2018 VCE Physics (NHT) examination report

Specific information

This report provides sample answers or an indication of what answers may have included. Unless otherwise stated, these are not intended to be exemplary or complete responses.

Section A – Multiple-choice questions

Question	Answer	Comments
1	B	$F = BIl$ $1.0 = B \times 2000 \times 10$ $B = 5 \times 10^{-5}\ \text{T}$
2	C	$g = \frac{GM}{r^2}$ $g = \frac{6.67 \times 10^{-11} \times 3.34 \times 10^{23}}{(2.44 \times 10^6)^2}$ $g = 3.74\ \text{N kg}^{-1}$
3	C	$F = \frac{kQ}{r^2}$ $F = \frac{9 \times 10^9 \times 5.0 \times 10^{-7}}{0.5^2}$ $F = 1.8 \times 10^4\ \text{V m}^{-1}$
4	D	The split-ring commutator will reverse the voltage every half turn.
5	C	$V_p = \sqrt{2} \times \text{V}_{\text{RMS}}$ $V_p = \sqrt{2} \times 240$ $V_p = 339\ \text{V}$
6	A	$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{200}{16}$ $\frac{N_p}{N_s} = \frac{15}{1}$
7	B	$P = VI$ $30 = 16 \times I$ $I = 1.9\ \text{A}$

Question	Answer	Comments
8	D	$mg - T = ma$ $9.8 - T = 1.96$ $T = 7.8\text{ N}$
9	B	$v^2 = u^2 + 2ax$ $v^2 = 2 \times 1.96 \times 4.0$ $v = 4.0\text{ m s}^{-1}$
10	A	$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$ $\gamma = \frac{1}{\sqrt{1 - 0.999^2}}$ $\gamma = 22.4$
11	D	$t = \frac{d}{v}$ $t = \frac{3 \times 10^{11}}{3 \times 10^8}$ $t = 1000\text{ s}$
12	C	$Ft = mv$ $F \times 1 \times 10^{-3} = 0.040 \times 50$ $F = 2 \times 10^3\text{ N}$
13	D	Polarisation is a property of transverse waves only. It is not limited to electromagnetic waves.
14	B	Electromagnetic waves have velocities through media that are a function of their wavelength. This gives rise to refraction.
15	D	
16	C	The results of the photoelectric effect experiment show that, if light intensity is increased, it will increase the number of photons striking the surface. This will result in more photoelectrons being released. However, each photon will have the same energy, so the maximum kinetic energy of the photoelectrons remains unchanged.
17	A	$E_{(J)} = E_{(eV)} \times 1.6 \times 10^{-19}$ $E_{(J)} = 2.0 \times 1.6 \times 10^{-19}$ $E_{(J)} = 3.2 \times 10^{-19}\text{ J}$
18	B	The number 0.000670 should be written, in scientific notation, as 6.70×10^{-4}. Therefore, it has three significant figures.
19	A	The value of an independent variable does not depend on the value of another.
20	A	Repeating experiments reduces the effect that random errors have on estimating the true value.

Section B

Question 1a.

$$T = \sqrt{\frac{4\pi^2 r^3}{GM}}$$

$$T = \sqrt{\frac{4\pi^2 \times (7.25 \times 10^6)^3}{6.7 \times 10^{-11} \times 6.0 \times 10^{24}}}$$

$$T = 6.1 \times 10^3 \text{ s}$$

Question 1bi.

The speed of the satellite is given by $v = \sqrt{\frac{GM}{r}}$.

Therefore, if *r* increases, the velocity will decrease.

Question 1bii.

If the satellite uses its motors to move to a higher orbit, then the total energy of the satellite will increase. This energy will be a combination of kinetic energy and gravitational potential energy. Since the velocity of the satellite will decrease, as shown in part i., the kinetic energy must decrease. Therefore, the gravitational potential energy will increase.

It is not correct to use the formula for gravitational potential energy, $E_{GPE} = mgh$, because *g* cannot be considered as being constant in questions involving satellite motion. The value for *g* decreases as *h* increases.

Question 2a.

$$E = \frac{V}{d}$$

$$E = \frac{5000}{0.1}$$

$$E = 5 \times 10^4 \text{ V m}^{-1}$$

Question 2b.

$$F = Eq$$

$$F = 5 \times 10^4 \times 1.6 \times 10^{-19}$$

$$F = 8 \times 10^{-15} \text{ N}$$

Question 2c.

$$qV = \frac{1}{2}mv^2$$

$$1.6 \times 10^{-19} \times 5000 = 0.5 \times 9.1 \times 10^{-31} \times v^2$$

$$v^2 = 1.8 \times 10^{15}$$

$$v = 4.2 \times 10^7 \text{ m s}^{-1}$$

Question 3a.

