AIITS 5

Name: _____   **Date:** _____

Instructions:

- Each MCQ has 4 options, with only one correct answer.

- The paper consists of 60 questions.

- Each subject consists of 15 questions.

- **Duration:** 180 minutes

- **Marking Scheme:**

    - Correct: +4 marks
    - Incorrect: -1 mark
    - Unattempted: No marks

- **Maximum Marks:** 240

- **Best of luck for your exam!**

BIOLOGY

1. Which of the following can explain the reduction of gametophytes as the plant evolves from algae to angiosperm?

  a. Smaller gametophytes can stay within the parental body and be protected from environmental stresses.

  b. Smaller gametophytes are just random events. It does not have any specific advantage as such.

  c. Production of larger gametophytes was too strenuous for the plants.

  d. None of the Above.

2. Asexual reproduction is a mode of reproduction in which a new offspring is produced by a single parent and the produced individuals are clones of their parents. Which of the following is not an asexual reproductive structure?

  a. Isogametes of Cladophora

  b. Zoospores of Chlamydomonas

  c. Conidia of Penicillium

  d. Gemmules in a sponge

3. In some chordates, the notochord is modified as the vertebral column. Such animals are called vertebrates. Which one of these statements can be deduced from the given statement?

  a. All chordates are vertebrates, but all vertebrates are not chordates.

  b. All vertebrates are chordates and all chordates are vertebrates.

  c. All vertebrates are chordates, but all chordates are not vertebrates.

  d. Chordates are not vertebrates and vertebrates are not chordates.

4. Suppose you are given a plant sample of a sorghum plant. You are observing its dark reaction. What will be the ratio of No. of carboxylation: No. of decarboxylation in the Hatch and Slack pathway?

  a. 1:2

  b. 2:1

  c. 1:1

  d. 1:3

5. In the glomerular capillary (GC), fluid moves into Bowman's capsule through its almost entire length. But in the muscle capillary (MC), fluid moves into interstitial space at its arteriolar end. Which of the following statements are INCORRECT?

  a. a and b

  b. c and d

  c. e and f

  d. b and f

6. If a woman with a severed corpus callosum viewed a photograph of a familiar face, first in her left field of vision and then in her right field, why would she find it difficult to put a name to the face in either field?

  a. Each cerebral hemisphere is specialized for different parts of this task - the right for language and the left for face recognition.

  b. Each cerebral hemisphere is specialized for different parts of this task - the right for face recognition and the left for language. Without an intact corpus callosum, either hemisphere cannot take advantage of the other's processing abilities.

  c. Each cerebral hemisphere is specialized for different parts of this task - the right for face recognition and the left for language. With or without an intact corpus callosum, either hemisphere can take advantage of the other's processing abilities.

  d. Each cerebral hemisphere is specialized for different parts of this task - the right for face recognition and the left for language. Without an intact corpus callosum, either hemisphere

can take advantage of the other's processing abilities.

7. Given below are four statements regarding the human blood circulatory system. Which two of the above statements are correct?

- **a.** (a) (d)
- **b.** (a) (b)
- **c.** (b) (c)
- **d.** (c) (d)

8. Identify whether the given nutrients are absorbed by active transport, simple diffusion, or facilitated transport.

- **a.** I - Active transport, II - Active transport, III - Facilitated, IV - Simple diffusion.
- **b.** I - Facilitated transport, II - Simple diffusion, III - Active transport, IV - Active transport.
- **c.** I - Active transport, II - Facilitated transport, III - Simple diffusion, IV - Simple transport.
- **d.** I - Simple transport, II - Simple transport, III - Facilitated transport, IV - Active Transport.

9. Which of the following statements about the structure and function of the plasma membrane is false?

- **a.** The plasma membrane is composed of a phospholipid bilayer with embedded proteins.
- **b.** The plasma membrane selectively allows the passage of certain molecules while preventing others from passing.
- **c.** The plasma membrane is a rigid structure but when required can modify its surface protein to behave like a dynamic and flexible structure.
- **d.** The plasma membrane plays a key role in maintaining the internal environment of the cell.

