Section- A

1. As $V_A - V_B = V_B - V_C$ magnitude of work done is same. (1)

2. $I = \frac{E}{r+R}$

3. Factors are:
   (i) magnetic permeability of the medium (1/2)
   (ii) electric permittivity of the medium (1/2)

4. Diagram (1)

5. In photon picture, intensity is determined by the number of photons crossing per unit time. (1)

Section – B

6. As the current leads the voltage by $\frac{\pi}{4}$, the element used in black box is a ‘capacitor’. (½)
   (ii) Phasor diagram (½)
\[
\tan \frac{\pi}{4} = \frac{V_c}{V_R} \\
V_c = VR \\
X_c = R \\
\text{Impedance } Z = \sqrt{(X_c^2 + R^2)} \quad (\frac{1}{2}) \\
Z = R\sqrt{2} \quad (\frac{1}{2}) 
\]

7. (i) Energy density \( u = \frac{B^2}{\mu_0} \quad (\frac{1}{2}) \) 
    \[ u = 11.5 \times 10^{-9} \text{ J/m}^3. \quad (\frac{1}{2}) \]

(ii) Speed \( \frac{\omega}{k} \quad (\frac{1}{2}) \) 
    \[ \text{speed} = 3 \times 10^8 \text{ m/s} \quad (\frac{1}{2}) \]

8. \( \frac{\mu_2}{\mu} - \frac{\mu_1}{\mu} = \frac{(\mu_2 - \mu_1)}{R} \quad (\frac{1}{2}) \)
   \[ \text{correct sign convention} \quad (\frac{1}{2}) \]
   \[ 1.0/\nu - 1.5/-30 = (1.0 - 1.5) / 20 \quad (\frac{1}{2}) \]
   \[ \nu = -13.3 \text{ cm} \quad (\frac{1}{2}) \]

9. Photodiode (\(\frac{1}{2}\)) Reverse biasing (\(\frac{1}{2}\))
   I-V characteristics NCERT page no. 487 (1)

10.a) need for long antenna diminishes, with explanation (1)
    power is inversely proportional to \((\text{wavelength})^2\) (\(\frac{1}{2}\)),
    signals from different transmitters can be distinguished (\(\frac{1}{2}\))

OR

Range: 76-88 MHz and 420-890 MHz (1)
Factors: by increasing height of transmitting antenna and using repeater stations. (1)

Section - C

11.(a) \( C = 5 \times 10^{-9} \text{ F}, U = 25 \text{ J} \)
    \[ U = \frac{Q^2}{2C} \quad (\frac{1}{2}) \]
    \[ Q^2 = 2UC = 2 \times 25 \times 5 \times 10^{-9} \]
    \[ Q = 5 \times 10^{-4} \text{ C} \quad (\frac{1}{2}) \]
    \[ Q = n e \quad (\frac{1}{2}) \]
n = \frac{Q}{e} = 3.125 \times 10^{15} \text{ electrons} \quad (\frac{1}{2})

(b) Without changing charge on the plates, we can make C half. \( C = \frac{\varepsilon_0 A}{d} \), i.e. double the plate separation or inserting dielectric of dielectric of a value such that C becomes (1).

12. (a) As the electrostatic field inside a conductor is zero, using Gauss’s law,
charge on the inner surface of the shell = -Q \quad (\frac{1}{2})

Charge on the outer surface of the shell = +Q \quad (\frac{1}{2})

(b) To show using Gauss’s law expression

Expression for electric field for radius, \( r = \frac{a}{2} \): \( E = \frac{1}{4\pi\varepsilon_0} \frac{4Q}{a^2} \) \quad (1)

Expression for electric field for radius, \( r = 2b \): \( E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{4b^2} \) \quad (1)

13. (i) \( E_1 = \frac{V}{2L} \), \( E_2 = \frac{V}{2L} \), \( E_3 = \frac{2V}{3L} \) \quad (\frac{1}{2})

\( E_2 < E_3 < E_1 \) \quad (\frac{1}{2})

