Quiz 6; Phys 100 Name _____

Uncertainty principle: $\Delta x \Delta s \geq h/4\pi m$. Planck's constant $h = 6.6 \times 10^{-34}$ J·s. Speed of light: $c = 3 \times 10^8$ m/s. Photons: $E = hf$.

1. (3 points) he uncertainty principle

(a) Means that nothing can be known exactly

(b) Expresses a limit of human powers of perception

(c) Is a principle useful in social science and humanities as well as in physics

(d) Comes about due to particle probabilities being described by waves

(e) Is true on account of lab equipment never being perfect

2. (4 points) Sketch a pure wave, that has a definite speed and therefore has $\Delta s = 0$. Explain, using the AM radio analogy to connect the amplitude with the probability, why this means that you know nothing about the location of particle described by a pure wave, and hence $\Delta x = \infty$.

Answer: You should sketch a sine wave, with constant amplitude. Since probability depends on the amplitude, and the amplitude does not change, that means the probability of finding the particle anywhere must be equal. This means we know nothing about the particles location, since no location is distinguished from any other.

3. (3 points) The electron in a ground-state hydrogen atom remains within a sphere measuring roughly 10^{-10} m across. An electron's mass is about 10^{-30} kg. Use this data along with Heisenberg's uncertainty principle to estimate the speed of this electron. (Hint: in the ground state, $\Delta s \approx s$.) What fraction of lightspeed is this?

Answer:

$$s \approx \frac{6.6 \times 10^{-34}}{4\pi 10^{-30} 10^{-10}} \approx 5 \times 10^5 \text{ m/s} \approx 0.002\, c$$

It's also OK if you omit the 4π and get $0.02\, c$—this is just an estimate.

4. (3 points) How does the unpredictability in quantum events differ from the unpredictability of the weather?

Answer: If you take a lot of data concerning quantum events, you still cannot find any pattern that allows you to improve the predictability of individual events. With the weather, if we had a lot more information, we could improve our predictive ability.

5. (3 points) The first few energy levels for an electron in an atom are $E_1 = 0$, $E_2 = 4$, $E_3 = 6$, $E_4 = 7$, in units of 10^{-18} J. Which of these quantum jumps creates the highest frequency photon?

(a) Level 3 to level 1

(b) Level 4 to level 2

(c) Level 2 to level 1

(d) Level 3 to level 2

(e) Level 4 to level 3

6. (4 points) Neil deGrasse Tyson explains how astrophysics is not just about pretty pictures of stars and galaxies. Give two examples of the kind of information we can get from doing spectroscopy on starlight.

Answer: We can look at the spectral lines and figure out the chemical compositions of stars. And we can look at the Doppler shifts in these lines to find out their speeds relative to us.