 1 to 24 are of **4 marks** each and Question No. 25 to 30 are of **8 marks** each.

**Part B : Mathematics (144 marks)** : Question No.31 to 32 and 39 to 60 are of **4 marks** each and Question No.33 to 38 are of **8 marks** each.

**Part C : Physics (144 marks)** : Question No. 61 to 84 are of **4 marks** each and Question No. 85 to 90 are of **8 marks** each.

**Negative Marking** : One fourth ( $\frac{1}{4}$ ) marks will be deducted for indicating incorrect response of each question.

## PART A – CHEMISTRY

- The IUPAC name of neopentane is  
(a) 2, 2 dimethylpropane (b) 2 methylpropane  
(c) 2, 2 dimethylbutane (d) 2- methylbutane
- Which one of the following reactions of xenon compounds is not feasible?  
(a)  $3\text{XeF}_4 + 6\text{H}_2\text{O} \longrightarrow 2\text{Xe} + \text{XeO}_3 + 12\text{HF} + 1.5\text{O}_2$   
(b)  $2\text{XeF}_2 + 2\text{H}_2\text{O} \longrightarrow 2\text{Xe} + 4\text{HF} + \text{O}_2$   
(c)  $\text{XeF}_6 + \text{RbF} \longrightarrow \text{Rb}[\text{XeF}_7]$   
(d)  $\text{XeO}_3 + 6\text{HF} \longrightarrow \text{XeF}_6 + 3\text{H}_2\text{O}$
- The major product obtained on interaction of phenol with sodium hydroxide and carbon dioxide is  
(a) salicylaldehyde (b) salicylic acid  
(c) phthalic acid (d) benzoic acid
- Which of the following statements is incorrect regarding physisorptions?  
(a) More easily liquefiable gases are adsorbed readily.  
(b) Under high pressure it results into multi molecular layer on adsorbent surface.  
(c) Enthalpy of adsorption ( $\Delta H_{\text{adsorption}}$ ) is low and positive.  
(d) It occurs because of van der Waal's forces.
- Which of the following has an optical isomer  
(a)  $[\text{Co}(\text{en})(\text{NH}_3)_2]^{2+}$  (b)  $[\text{Co}(\text{H}_2\text{O})_4(\text{en})]^{3+}$   
(c)  $[\text{Co}(\text{en})_2(\text{NH}_3)_2]^{3+}$  (d)  $[\text{Co}(\text{NH}_3)_3\text{Cl}]^+$
- Solid  $\text{Ba}(\text{NO}_3)_2$  is gradually dissolved in a  $1.0 \times 10^{-4}$  M  $\text{Na}_2\text{CO}_3$  solution. At what concentration of  $\text{Ba}^{2+}$  will a precipitate begin to form? ( $K_{\text{SP}}$  for  $\text{BaCO}_3 = 5.1 \times 10^{-9}$ )  
(a)  $5.1 \times 10^{-5}$  M (b)  $8.1 \times 10^{-8}$  M  
(c)  $8.1 \times 10^{-7}$  M (d)  $4.1 \times 10^{-5}$  M
- Calculate the wavelength (in nanometer) associated with a proton moving at  $1.0 \times 10^3$   $\text{ms}^{-1}$ .  
(Mass of proton =  $1.67 \times 10^{-27}$  kg and  $h = 6.63 \times 10^{-34}$  Js)  
(a) 0.40 nm (b) 2.5 nm (c) 14.0 nm (d) 0.32 nm
- In context with the transition elements, which of the following statements is incorrect?  
(a) In the highest oxidation states, the transition metal show basic character and form cationic complexes.  
(b) In the highest oxidation states of the first five transition elements (Sc to Mn), all the 4s and 3d electrons are used for bonding.  
(c) Once the  $d^5$  configuration is exceeded, the tendency to involve all the 3 d electrons in bonding decreases.  
(d) In addition to the normal oxidation states, the zero oxidation state is also shown by these elements in complexes.
- In an atom an electron is moving with a speed of 600 m/s with an accuracy of 0.005%. Certainty with which the position of the electron can be located is ( $h = 6.6 \times 10^{-34}$  kg  $\text{m}^2\text{s}^{-1}$ , mass of electron,  $e_m = 9.1 \times 10^{-31}$  kg):  
(a)  $5.10 \times 10^{-3}$  m (b)  $1.92 \times 10^{-3}$  m  
(c)  $3.84 \times 10^{-3}$  m (d)  $1.52 \times 10^{-4}$  m
- Which of the following pairs represent linkage isomers?  
(a)  $[\text{Pd}(\text{PPh}_3)_2(\text{NCS})_2]$  and  $[\text{Pd}(\text{PPh}_3)_2(\text{SCN})_2]$   
(b)  $[\text{Co}(\text{NH}_3)_5\text{NO}_3]\text{SO}_4$  and  $[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{NO}_3$   
(c)  $[\text{PtCl}_2(\text{NH}_3)_4]\text{Br}_2$  and  $[\text{PtBr}_2(\text{NH}_3)_4]\text{Cl}_2$   
(d)  $[\text{Cu}(\text{NH}_3)_4][\text{PtCl}_4]$  and  $[\text{Pt}(\text{NH}_3)_4][\text{CuCl}_4]$
- The bond dissociation energy of B – F in  $\text{BF}_3$  is  $646 \text{ kJ mol}^{-1}$  whereas that of C – F in  $\text{CF}_4$  is  $515 \text{ kJ mol}^{-1}$ . The correct reason for higher B – F bond dissociation energy as compared to that of C – F is  
(a) stronger  $\sigma$  bond between B and F in  $\text{BF}_3$  as compared to that between C and F in  $\text{CF}_4$ .  
(b) significant  $p\pi - p\pi$  interaction between B and F in  $\text{BF}_3$  whereas there is no possibility of such interaction between C and F in  $\text{CF}_4$ .  
(c) lower degree of  $p\pi - p\pi$  interaction between B and F in  $\text{BF}_3$  than that between C and F in  $\text{CF}_4$ .  
(d) smaller size of B- atom as compared to that of C- atom.