Since the velocity is at right angles to the field, the force will be at right angles to the velocity. The magnitude of the force remains constant regardless of the direction of the proton. A constant force at right angles to the direction of motion results in circular motion.

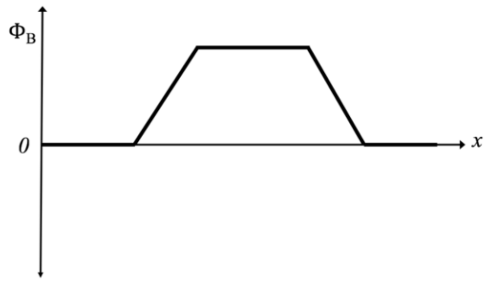
Question 3b.

$F = Bqv$

$F = 0.5 \times 1.6 \times 10^{-19} \times 5.00 \times 10^{7}$

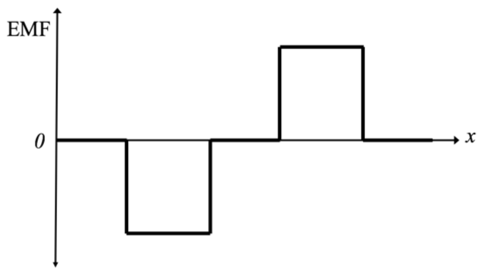
$F = 4.0 \times 10^{-12}$ N

Question 4a.



The position on the *x*-axis was not important.

Question 4b.



The position on the *x*-axis was not important and the graph did not have to line up with the graph in Question 4a.

Question 4c.

$\varepsilon = n\frac{\Delta\ \Phi}{\Delta\ t}$

$\varepsilon = 100 \times \frac{2.0 \times 10^{-3} \times 4.0 \times 10^{-4}}{2}$

$\varepsilon = 4.0 \times 10^{-5}$ V

Question 4d.

The loop is experiencing an increasing downwards flux. According to Lenz's law the induced flux will be upwards. Using the right-hand grip rule, the current will flow in an anticlockwise direction.

Question 5a.

$P_{loss} = I^2R$

$P_{loss} = 0.5^2 \times 4$

$P_{loss} = 1.0$ W

Question 5b.

Either:

- Output of $T_1 = 2.0 \times 8 = 16\ \text{V}$
  Voltage drop across transmission lines $= IR = 0.5 \times 4 = 2\ \text{V}$
  Voltage input to $T_2 = 16 - 2 = 14\ \text{V}$
  Voltage output from T_2 (globe voltage) $= 14 \div 8 = 1.75\ \text{V}$
- Power supply current $= 0.5 \times 8 = 4\ \text{A}$
  Therefore, input power $= 2 \times 4 = 8\ \text{W}$
  Power lost = 1 W (from Question 5a.)
  Power delivered $= 8 - 1 = 7\ \text{W}$
  Light globe current $= 0.5 \times 8 = 4\ \text{A}$
  Globe voltage $= 7\ \text{W} \div 4\ \text{A} = 1.75\ \text{V}$

Question 5c.

Students were required to identify one of the following:

- Increase the power supply voltage to at least 2.25 V.
- Change the T_1 ratio to at least 1:9.
- Change the T_2 ratio to at least 7:1.

Question 6a.

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

$$-20 = 0.5 \times 9.8 \times t^2$$

$$t = 2.0\ \text{s}$$

Question 6b.

$$x = v \times t$$

$$x = 25 \times 2$$

$$x = 50\ \text{m}$$

Question 6c.

$$Ek_{final} = Ek_{initial} + mgh$$

$$Ek_{final} = 0.5 \times 2 \times 25^2 + 2 \times 9.8 \times 20$$

$$Ek_{final} = 1017\ \text{J}$$

Question 7

$$Ek_{before} = 0.5 \times 0.5 \times 45^2$$
$$Ek_{before} = 506\ \text{J}$$

$$Ek_{after} = 0.5 \times 0.5 \times 40^2 + 0.5 \times 0.04 \times 63^2$$
$$Ek_{after} = 480\ \text{J}$$

The decrease in kinetic energy indicates an inelastic collision.

Question 8a.

Minimum speed occurs where $\frac{mv^2}{r} = mg$.

$v = \sqrt{rg}$

$v = \sqrt{9.8 \times 1.5}$

$v = 3.9 \text{ m s}^{-1}$

Question 8b.

$Ek_{bottom} = Ek_{top} + mgh$
$Ek_{final} = 0.5 \times 2.5 \times 6^2 + 2.5 \times 9.8 \times 3.0$
$Ek_{final} = 118.5 \text{ J}$

$118.5 = 0.5 \times 2.5 \times v^2$
$v = 9.8 \text{ m s}^{-1}$

Question 9a.

