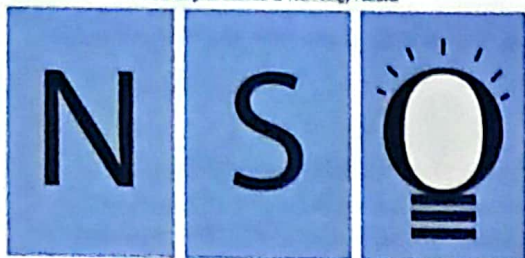




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**SOF NATIONAL SCIENCE
OLYMPIAD 2024-25**

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CLASS **12**
SET-B

Total Questions : 50 | Time : 1 hr.

Guidelines for the Candidate

1. You will get additional ten minutes to fill up information about yourself on the OMR Sheet, before the start of the exam.
2. Write your **Name, School Code, Class, Section, Roll No.** and **Mobile Number** clearly on the **OMR Sheet** and do not forget to sign it. We will share your marks / result and other information related to SOF exams on your mobile number.
3. The Question Paper comprises three sections :
Section - 1 : **Physics & Chemistry** (25 Questions)
Section - 2 : **Achievers Section** (5 Questions)
Section - 3 : **Mathematics** (20 Questions) or **Biology** (20 Questions)
4. **Section-1 and 2 are compulsory for all.** In Section-3 opt for Mathematics OR Biology and mark the same on the OMR Sheet. Each question in Achievers Section carries 3 marks, whereas all other questions carry one mark each.
5. All questions are compulsory. There is no negative marking. Use of calculator is not permitted.
6. There is only ONE correct answer. Choose only ONE option for an answer.
7. To mark your choice of answers by darkening the circles on the OMR Sheet, use **HB Pencil** or **Blue / Black ball point pen** only. E.g.
Q.16: If a mixture can be separated by magnetic separation, one of the constituents must be
A. Ferrous B. Non-ferrous C. Precious D. Non-metallic.
As the correct answer is option A, you must darken the circle corresponding to option A on the OMR Sheet.
8. Rough work should be done in the blank space provided in the booklet.
9. Return the OMR Sheet to the invigilator at the end of the exam.
10. Please fill in your personal details in the space provided before attempting the paper.
11. **Participate in SOF-Techfest IIT Bombay Innovation Challenge. Open for class 8, 9 & 10. For details, please visit : www.sofworld.org**

16. ● (B) (C) (D)

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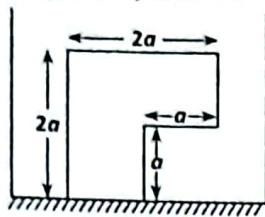
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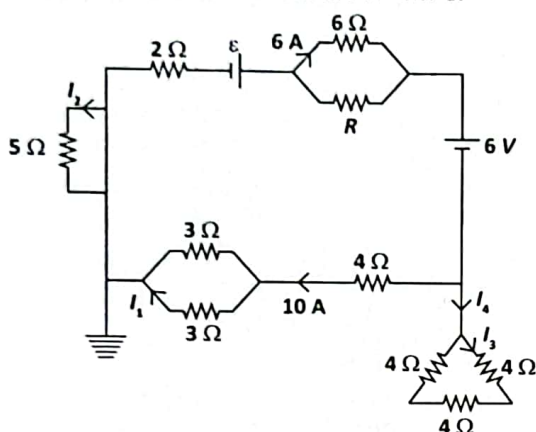
SECTION-1

PHYSICS

1. A piece of material with specific gravity ρ is placed in a container as shown in the given figure and water is poured slowly. Then, how will the piece topple?



- A. Clockwise, if $\rho < \frac{1}{2}$
 B. Anti-clockwise, if $\rho < \frac{1}{2}$
 C. Clockwise, if $\rho > 2$
 D. Anti-clockwise, if $\rho > 2$
2. The figure shows the network of resistors connected across the cell of an unknown emf $\mathcal{E}$.

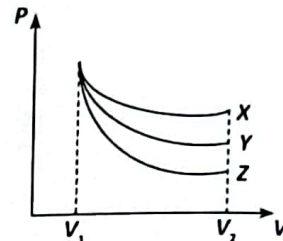


Which one of the following options is incorrect?

- A. The value of unknown resistance $R = 9 \Omega$.
 B. $I_1 = 5 \text{ A}$, $I_3 = 10 \text{ A}$, $I_4 = 10 \text{ A}$
 C. The emf of the sources is 117 V.
 D. $I_1 = 5 \text{ A}$, $I_3 = 0$, $I_4 = 0$
3. A charge particle of charge 1 C and mass 1 kg is released from rest at origin. The electric and magnetic fields are given as $\vec{E} = 10\hat{i} \text{ N/C}$ for $x = 1.8 \text{ m}$ and $\vec{B} = -5\hat{k} \text{ T}$ for $1.8 \text{ m} \leq x \leq 2.4 \text{ m}$. A screen is placed parallel to y - z plane at $x = 3 \text{ m}$. Neglect gravity. Which of the following statement(s) is/are correct?
- (i) The speed with which particle will collide the screen is 6 m/s.
 (ii) y -coordinate of particle where it collides with screen is $\frac{1.2(\sqrt{2}-1)}{\sqrt{2}} \text{ m}$.
 (iii) Time after which the particle will collide with the screen is $\frac{1}{5} \left(3 + \frac{\pi}{6} + \frac{1}{\sqrt{3}} \right) \text{ s}$.

- A. (i) only
 B. (ii) and (iii) only
 C. (i) and (iii) only
 D. (i), (ii) and (iii)

4. Expansion of an ideal gas takes place from a state at temperature T_1 and volume V_1 through three different paths X, Y and Z as shown in the given figure.

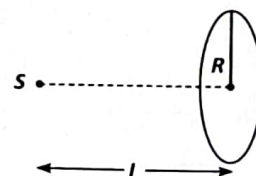


If $|\Delta E_x|$, $|\Delta E_y|$ and $|\Delta E_z|$ are the magnitude of change in internal energy along the three paths respectively, then read the given statements and select the option that correctly identifies them as true (T) and false (F) ones.