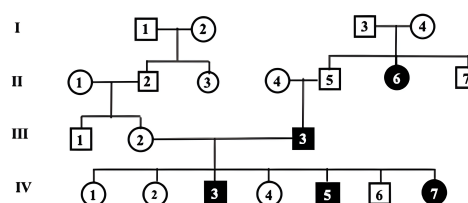**10.** Which of the following correctly explains the Michaelis-Menten kinetics?

- **a.** Km is said as reaction velocity.
- **b.** Km is the substrate concentration at which reaction velocity is maximum.
- **c.** Km is the dissociation constant of enzyme and substrate.

- **d.** Km is the binding affinity of the enzyme for the substrate.

11. The opening of axon membrane voltage-gated potassium channels is responsible for which part of the action potential?

- **a.** Depolarisation of the membrane
- **b.** Repolarisation of the membrane
- **c.** Contraction of the postsynaptic muscle fiber
- **d.** Signaling vesicular release of neurotransmitters

12. In the given pedigree, circles represent females and squares represent males. Filled shapes indicate affected individuals while unfilled shapes indicate unaffected individuals. Based on the pedigree information provided below, justify the inheritance pattern.

- **a.** Autosomal dominant
- **b.** Autosomal recessive
- **c.** X-linked dominant
- **d.** X-linked recessive

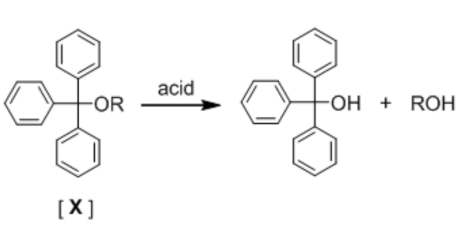**13.** Which of the following factors favor the formation of oxyhaemoglobin in lungs?

- **a.** pO2 decrease, pCO2 increase, Temperature increase, H+ concentration increase
- **b.** pO2 increase, pCO2 increase, Temperature increase, H+ concentration increase
- **c.** pO2 decrease, pCO2 decrease, Temperature decrease, H+ concentration decrease
- **d.** pO2 increase, pCO2 decrease, Temperature decrease, H+ concentration decrease

14. Jenny is about to face an interview. She experiences sweating, increased heart rate, and breathing during the first five minutes before the interview. Her restlessness is caused by which hormone?

a. Estrogen and progesterone

b. Oxytocin and vasopressin

c. Adrenaline and noradrenaline

d. Insulin and glucagon

15. If a tree flowers thrice in a year in October, January, and July in northern India, the plant is:

a. Photo and thermo sensitive

b. Photo and thermo insensitive

c. Photosensitive but thermo insensitive
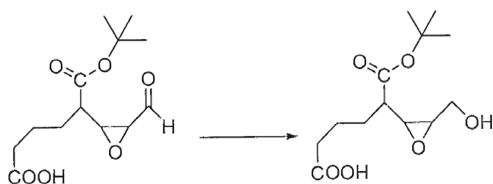
d. Thermo sensitive but photo insensitive

CHEMISTRY

16. Assuming Hund's rule is violated, the bond order and magnetic nature of the diatomic molecule B_2 would be:

a. Bond order = 1, diamagnetic

b. Bond order = 0, diamagnetic

c. Bond order = 1, paramagnetic

d. Bond order = 0, paramagnetic

17. The species that possesses the highest spin angular momentum (S) is:

a. $[Ni(NH_3)_6]Cl_2$

b. $[Co(NH_3)_6]Cl_2$

c. $[Fe(NH_3)_6]Cl_2$

d. $[Cu(NH_3)_6]Cl_2$

18. The acidic hydrolysis of ether (X) shown below is fastest when:

[**X**]

a. one phenyl group is replaced by a methyl group.

b. one phenyl group is replaced by a para-methoxyphenyl group.

c. two phenyl groups are replaced by two para-methoxyphenyl groups.

d. no structural change is made to X.

