### Answer Key

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1. \( \frac{l}{O} = \frac{f}{f-u} \Rightarrow \frac{l}{2} = \frac{20}{20 - (-20)} = \frac{1}{2} \Rightarrow l = 1 \text{mm} \)

2. \( (4) \)
   Suppose water is poured up to the height \( h \), So \( h \left( 1 - \frac{1}{\mu} \right) = 1 \text{ cm} \)
   \[ \Rightarrow h = 4 \text{ cm} \]

3. \( (4) \)
   \[ \frac{f_{\text{liq}}}{f_{\text{air}}} = \left( \frac{\mu_{\text{lens}} - 1}{\mu_{\text{lens}} - 1} \right) \]
   \[ \frac{f_{\text{liq}}}{8 \text{ cm}} = \left( \frac{\mu_{\text{glass}} - 1}{\mu_{\text{glass}} - 1} \right) \]
   \[ f_{\text{liq}} = \left[ \frac{3}{2} - 1 \right] (8 \text{ cm}) = \left[ \frac{1}{2} \right] (8 \text{ cm}) = 32 \text{ cm} \]

4. \( (4) \)
   \[ \frac{1}{F} = 2 + \frac{1}{f_m} \Rightarrow \frac{1}{F} = \frac{2}{20} + \frac{1}{\infty} \Rightarrow F = 10 \text{ cm} \]

5. \( (2) \)
   For objective lens \( \frac{1}{f_o} = \frac{1}{v_o} - \frac{1}{u_o} \)
   \[ \Rightarrow \frac{1}{(+4)} = \frac{1}{v_o} - \frac{1}{(-4.5)} \Rightarrow v_o = 36 \text{ cm} \]
   \[ \therefore |m_D| = \frac{v_o}{u_o} \left( 1 + \frac{D}{f_o} \right) = \frac{36}{4.5} \left( 1 + \frac{24}{8} \right) = 32 \]

6. \( (3) \)
   \[ v_i = -\left( \frac{f}{f-u} \right)^2 v_o \]
7. (2) 
For TIR at PQ : \( \theta < \phi \)

From geometry of figure \( \theta = 60^\circ \) i.e. \( 60^\circ > \phi \) \( \Rightarrow \sin 60^\circ > \sin C \)

\[ \Rightarrow \sin 60^\circ > \frac{\mu_{\text{rainer}}}{\mu_{\text{denser}}} \]

\[ \Rightarrow \frac{\sqrt{3}}{2} > \frac{\mu_{\text{liquid}}}{\mu_{\text{prism}}} \]

\[ \Rightarrow \mu_{\text{liquid}} < \frac{\sqrt{3}}{2} \mu_{\text{prism}} \]

\[ \Rightarrow \mu_{\text{liquid}} < \frac{\sqrt{3}}{2} (1.5) \]

\[ \Rightarrow \mu_{\text{liquid}} < 1.3 \]

8. (2) 
The intensity at a point on screen is given by

\[ I = 4I_0 \cos^2 \left( \frac{\phi}{2} \right) \]

Where \( \phi \) is the phase difference. In this problem \( \phi \) arises

(i) due to initial phase difference of \( \pi/4 \) and

(ii) due to path difference for the observation point situated at \( \theta = 30^\circ \).

Thus \( \phi = \frac{\pi}{4} + \frac{2\pi}{\lambda} (d \sin \theta) = \frac{\pi}{4} + \frac{2\pi}{\lambda} \frac{\lambda}{4} (\sin 30^\circ) = \frac{\pi}{4} + \frac{\pi}{4} = \frac{\pi}{2} \)

Thus \( \frac{\phi}{2} = \frac{\pi}{4} \) and \( I = 4I_0 \cos^2 (\pi/4) = 2I_0 \)

9. (1) 
The number of fringes shifting is decided by the extra path difference produced by introducing the glass plate. The extra path difference is \( (\mu - 1) t = n\lambda \)

\[ (1.5 - 1)(0.1 \times 10^{-3}) = n (500 \times 10^{-9}) \]

\[ n = 100 \]

10. (3) 
\( n_1\lambda_1 = n_2\lambda_2 \Rightarrow 60 \times 4000 = n_2 \times 6000 \Rightarrow n_2 = 40 \)

11. (4) 
\( \mu = \tan \theta_p \Rightarrow \theta_p = \tan^{-1} n \)

12. (1) 
Initially, the two polaroids are perpendicular to each other.
Now we are introducing a third Polaroid in between first and second polaroids.
Let us consider $\theta$ is the angle between crystallographic axes of first and second polaroids.

