INDIAN INSTITUTES OF SCIENCE EDUCATION AND RESEARCH

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Aptitude Test 2018 – Question Set Code: **C**

Name in BLOCK letters	Application Number
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Instructions to the Candidate

- Duration of this test is 180 minutes. There are 60 multiple choice questions in the test paper, 15 each from Biology, Chemistry, Mathematics and Physics. The question booklet contains 20 pages. Please check and report if any page is missing.
- Evaluation of the OMR sheet will be based on responses to all 60 questions.
- There is only one correct answer to each question. There will be negative marking. Marks for each question are: 3 **for a correct answer,** -1 **for a wrong answer,** 0 **for not attempting a question.**
- Darkening more than one option in the OMR sheet will be treated as a wrong answer.
- Please write your name (in BLOCK LETTERS) and application number as in the Hall Ticket at the appropriate places on the question paper and on the OMR sheet. You must sign the OMR sheet at the appropriate place.
- Please enter the Question Set code in your OMR sheet.
- Please carefully read the instructions given on the OMR sheet and fill the required information.
- Please write your application number in the boxes provided and also mark the appropriate bubbles on the OMR sheet carefully. Else your OMR sheet cannot be evaluated.
- For marking answers on the OMR sheet, **use only black/blue ball point pen.**
- Electronic gadgets such as mobile phones and calculating devices are strictly prohibited inside the examination hall.
- Exchange of items amongst the candidates is not permitted during the Aptitude Test.
- A candidate adopting unfair means during the Aptitude Test or violating any of the instructions shall be expelled from the examination hall and his/her candidature will be cancelled.
- You must return the OMR sheet after removing the student's copy.

BIOLOGY

1. Which one of the following statements about second messengers is correct?

[A] These are proteins which help digest the secondary metabolites from plants.
[B] These are signaling molecules generated during secondary infections in animals.
[C] These are molecules generated during secondary steps of hormone signaling.
[D] These are secondary metabolites produced by plants in response to an infection.

2. The glomerular filtration rate is NOT affected by

[A] increased dietary uptake of water and fluids.
[B] increased supply of nutrients to the blood in afferent arteriole.
[C] total volume of the blood flowing per minute through the Bowman's capsule.
[D] increased Renin production from Juxta glomerular cells.

3. Haplo-diploid insects have diploid females from fertilized eggs but haploid males from unfertilized ones. Such a haploid male with red eyes is crossed with a white eyed female. Assuming that the red-eye colour mutation is dominant over white-eye colour, which one of the following statements is true?

[A] All females will have red eyes and all males will have white eyes.
[B] Half of the males will have red and the other half will have white eyes.
[C] All females will have white eyes and all males will have red eyes.
[D] Half of the females will have red and the other half will have white eyes.

4. Match the entries in column I and II and choose the correct pairs from the choices below.

Column I	Column II
a. High BOD	1. Skin cancer
b. Ozone hole	2. Greenhouse gas
c. El Niño effect	3. Food chain
d. Biomagnification	4. Water pollution

[A] a-3, b-1, c-4, d-3 [B] a-4, b-1, c-2, d-3 [C] a-2, b-3, c-1, d-4 [D] a-1, b-2, c-4, d-3

5. DNA fragments of 100 base pairs (bp), 300 bp and 500 bp were separated by agarose gel electrophoresis. Pick the correct arrangement of the fragments separated on the gel in the increasing order of their migration from the wells.

[A] 100 bp < 300 bp < 500 bp
[B] 500 bp > 300 bp > 100 bp
[C] 500 bp < 300 bp < 100 bp
[D] 100 bp > 300 bp > 500 bp

6. Meiosis involves:

[A] Two cycles each of DNA replication, cell division and nuclear division.
[B] Two cycles of DNA replication but one cycle each of cell division and nuclear division.
[C] One cycle each of DNA replication, cell division and nuclear division.
[D] One cycle of DNA replication but two cycles each of cell division and nuclear division.

