Some equations:

$F = -ky$

$\bar{v} = 1/\lambda$

$\bar{v}$ = wavenumber

vibrational frequency of the molecule: $v_m = (1/2\pi)(k/\mu)^{1/2}$

$f = 2v_m$ f = frequency of interferogram, v_m = frequency of the radiation

$\Delta v = 1/\delta$

$P(\delta) = 1/2\ P(v)\cos 2\pi f t$

$A = \varepsilon bc$

$A_1 = \varepsilon_{1a}bc_a + \varepsilon_{1b}bc_b$

$A_2 = \varepsilon_{2a}bc_a + \varepsilon_{2b}bc_b$

$\nu = c/\lambda$ ν = frequency

$\nu = v/\lambda$ v = velocity

$E = h\nu$

$\Delta\lambda_{eff} = wD^{-1}$

$\dfrac{\sin\theta_1}{\sin\theta_2} = \dfrac{n_2}{n_1} = \dfrac{v_2}{v_1}$ v = velocity

$n\lambda = d(\sin\theta_i + \sin\theta_r)$

θ_i = incident angle, θ_r = refracted angle

$T = \dfrac{P}{P_o}$

Some constants:

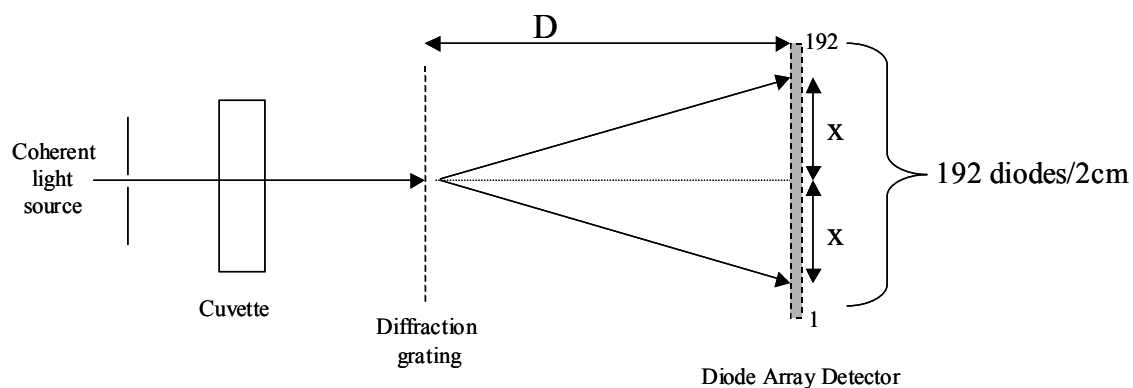h = 6.626 x 10^{-34} J *s

1. (8 points) Calculate the following for an emission line with a wavelength of 2.3 x10^{-9}cm.

   a. frequency

   b. energy in joules

2. (4 points) Calculate the wavelength of the Sodium D line at 589 nm in an aqueous solution having a refractive index of 1.13.

3. (3 points) Which light has more energy? Green light or yellow light?

4. (4 points) Put the following types of radiation in order from longest wavelength to shortest wavelength.

   radio, x-rays, UV, microwaves, yellow light, green light, gamma rays, infra red

   Longest wavelength——> shortest wavelength

5. (3 points) What quantum energy transition is associated with infrared radiation?

6. (3 points) What quantum energy transition is associated with microwave radiation?

7. (20 points) Using complete sentences, in well organized paragraphs, describe how a laser produces a coherent source of light. What does LASER stand for? What are the steps that are involved to produce the coherent light? What is coherent light?

8. (20 points.) You are designing a UV-Vis spectrophotometer with a diode array detector (see figure below). You purchased a diffraction grating with 1500 lines per millimeter and need to calibrate the diode array. To do this you need to know where a given wavelength hits the diode array. The array has 192 diodes over a distance of 2 cm, which are labeled 1-192. Which two diodes detect 270 nm first order light? The diode array is placed at a distance (D) of 2.00 cm from the diffraction grating. Assume the incident light is normal to the diffraction grating.

Coherent light source

Cuvette

Diffraction grating

D

192

X

X

1

192 diodes/2cm

Diode Array Detector

9. (20 points) A 2.0L bottle of diet coke was analyzed for caffeine and sodium benzoate content. 10.0 mL of soda was diluted to 250.0 mL in a volumetric flask. A 1.00 mL aliquot from the diluted sample was taken and the absorbance was measured in a 1.00-cm cell. The absorbance values at 225 nm and 270 nm were found to be 0.742 and 0.287, respectively. Beer's law was obeyed for both components at both wavelengths, and the absorbances of the components were additive at both wavelengths.

Compound	$\varepsilon_{225\ nm}$	ε	Molar mass
Sodium benzoate	7210	890	144.10g/mole
Caffeine	5510	8790	194.19g/mole

Calculate the mass, in grams, of caffeine and sodium benzoate in the original 2.0L bottle of diet coke.

SHOW YOUR WORK

10. (15 points) Sketch a block diagram of a single beam scanning UV-Vis absorption spectrophotometer and a single beam scanning fluorescence spectrophotometer. Indicate the critical difference between the designs of these two instruments. Which instrument design leads to greater sensitivity and why is this the case?