

IAT 2020

Biology

1. Which of the following root modifications is observed in maize?

- A. Fibrous roots B. Lateral root C. Prop roots D. Stilt

2. Which of the following chemical intermediates are products of light in photosynthesis?

- A. ATP and NADPH B. H_2O and NADPH
C. CO_2 and NADPH D. CO_2 and ATP

3. Which of the following organisms produce Cry proteins?

- A. *Bacillus thuringiensis* B. *Saccharomyces cerevisiae*
C. *Escherichia coli* D. *Pseudomonas syringe*

4. A hypothetical plant species shows two flower colour phenotypes- red and white. Red is dominant over white. In a population, this flower colour locus was found to be in Hardy-Weinberg equilibrium. If 490 out of a total population size of 1000 plants were found to be white-flowered, how many of the red-flowered plants will be heterozygous?

- A. 700 B. 90 C. 580 D. 420

5. Troponin controls binding of actin to myosin motor, thereby regulating muscle contraction. Binding of which metal ions to troponin is crucial for this purpose?

- A. *Na* B. *K* C. *Mg* D. *Ca*

6. The following word diagram depicts a food chain in a forest.

Trees (Aspen, willow) → Herbivore (Elk) → Predator (Wolf)

Which is the most likely outcome of depletion in predator population?

- A. Increased browsing by the herbivores stimulates the plant growth leading to increased primary productivity
B. Overgrowth of herbivore population causing reduction in tree populations and therefore, if the process continues the entire ecosystem will breakdown
C. No change in the ecosystem as the herbivore and the tree populations will continue to maintain equilibrium
D. Overgrowth of herbivore population without any change in the remaining part of the ecosystem

7. Which of the following is the correct description of interferon?

- A. A synthetic neurotransmitter used to treat neuronal diseases
- B. A class of proteins secreted by B-lymphocytes that categorically attack and destroy virus-infected cells
- C. Signalling molecules that interfere with its own synthesis inside a secretory cell
- D. A class of proteins secreted by virus infected cells and are involved in protecting uninfected cells

8. Which of the following products are expected when lipase acts on diglycerides?

- A. Fatty acids and glucose
- B. Glucose and galactose
- C. Fatty acids and glycerol
- D. Monoglycerides and glycerol

9. Radial symmetry is NOT found in which of the following taxa?

- A. Echinodermata
- B. Cnidaria
- C. Ctenophora
- D. Cyclostomata

10. Reabsorption of which of these molecules in kidney occurs via passive transport?

- A. Urea
- B. Glucose
- C. Sodium ions
- D. Amino acids

11. Match the human cell types or (column I) to the number of chromatids (column II)

Column I

- (a) G_2 phase cells
- (b) G_1 phase cells
- (c) Spermatogonia (pre-replication)
- (d) Ovum

Column II

- (i) 46
- (ii) 92
- (iii) 23

A. a-ii, b-i, c-iii, d-iii

B. a-ii, b-i, c-i, d-iii

C. a-ii, b-iii, c-i, d-iii

D. a-i, b-ii, c-iii, d-iii

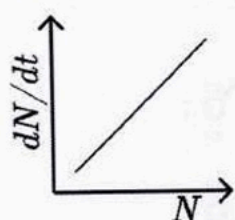
12. Which of the following processes is NOT involved in functionalisation of mRNA (from hnRNA) in eukaryotes?

- A. Amino acylation
- B. 5'-end capping
- C. Polyadenylation
- D. Splicing

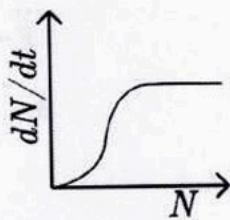
13. Which of the following processes increases the uptake of water and minerals by roots in legumes?

- A. Active uptake by xylem
- B. Pumping through plasmodesmata
- C. Pumping through cortical cells
- D. Formation of mycorrhizae

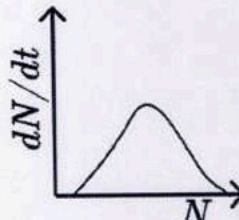
14. Which of the following graphs correctly represents the relationship between population growth rate (dN/dt) and population size (N), if the population shows logistic growth?



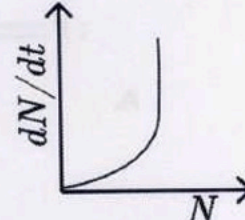
A.