19. A solution of (-)-1-chloro-1-phenylethane in toluene racemises slowly in the presence of a small amount of SbCl$_5$, due to the formation of:

a. Carbocation

b. Free radical

c. Carbanion

d. Carbene

20. Solubility product of silver bromide is 5.0×10^{-13}. The quantity of potassium bromide (molar mass 120 g/mol) required to be added to 1 L of 0.05 M solution of silver nitrate for complete precipitation of AgBr is:

a. 1.2×10^{-10} g

b. 1.2×10^{-9} g

c. 6.2×10^{-5} g

d. 5.0×10^{-8} g

21. Consider the bonding (Φ_b) and antibonding (Φ_a) molecular orbitals of the H$_2^+$ molecule formed by the linear combination of the atomic orbitals Ψ_X and Ψ_Y centered on the two H atoms X and Y. The correct statement is:

a. An electron present in the Φ_a orbital feels more electron-nuclei attraction compared to the one present in the Φ_b orbital.

b. For Φ_a, the probability density between the nuclei is increased by $c\Psi_X\Psi_Y$, where c is a positive real number.

c. For the function Φ_a, the probability density at any point on a plane midway between the nuclei and perpendicular to the internuclear axis is 0.5.

d. As the internuclear distance is increased from the equilibrium bond distance, the energy of Φ_b is increased and that of Φ_a is lowered.

22. Consider a 70% efficient hydrogen-oxygen fuel cell working under standard conditions at 1 bar and 298 K. Its cell reaction is:

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$$

The work derived from the cell on the consumption of 1.0×10^{-3} mol of $H_2(g)$ is used to compress 1.00 mol of a monoatomic ideal gas in a thermally insulated container. What is the change in temperature (in K) of the ideal gas?

Given: $E^\circ(O_2/H_2O) = 1.23\,V$, $E^\circ(H^+/H_2) = 0.00\,V$, $F = 96500\,C\,mol^{-1}$, $R = 8.314\,J\,mol^{-1}K^{-1}$.

a. 13.81 K

b. 12.92 K

c. 13.32 K

d. 13.23 K

23. One mole of d-2-bromobutane is hydrolysed in an alkaline medium to form butane-2-ol. The rate of formation of l-butane-2-ol is assumed to be twice that of d-butane-2-ol. The specific rotation of d-butane-2-ol is $+13.5^\circ$. After complete reaction, the specific rotation of the product mixture is:

a. -4.5°

b. $+4.5^\circ$

c. $+13.5^\circ$

d. -5.5°

24. For the identification of beta-naphthol using the dye test, it is necessary to use:

a. dichloromethane solution of beta-naphthol

b. acidic solution of beta-naphthol

c. neutral solution of beta-naphthol

d. alkaline solution of beta-naphthol

25. In a bimolecular reaction, the steric factor P was experimentally determined to be 4.5. The correct option(s) among the following is(are):

a. The value of the frequency factor predicted by the Arrhenius equation is higher than that determined experimentally.

b. The activation energy of the reaction is affected by the value of the steric factor.

c. Since $P = 4.5$, the reaction will not proceed unless an effective catalyst is used.

d. The experimentally determined value of the frequency factor is higher than that predicted by the Arrhenius equation.

