1. (1 pt) 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.

- [ ] A. Increasing the intensity of the light beam
- [ ] B. Decreasing the intensity of the light beam
- [ ] C. Increasing the wavelength of light
- [x] D. Decreasing the wavelength of light
- [x] E. Increasing the frequency of light
- [ ] F. Decreasing the frequency of light
- [ ] G. Increasing the voltage of the battery
- [ ] H. Decreasing the voltage of the battery
- [ ] I. Replacing the target with a material that has a larger work function
- [x] J. Replacing the target with a material that has a smaller work function

- [ ] B. Decreasing the intensity of the light beam
- [ ] C. Increasing the wavelength of light
- [x] D. Decreasing the wavelength of light
- [x] E. Increasing the frequency of light
- [ ] F. Decreasing the frequency of light
- [ ] G. Increasing the voltage of the battery
- [ ] H. Decreasing the voltage of the battery
- [ ] I. Replacing the target with a material that has a larger work function
- [x] J. Replacing the target with a material that has a smaller work function

3. (0.5 pts) What causes the electrons to be ejected from the left plate in this simulation?

- ( ) A. The force exerted on the electrons by the battery
- (x) B. The beam of light shining on the plate
- ( ) C. Both A and B.
- ( ) D. Neither A nor B.

a. (essay) Light is shining on a metal and electrons are being emitted. You turn the intensity down very very low.

1. 還是有 e^- 逸出，只是比 high intensity 還少

2. 光的 intensity 不影響 photoelectric effect 的"發生"，只影響電流大小（如果有 e^- 射出）

3. 這題以傳統(波) or 現代 ($h\nu$) 的觀點都解釋的通

→ 打那道光能產生效應，low $\xleftrightarrow{\text{intensity}}$ high

$\Updownarrow$

low $\xleftrightarrow{\text{current}}$ high

波：intensity $\propto (E)^2$

光子 intensity $\propto$ 光子個數

1. 變成完全沒有 e^- 從 plate 裡被打出來

2. 頻率決定了光電效應的產生，必須超過某個特定頻率才有 e^- 逸出

3. 這題以波就無法解釋，如果頻率太低即使 intensity 很高也無法使 e^- 逸出，相反地，(即便 intensity 很低) 頻率夠高也能產生 e^-

b. (essay) Light is shining on a metal plate and electrons are being emitted. Without changing the intensity, you make the wavelength longer and longer.

傳統認為把照射時間拉長累積能量即可，但實際上並沒有 e^- 逸出。

5. (0.25 each) 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?

○ **True** ✓ **False** As long as conditions do not change, all emitted electrons have the same initial kinetic energy.

✓ **True** ○ **False** The work function for the metal is different for different electrons.

○ **True** ✓ **False** The energy of the photons hitting the plate must be less than the work function of the metal.

✓ **True** ○ **False** The electrons emitted with the largest initial kinetic energy are those that were the least tightly bound in the metal.

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

使 e^- 從 sodium 逸出所需要的最小能量.

7. (a) 在有電流且電池電壓不小於零時，電流大小取決於被激發的電子數目，而非電池電壓大小。在電池電壓為零時，被激發的電子仍具有初速度，具動能，仍可造成電流。若要完全沒電流，電池需提供負電壓把電子壓回去。此時這個負電壓被稱為截止電壓。

而想讓電流為零，就要使動能最大的電子降為零，又電子動能的公式為 $E_k = \frac{1}{2}m_e v^2$，$E_k = \frac{1}{2}m_e v^2 = h\nu - W = e V_{stop}$，$h\nu$ 為光子所帶能量，W 為功函數，可知截止電壓與入射光之頻率與金屬種類有關

(b) $\frac{3\times10^8}{200\times10^{-9}} \times 6.63\times10^{-34} \times \frac{1}{1.6\times10^{-19}} - 4.07 = V_{stop} = 2.146\,eV$ //

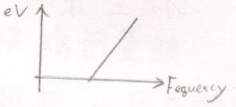
i. be a larger, negative number. $E_k = \frac{1}{2}m_e v^2 = h\nu - W = e V_{stop}$，$\nu = \frac{c}{\lambda}$，$\lambda$ 變小，ν 變大，則 V_{stop} 越大.

ii. G iii. E iv. C v. I vi. G

8. $h\nu - W = eV_{stop} \Rightarrow 6.63\times10^{-34} \times \frac{3\times10^{8}}{x\times10^{-9}} \times \frac{1}{1.6\times10^{-19}} - 2.3 = 0.5 \Rightarrow \frac{6.63\times3\times100}{1.6x} = 2.8$

$x = \frac{663\times3}{1.6\times2.8} \approx 443.97\,nm$ #

9. 由電子動能的公式 $E_K = h\nu - W = eV_{stop}$ 出發，我們可以發現公式中的 h、e 皆為已知，而 W 只與金屬材質有關，因此，我只要設定任意一個能夠激發出電子的光頻率，固定它後去找截止電壓，將兩者代入公式後即可求得 W。
在實驗過程中，因為光強度不會影響截止電壓與功函數，為了方便觀察電流，我把光強度調到最強。也是為了方便觀察，我光頻率不取底限頻率，而選擇較高的 $\nu = \frac{3\times10^{8}}{226\times10^{-9}}$ Hz，找到截止電壓約 1.8 V 代入公式



$E_K = 6.63\times10^{-34} \times \frac{3\times10^{8}}{226\times10^{-9}} \times \frac{1}{1.6\times10^{-19}} - W = 1.8 \Rightarrow W \approx 3.7\,eV$ #

10. Magnesium