2024 -2027 VCE Physics Units 3 and 4 Examination Suggested Answers

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SECTION A (1 mark each)

Question 1 Answer: B
v_H – remains constant
v_V – Goes from maximum to zero at the maximum height and then to maximum in the opposite direction.

Question 2 Answer: C
Using the right-hand rule: *I* – initially to the left; *F* – down, therefore, *B* – into the page

Question 3 Answer: A
$r = \frac{mv}{qB} \quad \therefore r \propto v$

Question 4 Answer: B
$$F = \frac{kq_1q_2}{r^2} = \frac{(8.99 \times 10^9)(3 \times 10^{-6})(4 \times 10^{-6})}{(3 \times 10^{-3})^2} = 11986.7 \text{ N}$$

Question 5 Answer: D
Using the right-hand grip rule: P – out of the page Q – into the page

Question 6 Answer: C
$\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t}$ and $T = \frac{1}{f}$
If frequency is halved, period will double (2*T*) and peak emf halve $\left(\frac{E}{2}\right)$.

Question 7 Answer: C
2nd dark fringe from the centre: pd = $\frac{3}{2}\lambda = \frac{3}{2}x$

Question 8 Answer: C
Elastic potential energy converts into kinetic energy:
$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$
$v \propto x$

Question 9 Answer: D
In circular motion, there must be a centripetal force acting towards the center of the circle (in this case, the planet) that keeps the satellite in orbit. For a satellite orbiting a planet, this centripetal force is provided by the gravitational force between the satellite and the planet. This gravitational force provides the necessary acceleration towards the center of the planet, keeping the satellite in its stable circular path.

Question 10 Answer: B
The time of flight of a projectile depends on its vertical motion because it determines how long the projectile remains in the air. The vertical component of the initial velocity determines how high the projectile goes and how long it takes to come back down. By decreasing the vertical component of the initial velocity, the ball's trajectory becomes shallower, reducing the maximum height it reaches and thereby shortening the time it takes for the ball to return to the ground.

Question 11 Answer: A

$\lambda = \frac{h}{p} = \frac{h}{mv}$

De Broglie wavelength is inversely proportional to mass.

Question 12 Answer: C

High voltage transmission minimizes the effects of electrical resistance in the wires ($P_{loss} = I^2R$), leading to more efficient transmission of electrical energy over long distances.

Question 13 Answer: B

emf is the negative rate of change of magnetic flux.

Question 14 Answer: C

Increasing the intensity without changing frequency increases the number of photons reaching the electrode each second, but not their individual energy. This increases the rate of electron emission without changing the energy transferred to each electron and therefore there is no change in maximum velocity.

Question 15 Answer: D

Using energy conservation:

$mgH = mgh + \frac{1}{2}m(v_B)^2$

$v_B = \sqrt{2g(H-h)}$

Question 16 Answer: B

The horizontal component is constant throughout the flight = speed at point B

Question 17 Answer: B

Using energy conservation:

$mgH = \frac{1}{2}m(v_C)^2$

$v_C = \sqrt{2gH}$

Question 18 Answer: C

Resolution refers to the ability of an imaging system to distinguish between closely spaced objects or details in an image. It is typically quantified by the smallest distance between two distinct points that can still be resolved as separate entities. Higher resolution allows for better discrimination between closely spaced objects, whereas lower resolution can cause them to appear merged or indistinguishable

Question 19 Answer: A

The emission of photoelectrons depends on the energy of individual photons rather than the intensity or duration of exposure of light.

Question 20 Answer: D

When the photons collide with an electron near the surface of the metal, its energy is acquired by the electron which may then escape from the metal if the energy is greater than work function of the metal.

SECTION B

A suggested marking scheme is marked in red. Alternative correct methods should also be considered.