(ii) \( V_d \propto E \) \quad (\frac{1}{2})

\( V_{d2} < V_{d3} < V_{d1} \) \quad (\frac{1}{2})

(iii) \( I = nAe V_d / J = \sigma E \) \quad (\frac{1}{2})

\( J = n e V_d \)

\( J_2 < J_3 < J_1 \) \quad (\frac{1}{2})

14. NCERT Exemplar Q4.21 \quad R_1, R_2, R_3 \ (each 1 mark)

15. NCERT pg no. 301 Q6.14 (1 mark each part)

16. Device: Transformer

Diagram on page number 260 NCERT part I \quad (1)

Principle: statement of mutual induction \quad (1)

Efficiency: Assuming no energy losses, the transformer is 100% efficient i.e. \( I_p V_p = I_s V_s \). \quad (\frac{1}{2})

17. \( \beta = \lambda D / d \) \quad (\frac{1}{2})

5th bright = 5\( \beta_1 = 5\lambda_1 D/d = 5 \times 480 \times 10^{-9} \times 2 / 3 \times 10^{-3} = 16 \times 10^{-4} \text{ m} \) \quad (1)

5th bright = 5\( \beta_2 = 5\lambda_2 D/d = 5 \times 600 \times 10^{-9} \times 2 / 3 \times 10^{-3} = 20 \times 10^{-4} \text{ m} \) \quad (1)

distance between two 5th bright fringes = (20 – 16) \times 10^{-4} = 4 \times 10^{-4} \text{ m} \quad (\frac{1}{2})

18. 'Light from the sun is unpolarised' means the electric field vector vibrates in all possible directions in the transverse plane rapidly and randomly. \ (1)
19. i) Page no. 391 figure 11.4 + explanation (½ + 1)  
ii) Page no. 392 + explanation (½ + 1)  

OR

(i) Davisson- Germer experiment (½)  
An electron of charge e, mass m accelerated through a potential difference of v volts, Kinetic energy equals the work done (eV) on it by the electric field:  
\[ K = eV \]  
\[ K = \frac{p^2}{2m}, \quad p = \sqrt{2mk} \]  
\[ p = \sqrt{2meV} \]  
The de- Broglie wavelength \( \lambda \) of the electron is:\  
\[ \lambda = \frac{h}{p} \]  
\[ \lambda = \frac{h}{\sqrt{2meV}} \]  

(ii) For same KE, \( \lambda \propto \frac{1}{\sqrt{m}} \)  
As mass of proton is greater than that of electron, \( \therefore \lambda_p < \lambda_e \). (½)

20. \( E = \frac{hc}{\lambda} = 6.6 \times 10^{-34} \times 3 \times 10^8 / 620 \times 10^{-9} (1) \)  
\[ = 3.2 \times 10^{-19} \text{ J} \]  
\[ = 3.2 \times 10^{-19} / 1.6 \times 10^{-19} = 2 \text{ eV} \]  
This corresponds to the transition “D” (1)

21. NCERT figure 13.1 on page no. 444 (1)  
Fission (1), Fusion (1)

22.(i) Modulation Index = \( \frac{A_m}{A_c} = 20/40 = 0.5 \) (½ + ½)  
The side bands are (2000 + 20) KHz  
= 2020 KHz and (2000 - 20) KHz  
= 1980 KHz (½ + ½)  
Amplitude versus \( \omega \) for amplitude modulated signal : page number 525 NCERT part (ii)  
Figure 15.9, \( A_c = 40 \) volts, \( \mu A_c/2 = 10 \) volts. (1)

Section - D

23. (a) critical thinking, hard working (1)  
(b) One should not touch electrical appliances with wet hands/ any one
precaution. (1)

\[ I_A = \frac{E}{r + R + R_A} \]  \hspace{1cm} (\frac{1}{2})

For an ideal ammeter \( R_A = 0 \)

\[ I = \frac{E}{r + R} \]  \hspace{1cm} (\frac{1}{2})

Percentage error: \( \left( \frac{l - I_A}{l} \right) \times 100 = \left( \frac{R_A}{R + r + R_A} \right) \times 100 \) \hspace{1cm} (1)

