LONDON SCIENCE COLLEGE

Name:

Date:

QUANTUM PHYSICS
TEST 3

AS-Level

Mark

Grade

PHYSICS

For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

Instructions

- Answer all questions
- Answer questions in the space provided
- All working must be shown

Information

- The marks for the questions are shown in brackets

1 When monochromatic light is shone on a clean metal surface, electrons are emitted from the surface due to the photoelectric effect.

(a) State and explain the effect on the emitted electrons of

(i) increasing the frequency of the light,

_____

_____

_____

_____

(2)

(ii) increasing the intensity of the light.

_____

_____

_____

_____

(2)

(b) The wave model was once an accepted explanation for the nature of light. It was rejected when validated evidence was used to support a particle model of the nature of light. Explain what is meant by **validated evidence**.

_____

_____

_____

_____

(2)

(c) The threshold frequency of lithium is 5.5×10^{14} Hz.

(i) Calculate the work function of lithium, stating an appropriate unit,

_____

_____

_____

_____

answer _____

(3)

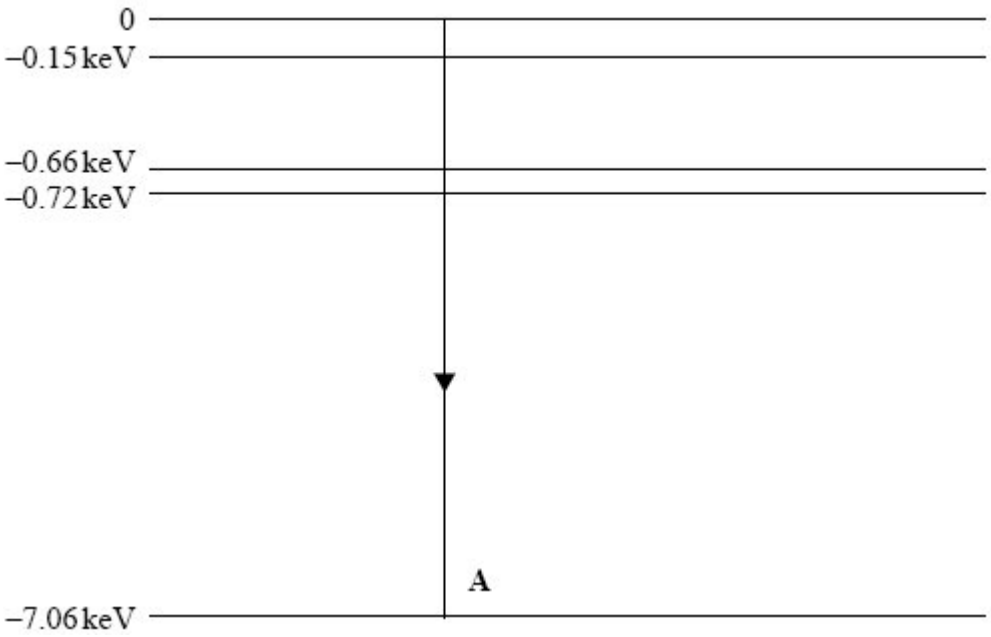
(ii) Calculate the maximum kinetic energy of the emitted electrons when light of frequency 6.2×10^{14} HZ is incident on the surface of a sample of lithium.

answer _____ J

(3)

(Total 12 marks)

2 (a) The diagram below shows some of the energy levels for an iron atom.



(i) Draw another arrow on the diagram above to represent the smallest energy change possible for an electron moving between two of the energy levels shown.
The electron energy change selected must result in energy being emitted from the atom.
Label this arrow **B**.

(1)

(ii) In the diagram above, when the energy change labelled **A** occurs an X-ray photon is emitted.
Show that the frequency of the photon is approximately 2×10^{18} Hz.

(3)

(b) (i) Radiation of frequency 2×10^{18} Hz has a wavelength of 1.5×10^{-10} m.
Calculate the speed of an electron that has a de Broglie wavelength of 1.5×10^{-10} m.

speed _____ m s^{-1}

(2)

(ii) Explain why electrons of this wavelength would be suitable to investigate the structure of a metallic crystal.

_____

_____

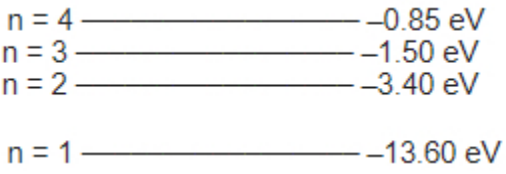
_____

_____

(2)

(Total 8 marks)

3 The diagram below shows part of an energy level diagram for a hydrogen atom.



(a) The level, n = 1, is the ground state of the atom.
State the ionisation energy of the atom in eV.

answer = _____ eV

(1)

(b) When an electron of energy 12.1 eV collides with the atom, photons of three different energies are emitted.