7. Which of the following is exclusively marine?

[A] Echinodermata [B] Cnidaria [C] Annelida [D] Porifera

8. How many histone molecules are required to wrap roughly 60,000 base pairs (bp) of DNA?

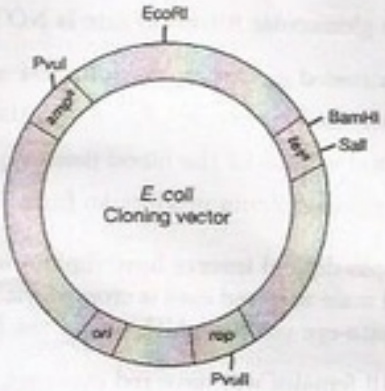
[A] 2.4×10^2 [B] 2.4×10^3 [C] 2.4×10^4 [D] 2.4×10^1

9. All species of vultures in India are threatened with extinction. What is the most likely outcome if all vultures in India go extinct?

[A] Number of sparrows will increase.
[B] Herbivore numbers will increase.
[C] Soil pollution will decrease.
[D] Nutrient recycling will be hampered.

10. A gene is inserted into the PvuII site of the cloning vector (given below) and transformed into *E. coli* cells. Which one of the following statements is then true?

[A] Recombinants can be selected by plating on tetracycline containing medium.
[B] Recombinants can be selected by plating simultaneously on ampicillin and tetracycline containing medium.
[C] Recombinants can be selected by plating on ampicillin containing medium.
[D] Recombinants cannot be selected by plating either on ampicillin or tetracycline containing medium.



11. What are Association areas?

[A] These are areas in the adrenal medulla secreting both epinephrin and norepinephrin hormones.
[B] These are areas in the hepatic cortex having localised bile ducts and blood capillaries.
[C] These are areas in the cerebral cortex with both sensory and motor neuron functions.
[D] These are areas in the renal cortex with intertwined Henle's loop and vasa recta.

12. Match the entries in column I and II and choose the correct pairs from below:

Column I	Column II
a. Golgi	1. Divide by fission
b. Endoplasmic Reticulum	2. Site of formation of glycoproteins and glycolipids
c. Cytoskeleton	3. Steroidal hormone synthesis site
d. Mitochondria	4. Mechanical support

[A] a-1, b-3, c-4, d-2 [B] a-2, b-3, c-4, d-1 [C] a-2, b-1, c-4, d-3 [D] a-3, b-4, c-1, d-2

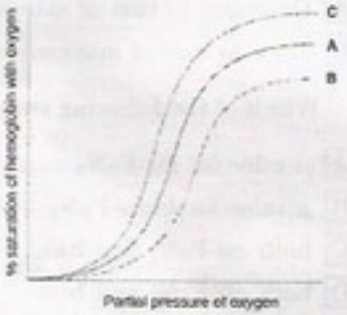
13. Which of the following antibodies is present abundantly in the colostrum secreted during the initial days of human lactation?

[A] IgA [B] IgG [C] IgE [D] IgD

14. Which compound given below inhibits cholesterol synthesis in humans?

[A] Cyclosporin A [B] Statins [C] Penicillin [D] Streptokinase

15. In the given graph curves A, B and C represent relation between partial pressure of oxygen (p_{O_2}) and saturation of hemoglobin with oxygen. If curve A represents condition of blood in a regular artery then please select the correct statement from below.



[A] Curve C represents blood present in left ventricle.
[B] Curve B represents blood present in left ventricle.
[C] Curve C represents blood present in right ventricle.
[D] Curve B represents blood present in pulmonary vein.

16. The melting point of Mn_4N is

[A] One-third to that of manganese metal.
[B] Same as that of manganese metal.
[C] Higher than that of manganese metal.
[D] One-fourth to that of manganese metal.

