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SAMPLE PAPER (MEGA COURSE)

Time : 3 Hours **Maximum Marks : 180**

Please read the instructions carefully. You are allotted 5 minutes specifically for this purpose.

INSTRUCTIONS

A. General :

1. This booklet is your Question Paper containing **60** questions.

3. The question paper contains **3** blank pages for your rough work. No additional sheets will be provided for rough work.

4. Blank papers, clipboards, log tables, slide rules, calculators, cellular phones, pagers and electronic gadgets in any form are not allowed to be carried inside the examination hall.

5. Fill in the boxes provided below on this page and also write your **Name** and **Form No.**.

6. The answer sheet, a machine-readable Objective Response Sheet (**ORS**), is provided separately.

7. DO NOT TAMPER WITH / MUTILATE THE ORS OR THE BOOKLET.

8. Do not open the question-paper booklet before being instructed to do so by the invigilators.

B. Question paper format

C. Marking scheme

Read the instructions printed on the back page (page no. **24**) of this booklet.

Name of the candidate

Form Number

I have read all the instructions and shall abide by them.

.....
Signature of the Candidate

I have verified all the information filled in by the candidate.

.....
Signature of the invigilator

USEFUL DATA

Atomic weights: Al = 27, Mg = 24, Cu = 63.5, Mn = 55, Cl = 35.5, O = 16, H = 1, P = 31, Ag = 108, N = 14, Li = 7, I = 127, Cr = 52, K=39, S = 32, Na = 23, C = 12, Br = 80, Fe = 56, Ca = 40, Zn = 65.5, Ti = 48, Ba = 137, U = 238, Co= 59, B =11, F = 19, He = 4, Ne = 20, Ar = 40 , Mo = 96, g = 10 m/s^2

PART I : MATHEMATICS

Single Correct Choice Type

This section contains 20 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

1. Let $x_1 = \tan^{-1}\frac{2}{\sqrt{3}} > x_2 > x_3$ ..... are positive real numbers satisfying $\sin(x_{n+1} - x_n) + 3^{\frac{1-2n}{2}} \sin x_n \sin x_{n+1} =$ 0 for n ◈ 1. Then $\lim_{n\to\infty} x_n$ equals

(A) $\frac{\pi}{8}$ (B) $\frac{\pi}{6}$ (C) $\frac{\pi}{10}$ (D) $\frac{\pi}{12}$

2. Let a, b and c be distinct real numbers such that $a^2 - b = b^2 - c = c^2 - a$, then (a + b) (b + c) (c + a) is equal to .....

(A) 1 (B) 2 (C) 3 (D) None

3. Let f(n) denote the square of the sum of the digits of natural number n, whee $f^2(n)$ denote f(f(n)), $f^3(n)$ denote f(f(f(n))) and so on. The value of $\frac{f^{2011}(2011) - f^{2010}(2011)}{f^{2013}(2011) - f^{2012}(2011)} =$ _____

(A) 1 (B) 2014 (C) 2011 (D) 2012

4. Number of ordered triplets (a, b, c) where $1 \le a, b, c \le 10$, such that $2^a + 3^b + 5^c$ is a multiple of 4 is

(A) 1000 (B) 500 (C) 250 (D) 125

5. Find the numbers of positive integers from 1 to 1000, which are divisible by at least 2, 3 or 5.

(A) 734 (B) 266 (C) 738 (D) 767

6. Let x and y be numbers in the open interval (0, 1). Suppose there exists a positive number 'a', different from 1 such that $\log_x a + \log_y a = 4 \log_{xy} a$. Which of the following statements are necessarily true?

