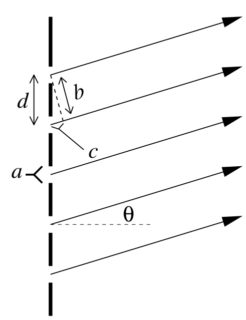
Circle the letter of the single best answer. Each question is worth 1 point

Physical Constants:

proton charge = $e = 1.60 \times 10^{-19}$ C
proton mass = $m_p = 1.67 \times 10^{-27}$ kg
electron mass = $m_e = 9.11 \times 10^{-31}$ kg
permittivity of free space = $\epsilon_0 = 8.85 \times 10^{-12}$ F/m
permeability of free space = $\mu_0 = 4\pi \times 10^{-7}$ T·m/A
Coulomb constant = $k_e = 9 \times 10^9$ N · m^2/C^2
speed of light = $c = 3 \times 10^8$ m/s
Planck's constant $h = 6.63 \times 10^{-34}$ J·s
$= 4.136 \times 10^{-15}$ eV·s
Bohr radius = $a_0 = 5.293 \times 10^{-11}$ m
Avogadro's number = $N_A = 6.023 \times 10^{23}$
H-atom gs energy = 2.18×10^{-18} J or 13.606 eV
Rydberg constant = $R_H = 1.10 \times 10^7$ m^{-1}
Stefan-Boltzmann = $\sigma = 5.67 \times 10^{-8}$ W · m^{-2} · K^{-4}
energy conversion: 1 eV = 1.60×10^{-19} J
1 u = 931.5 MeV/c^2

1. The parallel rays of a distant coherent light source pass through a diffraction grating producing a series of bright fringes on a distant wall (which is not shown). The rays displayed below go to make a first order bright fringe. Which of the distances denoted in the figure is equal to a wavelength of the light?



A. the width of a slit.

B. the distance between the rays as they leave the slits.

C. the extra distance each diffracted ray must travel when compared to the distance between the grating and wall.

D. the distance between the slits.

2. In Young's experiment (two slit interference) increasing the slit separation would result in the:

A. spacing between bright areas increasing

B. spacing between bright areas decreasing

C. bright areas become brighter

D. bright areas become sharper: less diffuse, more concentrated

3. In Young's experiment decreasing the wavelength would result in the:

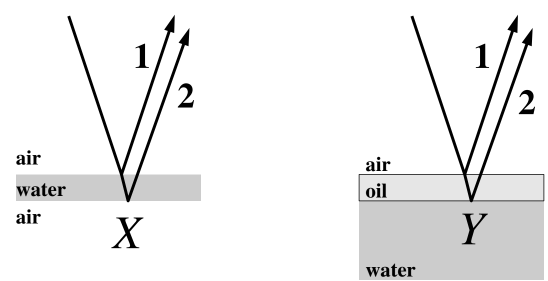
A. spacing between bright areas increasing

B. spacing between bright areas decreasing

C. bright areas become brighter

D. bright areas become sharper: less diffuse, more concentrated

4. Consider two situations involving very thin films (films so thin the thickness can be taken as zero). Situation X involves a film of water suspended in air; situation Y involves a film of oil on a puddle of water. Consider two beams (1 & 2) of reflected light as displayed below. In each situation are the two beams (relative to each other) most nearly: in phase or 180° out of phase? (indices of refraction: air:1, oil:1.2, water:1.3)



A. X: in phase; Y: in phase

B. X : in phase; Y: out of phase

C. X : out of phase; Y: in phase

D. X : out of phase; Y: out of phase

5. In a nuclear reaction, 9×10^7 Joules are released for every micro-gram of mass converted to energy. For a chemical reaction the equivalent figure would be:

   A. larger

   B. smaller

   C. same

   D. there is no mass change in chemical reactions.

6. Which of the below will *not* change the kinetic energy of the most energetic electrons emitted in the photoelectric effect?

