**CHEM 325**
**Spring 2009**
**Post-Exam 1**
**Due March 6, 2009 at 5:00 PM**

Name: _____

**Instructions**
Fill in only the answers below. Attach your work to these cover pages, but do not include the questions. Sign the affidavit at the bottom of the second page. A link to the full contest rules is posted on the *Announcements* section of the class web page.

1a. _____

b. _____

2. _____

3. _____

4.

5a. _____

b. _____

c. _____

d. _____

6. _____

7. _____

8. _____

9. _____

By my signature below I attest that I have abided by all the rules set forth on the web page.

_____ _____

Signature Date

**Instructor Use Only!**

| | |
|---|---|
| Number correct | |
| Work included | |
| Instructions followed | |
| Total | |

DO NOT TURN THESE QUESTIONS IN WITH THE ANSWER SHEET

1a. Is the integral $\int\int\int (xy)(z)(x^2 - y^2)dxdydz$ non-zero in $D_{2d}$ symmetry?

b. What irreducible representations are spanned by the direct product E x E in $D_{2d}$?

2. Is the transition from a state with $A_1$ symmetry to a state with $A_2$ symmetry electric dipole allowed in $C_{2v}$ symmetry? If it is allowed, in what polarization is it allowed?

3. The rotational constant for $^{12}C$-$^{16}O_2$ determined from rotational Raman spectroscopy is 0.39021 $cm^{-1}$. Determine the C–O bond length in picometers. The atomic mass of $^{12}C$ is 12.0000 amu and the atomic mass of $^{16}O$ is 15.9949 amu.

4. Draw a vector representation, using arrows to show the direction of the angular momentum vectors, of a rigid rotor's allowed orientations when $\ell = 2$. Indicate the magnitude of each vector and the different values of $L_z$ on your picture.

5a. Determine the equation in terms of *J* and *J*-1 that gives the splitting between the allowed molecular rotational transitions for a linear molecule when the centrifugal distortion is not zero.

b. Given that the spacing of the lines in the rotational spectrum of $^{35}Cl^{19}F$ is 1.033 $cm^{-1}$ and the isotopic mass of $^{35}Cl$ is 34.968853 amu and that of $^{19}F$ is 18.99840 amu, what is the Cl–F bond length in $^{35}Cl^{19}F$ in picometers?

c. Calculate *B* for $^{37}Cl^{19}F$.

d. Will the rotational transitions of $^{37}Cl^{19}F$ occur at higher, at lower, or at the same wavenumbers as those of $^{35}Cl^{19}F$?

6. The threshold frequency for the emission of a photoelectron from Na metal is $43.9 \times 10^{13}$ $s^{-1}$. What is the ionization energy of Na in kJ/mole?

7. Given that the Br-Br bond distance is 283.3 pm, what must a spectrometer's resolution be (in $cm^{-1}$) to distinguish between the Stokes lines arising from the $^{79}Br$-$^{81}Br$, $^{79}Br$-$^{79}Br$ and $^{81}Br$-$^{81}Br$ isotopomers in a rotational Raman spectrum? Assume that the resolution must be half of the smallest splitting that you seek to measure.

8. Naphthalene may be approximated as a 4.00 Å x 7.00 Å rectangular box. Calculate the expected wavenumber for the light absorbed to give the first excited state of naphthalene.

9. The lowest-lying excited state of a molecule is 15.0 $cm^{-1}$ above the ground state in energy. To what temperature, in K, must a sample of this molecule be cooled so that 90.0% of the molecules in the sample are in the ground state? Assume both states are singly degenerate.