17. Which of the following statements is valid for the dipole moment (μ) values of *cis*- and *trans*-F_2N_2?

[A] μ value for *cis*-F_2N_2 > μ value for *trans*-F_2N_2
[B] μ value for *trans*-F_2N_2 > μ value for *cis*-F_2N_2
[C] both *cis*-F_2N_2 and *trans*-F_2N_2 will have equal nonzero μ
[D] both *cis*-F_2N_2 and *trans*-F_2N_2 will have zero μ

18. Which of the following statements is correct about tetrahedral manganate and permanganate ions?

[A] Manganate is purple and paramagnetic
[B] Manganate is green and paramagnetic
[C] Permanganate is purple and paramagnetic
[D] Permanganate is green and diamagnetic

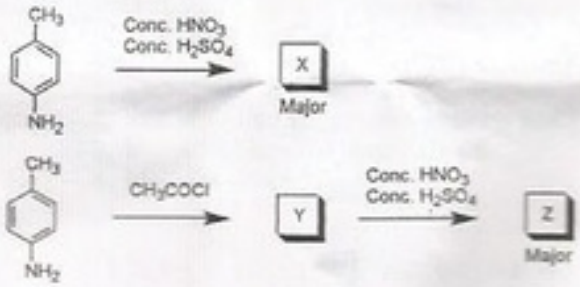
19. Among the lanthanides Eu, Tb, Er and Dy, which one readily forms stable divalent ions?

[A] Er [B] Eu [C] Tb [D] Dy

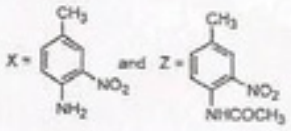
20. The correct order for decreasing basic strength of the molecules PH_3, AsH_3, SbH_3, and BiH_3 is:

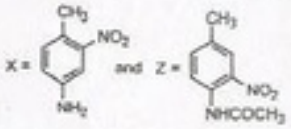
[A] $BiH_3 > AsH_3 > SbH_3 > PH_3$
[B] $BiH_3 > SbH_3 > AsH_3 > PH_3$
[C] $PH_3 > AsH_3 > SbH_3 > BiH_3$
[D] $PH_3 > SbH_3 > BiH_3 > AsH_3$

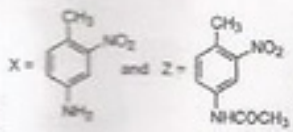
21. In the following reaction sequence,

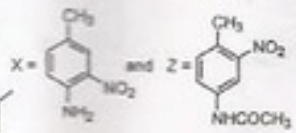


the major products **X** and **Z** are

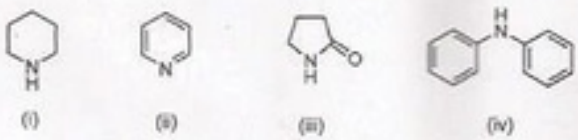
[A] 

[B] 

[C] 

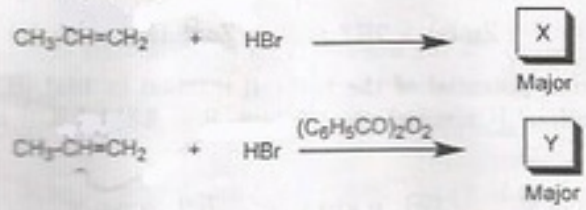
[D] 

22. Select the correct order of basicity for the following compounds.



[A] (iii) > (ii) > (i) > (iv)
[B] (iv) > (iii) > (ii) > (i)
[C] (i) > (ii) > (iv) > (iii)
[D] (ii) > (i) > (iv) > (iii)

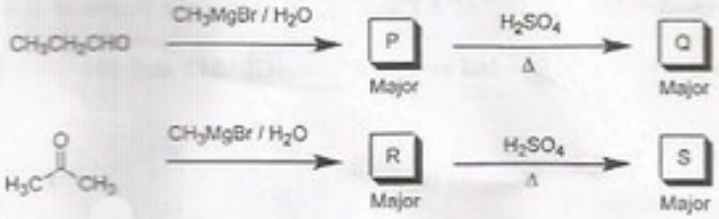
23.



Which of the following is the correct pair of intermediates responsible for the formation of **X** and **Y** as the major products, in their respective reactions shown above?

