homework3

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Started: September 22, 2009 1:05 PM
Questions: 44

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1. HW3 (Q1) (Points: 1)

Review both your answers and the answer key for homework#2 to make sure that you understand all the questions and how to answer them correctly. Select one problem for which you had the wrong answer. In the text box below,
i) identify the question number you are correcting
ii) state (copy) your original wrong answer,
iii) explain where your original reasoning was incorrect, the correct reasoning for the problem, and how it leads to the right answer.
If you got all the answers correct!!! Great ... then state which was your favorite / most useful homework problem and why!

New Insert equation

Save Answer

2. HW3 (Q2) (Points: 1)

Solar panels work because photons from the sun give their energy to electrons in the panels. At noon on a typical mid-June day in Boulder, the power of the visible radiation from the s is about 225 Watts per square meter. If you had solar panels on your roof covering an area of 2 meter by 6 meters, and the efficiency of the panel was 13% (meaning that 13 out of ev 100 photons hitting the panel sent an electron down the wire), how many electrons per second would you get?
(You can take the average energy of a solar photon to be that of green light, about 535 nm.)
(3 Significant Figs)
1.

Save Answer

3. HW3 (Q3) (Points: 1)

When doing calculations in modern physics, we often use different units than in classical physics because we are dealing with things that are so much smaller. Thus, instead of measuri energy in Joules and distance in meters, we often measure energy in electron volts (1 eV = 1.6 x 10-19J) and distance in nanometers (1 nm = 10-9m). So in many calculations in this homework set, it will make your life easier if you try to get used to these new units right away. One piece of information that will be very useful to you is the fact that hc = 1240 eV-nm You will also need to be able to do calculations thinking of energy in electron volts. In this problem, you work with this new energy unit.

An electron, initially on a metal plate held at -12 Volts is accelerated toward another metal plate held at 1 Volt. What is its final kinetic energy "(in electron volts, eV)?

1.

Save Answer

4. HW3 (Q4) (Points: 1)

An electron starts with some initial kinetic energy and travels through a potential difference of -6.1 Volt, after which it has slowed to a stop so that its kinetic energy is now zero. What was the initial kinetic energy of the electron (in electron volts, eV)?
1.

Save Answer

5. HW3 (Q5) (Points: 1)

It requires about 3.6 eV of energy to break apart or severely damage a DNA molecule. When we damage the DNA in our skin cells, our bodies respond by directing a lot of blood to repa and replace the damaged cells, and our skin takes on a bright red glow (the tell-tale signs of sunburn). We also increase our risk of skin cancer.
What wavelength of light, in nm, has just enough energy to damage our DNA?
1.

Save Answer

6. HW3 (Q6) (Points: 1)

Which wavelengths of light are most important for a good sunscreen to block?

- 1. Wavelengths very close to the one I calculated in the previous question
- 2. Wavelengths greater than or equal to the one I calculated in the previous question.
- 3. Wavelengths less than or equal to the one I calculated in the previous question.
- 4. All wavelengths are equally important to block.
- 5. The idea that sunscreen prevents sunburn is a myth created by multi-national corporations, so it does not matter what wavelengths are blocked.

Save Answer

7. HW3 (Q7) (Points: 1)

To answer the following questions, you should use the photoelectric effect simulation.

Suppose you set up the experiment so that the plate is ejecting electrons. Predict which of the following changes to the experiment could increase the maximum initial kinetic energy of the ejected electrons. (Select all that apply) Then test your prediction.

- 1. Replacing the target with a material that has a smaller work function
- 2. Decreasing the intensity of the light beam
- 3. Decreasing the frequency of light
- 4. Decreasing the voltage of the battery
- 5. Increasing the frequency of light

6. Replacing the target with a material that has a larger work function
7. Increasing the wavelength of light
8. none of the above
9. Increasing the voltage of the battery
10. Increasing the intensity of the light beam
11. Decreasing the wavelength of light

Save Answer

8. HW3 (Q8) (Points: 1)

Suppose now you set up the experiment so that the light intensity is non-zero but the plate is NOT ejecting electrons.
Predict which of the following changes to the experiment could make the plate start ejecting electrons? (Select all that apply) Then test your prediction.

