



VCE PHYSICS UNITS 3&4 [2020]

Unit 4 AOS 2 - How are light and matter similar? - Topic exam 1

YOUR NAME: Vishnu Prasad Sivakumar

STRUCTURE OF EXAM

Section A - Short Answer

13 questions

41 marks

41 marks

WHEN YOU FINISH

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SECTION A – SHORT ANSWER

Question 1

3 marks

A researcher is planning to use an optical microscope to view a bacterium. The bacterium is about 0.5 micrometres in diameter. If he chooses to use an optical microscope and light of frequency 6.7×10^{14} Hz, will he be able to see the bacterium clearly?

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Justify your answer.

Question 2

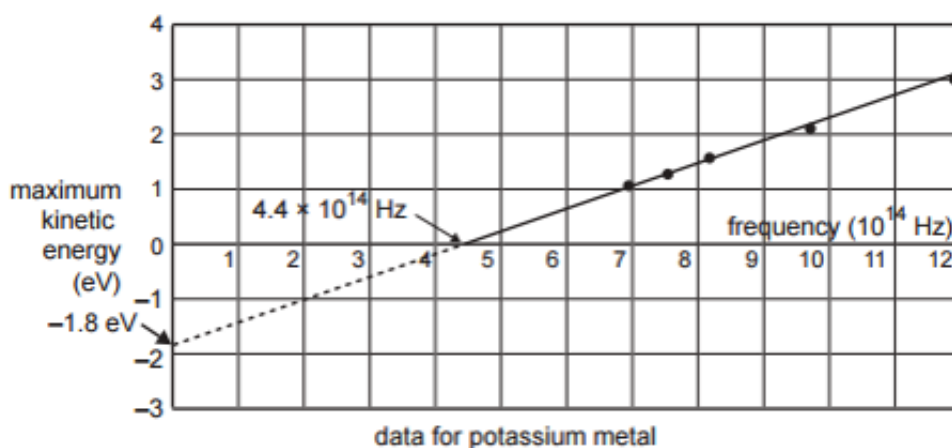
1 mark

State the key difference between a longitudinal wave and a transverse wave.

Question 3

2 marks

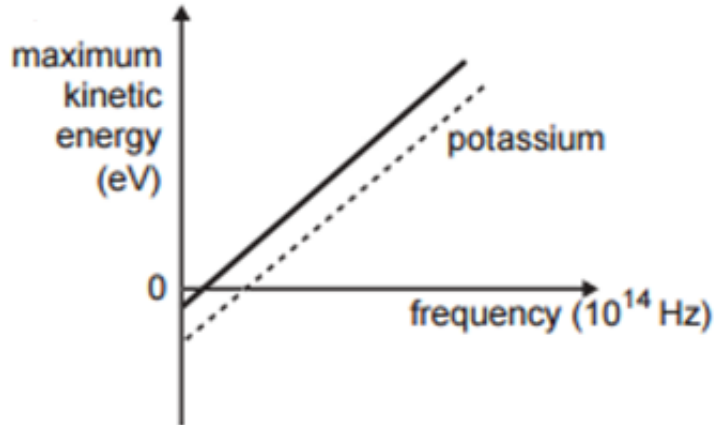
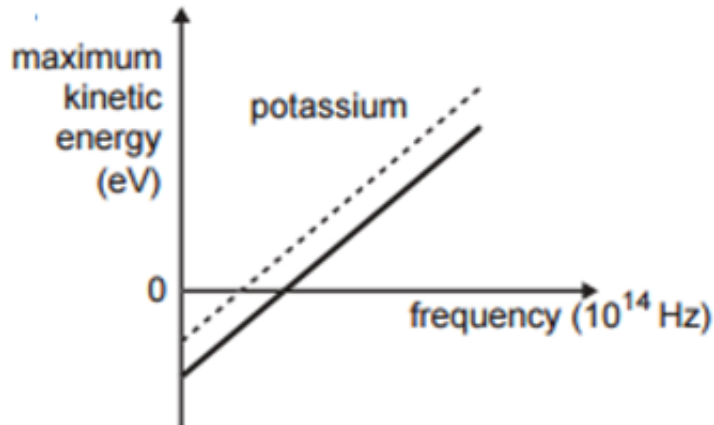
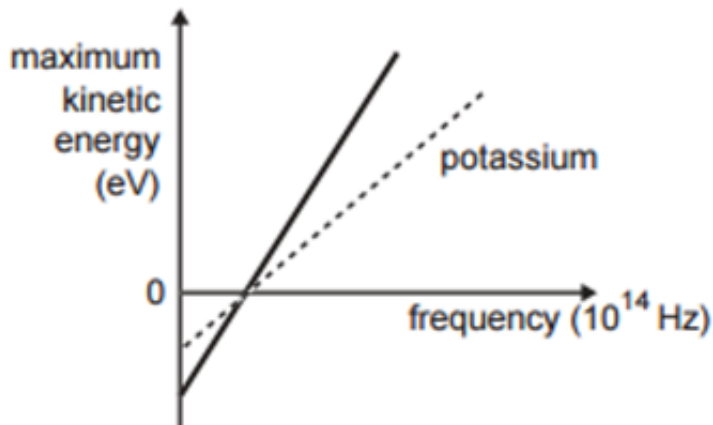
The data below was collected from an experiment in which different frequencies of light were directed at a potassium target.



