Physics 3AB - Year 12

Waves, Particles and Quanta Unit Test 2015

Name:

Mark: / 52

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Time Allowed: 50.0 Minutes

Notes to Students:

1. You must include **all** working to be awarded full marks for a question.
2. Marks will be deducted for incorrect or absent units and answers stated to an incorrect number of significant figures.
3. **No** graphics calculators are permitted – scientific calculators only.

Question 1 **(3 marks)**

A helium-neon laser puts out a beam of red light containing a very narrow range of frequencies centred at 4.74×10^{14} Hz. Calculate the energy of each photon at that frequency in eV.

Question 2 **(4 marks)**

Volume for volume, carbon dioxide gas is heavier than air. If the air inside an organ pipe is replaced with carbon dioxide, state what will happen to the value of the fundamental frequency of the organ pipe. Explain your reasoning.

Question 3 **(4 marks)**

A group of aliens on a spaceship travel past a laboratory on Earth at a speed of 0.70c. The humans in the laboratory are performing an experiment to measure the period of a mass oscillating on a spring. The humans measure the period of oscillation to be 2.00 s.

(a) Will the period measured by the aliens be? Circle your chosen response.

(1 mark)

(i) Greater than 2.00 s

(ii) Equal to 2.00 s

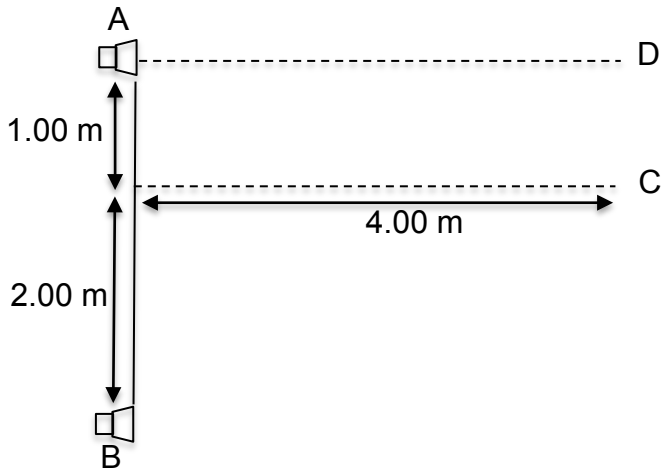
(iii) Less than 2.00s

(b) Explain the reasoning behind your choice in (a).

(3 marks)

Question 4 **(6 marks)**

Two small speakers, A and B, are connected to the same oscillator and emit waves of the same frequency in phase. The speakers are arranged as shown in the diagram below. The speed of sound in air is 340 ms^{-1}.



(a) Calculate the path difference for an observer standing at C.

(3 marks)

(b) If the observer at C hears a 'soft' sound, calculate the lowest possible frequency of the sound.

(3 marks)

Question 5 **(2 marks)**

State one similarity and one difference between quarks and leptons.

Question 6 **(3 marks)**

A tuning fork in air, where the speed of sound is 343 ms^{-1} produces a tone with a wavelength of 0.780 m. If the tuning fork is now placed in acetone, calculate the length of the wave created in the liquid when the tuning fork is struck. Sound waves travel at 1200 ms^{-1} in acetone.

Question 7 **(4 marks)**

The B-string from a guitar is fixed at both ends under tension with a vibrating length of 33.0 cm. Its third overtone oscillates at a frequency 984 Hz. Calculate the wave speed and wavelength of the standing wave that is setup.

Question 8 **(8 marks)**

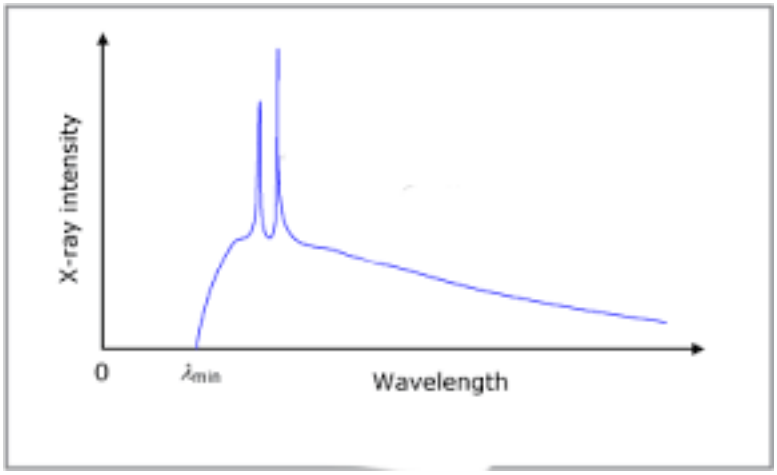
A cathode ray tube is a vacuum tube through which electrons are accelerated.

