On the following problems show all your work. Partial credit will be given, if earned. Write your answers in the blanks provided.

(18 pts) 1. A hydrogen atom is in a $4d$ state. $d$ means $l = 2$.

a) What is the binding energy of a $4d$ state? Express your answer in eV.
Ans. $0.85 \text{ eV}$

b) In the quantum mechanical description, what is the magnitude of the orbital angular momentum $L$ of the electron when it is in a $4d$ state? Express your answer in terms of $\hbar$ (h-bar).
Ans. $\sqrt{6} \hbar$

c) For an electron in a $4d$ state, what is the minimum possible angle between the orbital angular momentum vector $\vec{L}$ and the z-axis? Express your answer in degrees.
Ans. $35.3^\circ$
(20 pts) 2. When light of wavelength 250 nm falls on a certain metal surface, the maximum kinetic energy of the emitted photoelectrons is 3.20 eV. What is the maximum wavelength (in nm) of light that will produce photoelectrons from this surface?

Ans. $105 \text{ nm}$

(18 pts) 3. A sample of ground-state hydrogen atoms is irradiated with light of wavelength 82.0 nm and free electrons are produced. What is the maximum kinetic energy (in eV) of these photoelectrons?

Ans. $1.5 \text{ eV}$
(20 pts) 4. A photon of wavelength 0.2400 nm strikes a free electron that is initially at rest and is scattered at an angle of 180° from its original direction.

a) What is the magnitude of the momentum of the photon after it has scattered from the electron? Express your answer in kg · m/s.

\[ \text{Ans. } 2.7 \times 10^{-14} \text{ kg} \cdot \text{m/s} \]

b) What is the speed of the electron after the collision with the photon? Express your answer in m/s.

\[ \text{Ans. } 6.00 \times 10^6 \text{ m/s} \]
(24 pts) 5. The nucleus $^{15}_6\text{C}$ undergoes $\beta^-$ decay with a half-life of 2.45 s. The atomic mass of $^{15}_6\text{C}$ is 15.010599 u.

a) How many protons are in the daughter nucleus that is produced by this decay?

Ans. 7

b) What is the total kinetic energy of the decay products, the energy released in the decay? Express your result in MeV. Refer to the copy of Table 30.2 that is on the formula sheet.

Ans. 9.77 MeV

c) What is the activity, in decays/s, of a sample containing 5.0 grams of $^{15}_6\text{C}$?

Ans. $5.68 \times 10^{22}$ decays/s