After passing through first Polaroid, intensity becomes $\frac{I_0}{2}$

After passing through second Polaroid, intensity emitted out from second Polaroid is

$$= \frac{I_0}{2} \cos^2 \theta$$

After passing through third Polaroid, intensity emitted out is

$$= \left( \frac{I_0}{2} \cos^2 \theta \right) \cos^2 (90^\circ - \theta)$$

$$= \frac{I_0}{2} \cos^2 \theta \sin^2 \theta$$

$$= \frac{I_0}{8} 4 \sin^2 \theta \cos^2 \theta$$

$$= \frac{I_0}{8} (2 \sin \theta \cos \theta)^2$$

$$= \frac{I_0}{8} (\sin 2\theta)^2$$

$$= \frac{I_0}{8} \sin^2 2\theta$$

13. (2)

$$\lambda_{min} = \frac{hc}{eV} \Rightarrow \lambda_1 = \frac{hc}{eV_1} \text{ and } \lambda_2 = \frac{hc}{eV_2}$$

Given $V_2 = 1.5V_1$

$$\Delta \lambda = \lambda_1 - \lambda_2 = \frac{hc}{e} \left[ \frac{1}{V_1} - \frac{1}{V_2} \right]$$

$$26 \times 10^{-12} \text{ m} = \frac{(6.63 \times 10^{-34} \text{ J-s})(3 \times 10^8 \text{ m/s})}{(1.6 \times 10^{-19} \text{ C})} \left[ \frac{1}{V_1} - \frac{1}{1.5V_1} \right]$$

$$26 \times 10^{-12} \text{ m} = \frac{(6.63 \times 10^{-34} \text{ J-s})(3 \times 10^8 \text{ m/s})}{(1.6 \times 10^{-19} \text{ C})} \left[ \frac{1}{3V_1} \right]$$

$$V_1 = \frac{(6.63 \times 10^{-34} \text{ J-s})(3 \times 10^8 \text{ m/s})}{3(26 \times 10^{-12} \text{ m})(1.6 \times 10^{-19} \text{ C})} = 16 \text{ kV}$$

14. (3)

Since spot is same, hence $e/m$ should be same i.e., as $q_1 : q_2 : q_3 = 1 : 3 : 5$.

Hence $m_1 : m_2 : m_3 = 1 : 3 : 5$

15. (3)
\[ \lambda = \frac{h}{p} \] .......(1)

\[ \lambda = \frac{0.5 h}{100 (p + \Delta p)} \]

\[ \lambda = \frac{1}{200} \frac{h}{p + \Delta p} \]

\[ 199 \lambda = \frac{h}{200 (p + \Delta p)} \]

\[ 199 \lambda = \frac{h}{200 p + \Delta p} \]

\[ 199 = \frac{1}{200 p + \Delta p} \]

\[ 199 p + 199 \Delta p = 200 p \]

\[ p = 199 \Delta p \]

16. (2)

For the incident electron \( \frac{1}{2}mv^2 = eV \) or \( p^2 = 2meV \)

\[ \therefore \text{de-Broglie wavelength} \quad \lambda_i = \frac{h}{p} = \frac{h}{\sqrt{2meV}} \]

Shortest X-ray wavelength \( \lambda_2 = \frac{hc}{eV} \)

\[ \frac{\lambda_1}{\lambda_2} = \left( \frac{h}{\sqrt{2meV}} \right) \left( \frac{eV}{hc} \right) \]

\[ = \frac{1}{c} \frac{eV}{\sqrt{2meV}} \]

\[ = \frac{1}{c} \sqrt{\left( \frac{V}{2} \right) \left( \frac{e}{m} \right)} \]

\[ = \frac{1}{3 \times 10^8 \text{ m/s}} \sqrt{\left( \frac{10000 \text{ V}}{2} \right) \left( 1.8 \times 10^{11} \text{ C/kg} \right)} \]

\[ = 0.1 \]

17. (2)

In electric field photoelectron will experience force and accelerate opposite to the field so it’s K.E. increases (i.e. stopping potential will increase), no change in photoelectric current, and threshold wavelength.