(i) On the diagram above show with arrows the transitions responsible for these photons.

(3)

(ii) Calculate the wavelength of the photon with the smallest energy. Give your answer to an appropriate number of significant figures.

answer = _____ m

(5)

(Total 9 marks)

4 When light of a certain frequency is shone on a particular metal surface, electrons are emitted with a range of kinetic energies.

(a) Explain

- in terms of photons why electrons are released from the metal surface, and
- why the kinetic energy of the emitted electrons varies upto a maximum value.

The quality of your written communication will be assessed in this question.

_____

_____

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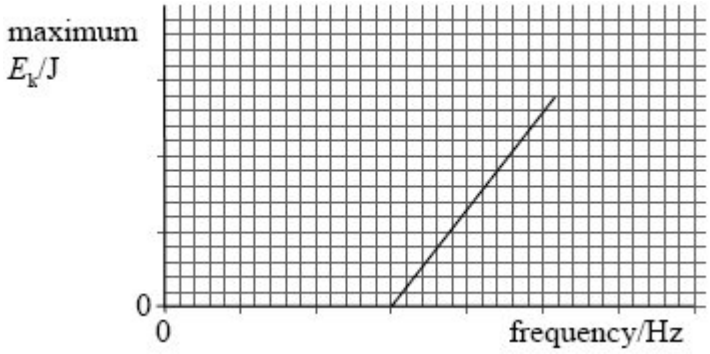
(6)

(b) The graph below shows how the maximum kinetic energy of the electrons varies with the frequency of the light shining on the metal surface.



(i) On the graph mark the *threshold frequency* and label it f_0.

(1)

(ii) On the graph draw a line for a metal which has a higher threshold frequency.

(2)

(iii) State what is represented by the gradient of the graph.

_____

(1)

(c) The threshold frequency of a particular metal surface is 5.6×10^{14} Hz. Calculate the maximum kinetic energy of emitted electrons if the frequency of the light striking the metal surface is double the threshold frequency.

answer = _____ J

(3)

(Total 13 marks)

5 (a) State what is meant by the wave-particle duality of electrons.

_____

_____

_____

(1)

(b) Electrons of wavelength 1.2×10^{-10} m are required to investigate the spacing between planes of atoms in a crystal.

(i) Calculate the momentum of an electron of this wavelength stating an appropriate unit.

momentum of electron = _____

(3)

(ii) Calculate the speed of such an electron.

speed of electron = _____ m s^{-1}

(2)

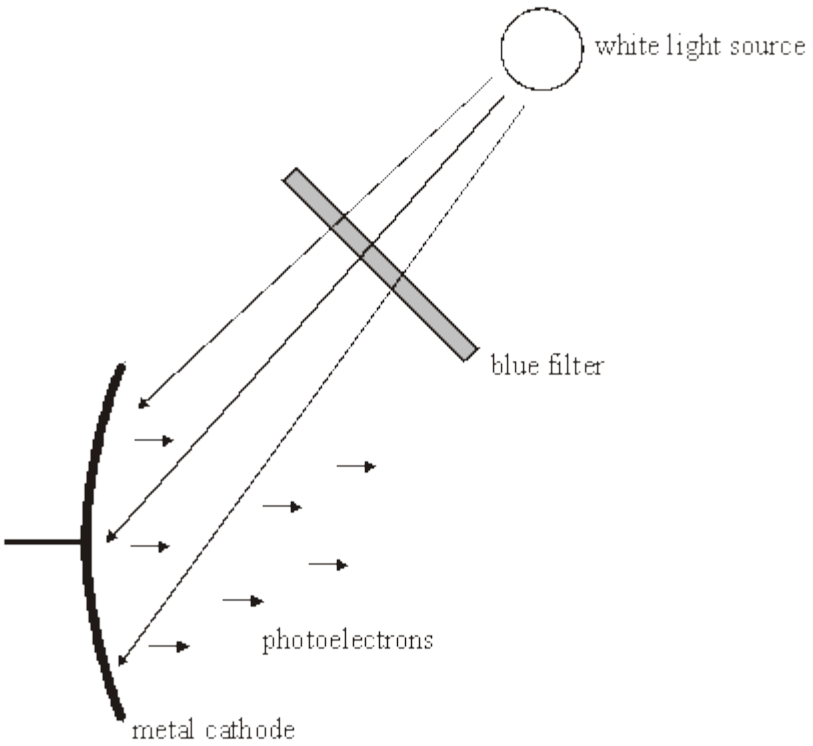
(iii) Calculate the kinetic energy of such an electron.

kinetic energy of electron = _____ J

(2)

(Total 8 marks)

6 The apparatus shown in the figure below can be used to demonstrate the photoelectric effect. Photoelectrons are emitted from the metal cathode when it is illuminated with white light which has passed through a blue filter.