B.



C.



D.

15. Which of the following processes gives rise to new organisms from unfertilized ova in some species of plants and animals?

- A. Autogamy and parthenogenesis
- B. Parthenogenesis and apomixis
- C. Syngamy and apomixis
- D. Xenogamy and autogamy

Chemistry

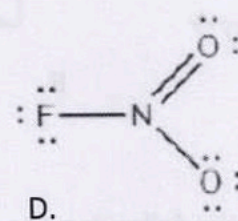
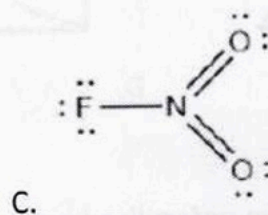
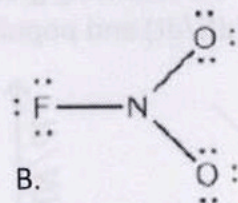
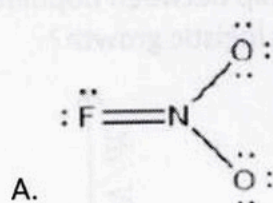
16. How many atoms are present in a hexagonal close-packed unit cell?

- A. 4 B. 2 C. 8 D. 6

17. The molar conductivity of 0.00241 M acetic acid is $32.87\text{ Scm}^2\text{mol}^{-1}$. If the limiting molar conductivity at 298 K is $390.5\text{ Scm}^2\text{mol}^{-1}$, what is the dissociation constant (mol L^{-1})?

- A. 5.36×10^{-5} B. 1.86×10^{-5} C. 5.36×10^{-4} D. 1.86×10^{-4}

18. What is the most appropriate Lewis structure of NO_2F ?



19. Common disaccharide sucrose is held together by a glycosidic linkage between

- A. C1 of β -D-glucose and C2 of α -D-fructose.
 B. C2 of α -D-glucose and C1 of β -D-fructose.
 C. C1 of α -D-glucose and C2 of β -D-fructose.
 D. C1 of α -D-glucose and C2 of α -D-fructose.

20. Select the correct option based on the increasing order of boiling point of the molecules given below.



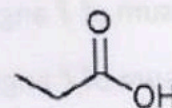
I



II



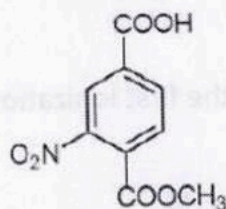
III



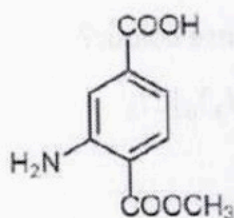
IV

A. $I < III < IV < II$ B. $II < I < IV < III$ C. $I < III < II < IV$ D. $III < I < II < IV$

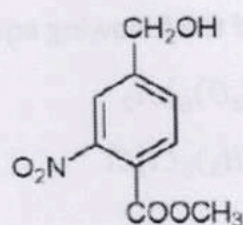
21. Identify the major product that forms easily and faster in the following reaction.
(Tetrahydrofuran = solvent)

 B_2H_6 in tetrahydrofuran

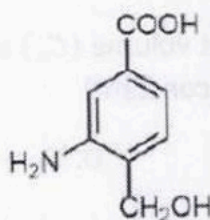
?



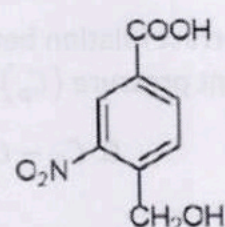
A.



B.



C.



D.

22. A first-order reaction is found to have a half-life of one second (sec). What will be the time required for 99.9% completion of the reaction?

A. 0.693 sec

B. 2 sec

C. 10 sec

D. 69.3 sec

23. The total number of nodes for a given principal quantum number n , and azimuthal quantum number ℓ , are

- A. sum of ℓ angular nodes and $n + \ell - 1$ radial nodes
- B. sum of ℓ angular nodes and $n - \ell - 1$ radial nodes
- C. sum of $\ell + 1$ angular nodes and $n - \ell - 1$ radial nodes
- D. sum of $\ell + 1$ angular nodes and $n + \ell - 1$ radial nodes

24. Which among the following is NOT correct?

- A. H_3PO_4 is a tribasic acid
- B. H_3PO_3 is a dibasic acid.
- C. H_3PO_2 is a monobasic acid.
- D. H_3PO_2 is a tribasic acid

25. Which among the following is NOT correct regarding the first ionization potential (IP_1) of period III elements Mg, Al, Si, P and S ?