18. (1)

\[ Z^{X_A} \xrightarrow{9a} Z_{-18}X^{A-36} \xrightarrow{5b} Z_{-13}X^{A-36} \]

Number of protons = \( Z - 13 \)
Number of neutrons = \( (A - 36) - (Z - 13) = (A - Z - 23) \)

\[ P = \frac{(Z - 13)}{(A - Z - 23)} \]

19. (1)

According to conservation of momentum, recoil momentum of nucleus is \( p = \frac{\hbar \omega}{c} \)

Recoil energy of nucleus is \( E = \frac{p^2}{2M} = \frac{\left(\frac{\hbar \omega}{c}\right)^2}{2M} = \frac{\hbar^2 \omega^2}{2Mc^2} \)

20. (2)

By using \( \frac{1}{\lambda} = RZ^2 \left[ \frac{1}{n_1^2} - \frac{1}{n_2^2} \right] \)

For Hydrogen atom \( \frac{1}{(\lambda_{\text{min}})_H} = R \left[ \frac{1}{1^2} - \frac{1}{\infty} \right] = R \implies (\lambda_{\text{min}})_H = \frac{1}{R} \) ....(i)

For hydrogen like atom \( \left( \frac{1}{\lambda_{\text{min}}} \right)_{\text{atom}} = RZ^2 \left( \frac{1}{2^2} - \frac{1}{\infty} \right) \)

\( (\lambda_{\text{min}})_{\text{atom}} = \frac{4}{RZ^2} \) ....(ii)

From equation (i) and (ii) \( \frac{1}{R} = \frac{4}{RZ^2} \implies Z = 2. \)

21. (1)

(1 = high, 0 = low)

Input to A is in the sequence, 1,0,1,0.

Input to B is in the sequence, 1, 0, 0, 1.

Sequence is inverted by NOT gate.

Thus inputs to OR gate becomes 0, 1, 0, 1 and output of OR gate becomes 0, 1, 1, 1

Since for OR gate 0 + 1 = 1. Hence choice (a) is correct.

22. (4)

Equivalent circuit can be redrawn as follows

![Equivalent Circuit Diagram]

\[ i = \frac{10}{2} = 5 \text{mA} = i_2 \]

\[ i_1 = 0 \]

23. (2)

\[ V = V_{CE} + i_C R_L \]

\( \Rightarrow 15 = 7 + I_C \times 2 \times 10^3 \Rightarrow i_C = 4 \text{mA} \)

\[ \beta = \frac{i_C}{i_b} \Rightarrow i_b = \frac{4}{100} = 0.04 \text{mA} \]

24. (1)
Charge carriers inside the $P$-type semiconductor are holes (mainly). Inside the conductor charge carriers are electrons and for cell ions are the charge carriers.

25. (3)
\[ V_{dc} = V_{ac} = \frac{2V_0}{\pi} = \frac{2 \times 6.28}{3.14} = 4V. \]

26. (1)
\[ \lambda = \frac{hc}{E} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{1.5 \times 1.6 \times 10^{-19}} = 8.25 \times 10^{-7} \text{m} = 8250 \text{Å} \]

The photon having wavelength equal to 8250Å or more than this will not able to overcome the energy gap of silicon.

27. (4)
Comparing with standard equation.

