Quiz 5; Phys 100 Name ______________

Planck's constant: $h = 6.6 \times 10^{-34}$ kg·m^2/s. Photon energy: $E = hf$. Uncertainty principle: $\Delta x \Delta p \geq h/4\pi$. Momentum = mass × speed.

1. (4 points) Think back to the electron beam in the vacuum tube in the lab where we created electric and magnetic fields and applied them to an electron beam. Say we were interested in the location of one of the electrons in the beam, measured along an x-axis along the direction of the beam. Estimate (give me a reasonable rough value for) Δx, the uncertainty in the electron's location. Then briefly explain your estimate—tell me why it shouldn't be ten times larger or ten times smaller than the value you gave me.

Answer: The length of the beam was something like 20 to 30 cm, before it hit the screen. The electron must be somewhere in the beam, so about 30 cm is a good estimate of Δx. (Anything from 10 to 50 cm would be reasonable.) If we said 3 cm, that would be considerably smaller than the beam, and we'd pretend to knowledge we don't have. If we said 300 cm = 3 m, that's significantly larger than the beam; we're not *that* uncertain.

2. (4 points) If Planck's constant h were zero, which of the following would be true?

(a) Gravitational forces would no longer exist

(b) We could no longer have stable measurements of the speed of light

(c) The Rarit-Tapper entanglement factor would metacoagulate unpaired electrons

(d) We could fix the location and momentum of a particle as precisely as we want

(e) High frequency photons would deviate from linear correlations with angular plasticity

3. (4 points) An electron (mass = 9.1×10^{-31} kg) has a velocity uncertainty $\Delta v = 1$ m/s. How large must its position uncertainty be? Express your answer in *meters*.

Answer: If the momentum uncertainty is minimal, then we can use $\Delta p = m\Delta v$ in the uncertainty principle, and get

$$\Delta x \approx \frac{h}{4\pi m \Delta v} = 5.8 \times 10^{-5}\text{m}$$

It would also be acceptable if you followed the textbook and dropped the 4π, getting 7.3×10^{-4} m.

4. (4 points) Which of the following is *not* true about dark matter?

(a) Must exist because otherwise many galaxy clusters could not hold together

(b) Is mostly in the form of supermassive black holes at the centers of galaxies

(c) Cannot be composed of the ordinary matter we are familiar with on Earth

(d) Is conjectured to be present due to its measured gravitational effects

(e) Is "dark" because electromagnetic forces don't affect it

5. (4 points) Which of the following is *not* true about dark energy?

(a) It may be related to the "cosmological constant"

(b) It provides a kind of repulsive gravity at long distances

(c) Is associated with an accelerating expansion of the universe

(d) It may be related to properties of the vacuum

(e) Is measurable in the location uncertainties of electrons