Physics

1. (a) The given length of the solenoid, I = 30 cm or 0.3 m.

Cross section area of the solenoid, A = 25 cm2 or 25 × 10 − 4 m2.
Number of turns, N = 500.
Current in the solenoid, I = 2.5 A.
Time for which the current flows, t = 10 − 3 s.
The formula for average back emf is,

e = dϕdt(1)

Change in flux is given by, dϕ = NAB and magnetic field strength is B = μONII.
Substitute the values in equation (1).

e = μONN2IAIt = 4π × 10 − 7 × (500)2 × 2.5 × 25 × 10 − 40.3 × 10 − 3 = 1.96 × 10 − 3
0.3 × 10 − 3 = 6.5 V

Thus, the average back emf in the solenoid is 6.5 V.

2. (b)
3. (d)
4. (c) Step 1: Power:

The power is defined as the work done in per unit time.
The following are given by the question:
The rated voltage of bulb, V = 220 V
The rated power of bulb, P = 200 W
The relationship between power, voltage, and resistance is given by

$$P = \frac{V^2}{R}$$

Step 2:
Derive the expression for the resistance,

$$R = \frac{V^2}{P}$$

Substitute the values

$$R = \frac{220^2}{200}$$
$$R = \frac{48400}{200}$$
$$R = \frac{484}{2}$$
$$R = 242\Omega$$

Hence, the resistance of the bulb is 242Ω.

5. (b)
6. (b) The frequency of the electromagnetic wave is same as that of oscillating charged particle about its equilibrium position, which is 10^9 Hz.
7. (d)
8. (c) Lens maker's formula,

$$\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

Here, $f=20$ cm, $\mu=1.55, R_1=R, R_2=-R$

$$\frac{1}{20}=(1.55-1)\left(\frac{1}{R}-\frac{1}{(-R)}\right) \text{ or } \frac{1}{20}=0.55\times\frac{2}{R}$$
$$\Rightarrow R=1.1\times 20=22 \text{ cm}$$

9. (a)

10. (b) Given- $n=1.5$

The reflected and refracted rays will be perpendicular to each other when the ray of light is incident at polarising angle p.

By Brewster's law,

$$\tan p=n$$
$$\text{or } \tan p=1.5$$
$$\text{or } p=57^\circ$$

11. (a)

12. (a)

13. (b)

14. (a) Kinetic energy is given by $E=\frac{1}{2}mv^2$

Same kinetic energy implies that electron has highest velocity (as mass is lowest).

Assume mass of electron as 1 unit. Now, mass of proton approx 1836 and mass of alpha particle is 4 times that is 7344.

Now calculate velocity in each case

For electron $v=\sqrt{2E}$, proton $v=\sqrt{\frac{2E}{1836}}$ and alpha particle $v=\sqrt{\frac{2E}{7344}}$

Also, de-Broglie wavelength is given by $\lambda=\frac{h}{mv}$

Now calculate momentum in each case

For electron $mv=\sqrt{2E}\times 1$ proton $mv=\sqrt{\frac{2E}{1836}}\times 1836$ and alpha particle $mv=\sqrt{\frac{2E}{7344}}\times 7344$

Clearly electron has least momentum. Hence it has largest de-Broglie wavelength. And Alpha particle has least wavelength

15. (a)

16. (d) As we know that for Paschen series,

$$\frac{1}{\lambda}=R\left(\frac{1}{3^2}-\frac{1}{n^2}\right)$$

Where,
$R=$ Rydberg's constant
$\lambda=$ wavelength
For the shortest wavelength, put $n=\infty$ and $R=1.097\times 10^7/\text{m}$
So now

$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{3^2} - \frac{1}{\infty^2}\right)$

$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{3^2}\right)$

$\lambda = 8.20 \times 10^{-7}$ m

$\lambda = 820$ nm

Final Answer: $\lambda = 820$ nm

17. (b)

18. (c) $r = 1.5 \times 10^{11}$ m; $v = 3 \times 10^4$ m/s; M is the mass of earth. According to Bohr model, $Mvr = \frac{nh}{2\pi}$. Thus, $n = 2.6 \times 10^{74}$ is the quanta number that charaactrizes the earth revolution.

19. (a)

20. (d)

21. (c)

22. (c)

23. (c) When a forward bias is applied to a p-n junction, it lowers the value of potential barrier. In the case of a forward bias, the potential barrier opposes the applied voltage. Hence, the potential barrier across the junction gets reduced.