(I) $(\log_a x + \log_a y)^2 = 4 \log_a x \log_a y$

(II) $x = y$

(III) $\log_{x^2} a = \log_x \sqrt{a}$

(A) I only (B) II only (C) I and II only (D) I, II and III

7. If $\theta \in (\pi/4, \pi/2)$ and $\sum_{n=1}^{\infty} \frac{1}{\tan^n \theta} = \sin\theta + \cos\theta$ then the value of $\tan\theta$ is :

(A) $\sqrt{3}$ (B) $\sqrt{2} + 1$ (C) $2 + \sqrt{3}$ (D) $\sqrt{2}$

8. If $\sin x + a \cos x = b$ then the value of $|a \sin x - \cos x|$ is equal to

(A) $\sqrt{a^2 + b^2 + 1}$ (B) $\sqrt{a^2 + b^2 - 1}$

(C) $\sqrt{a^2 - b^2 - 1}$ (D) $\sqrt{a^2 - b^2 + 1}$

9. Let (a_1, b_1) and (a_2, b_2) are the pairs of real numbers such that 10, a, b, ab constitute an arithmetic progression. The value of the product $(a_1 \cdot b_1 \cdot a_2 \cdot b_2)$, is

(A) 25 (B) –50 (C) 75 (D) 100

10. In ΔABC, AB = 1, BC = 1 and AC = $1/\sqrt{2}$. In ΔMNP, MN = 1, NP = 1 and $\angle MNP = 2\angle ABC$. The side MP equals

(A) $3\sqrt{2}$ (B) 7/4 (C) $2\sqrt{2}$ (D) $\sqrt{7}/2$

11. Let 'X' denotes the value of the product

$(1 + a + a^2 + a^3 + ...\infty)(1 + b + b^2 + b^3 + ...\infty)$

where 'a' and 'b' are the roots of the quadratic equation $11x^2 - 4x - 2 = 0$

and 'Y' denotes the numerical value of the infinite series

$(\log_b 2)^0 (\log_b 5^{4^0}) + (\log_b 2)^1 (\log_b 5^{4^1}) + (\log_b 2)^2 (\log_b 5^{4^2}) + (\log_b 2)^3 (\log_b 5^{4^3}) + ... \infty$

where b = 2000 then the value of (XY) equals

(A) $\frac{1}{5}$ (B) $\frac{11}{15}$

(C) $\frac{13}{6}$ (D) $\frac{22}{35}$

12. Let f(x) = 0 denotes a cubic whose roots are $\cot\frac{A}{2}$, $\cot\frac{B}{2}$, $\cot\frac{C}{2}$. If the triangle ABC is such that one of its angle is 90º then which one of the following holds good ?

(A) r + 2R = s (B) 3r + 2R = s + 2

(C) 1 + r + 4R = 2s (D) 4r + R = s

13. Consider a circle $x^2 + y^2 + ax + by + c = 0$ lying compltely in first quadrant. If m_1 and m_2 are the maximum and minimum values of y/x for all ordered pairs (x, y) on the circumference of the circle then the value of $(m_1 + m_2)$ is :

(A) $\frac{a^2 - 4c}{b^2 - 4c}$ (B) $\frac{2ab}{b^2 - 4c}$

(C) $\frac{2ab}{4c - b^2}$ (D) $\frac{2ab}{b^2 - 4ac}$

14. Let A(a, 0) and B(b, 0) be fixed distinct points on the x-axis, none of which coincides with the origin O(0, 0), and let C be a point on the y-axis. Let g be a line through the origin O(0, 0) and perpendicular to the line AC. The locus of the point of intersection of the lines g and BC if C varies along the y-axis, is (provided $c^2 + ab \neq 0$)

(A) $\frac{x^2}{a} + \frac{y^2}{b} = x$ (B) $\frac{x^2}{a} + \frac{y^2}{b} = y$

(C) $\frac{x^2}{b} + \frac{y^2}{a} = x$ (D) $\frac{x^2}{b} + \frac{y^2}{a} = y$

15. For which positive integers n is the ratio, $\frac{\sum_{k=1}^{n} k^2}{\sum_{k=1}^{n} k}$ an integer ?

(A) odd n only
(B) even n only
(C) n = 1 + 6k only, where $k \geq 0$ and $k \in I$
(D) n = 1 + 3k, integer $k \geq 0$

16. Let ℓ be a line y = mx + c which intersect the curve $y = x^4 - 6x^3 + 4x - 1$ in 4 points $A(x_1, y_1)$, $B(x_2, y_2)$, $C(x_3, y_3)$ and $D(x_4, y_4)$