- (i) $|\Delta E_x| < |\Delta E_y| < |\Delta E_z|$, if temperature in every process decreases.
 (ii) $|\Delta E_x| > |\Delta E_y| > |\Delta E_z|$, if temperature in every process decreases.
 (iii) $|\Delta E_x| > |\Delta E_y| > |\Delta E_z|$, if temperature in every process increases.
 (iv) $|\Delta E_x| < |\Delta E_y| < |\Delta E_z|$, if temperature in every process increases.

	(i)	(ii)	(iii)	(iv)
A.	T	F	F	T
B.	F	T	T	F
C.	T	F	T	F
D.	F	T	F	T

5. An isotropic point source(s) of light is having radiation power P . It is located on the axis of an ideal mirror plate. The distance (l) between the source and the plate exceeds the radius (R) of the plate as shown in the given figure.



What is the force that light exerts on the plate? (Take speed of light as c)

A.
$$\frac{2P}{c} \left[\frac{1}{1 + \left(\frac{l}{R} \right)^2} \right]$$

B. $\frac{P}{2c} \left[1 + \left(\frac{l}{R} \right)^2 \right]$

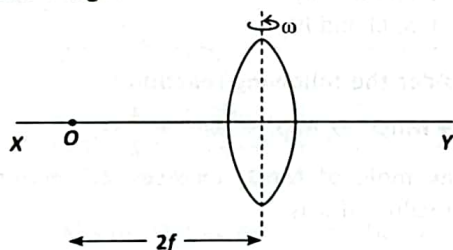
C. $\frac{P}{2c} \left[\frac{1}{1 + 2 \left(\frac{l}{R} \right)^2} \right]$

D. $\frac{P}{2c} \left[\frac{1}{1 + \left(\frac{l}{R} \right)^2} \right]$

6. Two parallel straight lines are inclined to the horizontal at an angle α . Riya projected a stone from mid point between the lines such that the stone grazes one of the lines and strikes the other at right angle. Here θ is the angle between direction of propagation and either of the lines. Which one of the following statements gives the correct relation between angles α and θ ?

- A. The value of $\tan \alpha$ is $(\sqrt{2} - 1) \cos \theta$.
 B. The value of $\tan \alpha$ is $(\sqrt{3} - 1) \cot \theta$.
 C. The value of $\tan \theta$ is $(\sqrt{3} - 1) \cot \alpha$.
 D. The value of $\tan \theta$ is $(\sqrt{2} - 1) \cot \alpha$.

7. The given figure shows a point object O , which is kept in front of a convex lens at a distance $2f$ from it. The lens starts to rotate about an axis perpendicular to the plane of paper keeping object fixed with respect to principal axis and OX remains in the same plane. If the lens is rotated by 2° then what is the speed of the image?



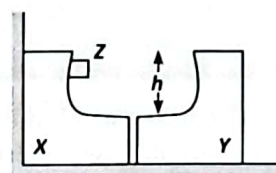
- A. $\frac{2f\pi\omega}{15}$
 B. $\frac{4f\pi\omega}{90}$
 C. $\frac{9f\pi\omega}{49}$
 D. $\frac{5f\pi\omega}{90}$

8. A moving hydrogen atom makes a head on inelastic collision with a stationary hydrogen atom. Before collision both atoms are in the ground state and after

collision they move together. What is the minimum velocity of the moving hydrogen atom if one of the atoms is to receive the minimum excitation energy after the collision?

- A. 5.93×10^3 m/s
 B. 3.123×10^5 m/s
 C. 7.2×10^6 m/s
 D. 6.246×10^4 m/s

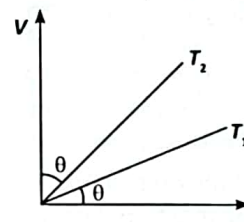
9. Two identical blocks X and Y , each having mass M , are placed as shown in the given figure. Both the blocks X and Y are smoothly conjugated, so that another block Z of mass m passes from X to Y with no jerk. All the surfaces are frictionless. The block Z is released from rest.



Which one of the following statements is correct?

- A. Block Z will move for a very small duration
 B. Block X will move for a very small duration
 C. Block Y will acquire maximum speed when Z is at the lowest point of Y and move towards left.
 D. Block Y will acquire maximum speed when Z is at the topmost point of Y .

10. The V - I graph for a conductor at temperatures T_1 and T_2 is shown in the given figure.



$T_2 - T_1$ is proportional to which one of the following?

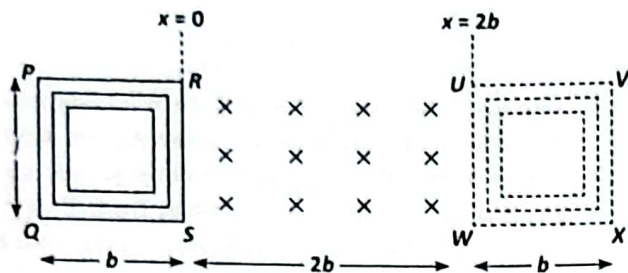
- A. $\sin 2\theta$
 B. $\cos 2\theta$
 C. $\cot 2\theta$
 D. $\tan 2\theta$

11. A block of mass m is kept on a rough horizontal turn table at a distance of 30 cm from the centre of the table. The coefficient of friction between turn table and block is 0.5. The turn-table starts rotating with uniform acceleration of 3 rad/s^2 .

Time after which slipping occurs between the block and the turn table is

- A. 2.2 s
 B. 3.5 s
 C. 1.34 s
 D. 4.24 s

12. A rectangular loop of wire with dimensions l and b has N turns and a total resistance R . The loop moves with a constant velocity towards right through a region of uniform magnetic field ranges from $x = 0$ to $x = 2b$, as shown in the given figure (Here, x is the distance between RS and UW).



For the given conditions in column I, there is an associate emf given in column II.

Now, match column I with column II and select the correct option from the given codes.