24. (b) 1ppm = 1 part per million $= \frac{1}{10^6}$.

so no. of pentavalent As atoms doped in given Si crystal , $= \frac{5\times10^{28}}{10^6} = 5 \times 10^{22}$ m^{-3}. As one pentavalent atoms donates one free electron to the crystal structure, so no. of free electrons in the given si crystal, $n_e = 5 \times 10^{22} m^{-3}$

Number of holes, $n_h = \frac{n_1^2}{n_c} = \frac{(1.5\times10^{16})^2}{5\times10^{22}}$

$4.5 \times 10^9 m^{-3}$

25. (c)

26. (a, b)

27. (a)

28. (a)

29. (c)

30. (b)

31. (a)

32. (c)

33. (b)

34. (a)

35. (d) Thick and short

Shunt should have low resistance $R = \frac{\rho l}{A}$ I should be less

A should be large

36. (b)

37. (c)

38. (a) Magnetic field strength, $B = 0.25$ T

Torque on the bar magnet, $\tau = 4.5 \times 10^{-2}$ J

The angle between the bar magnet and the external magnetic field, $\theta = 30°$

Torque is related to magnetic moment (M) as: $\tau = MB\sin\theta$

$\therefore M = \frac{\tau}{B\sin\theta} = \frac{4.5 \times 10^{-2}}{0.25 \times \sin 30°} = 0.36\ J/T$

Hence, the magnetic moment of the magnet is $0.36\ J/T$

Final Answer: $M = 0.36\ J/T$

39. (d)
40. (a) We know that

$e = \frac{d\phi}{dt} = M\frac{di}{dt}$

Therefore,

$d\phi = Mdi = 1.5 \times (20 - 0) = 30\ Wb$

Chemistry

41. (d)
42. (d)
43. (c) Transition element which does not exhibit variable oxidation states All the d-blocks elements exhibit various valency or have variable oxidation number. But scandium does not show because scandium has partially filled d orbitals in the ground state. In the case of scandium, the number of electrons in the 3 d and 4 s orbital is 1 and 2 respectively. Removing three electrons from its d and s orbital forms a very stable inert gas configuration. It loses 1 electron from d orbital and 2 electrons from s orbital to form a Sc^{3+} ion.
44. (d)
45. (a)
46. (b)
47. (a, c, d)
48. (b)
49. (d)
50. (d)
51. (c)
52. (b)
53. (d)
54. (b)
55. (d)
56. (c)
57. (d)
58. (c)
59. (c)
60. (b)
61. (a) Glyptal is a polyester obtained by condensation polymerization of glycerol and phthalic anhydride. It is used in the manufacture of paints and lacquers.
62. (d)
63. (a)
64. (b)
65. (d)
66. (c)
67. (b)
68. (c) Increases with an increase in temperature

The explanation for the correct option
Henry's law

According to Henry's law, a gas law, while the temperature is held constant, the amount of gas that is dissolved in a liquid is exactly proportional to the partial pressure of that gas above the liquid.

The formula is as follows:

$p \propto x$

$p = K_{Hx}$
$K_H = \frac{p}{x}$

P is the partial pressure of a gas.

x is the mole fraction.

K_H is the Henry's constant.

Henry's constant

Only the nature of gas or liquid and temperature affect Henry's constant value.

Therefore, the values of Henry's constant K_H increase as the temperature increases and vice versa.

The explanation for incorrect options

Henry's constant value increases with an increase in temperature.

69. (c)
70. (a)
71. (b)
72. (a)
73. (b)
74. (a)
75. (d)
76. (a)
77. (a)
78. (a)
79. (b)
80. (c)

Mathematics

81. (d)
82. (b)
83. (c)
84. (a)
85. (c)
86. (a)
87. (c)
88. (d)
89. (a) The given function is $y = x^2 e^{-x}$

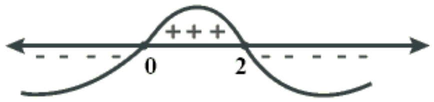
It will strictly increase in those intervals where $\frac{dy}{dx} > 0$

Now,

$$\frac{dy}{dx} = -x^2e^{-x} + e^{-x}(2x)$$
$$= e^{-x}(2x - x^2)$$

e^{-x} will be always positive, so the function will strictly increase in those intervals where $2x - x^2 > 0$

The number line showing the sign of $2x - x^2$ is shown in the figure.
so the function will strictly increase in (0,2)



90. (d)
91. (d)
92. (b)
93. (d)
94. (d)
95. (b)
96. (b)
97. (c)
98. (a) The correct option is a $\frac{a+b}{2}\int_a^b f(x)dx$