You may be awarded additional marks to those shown in brackets for the quality of written communication in your answers to parts (a) and (b).

(a) The intensity of the light source is reduced. State and explain the effect of this on the emitted photoelectrons.

(3)

(b) Explain why no photoelectrons are emitted when the blue filter is replaced by a red filter.

(3)

(c) When a metal of work function 2.30×10^{-19} J is illuminated with ultraviolet radiation of wavelength 200 nm, photoelectrons are emitted.

Calculate

(i) the frequency of the ultraviolet radiation,

_____

_____

(ii) the threshold frequency of the metal,

_____

_____

_____

(iii) the maximum kinetic energy of the photoelectrons, in J.

_____

_____

_____

_____

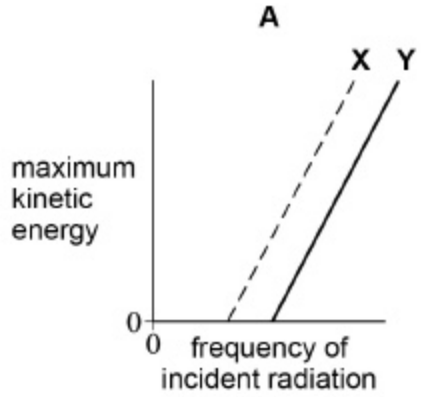
(5)

(Total 11 marks)

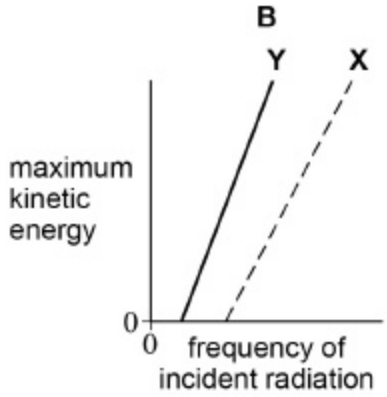
7 Line **X** on the graphs below shows how the maximum kinetic energy of emitted photoelectrons varies with the frequency of incident radiation for a particular metal.

Which graph shows the results for a metal **Y** that has a higher work function than **X**?

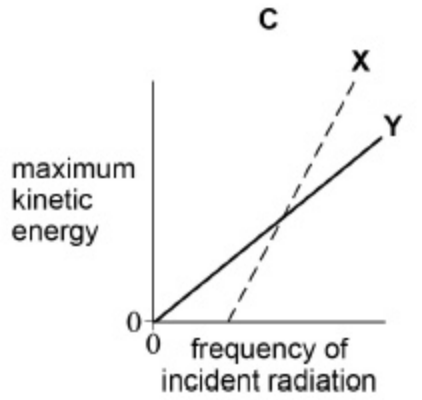
A



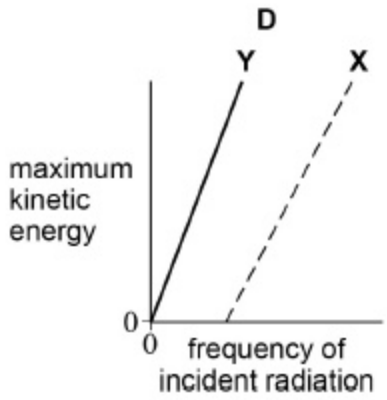
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)

8 Intensity maxima are produced on a screen when a parallel beam of monochromatic light is incident on a diffraction grating. Light of a longer wavelength can be used or the distance from the diffraction grating to the screen can be increased.

Which row gives the change in appearance of the maxima when these changes are made independently?

	Longer wavelength	**Distance from grating to screen increased**	
A	closer together	more widely spaced	⬭
B	more widely spaced	more widely spaced	⬭
C	more widely spaced	closer together	⬭
D	closer together	closer together	⬭

(Total 1 mark)

9 Light of wavelength 500 nm is passed through a diffraction grating which has 400 lines per mm.

What is the angular separation between the two second-order maxima?

A 11.5° ⬭

B 23.1° ⬭

C 23.6° ⬭

D 47.2° ⬭

(Total 1 mark)

10 A beam of light of wavelength λ is incident on a clean metal surface and photoelectrons are emitted. The wavelength of the light is halved but energy incident per second is kept the same.

Which row in the table is correct?

	Maximum kinetic energy of the emitted photoelectrons	**Number of photoelectrons emitted per second**	
A	Increases	Unchanged	⬭
B	Decreases	Increases	⬭
C	Increases	Decreases	⬭
D	Decreases	Unchanged	⬭

(Total 1 mark)

11 When a monochromatic light source is incident on two slits of the same width an interference pattern is produced.

One slit is then covered with opaque black paper.

What is the effect of covering one slit on the resulting interference pattern?

A The intensity of the central maximum will increase ⬭

B The width of the central maximum decreases ⬭

C Fewer maxima are observed ⬭

D The outer maxima become wider ⬭

(Total 1 mark)