Assignment //
Modern Physics

1. Radioactive iodine (^{131}I) has a half-life of 8 days. Iodine is absorbed especially strongly by the thyroid gland. Hence, radioactive iodine can cause thyroid cancer. How long does it take for the amount of ^{131}I to be reduced by a factor of 100?

$$N(t) = N_0 e^{-kt} \quad \text{where} \quad k = \frac{\ln 2}{t_{1/2}}$$

$$\frac{N(t)}{N_0} = \frac{1}{100} \Rightarrow \frac{1}{100} = e^{-kt}$$

$$-\ln 100 = -kt$$

$$t = t_{1/2} \frac{\ln 100}{\ln 2}$$

$$= 8 \text{ days} \frac{\ln 100}{\ln 2}$$

$$\therefore t = 53 \text{ days}.$$

Hence, after Chernobyl people were told to avoid vegetables grown in their garden for about 2 months.

2 a) Work Function $W = h\nu$

$= \frac{hc}{\lambda}$

$\therefore \lambda = \frac{hc}{W}$

$= \frac{6.64 \times 10^{-34} \text{ J sec} \times 3 \times 10^{8} \text{ m/sec}}{3.5 \text{ eV} \times 1.6 \times 10^{-19} \text{ J/eV}}$

$= 356 \text{ nm}$

b) Photon is in ultraviolet spectrum.

3a) $p_{human} \simeq 100 \text{ kg.} \times 2 \text{ m/sec}$

$= 200 \text{ kg m/sec}$

$\lambda_{dB} = \frac{h}{p} = \frac{6.64 \times 10^{-34}}{200} = 3.32 \times 10^{-36} \text{ m}$

b) $p_{prot} = 1.67 \times 10^{-27} \text{ kg.} \times 3 \times 10^{5} \text{ m/sec}$

$= 5 \times 10^{-22} \text{ kg m/sec}$

$\lambda_{dB} = \frac{h}{p} = \frac{6.64 \times 10^{-34}}{5 \times 10^{-22}} = 1.33 \times 10^{-12} \text{ m}$

c) $p_{alpha} = 4 \times 1.67 \times 10^{-27} \text{ kg.} \times 3 \times 10^{5} \text{ m/sec}$

$= 2 \times 10^{-21} \text{ kg m/sec}$

$\lambda_{dB} = \frac{6.64 \times 10^{-34}}{2 \times 10^{-21}} = 3.3 \times 10^{-13} \text{ m}$

4. $r = n^2 a_0$

$$n = \sqrt{\frac{r}{a_0}}$$

$$= \left(\frac{10^{-6}\ m}{5.29 \times 10^{-11}\ m} \right)^{1/2}$$

$$= 137$$

5. For H ground state $mvr = \hbar$

But $r = \dfrac{\hbar^2}{mke^2}$ (Bohr radius)

$$\therefore v = \frac{\hbar}{mr}$$

$$= \frac{\hbar}{m} \frac{mke^2}{\hbar^2}$$

$$= \frac{ke^2}{\hbar c} c$$

$$= \frac{9 \times 10^9 \ (1.6 \times 10^{-19})^2}{\frac{6.64}{2\pi} \times 10^{-34} \times 3 \times 10^8} c$$

$$= \frac{c}{137}$$

$$\therefore v = 2.2 \times 10^6 \text{ m/sec.}$$