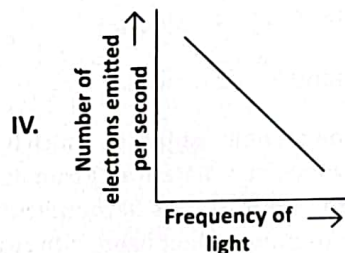
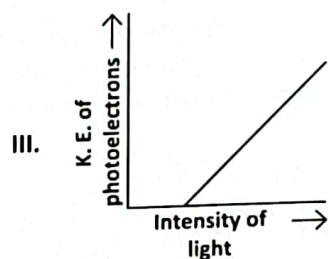
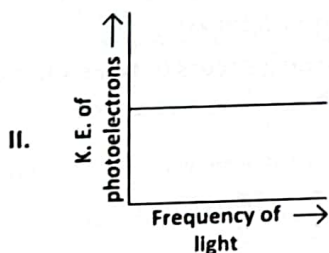
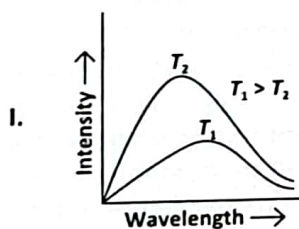
	Column I		Column II
(p)	$0 < x < b$,	(i)	$B \vee I \vee N$
(q)	$b < x < 2b$	(ii)	0
(r)	$2b < x < 3b$	(iii)	$\neg B \vee I \vee N$
(s)	$x > 3b$	(iv)	$B \vee N$
A.	(p)-(iii), (q)-(ii), (r)-(i), (s)-(iv)		
B.	(p)-(i), (q)-(iii), (r)-(iv), (s)-(ii)		
C.	(p)-(i), (q)-(iii), (r)-(iii), (s)-(iv)		
D.	(p)-(iii), (q)-(ii), (r)-(i), (s)-(ii)		

CHEMISTRY

13. An octahedral complex of platinum (X) contains four ammonia molecules, two chloride ions and two bromide ions. This complex gives only pale yellow precipitate with excess of silver nitrate solution. Identify the correct statement(s) regarding (X).

- I. The complex (X) shows both geometrical and optical isomerism.
 - II. The complex (X) is a heteroleptic complex where the oxidation state of central metal atom is +2.
 - III. The IUPAC name of the ionisation isomer of the complex (X) is tetraamminedibromidoplatinum (IV) chloride.
- A. I and II only
B. III only
C. II and III only
D. I only

14. Which of the following graphs do not represent the correct relationship between properties of incident light and the electron ejected from the metal surface?



- A. II, III and IV only
B. I and IV only
C. II and III only
D. I, II, III and IV

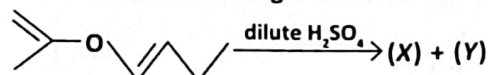
- 15. Consider the following reaction :**



If one mole of MnO_4^- oxidises 2.5 moles of M^{x+} , then value of x is

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

- 16. Consider the following reaction :**



Both (X) and (Y) give hydrazone derivative on reaction with hydrazine. (Y) is more reactive than (X) in nucleophilic addition reactions.

The correct statement(s) about (X) and (Y) is/are

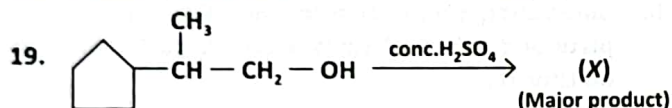
- I. (X) and (Y) can be distinguished by Tollens' reagent.
 II. On reduction with LiAlH_4 , (X) gives primary alcohol whereas (Y) gives secondary alcohol.
 III. On treatment with NaHSO_3 , both (X) and (Y) give water insoluble hydrogensulphite addition compound.
- A. I and III only
 B. II and III only
 C. I only
 D. III only

17. In which of the following sets, all the species have fractional bond order?

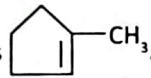
- A. Li_2 , O_2^- , N_2^{2-}
 B. O_2^- , C_6H_6 , Li_2
 C. N_2^{2-} , F_2 , O_2^-
 D. He_2^+ , C_6H_6 , O_2^-

18. Two isomeric hydrocarbons (P) and (Q) having molecular formula C_6H_{10} decolourise bromine water. On treatment with ammoniacal AgNO_3 solution, only (P) gives white ppt. On reduction with excess of H_2 in presence of Pt catalyst both (P) and (Q) give hexane. (P) and (Q) on warming with mercuric sulphate and dilute sulphuric acid at 333 K give respectively (S) and (T). (S) gives positive iodoform test but (T) does not. (P) and (Q) would be respectively

- A. Hex-1-yne and Hex-3-yne
 B. Hex-3-yne and Hex-2-yne
 C. Hex-2-yne and Hex-1-yne
 D. Hex-3-ene and Hex-1-ene.



Which of the following statements is correct for the product (X)?

- A. (X) is 
 B. Number of 1° H-atoms in (X) is six.
 C. Ozonolysis of (X) gives heptan-2, 6-dione.
 D. Both (B) and (C).

20. Identify (X) and (Y) from the information given below :
 (X) = An amino acid containing phenolic -OH group.
 (Y) = A chiral amino acid which loses its chirality on treatment with lithium aluminium hydride.

- | X | Y |
|---------------|------------|
| A. Tryptophan | Alanine |
| B. Tyrosine | Isoleucine |
| C. Proline | Histidine |
| D. Tyrosine | Serine |

21. Three experiments were performed as given in the following table and in each case the change in internal energy, ΔU was calculated.

Experiment	Heat	Work
I	50 J heat supplied to the system	150 J work done by the system
II	100 J heat supplied to the system	50 J work done on the system
III	150 J heat lost by the system	100 J work done by the system

If the change in internal energy for the experiments I, II and III were ΔU_1 , ΔU_2 and ΔU_3 respectively, then

- A. $\Delta U_1 > \Delta U_2 > \Delta U_3$
 B. $\Delta U_2 > \Delta U_3 > \Delta U_1$
 C. $\Delta U_3 > \Delta U_1 > \Delta U_2$
 D. $\Delta U_2 > \Delta U_1 > \Delta U_3$

22. One molal aqueous solutions of K_2HgI_4 , KCl , $\text{K}_4[\text{Fe}(\text{CN})_6]$ and Na_3PO_4 are taken separately.

If K_2HgI_4 and Na_3PO_4 ionise 50% each while $\text{K}_4[\text{Fe}(\text{CN})_6]$ and KCl ionise 25% each, then which of the following statements is incorrect?

