Quantum Ideas

Question Paper

Level	Pre U
Subject	Physics
Exam Board	Cambridge International Examinations
Topic	Quantum Ideas
Booklet	Question Paper

Time Allowed: **23 minutes**

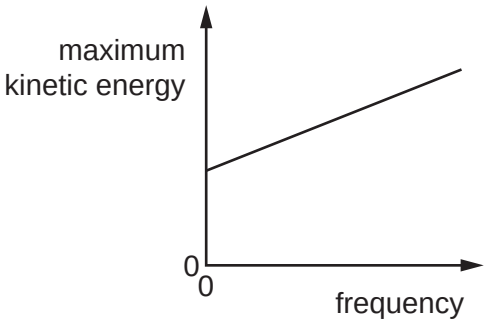
Score: **/19**

Percentage: **/100**

Grade Boundaries:

1 Which graph shows how the maximum kinetic energy of electrons ejected from a metal surface depends on the frequency of electromagnetic radiation absorbed by the surface?

A



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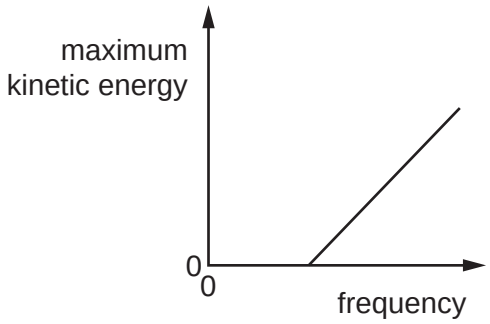

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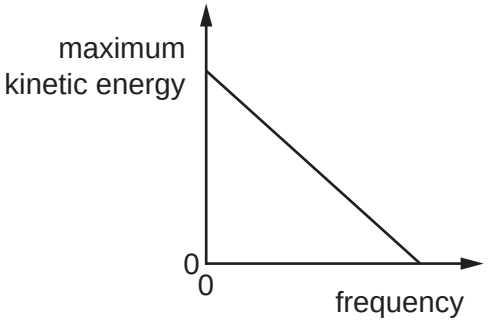

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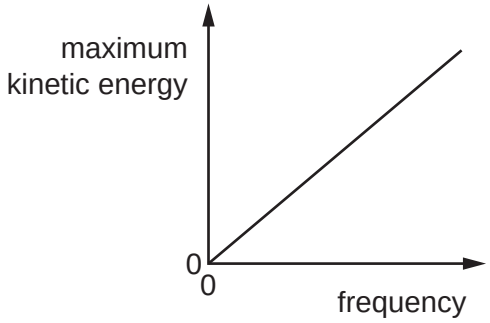

Space for working

2 Electrons are accelerated from rest through a potential difference V.

How is the de Broglie wavelength λ of the electrons related to V?

A $\lambda \propto V$ **B** $\lambda \propto \frac{1}{V}$ **C** $\lambda \propto \sqrt{V}$ **D** $\lambda \propto \frac{1}{\sqrt{V}}$

3 Monochromatic light of wavelength 650 nm is incident on a clean potassium surface.

The work function of potassium is 1.81 eV.

What is the maximum velocity of the electrons emitted?

A $1.3 \times 10^5\,\text{m s}^{-1}$

B $1.9 \times 10^5\,\text{m s}^{-1}$

C $5.2 \times 10^5\,\text{m s}^{-1}$

D $8.2 \times 10^5\,\text{m s}^{-1}$

Space for working

4 An electron of mass m and charge e is accelerated from rest through a potential difference of V.

What is the frequency of a photon whose wavelength is equal to the de Broglie wavelength of this electron? (c is the speed of light and h is the Planck constant.)

A $\frac{c\sqrt{2meV}}{h}$ **B** $\frac{h}{\sqrt{2meV}}$ **C** $\frac{hc}{eV}$ **D** $\frac{eV}{h}$

5 The photoelectric work function for sodium is 3.65×10^{-19} J.

Ultraviolet radiation of frequency 8.90×10^{14} Hz is directed at a clean sodium surface in a vacuum causing photoelectric emission.

