(5 pts) 1. Proton A has de Broglie wavelength $\lambda$. If electron B has twice the speed (which is much less than the speed of light) of proton A, the de Broglie wavelength of proton B is

(a) $2\lambda$
(b) $\lambda\sqrt{2}$
(c) $\lambda/\sqrt{2}$
(d) $\lambda/2$

(5 pts) 2. Consider a hypothetical single-electron Bohr atom for which an electron in the $n = 1$ shell has energy of -81.0eV while one in the $n = 3$ shell has total energy of -9.0eV. Which statements about this atom are correct? (there might be more than one correct choice)

(a) The energy needed to ionize the atom is 90.0eV.
(b) It takes 90.0eV to move an electron from the $n = 1$ to the $n = 3$ shell.
(c) If an electron makes a transition from the $n = 3$ to the $n = 1$ shell, it will give up 72.0eV of energy.
(d) If an electron makes a transition from the $n = 3$ to the $n = 1$ shell, it must absorb 72.0eV of energy.

(5 pts) 3. The atom having the electron configuration $1s^2, 2s^2, 2p^6, 3s^2, 3p^5$ has (there might be more than one correct answer)

(a) 17 orbital electrons.
(b) 11 orbital electrons.
(c) electrons with $l = 0, 1, 2$.
(d) electrons with $m_l = 0$ and $\pm 1$. 
4. In a transition from one vibrational state to another, a molecule emits a photon of wavelength 5.56 μm. The energy difference between these two states is closest to

(a) 0.223eV
(b) 2.23MeV
(c) 13.6eV
(d) 13.6MeV
(e) 0.223MeV

5. Modern nuclear bomb tests have created an extra high level of C-14 in our atmosphere. When future archeologists date samples from this era, without knowing about this testing, will their dates be too young?, too old? correct? if correct. why?

(a) too young.
(b) too old.
(c) correct, since the C-14 from bomb tests is different from that produced naturally.
(d) correct, because modern biological materials do not gather C-14 from bomb tests.

6. In massive stars, three helium atoms fuse together, forming a carbon nucleous. This reaction heats the core of the star. The net mass of the three helium nuclei must therefore be

(a) higher than that of the carbon nucleous.
(b) less than that of the carbon nucleous.
(c) the same due to mass conservation.

On the following problems show all your work. Partial credit will be given if earned.

7. A photon with wavelength of 0.1100nm collides with a free electron that is initially at rest. After the collision, the photon’s wavelength is 0.1132nm.

a) What is the kinetic energy of the electron after the collision? what is its speed?

b) If the electron is suddenly stopped (for example in a solid target) all of its kinetic energy is used to create a photon. What is the wavelength of this photon?

8. The neutral pion Π⁰ is an unstable particle produced in high energy collisions. Its mass is about 264 times that of the electron and it exists for an average lifetime of 8.410⁻¹⁷s before decaying into two gamma ray photons. Assuming that the mass and
energy of the particle are related by the Einstein relation $E = mc^2$, find the uncertainty in the mass of the particle and express it as a fraction of the particle’s mass (i.e. find the numerical value of $\Delta m/m$).

(10 pts) 9. a) Write out the electron configuration ($1s^2, 2s^2, \ldots$) for Ne ($Z = 10$), Ar ($Z = 18$) and Kr ($Z = 36$).
b) What do you conclude about the chemical behavior of these atoms?

(20 pts) 10. Suppose that 8.5gr of a nuclide of mass number 105 decays at a rate of $6.24 \times 10^{11}$ Bq. What is its half-lifetime? Hint: Use the fact that $\Delta N/\Delta t = -\lambda N$. You are given $\Delta N/\Delta t$ and can figure out N knowing the mass number and the mass of your sample.