Statement-1 : The sum $x_1 (x_2 + x_3 + x_4) + x_2(x_3 + x_4) + x_3x_4$ is independent of the gradient of the line ℓ.
because
Statement-2 : The sum $x_1(x_2 + x_3 + x_4) + x_2(x_3 + x_4) + x_3x_4$ vanishes
(A) Statement-1 is true, Statement-2 is true and Statement-2 is correct explanation for Statement-1
(B) Statement-1 is true, Statement-2 is true and Statement-2 is **NOT** the correct explanation for Statement-1
(C) Statement-1 is true, Statement-2 is false
(D) Statement-1 is false, Statement-2 is true

17. Let points A, B, C are represented by $(a \cos \theta_i, a \sin \theta_i)$ i = 1, 2, 3 and

$\cos (\theta_1 - \theta_2) + \cos (\theta_2 - \theta_3) + \cos (\theta_3 - \theta_1) = -\frac{3}{2}$

Statement-1 : Orthocentre of ΔABC is at oigin
because
Statement-2 : ΔABC is equilateral triangle
(A) Statement-1 is true, Statement-2 is true and Statement-2 is correct explanation for Statement-1
(B) Statement-1 is true, Statement-2 is true and Statement-2 is **NOT** the correct explanation for Statement-1
(C) Statement-1 is true, Statement-2 is false
(D) Statement-1 is false, Statement-2 is true

18. A triangle formed by 3 lines denoted by the equation $5x^3 - 11x^2y + 6xy^2 - y^3 = 0$ will always be
(A) acute angled
(B) obtuse angled
(C) right angled
(D) none

19. One diagonal of a square is the portion of the variable line $\lambda x + (\lambda - 1)y = \lambda^2$; $\lambda > 0$; $\lambda \neq 1$ which is intercepted between the axes. If the area of the square is $\frac{17}{4}$ then the number of vartices of the square whose both the coodinates are integers, is :
(A) one
(B) two
(C) four
(D) none

20. If $x, y, z \in R^+$ then the minimum value of $\frac{x^4 + y^4 + z^2}{xyz}$ is :

(A) $\sqrt{2}$
(B) 2
(C) $2\sqrt{2}$
(D) 4

PART II : CHEMISTRY

Single Correct Choice Type

This section contains 20 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

21. Total number of structural isomers possible from molecular formula $C_4H_{10}O$ is

(A) 4 (B) 5 (C) 6 (D) 7

22. 4 mole of A(g) and 10 mole of B(g) are allowed to react in a closed vessel. According to given reaction :

$$2A(g) + 3B(g) \rightarrow 4C(g)$$

Calculate volume of C(g) produced at 1 atm and 273 K after completion of reaction, if % yield of the reaction is 75.

(A) 8 × 22.4 L (B) 6 × 22.4 L

(C) 4 × 22.4 L (D) 10 × 22.4 L

23. Molecular species in which central atom **does not** use its $d_{x^2-y^2}$ orbital in hybridization

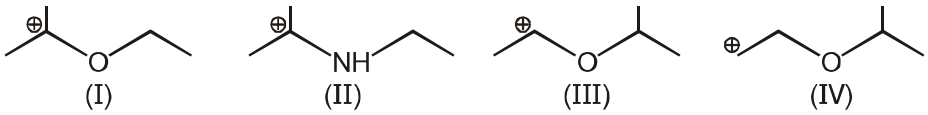
(A) PCl_5 (B) XeO_6^{6-} (C) SF_6 (D) IF_7

24. Which of the following is incorrect for 2M aqueous solution of KOH, if density of solution is 1.112 g/ml ?

(A) 2 molal KOH(aq) solution (B) 11.2% w/v KOH (aq) solution

(C) 10.07% w/w KOH (aq) solution (D) 5.6% w/v KOH (aq) solution

25. The correct stability order for the following species is



(I) (II) (III) (IV)