12. Using MO theory, predict which of the following species has the shortest bond length?
- (a)  $O_2^+$  (b)  $O_2^-$   
 (c)  $O_2^{2-}$  (d)  $O_2^{2+}$
13. A liquid was mixed with ethanol and a drop of concentrated  $H_2SO_4$  was added. A compound with a fruity smell was formed. The liquid was :
- (a) HCHO (b)  $CH_3COCH_3$   
 (c)  $CH_3COOH$  (d)  $CH_3OH$
14. Which of the following on heating with aqueous KOH, produces acetaldehyde?
- (a)  $CH_3CH_2Cl$  (b)  $CH_2ClCH_2Cl$   
 (c)  $CH_3CHCl_2$  (d)  $CH_3COCl$
15. Buna-N synthetic rubber is a copolymer of :
- (a)  $H_2C=CH-CH=CH_2$  and  $H_2C=C(CH_3)-CH=CH_2$   
 (b)  $H_2C=CH-CN$  and  $H_2C=CH-CH=CH_2$   
 (c)  $H_2C=CH-CN$  and  $H_2C=CH-C(CH_3)=CH_2$   
 (d)  $H_2C=CH-C(CH_3)=CH_2$  and  $H_2C=CH-CH=CH_2$
16. The two functional groups present in a typical carbohydrate are:
- (a)  $-CHO$  and  $-COOH$  (b)  $>C=O$  and  $-OH$   
 (c)  $-OH$  and  $-CHO$  (d)  $-OH$  and  $-COOH$
17. In which of the following arrangements, the sequence is *not* strictly according to the property written against it?
- (a)  $HF < HCl < HBr, HI$  : increasing acid strength  
 (b)  $NH_3 < PH_3 < AsH_3 < SbH_3$  : increasing basic strength  
 (c)  $B < C < O < N$  : increasing first ionization enthalpy  
 (d)  $CO_2 < SiO_2 < SnO_2 < PbO_2$  : increasing oxidising power
18. A binary liquid solution is prepared by mixing *n*-heptane and ethanol. Which one of the following statements is correct regarding the behaviour of the solution?
- (a) The solution is non-ideal, showing -ve deviation from Raoult's Law.  
 (b) The solution is non-ideal, showing +ve deviation from Raoult's Law.  
 (c) *n*-heptane shows +ve deviation while ethanol shows -ve deviation from Raoult's Law.  
 (d) The solution formed is an ideal solution.
19. The set representing the correct order of ionic radius is :
- (a)  $Na^+ > Li^+ > Mg^{2+} > Be^{2+}$   
 (b)  $Li^+ > Na^+ > Mg^{2+} > Be^{2+}$   
 (c)  $Mg^{2+} > Be^{2+} > Li^+ > Na^+$   
 (d)  $Li^+ > Be^{2+} > Na^+ > Mg^{2+}$
20. Arrange the carbanions,  $(CH_3)_3\bar{C}, \bar{C}Cl_3, (CH_3)_2\bar{C}H, C_6H_5\bar{C}H_2$  in order of their decreasing stability :
- (a)  $(CH_3)_2\bar{C}H > \bar{C}Cl_3 > C_6H_5\bar{C}H_2 > (CH_3)_3\bar{C}$   
 (b)  $\bar{C}Cl_3 > C_6H_5\bar{C}H_2 > (CH_3)_2\bar{C}H > (CH_3)_3\bar{C}$   
 (c)  $(CH_3)_3\bar{C} > (CH_3)_2\bar{C}H > C_6H_5\bar{C}H_2 > \bar{C}Cl_3$   
 (d)  $C_6H_5\bar{C}H_2 > \bar{C}Cl_3 > (CH_3)_3\bar{C} > (CH_3)_2\bar{C}H$
21. Knowing that the chemistry of lanthanoids(Ln) is dominated by its +3 oxidation state, which of the following statements is incorrect?
- (a) The ionic size of Ln (III) decrease in general with increasing atomic number  
 (b) Ln (III) compounds are generally colourless.  
 (c) Ln (III) hydroxide are mainly basic in character.  
 (d) Because of the large size of the Ln (III) ions the bonding in its compounds is predominantly ionic in character.
22. The alkene that exhibits geometrical isomerism is:
- (a) 2-methyl propene  
 (b) 2-butene  
 (c) 2-methyl-2-butene  
 (d) propene
23. The number of stereoisomers possible for a compound of the molecular formula  $CH_3-CH=CH-CH(OH)-Me$  is:
- (a) 2 (b) 4  
 (c) 4 (d) 6
24. In Cannizzaro reaction given below
- $$2PhCHO \xrightarrow{OH^-} PhCH_2OH + PhC(=O)O^-$$
- the slowest step is :
- (a) the transfer of hydride to the carbonyl group  
 (b) the abstraction of proton from the carboxylic group  
 (c) the deprotonation of  $PhCH_2OH$   
 (d) the attack of  $OH^-$  at the carbonyl group
25. On the basis of the following thermochemical data :
- (?  $fG^\circ H_{(aq)}^+ = 0$ )
- $$H_2O(l) \rightarrow H^+(aq) + OH^-(aq); \Delta H = -57.32 \text{ kJ}$$
- $$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l); \Delta H = -286.20 \text{ kJ}$$
- The value of enthalpy of formation of  $OH^-$  ion at  $25^\circ C$  is:
- (a)  $-228.88 \text{ kJ}$  (b)  $+228.88 \text{ kJ}$   
 (c)  $-343.52 \text{ kJ}$  (d)  $-22.88 \text{ kJ}$