[Given : K_f for water = $1.86 \text{ K kg mol}^{-1}$]

- A. Na_3PO_4 solution will have lowest freezing point.
 B. Both K_2HgI_4 and $\text{K}_4[\text{Fe}(\text{CN})_6]$ solutions will have same freezing point.
 C. Maximum freezing point depression will be shown by $\text{K}_4[\text{Fe}(\text{CN})_6]$ solution.
 D. KCl solution will have highest freezing point.

23. Consider the following statements.

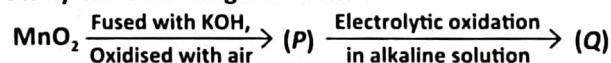
Statement I : The quantity of electricity in coulombs required to reduce 12.3 g of nitrobenzene to aniline is 57900 coulombs.

Statement II : On the electrolysis of acidified water, if volume of hydrogen liberated is 5.6 cm^3 , then the volume of oxygen liberated is 11.2 cm^3 .

In the light of the above statements, choose the most appropriate answer from the options given below.

- A. Both Statement I and Statement II are correct.
 B. Both Statement I and Statement II are incorrect.
 C. Statement I is correct but Statement II is incorrect.
 D. Statement I is incorrect but Statement II is correct.

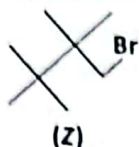
24. Study the following reactions :



Select the correct statement(s) about (P) and (Q).

- I. (P) is purple in colour and (Q) is green in colour.
 II. (P) is tetrahedral and (Q) is octahedral.
 III. (P) is paramagnetic and (Q) is diamagnetic.
 IV. (P) decomposes at 513 K to give (Q).
- A. III and IV only
 B. I and IV only
 C. III only
 D. I and II only

25. An alkyl bromide (X) on treatment with Na in ether gives hydrocarbon (Y). The hydrocarbon (Y) on monobromination gives the following compound (Z).



Identify the incorrect statement(s) about (X) and (Y).

- Molecular formula of (Y) is C_5H_{12} .
 - (X) is a tertiary alkyl bromide.
 - IUPAC name of (X) is 2-bromo-3-methylbutane.
 - (Y) has eight sp^3 hybridised carbon atoms.
- A. I, II and IV only
B. III and IV only
C. III only
D. I only

SECTION-2

ACHIEVERS SECTION

Directions (Q. No. 26 and 27) : Read the given passage and answer the following questions. Figure 1 shows a part of an RC circuit, in which potential drop across the resistor is V_R and figure 2 shows the variation of potential difference across resistor. Initially ($t = 0$) capacitor is uncharged.

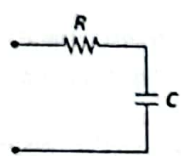


Figure 1

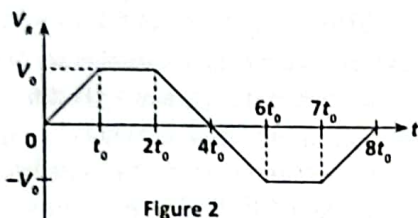
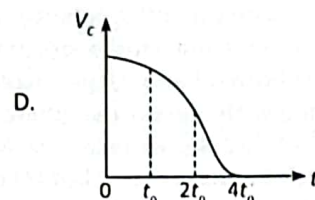
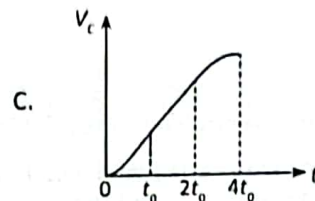
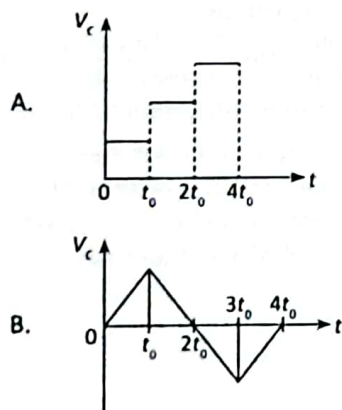


Figure 2

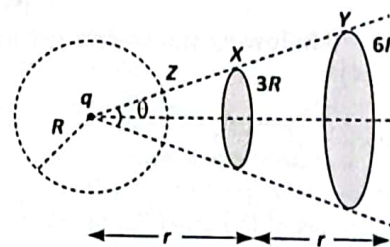
26. What is the value of current as function of time for $2t_0 \leq t \leq 4t_0$?

- A. $\frac{2V_0}{R} - \frac{V_0}{2t_0 R} t$
B. $\frac{V_0}{2R} - \frac{3V_0}{2t_0 R} t$
C. $\frac{V_0}{4R} - \frac{2V_0}{t_0 R} t$
D. $\frac{3V_0}{R} - \frac{V_0}{3t_0 R} t$

27. Which one of the following options represents the most appropriate graph of potential difference across capacitor versus time for $0 \leq t \leq 4t_0$?



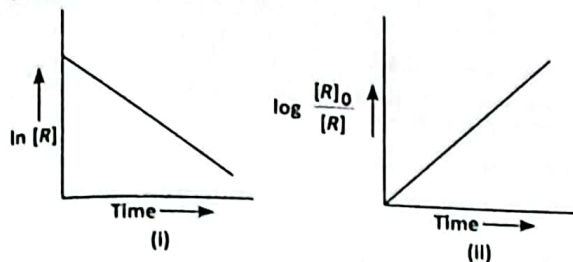
28. Two nonconducting plates X and Y of radii $3R$ and $6R$ respectively are kept at distance r and $2r$ from the point charge q . A surface Z cut out of a non conducting shell is kept such that its center coincides with the point charge as shown in the given figure. Each plate and spherical surface carries surface charge density σ .



Which of the following statement(s) is/are correct?

- If F_X , F_Y and F_Z are the forces on plate X, plate Y and spherical surface Z then, $F_X = F_Y > F_Z$.
 - If ϕ_1 is flux through surface of Y due to electric field of X and ϕ_2 is the flux through surface of X due to electric field of Y, then $\phi_1 = \phi_2$.
 - If distance r and radius R are doubled so that F_X becomes F'_X and F_Y becomes F'_Y . Then $F'_X > F_X$ and $F'_Y > F_Y$.
- A. (i) and (ii) only
B. (iii) only
C. (i) only
D. (i), (ii) and (iii)

29. Identify the correct statement(s) on the basis of following two graphs.



[Here, $[R]$ represents concentration of reactant at time t and $[R]_0$ represents initial concentration of reactant.]