(a) Calculate the smallest (minimum) wavelength of X-ray that can be produced by an electron as it crashes into the metal mask of a cathode ray tube operating with an accelerating voltage of 20.0 kilovolts.

(4 marks)

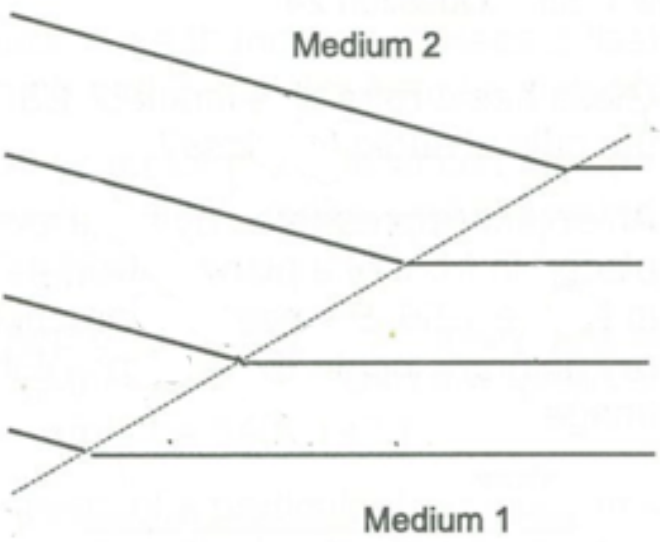
(b) The diagram below shows the X-ray spectra for this particular metal. If the accelerating voltage across the cathode tube were increased, state if the cut-off wavelength will change. Explain your reasoning.

(4 marks)



Question 9 **(4 marks)**

The diagram below shows sound waves refracting from medium 1 into medium 2. One medium is air and the other is water.



(a) State which of the two media is air.

(1 mark)

(b) Explain your reasoning.

(3 marks)

Question 10 **(14 marks)**

The energy of the ground state of an atom is known to be -5.00 eV. A gas of this atom is illuminated with 'white light' (400 – 700 nm). A spectrometer, which is sensitive to the 400 – 700 nm range is used to measure the radiation absorbed and emitted.

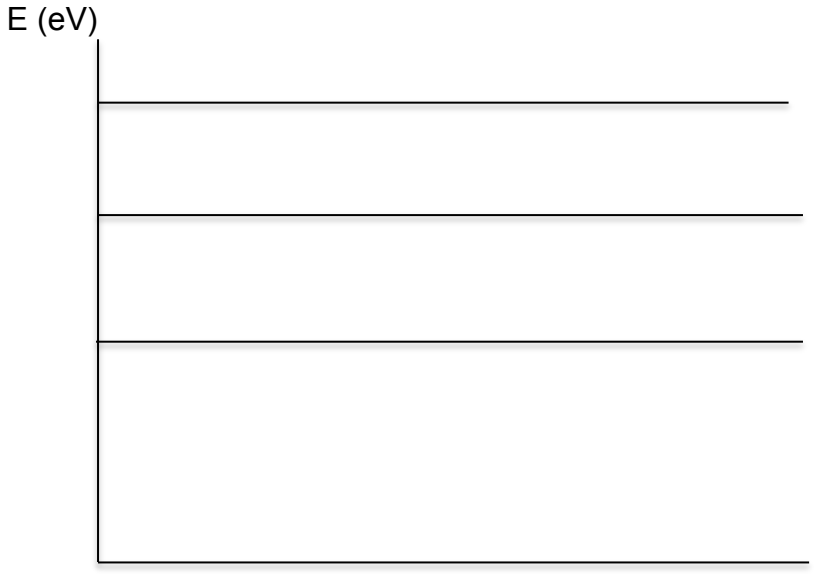
The sample is observed to absorb light at only 400 nm. After the 'white light' is turned off, the sample emits visible radiation of 400 nm and 600 nm wavelengths.

(a) On the diagram below, indicate the location and energy of;

1. The ground state
2. The ionisation level
3. The energy level to which the atom was first excited and
4. One other energy level that the experiment suggests might exist.

Space is given below for you to show your working.

(8 marks)



(b) On the diagram drawn in (a), sketch the possible decay pathways and state and/or calculate the wavelengths for the three transitions.

(4 marks)

(c) Explain why only two of these photons were detected by the spectrometer.

(2 marks)

END OF TEST