- A. $P < S$
- B. $Al < Mg$
- C. $Al < Si$
- D. $Si < P$

26. Which one of the following aqueous solutions gives the most intense colour?

- A. $0.1\text{ M } [Mn(H_2O)_6]Cl_2$
- B. $0.1\text{ M } [Mn(NH_3)_6]Cl_3$
- C. $0.1\text{ M } [Mn(NH_3)_5Cl]Cl$
- D. $0.1\text{ M } KMnO_4$

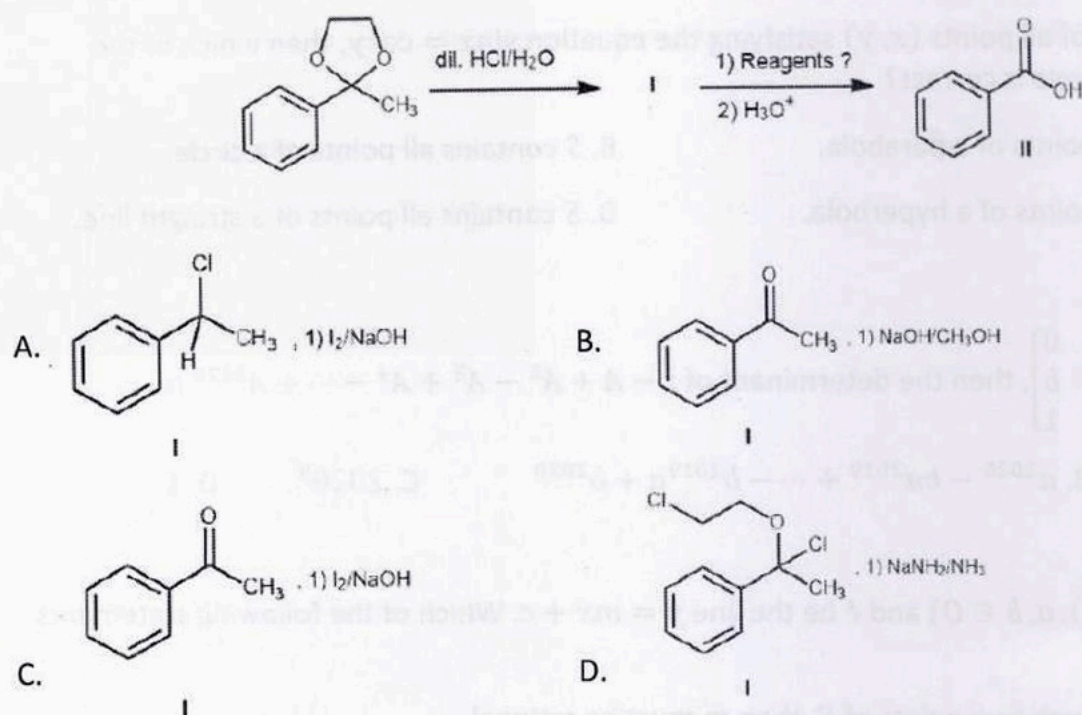
27. What is the correct relation between the heat capacity at constant volume (C_v) and heat capacity at constant pressure (C_p) for an ideal gas? (R =Universal gas constant)

- A. $C_v + C_p = 2R$
- B. $C_p - C_v = R$
- C. $C_v - C_p = 2R$
- D. $C_v + C_p = R$