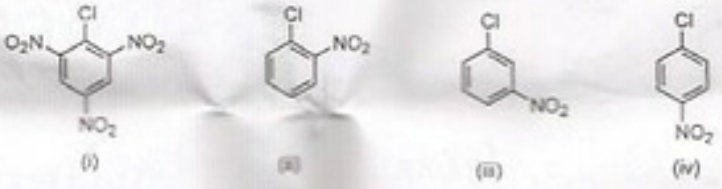
[A] 2° carbocation and 1° radical
[B] 1° carbocation and 2° radical
[C] 2° carbocation and 2° radical
[D] 1° carbocation and 1° radical

24. In the following reaction sequence, identify the relationship between the products **Q** and **S**:



[A] geometrical isomers
[B] identical products
[C] structural isomers
[D] optical isomers

25. Arrange the following compounds in increasing order of their rate of reaction towards hydroxyl ion (OH^-).



[A] (iv) < (ii) < (iii) < (i)
[B] (i) < (iii) < (ii) < (iv)
[C] (iii) < (iv) < (ii) < (i)
[D] (ii) < (iv) < (iii) < (i)

26. The kinetic energy of the photoelectrons ejected from a metal on irradiation with light of frequency 3.8×10^{16} Hz is K. When irradiated with light of frequency 2.4×10^{16} Hz, the kinetic energy of the photoelectrons becomes $K/2$. What is the threshold frequency (ν_0) of the metal?

[A] 2.0×10^{16} Hz [B] 1.2×10^{16} Hz [C] 1.5×10^{16} Hz [D] 1.0×10^{16} Hz

27. The heat of neutralization of the following reaction is -57.1 kJ mol^{-1}.

$$NaOH\ (aq) + HCl\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$$

Which one of the following processes is mainly responsible for the heat released?

[A] $NaCl \rightarrow Na^+ + Cl^-$
[B] $NaOH \rightarrow Na^+ + OH^-$
[C] $H^+ + OH^- \rightarrow H_2O$
[D] $Na^+ + Cl^- \rightarrow NaCl$

28. At 25 °C, the standard reduction potential for the half-cell reaction

$$Zn\ (s) + 2H^+\ (aq) \rightarrow Zn^{2+}\ (aq) + H_2\ (g)$$

is 0.28 V. What is the reduction potential of the half-cell reaction in 10M $[H^+]$ concentration, assuming all other species to be at unit concentration? [Universal gas constant, R = 8.314 J K^{-1} mol $^{-1}$; Faraday constant, F = 96500 C mol $^{-1}$]

[A] 0.339 V [B] 0.870 V [C] 0.290 V [D] 0.398 V

29. In a cubic-close packed structure containing **X**, **Y** and **Z** atoms, if **Z** occupies all the face centers, **X** occupies all the corners and **Y** occupies the body center of the cube, what is the formula of this compound?

[A] X_8YZ_6 [B] XYZ_3 [C] X_2YZ_3 [D] XYZ_2

30. At 298 K, the vapour pressure of an ideal solution containing 1 mol of liquid **L1** and 2 mol of liquid **L2** is 500 mm Hg. When 2 mol of **L1** is added to this solution, the vapour pressure of the solution increases by 5%. What are the respective vapour pressures (in mm Hg) of **L1** and **L2** in their pure states at 298 K?

[A] 500 and 500 [B] 563 and 469 [C] 513 and 494 [D] 500 and 1250

31. Let z be a given complex number with modulus $|z| < 1$. Then the set $\left\{\frac{z-w}{1-\bar{z}w} : |w| = 1, w \in \mathbb{C}\right\}$ is a

[A] Straight line. [B] Circle. [C] Hyperbola. [D] Parabola.

32. Let f, g, h be functions from $\mathbb{R}$ to $\mathbb{R}$, with f and g invertible. Which of the following is NOT always true?

[A] $f \circ (g \circ h) = (f \circ g) \circ h$.
[B] $f \circ (g + h) = (f \circ g) + (f \circ h)$.
[C] $(f.g) \circ h = (f \circ h).(g \circ h)$.
[D] $(f \circ g)^{-1} = g^{-1} \circ f^{-1}$.