Spring constant (*k*) is given by gradient of graph.

$k = \frac{60}{1.5} = 40 \text{ N m}^{-1}$

Question 9b.

$SPE_y = \frac{1}{2}kx^2 = 0.5 \times 40 \times 1^2 = 20 \text{ J}$

$SPE_x = \frac{1}{2}kx^2 = 0.5 \times 40 \times 0.5^2 = 5 \text{ J}$

$20 - 5 = 15 \text{ J}$

Question 9c.

The kinetic energy of the ball equals the energy stored in the spring minus the work done against gravity.

$SPE =$ area under graph.

$SPE = 0.5 \times 1 \times 40 - 0.5 \times 0.5 \times 20 = 15 \text{ J}$

Work against gravity = mgh $= 2 \times 9.8 \times 0.5 = 9.8 \text{ J}$

$\therefore E_k = 15 - 9.8 = 5.2 \text{ J}$

$E_k = \frac{1}{2}mv^2$

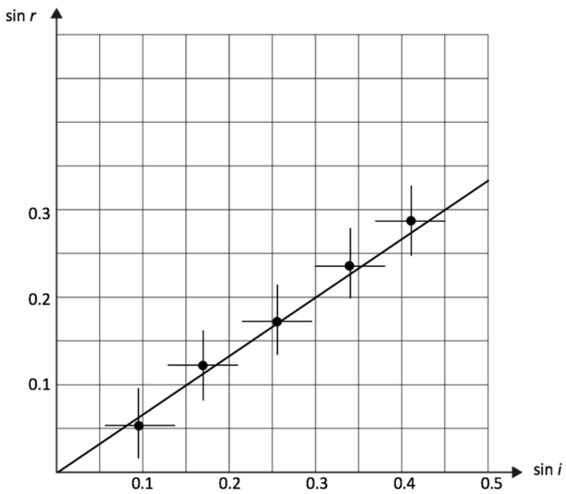
$5.2 = 0.5 \times 2 \times v^2$

$v = 2.28 \text{ m s}^{-1}$

Question 10a.

Variable	Classification
incident angle	independent
refracted angle	dependent
refractive index of the block or the frequency of the light	controlled

Question 10b.



Question 10c.

The refractive index of the block is found by taking the reciprocal of the gradient of the graph.

$$n_{block} = \frac{0.45}{0.3} = 1.5$$

The question required the correct number of significant figures. In this case, the answer should have been to two significant figures.

Question 11a.

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

$$f = \frac{3 \times 10^8}{3 \times 10^{-2}}$$

$$f = 10^{10}\ Hz$$

Question 11b.

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

$$pd = 1.5 \times 3$$

$$pd = 4.5 \text{ cm}$$

Question 11c.

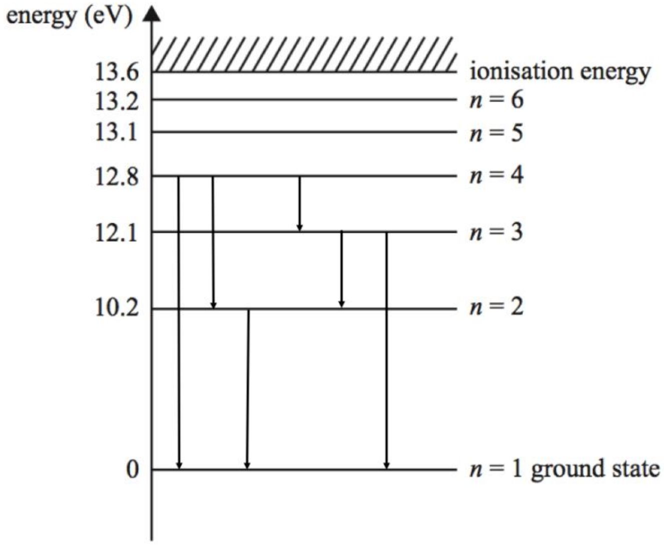
The pattern will widen.

The width of the pattern is proportional to the ratio $\frac{\lambda}{w}$, where *w* is the width of the gap. If the wavelength increases, the width of the pattern will also increase.

Question 11d.

The wavelength will be measured as longer. This is due to the Doppler effect.

Question 12



The energies are: 12.8 eV, 12.1 eV, 10.2 eV, 2.6 eV, 1.9 eV and 0.7 eV.

