# Question 5: Photoelectric Effect and Atomic Physics

## (a) Linear Momentum of Photoelectrons

Maximum kinetic energy is $K_{\max} = eV_s = (1.60 \times 10^{-19})(4.25) = 6.80 \times 10^{-19}$ J. The momentum is $p = \sqrt{2m_e K_{\max}}$.

$$p = \sqrt{2(9.11 \times 10^{-31})(6.80 \times 10^{-19})} \approx 1.114 \times 10^{-24}\,\text{Ns}$$

## (b) Ratio of Emitted Electrons to Incident Photons ($N_e/N_p$)

Rate of photoelectron emission:

$$N_e = \frac{I_{\text{sat}}}{e} = \frac{21.7 \times 10^{-9}}{1.60 \times 10^{-19}} = 1.356 \times 10^{11}\,\text{electrons/s}$$

Rate of photon incidence:

$$N_p = \frac{P_{\text{in}}}{E_p} = \frac{I \times A}{hc/\lambda} = \frac{(0.7)(10 \times 10^{-4})}{(6.63 \times 10^{-34})(3.00 \times 10^8)/(60 \times 10^{-9})} = 2.112 \times 10^{14}\,\text{photons/s}$$

The ratio is:

$$\frac{N_e}{N_p} = \frac{1.356 \times 10^{11}}{2.112 \times 10^{14}} \approx 6.42 \times 10^{-4}$$

## (c) Collision with Hydrogen Atom

The electron's kinetic energy is $K_{\max} = 4.25$ eV. The minimum energy to excite a hydrogen atom from its ground state ($n = 1$) to the first excited state ($n = 2$) is:

$$\Delta E = E_2 - E_1 = \left(-\frac{13.6}{2^2}\right) - \left(-\frac{13.6}{1^2}\right) = 10.2\,\text{eV}$$

Since the electron's energy (4.25 eV) is less than the required excitation energy (10.2 eV), the electron cannot excite the hydrogen atom. Therefore, no photons will be emitted.