Question 1 (3 marks)

$\varepsilon = Blv = 0.6 \times 3 \times 4 = 7.2\ V$ (1)

$I = \frac{V}{R} = \frac{7.2}{12}$ (1)

$I = 0.6\ \text{A}$ (1)

Question 2 (5 marks)

a. 2 marks

$m_1u_1 + m_2u_2 = (m_1 + m_2)v$

$2 \times 3.5 + 3 \times 1 = (2 + 3)v$ (1)

$v = \frac{10}{5}$ (1)

$v = 2\ \text{m s}^{-1}$

b. 3 marks

Before collision:

$E_k = \frac{1}{2} \times 2 \times 3.5^2 + \frac{1}{2} \times 3 \times 1.0^2 = 13.75\ \text{J}$ (1)

After collision:

$E_k = \frac{1}{2} \times (2 + 3) \times 2^2 = 10\ \text{J}$ (1)

Inelastic collision (1)

Question 3 (6 marks)

a. 3 marks

$A = \pi r^2 = \pi \times 0.05^2 = 0.008\ \text{m}^2$ (1)

$\Phi_B = B_\perp A = 0.15 \times 0.008 = 0.0012\ \text{Wb}$ (1)

$\varepsilon = \frac{\Delta\Phi_B}{\Delta t} = \frac{0.0012}{0.5} = 0.0024\ \text{V}$ (1)

b. 3 marks

Clockwise (1)

Initially the flux is downwards and decreasing. (1)

To oppose this, induced flux is increasing downwards. (1)

Question 4 (5 marks)

a. 2 marks

$I = \Delta p = m(v - u)$

$I = 90(0 - 27)$ (1)

$I = 2430$ N (1)

b. 2 marks

$I = F\Delta t$

$F = \frac{I}{\Delta t} = \frac{2430}{40 \times 10^{-3}}$ (1)

$F = 60750$ N (1)

c. 1 mark

It is converted into other forms of energy such as heat and sound.

Question 5 (10 marks)

a. 2 marks

$g = \frac{GM}{r^2}$

$r = \sqrt{\frac{GM}{g}} = \sqrt{\frac{\left(6.67 \times 10^{-11}\right)\left(5.68 \times 10^{26}\right)}{10.9}}$ (1)

$r = 5.90 \times 10^{7}$ m (1)

b. 3 marks

$r = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$ (1)

$r = \sqrt[3]{\frac{(6.67 \times 10^{-11})(5.68 \times 10^{26})(35100)^2}{4\pi^2}}$ (1)

$r = 1.06 \times 10^{8}$ m (1)

Question 5 (continued)

c. 2 marks

$$v = \sqrt{\frac{GM}{r}}$$

$$v = \sqrt{\frac{\left(6.67 \times 10^{-11}\right)\left(5.68 \times 10^{26}\right)}{1.06 \times 10^{8}}} \quad (1)$$

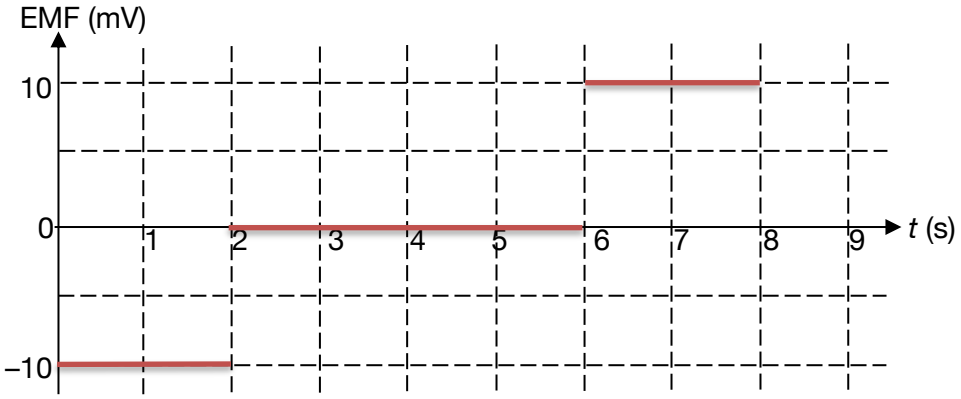
$v = 18928.48 \text{ m s}^{-1}$ (1) *Consequential on r from (b)*

d. 3 marks

Both are incorrect (1)
Velocity is independent of mass (1)
$v = \sqrt{\frac{GM}{r}}$ (1)