Question 13a.

$$Vq = \frac{1}{2}mv^2$$

$$4000 \times 1.6 \times 10^{-19} = 0.5 \times 9.1 \times 10^{-31} \times v^2$$

$$v^2 = \frac{4000 \times 1.6 \times 10^{-19}}{0.5 \times 9.1 \times 10^{-31}} = 1.4 \times 10^{15}$$

$$v = 3.7 \times 10^{7}\ \text{m s}^{-1}$$

$$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 3.7 \times 10^{7}}$$

$$\lambda = 2.0 \times 10^{-11}\ \text{m}$$

$$\lambda = 2.0 \times 10^{-2}\ \text{nm}$$

Question 13b.

$$E = \frac{hc}{\lambda}$$

$$E = \frac{4.14 \times 10^{-15} \times 3 \times 10^{8}}{2.0 \times 10^{-11}}$$

$$E = 6.5 \times 10^{4}\ \text{eV}$$

Question 13c.

Diffraction is dependent on wavelength. If the electrons have a de Broglie wavelength equal to the wavelength of the X-rays, then they will have the same diffraction pattern.

Question 14

$$L = \frac{L_0}{\gamma}$$

$$L = \frac{1 \times 10^{18}}{7.1}$$

$$L = 1.41 \times 10^{17}\,\text{m}$$

$$t = \frac{d}{v} = \frac{1.41 \times 10^{17}}{0.99 \times 3 \times 10^{8}}$$

$$t = 15\ \text{years}$$

OR

$$t = \frac{d}{v} = \frac{1.0 \times 10^{18}}{0.99 \times 3 \times 10^{8}} = 107\ \text{years}$$

$$t = t_0\gamma$$

$$107 = t_0 \times 7.1$$

$$t_0 = 15\ \text{years}$$

Question 15

$$E = mc^2$$

$$E = 2.5 \times 10^{-28} \times (3 \times 10^{8})^2$$

$$E = 2.3 \times 10^{-11}\ \text{J}$$

Question 16a.

$$h = \frac{3}{6 \times 10^{14}} = 5.0 \times 10^{-15}\ \text{eV s}$$

Students were required to find the gradient of the graph.

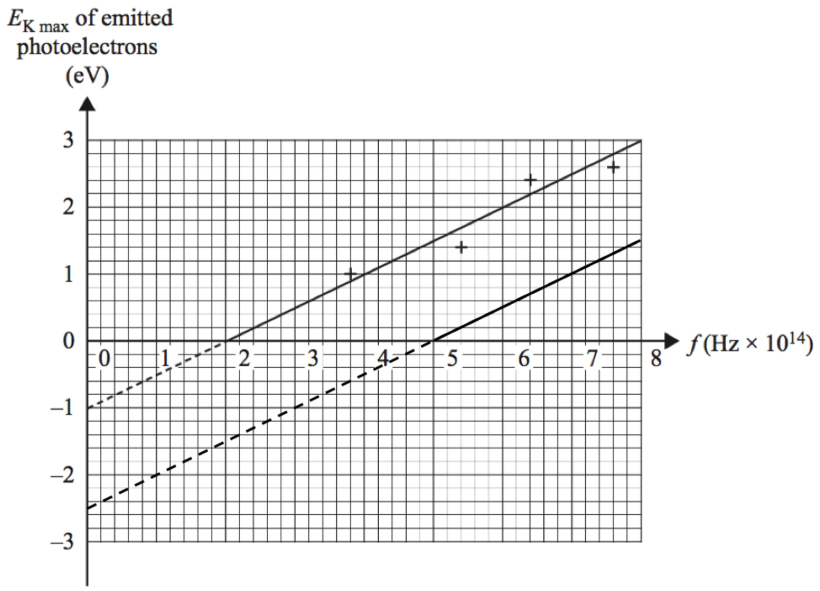
Question 16b.

2.0×10^{14} Hz

Question 16c.

1.0 eV

Question 16d.



Question 17

Students were required to identify one result that they wished to discuss. Options included the existence of a threshold frequency, the lack of delay in the release of photoelectrons at low intensities, or the fact that increasing the intensity of the light source does not increase the kinetic energy of the photo electrons. They were then required to identify the wave model prediction and how the results contradicted the prediction. Finally, they were required to identify how a particle model would support the prediction.

The following is an example of a possible response.

There should be no threshold frequency.

The wave model predicts that all light carries energy proportional to the amplitude of the wave. Therefore, all light should be able to produce photoelectrons.

The results show that only light with frequencies above a threshold frequency can produce photoelectrons. The particle model of light predicts that photons have an energy proportional to their frequency and only photons with a high enough frequency will have sufficient energy to release photoelectrons.

Question 18

Heisenberg's uncertainty principle states that the more precisely a particle's position is known, the less precisely its momentum can be known. Passing the electron through the slit reduces the uncertainty in the electron's position, which increases the uncertainty in its momentum and hence direction. This leads to the spreading out of the electron paths after the slit and the resulting diffraction pattern.