NSW EDUCATION STANDARDS AUTHORITY

Sample Questions | HIGHER SCHOOL CERTIFICATE EXAMINATION

This document shows the layout of the examination and provides some sample questions for each of the sections.

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A data sheet, formulae sheet and Periodic Table are provided at the back of this paper
- For questions in Section II, show all relevant working in questions involving calculations

Total marks: 100

Section I – 20 marks (pages 3–6)

- Attempt Questions 1–20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 7–20)

- Attempt Questions 21–xx
- Allow about 2 hours and 25 minutes for this section

The first HSC examination for the new Physics Stage 6 syllabus will be held in 2019.

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The Physics examination specifications can be found in the *Assessment and Reporting in Physics Stage 6* document.

Questions may require candidates to integrate knowledge, understanding and skills developed through studying the course. The Year 11 course is assumed knowledge for the Year 12 course.

There is no expectation that all the Year 12 content will be examined each year. In any given year, the examination will test a representative sample of the Year 12 content.

The following sample questions provide examples of some questions that may be found in HSC examinations for Physics. Each question has been mapped to show how the sample question relates to syllabus outcomes and content. Answers for the objective-response questions (Section I) and marking guidelines for the short-answer questions (Section II) are provided. The marking guidelines indicate the criteria associated with each mark or mark range.

In the examination, students will record their answers to Section I on a multiple-choice answer sheet and their answers to Section II in the spaces provided on the examination paper.

The sample questions and marking guidelines provide teachers and students with guidance as to the types of questions to expect and how they may be marked. They are not meant to be prescriptive. Each year the structure of the examination may differ in number and type of questions, focus on different syllabus outcomes and content, or have a different range and balance to those given in this set of sample questions.

Note:

- Comments in coloured boxes are annotations for the purpose of providing guidance for future examinations.
- In this set of sample questions, some stimuli are used in both Section I and Section II. This is to illustrate how the same content area can be examined differently.
- Teachers and students should still refer to past HSC examination papers for examples of questions that may be included.

This is NOT a complete sample examination paper. Seven sample questions are included in this section.

Past examination papers provide guidance for other types of multiple-choice questions that could be included.

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

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1 After DC voltage was applied to an apparatus containing hydrogen gas, the hydrogen separated into streams of oppositely charged particles.

What could be concluded from this observation?

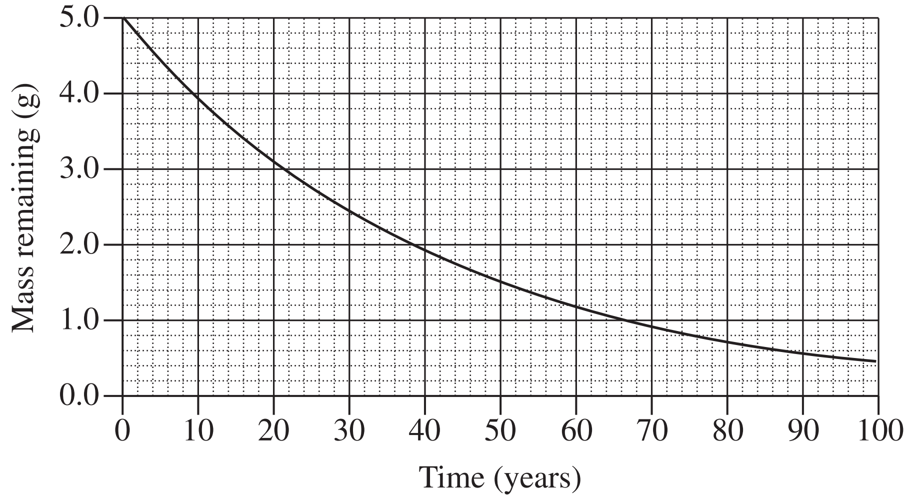
A. Hydrogen gas conducts electricity.

B. Hydrogen is the simplest element.

C. Hydrogen atoms have components.

D. Hydrogen atoms have a neutral charge.

2 A 5-gram sample of radioactive strontium-90 decayed over time. The graph shows the mass of strontium-90 remaining from the initial sample as a function of time.



What is the approximate value of the decay constant, in year^{-1}, for strontium-90?