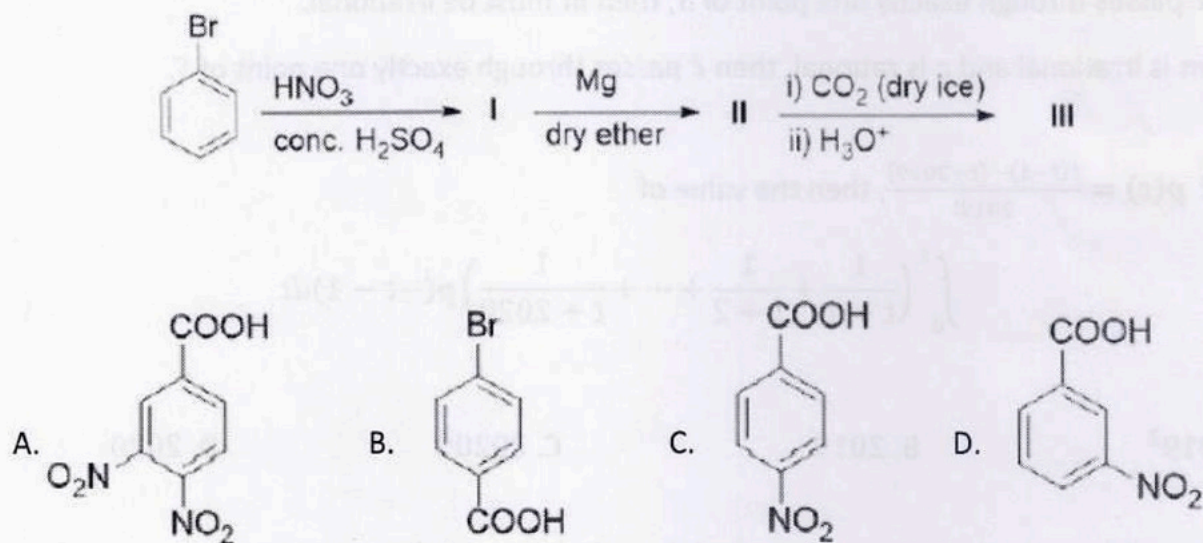
28. The number of unpaired electron(s) in the square planar complex $[Ni(CN)]^{2-}$ is/are

- A. 2
- B. 1
- C. 4
- D. 0

29. Select the most appropriate compound I and the reagents for the synthesis of compound II



30. Identify the final major product III in the following reaction sequence:



Mathematics

31. If S is the set of all points (x, y) satisfying the equation $\sin x = \cos y$, then which of the following statements is correct?

- A. S contains all points of a parabola. B. S contains all points of a circle.
C. S contains all points of a hyperbola. D. S contains all points of a straight line.

32. If $A = \begin{bmatrix} 1 & a & 0 \\ 0 & 1 & b \\ 0 & 0 & 1 \end{bmatrix}$, then the determinant of $I - A + A^2 - A^3 + A^4 - \dots + A^{2020}$ is

- A. 2020 B. $a^{2020} - ba^{2019} + \dots - b^{2019}a + b^{2020}$ C. 2020^3 D. 1

33. Let $S = \{(a, b) : a, b \in \mathbb{Q}\}$ and ℓ be the line $y = mx + c$. Which of the following statements is not correct?

- A. If ℓ passes through two points of S , then m must be rational.
B. If m is rational and c is irrational, then ℓ passes through at least one point of S .
C. If ℓ passes through exactly one point of S , then m must be irrational.
D. If m is irrational and c is rational, then ℓ passes through exactly one point of S .

34. If $p(t) = \frac{t(t-1)\dots(t-2019)}{2019!}$, then the value of

$$\int_0^1 \left(\frac{1}{t+1} + \frac{1}{t+2} + \dots + \frac{1}{t+2020} \right) p(-t-1) dt$$

is:

- A. 2019^2 B. 2019 C. 2020^2 D. 2020

35. Let a, b be nonzero real numbers. If $p(x) = x^n + c_{n-1}x^{n-1} + \dots + c_0$, where $c_{n-1}, \dots, c_0$ are integers and $n \geq 3$, then which of the following statements is correct?

- A. If $a + ib$ is a root of $p(x)$, then n must be even.
B. If a is a root of $p(x)$, then n must be odd.
C. If $a + ib$ is a root of $p(x)$, then $(a + ib)^2$ can never be a root of $p(x)$.
D. If a is a root of $p(x)$, then a must be an integer.

36. The number of skew-symmetric matrices $A = [a_{ij}]_{3 \times 3}$, where $a_{ij} \in \{-3, -2, -1, 0, 1, 2, 3\}$ is:

- A. 7^3 B. 3^7 C. 21^3 D. 7^6

37. Define binary operation $*$ on Q by $a * b = a + b - 3$. The inverse of 2 with respect to $*$ is

- A. 4 B. 2 C. 3 D. 5

38. Let $[x]$ denote the greatest integer less than or equal to x . The number of positive integer solutions of the equation

$$\left[\frac{x}{19}\right] = \left[\frac{x}{20}\right]$$

are:

- A. 190 B. 188 C. 189 D. 187

39. Let $f: \mathbb{R} \rightarrow \mathbb{R}$ and $g: \mathbb{R} \rightarrow \mathbb{R}$ be two functions such that

$$g \circ f(x) = \begin{cases} x^2, & \text{if } x \geq 0, \\ e^x - 1, & \text{if } x < 0. \end{cases}$$

Then which of the following statements is correct?