26. An isotope of copper, on bombardment with protons, undergoes a nuclear reaction yielding element X as shown below. To which group does element X belong in the periodic table?

$$^{63}_{29}Cu + ^{1}_{1}H \rightarrow 6\,^{1}_{0}n + 4\,^{4}_{2}\alpha + 2\,^{1}_{1}H + X$$

a. Group 6

b. Group 7

c. Group 8

d. Group 9

27. For the process $H_2O(l) \rightarrow H_2O(g)$ at $T = 100^\circ C$ and 1 atm pressure, the correct choice is:

a. $\Delta S_{system} > 0$ and $\Delta S_{surroundings} > 0$

b. $\Delta S_{system} > 0$ and $\Delta S_{surroundings} < 0$

c. $\Delta S_{system} < 0$ and $\Delta S_{surroundings} > 0$

d. $\Delta S_{system} < 0$ and $\Delta S_{surroundings} < 0$

28. Choose the correct statement(s) among the following:

a. $SnCl_2 \cdot 2H_2O$ is a reducing agent.

b. SnO_2 reacts with $Ca(OH)_2$ to form $K_2[Sn(OH)_6]$.

c. A solution of $PbCl_2$ in HCl contains Pb^{2+} and Cl^- ions.

d. The reaction of Pb_3O_4 with hot dilute nitric acid to give PbO_2 is a redox reaction.

29. Reagent(s) which can be used to bring about the following transformation is(are):

a. LiAlH$_4$ in (C$_2$H$_5$)$_2$O

b. BH$_3$ in THF

c. NaBH$_4$ in C$_2$H$_5$OH

d. Raney Ni/H$_2$ in NaOH

30. The number of geometrical isomers possible for the complex [Cr(NH$_3$)$_2$(H$_2$O)$_2$Cl$_2$]$^+$ is:

a. 3

b. 4

c. 5

d. 6

MATHEMATICS

31. Let $f(x) = x - \lfloor x \rfloor$, $x \in \mathbb{R}$, where $\lfloor x \rfloor$ is the greatest integer less than or equal to x. Then $f'\left(\frac{1}{2}\right)$ is

a. $3\frac{}{2}$

a. 1

b. 0

c. -1

32. The value of $\displaystyle\int_{\sqrt{\ln 2}}^{\sqrt{\ln 3}} \frac{x \sin(x^2)}{\sin(x^2) + \sin(\ln 6 - x^2)}\, dx$ is

a. $\frac{1}{4} \ln\left(\frac{3}{2}\right)$

b. $\frac{1}{2} \ln\left(\frac{3}{2}\right)$

c. $\ln\left(\frac{3}{2}\right)$

d. $\frac{1}{6} \ln\left(\frac{3}{2}\right)$

33. The value of the integral $\displaystyle\int_{1}^{100} \frac{\lfloor x \rfloor}{x}\, dx$ is

a. $\log\left(\frac{100^{99}}{99!}\right)$

b. $\log\left(\frac{100^{99}}{98!}\right)$

c. $\log\left(\frac{100^{98}}{99!}\right)$

d. $\log\left(\frac{100^{98}}{98!}\right)$

34. The number of real solutions of the equation $2\sin(3x) + \sin(7x) - 3 = 0$ in the interval $[-2\pi, 2\pi]$ is

a. 1

b. 2

c. 3

d. 4

35. The parabola $y^2 = 4x + 1$ divides the disc $x^2 + y^2 \leq 1$ into two regions with areas A_1 and A_2. Then $|A_1 - A_2|$ equals

a. $\frac{1}{3}$

b. $\frac{2}{3}$

c. $\frac{\pi}{4}$

d. $\frac{\pi}{3}$

36. Let $P = \{\theta : \sin\theta - \cos\theta = \sqrt{2}\cos\theta\}$ and $Q = \{\theta : \sin\theta + \cos\theta = \sqrt{2}\sin\theta\}$. Then

