Worksheet 3. Spectroscopy, Mostly.

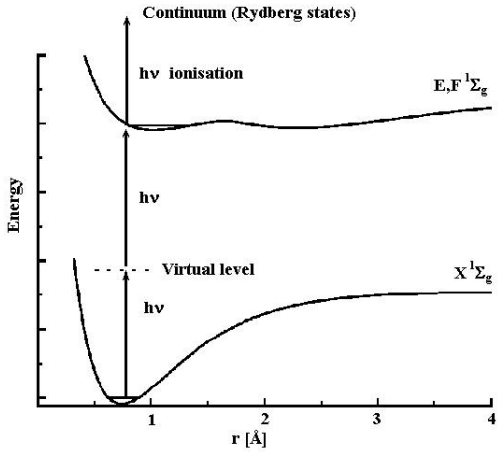
1. **Some physicists speculate that Planck's constant might not really be constant but, instead, vary slightly in space. A physicist speculates that Planck's constant on the moon is slightly smaller than Planck's constant on earth. We decide to test this hypothesis using the one-dimensional particle in a box. Which of the following observations are would support this hypothesis.**
   (a) the zero-point energy of the "moon box" is less than that of the "earth box."
   (b) the zero-point energy of the "moon box" is equal to that of the "earth box."
   (c) the zero-point energy of the "moon box" is greater than that of the "earth box."
   (d) the average position of the particle is further from the edges of the "moon box" than the "earth box."
   (d) the average position of the particle is closer to the edges of the "moon box" than the "earth box."
   (e) the average position of the particle in the "moon box" than the "earth box" is the same.

2. **Write down the time-dependent Schrodinger equation.**

3. **Which of the following common spectroscopic techniques requires going beyond the "weak-field" approximation. (I.e., which of the following experiments requires, at least, second-order time-dependent perturbation theory.)**

(a) infrared spectroscopy	(d) X-ray spectroscopy	(f) NMR spectroscopy
(b) microwave spectroscopy	(e) ESR/EPR (electron spin resonance) spectroscopy	(g) Raman spectroscopy
(c) UV-Vis spectroscopy		

4. **The following diagram typifies REMPI (Resonance Enhanced Multiphoton PhotoIonization).**



Which of our fundamental approximations is ALWAYS violated in this type of spectroscopy:

(a) long-wavelength approximation.	(c) long-time approximation.
(b) weak-field approximation.	

5. **Is the lowest excitation energy in the Hydrogen atom (1*s* to 2*s* or 2*p*) electric-dipole allowed or forbidden? Explain.**

6. **Is the lowest excitation energy in the Hydrogen molecule (H2; σ to σ^*) electric-dipole allowed or forbidden? Explain.**

7. **What is the lowest dipole-allowed excitation energy for a particle of mass 9.1×10^{-31} kg in a one-dimensional box of size 1.2×10^{-10} m.**

8. **What is the wavelength of the light that is required to perform the transition in Question 7. Is the long-wavelength approximation likely to be valid here?**

9. **Suppose that the one-dimensional box in Question 7 is oriented along the z axis. A laser is positioned perpendicular to the box along the x axis. In order to maximize the number of transitions we observe, we should choose the laser's polarization so that (there may be more than one answer)**
   (a) the light is linearly polarized, with the electric field in the *y* direction.
   (b) the light is linearly polarized, with the electric field in the *z* direction.
   (c) the light is linearly polarized, with the electric field halfway between the *y* and *z* directions.
   (d) the light is linearly polarized, with the magnetic field in the *y* direction.
   (e) the light is linearly polarized, with the magnetic field in the *z* direction.
   (f) the light is linearly polarized, with the magnetic field halfway between the *y* and *z* directions
   (g) the light is right-circularly polarized.
   (h) the light is left-circularly polarized.

10. **Look in your notes for the expression for electric-quadrupole transitions. Explain why the transition from the 3*d* metal-based orbital to the 4*s* metal-based orbital in a weakly coordinated transition metal complex is electric dipole forbidden, but electric quadrupole allowed.**