Year 12 *Trial Exam Paper*

2017

PHYSICS

Written examination

Worked solutions

This book contains:

- worked solutions
- mark allocations
- explanatory notes
- tips

SECTION A – Multiple-choice questions

Question 1

Answer: D

Explanatory notes

Magnetic field lines run out of a north pole and into a south pole.

Question 2

Answer: B

Explanatory notes

Use the right hand slap rule – fingers point in the direction of the magnetic field lines (right), thumb points in the direction of the current (into the page), palm faces the direction of the force.

Question 3

Answer: A

Explanatory notes

$$F = \frac{kq_1q_2}{r^2}$$

$$= \frac{9.0\times10^9 \times 0.01\times10^{-3} \times 0.03\times10^{-3}}{0.6^2}$$

$$= 7.5 \text{ N}$$

Like charges repel.

Question 4

Answer: A

Explanatory notes

$$W = qV$$

$$= 1.6\times10^{-19} \times 5000$$

$$= 8.0\times10^{-16} \text{ J}$$

Question 5

Answer: D

Explanatory notes

Gravitational fields can attract only, never repel, so Y and Z cannot be gravitational fields.

Question 6

Answer: C

Explanatory notes

$$\left(\frac{0.2}{12.1}+\frac{0.1}{3}\right)\times 100 = 5.0\%$$

Question 7

Answer: B

Explanatory notes

A discrete variable is measured in categories, as opposed to a continuous variable.

Independent variables are deliberately manipulated by the experimenter.

Question 8

Answer: B

Explanatory notes

A controlled variable is kept the same in all tests.

Question 9

Answer: D

Explanatory notes

A dependent variable is measured by the experimenter. An experiment is designed to investigate the effect that the independent variable has on the dependent variable.

Question 10

Answer: C

Explanatory notes

Decreasing energy is the same as increasing wavelength or decreasing frequency.

Question 11

Answer: A

Explanatory notes

The extent of diffraction is proportional to $\frac{\lambda}{w}$. A smaller gap width will result in more diffraction.

Question 12

Answer: D

Explanatory notes

Heisenberg's uncertainty principle states that the more precisely a particle's position is known, the less precisely its momentum can be known, and vice versa. As momentum is the product of mass (scalar) and velocity (vector), it gives information about the future position of the particle.

Question 13

Answer: C

Explanatory notes

$$v = f\lambda$$
$$= 300 \times 0.03$$
$$= 9.0 \text{ m s}^{-1}$$

Question 14

Answer: C

Explanatory notes

The wavelengths are increased by the Doppler effect, which corresponds with a decrease in frequency.

Question 15

Answer: D

Explanatory notes

Harmonics (or overtones) on a fixed string have a wavelength that is an integer multiple of the wavelength of the fundamental frequency $f_n = n f_0$, where $n = 1, 2, 3$ ... .

Question 16

Answer: B

Explanatory notes

A passenger at rest relative to the spaceship will observe no length contraction. Instead, they will measure the 'proper length' of the spaceship.

Question 17

Answer: A

Explanatory notes

Kinetic energy is gained as gravitational potential energy is lost:

$$E_K + U_g = E_{total}$$
$$E_K = -mg\Delta h + E_{total}$$

Hence,

$$\Delta E_K = \Delta E_G$$
$$\Delta E_K = mg\Delta h$$

which is a linear relationship between E_K and Δh with a maximum value of E_K when $h = 0$.

Question 18

Answer: B

Explanatory notes

At the bottom of its swing:

$$T - mg = \frac{mv^2}{r}$$
$$T = \frac{mv^2}{r} + mg$$
$$= \frac{0.06 \times 2.3^2}{0.4} + 0.06 \times 9.8$$
$$= 1.38 \text{ N}$$

Question 19

Answer: A

Explanatory notes

In a synchrotron, electrons are accelerated at close to the speed of light. Magnets are used to change the direction of the electrons, causing high-frequency light to be emitted.

Question 20

Answer: B

Explanatory notes

The stopping voltage is increased until even the most energetic electrons are repelled and the photocurrent drops to zero. This allows the experimenter to calculate the maximum kinetic energy of the ejected electrons.

SECTION B

Question 1a.

Worked solution

$$F = \frac{GM_1M_2}{r^2}$$
$$= \frac{6.67\times10^{-11}\times410\times1.3\times10^{22}}{\left(1.25\times10^7+1.2\times10^6\right)^2}$$
$$= 1.9 \text{ N}$$

Mark allocation: 3 marks

- 1 mark for correct calculation of radius (12 500 000 m + 1 200 000 m = 1.37×10^7 m)
- 1 mark for correct calculation of force (award this mark even if altitude is used instead of radius; e.g. F = 2.3 N if $r = 1.25 \times 10^7$ m)
- 1 mark for using two significant figures in the answer

Tip

- *Remember that orbital radius, not altitude, is used in calculations such as this.*

Question 1b.