1. Replacing the target with a material that has a smaller work function
2. Decreasing the voltage of the battery
3. Decreasing the wavelength of light
4. Decreasing the intensity of the light beam
5. Increasing the voltage of the battery
6. Increasing the intensity of the light beam
7. Decreasing the frequency of light
8. none of the above
9. Increasing the frequency of light
10. Increasing the wavelength of light
11. Replacing the target with a material that has a larger work function

Save Answer

9. HW3 (Q9) (Points: 1)

What causes the electrons to be ejected from the left plate in this simulation?

1. The force exerted on the electrons by the battery
2. The beam of light shining on the plate
3. Both A and B.
4. Neither A nor B.

Save Answer

10. HW3 (Q10) (Points: 1)

The following true/false questions refer to this scenario:
If you have the experiment set-up so that electrons are being emitted from the metal plate, which of the following are true and false?

Emitted electrons have a broad variation in initial kinetic energy.

1. True
2. False

Save Answer

11. HW3 (Q11) (Points: 1)

The work function for the metal is different for different electrons.

1. True
2. False

Save Answer

12. HW3 (Q12) (Points: 1)

The energy of the photons hitting the plate must be equal to or more than the work function of the metal.

1. True
2. False

Save Answer

13. HW3 (Q13) (Points: 1)

The electrons emitted with the largest initial kinetic energy are those that were the least tightly bound in the metal.

1. True
2. False

Save Answer

14. HW3 (Q14) (Points: 2)

Explain what the phrase - 'the work function for sodium' - means in a way that would make sense to a non-science person.

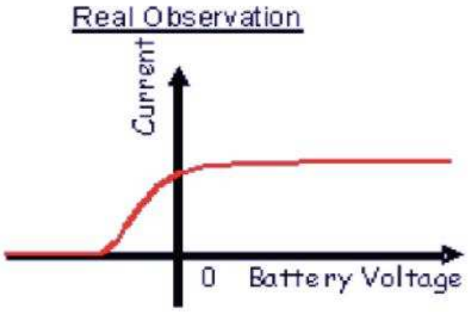
New Insert equation

Save Answer

15. HW3 (Q15) (Points: 2)

In the photoelectric effect experiment, the graph of current vs battery voltage for a metal with light of a particular frequency shining on it looks like the curve below. This graph represe current vs voltage for 175nm light shining onto Lead (Pb) which has a work function of 4.14 eV.

Explain your reasoning for why this curve has the shape that it does. In your answer, you should address: Why is current level at V>0, why does current go to zero at some negative voltage and what determines that voltage, and why does current start decreasing steadily at V<0?



New Insert equation

Save Answer

16. HW3 (Q16) (Points: 1)

What is the stopping potential (in V) in the situation described above (175nm light shining onto Lead with a work function of 4.14eV)? (Remember stopping voltage is expressed as a positive number).

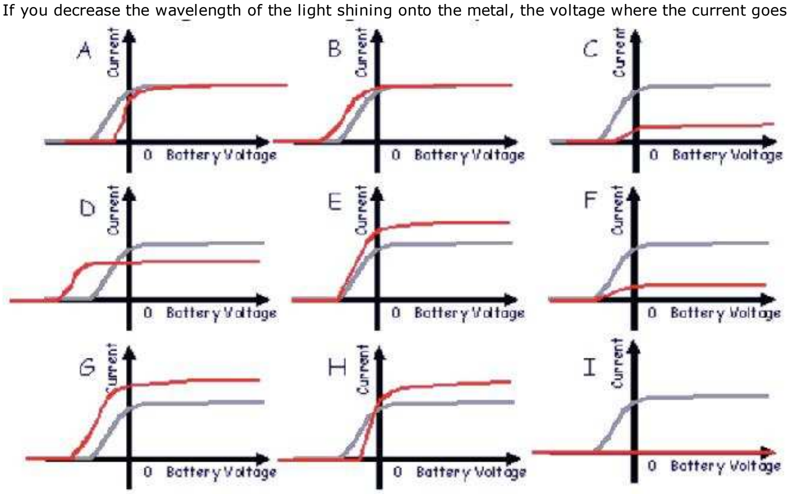
1.

Save Answer

17. HW3 (Q17) (Points: 1)

In the graphs below, the gray curve is always the same and represents the situation you explained above (the current vs voltage for 175nm light shining onto Lead (Pb) which has a wo function of 4.14 eV). The red curves now represent the current vs voltage after a change in the experiment.

If you decrease the wavelength of the light shining onto the metal, the voltage where the current goes to zero...



1. becomes a larger, negative number (more negative)
2. becomes a smaller, negative number (less negative)
3. is unchanged

Save Answer

18. HW3 (Q18) (Points: 1)

The maximum current (the current at positive battery voltages)...