- A. g is onto. B. f is onto. C. g is one-one. D. f is one-one.

40. $F(x) = \int_0^{e^x} (t^3 + 2t^2 - t - 2) dt$, then for how many real numbers x does $F'(x) = 0$?

- A. 0 B. 3 C. 2 D. 1

41. Let C be a circle which passes through $(-2, 1)$ and $(0, 3)$ and whose centre lies on the line $y - x = 1$. Then which of the following points lies on C ?

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

42. For what value of t does $f(x) = x^3 + tx^2 + (2 - t)x - 3$ have only real roots?

- A. $t = 0$. B. $t = 4$. C. $t = 2$. D. $t = -1$

43. If $f(x) = ax^2 + bx + c$ and $f\left(\frac{1}{n}\right) = \frac{n+1}{n^2}$ for all $n \in \mathbb{N}$, then what is the value of $\lim_{x \rightarrow 0} f'(x)$?

- A. 2 B. 0 C. 1 D. -1

44. A bag contains 8 balls, of which 5 are green and 3 are red. The probability that two balls chosen at random are of the same colour is:

- A. 12/28 B. 14/28 C. 15/28 D. 13/28

45. Consider the differential equation $f'' + pf' + qf = 0$ where p and q are constants, $p^2 = 4q$ and $q \neq 0$. If y is a nonzero solution of the equation, then which of the following statements is correct?

- A. $(1+x)y$ can never be a solution B. y^2 can never be a solution
C. y' can never be a solution D. xy can never be a solution

Physics

46. The potential energy of a point particle of mass m undergoing rectilinear motion along the x -axis is given by

$$V(x) = Ax + Bx^2$$

What is the maximum speed attained by the particle if it starts from rest at $x = \frac{A}{B}$?

A. $\frac{3A}{\sqrt{2Bm}}$

B. $\frac{A}{\sqrt{2Bm}}$

C. $\frac{2A}{\sqrt{Bm}}$

D. $A \sqrt{\frac{2}{Bm}}$

47. Two identical containers kept at the same temperature carry the same gas with different molecular mean free paths l_1 and l_2 . The gas from the first container is completely transferred into the second at the same temperature. What is the molecular mean free path of the resultant mixture in the second container?

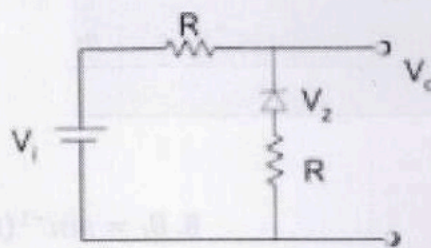
A. $\frac{l_1 l_2}{l_1 + l_2}$

B. $\sqrt{l_1 l_2}$

C. $l_1 + l_2$

D. $\sqrt{l_1^2 + l_2^2}$

48. Consider the circuit with a Zener diode whose breakdown voltage $V_z = 4$ V. What is the voltage V_0 if $V_i = 20$ V?



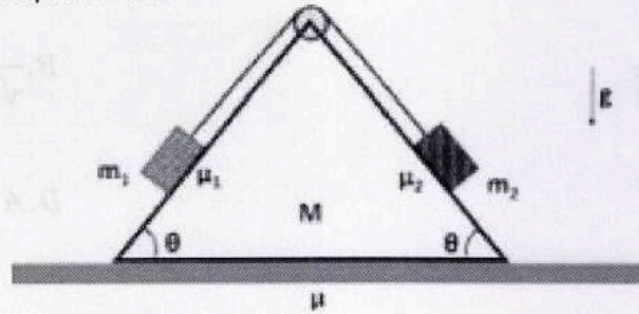
A. 8V

B. 12V

C. 10V

D. 16V

49. Consider a mass-pulley system as shown in the figure. There is a wedge of mass M and equal wedge angles θ lying on a rigid horizontal table. The coefficient of friction between the wedge and the table is μ . There are two blocks of mass m_1 and m_2 lying on the incline of the wedge. The coefficients of friction between the blocks and wedge are μ_1 and μ_2 as shown in the figure. Consider $m_1 > m_2$ and the coefficients of friction (μ, μ_1 and μ_2) to be less than $\tan\theta$. Gravity is acting downwards with acceleration due to gravity g . What should be the value of $\frac{m_1}{m_2}$ so that the system is in equilibrium?