Let $I = \int_a^b xf(x)dx \quad (1)$

$$\therefore I = \int_a^b (a+b-x)f(a+b-x)dx, \left(\because \int_a^b f(x)dx = \int_a^b f(a+b-x)dx\right)$$
$$\Rightarrow I = \int_a^b (a+b-x)f(x)dx$$
$$\Rightarrow I = (a+b)\int_a^b f(x)dx - I[\text{ Using (1) }]$$
$$\Rightarrow I + I = (a+b)\int_b^b f(x)dx$$
$$\Rightarrow 2I = (a+b)\int_{b^a}^b f(x)dx$$
$$\Rightarrow I = \left(\frac{a+b}{2}\right)\int_a^b f(x)dx$$

99. (b)
100. **(d)** The given curves are $y = x^2$ and $y^2 = x$ i.e. $y = \sqrt{x}$
To find the intersection point of two curves, let us have

$$x^2 = \sqrt{x}$$
$$\Rightarrow x^4 = x$$
$$\Rightarrow x^4 - x = o$$
$$\Rightarrow x(x^3 - 1) = o$$
$$\Rightarrow x = 0 \text{ and } x = 1$$

$\Rightarrow$ (o, 0) and (1,1) are the points of intersection of two curves.

$\therefore$ Area bounded by these two curves $= \int_0^1 (x^2 - \sqrt{x})dx$

$$= \left| \frac{x^3}{3} - \frac{(x)^{\frac{3}{2}}}{\frac{3}{2}} \right|_0^1$$
$$= \frac{1}{3} - \frac{2}{3} = -\frac{1}{3}$$

Hence, area bounded by two parabolas $y = x^2$ and $y^2 = x$ is $-\frac{1}{3}$.

101. **(c)**
102. **(d)**
103. **(a)**
104. **(b)**
105. **(a)**

106. **(b)** It is given that $|\vec{a}| = 3$ and $|\vec{b}| = \frac{\sqrt{2}}{3}$ We know that $\vec{a} \times \vec{b} = |\vec{a}||\vec{b}|\sin\theta\dot{n}$, where is a unit vector perpendicular to both $\vec{a}$ and $\vec{b}$ and θ is the angle between $\vec{a}$ and $\vec{b}$.

Now, $\vec{a} \times \vec{b}$ is a unit vector if $|\vec{a} \times \vec{b}| = 1$

$$|\vec{a} \times \vec{b}| = 1$$
$$\Rightarrow |\vec{a}||\vec{b}|\sin\theta\vec{n}\ | = 1$$
$$\Rightarrow |\vec{a}||\vec{b}|\sin\theta\ | = 1$$
$$\Rightarrow 3 \times \frac{\sqrt{2}}{3} \times \sin\theta = 1$$
$$\Rightarrow \sin\theta = \frac{1}{\sqrt{2}}$$
$$\Rightarrow \theta = \frac{\pi}{4}$$

Hence, $\vec{a} \times \vec{b}$ is a unit vector if the angle between $\vec{a}$ and $\vec{b}$ is $\frac{\pi}{4}$.

107. **(d)** We have $|\vec{a}| = 1, |\vec{b}| = 1, |\vec{c}| = 1$

Also $\vec{a} + \vec{b} + \vec{c} = \vec{0}$

Squaring we get,

$$|\vec{a}|^2 + |\vec{b}|^2 + |\vec{c}|^2 + 2(\vec{a}\cdot\vec{b} + \vec{b}\cdot\vec{c} + \vec{c}\cdot\vec{a}) = 0$$
$$\Rightarrow 1 + 1 + 1 + 2(\vec{a}\cdot\vec{b} + \vec{b}\cdot\vec{c} + \vec{c}\cdot\vec{a}) = 0$$
$$\therefore \vec{a}\cdot\vec{b} + \vec{b}\cdot\vec{c} + \vec{c}\cdot\vec{a} = -\frac{3}{2}$$

108. **(c)** It is given that

$$\frac{x+1}{2} = \frac{y}{3} = \frac{z-3}{6}$$
$$10x + 2y - 11z = 3$$

Here the direction ratios of the line $=(2,3,6)$
Direction ratios of the normal to plane $=(10,2,-11)$
Angle between the line and the plane can be written as

$$\sin^{-1}\left(\frac{a\times a'+b\times b'+c\times c'}{\sqrt{a^2+b^2+c^2}\sqrt{a'^2+b'^2+c'^2}}\right)$$

Where (a, b, c) are the direction ratios of a line and (a, b, c)
are the direction ratios of the normal to the plane
Substituting the values

$$=\sin^{-1}\left(\frac{2\times 10+3\times 2+6\times(-11)}{\sqrt{2^2+3^2+6^2}\sqrt{10^2+2^2+11^2}}\right)$$