Worked solution

Find the area under the graph (12 squares) and multiply by the mass of the probe:

$$12\times2.5\times10^6\times1.0\times10^{-3} = 30\,000 \text{ J kg}^{-1}$$
$$30\,000\times410 = 1.23\times10^7 \text{ J}$$

Mark allocation: 3 marks

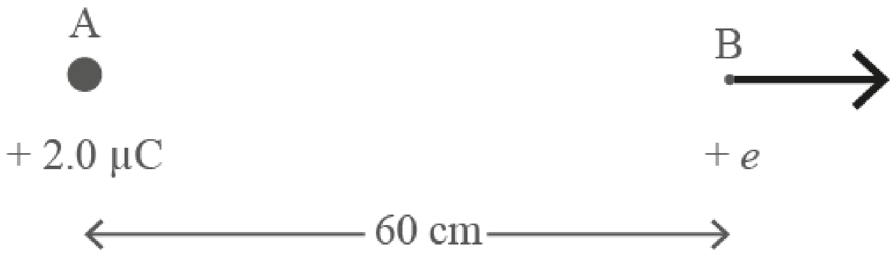
- 1 mark for attempting to find the area under the graph (even if incorrect)
- 1 mark for calculating the correct area under the graph (accept 11–12 squares, 28 750 ± 250 J kg^{-1})
- 1 mark for finding the correct energy (accept from 1.1×10^7 J to 1.3×10^7 J)

Tip

- *The following rules may help you to count squares more quickly – if more than half a square is filled, count it as 1. If less than half a square is filled, count it as 0.*

Question 2a.

Worked solution



Mark allocation: 1 mark

- 1 mark for an arrow from point *B*, horizontally to the right

Question 2b.

Worked solution

$$E = \frac{kq}{r^2}$$
$$= \frac{9.0\times10^{9}\times2.0\times10^{-6}}{0.6^2}$$
$$= 5.0\times10^{4}\ \text{N C}^{-1}$$

Mark allocation: 2 marks

- 1 mark for substituting values correctly
- 1 mark for the correct answer

Tip

- *A very common mistake is forgetting to square the radius when entering values into a calculator. Ensure that you check the values before entering them into your calculator.*

Question 3a.

Worked solution

Worked solution

$$F = qvB$$
$$= 1.6\times10^{-19}\times1.5\times10^{7}\times8.0\times10^{-3}$$
$$= 1.92\times10^{-14}\ \text{N}$$

Mark allocation: 2 marks

- 1 mark for substituting values correctly
- 1 mark for the correct answer

Question 3b.

Worked solution

Option C – down the page.

Mark allocation: 1 mark

- 1 mark for the correct answer

Explanatory note

Use the right hand slap rule: The thumb points in the direction of the current (opposite to the direction of electron motion) and the fingers point in the direction of the magnetic field. The palm points in the direction of the force.

Question 3c.

Worked solution

$$r = \frac{mv}{qB}$$
$$= \frac{9.1\times10^{-31}\times1.5\times10^{7}}{1.6\times10^{-19}\times8.0\times10^{-3}}$$
$$= 0.011\ \text{m}$$

Mark allocation: 2 marks

- 1 mark for substituting values correctly
- 1 mark for the correct answer

Note: Consequential marks awarded if $r = \dfrac{mv^2}{\text{answer 3a.}}$ is used.

Question 4a.

Worked solution

Clockwise

Current flows in the direction $D \rightarrow C \rightarrow B \rightarrow A$.

The force on side *DC* is down and the force on side *AB* is up, according to the right hand slap rule.

Mark allocation: 3 marks

- 1 mark for the correct direction
- 1 mark for correctly identifying the direction of current flow through at least one side of the loop
- 1 mark for correctly identifying the direction of the force on at least one side of the loop

Question 4b.

Worked solution

The direction of the current flowing in the coil will reverse.

This ensures that the coil continues to rotate in the same direction.

Mark allocation: 2 marks

- 1 mark for identifying the reversal of current flow
- 1 mark for identifying continuous rotation

Question 5a.

Worked solution

$$\begin{aligned}\Phi &= BA \\ &= 6.0\times10^{-3}\times0.03 \\ &= 1.8\times10^{-4}\ \text{Wb}\end{aligned}$$

Mark allocation: 2 marks

- 1 mark for the correct value for flux
- 1 mark for the correct unit

Tip

- *Calculations of flux do not include the number of loops,* n.

Question 5b.

Worked solution

Find the time taken for one-quarter turn of the coil:

$$\begin{aligned}\Delta t &= \frac{1}{4}\times\frac{1}{20} \\ &= 0.0125\ \text{s}\end{aligned}$$

Calculate EMF:

$$\begin{aligned}\varepsilon &= N\frac{\Delta\Phi}{\Delta t} \\ &= 200\times\frac{1.8\times10^{-4}}{0.0125} \\ &= 2.9\ \text{V}\end{aligned}$$