26. Copper crystallises in *fcc* with a unit cell length of 361 pm. What is the radius of copper atom?  
 (a) 127 pm (b) 157 pm  
 (c) 181 pm (d) 108 pm
27. In a fuel cell methanol is used as fuel and oxygen gas is used as an oxidizer. The reaction is  

$$\text{CH}_3\text{OH}(l) + 3/2 \text{O}_2(g) \longrightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(l)$$
 At 298 K standard Gibb's energies of formation for  $\text{CH}_3\text{OH}(l)$ ,  $\text{H}_2\text{O}(l)$  and  $\text{CO}_2(g)$  are  $-166.2$ ,  $-237.2$  and  $-394.4 \text{ kJ mol}^{-1}$  respectively. If standard enthalpy of combustion of methanol is  $-726 \text{ kJ mol}^{-1}$ , efficiency of the fuel cell will be:  
 (a) 87% (b) 90%  
 (c) 97% (d) 80%
28. Two liquids X and Y form an ideal solution. At 300 K, vapour pressure of the solution containing 1 mol of X and 3 mol of Y is 550 mmHg. At the same temperature, if 1 mol of Y is further added to this solution, vapour pressure of the solution increases by 10 mmHg. Vapour pressure (in mmHg) of X and Y in their pure states will be, respectively:  
 (a) 300 and 400 (b) 400 and 600  
 (c) 500 and 600 (d) 200 and 300
29. Given:  

$$E^\circ_{\text{Fe}^{3+}/\text{Fe}} = -0.036\text{V}, E^\circ_{\text{Fe}^{2+}/\text{Fe}} = -0.439\text{V}$$
 The value of standard electrode potential for the change,  

$$\text{Fe}^{3+}_{(\text{aq})} + e^- \longrightarrow \text{Fe}^{2+}_{(\text{aq})}$$
 will be:  
 (a) 0.385 V (b) 0.770 V  
 (c)  $-0.270 \text{ V}$  (d)  $-0.072 \text{ V}$
30. The half life period of a first order chemical reaction is 6.93 minutes. The time required for the completion of 99% of the chemical reaction will be ( $\log 2 = 0.301$ )  
 (a) 23.03 minutes (b) 46.06 minutes  
 (c) 460.6 minutes (d) 230.03 minutes

PART B – MATHEMATICS

**Directions:** Question number 31 to 35 are Assertion-Reason type question. Each of these questions contains two statements:

**Statement-1 (Assertion) and Statement-2 (Reason).**

Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

31. **Statement-1 :**  $\sim (p \leftrightarrow \sim q)$  is equivalent to  $p \leftrightarrow q$ .  
**Statement-2 :**  $\sim (p \leftrightarrow \sim q)$  is a tautology  
 (a) Statement-1 is true, Statement-2 is true;  
 Statement-2 is not a correct explanation for Statement 1.  
 (b) Statement-1 is true, Statement-2 is false.  
 (c) Statement-1 is false, Statement-2 is true.  
 (d) Statement-1 is true, Statement-2 is true, Statement-2 is a correct explanation for statement -1
32. Let A be a  $2 \times 2$  matrix  
**Statement -1 :**  $\text{adj}(\text{adj} A) = A$   
**Statement -2 :**  $|\text{adj} A| = |A|$   
 (a) Statement-1 is true, Statement-2 is true.  
 Statement-2 is not a correct explanation for Statement-1.  
 (b) Statement-1 is true, Statement-2 is false.  
 (c) Statement -1 is false, Statement-2 is true.  
 (d) Statement-1 is true, Statement -2 is true.  
 Statement-2 is a correct explanation for Statement-1.

33. Let  $f(x) = (x+1)^2 - 1, x \geq -1$   
**Statement -1 :** The set  $\{x : f(x) = f^{-1}(x)\} = \{0, -1\}$   
**Statement-2 :**  $f$  is a bijection.  
 (a) Statement-1 is true, Statement-2 is true.  
 Statement-2 is not a correct explanation for Statement-1.  
 (b) Statement-1 is true, Statement-2 is false.  
 (c) Statement-1 is false, Statement-2 is true.  
 (d) Statement-1 is true, Statement-2 is true.  
 Statement-2 is not a correct explanation for Statement-1.
34. **Statement-1 :**  
 The variance of first  $n$  even natural numbers is  $\frac{n^2 - 1}{4}$ .  
**Statement-2 :**  
 The sum of first  $n$  natural numbers is  $\frac{n(n+1)}{2}$  and the sum of squares of first  $n$  natural numbers is  $\frac{n(n+1)(2n+1)}{6}$ .  
 (a) Statement-1 is true, Statement-2 is true  
 Statement-2 is not a correct explanation for Statement-1.  
 (b) Statement-1 is true, Statement-2 is false.  
 (c) Statement-1 is false, Statement-2 is true.  
 (d) Statement-1 is true, Statement-2 is true.  
 Statement-2 is a correct explanation for Statement-1.