(A) II > IV> I > III (B) II > I > III > IV

(C) I > II > III > IV (D) I > III > II > IV

26. The orbit angular momentum of an electron in a Bohr's orbit of He^+ is 3.1652×10^{-34} kg-m^2/sec. Calculate radius of the orbit ($h = 6.626 \times 10^{-34}$ J-sec)

(A) 0.529 Å (B) 2.3805 Å

(C) 4.761 Å (D) 1.058 Å

27. Select **incorrect** match in given chemical reaction :

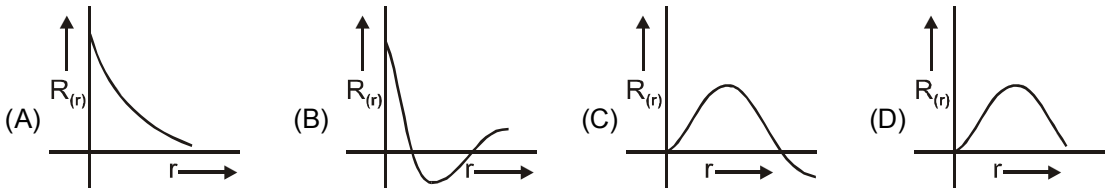
(A) $Zn + 2HCl \longrightarrow ZnCl_2 + H_2\uparrow$ (non metal displacement reaction)

(B) $CaH_2 + H_2O \longrightarrow Ca(OH)_2 + H_2\uparrow$ (Metal displacement reaction)

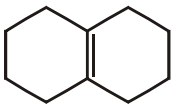
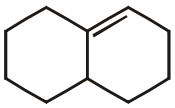
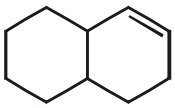
(C) $Cl_2 + H_2O \longrightarrow HCl + HOCl$ (Disproportionation reaction)

(D) $2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + H_2O\uparrow$ (Redox Thermal decomposition reaction)

28. The graph representing two radial node is :



29. Decreasing order of heat of hydrogenation ?

(I)  (II)  (III) 

(A) I > II > III (B) II > I > III (C) III > II > I (D) II > III > I

30. Which is favourable condition for the formation of NH_3 ?

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ ΔH = –ve

(A) Low pressure and low temperature

(B) High pressure and high temperature

(C) High pressure and low temperature

(D) Low pressure and high temperature

31. Which of the property does not follow following order N > P > As

(A) Atomic size (B) Ionization energy

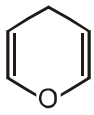
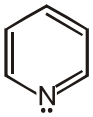
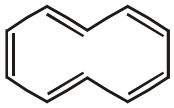
(C) Electronegativity (D) Basic nature of their hydride

32. Select the reaction for which $K_p > K_c$ at 800K.

(A) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ (B) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

(C) $2NO_2(g) \rightleftharpoons N_2O_4(g)$ (D) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

33. Which of the following is aromatic ?

(A)  (B)  (C)  (D) 

34. A mixture of 0.002 mole of $KBrO_3$ and 0.01 mole of KBr was treated in acidic medium and bromine formed and this bromine reacted with excess of KI and I_2 liberated and this I_2 reacted with $Na_2S_2O_3$.

The volume of 0.1 M $Na_2S_2O_3$ solution required to consume the liberated iodine will be

(A) 150 ml (B) 120 ml

(C) 90 ml (D) 60 ml

35. 2 × 'P' $\xrightarrow{-H_2O}$ pyro-oxy-acid, 'P' can't be

(A) H_4SiO_4 (B) H_3PO_4

(C) H_2SO_4 (D) $HClO_4$

36. If initial rate of effusion ratio $\left(\frac{r_{CH_4}}{r_{HBr}}\right)$ for CH_4 & HBr is 4.5 : 1, at certain temperature then mole fraction of CH_4 in initial mixture is

(A) 0.165 (B) 0.34

(C) 0.66 (D) 0.50

37. In which of the following functional group isomerism not possible ?

(A) Carboxylic acid (B) aldehyde

(C) Ether (D) Alkylhalide

38. For different gases P, Q, R and S values of Vander waal constant "a" are given as

Gas	P	Q	R	S
Vander waal constant "a" (atm. $L^2 mol^{-2}$)	1.25	1.5	2	1.75

then which of the following gas is required minimum liquefaction pressure?