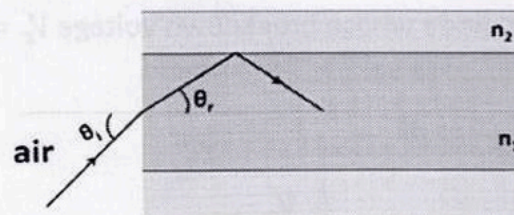
A. $\frac{\mu_1\mu_2\cos\theta + \sin\theta}{\sin\theta - \mu\cos\theta}$

B. $\frac{\mu_1\cos\theta + \sin\theta}{\sin\theta - \mu_2\cos\theta}$

C. $\frac{\mu_2\cos\theta + \sin\theta}{\sin\theta - \mu_1\cos\theta}$

D. $\frac{\mu\cos\theta + \sin\theta}{\sin\theta - \mu_1\cos\theta}$

50. What is the maximum angle of incidence θ_i in the figure for which the ray would satisfy the condition for total internal reflection at the boundary of media of refractive indices n_1 and n_2 , where $n_1 > n_2$?



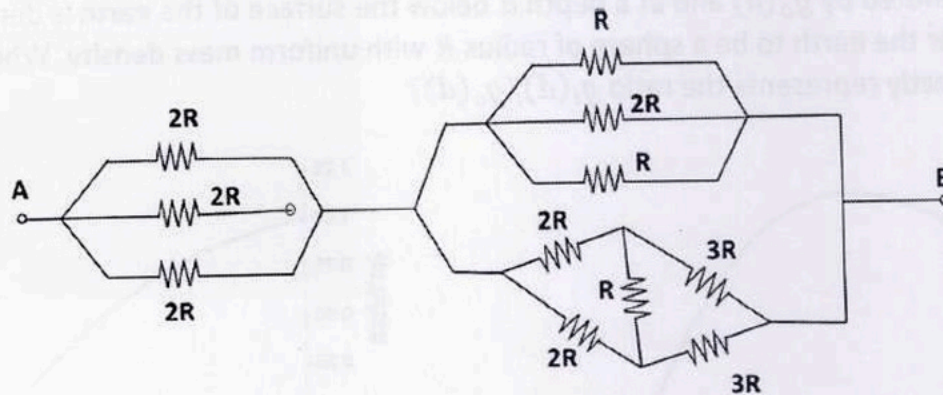
A. $\theta_i = \sin^{-1}(n_1^2 - n_2^2)$

B. $\theta_i = \sin^{-1}(n_1 - n_2)^2$

C. $\theta_i = \sin^{-1}\left(\sqrt{\frac{n_2}{n_1}}\right)$

D. $\theta_i = \sin^{-1}\left(\sqrt{n_1^2 - n_2^2}\right)$

51. What is the equivalent resistance between the points A and B in the figure?



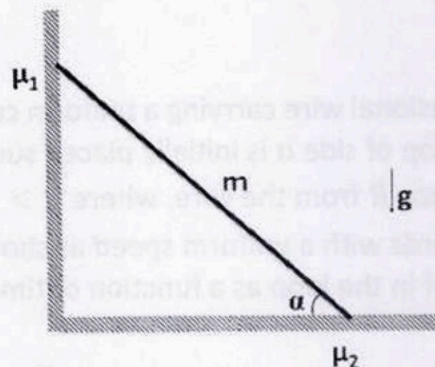
A. $39R/10$

B. $39R/29$

C. $68R/87$

D. $87R/68$

52. Consider a solid rod of mass m and uniform density resting against a vertical wall and horizontal floor as shown in the figure. The coefficients of friction of the rod with the wall and with the floor are given to be μ_1 and μ_2 respectively. Gravity is acting downwards with acceleration due to gravity g . What should be the value of the inclination angle α so that the rod stays in equilibrium?