On further calculation

$$=\sin^{-1}\left(\frac{20+6-66}{7\times 15}\right)$$
$$=\sin^{-1}\left(\frac{-40}{7\times 15}\right)$$

So we get

$$=\sin^{-1}\left(-\frac{8}{21}\right)$$

By taking magnitude we get

$$=\sin^{-1}\left(\frac{8}{21}\right)$$

109. **(b)**

110. **(c)** The given equations can be written in the standard form as

$$\frac{x-1}{-3}=\frac{y-2}{\frac{2p}{7}}=\frac{z-3}{2}\text{ and }\frac{x-1}{\frac{-3p}{7}}=\frac{y-5}{1}=\frac{z-6}{-5}$$

The direction ratios of the lines are $-3,\frac{-3p}{7},2$ and $\frac{-3p}{7},1,-5$ respectively. Two lines with direction ratios $a_1,\ b_1,c_1$ and $a_2,\ b_2,c_2$, are perpendicular to each other, if $a_1a_2+b_1b_2+c_1c_2=0$.

$$\therefore(-3)\left(\frac{-3p}{7}\right)+\left(\frac{-3p}{7}\right)\cdot(1)+(2)\cdot(-5)=0$$
$$\Rightarrow\frac{9p}{7}+\frac{2p}{7}=10$$
$$\Rightarrow 11p=70$$
$$\Rightarrow p=\frac{70}{11}$$

111. **(d)** Probability of getting a head and tail in a single toss of a coin $P(H)=P(T)=\frac{1}{2}$ The sample space of three toses of a coin is

$S=\{HHH,HHT,HTH,THH,THT,TTH,HTT,TTT\}$

It can be seen that random variable X (say) can take the value of 0,1,2 ot 3 .

$P(X = 0) = P$ (probability of getting all tails) $= P\{TTT\} = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8}$

$P(X = 1) = P$ (probability of getting one head and two tails)

$$= P\{TTH\} + P\{THT\} + P\{HTT\}$$
$$= \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} + \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} + \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8} + \frac{1}{8} + \frac{1}{8} = \frac{3}{8}$$

$P(X = 2) = P$ (Probability of getting two heads and one tail)

$$= P\{HHT\} + P\{HTH\} + P\{THH\}$$
$$== \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} + \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} + \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8} + \frac{1}{8} + \frac{1}{8} = \frac{3}{8}$$

$P(X = 3) = P($ probability of getting three heads $) = PHHH = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8}$

Therefore, the required probability distribution is as follows:

X	0	1	2	3
P(X)	$\frac{1}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{8}$

Hence, mean $= \sum XP(X) = 0 \times \frac{1}{8} + 1 \times \frac{3}{8} + 2 \times \frac{3}{8} + 3 \times \frac{1}{8}$

$$= \frac{3}{8} + \frac{6}{8} + \frac{3}{8} = \frac{12}{8} = \frac{3}{2} = 1.5$$

112. **(c)**

113. **(b)**

114. **(d)**

115. **(c)**

116. **(d)** Since, B is the inverse of A.

ie, $B = 10A^{-1}$

$$\therefore (10)A^{-1} = \begin{bmatrix} 4 & 2 & 2 \\ -5 & 0 & \alpha \\ 1 & -2 & 3 \end{bmatrix}$$
$$\therefore (10)A^{-1} \cdot A = \begin{bmatrix} 4 & 2 & 2 \\ -5 & 0 & \alpha \\ 1 & -2 & 3 \end{bmatrix} A$$
$$\Rightarrow 10I = \begin{bmatrix} 4 & 2 & 2 \\ -5 & 0 & \alpha \\ 1 & -2 & 3 \end{bmatrix} \begin{bmatrix} 1 & -1 & 1 \\ 2 & 1 & -3 \\ 1 & 1 & 1 \end{bmatrix}$$
$$\Rightarrow \begin{bmatrix} 10 & 0 & 0 \\ 0 & 10 & 0 \\ 0 & 0 & 10 \end{bmatrix} = \begin{bmatrix} 10 & 0 & 0 \\ -5+\alpha & 5+\alpha & -5+\alpha \\ 0 & 0 & 10 \end{bmatrix}$$
$$\Rightarrow 5 + \alpha = 10$$
$$\Rightarrow \alpha = 5$$

117. **(b)**

118. **(b)**

119. **(d)**

120. **(d)**

Biology

121. (a)
122. (c)
123. (a)
124. (a)
125. (a)
126. (c)
127. (a)
128. (b)
129. (c)
130. (a)
131. (b)
132. (b)
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152. (d)
153. (d)
154. (c)
155. (a)
156. (b)
157. (c)
158. (d)
159. (a)
160. (a)