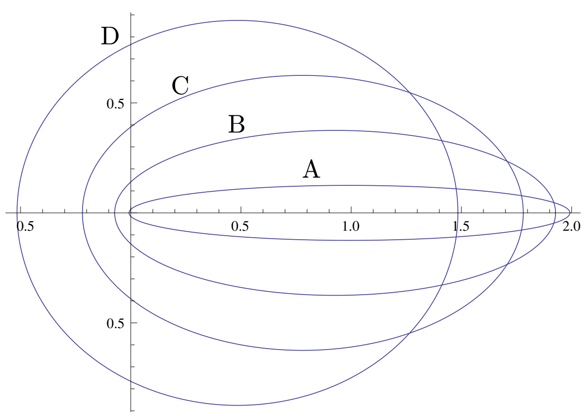
   A. changing the color of the light

   B. changing the brightness of the light

   C. changing the frequency of the light

   D. changing the metal the light is hitting

7. The below diagram shows all the possible Bohr-Sommerfeld H-atom orbits for a particular value of the principal quantum number n. Which of the below statements is correct.



   A. $n = 5$, D=s orbit, A=f orbit

   B. $n = 4$, D=s orbit, A=d orbit

   C. $n = 4$, A=s orbit, D=f orbit

   D. $n = 3$, A=s orbit, D=d orbit

8. In β^+ decay the daughter nucleus, compared to the parent nucleus, has a:

   A. larger atomic number

   B. smaller atomic number

   C. larger mass number

   D. smaller mass number

9. How many of the following statements are true?

   - In alpha decay a helium nucleus is in the final state.
   - There is always a neutrino (or anti-neutrino) in the final state of beta decay.
   - Electron capture is exactly what it sounds like: a proton eats an orbitting electron to become a neutron and a neutrino.
   - In gamma decay, light is always produced.

   A. 1   C. 3

   B. 2   D. 4

10. Consider 1 gram samples of the following isotopes; which of the below would have the greatest activity? (Hint: mole)

   A. ${}^{3}_{1}$H with half-life=12.3 years

   B. ${}^{60}_{27}$Co with half-life=5.4 years

   C. ${}^{192}_{77}$Ir with half-life=74 days

   D. ${}^{239}_{94}$Pu with half-life=24,100 years

11. Consider the reaction:

$$ {}^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \longrightarrow {}^{139}_{53}\mathrm{I} + {}^{95}_{39}\mathrm{Y} + 2 \times {}^{1}_{0}\mathrm{n} $$

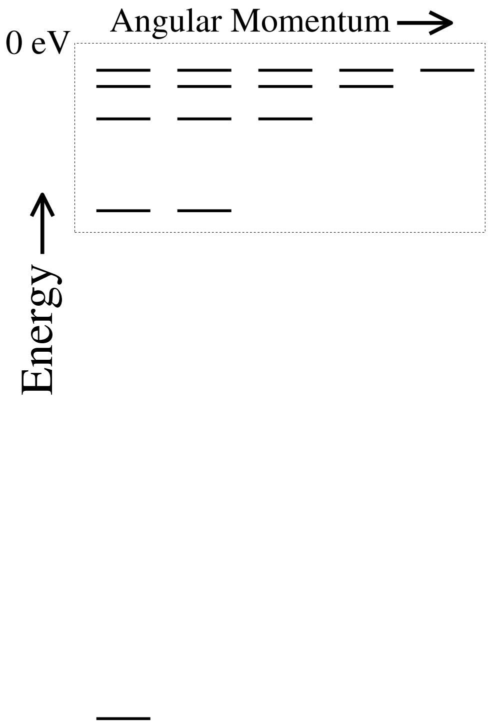
and the following atomic masses: ${}^{235}_{92}\mathrm{U} = 235.0439$ u, ${}^{139}_{53}\mathrm{I} = 138.9350$ u, ${}^{95}_{39}\mathrm{Y} = 94.9134$ u, neutron $= {}^{1}_{0}\mathrm{n} = 1.0087$ u. The energy released in this reaction is most nearly:

   A. 175 MeV

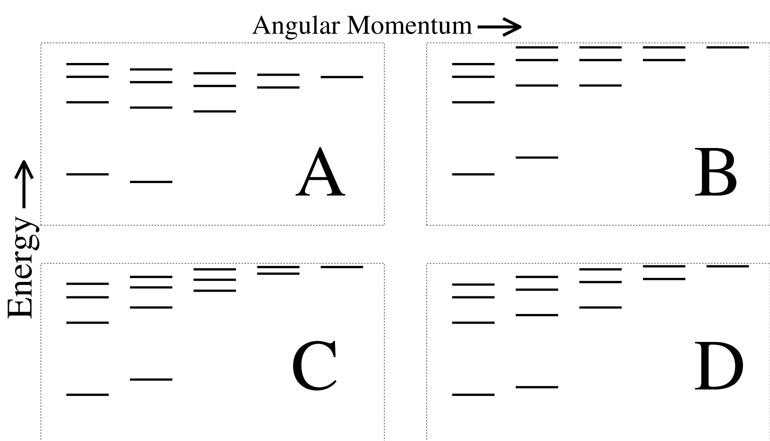
   B. 200 MeV

   C. 225 MeV

   D. 250 MeV



12. The above diagram displays the energy levels of the H-atom. In the below diagrams we focus on the excited states (and drop the ground state to save space). Which of the below diagrams displays how these energy levels are modified for partial nuclear shielding in a high Z atom, e.g., potassium.

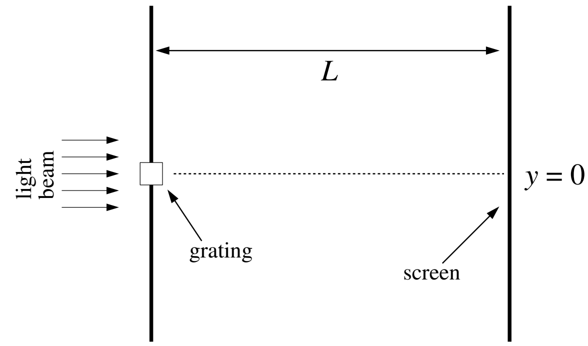


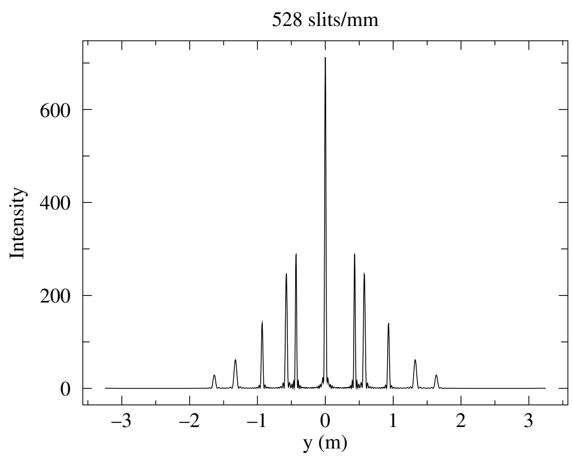
The following questions are worth 12 pts each

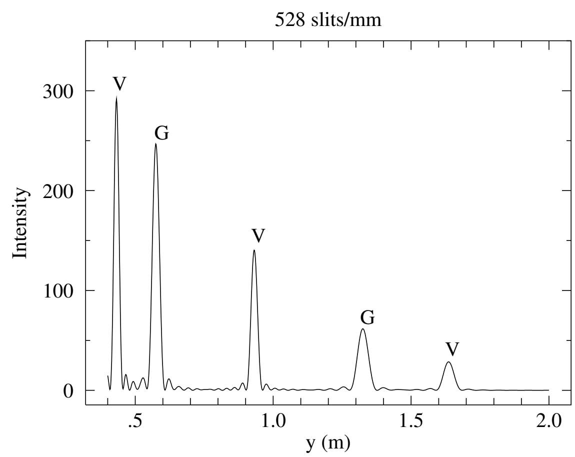
Record your steps! (Grade based on method displayed not just numerical result)