1. increases
2. decreases
3. stays the same

Save Answer

19. HW3 (Q19) (Points: 2)

Briefly explain your reasoning behind these answers:

New Insert equation

Save Answer

20. HW3 (Q20) (Points: 1)

Which graph would represent this decrease in wavelength?

1. A
2. B
3. C
4. D
5. E
6. F
7. G
8. H
9. I

Save Answer

21. HW3 (Q21) (Points: 1)

Which graph would represent an increase in the intensity (write the letter in upper case)?

1.

Save Answer

22. HW3 (Q22) (Points: 1)

Which graph would represent an increase in wavelength to 290nm?

1.

Save Answer

23. HW3 (Q23) (Points: 1)

Which graph would represent an increase in wavelength to 500 nm?

1.

Save Answer

24. HW3 (Q24) (Points: 1)

Which graph would represent a switch to sodium?

1.

Save Answer

25. HW3 (Q25) (Points: 1)

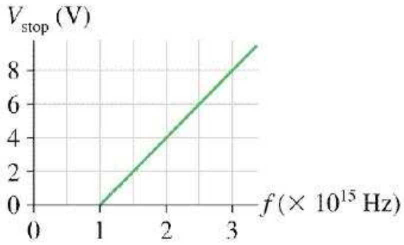
What change or combination of changes would you need to explain the change observed in Graph H above? (check all that apply)

1. decrease in wavelength
2. decrease in intensity
3. increase in wavelength
4. increase in intensity

Save Answer

26. HW3 (Q26) (Points: 1)

In the graph below which measures V as a function of f for the photoelectric effect, calculate the work function in eV. What material is it?



- 1. Sodium (Na)
- 2. Calcium (Ca)
- 3. Cadmium
- 4. Aluminum (Al)
- 5. Silver (Ag)
- 6. Platinum (Pt)
- 7. Magnesium (Mg)
- 8. Nickel (Ni)
- 9. Selenium (Se)
- 10. Lead (Pb)

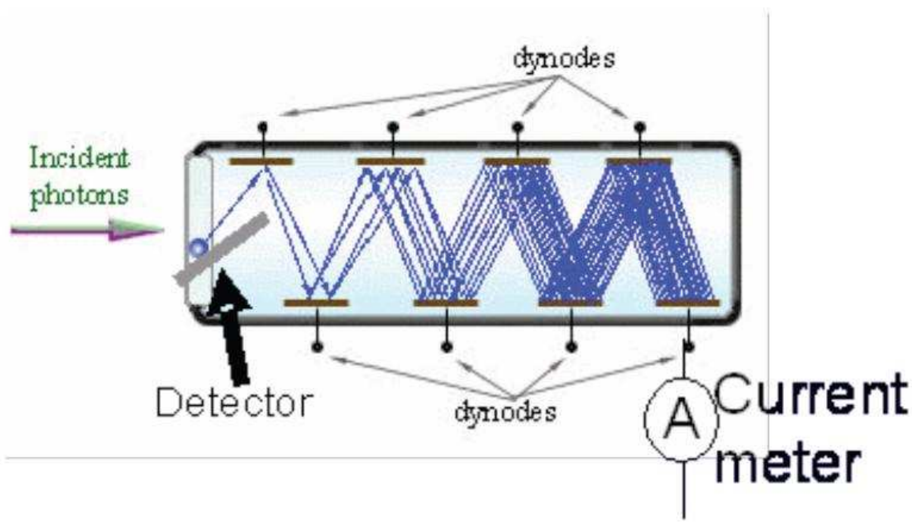
Save Answer

27. HW3 (Q27) (Points: 1)

Photomultiplier tubes (PMTs) are used in many instruments that need to measure very small amounts of light. These PMTs use the photoelectric effect to detect single photons of light. A common design is to have the detector metal sitting at the end of a long tube. Light hitting the detector can release electrons via the photoelectric effect. A voltage is placed on a series of plates, called dynodes, within the photomultiplier tube, which accelerates the electrons towards each of them successively. The photon kicks a single electron out of the detector which is then accelerated so that when it hits the first dynode it knocks out multiple electrons, each of which knock out more electrons from the second dynode, etc., so that by the end of the series of dynodes there is a large pulse of electrons. These can then be detected by a standard ammeter at the end of the photomultiplier tube.
You want to manufacture a series of PMTs to sell to customers interested in measuring different wavelengths of light.