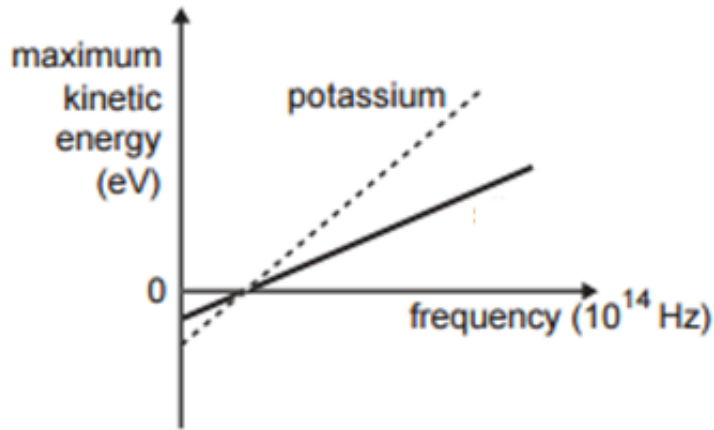
At one point the maximum Kinetic Energy of an ejected electron was measured to be 1eV. What was the corresponding energy of the incident photon in J?

Question 4 (2 marks)

A new target metal with a lower work function replaces the potassium. Which of the graphs below best depicts the expected results when the experiment is repeated? For reference, the original graph is shown as a dotted line.

A**B****C**

D

**Question 5**

2 marks

The stopping voltage measured in a particular photoelectric experiment was measured to be 3.2 Volts.

Calculate the size of the maximum kinetic energy of the ejected electrons in Joules.

Question 6

3 marks

The stopping voltage measured in a particular photoelectric experiment was measured to be 3.2 Volts .

The intensity of the light incident on the target material was then doubled. What effect did this have on the stopping voltage?
Explain your answer.

Question 7 (4 marks)

Vishvi is carrying out photoelectric effect experiments. Her apparatus is shown in Figure 1.

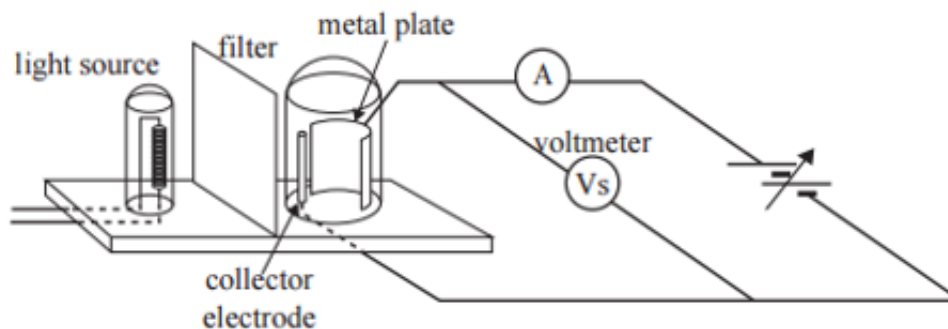


Figure 1

Vishvi uses two metal plates in the photoelectric cell. One plate is made of zinc and the other is made of aluminium. Vishvi uses light of a particular frequency to illuminate the zinc plate and then the aluminium plate, but finds that photoelectrons are emitted only by the zinc plate. The threshold frequency of zinc for photoelectric emission is 7.40×10^{14} Hz and that of aluminium is 9.90×10^{14} Hz.

Question 7.a

1 mark

Calculate the maximum wavelength (in nm) of the light required to emit electrons from the zinc plate.

Question 7.b

2 marks

In another photoelectric experiment, Vishvi uses light with a frequency of 7.50×10^{14} Hz to eject photoelectrons from a sodium surface. The work function of sodium is 2.28 eV.

Calculate the maximum kinetic energy (in eV) of these photoelectrons.