Question 6 (5 marks)

a. 3 marks



Correct graph – 2 marks
Correct t-axis – 1 mark
Positive and negative sections can be swapped.

b. 2 marks

$$\varepsilon = \frac{\Delta \Phi_B}{\Delta t}$$

$\Delta \Phi_B = \varepsilon \times \Delta t = 10 \times 10^{-3} \times 2 = 0.02 \text{ Wb}$ (1)

$\Phi_B = B_{\perp} A$

$B = \frac{\Phi_B}{A} = \frac{0.02}{0.04 \times 0.05} = 10 \text{ T}$ (1)

Question 7 (5 marks)

a. 2 marks

$$F = \frac{Gm_1m_2}{r^2} = \frac{(6.67 \times 10^{-11})(1.99 \times 10^{30})(6500)}{(1.61 \times 10^{11})^2} \quad (1)$$

$F = 33.28 \text{ N}$ (1)

c. 3 marks

Minimum energy is given by the maximum wavelength (1)

$$E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34})(3 \times 10^{8})}{2.8 \times 10^{-5}} \quad (1)$$

$E = 7.1 \times 10^{-21} \text{ J}$ (1)

Question 8 (9 marks)

a. 2 marks

Correct direction – 1 mark
At least 4 equally spaced lines – 1 mark

b. 2 marks

$$E = \frac{V}{d} = \frac{12}{0.025} \quad (1)$$

$E = 480 \text{ N C}^{-1}$ (1)

c. 2 marks

$$\frac{1}{2}mv^2 = qV = 1.6 \times 10^{-19} \times 12 \quad (1)$$

$E_k = 1.92 \times 10^{-18} \text{ J}$ (1)

d. 3 marks

Nami is correct (1)

Force is proportional to the electric field ($F = qE$) (1)

Since the electric field between the plates is constant, the electron experiences a constant force (1)

Question 9 (6 marks)

a. 1 mark

$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{4.55 \times 10^{14}} = 659 \text{ nm}$ (1)

b. 2 marks

D is the 3rd dark fringe from the centre:

$pd = \frac{5\lambda}{2}$ (1)

$pd = 1674.5\ nm$ (1). *Consequential on λ from (a)*

c. 1 mark

The bright and dark fringes will come closer together (1)

Higher frequency equates to a lower wavelength, and the fringe spacing is proportional to wavelength ($\Delta x = \frac{\lambda L}{d}$)

d. 2 marks

The bright and dark fringes are formed due to interference. (1)

Interference is a wave phenomenon (1)

Question 10 (4 marks)

a. 2 marks

$f = \frac{1}{T} = \frac{1}{1.8} = 0.56 \text{ Hz}$ (1)

$f_4 = \frac{2v}{L}$

$v = \frac{Lf_4}{2} = \frac{2.2 \times 0.56}{2} = 0.62\ ms^{-1}$ (1)

OR

$\lambda = \frac{L}{2} = \frac{2.2}{2} = 1.1\ m$

$v = f\lambda = 0.56 \times 1.1 = \ 0.62\ ms^{-1}$

b. 2 marks

$f_4 = \frac{2v}{L} = \frac{2 \times 6}{2.2}$ (1) $= 5.6 \text{ Hz}$ (1)

Question 11 (11 marks)

a. 2 marks

Using energy conservation:

$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$ (1)

$$v = \sqrt{\frac{180 \times 0.1^2}{0.2}}$$ (1)

$$v = 3 \text{ m s}^{-1}$$

b. 2 marks

$u = v_V \sin(\theta) = 3\sin(30°) = 1.5\ m\ s^{-1}$ (1)

$v = u + at$

$0 = 1.5 \times -9.80 \times t$

$t = 0.15$ s (1)

c. 2 marks

$s = ut + \frac{1}{2}at^2$

$s = 1.5 \times 0.45 + \frac{1}{2} \times -9.80 \times 0.45^2$ (1)

$s = -0.31725\ m$

Height of platform = 0.32 m (1)

d. 2 marks

$Range = v_h t = 3\cos(30°) \times 0.45$ (1)

