Numerical answer type questions.

Q48. Intensity of plane em wave in a linear dielectric media is given by (eg refer to Introduction to Electrodynamics, 3rd edition, D. J. Griffith, page: 383)

$I = \frac{1}{2} v\epsilon E_0^2,\ Since: \epsilon = 3\epsilon_0\ and\ \mu = \mu_0,\ v = \frac{1}{\sqrt{\mu\epsilon}} = \frac{1}{\sqrt{\mu_0(3\epsilon_0)}} = \frac{c}{\sqrt{3}}$. So,

$$E_0 = \sqrt{\frac{2I\sqrt{3}}{c3\epsilon_0}} = 0.2087 \times 10^3 \frac{V}{m} = 0.21 \times 10^3 \frac{V}{m}.$$

Response given in answer sheet: 6.5 – 6.7 instead of 0.21.

Q55. rms velocity of ideal gas is given by v_{rms}, where;

$$v_{rms} = \sqrt{\frac{3kT}{m}}.\ p = mv_{rms} = \sqrt{3mkT}.$$

De-Broglie wavelength is; $\lambda = \frac{h}{p} = \frac{h}{\sqrt{3mkT}}$,

For quantum effect to be important interatomic distance s_0 should be of the order of this wavelength. Interatomic distance is one where considering a box of side s_0 the volume of the box s_0^3 contains same density of molecules as contains a box of volume of V. So if there are N molecules in volume V, n = N/V is the molecular number density. s_0^3 contains 1 molecule. So s_0 is approximately $n^{(-1/3)}$ … Refer eg to Statistical Physics by F. Reif (Berkley Physics Course, Volume 5, Page 239)

So from uncertainty relation, $s_0 p_0 \simeq \hbar\ or \frac{s_0 h}{\lambda} \simeq \left(\hbar = \frac{h}{2\pi}\right);\ s_0 \simeq \frac{\lambda}{2\pi} = \frac{\hbar}{\sqrt{3mkT}}$.

So we have: $s_0 = n^{-\frac{1}{3}} = \frac{\hbar}{\sqrt{3mkT}}$ or squaring and rearranging: $3mkT = \hbar^2 n^{\frac{2}{3}}$. This gives $T = \frac{\hbar^2 n^{\frac{2}{3}}}{3mk}$. Substituting all given values, we get $T = 2.13 \times 10^{-3} K$.

Response given in answer sheet: 78 – 90 instead of 2.13.