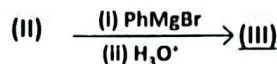
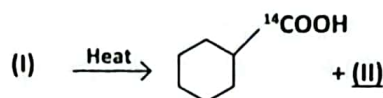
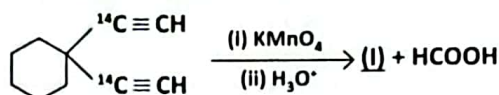
- I. Graph (i) represents zero order reaction while graph (ii) represents first order reaction.
 II. If the slope of graph (ii) is $2 \times 10^{-4} \text{ s}^{-1}$, then the rate constant is $4.606 \times 10^{-4} \text{ s}^{-1}$.

III. For graph (i), slope = $\frac{k}{2.303}$

IV. For graph (i), $t_{1/2} = \frac{[R]_0}{2k}$ and for graph (ii), $t_{1/2} = \frac{0.693}{k}$.

- A. I and IV only
 B. II only
 C. II and III only
 D. I and III only

30. Study the given reactions and fill in the blanks by selecting the correct option.



- | | (I) | (II) | (III) |
|----|-----|--------------------|-------|
| A. | | CO_2 | |
| B. | | CO_2 | |
| C. | | $^{14}\text{CO}_2$ | |
| D. | | $^{14}\text{CO}_2$ | |

SECTION-3

MATHEMATICS

31. Let $E = \{1, 2, 3, 4\}$ and $F = \{1, 2\}$. The number of onto functions from E to F is

- A. 14
 B. 16
 C. 8
 D. 10

32. The total number of times the digit 3 will be written when listing integers from 1 to 1000 is

- A. 300
 B. 297
 C. 243
 D. 273

33. If matrix $A = \begin{bmatrix} a & b & c \\ b & c & a \\ c & a & b \end{bmatrix}$, where a, b and c are real positive numbers, $abc = 1$ and $A^T A = I$, then which of the following is/are true?

- A. $a + b + c = 5$
 B. $a^2 + b^2 + c^2 = 6$
 C. $ab + bc + ca = 2$
 D. $a^3 + b^3 + c^3 = 4$

34. $(\sqrt{3} + 1)^4 + (\sqrt{3} - 1)^4$ is a/an

- A. Rational number
 B. Irrational number
 C. Negative integer
 D. None of these

35. If the sum of an infinite G.P. is $\frac{7}{2}$ and sum of the squares of its terms is $\frac{147}{16}$, then the sum of the cubes of its terms is

- A. $\frac{315}{19}$
 B. $\frac{700}{39}$
 C. $\frac{985}{13}$
 D. $\frac{1029}{38}$

36. $\tan^{-1}(-\sqrt{3}) + \sec^{-1}(-2) - \text{cosec}^{-1}\left(\frac{2}{\sqrt{3}}\right)$ is equal to

- A. $\frac{5\pi}{6}$
 B. $\frac{2\pi}{3}$
 C. 0
 D. None of these

37. Derivative of $y = \cos^{-1} \sqrt{\frac{\cos 3x}{\cos^3 x}}$ with respect to x , is

- A. $\frac{6}{\cos 4x + \cos 2x}$
 B. $\frac{6}{\sqrt{\cos 4x + \cos 2x}}$
 C. $\frac{\sqrt{6}}{\cos 4x + \cos 2x}$
 D. None of these

38. The mean and variance of 7 observations are 8 and 16 respectively. If five of the observations are 2, 4, 10, 12 and 14, then find the remaining observations.

A. 4 and 8
B. 4 and 6
C. 6 and 8
D. 4 and 10

39. A box with a square base and a square top is to be made from 400 m² of lumber. If its volume is maximum, then the ratio of an edge of the base and height is

A. 1 : 1
B. 1 : 2
C. 2 : 1
D. None of these

40. Let z_1 and z_2 be complex numbers such that $z_1 \neq z_2$, $|z_1| = |z_2|$. If z_1 has positive real part and z_2 has negative imaginary part, then $\frac{z_1 + z_2}{z_1 - z_2}$ may be

A. Real and positive
B. Real and negative
C. Pure imaginary
D. None of these

41. $\int \frac{x^2(1 - \ln x)}{(\ln x)^4 - x^4} dx$ is equal to

A. $\frac{1}{2} \ln\left(\frac{x}{\ln x}\right) - \frac{1}{4} \ln(\ln^2 x - x^2) + C$
B. $\frac{1}{4} \ln\left(\frac{\ln x - x}{\ln x + x}\right) - \frac{1}{2} \tan^{-1}\left(\frac{\ln x}{x}\right) + C$
C. $\frac{1}{4} \ln\left(\frac{\ln x + x}{\ln x - x}\right) + \frac{1}{2} \tan^{-1}\left(\frac{\ln x}{x}\right) + C$
D. $\frac{1}{4} \ln\left(\frac{\ln x - x}{\ln x + x}\right) + \frac{1}{2} \tan^{-1}\left(\frac{\ln x}{x}\right) + C$

42. $\lim_{x \rightarrow 0} \frac{8}{\sin^8 x} \left(1 - \cos \frac{x^2}{2} - \cos \frac{x^2}{4} + \cos \frac{x^2}{2} \cos \frac{x^2}{4}\right) =$

A. $\frac{1}{16}$
B. $\frac{1}{32}$
C. $\frac{1}{64}$
D. $\frac{1}{8}$

43. Consider the differential equation $y^2 dx + \left(x - \frac{1}{y}\right) dy = 0$. If $y(1) = 1$, then x is given by

A. $3 - \frac{1}{y} + \frac{e^{1/y}}{e}$
B. $1 + \frac{1}{y} - \frac{e^{1/y}}{e}$
C. $1 - \frac{1}{y} + \frac{e^{1/y}}{e}$
D. None of these

44. The point on the line $\frac{x+2}{2} = \frac{y+6}{3} = \frac{z-34}{-10}$ which is nearest to the line $\frac{x+6}{4} = \frac{y-7}{-3} = \frac{z-7}{-2}$ is (a, b, c) , where $a + b + c =$

A. 9
B. 10
C. 11
D. 12

45. If $\cos^3 0 + \cos^3(120^\circ + 0) + \cos^3(240^\circ + 0) = a \cos 30$, then the value of a is

A. $\frac{1}{2}$
B. $\frac{1}{4}$
C. $\frac{3}{4}$
D. $\frac{7}{4}$

46. Find a equation of the line through the point of intersection of the lines $x - y + 1 = 0$ and $2x - 3y + 5 = 0$ and whose distance from the point $(3, 2)$ is $\frac{7}{5}$.