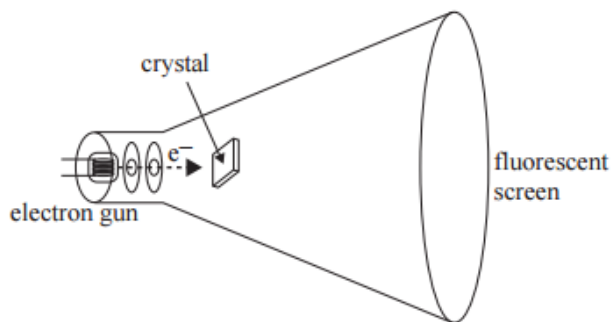
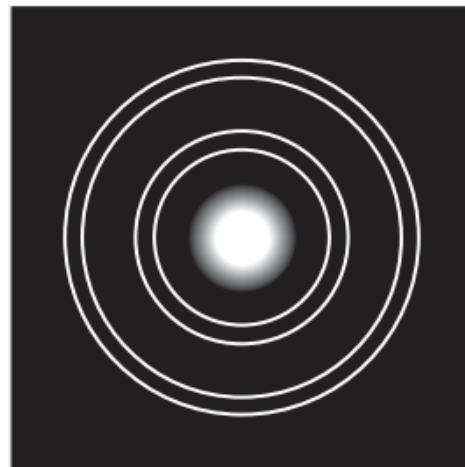
Question 7.c

1 mark

Calculate the stopping voltage that would be required to just prevent the most energetic electrons from reaching the collector electrode.

Question 8 (4 marks)

Students study diffraction of electrons by a crystal lattice. The apparatus is shown in Figure 4a. In this apparatus electrons of mass 9.1×10^{-31} kg are accelerated to a speed of 1.5×10^7 ms⁻¹. The electrons pass through the crystal, and the diffraction pattern is observed on a fluorescent screen. The pattern the students observe is shown in Figure 4b.

**Figure 4a****Figure 4b****Question 8.a**

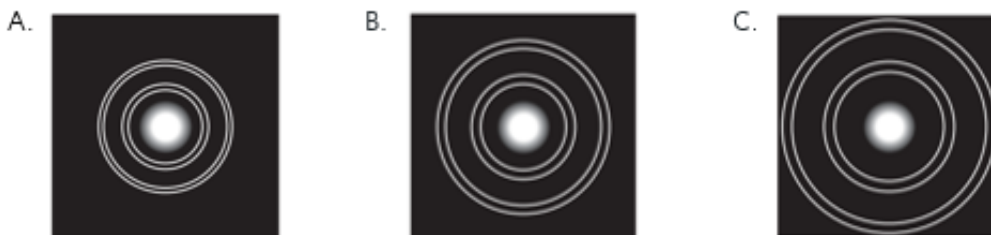
2 marks

Calculate the de Bröglie wavelength of the electrons (in nm). Show your working.

Question 8.b

2 marks

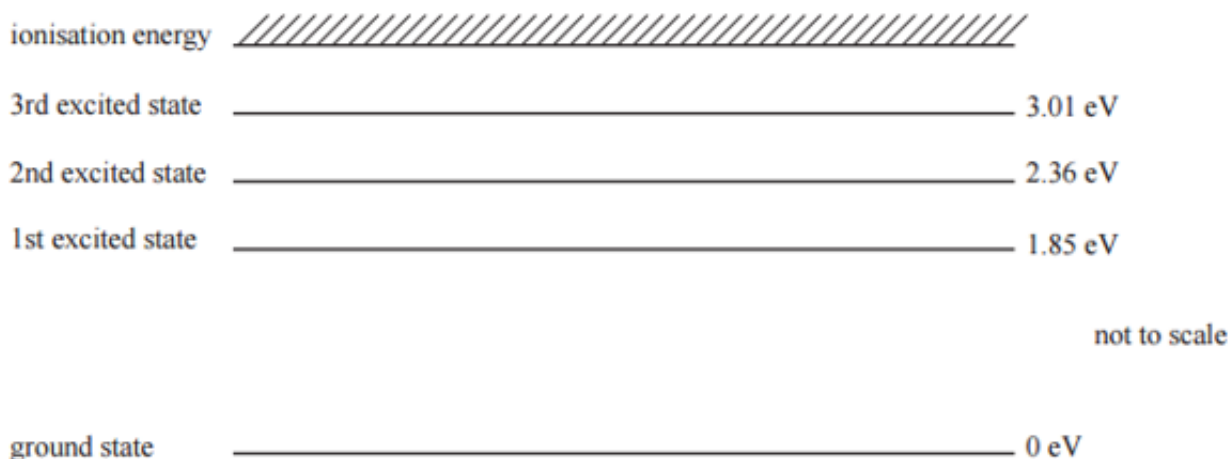
The students now increase the accelerating voltage and hence the speed of the electrons. Which one of the options below now best shows the pattern they will observe on the screen? Explain your answer.



Question 9

3 marks

On the diagram below identify all of the possible electron transitions for an electron initially in the $n=4$ energy level as it returns to ground state. Use arrows to show these possible transitions.