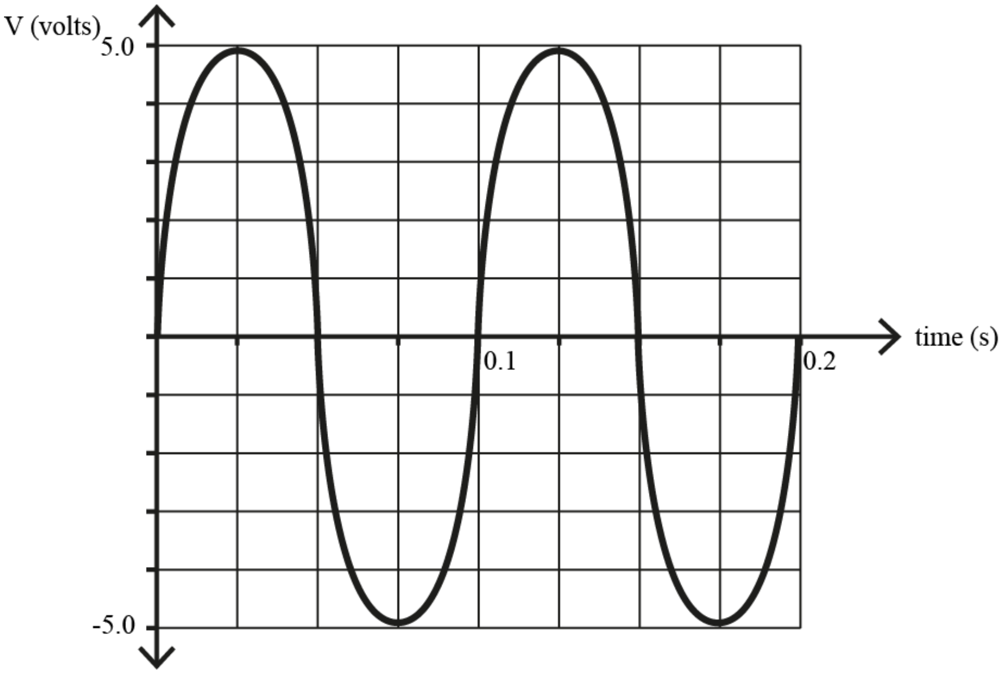
Mark allocation: 2 marks

- 1 mark for the correct Δt value
- 1 mark for the correct answer

Question 5c.

Worked solution

$$V_{\text{peak}} = V_{\text{RMS}} \times \sqrt{2}$$
$$= 3.5 \times \sqrt{2}$$
$$= 4.9 \text{ V}$$



Note that the opposite phase (flipped graph) is equally correct.

Mark allocation: 2 marks

- 1 mark for a graph that peaks at ± 4.9 V (5 V is acceptable)
- 1 mark for any sinusoidal curve that shows alternating current and that has a period of 0.1 second

Question 6a.

Worked solution

$$v = f\lambda$$
$$340 = 500 \times \lambda$$
$$\lambda = \frac{340}{500}$$
$$= 0.68 \text{ m}$$

Question 6b.

Worked solution

	Perception of sound
At *L*	Louder than normal (constructive interference)
From *L* to *M*	Alternating loud and soft (nodes and antinode)
At *M*	Quieter than normal (path difference = $\frac{3.8-1.14}{0.76} = 3.5\lambda$, destructive interference)

Mark allocation: 3 marks

- 1 mark for each correct answer listed in the table (up to 3 marks)

Question 6c.

Worked solution

Bess hears the 1000 Hz tone more loudly than the 11 000 Hz tone.

The lower frequency tone has a larger wavelength than the higher frequency tone.

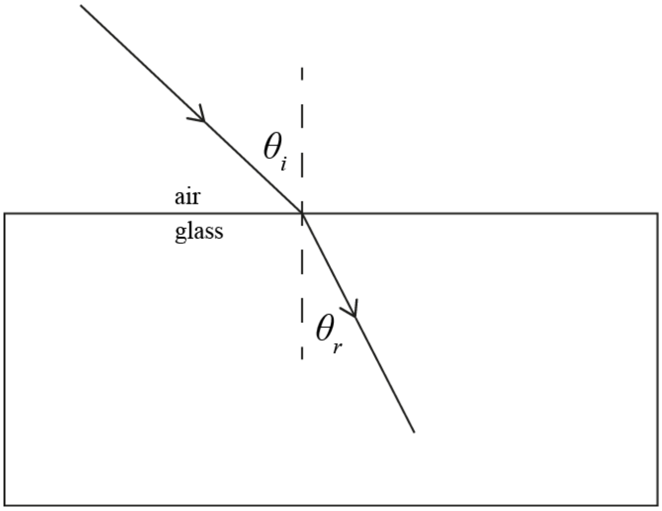
The larger wavelength means the 1000 Hz tone undergoes more diffraction.

Mark allocation: 3 marks

- 1 mark for identifying the 1000 Hz tone is louder
- 1 mark for comparing the wavelengths
- 1 mark for mentioning different levels of diffraction are caused by the wavelengths

Question 7a.

Worked solution



Mark allocation: 2 marks

- 1 mark for the correct location of θ_i
- 1 mark for the correct location of θ_r

Note: No marks will be awarded if the normal line is not included (need not be dotted or labelled).

Question 7b.

Worked solution

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$1.00\sin(38.7°) = n_2 \sin(23.8°)$$

$$n_2 = \frac{1.00\sin(38.7°)}{\sin(23.8°)}$$

$$= 1.55$$

Mark allocation: 2 marks

- 1 mark for substituting values correctly
- 1 mark for the correct answer

Question 7c.

Worked solution

Glass into air

$$\sin\theta_c = \frac{n_2}{n_1}$$

$$\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

$$= \sin^{-1}\left(\frac{1.00}{1.55}\right)$$

$$= 40.2°$$

Mark allocation: 2 marks

- 1 mark for the correct direction (i.e. glass into air)
- 1 mark for the correct calculation

Question 8

Worked solution

The students observe no light passing through the second filter.

This result suggests that light is made up of transverse waves.