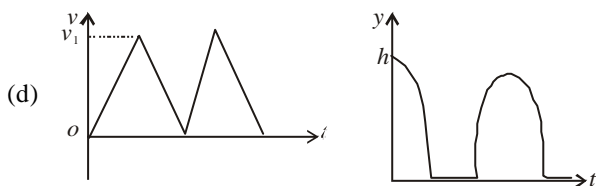
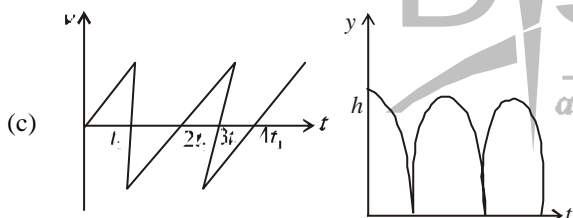
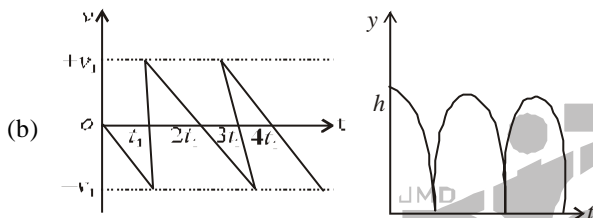
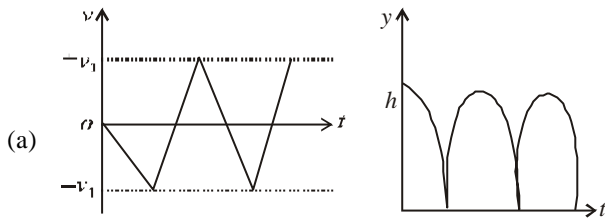
35. Let  $f(x) = x|x|$  and  $g(x) = \sin x$ .
- Statement-1 :**  $f$  is differentiable at  $x = 0$  and its derivative is continuous at that point.
- Statement-2 :**  $f$  is twice differentiable at  $x = 0$ .
- (a) Statement-1 is true, Statement-2 is true; Statement-2 is not a correct explanation for Statement-1.  
 (b) Statement-1 is true, Statement-2 is false.  
 (c) Statement-1 is false, Statement-2 is true.  
 (d) Statement-1 is true, Statement-2 is true; Statement-2 is a correct explanation for Statement-1.
36. The area of the region bounded by the parabola  $(y - 2)^2 = x - 1$ , the tangent of the parabola at the point  $(2, 3)$  and the  $x$ -axis is:
- (a) 6 (b) 9  
 (c) 12 (d) 3
37. Given  $P(x) = x^4 + ax^3 + bx^2 + cx + d$  such that  $x = 0$  is the only real root of  $P'(x) = 0$ . If  $P(-1) < P(1)$ , then in the interval  $[-1, 1]$ :
- (a)  $P(-1)$  is not minimum but  $P(1)$  is the maximum of  $P$   
 (b)  $P(-1)$  is the minimum but  $P(1)$  is not the maximum of  $P$   
 (c) Neither  $P(-1)$  is the minimum nor  $P(1)$  is the maximum of  $P$   
 (d)  $P(-1)$  is the minimum and  $P(1)$  is the maximum of  $P$
38. The shortest distance between the line  $y - x = 1$  and the curve  $x = y^2$  is:
- (a)  $\frac{2\sqrt{3}}{8}$  (b)  $\frac{3\sqrt{2}}{5}$   
 (c)  $\frac{\sqrt{3}}{4}$  (d)  $\frac{3\sqrt{2}}{8}$
39. Let the line  $\frac{x-2}{3} = \frac{y-1}{-5} = \frac{z+2}{2}$  lie in the plane  $x + 3y - \alpha z + \beta = 0$ . Then  $(\alpha, \beta)$  equals
- (a)  $(-6, 7)$  (b)  $(5, -15)$   
 (c)  $(-5, 5)$  (d)  $(6, -17)$
40. From 6 different novels and 3 different dictionaries, 4 novels and 1 dictionary are to be selected and arranged in a row on a shelf so that the dictionary is always in the middle. Then the number of such arrangement is:
- (a) at least 500 but less than 750  
 (b) at least 750 but less than 1000  
 (c) at least 1000  
 (d) less than 500
41. In a binomial distribution  $B\left(n, p = \frac{1}{4}\right)$ , if the probability of at least one success is greater than or equal to  $\frac{9}{10}$ , then  $n$  is greater than:
- (a)  $\frac{1}{\log_{10} 4 + \log_{10} 3}$  (b)  $\frac{9}{\log_{10} 4 - \log_{10} 3}$   
 (c)  $\frac{4}{\log_{10} 4 - \log_{10} 3}$  (d)  $\frac{1}{\log_{10} 4 - \log_{10} 3}$
42. The lines  $p(p^2 + 1)x - y + q = 0$  and  $(p^2 + 1)^2x + (p^2 + 1)y + 2q = 0$  are perpendicular to a common line for:
- (a) exactly one values of  $p$   
 (b) exactly two values of  $p$   
 (c) more than two values of  $p$   
 (d) no value of  $p$
43. If  $A, B$  and  $C$  are three sets such that  $A \cap B = A \cap C$  and  $A \cup B = A \cup C$ , then
- (a)  $A = C$  (b)  $B = C$   
 (c)  $A \cap B = \phi$  (d)  $A = B$
44. For real  $x$ , let  $f(x) = x^3 + 5x + 1$ , then
- (a)  $f$  is onto  $\mathbb{R}$  but not one-one  
 (b)  $f$  is one-one and onto  $\mathbb{R}$   
 (c)  $f$  is neither one-one nor onto  $\mathbb{R}$   
 (d)  $f$  is one-one but not onto  $\mathbb{R}$
45. The differential equation which represents the family of curves  $y = c_1 e^{c_2 x}$ , where  $c_1$ , and  $c_2$  are arbitrary constants, is
- (a)  $y'' = y'y$  (b)  $yy'' = y'$   
 (c)  $yy'' = (y')^2$  (d)  $y' = y^2$
46. Let  $a, b, c$  be such that  $b(a + c) \neq 0$  if
- $$\begin{vmatrix} a & a+1 & a-1 \\ -b & b+1 & b-1 \\ c & c-1 & c+1 \end{vmatrix} + \begin{vmatrix} a+1 & b+1 & c-1 \\ a-1 & b-1 & c+1 \\ (-1)^{n+2}a & (-1)^{n+1}b & (-1)^n c \end{vmatrix} = 0,$$
- then the value of  $n$  is:
- (a) any even integer (b) any odd integer  
 (c) any integer (d) zero
47. The remainder left out when  $8^{2n} - (62)^{2n+1}$  is divided by 9 is:
- (a) 2 (b) 7  
 (c) 8 (d) 0