A. $4x + 3y + 1 = 0$
B. $3x + 4y - 6 = 0$
C. $4x - 3y + 1 = 0$
D. $3x + 4y + 6 = 0$

47. The maximum value of $z = 2x + 5y$ subject to $x + 4y \leq 24$, $3x + y \leq 21$, $x + y \leq 9$, $x, y \geq 0$ is

A. 30
B. 33
C. 35
D. 27

48. The vectors $\vec{a}$, $\vec{b}$ and $\vec{c}$ are of the same length and taken pair wise they form equal angles. If $\vec{a} = \hat{i} + \hat{j}$ and $\vec{b} = \hat{j} + \hat{k}$, then $\vec{c}$ is equal to

A. $\hat{i} + \hat{k}, \frac{1}{3}(-\hat{i} + 4\hat{j} - \hat{k})$
B. $\hat{i} + 2\hat{j} + 3\hat{k}, \hat{i} + \hat{j}$
C. $-\hat{i} + \hat{j} + 2\hat{k}, \hat{i} + \hat{k}$
D. $\frac{1}{3}(-\hat{i} + 4\hat{j} - \hat{k}), \hat{j} + \hat{k}$

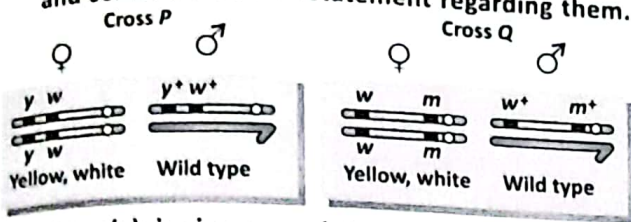
49. If a, b, c are positive and not all equal, then the value of the determinant $\begin{vmatrix} a & b & c \\ b & c & a \\ c & a & b \end{vmatrix}$ is

A. > 0
B. ≥ 0
C. ≤ 0
D. < 0

50. If A and B are two independent events such that $P(\bar{A} \cap B) = \frac{2}{15}$ and $P(A \cap \bar{B}) = \frac{1}{6}$, then $P(A)$ and $P(B)$ respectively are

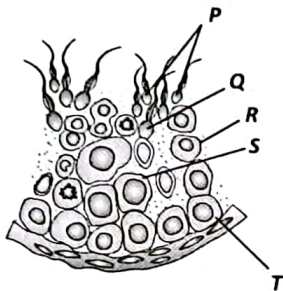
A. $\frac{1}{5}, \frac{1}{7}$
B. $\frac{5}{6}, \frac{4}{5}$
C. $\frac{1}{6}, \frac{1}{7}$
D. None of these

31. Refer to the given figures of cross P and cross Q, and select the correct statement regarding them.



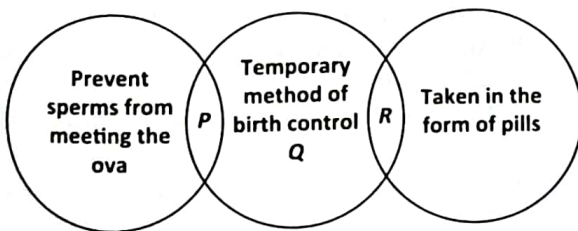
Note : (+) sign in superscript represents dominant wild type alleles

- A. In cross P, the strength of linkage between genes y and w is higher than the cross Q genes w and m .
B. In cross P, the strength of linkage between genes y and w is lesser than the cross Q genes w and m .
C. Both cross P genes y and w and cross Q genes w and m have the same strength of linkage.
D. The percentage of recombinants produced in cross P is higher than cross Q.
32. The given figure shows stages in the development of sperms from spermatogonia in a human male.



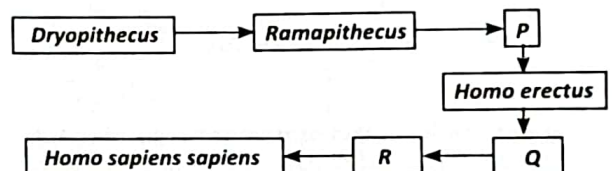
Identify the cells P-T and select the incorrect statement regarding them.

- A. The process of transformation of P to Q is called spermiogenesis.
B. Both S and R divide by meiosis I and II respectively to form haploid germ cells.
C. T present on the inner wall of seminiferous tubules multiply by mitotic division and increase in numbers.
D. P is released from seminiferous tubules by the process of spermiation.
33. Refer to the given Venn diagram and select the correct statement regarding P, Q and R.



- A. P could be cervical cap which is a hemisphere dome like rubber used to cover the penis during coitus.
B. Q could be Lippes loop which is an injection given once every three months that prevents ovulation.
C. R could be *Saheli* which contains a steroidal preparation called centchroman which is taken once in a week after an initial intake of thrice a week dose for 6 months.
D. Q could be subcutaneous implant which works like R by blocking ovulation and thickening the cervical mucus to prevent sperm transport.

34. The given flow chart shows the chronological order of evolution of human from early to recent. Identify the missing links P, Q and R and select the correct option.