$Range = v_h t = 1.17$ m (1)

e. 3 marks

Quantity	Increases/decreases/stays the same
The speed with which the marble leaves the inclined plane.	Decreases
The time taken to reach the maximum height.	Decreases
The horizontal distance from the base of the inclined plane to where the marble lands.	Decreases

1 mark each

Question 12 (7 marks)

a. 2 marks

$$p_{X-ray} = \frac{E}{c} = \frac{30000 \times 1.6 \times 10^{-19}}{3 \times 10^{8}} = 1.6 \times 10^{-23} \text{ kg m s}^{-1} \quad (1)$$

$$p_{X-ray} = p_e$$

$$v = \frac{p_e}{m} = \frac{1.6 \times 10^{-23}}{9.11 \times 10^{-31}} = 1.76 \times 10^{7} \text{m s}^{-1} \quad (1)$$

b. 2 marks

The fringe spacing in the diffraction pattern decreases. (1)
As the momentum increases, the wavelength decreases ($p = \frac{h}{\lambda}$) and the extent of diffraction is proportional to the wavelength. (1)

c. 3 marks

Neither student/statements are correct. (1)
Madi is incorrect as X-rays travel at the speed of light and the electrons have mass, therefore they travel slower than the speed of light. (1)
Mada is incorrect as the X-rays and electrons have a similar wavelength and momentum but have different energies. (1)

Question 13 (5 marks)

a. 2 marks

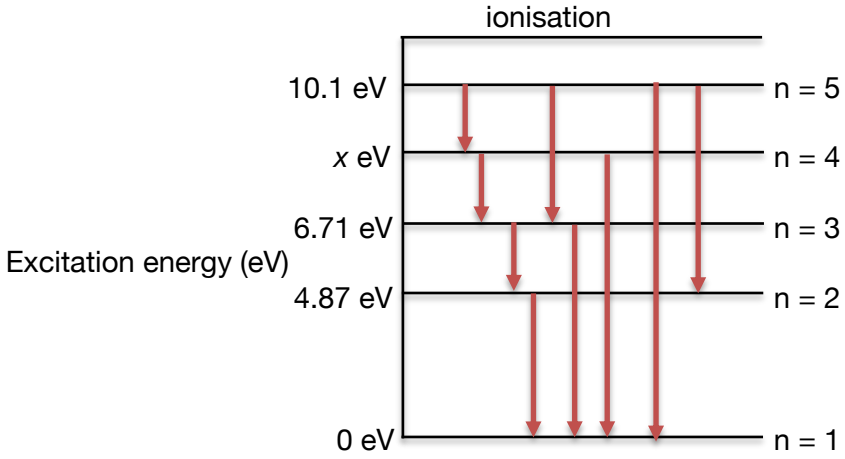
Only discrete energies of photons can be absorbed or emitted (1)
As a photon of energy 1.84 eV is absorbed the atom transition to level n = 3 (6.71 – 4.87 = 1.84 eV), but it will need to emit a photon of energy 4.87 eV to transition to n = 1. (1)

b. 2 marks

10.1 eV – 4.87 eV = 5.23 eV, therefore 3.37 eV should be the transition to n = 4 (1)
x = 4.87 eV + 3.37 eV = 8.24 eV (1)

c. 1 mark

9 lines (1)



Question 14 (7 marks)

a. 2 marks

110 m will be different (1)
Due to special relativity length contraction (1) occurs in the direction of motion. (1)

b. 3 marks

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = \gamma = \frac{1}{\sqrt{1 - 0.75^2}} = 1.51 \text{ (1)}$$