28. (2)
Optical source frequency \[ f = \frac{c}{\lambda} = \frac{3 \times 10^8}{1.3 \times 10^{-6}} = 2.3 \times 10^{14} \text{Hz} \]

\[ \therefore \text{Number of channels or subscribers} = \frac{2.3 \times 10^{14}}{20 \times 10^3} = 1.15 \times 10^{10} \]

29. (3)
\[ m = \sqrt{m_1^2 + m_2^2} = \sqrt{(0.16) + (0.09)} = 0.5 \]

30. (2)
\[ P = \frac{P}{\left(1 + \frac{m_0^2}{2}ight)} = \frac{10000}{1.125} = 8.89 \text{ kW} \]

31. (1)
1% of 10 GHz = 10 \times 10^9 \times \frac{1}{100} = 10^8 \text{Hz}

Number of channels = \frac{10^9}{5 \times 10^7} = 2 \times 10^4

32. (1)
As per photoelectric equation,
\[ K = \frac{hc}{\lambda} - \phi = \frac{(1242eV \cdot \text{nm}/450\text{nm}) - 2eV}{450\text{nm}} = 0.76eV \]

When a charged particle is sent perpendicular to a magnetic field, it goes along a circle of radius, \[ r = \frac{mv}{qB} = \sqrt{\frac{2mK}{qB}} \text{ where } mv = p = \sqrt{2mK} \]

On substituting the values of r=0.20m, m=9.1X10^{-31}kg, K=1.2X10^{-19}J, q=1.6X10^{-19}C, In the above equation, we get, B=1.46X10^{-19}T

33. (2)
34. \( E_1 = \frac{h(v_1 - v_0)}{E_2} = \frac{n}{1} \)

On solving, \( v_0 = \frac{m_2 - m_1}{n - 1} \)

35. (3)

We know that, \( eV_0 = h(v - v_0) \)

\[ V_0 = \frac{h(v - v_0)}{e} \]

Maximum is the frequency, kinetic energy of the emitted photoelectrons will be maximum and hence the stopping potential will also increase accordingly as it is the potential required to stop the highly energetic photoelectrons.

Shortest is the wavelength, more is the stopping potential.

Stopping potential is related to shortest wavelength.

36. (1)

de Broglie wavelength is given by \( \lambda = \frac{h}{p} \) where \( h \) is the Planck’s constant and \( p \) is the momentum of the particle. Since in the given case momentum of all the particles is same hence de Broglie wavelength, \( \lambda \), will also be same for all.

37. (4)

In the de Broglie wavelength equation for a charged particle,

\[ \lambda = \frac{h}{\sqrt{2mE}} \]

Since \( h \) and \( m \) remains the same hence,

\[ \frac{\lambda'}{\lambda} = \frac{\sqrt{E'}}{\sqrt{E}} \]

Where \( \lambda' \) is the 0.5nm and \( \lambda \) is 1nm; 

\( E \) is the initial energy and \( E' \) is the energy corresponding to \( \lambda' \)

On solving, we get \( E' = 4E \)

Required energy = \( E' - E = 4E - E = 3E \)

38. (2)

Maximum kinetic energy,

\[ K_{\text{max}} = \frac{hc}{\lambda} - W_0 \quad \text{or} \quad W_0 = \frac{hc}{\lambda} - K_{\text{max}} = \frac{1240}{400} - 1.68 = 1.42 \text{ eV} \]

39. (2)

From the figure, it is clear that since the stopping potential is the same for both the curves \( v_a = v_b \).

Also the intensity of radiation \( b \) is more therefore \( I_b > I_a \). Correct choice is (B).

40. (1)

The half life of a radioactive element is 3 and the mean life is \( T_m = \frac{1}{\lambda} \).
number of half lives in 19 days is
\[ n = \frac{19}{3.8} = 5 \]

number of atoms left undecayed after 19 days is
\[ N = N_0 \left(\frac{1}{2}\right)^5 = \frac{N_0}{32} = \frac{16g}{32} = 0.5g \]
. correct choice is (A).

41. (3)

the range of transmission in then the coverage area is
\[ A = \pi d^2 = \pi \left(\sqrt{2Rh}\right)^2 \]
\[ A = 2\pi Rh \]

42. (3)

the statements (A), (B) and (D) are correct. since space wave propagation is line of sight propagation, correct choice is (C) for the incorrect statement.

43. (2)

the modulated wave is the superposition of modulating signal on carrier wave such that the amplitude of modulated wave varies in accordance with modulating signal, thus option (B) in correct.