What is the kinetic energy of the fastest electrons emitted?

A 2.25×10^{-19} J

B 3.65×10^{-19} J

C 5.90×10^{-19} J

D 9.55×10^{-19} J

6 Two phenomena P and Q are described.

P When ultraviolet light shines on zinc, electrons are emitted from the surface.

Q When electrons are passed through graphite, a pattern of rings may be observed on a screen.

Which different models are used to explain the phenomena?

	P	Q
A	particle	particle
B	particle	wave
C	wave	particle
D	wave	wave

7 In a laser beam, each photon has an energy of 1.9 eV.

What is the wavelength of the electromagnetic waves emitted by the laser?

A 0.65×10^{-6} m **B** 1.0×10^{-6} m **C** 1.2×10^{-6} m **D** 1.4×10^{-6} m

8 In 2010 the Japanese launched the world's first interplanetary solar sail spacecraft, called IKAROS. This works because photons reflected from the sail, of area A, undergo a change of momentum and, by Newton's third Law, exert a forward force on the sail.

A beam of light of intensity I is reflected at right angles to a solar sail.

The momentum of a photon f is given by the expression $\frac{hf}{c}$, where f is the frequency of the light, h is the Planck constant and c is the speed of light.

What is the force exerted on the sail?

A $\frac{IA}{hf}$ **B** $\frac{2hf}{c}$ **C** $\frac{I}{c}$ **D** $\frac{2IA}{c}$

Space for working

9 The Sun has a power output of 3.8×10^{26} W. Approximately 10% of this is given out in the form of visible light. Take the average wavelength of visible light to be 500 nm.

What is the approximate number of photons of visible light that are given out per day by the Sun?

A 10^{44} **B** 10^{45} **C** 10^{49} **D** 10^{50}

10 A laser used as a screen pointer emits light of wavelength λ.

What is its power if it emits n photons per second?

A $\frac{n\lambda}{hc}$

B $\frac{hc}{n\lambda}$

C $\frac{\lambda}{nhc}$

D $\frac{nhc}{\lambda}$

11 In a demonstration of the photoelectric effect, it is found that a stopping potential of 1.70 V is required for the photoelectric current to be reduced to zero. The light used in the demonstration has a frequency of 6.0×10^{14} Hz.

What is the work function of the metal?

A 0.79 eV **B** 2.28 eV **C** 2.49 eV **D** 4.19 eV

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12 When a sample of sodium is illuminated with yellow light electrons are ejected from the surface by the photoelectric effect.

Which row describes what happens when the yellow light source is replaced by a blue light source of the same intensity?

	number of electrons emitted per second	maximum kinetic energy of the electrons
A	decreases	decreases
B	decreases	increases
C	stays the same	decreases
D	stays the same	increases

13 White light falls on a photoelectric surface causing the release of photoelectrons, many of which are moving when released.

The threshold frequency for this surface is 5.3×10^{14} Hz (yellow light).

Which statement is correct?

A If a red filter is interposed, the number of photoelectrons released per second will decrease to zero.

B If a violet filter is interposed, the number of photoelectrons released per second will increase.

C If the light is focussed onto a small patch, the electrons released will, on average, be moving more quickly.

D It takes a little while for enough energy to accumulate on the surface before any photoelectrons are released.

14 What is the energy of a photon of light of wavelength 3.1×10^{-7} m?

A 4.0 eV

B 6.4×10^{-19} eV

C 1.0×10^{-37} eV

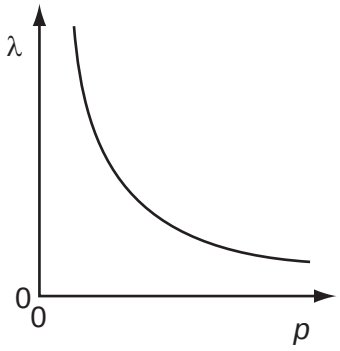
D 2.1×10^{-40} eV

Space for working

15 An electron of momentum p has a corresponding de Broglie wavelength λ.

Which graph shows the relationship between λ and p?