Which material(s) would you use if you wanted to:

Detect only wavelengths of 450.9 nm and shorter?



- 1. Sodium (Na)
- 2. Carbon (C)
- 3. Calcium (Ca)
- 4. Aluminum (Al)
- 5. Silver (Ag)
- 6. Cesium (Cs)
- 7. Magnesium (Mg)
- 8. Nickel (Ni)
- 9. Selenium (Se)
- 10. It is not possible to do this using a PMT only

Save Answer

28. HW3 (Q28) (Points: 1)

Detect all wavelengths longer than 450.9 nm?

- 1. Sodium (Na)
- 2. Carbon (C)
- 3. Calcium (Ca)
- 4. Aluminum (Al)

5. Silver (Ag)
6. Cesium (Cs)
7. Magnesium (Mg)
8. Nickel (Ni)
9. Selenium (Se)
10. It is not possible to do this using a PMT only

Save Answer

29. HW3 (Q29) (Points: 1)

Detect only wavelengths of 289.7 nm and shorter?

1. Sodium (Na)
2. Carbon (C)
3. Calcium (Ca)
4. Aluminum (Al)
5. Silver (Ag)
6. Cesium (Cs)
7. Magnesium (Mg)
8. Nickel (Ni)
9. Selenium (Se)
10. It is not possible to do this using a PMT only

Save Answer

30. HW3 (Q30) (Points: 1)

For many applications, there is a need to detect near IR light. There is an exotic alloy - Gallium Arsenide (GaAs) - that can detect light up to wavelengths of 920 nm.

What is the work function of this material (in eV)?

1.

Save Answer

31. HW3 (Q31) (Points: 1)

This statement is for questions 31 and 33.
As all real metals, GaAs have electrons distributed in a whole range of energy levels. If you used a GaA PMT to measure 700 nm light, what is the minimum and maximum KE that you would expect for the electrons kicked off of the detectors surface (in eV)?

Minimum KE?

1.

Save Answer

32. HW3 (Q32) (Points: 1)

Maximum?

1.

Save Answer

33. HW3 (Q33) (Points: 1)

How fast (in m/s) are the fastest electrons traveling when they first get kicked out of the metal? (useful conversion:
1.6*10^-19 J = 1 eV) (3 SigFigs)

1.

Save Answer

34. HW3 (Q34) (Points: 1)

As metals are heated the electrons gain energy. The amount of thermal energy is given by 1.5 kT, where k is Boltzmann's constant.
On average, how much thermal energy (in eV) do the electrons have at room temperature? (3 SigFigs)

1.

Save Answer

35. HW3 (Q35) (Points: 1)

The thermal energy represents only the average. The energies of individual electrons vary and are distributed according to what is known as the Fermi-Dirac distribution. If you are curious as to the exact formula for this distribution you can look it up in a physics book or google it, but you do not need to know it for this problem. Most of the electrons are pretty close
to the average energy, but there are a few that have much higher energy.
At what temperature (in degrees Kelvin) will those electrons with 25 times the average thermal energy come out of a GaAs cathode in a PMT? (Even at room temperature, an occasional electron will come out of the PMT cathode. This limits the sensitivity of the PMT because these so-called "dark counts" look just like the signal produced when a photon kicks out an electron. Because of this, the most sensitive PMTs are cooled to very low temperatures to reduce the dark counts.)
(3 SigFigs)

1.

Save Answer

36. HW3 (Q36) (Points: 1)

If you now increase the wavelength from 700nm to 800 nm and measure the 800nm light (with the same number of photons hitting the detector), what would you expect to see? (check all that apply)

1. more electrons being kicked off
2. no change in the number of electrons being kicked off
3. fewer electrons being kicked off
4. a bigger range in the KEs of the electrons being kicked off
5. no change in the range in the KEs of the electrons being kicked off
6. a smaller range in the KEs of the electrons being kicked off

