Name:  

**Quiz 2** Propagation of error, basic spectroscopy, lasers and PMT's.

1. Which one of the following statements about the photoelectric effect is false?  
   - a. The work function of a metal determines the wavelength of light that will produce a photoelectron.  
   - b. Low work function metals emit photoelectrons at low light intensity.  
   - c. The stopping potential is lower for higher work function metals.  
   - d. The photoelectric effect established the magnitude of Plank's constant.  
   - e. Infrared radiation cannot be detected by phototubes.  

   **3 pts**

2. Which one of the following statements about spectroscopy is false?  
   - a. Electronic spectra are generally much higher frequency than vibrational spectra.  
   - b. Vibrational fine structure appears in electronic spectra.  
   - c. Fluorescence arises from the ground vibrational state of an excited electronic state to excited vibrational states of the ground electronic state.  
   - d. Electronic spectra of gas phase atoms are generally more complex and comprise broader bands than do spectra of small gas phase molecules.  
   - e. Absorbance bands originate in transitions from the ground vibrational state of the ground electronic state to excited vibrational states of excited electronic states.  

   **3 pts**

3. Calculate the longest wavelength of light (in nm) that can ionize a helium atom given that the ionization potential of He is 24.58 eV.

\[
\text{Wavelength (nm)} = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s}}{1.602 \times 10^{-19} \text{ J/ev}} \times \frac{24.58 \text{ ev}}{3.00 \times 10^8 \text{ m/s}}
\]

\[
\text{Wavelength (nm)} = 5.04 \times 10^{-8} \text{ m} = 50.48 \text{ nm}
\]

5 pts

11 pts
4. An instrument signal was found to obey the following function:

\[ Q = kC \]

- \( Q \) is the instrument signal
- \( K \) is a constant of calibration
- \( C \) is the concentration

\[ K = 22 \pm 1 \text{ ppm}^{-1} \]

\[ Q = 2.3 \pm 0.2 \text{ (s.d=0.2)} \]

Calculate \( C \) and \( s_C \):

\[ C = \frac{Q}{k} = \frac{2.3}{22.1 \text{ ppm}^{-1}} = 0.102 \text{ ppm} \]

\[ s_C = \left( \frac{s_Q^2}{Q} \right) + \left( \frac{s_k^2}{k} \right) \]

\[ \left( \frac{2.3}{22.1} \right)^2 + \left( \frac{0.2}{2.3} \right)^2 \]

\[ = 0.098 \]

\[ s_C = \sqrt{0.098} \times 0.102 \text{ ppm} = 0.012 \text{ ppm} \]

5. A laser beam strikes a 500 line/mm diffraction grating at normal incidence and is deflected at the following angles: 0°, 18.44°, 38.25° and 71.65°. What is the wavelength of the laser?

\[ \lambda = \frac{d \sin \theta}{m} \]

\[ \theta = 18.44^\circ \]

\[ m = 1 \text{ (for first order)} \]

\[ \lambda = \frac{6 \times 10^{-4} \text{ m}}{18.44^\circ} \times \frac{1 \text{ mm}}{10^{-2} \text{ m}} \times \frac{10^{-6} \text{ mm}}{1 \text{ m}} \]

\[ = \frac{6.328 \times 10^{-9} \text{ m}}{18.44^\circ} \]

\[ = 632.8 \text{ nm} \]

6. Sketch the energy level diagram for a 4-level laser and draw in and label the arrows corresponding to absorption, intersystem crossing, lasing and relaxation to the ground state.
6. Complete the following table:

<table>
<thead>
<tr>
<th>Type of spectroscopy</th>
<th>Usual Wavelength Range</th>
<th>Name of Spectroscopy</th>
<th>Type of Quantum Transition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamma ray emission</td>
<td>0.005 – 1.4 Ångstrom</td>
<td></td>
<td>nuclear</td>
</tr>
<tr>
<td>X-Ray Absorption</td>
<td>0.1 – 100 Ångstrom</td>
<td>X-Ray Spectroscopy</td>
<td>core e⁻</td>
</tr>
<tr>
<td>Vacuum Ultraviolet</td>
<td>10 – 180 nm</td>
<td>VUV</td>
<td>valence e⁻</td>
</tr>
<tr>
<td>Ultraviolet-Visible</td>
<td>180 – 600 nm</td>
<td>UV-Vis</td>
<td>valence e⁻</td>
</tr>
<tr>
<td>Infrared Absorption</td>
<td>4000 – 400 cm⁻</td>
<td>FTIR</td>
<td>vibrations</td>
</tr>
<tr>
<td>Microwave Absorption</td>
<td>0.75 – 375 mm</td>
<td>Microwave</td>
<td>rotations</td>
</tr>
<tr>
<td>Electron Spin Resonance</td>
<td>3 cm</td>
<td>ESR</td>
<td>e⁻ spin</td>
</tr>
<tr>
<td>Nuclear Magnetic Resonance</td>
<td>0.5 – 10 m</td>
<td>NMR</td>
<td>nuclear spin</td>
</tr>
</tbody>
</table>

7. Define the following:
Stokes shift:
shift in wavelength to lower energy
longer wavelength

Coherent Radiation:
Radiation where in all photons are in phase at identical wavelength.

Fluorescence:
Light emission from excited electronic state to lower or ground electronic state. Distinct from phosphorescence in that fluorescent lifetimes are typically < 10 μs.