48. Let  $y$  be an implicit function of  $x$  defined by  $x^{2x} - 2x^x \cot y - 1 = 0$ . Then  $y'(1)$  equals  
 (a) 1 (b)  $\log 2$   
 (c)  $-\log 2$  (d)  $-1$
49. If the roots of the equation  $bx^2 + cx + a = 0$  be imaginary, then for all real values of  $x$ , the expression  $3b^2x^2 + 6bcx + 2c^2$  is :  
 (a) less than  $4ab$  (b) greater than  $-4ab$   
 (c) less than  $-4ab$  (d) greater than  $4ab$
50. The sum to infinite term of the series  $1 + \frac{2}{3} + \frac{6}{3^2} + \frac{10}{3^3} + \frac{14}{3^4} + \dots$  is.  
 (a) 3 (b) 4  
 (c) 6 (d) 2
51. The projections of a vector on the three coordinate axis are 6, -3, 2 respectively. The direction cosines of the vector are :  
 (a)  $\frac{6}{5}, \frac{-3}{5}, \frac{2}{5}$  (b)  $\frac{6}{7}, \frac{-3}{7}, \frac{2}{7}$   
 (c)  $\frac{-6}{7}, \frac{-3}{7}, \frac{2}{7}$  (d) 6, -3, 2
52. Let **A** and **B** denote the statements  
**A** :  $\cos \alpha + \cos \beta + \cos \gamma = 0$   
**B** :  $\sin \alpha + \sin \beta + \sin \gamma = 0$   
 If  $\cos(\beta - \gamma) + \cos(\gamma - \alpha) + \cos(\alpha - \beta) = -\frac{3}{2}$ , then :  
 (a) **A** is false and **B** is true (b) both **A** and **B** are true  
 (c) both **A** and **B** are false (d) **A** is true and **B** is false
53. One ticket is selected at random from 50 tickets numbered 00, 01, 02, ..., 49. Then the probability that the sum of the digits on the selected ticket is 8, given that the product of these digits is zero, equals:  
 (a)  $\frac{1}{7}$  (b)  $\frac{5}{14}$   
 (c)  $\frac{1}{50}$  (d)  $\frac{1}{14}$
54. Three distinct points A, B and C are given in the 2-dimensional coordinates plane such that the ratio of the distance of any one of them from the point (1, 0) to the distance from the point (-1, 0) is equal to  $\frac{1}{3}$ . Then the circumcentre of the triangle ABC is at the point:  
 (a)  $(\frac{5}{4}, 0)$  (b)  $(\frac{5}{2}, 0)$   
 (c)  $(\frac{5}{3}, 0)$  (d) (0, 0)
55. If the mean deviation of the numbers 1, 1 + d, 1 + 2d, ..., 1 + 100d from their mean is 255, then  $d$  is equal to :  
 (a) 20.0 (b) 10.1  
 (c) 20.2 (d) 10.0
56. The ellipse  $x^2 + 4y^2 = 4$  is inscribed in a rectangle aligned with the coordinate axes, which in turn is inscribed in another ellipse that passes through the point (4, 0). Then the equation of the ellipse is :  
 (a)  $x^2 + 12y^2 = 16$  (b)  $4x^2 + 48y^2 = 48$   
 (c)  $4x^2 + 64y^2 = 48$  (d)  $x^2 + 16y^2 = 16$
57. If  $\left|z - \frac{4}{z}\right| = 2$ , then the maximum value of  $|Z|$  is equal to :  
 (a)  $\sqrt{5} + 1$  (b) 2  
 (c)  $2 + \sqrt{2}$  (d)  $\sqrt{3} + 1$
58. If P and Q are the points of intersection of the circles  $x^2 + y^2 + 3x + 7y + 2p - 5 = 0$  and  $x^2 + y^2 + 2x + 2y - p^2 = 0$  then there is a circle passing through P, Q and (1, 1) for:  
 (a) all except one value of  $p$   
 (b) all except two values of  $p$   
 (c) exactly one value of  $p$   
 (d) all values of  $p$
59. If  $\vec{u}, \vec{v}, \vec{w}$  are non-coplanar vectors and  $p, q$  are real numbers, then the equality  $[3\vec{u} p \vec{v} p \vec{w}] - [p \vec{v} \vec{w} q \vec{u}] - [2\vec{w} q \vec{v} q \vec{u}] = 0$  holds for :  
 (a) exactly two values of  $(p, q)$   
 (b) more than two but not all values of  $(p, q)$   
 (c) all values of  $(p, q)$   
 (d) exactly one value of  $(p, q)$
60.  $\int_0^\pi [\cot x] dx$ , where  $[ \cdot ]$  denotes the greatest integer function, is equal to :  
 (a) 1 (b)  $-1$   
 (c)  $-\frac{\pi}{2}$  (d)  $\frac{\pi}{2}$

PART C – PHYSICS

61. Consider a rubber ball freely falling from a height  $h = 4.9$  m onto a horizontal elastic plate. Assume that the duration of collision is negligible and the collision with the plate is totally elastic.

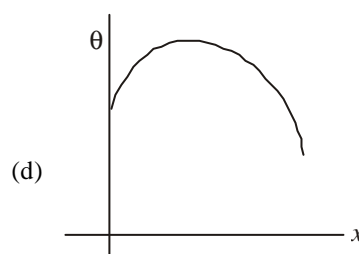
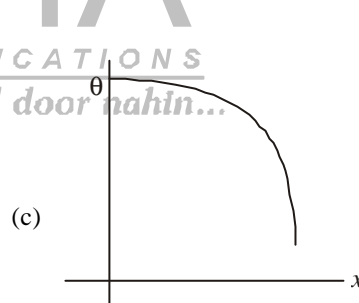
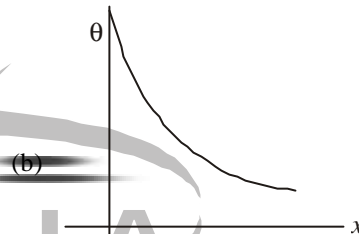
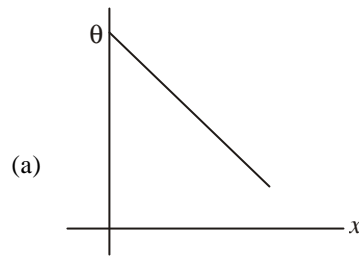
Then the velocity as a function of time and the height as a function of time will be :



