

所別： 電機工程學系碩士班 Z1組 科目：近代物理

1. An unstable atomic state has a lifetime of  $1 \mu\text{s}$ . (a) Roughly estimate the minimum uncertainty in its energy. (b) Assuming that the photon emitted when this state decays has a wavelength of  $450 \text{ nm}$ , what are the uncertainty and fractional uncertainty in its wavelength? 15 %
2. Given a crystal with three diffraction peaks at  $\theta = 36.7^\circ$ ,  $52.8^\circ$ , and  $84.5^\circ$  obtained by x-ray ( $\lambda = 0.0438 \text{ nm}$ ) diffraction. What are the orders of these peaks, and what is the spacing of the crystal planes? 15 %
3. Make sketches of the probability density for the first four energy levels of a particle in a non-rigid box. Draw next to each graph the corresponding graph for the rigid box. 8 %
4. A  $60 \text{ W}$  lightbulb actually produces  $3 \text{ W}$  of visible light. (a) How many visible photons are produced each second? Use the average wavelength of  $600 \text{ nm}$ . (b) Estimate the quantum efficiency, i.e. the ratio of the output photon over input electron, of the lightbulb. 12 %
5. What frequency is required to induce electron spin transitions from the parallel to the antiparallel, or vice versa, if the magnetic field is  $0.1 \text{ Tesla}$ ? 15%  
(Note that  $1\text{J}=0.738 \text{ ft}\cdot\text{lb}$ ;  $1\text{N}=0.2248 \text{ lb}$ , and  $1\text{m}=3.281 \text{ ft}$ ).
6. The Schrodinger's equation of one dimensional simple harmonic oscillator is 
$$\left(\frac{-\hbar^2}{2m} \frac{d^2}{dx^2} + \frac{m}{2} \omega^2 x^2\right)\psi(x) = E\psi(x)$$
. Prove that the energy  $E$  can only have positive values. 10%.
7. Calculate the Fermi energy at  $T = 0$  for copper with density  $N/V = 8.47 \times 10^{22} / \text{cm}^3$ . 10%
8. Discuss the differences among the band structures of metals, semiconductors, and insulators. 15%

(Some useful numbers:  $k_B = 1.38 \times 10^{-23} \text{ J/K}$ ,  $h = 6.63 \times 10^{-34} \text{ J}\cdot\text{s}$ ,  $c = 3.00 \times 10^8 \text{ m/s}$ ,  $m_e = 9.11 \times 10^{-31} \text{ kg}$ )