44. (4)

the antenna should have a size comparable to the wavelength of the signal(at least in dimensions)

45. (3)

given \( R_c = 2.0k, \beta = 100, Output ac voltage = 2.0V \).

the ac collector current ,
\[ i_c = \frac{2.0V}{2.0 \times 10^3 \Omega} = 1.0 \text{ mA} \]

and the signal current through the base,
\[ i_b = \frac{i_c}{\beta} = \frac{1 \text{ mA}}{100} = 0.010 \text{ mA} = 10 \mu \text{ A}. \]

voltage gain,
\[ \frac{V_o}{V_i} = \beta \frac{R_o}{R_i} = 100 \times \frac{2000}{1000} = 200 \]
\[ V_i = \frac{V_o}{200} = \frac{2}{200} = 0.01V \]

thus the input voltage is 0.01 V, and the base current is 10 \( \mu \) A. the correct choice is (C).

46. (1)

47. (3)

Three, which are \( \text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3 \)
1. \( \text{CH}_3\text{OCH}_2\text{CH}_2\text{CH}_3 \)
2. \( \text{CH}_2\text{OCH} (\text{CH}_3)_2 \)
3. Here, I and II, I and III are pairs of metamers.

48. (1)
49. (4)

50. (1)

\[
\text{CH}_3\text{CH}_2\text{ONa} + \text{C}_2\text{H}_5\text{Br} \xrightarrow{\text{Williamson synthesis}} \text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3 + \text{NaBr}
\]

Ethoxyethane

51. (4)

2,4,6-trinitrophenol, benzoic acid and benzenesul-phonic acid are more acidic than carbonic acid and hence dissolve in NaHCO\textsubscript{3} solution. In contrast, o-nitrophenol is less acidic than carbonic acid and does not dissolve in NaHCO\textsubscript{3} solution.

52. (4)

Due to greater electron withdrawing effect of NO\textsubscript{2} group or Cl-atom, nitrophenols are stronger acids than p-chlorophenol. Out of nitrophenols, p-nitrophenol is the strongest acid.

53. (4)

54. (2)

As propanone is a ketone so A must be a secondary alcohol that is, isopropyl alcohol.

55. (2)

56. (1)

57. (4)

58. (1)

59. (1)

60. (1)

CH\textsubscript{3}Cl has higher dipole moment than CH\textsubscript{3}F due to much longer C-C bond length than C-F bond length.

61. (2)

Since the order of stability of carbocations decreases in the order tert-butyl > allyl > sec-butyl > n-butyl, so tert-butyl chloride is the most reactive compound.

62. (4)

63. (2)

64. (1)

In presence of alc. KOH cis-alkene is formed, hence on reaction with alc. KOH, 2-bromopentane produces cis-2-pentene.

65. (3)

The reaction occurs only in the presence of peroxides because hydroquinone and diphenylamine are radical scavengers.

66. (2)

67. (3)

68. (2)

\[
\text{C}_4\text{H}_5\text{I} \xrightarrow{\text{Alc. KOH}} \text{CH}_2 = \text{CH} \xrightarrow{\text{Br}} \text{BrCH}_2\text{CH}_2\text{Br} \xrightarrow{\text{KCN}} \text{NCCH}_2\text{CH}_2\text{CN}
\]

69. (1)

70. (2)

71. (3)

72. (1)

73. (1)

74. (4)

75. (4)

76. (4)

During reaction of HCN and CH\textsubscript{3}CHO, a chiral carbon is synthesized. The attack of CN\textsuperscript{-} on the flat aldehyde molecule can occur from either side, the product formed is a racemic mixture.

77. (2)
RCOCl $\xrightarrow{\text{Pd-BaSO}_4}$ RCHO + HCl

78. (1)

C$_2$H$_5$OH + CH$_3$COOH $\rightarrow$ CH$_3$COOC$_2$H$_5$ + H$_2$O

Ethyl alcohol Acetic acid

79. (3)

Its dissociation constant is less as compound to carboxylic acids

80. (3)

81. (2)

82. (1)

CH$_3$COOH is a $\beta$-carboxylic acid, which undergo decarboxylation simply on heating.

