

MIDTERM EXAMINATION (100 POINTS)
IN CLASS

1. (30 points)
 - a) (15 pts) Given a population of CO molecules initially in their $J=1$ rotational excited state, determine how long it will take before 90% of the population is lost to the ground ($J=0$) state by spontaneous emission. The rotational constant is 57.8975 GHz and the transition dipole is 0.04 Debye (1 Debye = 10^{-18} esu-cm = 3.33564×10^{-30} coulomb-m).
 - b) (15 pts) Determine a formula for the temperature at which spontaneous and stimulated emission of radiation at a given frequency are equal in rate. You may assume that the radiation field is thermal: $\rho(\nu) = \rho_T(\nu)$.

2. (50 points)
 - a) (10 pts) Consider the lithium atom, which contains three electrons. Write a valid wave function/wave functions for the ground state configuration.
 - b) (20 pts) Determine the term symbols for the excited configuration $1s3d^2$. Order the terms. Ignoring the selection rule for configurations, can any of these terms emit to ground state terms?
 - c) (20 pts) Consider the molecular ion N_2^+ , which possesses 13 electrons. Determine the term symbols for two possible lowest terms, assuming that you do not know if $\sigma_g 2p < \pi_u 2p$ or the reverse. Do not neglect the g and u symbols. If spin-orbit splitting occurs in one or both of the "lowest energy" terms, show the states allowed and their spin-orbit energies.

3. (20 points) Obtain a formula for the dissociation energy D_e of a diatomic molecule in its ground electronic state using the vibrational energy formula from the Morse oscillator.