(A) Q (B) R (C) P (D) S

39. Molecule with highest dipole moment is :

(A) CO_2 (B) SO_2 (C) SO_3 (D) SiO_2

40. The equivalent weight of $MnSO_4$ is M/4 (M = Molecular weight), when it is converted to :

(A) MnO (B) MnO_4^{2-} (C) MnO_2 (D) MnO_4^-

PART III : PHYSICS
Single Correct Choice Type

This section contains 20 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

41. A helical spring is initially unstretched. It is first stretched by a length x and then again by a further length x. The works done in the two cases are W_1 and W_2 respectively. Then,

(A) $W_2 = W_1$ (B) $W_2 = 2\,W_1$

(C) $W_2 = 3\,W_1$ (D) $W_2 = 4\,W_1$

42. Power applied to a particle varies with time as $P = (4t^3 - 5t + 2)$ watt, where t is in second. Find the change in its K.E. between time t = 2 and t = 4 sec.

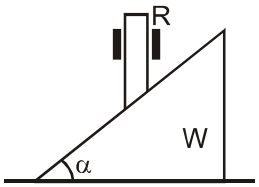
(A) 184 J (B) 200 J (C) 214 J (D) 224 J

43. The equations of motion of a projectile are given by $x = 36t$ and $2y = 96t - 9.8t^2$. The angle of projection is

(A) $\sin^{-1}(4/5)$ (B) $\sin^{-1}(3/5)$

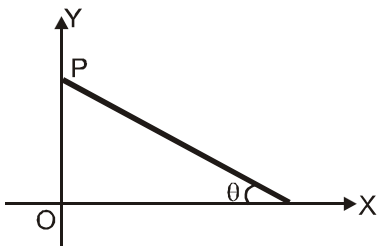
(C) $\sin^{-1}(2/5)$ (D) $\sin^{-1}(3/4)$

44. In the arrangement shown, all surfaces are frictionless. The rod R is constrained to move vertically. The vertical acceleration of R is a_1 and the horizontal acceleration of the wedge W is a_2. The ratio a_1/a_2 is equal to



(A) $\sin\alpha$ (B) $\cos\alpha$ (C) $\tan\alpha$ (D) $\cot\alpha$

45. A rod PQ of length ℓ is resting on two mutually perpendicular axes as shown in the figure. If the tip P begins to slide down with a constant speed of $\sqrt{3}$ m/s, the speed of tip Q when $\theta = 30°$ will be



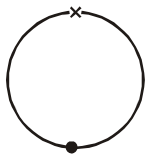
(A) $\sqrt{3}$ m/s. (B) 1 m/s. (C) 3 m/s. (D) 2 m/s.

46. Mercury stands at a height h in a barometer. A small hole is made at a height h′ (less than h). The mercury comes out of the hole with a speed v equal to

(A) $\sqrt{2gh'}$ (B) $\sqrt{2g(h-h')}$

(C) $\sqrt{2gh}$ (D) mercury does not dome out.

47. A uniform disc of mass M and radius R is supported vertically by a pivot at its periphery as shown. A particle of mass M is fixed to the rim and raised to the highest point above the centre. The system is then released from rest and it can rotate about its pivot freely. The angular speed of the system when the attached object is directly beneath (below) the pivot is

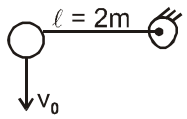


(A) $\sqrt{\frac{24g}{11R}}$ (B) $\sqrt{\frac{8g}{11R}}$ (C) $\sqrt{\frac{8g}{3R}}$ (D) $\sqrt{\frac{3g}{8R}}$

48. A block is resting on a horizontal plate in the xy plane and the coefficient of friction between block and plate is μ. The plate begins to move with velocity $u = bt^2$ in x direction. At what time will the block start sliding on the plate.