83. (3)

In this reaction

[A] = CH$_3$CH$_2$CH$_2$OH$^+$MgBr$^+$

[B] = CH$_3$CH$_2$CH$_2$OH

[C] = CH$_3$CH$_2$CH$_2$COOH

84. (2)

Baeyer-Villiger oxidation of cyclohexanone gives a ring expanded product known as lactone.

85. (2)

HC $\xrightarrow{1\%\text{HgSO}_4}$ CH$_3$CHO $\xrightarrow{\text{CH}_3\text{MgX}}$

(a)

CH$_3$ - CHOH - CH$_3$ $\xrightarrow{[\text{O}]}$ CH$_3$COCH$_3$

(b)

86. (3)

87. (4)

88. (4)

$\alpha$-D- (+)-glucose and $\beta$-D- (+)-glucose have different configuration at C-1 and are anomers.

89. (1)

90. (1)

**BOTANY**

91. Microbes in human welfare

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92. Organisms and population

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(i) exponential growth concept

93. Ecosystem

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94. Biodiversity and conservation

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95. Microbes in human welfare

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96. Organism and population

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97. Ecosystem  
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98. Biodiversity and conservation

99. Environmental issue  
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100. Microbes in human welfare  
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101. Organisms and populations  
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     13.2.1

102. Ecosystem  
     Page no. 250, 14.6

103. Biodiversity and conservation  
     Page no. 265, (iii)

104. Environmental issue  
     Fact based

105. Microbes in human welfare  
     Page no 185-186

106. Organisms and population  
     Page no. 222, 1st paragraph

107. Ecosystem  
     Page no 245, 14.4

108. Biodiversity and conservation  
     Page no 265-266, 15.2.1

109. Environmental issue  
     Fact based

110. Microbes in human welfare  
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111. Organisms and population  
     Page no. 226 1st paragraph

112. Unit X-Ecology facts

113. Biodiversity and conservation  
     Page no. 263-264, 15.1.4

114. Environmental issue
115. Environmental issue  
   Page no. 275 1st paragraph

116. Organisms and population  
   Page no. 223, 13.1.2

117. Ecosystem  
   Page no. 251, 14.6.1

118. Biodiversity and conservation  
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119. Environmental issues  
   Page no. 276, fig 16.5

120. Microbes in human welfare  
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121. Microbes in human welfare  
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122. Ecosystem  
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123. Biodiversity and conservation  
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124. Environmental issues  
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125. Microbes in human welfare  
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126. Environmental issue  
   Page no. 277, 16.3.1

127. Ecosystem  
   Page no. 254, 14.7.2

128. Biodiversity and conservation  
   Page no. 261, 1st paragraph

129. Environmental issue  
   Page no. 275, 2nd paragraph

130. Microbes in human welfare  
   Page no 183-184, 10.3

131. Organisms and population  
   Page no. 219, 1st paragraph
132. Environmental issues
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133. Biodiversity and conservation
Page no. 259, 1st paragraph

134. Environmental issues
Page no. 274 fig no. 16.3

135. Ecosystem
Page no. 246, fig 14.2

**ZOOLOGY**

136. Blood and urine analysis is effective only when disorder or disease has progressed in body.
137. Brassica napus - hirudin
138. SCID is the first disease to be treated through gene therapy
139. Hind II is the first REN to be discovered.
143. Sticky ends should be complementary to be ligated by DNA ligase and hence DNA should be cut using the same REN.
144. Denaturation 90-98C, annealing – 55C, Polymerisation -72C
147. DNA being negatively charged moves towards anode.
156. Gene of interest can be cloned in host cell only when cloning vector has ori gene.
159. REN is found only in prokaryotes.
160. If gene of interest is inserted using Cla I REN then both antibiotic resistance genes remain functional. Hence the transformed cell shall be resistant to both tetracycline and ampicillin.
161. Recognition sites are made of 4-6 base pairs.
163. REN and DNA ligase works antagonistic.
164. A. tumefaciens and biolistic methods are used for plant cells.
167. A. tumefaciens infects all dicots and creating GMO is not economical.
170. Mature insulin is made of A and B chains.
175. Mule is a hybrid of female horse and male donkey.
180. Semen is released in either vagina or uterus.