Physics 3AB

Particles, Waves and Quanta Test 2014

Name:	Mark: / 54 = %

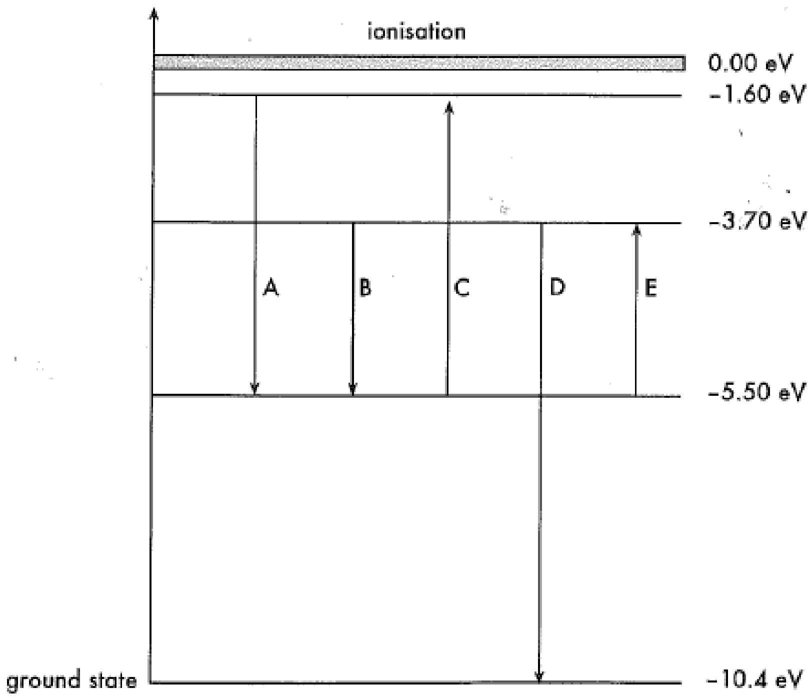
Time Allowed: **50 minutes**

Notes to Students:

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

Question 1 **(7 marks)**

The diagram below shows the atomic energy levels for mercury.



atomic energy levels of mercury

(a) State which transition (A, B, C, D, or E) on the energy level diagram demonstrates the change in atomic energy levels for the emission of a photon of energy 2.88×10^{-19} J. Include appropriate working to justify your answer.

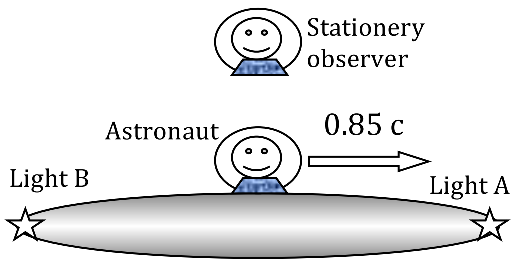
(3 marks)

(b) Calculate the shortest wavelength of photon that can be produced when the atom is bombarded with 7.00 eV electrons.

(4 marks)

Question 2 **(6 marks)**

An astronaut flies past a stationary observer at a constant 85% of the speed of light. His spacecraft has two lights, A at the front and B at the rear. The stationary observer sees the two lights A and B turn on simultaneously.



(a) The astronaut is positioned in the middle of his spaceship and is able to observe both lights at the same time. State the order in which the astronaut sees the lights turn on and explain your reasoning. (3 marks)

(b) A chemical reaction that takes 60.0 s in the laboratory on Earth has been taken on the spacecraft. The astronaut carries out the same experiment, while the spacecraft is moving, and times its duration. Will the duration of the experiment be; Circle your chosen response

(i) greater than 60 seconds

(ii) equal to 60 seconds

(iii) less than 60 seconds

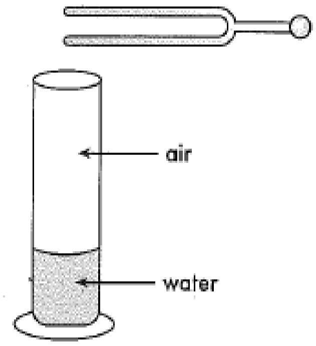
(1 mark)

(c) Explain your reasoning for your choice in (b).

(2 marks)

Question 3 **(2 marks)**

A student holds a vibrating 256 Hz tuning fork above a measuring cylinder full of water. He then lowers the water height, creating an air column, as shown in the diagram below.



He observes that the sound produced becomes quite loud for the first time when the length of the air column is 32.0 cm. The student then selects a tuning fork of a higher frequency and vibrates it above the 32.0 cm air column. It also produces quite a loud sound.

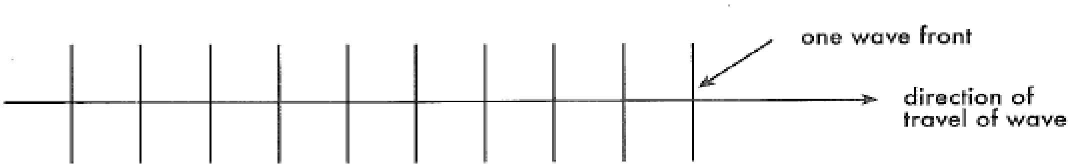
What is a possible frequency for the second tuning fork?

Question 4 **(4 marks)**

A microwave oven has a power output of 700 W at a frequency of 2450 MHz. Assuming the microwave oven is 100% efficient, calculate the number of photons released in the 2.00 minutes taken to heat a cup of coffee.