62. The height at which the acceleration due to gravity becomes  $\frac{g}{9}$  (where  $g$  = the acceleration due to gravity on the surface of the earth) in terms of  $R$ , the radius of the earth, is :

- (a)  $\frac{R}{\sqrt{2}}$                       (b)  $R/2$
- (c)  $\sqrt{2}R$                       (d)  $2R$

63. A long metallic bar is carrying heat from one of its ends to the other end under steady-state. The variation of temperature  $\theta$  along the length  $x$  of the bar from its hot end is best described by which of the following figures?

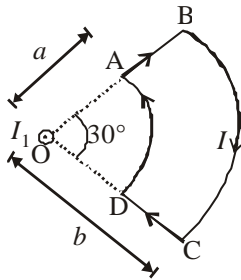


64. Two points P and Q are maintained at the potentials of 10 V and  $-4$  V, respectively. The work done in moving 100 electrons from P to Q is :

- (a)  $9.60 \times 10^{-17} \text{ J}$                       (b)  $-2.24 \times 10^{-16} \text{ J}$
- (c)  $2.24 \times 10^{-16} \text{ J}$                       (d)  $-9.60 \times 10^{-17} \text{ J}$

**Directions :** Question numbers 65 and 66 are based on the following paragraph.

A current loop ABCD is held fixed on the plane of the paper as shown in the figure. The arcs BC (radius =  $b$ ) and DA (radius =  $a$ ) of the loop are joined by two straight wires AB and CD. A steady current  $I$  is flowing in the loop. Angle made by AB and CD at the origin  $O$  is  $30^\circ$ . Another straight thin wire with steady current  $I_1$  flowing out of the plane of the paper is kept at the origin.



65. The magnitude of the magnetic field ( $B$ ) due to the loop ABCD at the origin ( $O$ ) is :

- (a)  $\frac{\mu_o I(b-a)}{24ab}$
- (b)  $\frac{\mu_o I}{4\pi} \left[ \frac{b-a}{ab} \right]$
- (c)  $\frac{\mu_o I}{4\pi} [2(b-a) + \frac{\pi}{3}(a+b)]$
- (d) zero

66. Due to the presence of the current  $I_1$  at the origin:

- (a) The forces on AD and BC are zero.
- (b) The magnitude of the net force on the loop is given by

$$\frac{I_1 I}{4\pi} \mu_o [2(b-a) + \frac{\pi}{3}(a+b)].$$

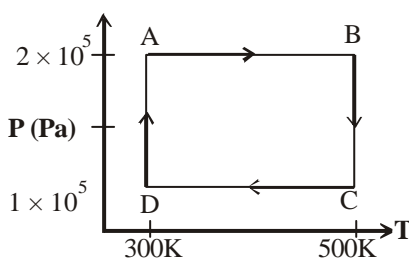
- (c) The magnitude of the net force on the loop is given by

$$\frac{\mu_o I I_1}{24ab} (b-a).$$

- (d) The forces on AB and DC are zero.

**Directions :** Question numbers 67, 68 and 69 are based on the following paragraph.

Two moles of helium gas are taken over the cycle ABCDA, as shown in the P-T diagram.



67. Assuming the gas to be ideal the work done on the gas in taking it from A to B is :

- (a) 300 R
- (b) 400 R
- (c) 500 R
- (d) 200 R

68. The work done on the gas in taking it from D to A is :

- (a) +414 R
- (b) -690 R
- (c) +690 R
- (d) -414 R

69. The net work done on the gas in the cycle ABCDA is :

- (a) 276 R
- (b) 1076 R
- (c) 1904 R
- (d) zero

70. In an experiment the angles are required to be measured using an instrument. 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half- a degree (=  $0.5^\circ$ ), then the least count of the instrument is :

- (a) half minute
- (b) one degree
- (c) half degree
- (d) one minute

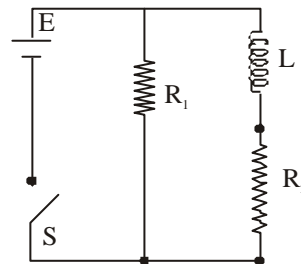
71. A charge  $Q$  is placed at each of the opposite corners of a square. A charge  $q$  is placed at each of the other two corners. If the net electrical force on  $Q$  is zero, then  $Q/q$  equals:

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

72. One kg of a diatomic gas is at a pressure of  $8 \times 10^4 \text{ N/m}^2$ . The density of the gas is  $4 \text{ kg/m}^3$ . What is the energy of the gas due to its thermal motion?

- (a)  $5 \times 10^4 \text{ J}$
- (b)  $6 \times 10^4 \text{ J}$
- (c)  $7 \times 10^4 \text{ J}$
- (d)  $3 \times 10^4 \text{ J}$

73.



An inductor of inductance  $L = 400 \text{ mH}$  and resistors of resistance  $R_1 = 2\Omega$  and  $R_2 = 2\Omega$  are connected to a battery of emf 12 V as shown in the figure. The internal resistance of the battery is negligible. The switch  $S$  is closed at  $t = 0$ . The potential drop across  $L$  as a function of time is :

- (a)  $\frac{12}{t} e^{-3t} \text{ V}$
- (b)  $6(1 - e^{-t/0.2}) \text{ V}$
- (c)  $12e^{-5t} \text{ V}$
- (d)  $6e^{-5t} \text{ V}$

This question contains statement-1 and statement- 2. Of the four choices given after the statements, choose the one that best describes the two statements.