33. Consider a matrix $A = \begin{pmatrix} 1 & 0 & 0 \\ 2 & x & y \\ 4 & 3 & 5 \end{pmatrix}$ with integer entries and determinant -5. Then a possible value for y is

[A] 1. [B] 8. [C] 10. [D] 6.

34. The integral $\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \left(\frac{(1+\sqrt{|x|})\sin^2(x) + \sin(x)}{1+\sqrt{|x|}}\right) dx$ is equal to

[A] 2π. [B] $\frac{\pi}{2}$. [C] 0. [D] π

35. Let ℓ_0 be the line defined by the vector equation $\hat{i} + 2\hat{j} + 3\hat{k} + \lambda(\hat{i} + \hat{j} + \hat{k})$, with λ real. Which of the following vector equations, with μ real, defines a line which intersects ℓ_0?

[A] $-\hat{i} - 2\hat{j} - 3\hat{k} + \mu(-\hat{i} - \hat{j} - \hat{k})$.
[B] $3\hat{i} - 2\hat{j} + \hat{k} + \mu(-\hat{i} + \hat{j})$.
[C] $\hat{i} + 3\hat{j} + 5\hat{k} + \mu(2\hat{i} + 3\hat{j} + 4\hat{k})$.
[D] $2\hat{i} + 3\hat{j} + \mu(\hat{i} - \hat{j})$.

36. For a given matrix, let R_i denote the sum of all entries in its i^{th} row and C_j denote the sum of all entries in its j^{th} column. How many 3×3 matrices with nonnegative integer entries are there such that $R_1 = R_2 = C_1 = C_2 = 2$ and $R_3 = C_3 = 1$?

[A] 12. [B] 11. [C] 13. [D] 14.

37. Let $P(n)$ be a statement for each natural number n. Assume that $P(n+1)$ is a true statement whenever $P(n)$ is a true statement. Suppose $P(2018)$ is true. Then which one of the following statements is true?

[A] $P(n)$ is true for all n.
[B] $P(n)$ is false for infinitely many values of n.
[C] $P(n)$ is false for at most finitely many values of n.
[D] $P(n)$ is true for exactly two values of n.

38. Let $y = f(x)$ be the equation of the curve passing through the point $(1, 1)$ having slope $\log_e x$ for positive values of x. Then the curve

[A] passes through the point $(2, 3 - \log_e 4)$.
[B] does not pass through the point $(2, -\log_e 4)$.
[C] passes through the point $(2, 3 + \log_e 4)$.
[D] passes through the point $(2, \log_e 4)$.

39. How many functions $f : \mathbb{R} \to \mathbb{R}$ satisfy $f(1) = 10$ and $|f(x) - f(y)| = |x - y|$ for all $x, y \in \mathbb{R}$?

A 3. B 2. C 4. D 1.

40. For a real number a, let $\tan^{-1}(a)$ denote the real number θ, $-\frac{\pi}{2} < \theta < \frac{\pi}{2}$; such that $\tan(\theta) = a$. The function $f(x) = \tan^{-1}(bx^2 + 2bx + c)$, where b and c are positive real numbers, is increasing on

A $(-1, \infty)$. B $(-2, 2)$. C $(-\infty, c)$. D $(-2, b)$.

41. A number is picked uniformly randomly from the set of five digit natural numbers. What is the probability that at least one of the digits of the number thus picked is 0?

A $\frac{3987}{10000}$. B $\frac{2601}{10000}$. C $\frac{3095}{10000}$. D $\frac{3439}{10000}$.

42. How many functions $f : \mathbb{N} \longrightarrow \mathbb{N}$ satisfy

$$\text{lcm}(f(n), n) - \text{hcf}(f(n), n) < 5?$$

Here 'lcm' denotes the least common multiple and 'hcf' denotes the highest common factor.

A 0. B Infinitely many. C 1. D More than one but finitely many.