Please use pen and paper to complete your response.

Question 10 (5 marks)

An energy-level diagram for a sodium atom is shown in Figure 25.

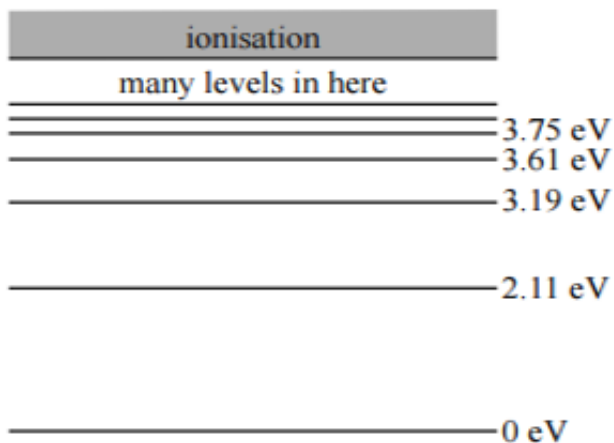


Figure 25

Question 10.a

2 marks

An atom is in the 3.19eV state. It returns to the ground state, emitting one or more photons. Calculate the longest wavelength of light that could be emitted by the atom.

Question 10.b

3 marks

Explain, with a calculation, why the emission spectrum of sodium shows a spectral line at 588.63 nm.

Question 11 (5 marks)

Figure 6 shows the energy level diagram for the hydrogen atom.

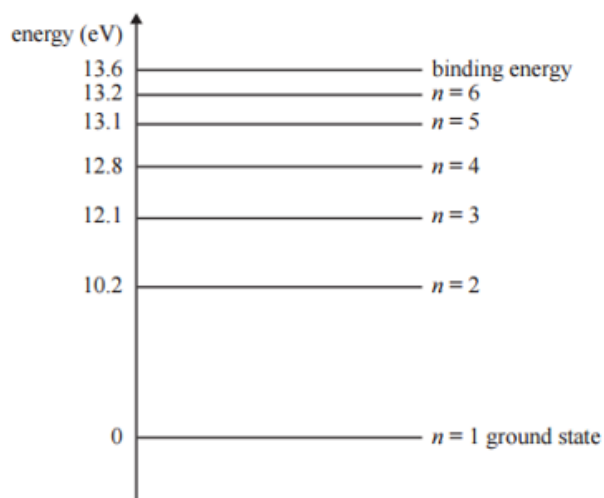


Figure 6

A particular hydrogen atom makes a transition from the $n = 2$ level to the $n = 4$ level by absorbing a photon.

Question 11.a

2 marks

Calculate the wavelength of the photon involved (in nm).

Question 11.b

3 marks

The energy levels of the hydrogen atom are discrete (quantised) and there are no stable levels between them. In terms of the properties of the electron, explain why only certain energy levels are stable.

Question 12

4 marks

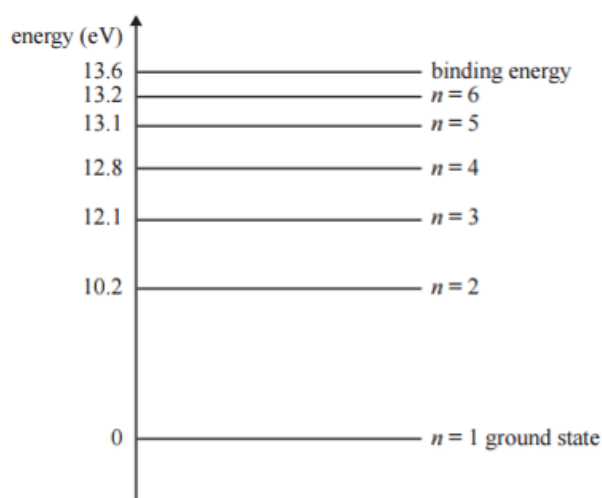
There are many ways to generate light such as incandescent bulbs, LASERs, LEDs and synchrotron. Identify the properties of light correctly associated with their method of production in the table below. Using the table as a guide enter either true or false for each method.

Method of production of light	Property of light produced	True/false
Synchrotron	Highly polarised and bright	
LED	Large distribution of photon energies produced	
Incandescent light bulb	Coherent light produced, mainly in the visible spectrum	
LASER	Coherent light produced with a narrow range of wavelengths	

Question 13

3 marks

A sample of hydrogen is exposed to a range of frequencies of light. One of the frequencies that is absorbed corresponds to that of photons with a momentum of $7.0 \times 10^{-27} \text{ kg ms}^{-1}$. As this photon is absorbed, an electron moves from ground state to an excited state. On the diagram below add arrows to show all possible transitions of this electron as it returns to ground state.

**Figure 6**

Please use pen and paper to complete your response.