Mark allocation: 2 marks

- 1 mark for stating that no light passes through the second filter
- 1 mark for describing light as a transverse wave

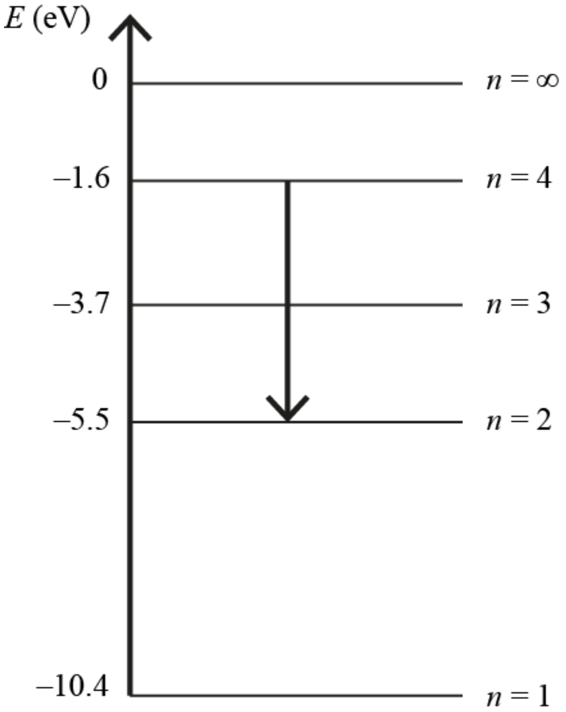
Question 9a.

Worked solution

$$E = hf$$
$$= 4.14\times10^{-15}\times9.42\times10^{14}$$
$$= 3.90 \text{ eV}$$

For the transition $n = 4$ to $n = 2$:

$$\Delta E = 5.5 - 1.6$$
$$= 3.9 \text{ eV}$$



Mark allocation: 3 marks

- 1 mark for the correct energy
- 1 mark for an arrow between $n = 4$ and $n = 2$
- 1 mark if the arrow is downwards (between any energy levels)

Tip

- *Emitted photons are always the result of a transition towards the ground state (a downwards arrow).*

Question 9b.

Worked solution

Electrons have wavelengths that are dependent on their energy $E = \frac{hc}{\lambda}$.

Electrons form standing waves when their orbit is an integer multiple of their wavelength.

Only electrons with energies corresponding to these wavelengths are permitted.

Mark allocation: 3 marks

- 1 mark for mentioning electron wavelength
- 1 mark for linking wavelength with energy or momentum (equation not required)
- 1 mark for mentioning standing waves

Question 10a.

Worked solution

$$V_{\text{drop}} = I \times R = 10 \times 6 = 60\ \text{V}$$

$$V_{\text{supply}} = 250 - 60 = 190\ \text{V}$$

Mark allocation: 2 marks

- 1 mark for the calculation of V_{drop}
- 1 mark for the calculation of V_{supply}

Question 10b.

Worked solution

10 ÷ 5 = 2.0 A

Mark allocation: 1 mark

- 1 mark for the calculation of the current

Explanatory note

As the current passes from the transmission lines to the house, the 5 : 1 step-down transformer will step-up the current by a factor of 5. Therefore, the current in the transmission lines is 5 times lower than in the house.

Question 10c.

Worked solution

$$P_{\text{loss}} = I^2 R = 2^2 \times 6 = 24\ \text{W}$$

$$\frac{24}{2500} \times 100 = 0.96\%$$

Mark allocation: 3 marks

- 1 mark for $P_{\text{loss}} = I^2 R$
- 1 mark for the correct power loss (24 W)
- 1 mark for the correct percentage calculation (0.96%)

Tip

- *When power is lost in transmission lines, the current is not affected (recall Kirchhoff's current law). The resistance of the transmission lines causes a drop in electrical potential energy (voltage).*

Question 11a.

Worked solution

$$\begin{aligned} E_K &= E_g \\ &= mg\Delta h \\ &= 200 \times 9.8 \times 2.5 \\ &= 4900 \text{ J} \end{aligned}$$

Mark allocation: 2 marks

- 1 mark for $E_K = E_g$
- 1 mark for the correct answer

Tip

- *In 2017, VCAA asks students to use* g *= 9.8 m* s^{-2}*. In previous years the value has been 10 m* s^{-2}*. You should get into the habit of using the more precise value.*

Question 11b.

Worked solution

$$\begin{aligned} m_1 v_1 &= m_2 v_2 \\ 200 \times 20 &= 285 \times v_2 \\ v_2 &= \frac{4000}{285} \\ &= 14 \text{ m s}^{-1} \end{aligned}$$

Mark allocation: 2 marks

- 1 mark for a correct statement of conservation of momentum (e.g. $m_1 v_1 = m_2 v_2$)
- 1 mark for the correct answer

Question 11c.

Worked solution

In an elastic collision, kinetic energy is conserved:

$$E_{\text{K(initial)}} = \frac{1}{2}mv^2$$
$$= \frac{1}{2} \times 200 \times 20^2$$
$$= 40\ 000 \text{ J}$$
$$E_{\text{K(final)}} = \frac{1}{2} \times 285 \times 14^2$$
$$= 27\ 930 \text{ J}$$

As kinetic energy is not conserved, the collision is inelastic.

Mark allocation: 2 marks

- 1 mark for an attempt to calculate kinetic energy before AND after the collision
- 1 mark for the correct values of kinetic energy

Note: Consequential marks awarded for $E_{\text{K(final)}} = \frac{1}{2} \times 285 \times$ [answer from **part b.**]^2.

Tip

- *Remember that momentum is conserved in all collisions, but kinetic energy is conserved only in elastic collisions.*

Question 11d.