a. $P \subset Q$ and $Q - P \neq \phi$

b. $Q \not\subset P$

c. $P \not\subset Q$

d. $P = Q$

37. If $\displaystyle\int \frac{1}{(1+x)\sqrt{x}}\,dx = f(x) + A$, where A is an arbitrary constant, then $f(x)$ is

a. $2\tan^{-1} x$

b. $2\tan^{-1}\sqrt{x}$

c. $2\cot^{-1}\sqrt{x}$

d. $\ln(1+x)$

38. Given $x \in \mathbb{C}$, the equation $|z - z_0| = R$ of a circle centred at z_0 with radius R can be written as

a. $|z|^2 - 2\operatorname{Re}(zz_0) + |z_0|^2 = R^2$

b. $|z|^2 - 2\operatorname{Re}(z\overline{z_0}) + |z_0|^2 = R^2$

c. $|z|^2 - 2\operatorname{Im}(z\overline{z_0}) + |z_0|^2 = R^2$

d. $|z|^2 - 2\operatorname{Im}(zz_0) + |z_0|^2 = R^2$

39. Let $f : \mathbb{R} \to \mathbb{R}$ satisfy $f(x) = e^{x^2/2} \int_0^x t f(t)\, dt$. Then which of the following is correct?

a. $5 < f(\sqrt{2}) < 6$

b. $2 < f(\sqrt{2}) < 3$

c. $3 < f(\sqrt{2}) < 4$

d. $4 < f(\sqrt{2}) < 5$

40. Suppose the system $\begin{cases} ax + by + z = 0 \\ x + ay + z = 0 \\ x + y + az = 0 \end{cases}$ has infinitely many solutions. The set of possible a values is

a. $\{1, -1\}$

b. $\{2, -2\}$

c. $\{-1, 2\}$

d. $\{1, -2\}$

41. In a regular 15-sided polygon, if a diagonal is chosen at random, the probability that it is either the shortest or longest diagonal is

a. $\frac{2}{3}$

b. $\frac{5}{6}$

c. $\frac{8}{9}$

d. $\frac{9}{10}$

42. Consider the differential equation $\cos(y)\frac{dy}{dx} + \frac{1}{x}\sin(y) = x$ for $x > 0$, with $y = \frac{\pi}{2}$ at $x = \sqrt{3}$. The value of y at $x = \sqrt{\frac{3}{2}}$ is

a. $\pi/6$

b. $\pi/3$

c. $\pi/2$

d. $\pi/4$

43. If one end of the focal chord of the parabola $y^2 = 16x$ is at $(1, 4)$, then the length of this focal chord is

a. 25

b. 24

c. 20

d. 22

44. How many solutions does $\tan(2x) = \cos\left(\frac{x}{2}\right)$ have on $[0, 2\pi]$?

a. 2

b. 3

c. 4

d. 5

45. In the middle term of $\left(\frac{1}{x} + x\sin x\right)^{10}$ is equal to $7\frac{7}{8}$, then the value of x is

a. $2n\pi + \frac{\pi}{6}$

b. $n\pi + \frac{\pi}{6}$

c. $n\pi + (-1)^n \frac{\pi}{6}$

d. $n\pi + (-1)^n \frac{\pi}{6}$

PHYSICS

46. A projectile fired from ground returns to ground. If at time t_1 its velocity vector $\vec{v}_1$ and at time t_2 its velocity $\vec{v}_2$ satisfy $\vec{v}_1 + \vec{v}_2 = 0$, then:

a. $t_1 + t_2 = T$ (total flight time)

b. $t_2 - t_1 = T/2$

c. Both must be equidistant from $T/2$

d. Only possible if $t_1 = T/2$ and $t_2 = T/2$

47. A small block of mass m rests on the inner surface of a smooth hemisphere (radius R) rotating with constant angular speed ω. In the rotat-

ing frame, equilibrium along the surface's tangent leads to one of these relations between g, ω, R, and θ:

a. $g = \omega^2 R \sin \theta$

b. $g = \omega^2 R \cos \theta$

c. $g = \omega^2 R \tan \theta$

d. $g = \omega^2 R \cot \theta$

48. Two bodies, each of mass M, are kept fixed with a separation of $2L$. A particle of mass m is projected from the midpoint of the line joining their centers, perpendicular to the line. The gravitational constant is G. Choose the correct statement:

