

**Due by 5:00 PM Friday, December 11**  
**NO LATE PAPERS ACCEPTED!**

Complete these problems on separate paper and staple it to these sheets when you are finished. Please put your name or initials on each sheet as well. Clearly mark your answers. **YOU MUST SHOW YOUR WORK TO RECEIVE CREDIT.**

**Instructions**

- This is **NOT** an open-book, open-note take exam. You **MAY NOT** consult any human or nonhuman resource besides Dr. Lamp as you complete the exam. This exam **MUST** be completed **INDIVIDUALLY** and in your own words. Group work or plagiarism will result in a zero for the exam.
- You will be allowed to ask Dr. Lamp a maximum of two (2) questions regarding the exam. Additional questions may be asked at a 3-point penalty per question. If you are working on the exam in the evening, you may try to reach Dr. Lamp on his cell phone at 660-341-0067 before 10:00 PM.
- Before opening the exam, prepare for it like you would for a traditional, in-class exam. Review concepts and examples from the text, as well as those discussed in class. This preparation will help to maximize your effort on the exam and allow you to complete it more efficiently.

**Time Restriction**

You may spend no more than two (2) hours working on this exam. This must be in one continuous block of time. You are on your honor to adhere to this restriction and record the time spent in the chart below.

Date	Time Began	Time Finished	Total Time
Total Time Spent on the Exam			

**Pledge**

I pledge on my honor that I have completed the exam in accordance with the above instructions and that I have not provided or received unethical assistance. I realize that failure to comply with these instructions will result in a score of zero on the exam.

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

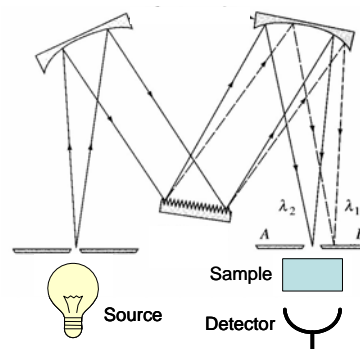
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**Warm-up (2 points each)**

1. An \_\_\_\_\_ is an instrument that uses the combination of a coarsely ruled grating and a prism to achieve wavelength resolution by dispersing light in two dimensions.
2. An inductively coupled plasma is produced by interaction of ionized \_\_\_\_\_ gas with an induced radio-frequency magnetic field.

**Complete seven of the following, be concise. Clearly indicate which problem is not to be graded. (14 points each)**

3. Briefly compare and contrast 2 of the following 3 items:
  - a. linear dispersion versus angular dispersion
  - b. deuterium arc lamp versus tungsten lamp
  - c. stray light versus scattered light
4. Compare and contrast the operation of a PMT versus a PDA as a detector in a spectroscopic measurement, as well as any benefits or challenges associated with each device. Feel free to use well-labeled sketches to clarify your discussion.
5. Suggest reasons why spectrophotometric precision is poorer:
  - a. when the absorbance is near zero,
  - b. when the absorbance is greater than three.
6. 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.



7. Beer's law is theoretically valid only if monochromatic radiation is used. In practice, it is impossible to deliver truly "monochromatic" radiation. What components of the spectrophotometer determine how monochromatic the incident beam is? What will the impact be for a quantitative measurement if the beam is too polychromatic?
8. Draw and label a diagram of an instrument used for flame atomic emission spectroscopy of solution-phase samples. How would a ICP-AES instrument differ?
9. Why does the identity of flame components and fuel to oxidant ratio play a major role in detectability and sensitivity for atomic spectroscopy?

10. Describe the operation of a pneumatic nebulizer and graphite furnace atomizer as sample introduction methods for AAS. Specifically note the benefits and challenges of each sample introduction technique.
11. You have been given the task of establishing the detection limits for the determination of several elements using atomic spectroscopy. The data below are the detection limits in ppb that were determined for Flame AAS, Flame AES, GFAAS and ICP-AES for two elements. Your colleague is somewhat confused by the different behavior of each element. Clearly explain the trends in the data, including why the trends for the two elements are different. (15 points)

Element	Flame AAS	GFAAS	Flame AES	ICP AES
K	1	0.004	0.01	30
Ag	0.9	0.001	2	0.2

### Possibly Useful Information

$\eta_1 \sin \theta_1 = \eta_2 \sin \theta_2$	$R = \frac{\lambda}{\Delta \lambda} = nN$
Planck's Constant = $6.63 \times 10^{-34}$ Js	$c = 3.00 \times 10^8$ ms <sup>-1</sup>
$\Delta \lambda_{\text{eff}} = wD^{-1}$	$n\lambda = d(\sin i + \sin r)$
$D = \frac{dy}{d\lambda} = F \frac{dr}{d\lambda}$	$\frac{dr}{d\lambda} = \frac{n}{d \cos r}$
$T = P/P_0$	$D^{-1} = 1/D$
$A = -\log T = \log(P_0/P) = \epsilon bc$	$E = \frac{hc}{\lambda}$

### PERIODIC CHART OF THE ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VIIIB	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
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#### † 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)
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