Modern Physics

Problem 1 (10%)
A particle has a lifetime of 10^{-7} s when measured at rest. How far does it go before decaying if its speed is 0.99c when it is created?

Problem 2 (15%)
A measurement establishes the position of a proton with an accuracy of $\pm 10^{-11}$ m. Find the uncertainty in the proton's position 1 s later. Assume the velocity of the proton is much less than the light velocity in vacuum.

Problem 3 (20%)
The wave function of 1s electrons in the hydrogen atoms is

$$\varphi = \frac{e^{-r/a_0}}{\sqrt{\pi} a_0^{\frac{3}{2}}}$$

(1) Find the average value of $1/r$ for an electron in the hydrogen atom.
(2) How much more likely is a 1s electron in a hydrogen atom to be at the distance a_0 from the nucleus than that at the distance $a_0/2$

Problem 4 (15%)
Find the S, L, and J values in a many-electron atom that correspond to each of the following states:

(1) $^1S_0$ (2) $^2D_{3/2}$ (3) $^3P_2$

Problem 5 (15%)
If λ is the mean free path between the collisions of a free electron and the average time τ between collision is $\tau = \lambda/V_F$, where V_F is the Fermi velocity
Find the resistivity ρ in terms of m, n, e, λ, and V_F. (m, n, and e are the electron mass, density, and charge, respectively.)

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Microelectronics

Problem 6: If you put a p-n junction diode together with a n-p junction diode side by side (figure 1), can they become a pnp transistor (BJT)?   and why?   (10%)
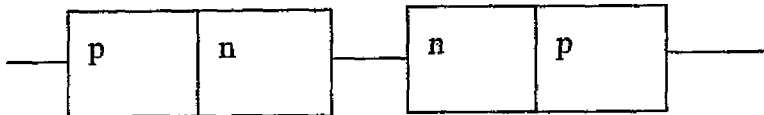

Figure 1

Problem 7:   Figure 2 shows a universal BJT amplifier configuration.   This BJT has common emitter current gain β.   And C1, C2 and C3 are very large.

(a) What are purposes of capacitors C1, C2, and C3,? (6%)

(b) In the common emitter mode, please draw the hybrid π small signal circuit from figure 2 (9 %) (Small signal parameters (hybrid π model) such as $r\pi$, gm, re, ro, $\cdots$ can be used).

Figure 2