

※ 注意：請於試卷內之「非選擇題作答區」作答，並應註明作答之題號。

1. A stationary body explodes into two fragments each of mass 2.0 kg that move apart at speeds of  $0.8c$  relative to the original body. Find the mass of the original body. (8 points) ( $c$ : light speed)
2. Find the maximum frequency present in the radiation from an x-ray machine whose accelerating potential is 10000 V? (7 points)
3. For an electron (mass =  $9.1 \times 10^{-31}$  kg) in a box (0.1 nm across), what is (are) possible permitted energy (energies)? (A) 6 eV, (B) 342 eV, (C) 76 eV, (D) 608 eV, (E) 30 eV. (7 points)

4. Find the relation of the wavelengths of the spectral lines of positronium and hydrogen atoms, denoted as  $\lambda_P$  and  $\lambda_H$ , respectively. (10 points)

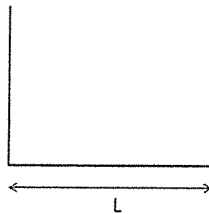
(Note: positronium atom is a system consists of a positron and an electron. The mass of positron is the same as that of an electron. And its charge is  $+1e$ .)

5. An eigenfunction of the operator  $d^2/dx^2$  is  $\psi=e^{3x}$ . Find the corresponding eigenvalue. (8 points)

6. Find the average value of  $1/r$  for a 1s electron in the hydrogen atom. (10 points)

Note: the wavefunction of a 1s electron is  $\psi = \frac{e^{-r/a_0}}{\sqrt{\pi a_0^3}}$

7. For a particle in a box and consider it as 1D problem, where  $L=1\text{nm}$  and  $m=1m_0$ ,  $m_0= 9.11 \times 10^{-31}\text{kg}$ .  
(1) Please calculate the eigen energy of the first, second and third subband and plot out the first 3 eigen functions in this box shown below. (5 points)



- (2) According to the selection rule where the allowed transition between different eigen energy needs to follow the rule that

$$\int_{-\infty}^{\infty} x \psi_m \psi_n^* dx \neq 0$$

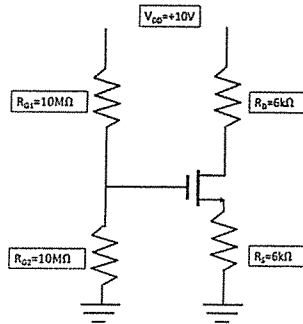
Please verify if the transition from 3<sup>rd</sup> band to 1 state is allowed or not. Please also verify if the transition from 3 to 2 or 2 to 1 is allowed or not. (5 points)

8. please explain the Rayleigh scattering and Raman scattering (5 points)

9. The fine-structure splitting of the  $2P_{3/2}$  and  $2P_{1/2}$  levels in hydrogen is  $3.0 \times 10^{-5}$  eV. From this, estimate the magnetic field that the 2p electron in hydrogen experiences. (Assume  $\mathbf{B}$  is parallel to the z axis.) (10points)

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10. For a pn junction diode, The  $N_A=10^{17}\text{cm}^{-3}$ ,  $N_D=5.0 \times 10^{16}\text{cm}^{-3}$ , please find that at  $T=300\text{K}$ , the built-in voltage, the width of the depletion region, and the distance it extends in the p-side and n-side of the junction. Please use  $n_i=1.0 \times 10^6\text{cm}^{-3}$ . (10 points)
11. Consider a CMOS devices, the gate length  $L=0.2 \mu\text{m}$ , oxide thickness  $t_{ox}=10\text{nm}$ , electron mobility  $\mu_n = 500 \text{ cm}^2/\text{Vs}$ , and  $V_T=1.0\text{V}$ . (15 points)
- (1) Please calculate  $C_{ox}$
  - (2) If the transistor channel width  $W=20\mu\text{m}$ , please calculate the values of  $V_{gs}$  and  $V_{DS,\min}$  needed to operate the transistor in the saturation region with a dc current  $I_D=80\mu\text{A}$ .
  - (3) Analyze the circuit show below to determine the voltages at all nodes and the current through all branches. (i.e. assume  $\lambda = 0$ )



Parameters you may use:

c: light speed,  $3 \times 10^8 \text{ m/s}$

e:  $1.6 \times 10^{-19} \text{ C}$

h:  $6.63 \times 10^{-34} \text{ J*s}$

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