國立臺灣大學98學年度碩士班招生考試試題

題號：406
科目：近代物理學(B)

1. How much time does a meter stick moving at 0.1c (c is the speed of light) relative to an observer take to pass the observer? The meter stick is parallel to its direction of motion. (5 points)
2. What is the maximum wavelength of light that will cause photoelectrons to be emitted from sodium? (The work function of sodium: 2.3eV) (5 points) What will be the maximum kinetic energy of the photoelectrons if light of 200 nm wavelength falls on a sodium surface? (5 points)
3. An unstable elementary particle called the eta meson has a rest mass of 549 MeV/c^2 and a mean lifetime of 7.0×10^{-19} s. What is the uncertainty in its rest mass? (10 points)
4. Of the following quantities, which increase and which decrease in the Bohr model as n (the principal quantum number) increases? Frequency of revolution, electron speed, electron wavelength, angular momentum, potential energy, kinetic energy, total energy.(10 points)
5. The Zeeman components of a 500-nm spectral line are 0.0116 nm apart when the magnetic field is 1.0 T. Find the ratio e/m for the electron from these data. (5 points)
6. What is Bose-Einstein distribution function? (3 points) What is the Fermi-Dirac distribution function? (3 points) What is the difference between these two-distribution function? (4 points)
7. From the selection rule, we know that the allowed transition between each energy state of hydrogen atom is decided by

$$\int_{-\infty}^{\infty} u\psi_{nlm}\psi^{*}_{n'l'm'}dV \neq 0,$$

where n, l, and m are the principle, orbital, and magnetic quantum numbers, respectively, and u represents either the x, y, or z coordinate. V is the whole volume. Please explain that why the allowed transitions require that $\Delta l = l - l' = \pm 1$? (5 points)
8. From Bohr's theory, an electron can circle a nucleus on if its orbit contains an integral number of de Broglie wavelengths. Please derive the Bhor radius of a hydrogen atom in the vacuum. (3 points) If the hydrogen atom is put inside a semiconductor where the dielectric constant is $10\varepsilon_0$, what is the change of Bhor radius (4 points)? Do you think the electron is much easier to stay in the orbital of hydrogen atom or not in the semiconductor? (3 points)
9. Electrons with energy of 1.5 eV are incident on a barrier 10.0eV high and 0.50nm wide, shown in **Fig. A**. Please calculate the transmission probabilities. (10 points)

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10. You are asked to derive the equations that describe the I-V characteristics of a NMOS transistor which is operated at an **excess gate voltage** of $v_{GS}-V_t$. Let the capacitance per unit **gate** area shown in **Fig. B** denoted by C_{ox}.

(a) Consider an infinitesimal stripe of width W and length dx at distance x from the source, what is the capacitance of this stripe? (2 points)

(b) Consider a voltage v(x) in the channel at point x, what is the electron charge dq in the infinitesimal stripe of the channel at point x? Derive your answer as a function of excess gate voltage, W, dx, and C_{ox}. (3 points)

(c) Since the electric field (E) causes the electron charge dq to drift toward the drain with a velocity $dx/dt=-\mu_n E$, where μ_n is the mobility of electrons in the channel. What is the drain to source current as contributed from this infinitesimal stripe? Derive your answer as a function of excess gate voltage, dq, μ_n, and $dv(x)/dx$. (5 points)

(d) Following (c), derive the i_D-v_{DS} characteristics for a NMOS transistor in the triode region, assuming v(0)=0 and $v(L)=v_{DS}$. (5 points)

11. Refer to **Fig. C**,

(a) What type of single stage amplifier (common emitter, common gate, or common source) is this circuit belonged to? (2 points)

(b) Draw a small –signal equivalent circuit of **Fig. C** (4 points)

(c) Derive the open-circuit voltage gain of **Fig. C** by assuming $R_L=\infty$. (4 points)

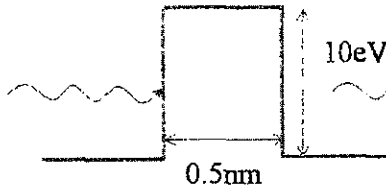

Fig. A

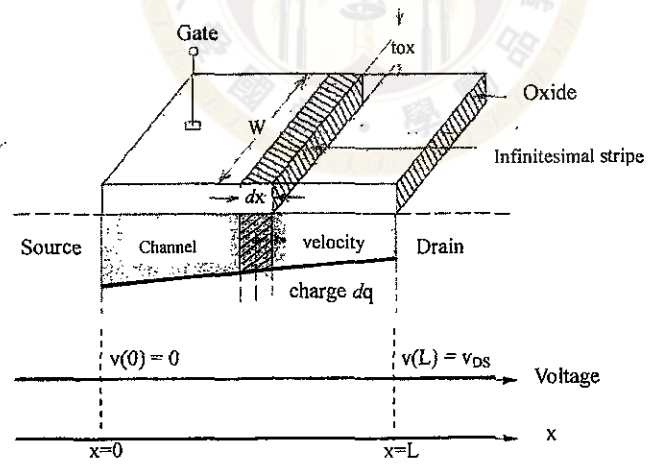

Fig. B

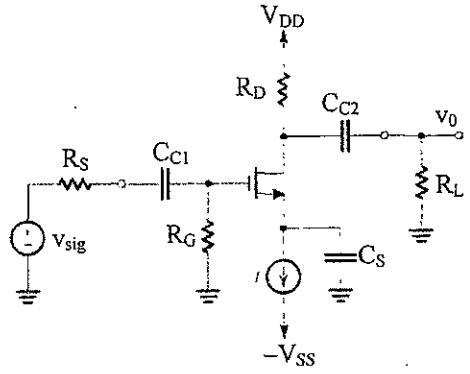

Fig. C

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