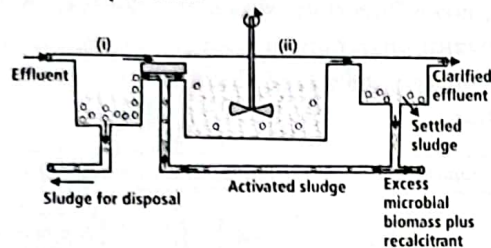
- A. P – *Australopithecus*, Q – Neanderthal man, R – Cro-magnon man
B. P – *Australopithecus*, Q – Neanderthal man, R – *Homo habilis*
C. P – *Homo habilis*, Q – Cro-magnon man, R – *Homo sapiens fossilis*
D. P – *Homo habilis*, Q – *Australopithecus*, R – Cro-magnon man
35. The immunity that an individual acquires after the birth is called acquired immunity. It is characterised by memory. Immune responses are carried out with the help of two types of cells X and Y present in our blood. X produces an army of proteins and Y themselves do not secrete those proteins but help X to produce them. Identify X and Y and select the incorrect statement regarding them.
- A. X secretes α -interferon which protect non-infected cells.
B. Y type of cells also react against transplants and provides immunity against cancer cells.
C. Immune response produced by X is called cell-mediated immunity whereas that produced by Y is called antibody-mediated immune response.
D. Both A and C

36. In the given table, the disease, its related hormone and cause are given. Select the correct match.

	Disease	Hormone	Cause
(i)	Graves' disease	Growth hormone	Hyposecretion of thyroid hormone
(ii)	Acromegaly	TSH	Hyposecretion of growth hormone
(iii)	Diabetes insipidus	ADH	Hyposecretion of ADH causing reduced absorption of water
(iv)	Cretinism	Thyroxine	Hyposecretion of thyroid hormone in infants

- A. (i) and (iii) only B. (ii) and (iii) only
C. (iii) and (iv) only D. (i) and (iv) only

37. Given figure represents an overview of sewage treatment process.

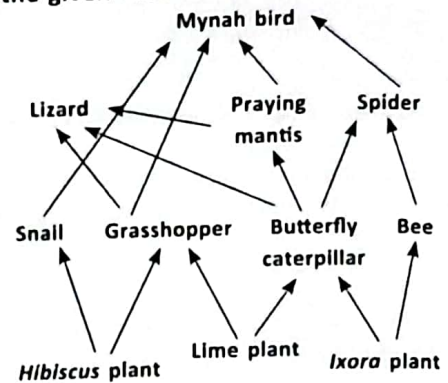


Select the incorrect statement regarding this.

- A. (ii) could be a settling tank, in which primary sludge is produced and is used as an inoculum in the aeration tanks.
B. (i) could be the primary settling tank where heavy impurities (such as sand, small pebbles, etc.) settle down.
C. (ii) could be the aeration tank where the primary effluent is mechanically agitated.
D. None of these
38. Consider the following statements and select the correct option stating which ones are true (T) and which ones are false (F).
- Oxygen easily binds with haemoglobin in the pulmonary blood capillaries under the low partial pressure.
 - About 3 percent of oxygen in blood is dissolved in the plasma which carries oxygen to the body cells.
 - pO_2 in the alveoli is higher than that of the deoxygenated blood in the pulmonary artery.
 - The formation of carbamino haemoglobin occurs on the alveolar surface only.

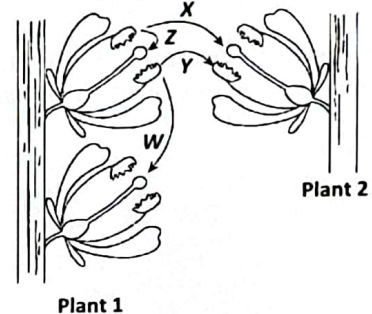
	I	II	III	IV
A.	F	T	F	F
B.	T	T	F	F
C.	F	T	T	F
D.	T	F	T	T

39. Study the given food web.



Which of the following statements is incorrect about the given food web ?

- A. There are only three food chains with only three organisms in each.
B. There are more preys than predators.
C. All the herbivores are preys.
D. None of these
40. The given diagram shows two plants of the same species. Refer to the diagram and select the correct option regarding (i) and (ii).



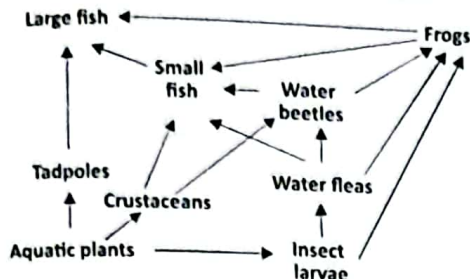
- (i) Which arrow indicates a process that would not lead to sexual reproduction?
(ii) Which arrow represents a type of pollination that would result in greater adaptability of the particular species to potential environmental changes?
- A. (i)-Y, (ii)-Z B. (i)-Z, (ii)-X
C. (i)-Y, (ii)-X D. (i)-X, (ii)-Y

41. Match the following columns and select the correct option.

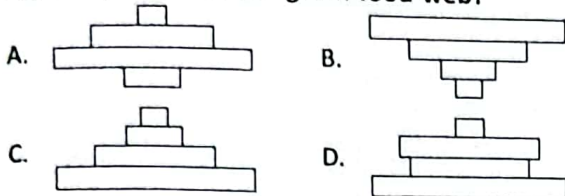
Column I	Column II
(a) Isolation of genetic material	(i) Separation and purification of the product
(b) Fragmentation of DNA	(ii) Recombinant protein
(c) Isolation of desired DNA fragment	(iii) Transformation
(d) Amplification of gene of interest	(iv) DNA ligase
(e) Ligation of the DNA	(v) Polymerase chain reaction
(f) Insertion of recombinant DNA into the host	(vi) Agarose gel electrophoresis

- (g) Extraction of desired gene product
(h) Downstream processing
- (vii) Restriction enzymes
(viii) Ethanol
- | | (a) | (b) | (c) | (d) | (e) | (f) | (g) | (h) |
|----|--------|--------|-------|------|------|-------|------|-------|
| A. | (viii) | (iv) | (iii) | (ii) | (i) | (vi) | (v) | (vii) |
| B. | (viii) | (vii) | (vi) | (v) | (iv) | (iii) | (ii) | (i) |
| C. | (viii) | (vii) | (v) | (vi) | (iv) | (iii) | (i) | (ii) |
| D. | (ii) | (viii) | (iii) | (v) | (iv) | (vi) | (i) | (vii) |

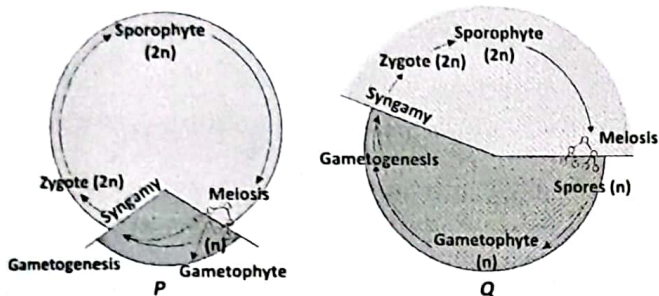
42. The given diagram shows a food web.