43. Let a, b be distinct positive real numbers, whose geometric mean equals $\frac{a^{t-99} + b^{t-99}}{a^{t-100} + b^{t-100}}$. Then t must equal

A 99. B $\frac{199}{2}$. C 199. D $\frac{99}{2}$.

44. Let f and g be two functions on $\mathbb{R}$ defined by

$$f(x) = \sqrt{x^2 + 1} - x,$$
$$g(x) = \sin(\pi e^{1-x}).$$

Define a function $h : \mathbb{R} \to \mathbb{R}$ by $h(x) = \max\{f(x), g(x)\}$. Then what can be said about $\lim_{x \to \infty} h(x)$?

A It does not exist.
B It is equal to 0.
C It is equal to 1.
D It is equal to -1.

45. Let $\mathcal{P}$ denote a parabola in the plane and let a point $A \in \mathcal{P}$ be given. How many lines ℓ in the plane satsify $\ell \cap \mathcal{P} = \{A\}$?

A Infinitely many. B 2. C 1 D 0.

46. A cylindrical vessel of radius 5 cm is filled with water up to a height of 20 cm. The cylinder is open to atmosphere at the top. A small aperture of radius 2 mm is made on the side of the cylinder at a height of 5 cm from the bottom of the vessel. For approximately how long will water leak out of the aperture?

A 2 minutes and 48 seconds
B 1 minute and 48 seconds
C 2 minutes and 11 seconds
D 1 minute and 11 seconds

47. Two simple pendulums of length 1 m each, with bobs having masses 1 kg and 2 kg, are hanging from the ceiling of an elevator. The elevator starts moving vertically downwards with acceleration $g/10$. Assuming $g = 10\ \text{m/s}^2$, approximately what are the time periods of the two pendulums?

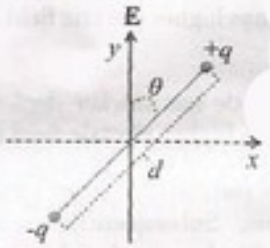
A 2.1 s and 3.0 s.
B 2.1 s and 2.1 s.
C 1.9 s and 2.7 s.
D 1.9 s and 1.9 s.

48. What is the probability that a radioactive nucleus will not have decayed after a time equal to twice its half-life?

A 0.75 B 0.25 C 0.01 D 0.50

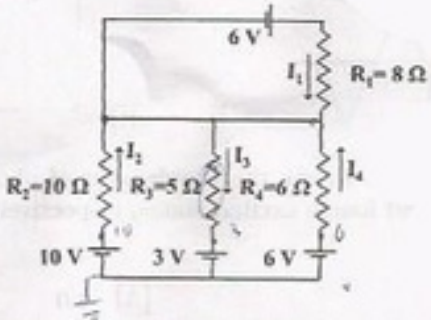
49. An electric dipole having point charges $+q$ and $-q$, separated by a fixed distance d is kept under the influence of a uniform electric field $\mathbf{E}$, such that the axis of the dipole is making an angle $\theta = 45°$ with the direction of $\mathbf{E}$, as shown in the figure. If the electric dipole is allowed to rotate in the xy-plane with its center being stationary, what is the magnitude of the net torque acting on the electric dipole?

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



50. In the circuit shown, what is the approximate current passing through the resistor R_3?

A 0.28 A
B −0.2 A
C 0.75 A
D 0.84 A



51. An electromagnetic wave propagates along z-direction. The corresponding electric field is along x-direction. Which of the following is an acceptable direction for the magnetic field, considering $\hat{x}$, $\hat{y}$, and $\hat{z}$ to be the unit vectors in a Cartesian co-ordinate system?