A. $\tan^{-1}\left(\frac{\mu_1}{\mu_2}\right)$

B. $\tan^{-1}\left(\frac{1 - \mu_2}{2\mu_1\mu_2}\right)$

C. $\tan^{-1}\left(\frac{1 - \mu_1\mu_2}{2\mu_2}\right)$

D. $\tan^{-1}\left(\frac{\mu_2}{\mu_1}\right)$

53. The charge distribution inside a sphere of radius $R = 2a/b$ is given by the volume charge density $\rho = ar^2 - br^3$, where a and b are constants and r is the radial distance from the center of the sphere. At what distance from the center of the sphere, will the electric field go to zero?

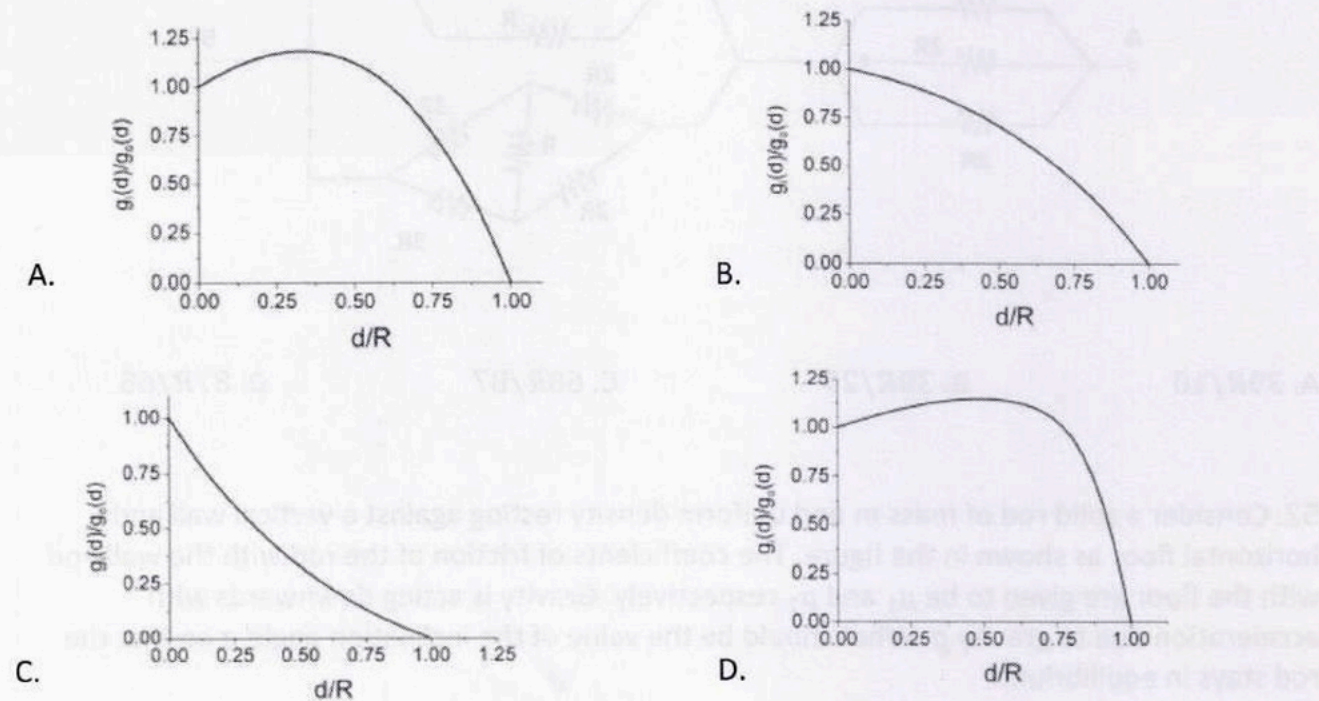
A. $4a/3b$

B. $3a/2b$

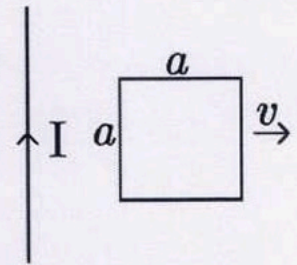
C. a/b

D. $6a/5b$

54. The acceleration due to earth's gravity on a point particle at a height h above the surface of the earth is denoted by $g_o(h)$ and at a depth d below the surface of the earth is denoted by $g_i(d)$. Consider the earth to be a sphere of radius R with uniform mass density. Which of the following correctly represents the ratio $g_i(d)/g_o(d)$?



55. Consider an infinite one-dimensional wire carrying a uniform current I as shown in the figure. A square loop of side a is initially placed such that the center of the loop is at a distance R from the wire, where $R > \frac{a}{2}$. The square loop is then moved rightwards with a uniform speed as shown in the figure. What is the induced emf in the loop as a function of time t ?



