/300 pts.

MIDTERM EXAM

Chemistry 823
Winter Quarter 2007

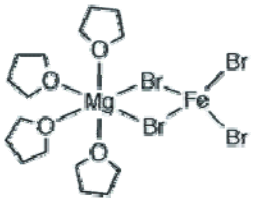
Thursday, February 22, 2007

Start each question on a separate page in your answer book.

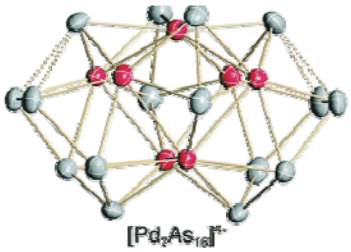
Be sure to write your name clearly on each answer book you use.

1. [40 points] Determine the point group to which each of the following molecules belong. Be sure to state any assumptions that you make.

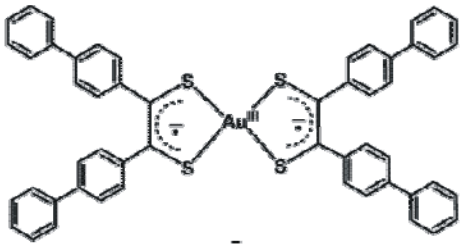
(a)



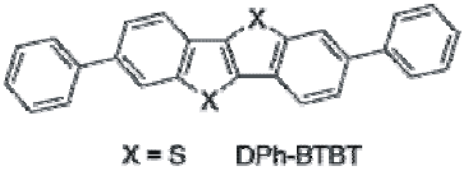
(b)



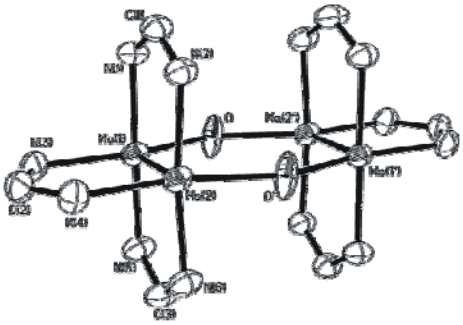
(c)



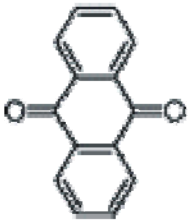
(d)



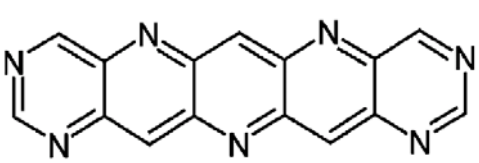
(e)



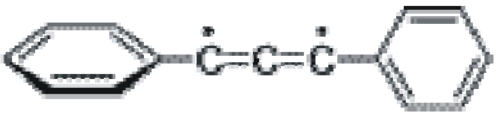
(f)



(g)



(h)



2. [30 points] Discuss the classical description of light absorption in terms of the polarizability and polarization. Address the issues of non-linear interactions with the electric field and with the resulting line shapes that arise from the classical description. Use complete sentences in your answer.

3. [30 points] Consider the entire electromagnetic spectrum. Provide a written description of the types of chemical phenomena that are observable in various regions of the spectrum. Provide a reasonable set of boundaries for each region, using which ever units you deem appropriate. Use complete sentences in your answer. You may wish to use figure(s) to assist your written description.

4. [20 points] Calculate the value of Brewster's angle for (a) liquid trimethoxyborine (n = 1.357) and (b) liquid carbon disulfide (n = 1.632).

5. [30 points] Derive the multiplication table (Note: ***not*** the character table) for **all** the operations of the D_{3d} point group. Identify the subgroups for this point group. Using similarity transformations, arrange the elements of the group into classes. [**Show your work!**]

6. [30 points] Light, polarized at 35° to the plane of incidence, in air (index of refraction of 1.000) strikes a smooth glass surface at an angle of 28° (with respect to the surface normal). The index of refraction of the glass is 1.550. Calculate (a) the amplitudes and (b) the intensities of the *reflected p* and *s* components. If we define the polarization of the beam as $P = (I_p - I_s)/(I_p + I_s)$, calculate (c) the polarization of the *incident* and *refracted* beams.

7. [20 points] What factors contribute to the probability for a transition to occur between two quantum levels in the presence of an electromagnetic field? Use complete sentences in your answer, providing a description of the physical significance of each factor.

8. [20 points] A 4.0-cm tall light bulb is placed a distance of 45.7 cm from a double convex lens having a focal length of 15.2 cm. Determine the image distance and the image size.

9. [20 points] Provide a written description of two of the following: chromatic aberration, spherical aberration, coma and astigmatism. For each give a physical description of how the effect comes about and how the effect can be minimized in an experiment. Use complete sentences in your answer. You may wish to use figure(s) to assist your written description.

10. [30 points] Decompose the following reducible representations for D_{4h}:

	E	$2C_4$	C_2	$2C_2'$	$2C_2''$	i	$2S_4$	σ_h	$2\sigma_v$	$2\sigma_d$
Γ_1	6	0	2	2	2	-2	0	2	2	-2
Γ_2	9	1	1	1	1	-3	1	-3	1	1
Γ_3	7	-1	-1	-1	-1	-1	3	-1	-1	-1
Γ_4	11	-1	7	-1	1	-1	-1	-5	-1	-3

11. [20 points] For a grating, how many grooves/mm would be required in order for the first-order diffraction for a 500-nm source to be observed at a reflection angle of -40° when the angle of incidence is 60°? At what angle would 800-nm light be observed with this grating in second order?

12. [10 points] The girl in Manet's painting *The Bar at the Folies Bergeres* (below) is standing in front of a large planar mirror. Reflected in it is her back and a man in evening dress with whom she appears to be talking. It would seem that Manet's intent was to give the feeling that the viewer is standing where that gentleman must be. Explain the feasibility of this from the perspective of geometrical optics.

Useful Information

$h = 6.6260755 \times 10^{-34}$ J·s

$\epsilon_0 = 8.854187816 \times 10^{-12}$ F/m

$\mu_0 = 4\pi \times 10^{-7}$ H/m

$c = 2.99792458 \times 10^{8}$ m/s

$e = 1.60217733 \times 10^{-19}$ C

$1\ J = 8.359 \times 10^{-2}\ cm^{-1}$

$N_0 = 6.0221367 \times 10^{23}\ mol^{-1}$

$k = 1.380658 \times 10^{-16}$ J/K

$m_e = 9.1093897 \times 10^{-31}$ kg

$m_p = 1.6726229 \times 10^{-27}$ kg

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$1/f = (n-1)\ [1/R_1 - 1/R_2]$

$1/f = 1/S_1 + 1/S_2$

$d\ (\sin\alpha + \sin\beta) = m\lambda$

$(d\theta/d\lambda) = (B/b)\ (dn/d\lambda)$

$(R_s/E_s) = -\sin(\phi-\phi')/\sin(\phi+\phi')$

$(R_p/E_p) = \tan(\phi-\phi')/\tan(\phi+\phi')$

$(E_s'/E_s) = [2 \sin\phi' \cos\phi]/\sin(\phi+\phi')$

$(E_p'/E_p) = [2 \sin\phi' \cos\phi]/[\sin(\phi+\phi') \cos(\phi-\phi')]$