Worked solution

The lost gravitational potential energy was used to break the wood.

$$mg\Delta h_1 = E_{\text{wood}} + mg\Delta h_2$$
$$200 \times 9.8 \times 5 = E_{\text{wood}} + 200 \times 9.8 \times 1.3$$
$$E_{\text{wood}} = 7252 \text{ J}$$

Mark allocation: 2 marks

- 1 mark for a correct expression of energy conservation
- 1 mark for the correct answer

Tip

- *A good approach to energy conservation questions is to set out an equation that shows energy before the collision = energy after the collision.*

Question 12

Worked solution

First, find the angle at the top of the triangle, between the string and the pole:

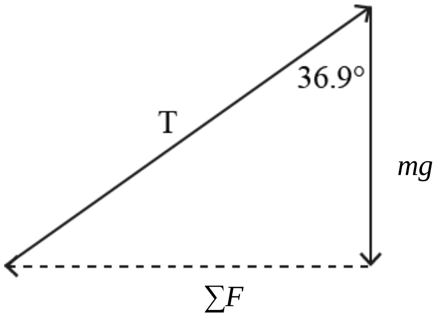
$$\cos\theta = \frac{12}{15}$$

$$\theta = \cos^{-1}\left(\frac{12}{15}\right)$$

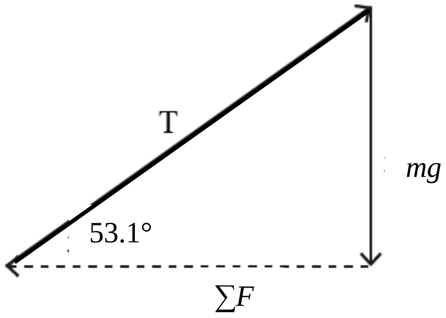
$$= 36.9°$$

(Alternatively, the angle between the string and the horizontal may be calculated, which gives $\theta = 53.1°$.)

Next, draw a triangle to represent the forces that act on the ball.



OR



Finally, solve to find the net force:

$$\tan 36.9° = \frac{\Sigma F}{mg}$$

$$\Sigma F = mg \tan 36.9°$$

$$= 0.063 \times 9.8 \times \tan 36.9°$$

$$= 0.46 \text{ N}$$

OR

$$\tan 53.1° = \frac{mg}{\Sigma F}$$

$$\Sigma F = \frac{mg}{\tan 53.1°}$$

$$\Sigma F = \frac{0.063 \times 9.8}{\tan 53.1°}$$

$$= 0.46 \text{ N}$$

Mark allocation: 3 marks

- 1 mark for correctly calculating the angle
- 1 mark for correctly substituting values into the 'tan θ' equation
- 1 mark for the correct answer

Tip

- *When using triangles like these, make sure you don't combine force quantities (i.e. tension, weight etc.) with dimension quantities (i.e. length, radius etc.).*

Question 13a.

Worked solution

In the vertical component:

$$u = 0 \text{ m s}^{-1}$$
$$a = -9.8 \text{ m s}^{-2}$$
$$s = -2 \text{ m}$$
$$t = ?$$
$$s = ut + \frac{1}{2}at^2$$
$$-2 = 0 \times t + \frac{1}{2} \times -9.8 \times t^2$$
$$t = \sqrt{\frac{2}{4.9}}$$
$$= 0.639 \text{ s}$$

In the horizontal component:

$$s = 5.0 \text{ m}$$
$$t = 0.639 \text{ s}$$
$$s = ut$$
$$5.0 = u \times 0.639$$
$$u = \frac{5.0}{0.639}$$
$$= 7.8 \text{ m s}^{-1}$$

Mark allocation: 3 marks

- 1 mark for correctly substituting into the horizontal calculation
- 1 mark for the correct flight time
- 1 mark for the correct answer

Question 13b.

Worked solution

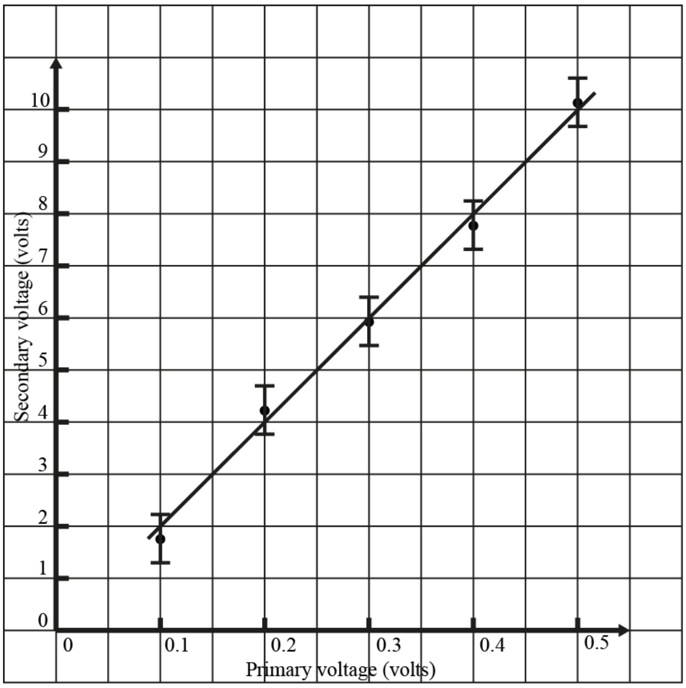
$$u = 4.9 \text{ m s}^{-1}$$
$$a = -9.8 \text{ m s}^{-2}$$
$$s = -6 \text{ m}$$
$$v = ?$$
$$v^2 = u^2 + 2as$$
$$= 4.9^2 + 2 \times -9.8 \times -6$$
$$v = \sqrt{4.9^2 + 2 \times -9.8 \times -6}$$
$$= 11.9 \text{ m s}^{-1}$$

Mark allocation: 2 marks

- 1 mark for substituting correctly
- 1 mark for the correct answer

Question 14a.

