Physics 228 Second Exam Solutions

1. The relativistic factor γ is given by

$$E = \gamma mc^2$$
$$\gamma = \frac{400\text{ GeV}}{938.2\text{ MeV}} = 426$$

2. For λ=250 nm, the photoelectrons have maximum kinetic energy

$$K = \frac{hc}{\lambda} - \phi = 0.23\text{ eV}$$

3. For a particle in a 1-dimensional box of width 0.5 nm, we have

$$E_n = \frac{h^2}{8mL^2}n^2$$
$$E_2 - E_1 = \frac{3h^2}{8mL^2} = 4.52\text{ eV}$$

4. For helium Z=2, and the energy levels are given by

$$E_n = -\frac{54.4\text{ eV}}{n^2}$$
$$E_3 - E_1 = 54.4\text{ eV}\left(\frac{1}{1^2} - \frac{1}{3^2}\right) = 48.4\text{ eV}$$
$$\Rightarrow \lambda = 25.6\text{ nm for 1s to 3p}$$

16. Twin B sees the distance 4 light years as contracted by the factor γ=1.25;
thus he sees it as 3.2 light years.

17. Proper time is measured between two events occurring at the same spatial coordinates.

18. The total energy of the system is conserved. Since $\beta = v/c = 0.6$, we have γ=1.25, and thus

$$E_i = Mc^2 = E_f = 2\gamma mc^2$$
$$m = \frac{M}{2.5} = 0.4\,M$$

19. The wavefunction is not spherically symmetric; this rules out the answers with ℓ=0. The state with n=ℓ is not allowed, leaving only the n=2 and n=3 choices. Since there is a node in r (where the wavefunction is zero) it must be n=3.

20. In the Bohr model the electron moves in a circular orbit where the orbital angular momentum of the electron is L=n$\hbar$. Thus this leads to discrete values for L, r and v

21. Power is equal to energy per unit time; thus we have

$$P = 10^{17}\frac{photons}{\text{sec}} \times \frac{1240\text{ eV - nm}}{(633\text{ nm})\,photon}$$
$$\times \frac{1.6\times 10^{-19}\text{ J}}{eV} = 31.3\text{ mW}$$

22. The Planck blackbody formula cuts off the ultraviolet (short wavelength) end of the spectrum, avoiding the "ultraviolet catastrophe" of the classical formula.

23. Since the energy levels are

$$E_n = \frac{h^2}{8mL^2}n^2$$

the lowest energy state is 130 keV.

24. They have the same momentum, p=h/λ.

25. See Ex. 42.4. Ratio = 2.1.

26. Since Z = 12 we need 12 electrons. The lowest-energy configuration is $1s^2 2s^2 2p^6 3s^2$.

27. The state $4d^{12}$ cannot exist since there are only 10 d states available.