Save Answer

37. HW3 (Q37) (Points: 2)

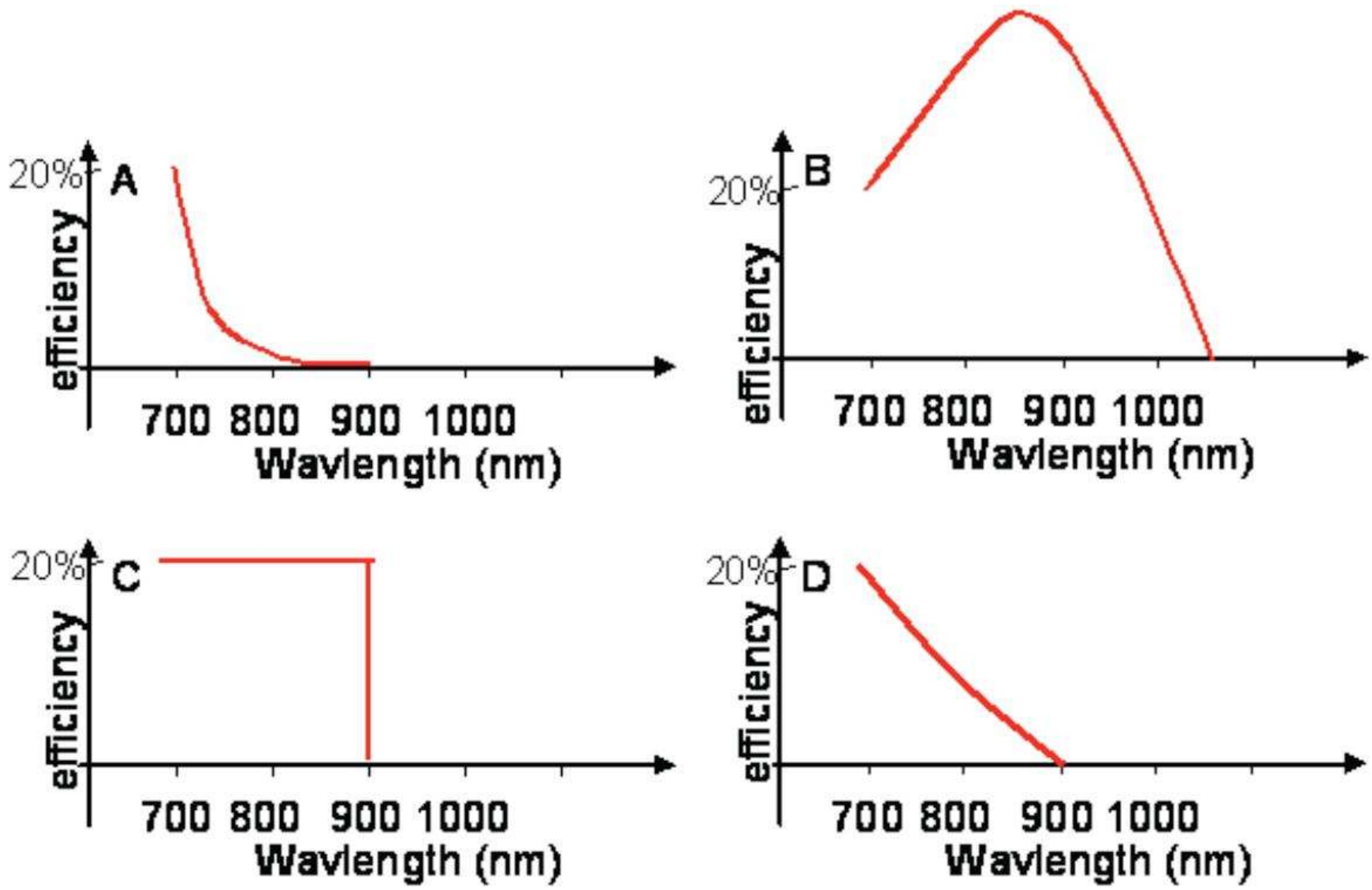
Explain your reasoning to the question above.

New Insert equation

Save Answer

38. HW3 (Q38) (Points: 1)

If this GaA PMT can detect photons at 700 nm with 20% efficiency (in other words, 1 absorbed photon by GaAs out of every 5 produces an electron), which of the following represents likely efficiency curve as a function of wavelength? GaAs is a metal. Metals have equally spaced energy levels, so the number of electrons at higher potential energies (i.e., shallower in the potential well) is approximately the same as the number at lower potential energies (deeper in the potential well).