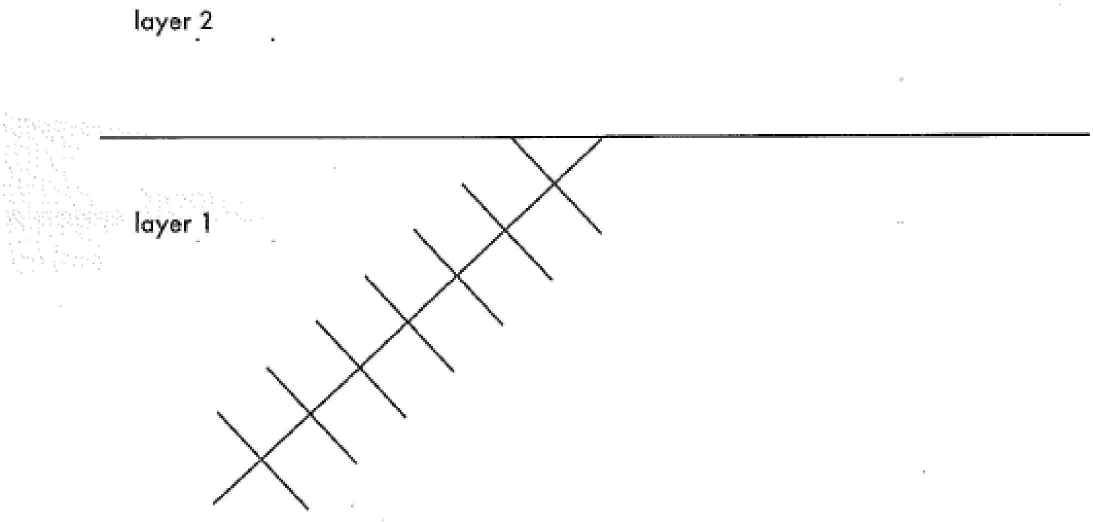
Question 5 **(3 marks)**

A sound wave can be represented by wavefronts at a particular instant of time. The direction of wave travel is shown by a line drawn perpendicular to each wave front. The diagram below shows a sound wave travelling to the right at a certain instant of time.



Under certain atmospheric conditions the air can form layers in which the sound has different speeds. In a particular case, sound travels from one layer (layer 1) to another (layer 2) where the temperature is approximately 25.0% greater. The diagram below only shows the sound in layer 1.

On the diagram below, sketch the wavefronts in layer 2.



Question 6 **(8 marks)**

Light from different lamps is passed through a spectrometer. For each of the following cases;

1. State the type of spectrum that would be observed

2. Describe the spectrum that would be observed

(a) Light from an incandescent globe – e.g. a tungsten filament light globe.
(2 marks)

(b) Light from an incandescent globe that has passed through a coloured solution.
(3 marks)

(c) Light from a mercury vapour discharge lamp.
(3 marks)

Question 7 **(3 marks)**

(a) What is the name given to a particle that is made up of quarks?
(1 mark)

____

(b) All quarks all have an associated particle called an antiquark. State;

(i) One property a quark and its antiquark have in common.
(1 mark)

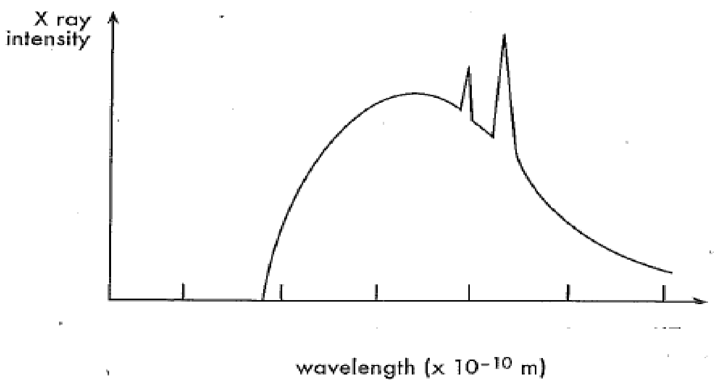
____

(ii) One property that is different for a quark and its antiquark.
(1 mark)

____

Question 8 **(8 marks)**

The graph below shows the spectrum obtained when a molybdenum anode in an X-ray tube is bombarded with electrons accelerated across a potential difference of 34.0 kV.



(a) Calculate the lowest wavelength of X-ray that can be produced by this X-ray tube.
(4 marks)

(b) Explain the formation of the Bremsstrahlung radiation (the continuous background radiation).

(3 marks)

(c) Explain why there is a cutoff wavelength of X-ray that is produced.

(2 marks)

Question 9 **(12 marks)**

Two pipes open at both ends are 0.840 m and 0.850 m long. They are sounded together at their fundamental frequencies and produce beats at the rate of 46 every 20 seconds.

(a) Calculate the beat frequency produced by the pipes.

(2 marks)

(b) Show that for two such pipes the beat frequency is equal to

(2 marks)

$$f_{beat} = \frac{v}{2}\left|\frac{1}{L_1} - \frac{1}{L_2}\right|$$

Where: v = speed of sound in air
L_1 = length of pipe 1
L_2 = length of pipe 2

(c) Calculate the speed of sound in air for the pipes.

(2 marks)

(d) Calculate the 3rd overtone of the 0.84 m long pipe.

(3 marks)

(e) If the gas in the pipe was replaced with carbon dioxide gas at the same temperature, how would the fundamental frequency of the pipes change? Explain your reasoning.
[speed of sound in carbon dioxide is 269 ms^{-1}]

(3 marks)

End of Test