CHEM 322 **Name**___________________________________
Exam 3 **Fall 2012**

Complete the following as instructed. Clearly mark your answers. YOU MUST SHOW YOUR WORK TO RECEIVE CREDIT.

Warm-up (3 points each)

1. A cascade of electrons between a series of ___________________________________ in an electron multiplier or PMT results in the high sensitivity of the device.

2. A Fourier transform must be applied to deconvolute the mass spectrum from data obtained from an ___________________________________ mass analyzer.

3. The _____________________________________ is a quantitative measure of how a grating spreads incident wavelengths along the focal plane of the monochromator.

4. The ______________________________________ is a measure of the average distance a particle can move before colliding with another particle.

Complete four (4) of the following. Be concise in your answers and show work for problems involving calculations. Clearly indicate which problem is not to be graded. (15 points each)

5. Mass spectra from electron impact (EI) sources are typically much more complicated than those from chemical ionization (CI), explain why this is the case. Why do typical MS instruments designed for organic mass spectrometry often have both EI and CI capabilities?

6. The overall resolving power of a mass spectrometer is the result of limitations from all components of the MS. Describe how each of the following serves to limit resolution in a MS experiment.
   a. The ionization source (such as an ICP source)
   b. The mass analyzer (such as a quadropole)
   c. The detector (such as an electron multiplier)

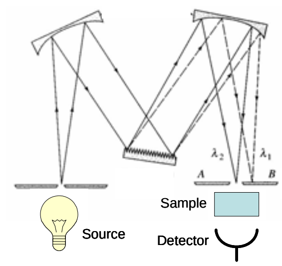
7. Electrospray ionization (ESI), matrix-assisted laser desorption ionization (MALDI) and atmospheric pressure chemical ionization (APCI) are relatively new approaches to ionizing large molecules. Compare how ions are formed in each process and discuss the similarities and differences in the spectra observed from the sources.

8. Currently, two of the most popular mass analyzers are the quadrupole mass filter and the time of flight mass analyzer. These two devices have very different principles of operation. Clearly describe how each device serves to separate ions and the key benefits and limitations of each device.

9. The mating of mass spectrometry and separations techniques has been and continues to be an area of great interest. Why is this so? Select one separation technique and clearly describe how mass spectrometry has been incorporated as a detection scheme for the separation. Draw a diagram of the instrument and describe in detail how the separation and mass analysis components are interfaced and how ions are formed.

Spectroscopy. Complete two (2) of the following. Be concise in your answers and show work for problems involving calculations. Clearly indicate the problem not to be graded. (15 points each)

10. There is currently a great deal of interest in decreasing the size of traditional bench-top instruments, resulting in small, portable analytical devices. This is true for optical instruments as well, leading to the development of devices like the Ocean Optics spectrometers we use in several courses. Typically, the resolution for these small instruments is poorer than that for traditional bench-top devices. Discuss possible reasons for this observation. For convenience, you may want to consider "large" and "small" versions of the design at the right.



11. <u>Select two of the pairs</u> of terms below and briefly compare and contrast the terms within each pair.
    a. linear dispersion versus angular dispersion
    b. deuterium arc lamp versus tungsten lamp
    c. photomultiplier tube versus photodiode array

12. Can a grating monochromator with the characteristics shown below completely separate the sodium lines at 589.0 and 589.6 nm?

Focal length	0.50 m
Groove density	1640 lines/mm
Order **n** (at 589 nm)	1
Diffraction angle	10.0^{o}
Incident angle	52.5^{o}
Slit width	0.10 mm

Possibly Useful Information

$E = \frac{hc}{\lambda} = h\nu$	$c = 3.00 \times 10^{8}\ ms^{-1}$
$\lambda = \frac{RT}{\sqrt{2}\pi d^{2} N_{A} P} \approx \frac{5\,cm}{mtorr}$	$F_{M} = Bzev = \frac{mv^{2}}{r} = F_{c}$
$\frac{m}{z} = \frac{B^{2} r^{2} e}{2V} = F_{c}$	$U_{dc} + V_{ac} \cos \omega t$
$\eta_{1} \sin\theta_{1} = \eta_{2} \sin\theta_{2}$	$R = \frac{\lambda}{\Delta\lambda} = nN$
Planck's Constant = 6.63 x 10-34 Js	c = 3.00 x 108 ms^{-1}
$\Delta\lambda_{eff} = wD^{-1}$	$n\lambda = d(\sin i + \sin r)$
$D = \frac{dy}{d\lambda} = F\frac{dr}{d\lambda}$	$\frac{dr}{d\lambda} = \frac{n}{d \cos r}$
$T = P/P_{0}$	$D^{-1} = 1/D$
$A = -\log T = \log(P_{0}/P) = \varepsilon bc$	$E = \frac{hc}{\lambda}$

PERIODIC CHART OF THE ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	INERT GASES
1 H 1.00797																1 H 1.00797	2 He 4.0026
3 Li 6.939	4 Be 9.0122											5 B 10.811	6 C 12.0112	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183
11 Na 22.9898	12 Mg 24.312											13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
55 Cs 132.905	56 Ba 137.34	*57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	‡89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 ? (271)	111 ? (272)	112 ? (277)						

Numbers in parenthesis are mass numbers of most stable or most common isotope.

Atomic weights corrected to conform to the 1963 values of the Commission on Atomic Weights.

The group designations used here are the former Chemical Abstract Service numbers.

* Lanthanide Series

58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm (147)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97

‡ Actinide Series

90 Th 232.038	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (256)	103 Lr (257)