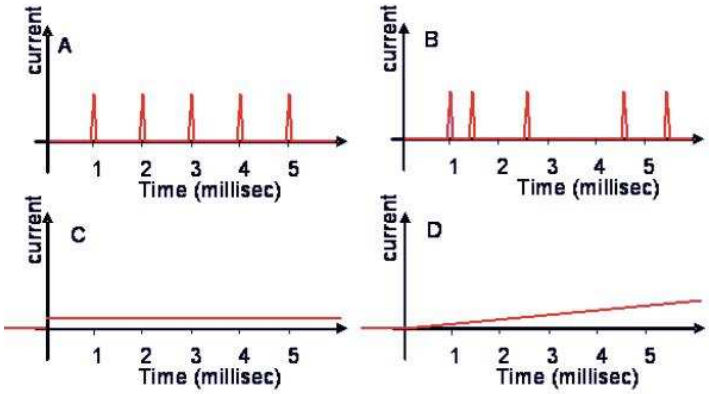
i

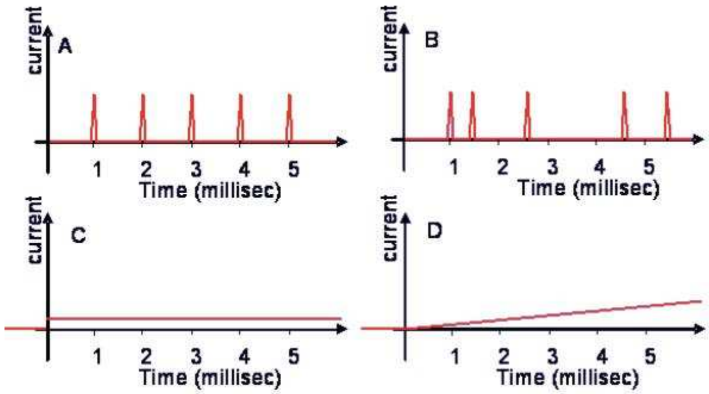
1. A
2. B
3. C
4. D

Save Answer

39. HW3 (Q39) (Points: 1)

The concentration of the important pollutant NO2 in the atmosphere can be measured with a laser and a PMT. Laser light of a certain color is used to excite an NO2 molecule to a higher energy state, and the PMT is used to detect the light given off by the NO2 molecule when it returns to its lowest energy state. The amount of light detected tells one how much NO2 the is. If we are using a PMT to detect this light and we detect and count 1000 photons in a second:
Which of the following graphs represents the current signal we would expect to see as a function of time during a portion of this one second counting time?





- 1. A
- 2. B
- 3. C
- 4. D

Save Answer

40. HW3 (Q40) (Points: 1)

If air sample A indicates 1000 photons detected and air sample B indicates 1003 photons detected, which of the following conclusions can you make:

- 1. There is more NO2 in air sample A
- 2. There is more NO2 in air sample B
- 3. You cannot distinguish which air sample has more NO2

Save Answer

41. HW3 (Q41) (Points: 1)

This statement applies to the following 3 questions:
A digital camera basically has an array of tiny light detectors (2000x1500 = 3MegaPixels = 3 million very tiny detectors covering a cm2 or so). In each of these detectors, photons that hit the detector excite electrons and these excited electrons are counted.
In a typical picture, the detector array in the camera is exposed to about 4.5x10-6 Watts of light for 10 ms. If you take 535 nm as an average wavelength for the light, what is the avera number of photons that hit each pixel in a typical picture?
(4 SigFigs, make sure to input answer in the format 1.234E5)
1.

Save Answer

42. HW3 (Q42) (Points: 1)

If you have very low intensity green light (4x10-11 Watts at 570 nm) evenly illuminating the entire array of detectors, what will the camera's detectors see during the exposure time of 10ms?

- 1. All pixels in the array count about the same number of excited electrons
- 2. The pixels in the center of the array will count the largest number of excited electrons and this will drop off towards the edges
- 3. Random pixels will have several excited electrons, others will have only one excited electron, and others will have no excited electrons.

Save Answer

43. HW3 (Q43) (Points: 1)

You now have a higher intensity green light (6x10-6 Watts at 570 nm) evenly illuminating the entire array of detectors.
What will the camera's detectors see during the exposure time of 10ms?

- 1. All pixels in the array count about the same number of excited electrons
- 2. The pixels in the center of the array will count the largest number of excited electrons and this will drop off towards the edges
- 3. Random pixels will have several excited electrons, others will have only one excited electron, and others will have no excited electrons.

Save Answer

44. HW3 (Q44) (Points: 0)

Approximately how long did it take you to complete this homework?

1. 1hr
2. 2hr
3. 3hr
4. 4hr
5. 5hr
6. 6hr
7. 7hr+

Save Answer

Finish Save All Help