Question			Answer	Max mark	Additional guidance
7.	(a)		Frequency of UV/photons/light is not high enough. **OR** Frequency of UV/photons/light is less than threshold frequency. **OR** Energy of photons (of UV light) is not high enough. **OR** Energy of photons (of UV light) is less than work function. **OR** May not be a 'clean plate'.	**1**	Do not accept "gold" for metal plate.
	(b)	(i)	$6{\cdot}94 \times 10^{-19}$ joules of energy is the minimum energy required for (photo) electrons to be emitted/ejected/ photoemission (of electrons).	**1**	Do not accept "to cause photoelectric effect" alone.
		(ii)	No change (to the kinetic energy). **(1)** As the irradiance does not affect the energy of the photons/ $E = hf$ is unchanged. **(1)**	**2**	Look for this first – if incorrect or missing then 0 marks.
	(c)		Lower starting frequency. **(1)** Same gradient. **(1)**	**2**	**Independent marks** Do not accept: Additional line starting at origin.
	(d)		Each photon contains a fixed/discrete amount of energy. **OR** Each photon removes one electron.	**1**	Some indication of quantisation of energy. If light was a wave then the photoelectric effect would occur regardless of the frequency of the light, it would just take longer for electrons to absorb the energy required to be ejected.

Q7(a)

Maximum Mark: 1

RESPONSE 1

The work function of the metal plate is greater than the energy produced by the protons, stopping them from leaving the plate.

RESPONSE 2

The energy provided by the ultra violent light is smaller than that of the work function of the metal.

RESPONSE 3

The frequency of ultraviolet light is not larger than the threshold frequency for gold.

RESPONSE 4

Ultraviolet cannot make the gold leaf deflect because it is not of a sufficiently high frequency.

Q7(b)(i)

Maximum Mark: 1

RESPONSE 1

6.94 Joules of energy, is the minimum amount of energy required for photoelectric emission to occur.

RESPONSE 2

The energy taken to discharge a photoelectron

RESPONSE 3

The minimum energy required by an a photon to cause photoemission of an electron from the metal plate.

Q7(b)(ii)

Maximum Mark: 2

RESPONSE 1

The frequency of UV light is still the same and therefore there is no effect on the maximum kinetic energy

RESPONSE 2

This has no effect on the maximum kinetic energy of the photoelectrons because irradiance only affects how many photoelectrons are emitted, not their kinetic energy. The only way to change this is to change the frequency of the light emitted from the source by changing the source of light.

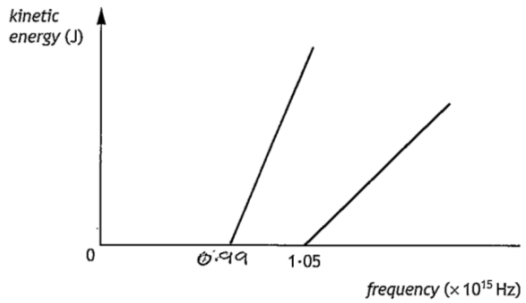
RESPONSE 3

Decreases current but does not have any effect on E_K as $E_K = hf - hf_0$ and if the frequency of the light remains the same and the metals work function then the maximum kinetic energy of the electron will not change.

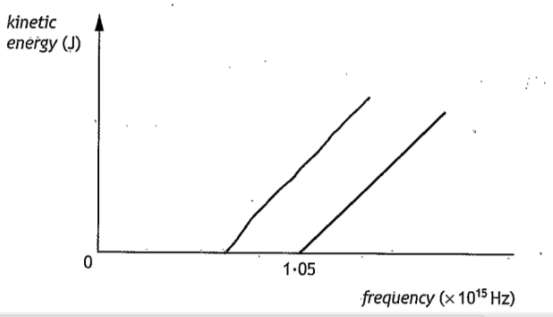
Q7(c)

Maximum Mark: 2

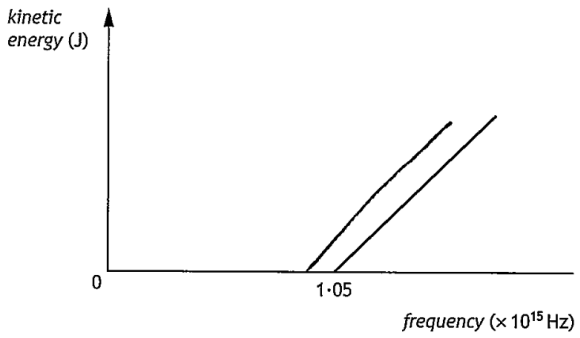
RESPONSE 1



RESPONSE 2



RESPONSE 3



Q7(d)

Maximum Mark: 1

RESPONSE 1

- A photon is a bundle of energy and to eject an electron from a metal surface energy is required (a certain amount ie. Work function)

One photon ejects one electron (above fo).

Increasing irradiance increases no. of electrons emitted (per second)

RESPONSE 2

It isn't due to ionisation as a positive plate would also discharge. It isn't due to waves as total energy hitting plate isn't what causes photoemission since light of any frequency would cause photoemission if incident for a period of time, which isn't the case. Therefore light must be made up of discrete particles called photons which have their own energy energies.

RESPONSE 3

This is because the photons of light exist on energy levels, and through absorbing energy from a photon they can move up energy levels and fly off.

Q7(a)	1	
Response 1	**0**	In their response, the candidate confuses ‘protons’ with photons, also suggesting that protons are ejected from the plate.
Response 2	**0**	The candidate does not include ‘the energy of photons’ in their response.
Response 3	**0**	The candidate’s response suggests that electrons are ejected from the gold leaf, rather than from the plate of the electroscope.
Response 4	**0**	The candidate’s response suggests that the gold leaf is made to deflect by the ultraviolet light.

Question /Response	Mark	Commentary
Q7(b)(i)	**1**	
Response 1	**0**	The candidate's response would have been acceptable if the correct energy had been quoted ($6{\cdot}94 \times 10^{-19}$ J).
Response 2	**0**	The candidate's statement is incorrect.
Response 3	**0**	The candidate's statement defines work function, but does not answer the question.
Q7(b)(ii)	**2**	
Response 1	**1**	The candidate's statement is correct, but their justification is not sufficient for the second mark to be awarded.
Response 2	**1**	The candidate's statement is correct, but their justification is not sufficient for the second mark to be awarded. Justification has to be in terms of photon energy.
Response 3	**2**	The candidate's statement is correct and their justification is acceptable.
Q7(c)	**2**	
Response 1	**1**	The candidate has shown a lower threshold frequency, but the gradient of their line is not the same as the given line.
Response 2	**2**	The candidate has shown a lower threshold frequency, and the gradient of their line is acceptable as the same as the given line.
Response 3	**2**	The candidate has shown a lower threshold frequency. Although not drawn using a ruler the line is acceptable and shows the same gradient as the given line.
Q7(d)	**1**	
Response 1	**1**	The candidate's explanation is acceptable.
Response 2	**1**	The candidate's explanation is acceptable, being sufficiently close to the alternative acceptable explanation on the right hand side of the marking instructions.
Response 3	**0**	The candidate's explanation is not acceptable.