Worked solution



Mark allocation: 5 marks

- 1 mark for the correct scale and label on the *x*-axis
- 1 mark for the correct scale and label on the *y*-axis
- 1 mark for correctly plotted points
- 1 mark for correct uncertainty bars
- 1 mark for a correct trend line

Note: Subtract 1 mark if the axes are reversed (i.e. primary on the vertical axis, secondary on the horizontal axis).

Question 14b.

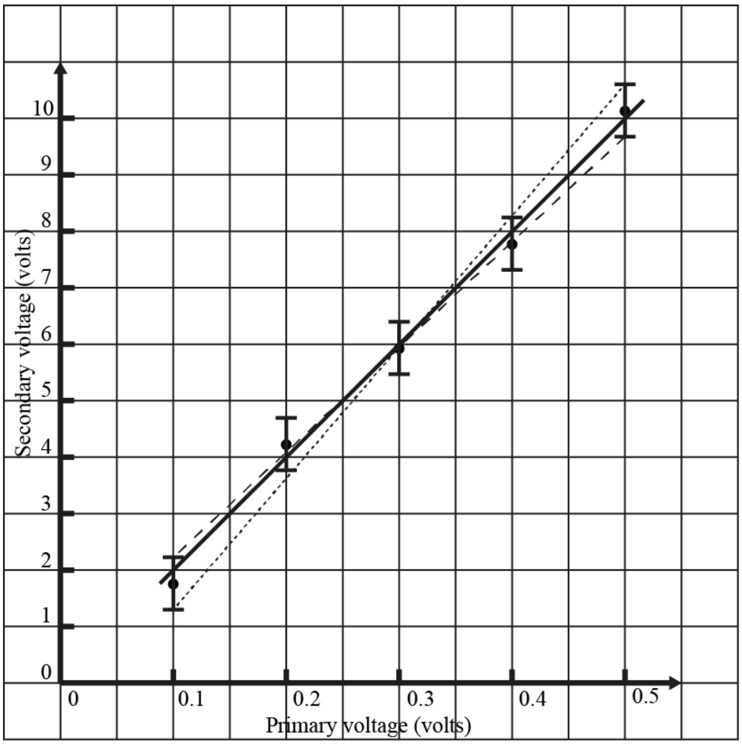
Answer

Highest possible value: 23.25

Lowest possible value: 18.5

Worked solution

Use the error bars on the first and last point to draw lines with the maximum and minimum gradient, as shown below. Calculate the gradient of each line.



Maximum gradient:

$$\frac{10.5-1.2}{0.5-0.1}=23.25$$

Minimum gradient:

$$\frac{9.6-2.2}{0.5-0.1}=18.5$$

Mark allocation: 3 marks

- 1 mark for an attempt to calculate the gradient of the trend lines
- 1 mark for the correct maximum gradient (accept 22.75 to 23.75)
- 1 mark for the correct minimum gradient (accept 18 to 19)

Question 15a.

Worked solution

Chris is at rest relative to the object being measured and so records the proper length of the train.

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$= \frac{1}{\sqrt{1-0.98^2}}$$

$$= 5.03$$

$$l = \frac{l_0}{\gamma}$$

$$l = \frac{10}{5.03}$$

$$= 2.0 \text{ m}$$

Mark allocation: 2 marks

- 1 mark for the correct Lorentz factor (γ)
- 1 mark for the correct answer

Note: 1 mark should be awarded for an answer of 50 m if the correct value of γ is used but applied incorrectly.

Tip

- *Make sure you are consistently able to identify proper length and proper time correctly.*

Question 15b.

Worked solution

Deb is at rest relative to the falling ball, so she records the proper time.

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$= \frac{1}{\sqrt{1-\left(\frac{2.97}{3.00}\right)^2}}$$

$$= 7.09$$

$$t = t_0\gamma$$

$$4.0 = t_0 \times 7.09$$

$$t_0 = \frac{4.0}{7.09}$$

$$= 0.56 \text{ s}$$

Mark allocation: 2 marks

- 1 mark for the correct Lorentz factor (γ)
- 1 mark for the correct answer

Question 15c.

Answer

Neither

Worked solution

Einstein’s first postulate states that the laws of physics are the same for all observers. This means that no law of physics can identify a state of absolute rest.

Mark allocation: 3 marks

- 1 mark for circling ‘Neither’
- 1 mark for correctly stating (or paraphrasing) Einstein’s first postulate
- 1 mark for stating that absolute rest does not exist or cannot be identified

Question 15d.

Worked solution

$$\begin{aligned} E &= 25\times10^{6}\ \text{eV} \\ &= 25\times10^{6}\times1.6\times10^{-19} \\ &= 4.0\times10^{-12}\ \text{J} \end{aligned}$$

$$\begin{aligned} E &= \Delta mc^{2} \\ 4.0\times10^{-12} &= \Delta m\times9.0\times10^{16} \\ \Delta m &= 4.4\times10^{-29}\ \text{kg} \end{aligned}$$

No protons or neutrons are destroyed.

Mark allocation: 3 marks

- 1 mark for the correct conversion to joules
- 1 mark for the correct value for mass
- 1 mark for identifying that no particles are destroyed

Note: Some protons are converted to neutrons in this process.

