Christ Church Grammar School

Science Department
Year 12 2022

ATAR PHYSICS
UNIT 4: REVOLUTIONS IN MODERN PHYSICS
TOPIC TEST 2022

Teacher: CJO HKR
(Please circle)

Time allowed for this paper

Working time for paper: 50 minutes.

NAME: _____

Instructions to candidates:

- You must include **all** working to be awarded full marks for a question. Answers should be expressed to 3 significant figures unless otherwise indicated.
- Marks may be deducted if diagrams are not drawn neatly with a ruler and to scale (if specified).
- Marks will be deducted for incorrect or absent units.
- **No** graphics calculators are permitted – scientific calculators only.

Mark:	/ 51
=	%

Question 1 **(3 marks)**

Explain why hydrogen has many spectral lines.

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Question 2 **(6 marks)**

For each of the following questions, select the appropriate answer and fully justify your response.

(a) A new particle discovered in 2014 contains five quarks. To which one of the following categories does the particle belong?

(3 marks)

(A) Baryon

(B) Boson

(C) Hadron Selection: _____

Reasoning_____

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(b) Which of the following particles is governed by the weak force and is also influenced by the electromagnetic force?

(3 marks)

(A) Neutrinos

(B) Quarks

(C) Mesons

(D) Uncharged Leptons Selection: _____

Reasoning_____

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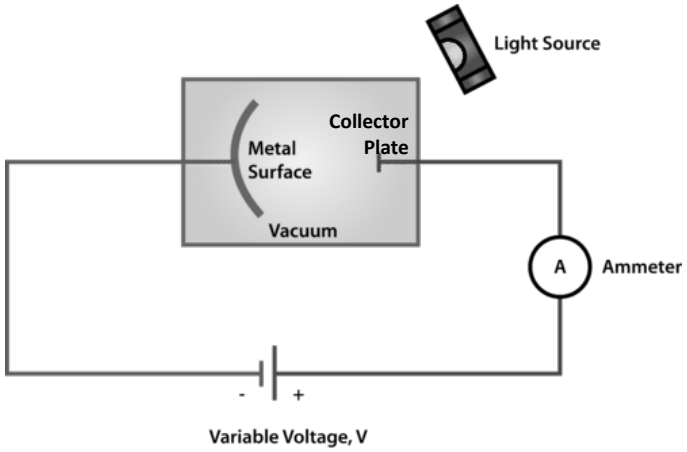
Question 3 **(15 marks)**

A photoelectric effect apparatus is set up as per the diagram below, so that when monochromatic light shines upon a metal surface, all of the electrons emitted from the metal surface can be detected by a simple circuit.



A light source of power 3.00 W emits light with a wavelength of 4.60×10^{-7} m. All of the light is incident on a metal surface with a threshold frequency of 5.45×10^{14} Hz and causes electrons to be emitted at a rate of 6.69×10^{18} electrons per second.

(a) Calculate the photoelectric current detected through the circuit.

(2 marks)

(b) Calculate the maximum kinetic energy of a photoelectron ejected from the metal when it reaches the **collector plate**, if the variable voltage is set to 6.00 V.

(6 marks)

A new light source is now shone upon the metal plate, which has the same power output, but a longer wavelength of 6.90×10^{-7} m.

(c) Calculate the number of photons arriving on the plate per second.

(3 marks)

(d) Describe the impact on the photoelectron current of the above change and explain why.

(4 marks)

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Question 4 **(7 marks)**

An astronaut travels to a distant star 10.5 light years away, but to her surprise she finds that the journey only took her 8.98 years. She reasons that in order for this to be possible, she must have travelled faster than the speed of light.

(a) Explain why this reasoning is incorrect and explain the observations both from the perspective of an earthbound observer and the astronaut. (3 marks)

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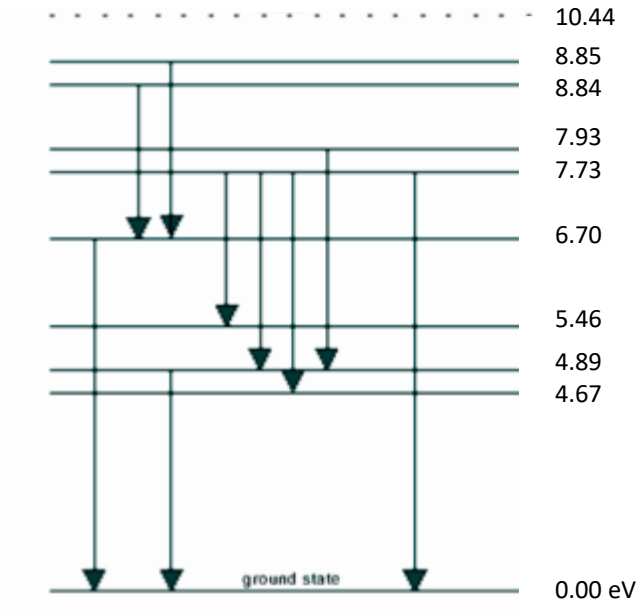
(b) Prove that with a speed of 0.760 c, these observations are possible.

(4 marks)

Question 5 **(5 marks)**

The following diagram shows the allowed electron transitions for mercury. If there is no allowable transition downwards between energy levels shown, also assume this transition is not allowable upwards.



(a) A ground state electron in a mercury atom is bombarded with electrons of kinetic energy 8.00 eV. Determine all possible scattered electron energies.

(2 marks)

(b) Determine which two energy levels are involved in the production of the violet line in mercury's emission spectrum, with a wavelength of 408 nm.

(3 marks)

Question 6 **(7 marks)**

(a) Explain how electromagnetic radiation is produced, and state which type(s) of radiation can be emitted due to the thermal motion of particles.

(3 marks)

Classical physics considers electromagnetic radiation as a wave only, and this leads to the conclusion that even relatively low temperature objects should emit high energy radiation.

(b) Making reference to the statement above, explain how experimental findings have altered our understanding and supported the particle model of light. Support your explanation with a diagram.

(4 marks)

Question 7 **(8 marks)**

In a linear particle accelerator, an alpha particle of mass 6.64×10^{-27} kg is accelerated through an electric field to a final kinetic energy of 5.37 GeV.

(a) Calculate its final speed

(5 marks)

(b) Calculate its final momentum. (If you failed to answer part (a), use a speed of 0.880c)

(3 marks)

END OF TEST