a. Escape velocity occurs at $4\sqrt{\dfrac{GM}{L}}$

b. The system's potential energy is $-\dfrac{2GMm}{L}$

c. Minimum escape velocity is $\sqrt{\dfrac{2GM}{L}}$

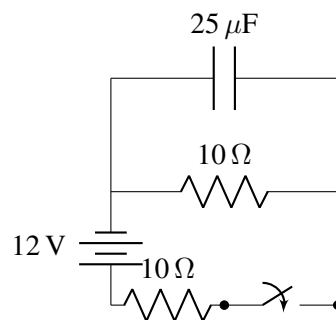**d.** The particle always moves in circular orbit

49. A large cylindrical tank has a hole of area A at its bottom. Water is poured in the tank by a tube of equal cross-sectional area A ejecting water at the speed v.

a. The water level in the tank will keep on rising

b. No water can be stored in the tank

c. The water level will rise to a height $\dfrac{v^2}{2g}$ and then stop

d. The water level will oscillate

50. A ferromagnet obeys the Weiss mean-field relation $M = N\mu_B \tanh\left(\dfrac{\mu_B(H + \lambda M)}{kT}\right)$. Near the Curie temperature $T_C = \dfrac{\lambda\mu_B^2 N}{k}$, the initial susceptibility diverges as:

a. $\chi \propto (T - T_C)^{-1}$

b. $\chi \propto (T_C - T)^{-1}$

c. $\chi \propto (T_C - T)^{-2}$

d. $\chi \propto (T - T_C)^{1/2}$

51. The switch S shown in the figure is kept closed for a long time and is then opened at $t = 0$. Find the current in the middle $10\,\Omega$ resistor at $t = 1.0\,\text{ms}$.
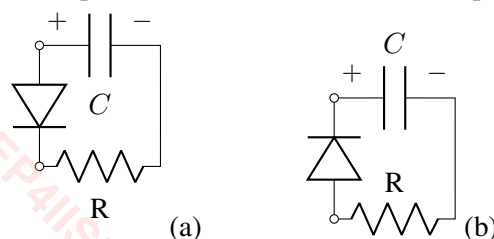

a. 0.20 mA

b. 0.24 mA

c. 0.48 mA

d. 0.11 mA

52. A circular Fresnel zone plate focuses light to its focal point F. At F, a linear polarizer is rotated. Which combination maximizes transmitted intensity at F?

a. Polarizer axis $\perp$ to incident polarization

b. Polarizer axis $\parallel$ to incident polarization

c. Polarizer at $45°$ to incident polarization

d. Polarizer orientation has no effect

53. Two identical capacitors A and B are charged to the same potential V and are connected in two circuits at $t = 0$ as shown in figure. The charges on the capacitors at a time $t = CR$ are, respectively:

a. VC, VC

b. $\dfrac{VC}{e}, VC$

c. $VC, \dfrac{VC}{e}$

d. $\dfrac{VC}{e}, \dfrac{VC}{e}$

54. A simple pendulum of length L oscillates with amplitude θ_0. Its exact period T is

$$T = 4\sqrt{\frac{L}{g}} \int_0^{\pi/2} \frac{d\phi}{\sqrt{1 - \sin^2(\theta_0/2)\sin^2\phi}}$$

For $\theta_0 = 90°$, the leading correction to small-angle period is approximately:
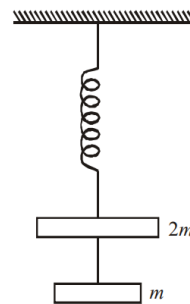
a. +5%

b. +10%

c. +15%

d. +20%

55. A reversible engine extracts heat Q_H from a reservoir whose temperature decreases linearly from T_1 to T_2 while delivering Q_L to a constant-temperature sink at $T_0 < T_2$. The maximum efficiency is:

a. $1 - \dfrac{T_0}{T_1}\dfrac{\ln\left(\dfrac{T_1}{T_2}\right)}{\ln\left(\dfrac{T_1}{T_2}\right)}$