Question 16a.

Worked solution

The work done by the electron gun is equal to the kinetic energy of the electron. Once the velocity of the electron is found, the wavelength can be calculated.

$$\begin{aligned} \frac{1}{2}mv^{2} &= qV \\ \frac{1}{2}\times9.11\times10^{-31}\times v^{2} &= 1.6\times10^{-19}\times15 \\ v &= \sqrt{\frac{1.6\times10^{-19}\times15}{\frac{1}{2}\times9.11\times10^{-31}}} \\ &= 2.30\times10^{6}\ \text{m s}^{-1} \end{aligned}$$

$$\begin{aligned} \lambda &= \frac{h}{mv} \\ &= \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times2.30\times10^{6}} \\ &= 3.17\times10^{-10}\ \text{m} \end{aligned}$$

Mark allocation: 3 marks

- 1 mark for the correct velocity
- 1 mark for substituting correctly into the De Broglie wavelength formula
- 1 mark for the correct answer

Question 16b.

Worked solution

The radiation must consist of photons with the same wavelength as the electrons.

$$c = f\lambda$$

$$f = \frac{c}{\lambda}$$

$$= \frac{3.0 \times 10^{8}}{3.2 \times 10^{-10}}$$

$$= 9.38 \times 10^{17} \text{ Hz}$$

Mark allocation: 2 marks

- 1 mark for substituting correctly
- 1 mark for the correct answer

Question 16c.

Worked solution

$$p_{\text{flea}} = mv$$

$$= 200 \times 10^{-6} \times 2.0$$

$$= 4.0 \times 10^{-4} \text{ kg m s}^{-1}$$

$$p_{\text{violet}} = \frac{h}{\lambda}$$

$$= \frac{6.63 \times 10^{-34}}{400 \times 10^{-9}}$$

$$= 1.66 \times 10^{-27} \text{ kg m s}^{-1}$$

$$\frac{4.0 \times 10^{-4}}{1.66 \times 10^{-27}} = 2.4 \times 10^{23} \text{ photons}$$

Mark allocation: 3 marks

- 1 mark for the correct momentum of the flea
- 1 mark for the correct momentum of the violet photon
- 1 mark for the correct answer

Question 17a.

Worked solution

Under the wave model:

- The kinetic energy of ejected electrons should be proportional to the intensity of incident light.
- Electrons should be ejected from the metal by light at any frequency above a minimum intensity.
- A time delay should be observed, particularly at low intensities, as energy is gradually transferred to the metal by the light waves.

Mark allocation: 3 marks

- 1 mark for relating kinetic energy to light intensity
- 1 mark for mentioning that any frequency of light should eject electrons
- 1 mark for mentioning a time delay

Tip

- *These questions may be answered in dot points. You may find this a quicker and easier way to express your ideas.*

Question 17b.

Worked solution

Newton claimed that time and space were absolute and unchanging.

Einstein claimed that time would dilate and that space would contract relative to a stationary observer.

Experiments with atomic clocks and the observation of muons on the Earth's surface support Einstein's conclusions.

Mark allocation: 4 marks

- 1 mark for describing Newton's idea of absolute time and space
- 1 mark for mentioning time dilation
- 1 mark for mentioning length contraction
- 1 mark for mentioning muons or atomic clocks

Question 17c.

Worked solution

$$E_{\text{K(classical)}} = \frac{1}{2} \times m \times v^2$$
$$= \frac{1}{2} \times 10.0 \times \left(0.7 \times 3.0 \times 10^8\right)^2$$
$$= 2.2 \times 10^{17} \text{ J}$$

$$E_{\text{K(relativistic)}} = \left(\gamma - 1\right) \times m \times c^2$$
$$= \left(1.4 - 1\right) \times 10.0 \times \left(3.0 \times 10^8\right)^2$$
$$= 3.6 \times 10^{17} \text{ J}$$

The relativistic calculation is the most appropriate to use in this circumstance.

Mark allocation: 3 marks

- 1 mark for correctly calculating classical kinetic energy
- 1 mark for correctly calculating relativistic kinetic energy
- 1 mark for identifying relativistic kinetic energy as being the most appropriate

Question 18a.

Worked solution

Use the work function to calculate the threshold frequency:

$$W = h f_0$$

$$2.9 = 4.14 \times 10^{-15} \times f_0$$

$$f_0 = \frac{2.9}{4.14 \times 10^{-15}}$$

$$= 7.0 \times 10^{14} \text{ Hz}$$

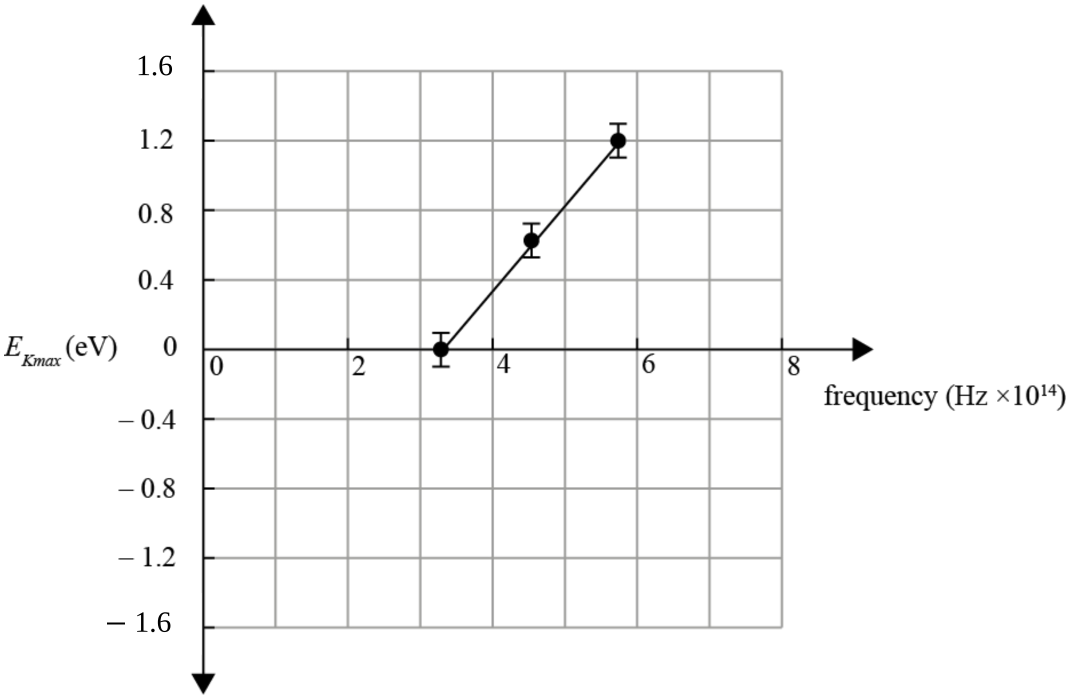
Mark allocation: 2 marks

- 1 mark for attempting to use the work function
- 1 mark for the correct answer

Question 18b.

Worked solution

Draw a trend line for the data.



Calculate the gradient of the trend line:

$$h = \frac{1.2 - 0}{(5.7 - 3.2) \times 10^{14}}$$

$$= 4.8 \times 10^{-15} \text{ eV s}$$

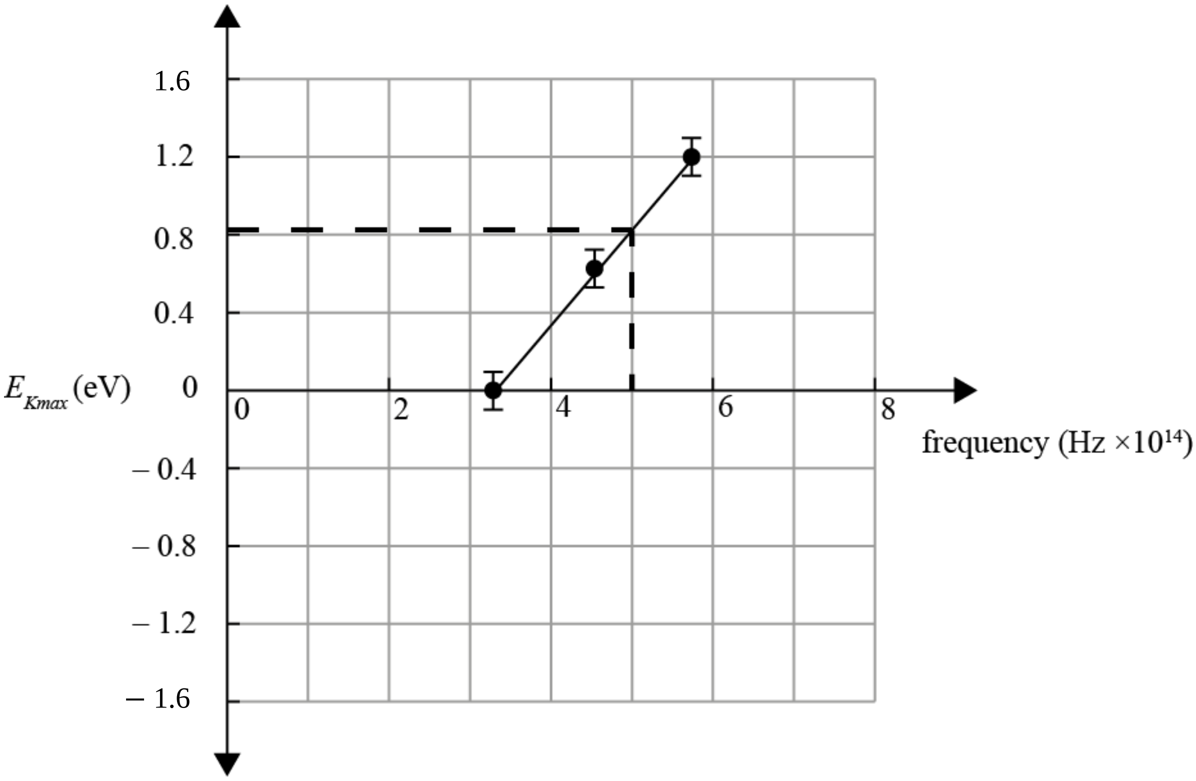
Mark allocation: 3 marks

- 1 mark for drawing the trend line
- 1 mark for attempting to find the gradient
- 1 mark for the correct gradient (accept from 4.7×10^{14} to 4.9×10^{14} eV s)

Question 18c.

Worked solution

Use the trend line to predict the E_{Kmax}.



Convert from eV to V.

E_{Kmax} = 0.81 eV indicates V_0 = 0.81 volts.

Mark allocation: 1 mark

- 1 mark for indicating use of the trend line to predict the value of E_{Kmax} (accept 0.70 to 0.90 volts)

END OF WORKED SOLUTIONS