74. **Statement 1** : The temperature dependence of resistance is usually given as  $R = R_0 (1 + \alpha \Delta t)$ . The resistance of a wire changes from  $100\Omega$  to  $150\Omega$  when its temperature is increased from  $27^\circ\text{C}$  to  $227^\circ\text{C}$ . This implies that  $\alpha = 2.5 \times 10^{-3}/^\circ\text{C}$ .

**Statement 2** :  $R = R_0 (1 + \alpha \Delta t)$  is valid only when the change in the temperature  $\Delta T$  is small and  $\Delta R = (R - R_0) \ll R_0$ .

- (a) Statement-1 is true, Statement-2 is true; Statement-2 is the correct explanation of Statement-1.  
 (b) Statement-1 is true, Statement-2 is true; Statement-2 is not the correct explanation of Statement-1.  
 (c) Statement-1 is false, Statement-2 is true.  
 (d) Statement-1 is true, Statement-2 is false.
75. The transition from the state  $n = 4$  to  $n = 3$  in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition from :
- (a)  $3 \rightarrow 2$  (b)  $4 \rightarrow 3$   
 (c)  $5 \rightarrow 4$  (d)  $2 \rightarrow 1$

76. A mixture of light, consisting of wavelength  $590\text{ nm}$  and an unknown wavelength, illuminates Young's double slit and gives rise to two overlapping interference patterns on the screen. The central maximum of both lights coincide. Further, it is observed that the third bright fringe of known light coincides with the 4th bright fringe of the unknown light. From this data, the wavelength of the unknown light is:

- (a)  $885.0\text{ nm}$  (b)  $442.5\text{ nm}$   
 (c)  $776.8\text{ nm}$  (d)  $393.4\text{ nm}$

77. A particle has an initial velocity of  $3\hat{i} + 4\hat{j}$  and an acceleration of  $0.4\hat{i} + 0.3\hat{j}$ . Its speed after  $10\text{ s}$  is :

- (a)  $7\sqrt{2}$  units (b)  $7$  units  
 (c)  $8.5$  units (d)  $10$  units

78. The surface of a metal is illuminated with the light of  $400\text{ nm}$ . The kinetic energy of the ejected photoelectrons was found to be  $1.68\text{ eV}$ . The work function of the metal is :

( $hc = 1240\text{ eV}\cdot\text{nm}$ )

- (a)  $1.41\text{ eV}$  (b)  $1.51\text{ eV}$   
 (c)  $1.68\text{ eV}$  (d)  $3.09\text{ eV}$

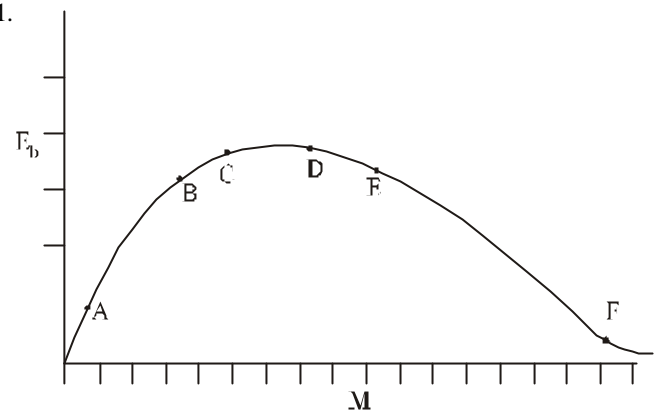
79. Three sound waves of equal amplitudes have frequencies  $(\nu - 1)$ ,  $\nu$ ,  $(\nu + 1)$ . They superpose to give beats. The number of beats produced per second will be :

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

80. A motor cycle starts from rest and accelerates along a straight path at  $2\text{ m/s}^2$ . At the starting point of the motor cycle there is a stationary electric siren. How far has the motor cycle gone when the driver hears the frequency of the siren at  $94\%$  of its value when the motor cycle was at rest? (Speed of sound =  $330\text{ ms}^{-1}$ )

- (a)  $98\text{ m}$  (b)  $147\text{ m}$   
 (c)  $196\text{ m}$  (d)  $49\text{ m}$

81.



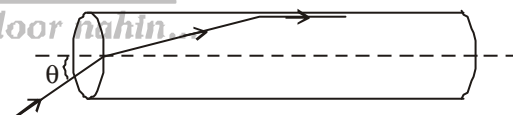
The above is a plot of binding energy per nucleon  $E_b$ , against the nuclear mass  $M$ ; A, B, C, D, E, F correspond to different nuclei. Consider four reactions :

- (i)  $A + B \rightarrow C + \epsilon$  (ii)  $C \rightarrow A + B + \epsilon$   
 (iii)  $D + E \rightarrow F + \epsilon$  and (iv)  $F \rightarrow D + E + \epsilon$ ,

where  $\epsilon$  is the energy released? In which reactions is  $\epsilon$  positive?

- (a) (i) and (iii) (b) (ii) and (iv)  
 (c) (ii) and (iii) (d) (i) and (iv)

82. A transparent solid cylindrical rod has a refractive index of  $\frac{2}{\sqrt{3}}$ . It is surrounded by air. A light ray is incident at the mid-point of one end of the rod as shown in the figure.



The incident angle  $\theta$  for which the light ray grazes along the wall of the rod is :

- (a)  $\sin^{-1}\left(\frac{\sqrt{3}}{2}\right)$  (b)  $\sin^{-1}\left(\frac{2}{\sqrt{3}}\right)$   
 (c)  $\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$  (d)  $\sin^{-1}\left(\frac{1}{2}\right)$

83. Two wires are made of the same material and have the same volume. However wire 1 has cross-sectional area  $A$  and wire 2 has cross-sectional area  $3A$ . If the length of wire 1 increases by  $\Delta x$  on applying force  $F$ , how much force is needed to stretch wire 2 by the same amount?

