**PHYS301 HW 3 Dr. Amir**

**Uncertainty Principle**

**6.** (I) The lifetime of a typical excited state in an atom is about 10ns. Suppose an atom falls from one such excited state and emits a photon of wavelength about 500 nm. Find the fractional energy uncertainty and wavelength uncertainty of this photon.

The uncertainty in the energy is found from the lifetime and the uncertainty principle.





The wavelength uncertainty is the absolute value of this expression, and so 

**7.** (I) A radioactive element undergoes an alpha decay with a lifetime of  If alpha particles are emitted with 5.5-keV kinetic energy, find the uncertainty in the particle energy.

The uncertainty in the energy is found from the lifetime and the uncertainty principle.



**8.** (II) A 12-g bullet leaves a rifle horizontally at a speed of  (*a*) What is the wavelength of this bullet? (*b*) If the position of the bullet is known to a precision of 0.65 cm (radius of the barrel), what is the minimum uncertainty in its vertical momentum?

8. (*a*) We find the wavelength from Eq. 37-7.



(*b*) Use Eq. 38-1 to find the uncertainty in momentum



**10.** (II) What is the uncertainty in the mass of a muon  specified in  given its lifetime of 2.20μs

10. We find the uncertainty in the energy of the muon from Eq. 38-2, and then find the uncertainty in the

mass.



**11.** (II) A free neutron (m=1.67 has a mean life of 900s. What is the uncertainty in its mass (in kg)?

11. We find the uncertainty in the energy of the free neutron from Eq. 38-2, and then the mass uncertainty from Eq. 36-12. We assume the lifetime of the neutron is good to two significant figures. The current experimental lifetime of the neutron is 886 seconds, so the 900 second value is certainly good to at least 2 significant figures.



**14.** (II) How accurately can the position of a 3.50-keV electron be measured assuming its energy is known to 1.00*%*?

**Free Particles;** 14. We assume the electron is non-relativistic. The momentum is calculated from the kinetic energy, and the position uncertainty from the momentum uncertainty, Eq. 38-1. Since the kinetic energy is known to 1.00%, we have 

**Plane Waves; Wave Packets**

**18.** (I) A free electron has a wave function where *x* is given in meters. Determine the electron’s (*a*) wavelength, (*b*) momentum, (*c*) speed, and (*d*) kinetic energy.

18. The wave function is given in the form 

(*a*) 

(*b*) 

(*c*) 

(*d*) 

**19.** (I) Write the wave function for (*a*) a free electron and (*b*) a free proton, each having a constant velocity The general equation for a free particle ca be written as

19. The general expression for the wave function of a free particle is given by Eq. 38-3a. The particles are not relativistic.

(*a*) 



(*b*) 