To receive full credit your answers should have exactly three significant figures

13. A beam of light, consisting of a mixture of two wavelengths (violet and green), is normally incident on a diffraction grating with 528 slits/mm. The light intensity on a screen $L = 2$ m from the slit is plotted below: the left plot shows both sides of the pattern; the right expands the $y > 0$ side of the left plot and labels each peak with its color (V or G). (A) Directly on the left plot record the order number (m) of each peak-pair. (B) Calculate the violet wavelength using the rightmost peak labeled 'V' in the diagram on the right.

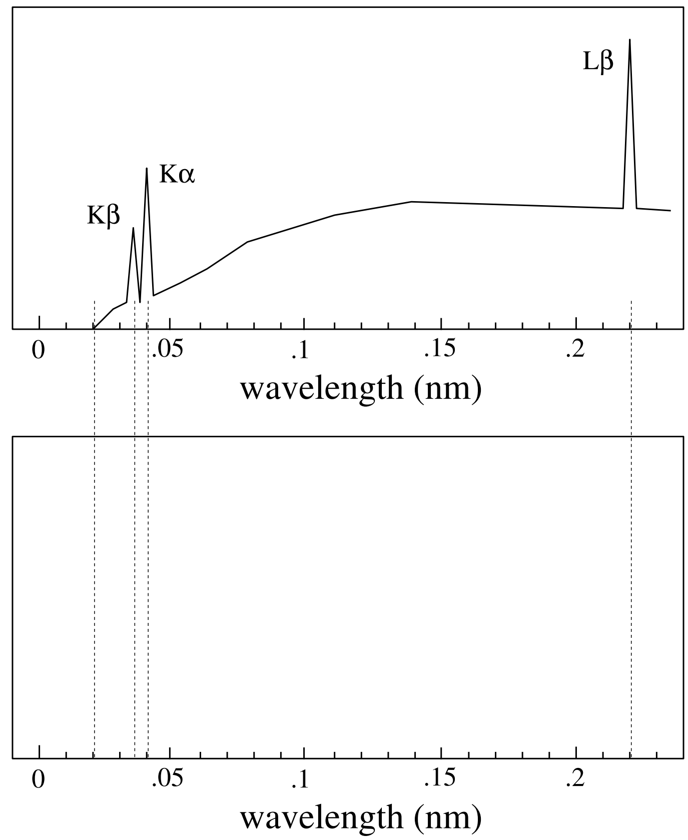






14. Consider the below spectra of the X-ray light produced by an X-ray tube.

   A. Based on the value of λ_{min} determine the accelerating voltage.
   B. Based the the wavelengths of the characteristic X-rays, determine the atomic number, Z, of the target.
   C. Using the blank spectra below, sketch the X-ray spectra that would result from doubling the accelerating voltage. (The dotted vertical lines serve only to exactly locate where features in the top plot are.)



15. Report the electron configuration of the four elements shaded in the below periodic table. You may abbreviate the start of the configuration by using an inert gas as a starting point, e.g., [Xe]

H	He																
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No

16. The mythical element Vy has the energy levels shown right. As usual the electron is in the ground state. When the electron is in the ground state Vy will *absorb* a particular color of green light. Directly on this level diagram show and label **A** the transition (with arrow showing jump direction) when the electron absorbs green light. When the atom is excited (for example as in a fluorescent light) it *emits* in addition to the previously mentioned green light a slightly different green-color light and violet light. Directly on this level diagram show and label **B** the transition (with arrow showing direction) when the electron emits violet light. Find below the spectrum display you used in Quiz 9. Sketch in the display where the three colors would appear; label on the display the **A** and **B** colors. Describe in words how the spectra would appear to my eye.