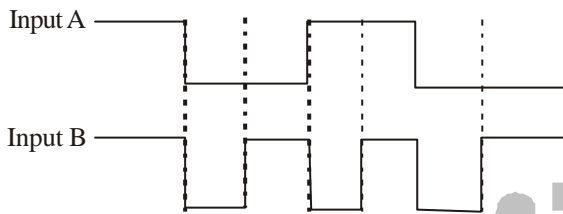
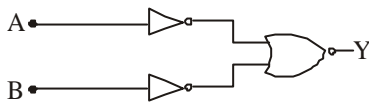
- (a)  $4F$  (b)  $6F$   
 (c)  $9F$  (d)  $F$

84. This question contains Statement-1 and Statement-2. Of the four choices given after the statements, choose the one that best describes the two statements.

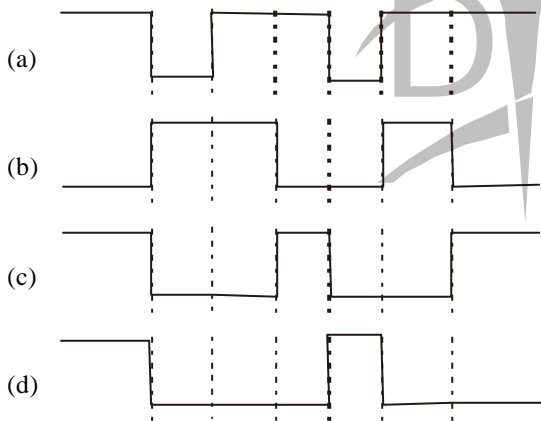
**Statement-1 :** For a charged particle moving from point P to point Q, the net work done by an electrostatic field on the particle is independent of the path connecting point P to point Q.

**Statement-2 :** The net work done by a conservative force on an object moving along a closed loop is zero.

- (a) Statement-1 is true, Statement-2 is true; Statement-2 is the correct explanation of Statement-1.  
 (b) Statement-1 is true, Statement-2 is true; Statement-2 is not the correct explanation of Statement-1.  
 (c) Statement-1 is false, Statement-2 is true.  
 (d) Statement-1 is true, Statement-2 is false.
85. The logic circuit shown below has the input waveforms 'A' and 'B' as shown. Pick out the correct output waveform.



Output is



86. If  $x$ ,  $v$  and  $a$  denote the displacement, the velocity and the acceleration of a particle executing simple harmonic motion of time period  $T$ , then, which of the following does not change with time?

- (a)  $aT/x$  (b)  $aT + 2\pi v$   
 (c)  $aT/v$  (d)  $a^2T^2 + 4\pi^2v^2$

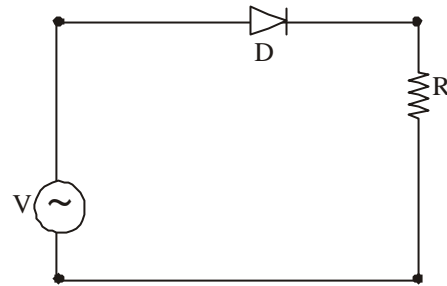
87. A thin uniform rod of length  $l$  and mass  $m$  is swinging freely about a horizontal axis passing through its end. Its maximum angular speed is  $\omega$ . Its centre of mass rises to a maximum height of :

- (a)  $\frac{1}{6} \frac{l\omega^2}{g}$  (b)  $\frac{1}{2} \frac{l^2\omega^2}{g}$   
 (c)  $\frac{1}{6} \frac{l^2\omega^2}{g}$  (d)  $\frac{1}{3} \frac{l^2\omega^2}{g}$

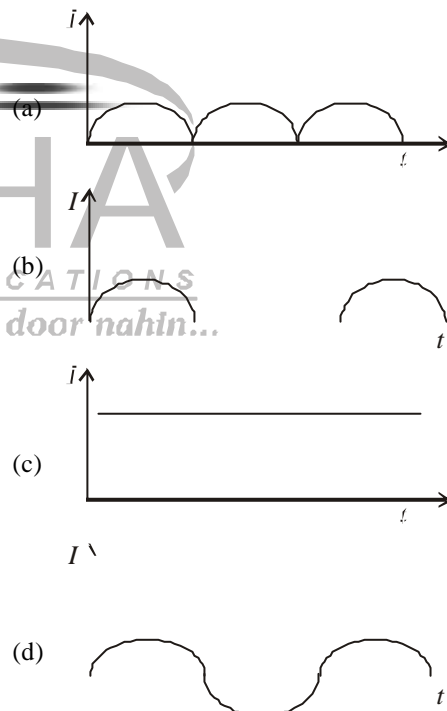
88. In an optics experiment, with the position of the object fixed, a student varies the position of a convex lens and for each position, the screen is adjusted to get a clear image of the object. A graph between the object distance  $u$  and the image distance  $v$ , from the lens, is plotted using the same scale for the two axes. A straight line passing through the origin and making an angle of  $45^\circ$  with the  $x$ -axis meets the experimental curve at P. The coordinates of P will be :

- (a)  $\left(\frac{f}{2}, \frac{f}{2}\right)$  (b)  $(f, f)$   
 (c)  $(4f, 4f)$  (d)  $(2f, 2f)$

89. A p-n junction (D) shown in the figure can act as a rectifier. An alternating current source (V) is connected in the circuit.



The current (I) in the resistor (R) can be shown by :



90. Let  $P(r) = \frac{Q}{\pi R^4} r$  be the charge density distribution for a solid sphere of radius  $R$  and total charge  $Q$ . For a point 'p' inside the sphere at distance  $r_1$  from the centre of the sphere, the magnitude of electric field is :

- (a)  $\frac{Q}{4\pi \epsilon_0 r_1^2}$  (b)  $\frac{Qr_1^2}{4\pi \epsilon_0 R^4}$   
 (c)  $\frac{Qr_1^2}{3\pi \epsilon_0 R^4}$  (d) 0