Which of the following represents a pyramid of biomass, based on the given food web?



43. Refer to the given figures and select the correct statement regarding them.



- A. Figure P is life cycle pattern in *Fucus* in which sporophytic generation is dominant and dependent while gametophytic generation is highly reduced and independent.
- B. Figure Q is life cycle pattern in *Polysiphonia* in which there is clear alternation of generation between a haploid gamete producing gametophyte and a diploid spore producing sporophyte.
- C. Figure P is life cycle pattern in *Cladophora* in which zygote remains single celled and protoplast of the zygote cleaves into meiospores.
- D. Figure Q is the life cycle pattern in *Marchantia* in which the zygote remains single celled, it does not multiply itself.

44. A cell having 12 chromosomes and 12 picograms (pg) DNA went under cell division.

Which of the following options correctly identifies the number of chromosomes and amount of DNA in each nucleus at the given stages of nuclear division?

End of telophase of mitosis		End of telophase II of meiosis	
Number of chromosomes	Amount of DNA (in pg)	Number of chromosomes	Amount of DNA (in pg)
A. 12	6	6	3
B. 24	12	12	6
C. 12	12	6	6
D. 24	6	12	6

45. Read the given statements and select the option that correctly identifies them as true (T) and false (F) ones.

- Nitrogenous base is linked to the pentose sugar through a N-glycosidic linkage.
- Phosphate group is linked to OH of 5'C of a nucleoside through phosphoester linkage to form a nucleotide.
- Two nucleosides are linked through 3' - 5' N-glycosidic linkage.
- Negatively charged DNA is wrapped around positively charged histone octamer to form nucleosome.
- The chromatin that is more densely packed and stains dark is called euchromatin.

	I	II	III	IV	V
A.	T	T	T	F	F
B.	F	T	T	F	T
C.	T	T	F	T	F
D.	F	F	T	T	F

46. Match the columns and select the correct option from the given codes.

	Column I		Column II
P.	Epithelial cells of Bowman's capsule	(i)	Juxtamedullary
Q.	Extension of cortex between the medullary pyramids as renal columns	(ii)	Vasa recta
R.	Nephrons with long loop of Henle running deep into medulla	(iii)	Juxtaglomerular apparatus
S.	A fine vessel of peritubular capillaries running parallel to Henle's loop	(iv)	Podocytes
T.	A special sensitive region formed by cellular modifications in the DCT and afferent arteriole at the location of their contact	(v)	Columns of Bertin

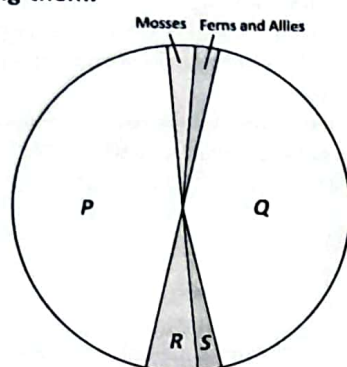
- A. P-(iii), Q-(ii), R-(i), S-(iv), T-(v)
- B. P-(v), Q-(i), R-(ii), S-(iii), T-(iv)
- C. P-(iv), Q-(v), R-(i), S-(ii), T-(iii)
- D. P-(iv), Q-(iii), R-(ii), S-(v), T-(i)

47. Chordates are bilaterally symmetrical, triploblastic and coelomate organisms. They are divided into 3 sub-phyla. In subphylum 'P', notochord is present only in larval tail and disappears in the adult. In members of subphylum 'Q', notochord extends from head to tail region and is persistent throughout their life. In subphylum 'R', notochord is replaced by bony vertebral column in adult.

Identify P, Q and R and select the option that incorrectly matches them with their example.

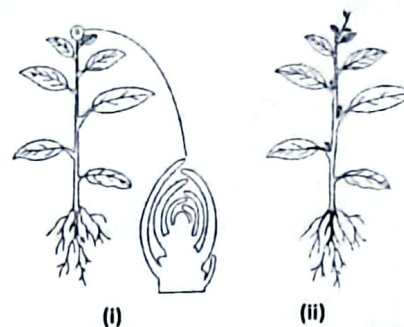
- A. Subphylum P – *Salpa*
- B. Subphylum Q – *Ascidia*
- C. Subphylum R – *Testudo*
- D. None of these

48. Refer to the given pie chart showing global biodiversity in terms of number of species of major taxa of plants. Identify P, Q, R and S and select the correct option regarding them.



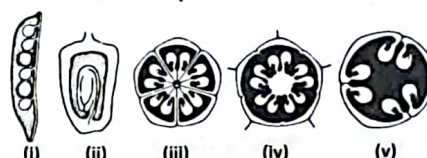
- A. S is formed as a resultant of symbiotic relationship between P and R.
- B. S can easily be cultured in the laboratory whereas it is quite difficult to culture P and R.
- C. The members of P are seeded plants which show diplontic life cycle pattern.
- D. The number of P in India is estimated to be 72,000 while in the world Q is estimated to be 17,500.

49. Refer to the given figures and select the correct option.



- A. (i)–Plant showing apical dominance, (ii)–Decapitated plant showing growth of lateral buds
- B. (i)–Plant with apical bud removed, (ii)–Plant with apical bud intact
- C. (i)–Plant with apical bud intact, (ii)–Plant with apical bud removed
- D. Both A and C

50. The given figures represent different types of placentation. Identify (i), (ii), (iii), (iv) and (v) and select the correct option.



- A. (i)–Marginal placentation, (ii)–Basal placentation, (iii)–Free-central placentation, (iv)–Axile placentation, (v)–Parietal placentation
- B. (i)–Marginal placentation, (ii)–Basal placentation, (iii)–Axile placentation, (iv)–Free-central placentation, (v)–Parietal placentation
- C. (i)–Basal placentation, (ii)–Axile placentation, (iii)–Marginal placentation, (iv)–Parietal placentation, (v)–Free-central placentation
- D. (i)–Parietal placentation, (ii)–Free-central placentation, (iii)–Marginal placentation, (iv)–Axile placentation, (v)–Basal placentation

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