Section –E

24. (a) Condition \( qE = qvB \) \hspace{1cm} (\frac{1}{2})

\[ v = \frac{E}{B} \]  \hspace{1cm} (\frac{1}{2})

Trajectory becomes helical about the direction of magnetic field \hspace{1cm} (1)

(b) To derive the expression of magnetic force acting per unit length of the wire:

\[ \frac{F_m}{l} = \frac{\mu_0 l I_2}{2\pi h}, \] upwards on wire AB \hspace{1cm} (2)

At equilibrium Magnetic Force per unit length = mass per unit length \( \times \) g

\[ \frac{\mu_0 l I_2}{2\pi h} = \frac{m}{l} g \] \hspace{1cm} (1)

OR

(a) Using the condition \( mvr = \frac{nh}{2\pi} \) \hspace{1cm} (1/2)

For H-atom \( n=1 \), \( v = \frac{h}{2\pi mr} \)

Time period \( T = \frac{2\pi r}{2\pi mr} \)

\[ \therefore T = \frac{4\pi^2 mr^2}{h}, \quad l = \frac{Q}{T} = \frac{eh}{4\pi^2 mr^2} \] \hspace{1cm} (1/2)

\[ M = l \] \hspace{1cm} (1/2)

\[ M = \left( \frac{eh}{4\pi^2 mr^2} \right)(\pi r^2) \]

\[ M = \frac{eh}{4\pi m} \] \hspace{1cm} (1/2)

(b) Diagram for magnetic field lines Cu- diamagnetic \hspace{1cm} (1)

Al- Paramagnetic \hspace{1cm} (1)

Fe- Ferromagnetic \hspace{1cm} (1)

25. (a) Diagram (2) + labelling \hspace{1cm} (\frac{1}{2})

(b) \( m_e = 1 + 25/5 = 6 \) \hspace{1cm} (\frac{1}{2})

\( m_o = 30 / m_e = 5 \) \hspace{1cm} (\frac{1}{2})

\( m_o = v_o / -u_o v_o = - 5 u_o \)
\[ \frac{1}{f_o} = \frac{1}{v_o} - \frac{1}{u_o f_o} = -\left(\frac{5}{6}\right) u_o \ (\frac{1}{2}) \]

\[ u_o = 1.5 \text{ cm}, \ v_o = 7.5 \text{ cm} \]

\[ u_e = -4.17 \text{ cm} \ (\frac{1}{2}) \]

Length of the tube = \(u_e + v_o = 11.67 \text{ cm} \ (\frac{1}{2})\)

OR

(a) Diagram (2) + labelling (\(\frac{1}{2}\))

(b) \[ m = -\frac{f_o}{f_e} \ (\frac{1}{2}) \]

\[ f_o = 5 f_e \ (\frac{1}{2}) \]

\[ L = f_o + f_e \ (\frac{1}{2}) \]

\[ f_e = \frac{36}{6} = 6 \text{ cm} \ (\frac{1}{2}) \]

\[ f_o = 30 \text{ cm} \ (\frac{1}{2}) \]

26. (a) circuit diagram (1)

NCERT page no.492 (explanation: 2)

(b) NCERT page no. 511 Q. No.14.17 Logic operation (1) Truth table (1)

OR

Diagram (1 \(\frac{1}{2}\))

Input Characteristics (1 \(\frac{1}{2}\))

Output Characteristics (1 \(\frac{1}{2}\))

Current amplification factor (\(\frac{1}{2}\))
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>N(H)</td>
<td>Numerical + HOTS</td>
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<tr>
<td>N (U)</td>
<td>Numerical + Understanding</td>
</tr>
<tr>
<td>N (A)</td>
<td>Numerical + Application</td>
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<tr>
<td>K</td>
<td>Knowledge</td>
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<td>K (7 marks)</td>
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<td>H (10 Marks)</td>
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<tr>
<td>EMD (11 Marks)</td>
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<td><strong>Total</strong></td>
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