A.
$$\frac{\mu_0 I a^2 v}{2\pi \left[(R + vt)^2 - \frac{a^2}{4} \right]}$$

B.
$$\frac{3\mu_0 I a^2 v}{4\pi \left[(R + vt)^2 - \frac{a^2}{4} \right]}$$

C.
$$\frac{\mu_0 I a^2 v}{4\pi \left[(R + vt)^2 - \frac{a^2}{4} \right]}$$

D.
$$\frac{3\mu_0 I a^2 v}{2\pi \left[(R + vt)^2 - \frac{a^2}{4} \right]}$$

56. The electric field of an electromagnetic wave is given by $\vec{E}(x, t) = E_0 \hat{z} \cos(ax + bt)$

If c is the speed of light, then the value of b is

- A. ac B. $2\pi ac$ C. $\sqrt{2}ac$ D. $\frac{ac}{2\pi}$

57. An electron of mass m_e has a speed u_n in the n^{th} Bohr orbit of a hydrogen atom. The normalized speed V_n is given as $V_n = u_n/c = 1/685$ and the mass of the electron in the units of energy is given as $M_e = m_e c^2 = 0.51 \times 10^6 \text{ eV}$, where c is the velocity of light in a vacuum. It is given that $\frac{e^2}{2\epsilon_0 h c} = 1/137$. The Planck's constant h is given as $4.13 \times 10^{-15} \text{ eV}\cdot\text{sec}$. The electron makes a transition from n^{th} orbit to the ground state of the atom. What is the frequency of the emitted photon?

- A. $3.29 \times 10^{15} \text{ Hz}$ B. $2.47 \times 10^{15} \text{ Hz}$ C. $2.93 \times 10^{15} \text{ Hz}$ D. $3.16 \times 10^{15} \text{ Hz}$

58. In the photoelectric effect experiment, the frequency of the incident light is changed from red to blue while keeping the energy per unit area per unit time of the incident radiation fixed. What will happen to the saturation current?

- A. Saturation current doesn't depend on frequency and therefore will be same for red and blue light
 B. Saturation current depends on intensity and therefore will be same for red and blue light
 C. Saturation current for blue colour light is larger than red colour light
 D. Saturation current for blue colour light is smaller than red colour light

59. An ideal rigid diatomic gas undergoes expansion at constant pressure when ΔQ heat is added to it. What is the ratio of the change in the internal energy ΔU to the heat supplied ΔQ ?

- A. $\frac{\Delta U}{\Delta Q} = \frac{3}{5}$ B. $\frac{\Delta U}{\Delta Q} = \frac{5}{7}$ C. $\frac{\Delta U}{\Delta Q} = \frac{7}{9}$ D. $\frac{\Delta U}{\Delta Q} = \frac{2}{3}$

60. The fundamental constants are given to be permittivity constant (ϵ_0), Planck's constant (h), velocity of light (c), Newton's constant (G) and Boltzmann's constant (k_B). Which of the following quantities constructed out of the above constant has the dimensions of an electric charge?

- A. $\sqrt{\frac{hG}{\epsilon_0^3}}$ B. $\sqrt{hc}$ C. $k_B \sqrt{hc}$ D. $\sqrt{\epsilon_0 hc}$

ANSWER KEY 2020

Question Number	Answer	Question Number	Answer	Question Number	Answer	Question Number	Answer
1	(D)	16	(D)	31	(D)	46	(A)
2	(A)	17	(B)	32	(D)	47	(A)
3	(A)	18	(D)	33	(B)	48	(B)
4	(D)	19	(C)	34	(C)	49	(C)
5	(D)	20	(C)	35	(D)	50	(D)
6	(B)	21	(B)	36	(A)	51	(A)
7	(D)	22	(C)	37	(A)	52	(C)
8	(C)	23	(B)	38	(C)	53	(D)
9	(D)	24	(D)	39	(D)	54	(A)
10	(A)	25	(A)	40	(D)	55	(A)
11	(B)	26	(D)	41	(C)	56	(A)
12	(A)	27	(B)	42	(B)	57	(D)
13	(D)	28	(D)	43	(C)	58	(D)
14	(C)	29	(C)	44	(D)	59	(B)
15	(B)	30	(C)	45	(B)	60	(D)