A $\frac{1}{\sqrt{2}}(\hat{y}+\hat{z})$
B $\frac{1}{\sqrt{2}}(\hat{x}+\hat{y})$
C $\frac{1}{\sqrt{2}}(\hat{x}+\hat{z})$
D $\frac{1}{\sqrt{3}}(\hat{x}+\hat{y}+\hat{z})$

52. An iron ring of radius 2.1 m is to be fitted on top of the rim of a wheel of radius 2.121 m. The coefficient of volume expansion for iron is $3.6 \times 10^{-5}\ K^{-1}$. By approximately how much should the temperature of the iron ring be increased so that it fits the rim of the wheel?

[A] 532 °C [B] 378 °C [C] 833 °C [D] 278 °C

53. An object of mass 100 g is sliding under gravity from point A to point B on a frictionless slide from a height of 5 m, as shown in the figure. After what distance will the object stop on the following flat track beyond point B if the coefficient of kinetic friction between the flat track and the object is 0.5?

[A] 10 m
[B] 1 m
[C] 2.5 m
[D] 20 m

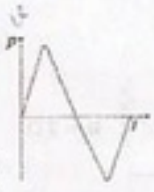
54. A current of 45 A is passing through an infinitely long wire which lies along the axis of an infinitely long solenoid of radius 1 cm. The magnetic field produced by the solenoid in the direction of the current in the wire is 4 mT. What is the approximate magnitude of the resultant magnetic field at a point 3 mm radially away from the solenoid axis? (Use $\mu_o = 4\pi \times 10^{-7}$ T m/A.)

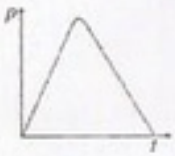
[A] 1 mT [B] 7 mT [C] 3 mT [D] 5 mT

55. For a p-n junction normal diode and a Zener diode, which of the following statements is true?

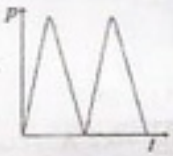
[A] The Zener diode has thicker depletion region and normal diode has higher electric field across the junction.
[B] The normal diode has thicker depletion region and Zener diode has higher electric field across the junction.
[C] The normal diode has thicker depletion region and higher electric field across the junction.
[D] The Zener diode has thicker depletion region and higher electric field across the junction.

56. Starting from rest, a car moves with a constant acceleration, and comes to a momentary stop with the same constant deceleration. Subsequently, it reverses its motion and returns to its original position in a similar manner. Which one of the following graphs of momentum (p) versus time (t) best describes the motion of the car?

[A] 

[B] 

[C] 

[D] 

57. λ_2 and λ_4 are the wavelengths of photons required to excite the Hydrogen atom from its ground state to its second and fourth excited states, respectively. What is the correct ratio λ_2/λ_4?

[A] 4.0 [B] 0.8 [C] 0.25 [D] 1.25

58. A jeweler is holding a gold chain of uniform mass per unit length hanging vertically just above a weighing scale as shown in the figure. He offers to charge the customer for half of the maximum reading of the scale, after he releases the chain. What percentage more than the actual price does the customer pay if he agrees to the offer?

[A] 5
[B] 25
[C] 20
[D] 50

59. A planet of mass m moves in an elliptical path around the Sun (which is at one of the foci of the ellipse), so that its maximum and minimum distances from the Sun are r_{max} and r_{min}, respectively. Taking the gravitational constant to be G and the mass of the Sun to be M_s, what is the angular momentum of the planet relative to the center of the Sun?

A $2G\left[M_s^2 m r_{max} r_{min} / (r_{max} + r_{min})\right]^{1/2}$

B $\left[2GM_s m^2 r_{max} r_{min} / (r_{max} + r_{min})\right]^{1/2}$

C $\left[2GM_s m^2 r_{max} r_{min} / (r_{max} - r_{min})\right]^{1/2}$

D $2G\left[M_s^2 m r_{max} r_{min} / (r_{max} - r_{min})\right]^{1/2}$

60. Two posts of heights 20 m and 10 m are 60 m apart, as shown in the figure. Food grains are continuously distributed between the two posts. A crow sitting on top of the taller post wants to pick up a grain and sit on the other post. What should be the distance of the grain it picks from the bottom of the taller post to minimize the total flight length?

A 40 m

B 30 m

C 20 m

D 50 m