A



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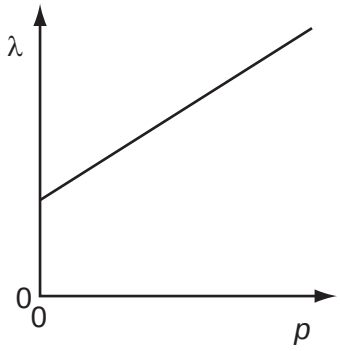

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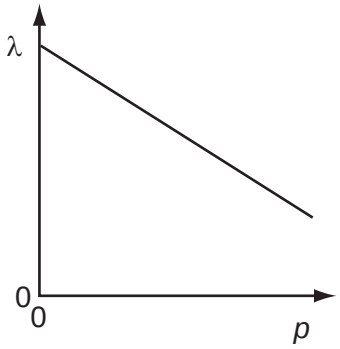

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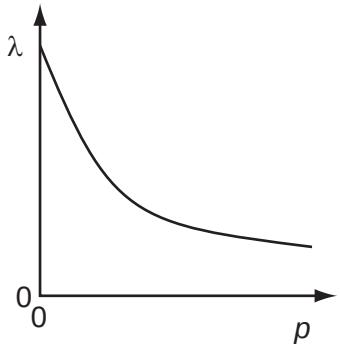


Space for working

16 What is the de Broglie wavelength of an electron having an energy of 54 eV?

A 3.7×10^{-27} m

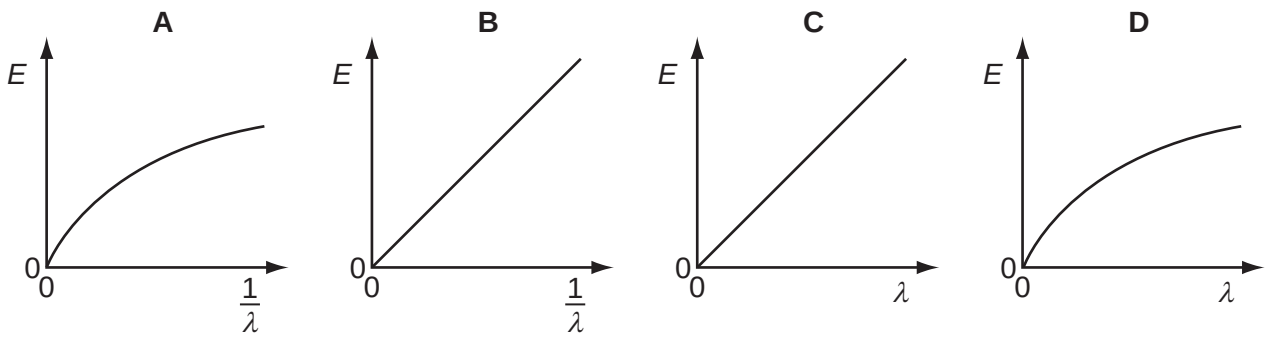
B 6.7×10^{-20} m

C 1.7×10^{-10} m

D 2.3×10^{-8} m

Space for working

17 Which graph shows the relationship between photon energy E and wavelength λ of electromagnetic waves?



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19 Which piece of evidence about the photoelectric effect **cannot** be explained using a wave model?

A Increasing the intensity of the illumination increases the rate at which electrons are ejected.

B Shining ultraviolet radiation onto a zinc surface ejects electrons.

C Shining visible light onto a potassium surface ejects electrons.

D There is a threshold frequency below which no electrons are ejected from a metal surface.

Space for working