$$L = \frac{L_0}{\gamma} = \frac{110}{1.51} = 72.84 \text{ m (1)}$$

c. 2 marks

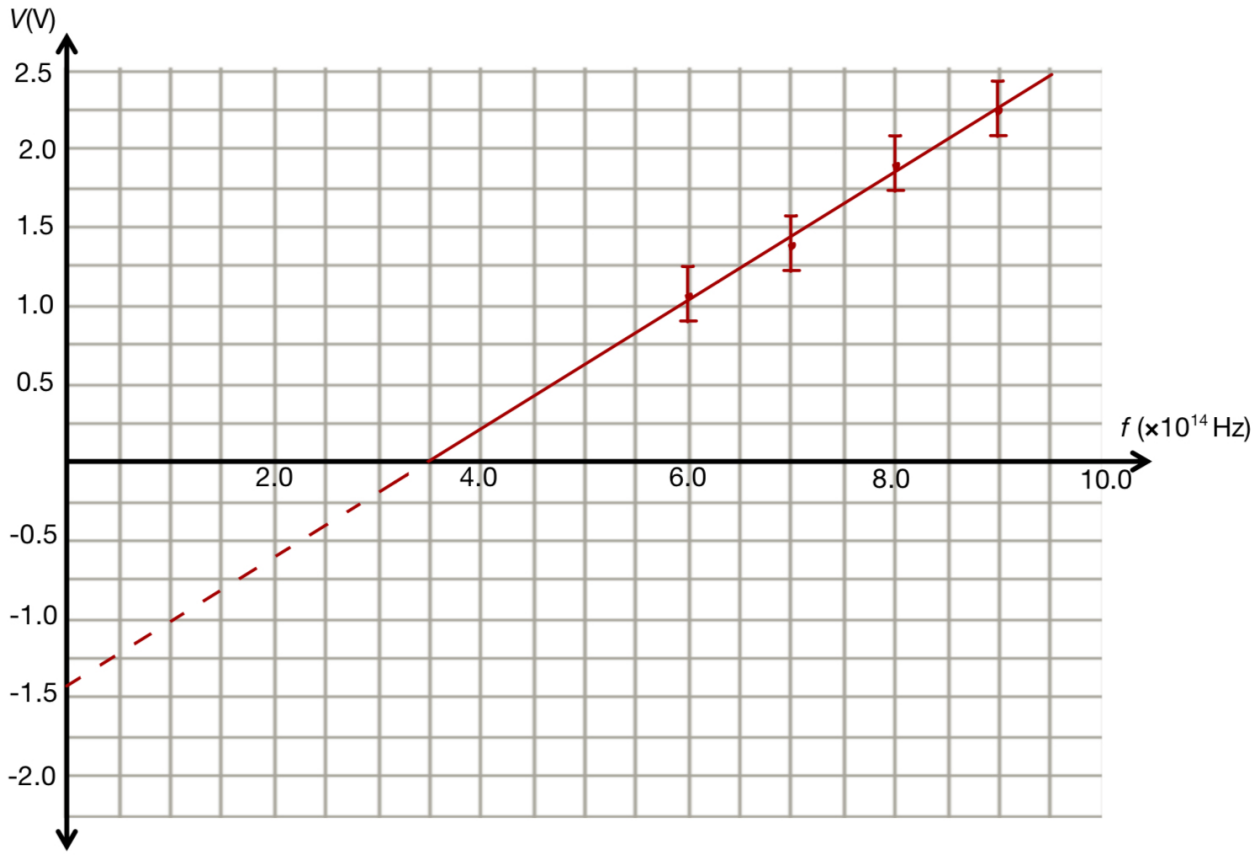
$$E_k = (\gamma - 1)mc^2$$

$$m = \frac{E_k}{(\gamma - 1)c^2} = \frac{1.61 \times 10^{20}}{(1.51 - 1)(3 \times 10^8)^2} \text{ (1)}$$

$$m = 3507.6 \text{ kg (1)}$$

Question 15 (12 marks)

a. 5 marks



Correct data points (2)
Uncertainty bars (1)
Line of best fit (1)
Dotted line below x-axis or no line (1)

b. 3 marks

$$h = \frac{rise}{run} = \frac{2.25 - 0}{(9.0 - 3.5) \times 10^{14}} \text{ (1)}$$

$h = 4.09 \times 10^{-15}$ (1) eV s (1)

Points used must be on the line of best fit

c. 2 marks

$\phi = hf_0 = 4.14 \times 10^{-15} \times 3.5 \times 10^{14}$(1) $= 14.49$ eV(1)

d. 2 marks

Minimum energy of the photon required (1) to release an electron from the surface of the sodium cathode (1)

End of 2024 - 2027 Kilbaha VCE Physics Units 3 and 4 Examination
Suggested Answers