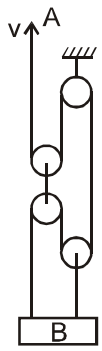
(A) $\frac{\mu b}{g}$ (B) $\frac{\mu bb}{2}$ (C) $\frac{\mu g}{b}$ (D) $\frac{\mu g}{2b}$

49. A small sphere is given vertical velocity of magnitude $v_0 = 5$ m/s and it swings in a vertical plane about the end of massless string. The angle θ with the vertical at which string will break, knowing that it can withstand a maximum tension equal to twice the weight of the sphere, is [$g = 10$ m/s^2]



(A) $\cos^{-1}\frac{2}{3}$ (B) $\cos^{-1}\left(\frac{1}{4}\right)$ (C) 60° (D) 30°

50. In the arrangement shown, end A of light inextensible string is pulled with constant velocity v. The velocity of block B is

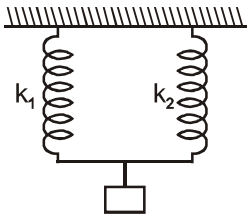


(A) 2v/3 (B) v (C) v/3 (D) data insufficient

51. The moment of inertia of a uniform flat disc about its own axis is I. The radius of the disc is a. A quadrant of the disc is cut off and separated. The moment of the remaining part of the disc about the same axis will be:

(A) $\frac{3I}{4}$ (B) $\frac{3I}{8}$ (C) $\frac{I}{3}$ (D) $\frac{2I}{3}$

52. Two vertically arranged springs of equal length support a horizontally suspended weightless rod. Spring constant k_1 = 30 N/m and k_2 = 50 N/m, the distance between them is d = 1 m. At what distance from a spring with stiffness k_1 should we hang a mass so that the rod will be in a horizontal position (Figure).



(A) 0.375 m (B) 0.625 m (C) 0.5 m (D) 0.75 m

53. A thin wire of length ℓ when heated to a certain temperature increases its length by 1%. A sheet of the same material of area $2\ell \times \ell$ is heated to the same temperature then increases in area will be
(A) 4% (B) 2.5% (C) 2% (D) 1.5%

54. In a wire of young's modulus Y, the longitudinal strain produced is α then the strain energy per unit volume stored in the wire will be

(A) $Y\alpha^2$ (B) $2Y\alpha^2$ (C) $\frac{Y\alpha^2}{2}$ (D) $\frac{Y^2\alpha}{2}$

55. Suppose that thermal energy released by cooling water of volume 1 m^3 by 1°C is used to raise temperature of air by 1°C at constant volume. What is volume of air that can be heated by 1°C :
(Given : 1 cal = 4.2 J ; S_{air} = 1 J/gm°C ; S_{water} = 1 cal/gm°C ; d_{air} = 1.2 kg/m^3 ; d_{water} = 1 gm/cc)

(A) 3500 m^3 (B) 3.5 m^3 (C) 1 m^3 (D) $\frac{5}{6}m^3$

56. A wheel of radius R rolls on the ground with a uniform velocity v. The acceleration of lowermost point of the wheel with respect to ground is :

(A) $\frac{v^2}{R}$ (B) $\frac{2v^2}{R}$ (C) $\frac{v^2}{2R}$ (D) Zero

57. A uniform rod of mass M has an impulse applied at right angles to one end. If the other end begins to move with speed V, the magnitude of the impulse is

(A) MV (B) $\frac{MV}{2}$ (C) 2MV (D) $\frac{2MV}{3}$

58. A particle of mass m moving along the x-axis as a potential energy $U(x) = a + bx^2$ where a and b are positive constants. It will execute simple harmonic motion with a frequency determined by the value of
(A) b alone (B) b and a alone (C) b and m alone (D) b,a and m alone

59. The average degree of freedom per molecule of a gas is 6. The gas performs 25 J work, while expanding at constant pressure. The heat absorbed by the gas is
(A) 75 J (B) 100 J (C) 150 J (D) 125 J

60. In an SHM what fraction of the total energy is potential when the displacement is $\frac{1}{2}$ of the amplitude?

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