b. $1 - \dfrac{T_0}{\sqrt{T_1 T_2}}$

c. $1 - \dfrac{T_0(T_2 - T_1)}{T_1 T_2 \ln(T_2/T_1)}$

d. $1 - \dfrac{T_0}{T_1 + T_2}$

56. A thin ring, a disk and an annular cylinder, of same mass M, are released from a point 3.6 m from the ground up an inclined plane of 30° inclination. The ring and the disk have the same radius R. For the annular cylinder, the outer radius is R and the inner radius is $R/2$. Times taken by the ring, disk and annular cylinder, respectively, to reach the ground are in the ratio,
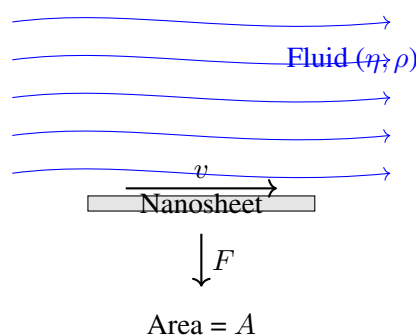
a. $\sqrt{2} : \sqrt{1.5} : \sqrt{1.6}$

b. $\sqrt{1.4} : \sqrt{1.5} : \sqrt{2}$

c. $\sqrt{2} : \sqrt{1.5} : \sqrt{1.5}$

d. $\sqrt{1.4} : \sqrt{1.5} : \sqrt{1.6}$

57. The string between blocks of mass m and $2m$ is massless and inextensible. The system is suspended by a massless spring as shown. If the string is cut find the magnitudes of accelerations of mass $2m$ and m (immediately after cutting)

a. g, g

b. $g, \dfrac{g}{2}$

c. $\dfrac{g}{2}, g$
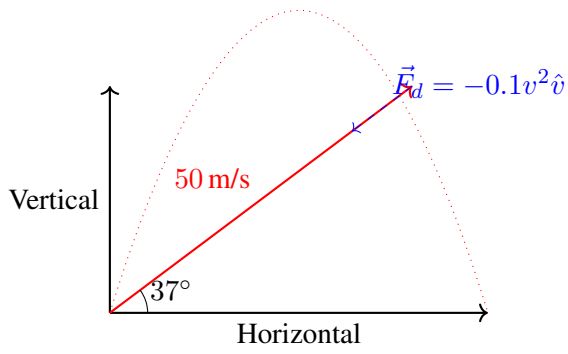
d. $\dfrac{g}{2}, \dfrac{g}{2}$

58. The drag force (F) on a nanosheet in fluid depends on velocity (v), area (A), viscosity (η), and density (ρ). The dimensionless group is:

Area $= A$

a. $\dfrac{F}{\eta v A}$

b. $\dfrac{F}{\rho v^2 A}$

c. $\dfrac{\eta v}{\rho A}$

d. $\dfrac{\rho A}{F v^2}$

59. A projectile is launched at 50 m/s, 37° to the horizontal. The drag force is $\vec{F}_d = -0.1v^2\hat{v}$. The approximate time of flight is:

d. 10.0 s

$\vec{F}_d = -0.1v^2\hat{v}$

50 m/s

Vertical

37°

Horizontal

a. 5.2 s

b. 3.0 s

c. 7.1 s

60. A rod (mass M, length L) is pivoted at one end. A ball (mass m) hits the free end with speed v and sticks. The angular velocity just after collision is:

a. $\dfrac{mv}{ML}$

b. $\dfrac{3mv}{(M + 3m)L}$

c. $\dfrac{mv^2}{ML}$

d. $\dfrac{Mv}{mL}$

ANSWER KEY

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

Self-Assessment Key

Subject	Q. Attempted	Correct	Wrong	Accuracy (%)
Physics				
Chemistry				
Biology				
Mathematics				

TOTAL SCORE
———
OUT OF 240