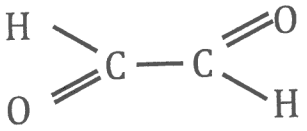
FYS-5206 **OPTICAL SPECTROSCOPY** **EXAM 2-2014**
May 23, 2014

ALLOWED BELONGINGS

- Note sheet, a two-sided A4 written by yourself to memorize details. Return the note sheet with your answers.
- Simple scientific calculator
- MAOL table book or equivalent

1. Glyoxal (on the right) belongs to C_{2h} point group.
   a) How many normal vibration modes this molecule has?
   b) There is one specific requirement based on molecular symmetry that tells if the vibrational transition is IR absorption active. What is this requirement? And what is the requirement for Raman active vibrational transitions?
   c) Draw one example of normal vibrational modes for each symmetry species in the point group.



C_{2h}	I	C_2	i	σ_h		
A_g	1	1	1	1	R_z	$\alpha_{xx},\alpha_{yy},\alpha_{zz},\alpha_{xy}$
B_g	1	−1	1	−1	R_x,R_y	α_{xz},α_{yz}
A_u	1	1	−1	−1	T_z	
B_u	1	−1	−1	1	T_x,T_y	

2. Draw and explain potential curves and related spectral shapes of vibronic absorption transitions when a) $r_e' = r_e''$ b) $r_e' > r_e''$ c) $r_e' >> r_e''$. d) How does the absorption spectrum look like when the upper state is dissociative?

3. Gas cuvette having width of 5 cm contains a gas mixture including Na vapor. Light is transmitted through the cuvette. The spectrum of the light is measured at the wavelength of a Na resonance line (589.5924 nm, $A_{ki} = 0.618 \cdot 10^8\ s^{-1}$, $g_i = 2$ ja $g_k = 4$). There is no absorption due to other gas components at this wavelength. The light transmission is 50.0 % and 96.841 % at the line center and 0.50 pm off from the line center, respectively. Na absorption line is broadened due to Doppler-broadening (Na atomic weight is about 23). What is the density of Na atoms (m^{-3}) in the cuvette?

   Hint: $$\kappa^{ik} = \frac{1}{8\pi} \frac{c^2}{\nu_{ik}^2} \frac{g_k}{g_i} n_i A_{ki}$$

4. Explain the following. You can draw pictures to clarify your answer.
   a) Raman spectroscopy. Why fluorescence can be a problem?
   b) Photoacoustic spectroscopy
   c) Differential absorption LIDAR
   d) Relaxation routes of a molecule in the first excited electronic state

5. There is a single-color pyrometer that detects at 0.65 µm wavelength, and a two-color pyrometer that detects at 1.2 µm and 1.6 µm wavelengths. Temperature of a target was measured with both of the devices. The target has emissivity of 0.7 and 0.65 at wavelengths of 0.5 µm and 1.0 µm, respectively. The emissivity of the target is assumed to change linearly as a function of the wavelength. The operator of the devices does not know the emissivity values. Which one of the pyrometers gives a result that is closer to the real temperature of the target.