A. 0.006

B. 0.011

C. 0.014

D. 0.025

A variety of stimulus material, such as text, diagrams, pictures, graphs, photographs and illustrations, may be included in questions in Section I. However, stimulus material will only be included when it is essential for answering the question.

3 What is the magnitude of the momentum (in kg m s^{-1}) of an electron travelling at $0.8c$?

A. 2.19×10^{-22}

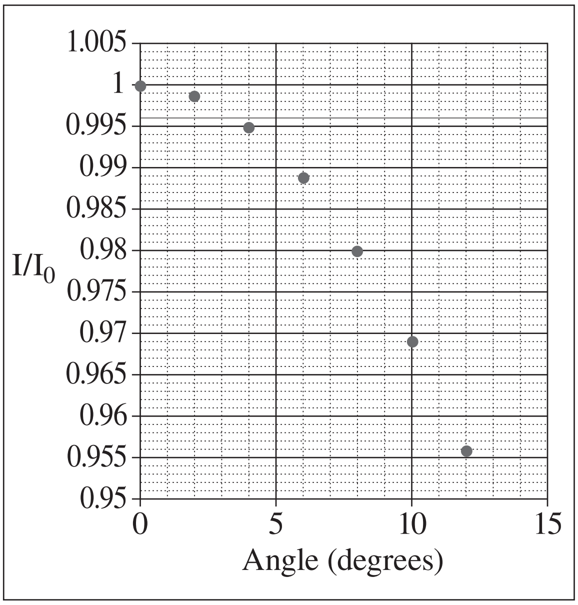
B. 3.64×10^{-22}

C. 4.89×10^{-22}

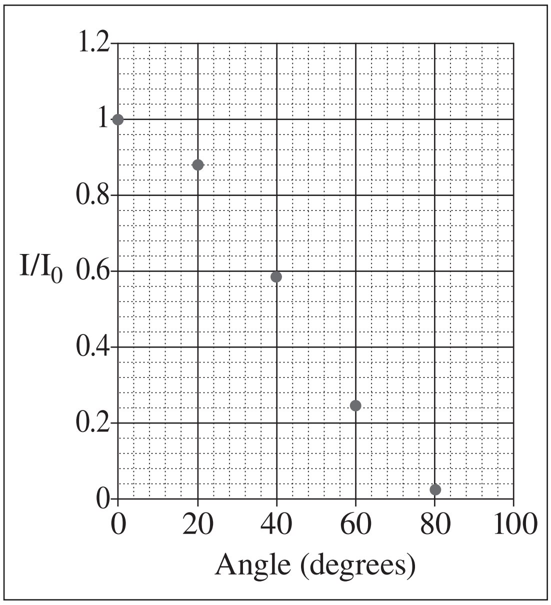
D. 5.99×10^{-22}

4 Anna and Bo carried out independent experiments to investigate Malus's Law. They graphed the results of their experiments. The graphs are shown below.

Anna's graph



Bo's graph



Based on the two graphs, which of the following is correct?

A. Anna has taken more measurements but Bo has used a better data range.

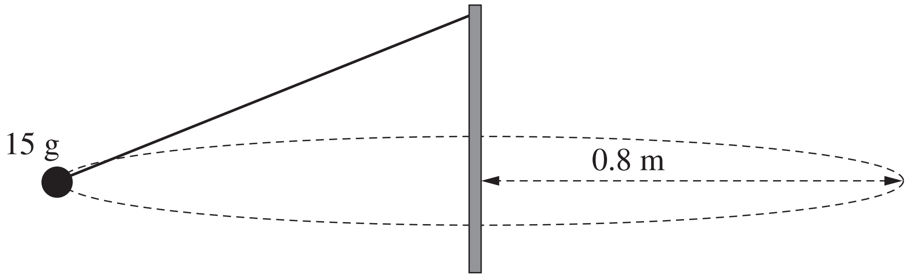
B. Bo's graph is more precise as the angles in Anna's graph are too small.

C. Anna's graph is more valid as Bo's graph shows a straight line relationship.

D. Anna's measurements are more reliable than Bo's as a line of best fit cannot be drawn for Bo's graph.

Question 22 (b) is a short-answer question based on a similar stimulus and demonstrates another method of examining the content area.

5 A 15-gram metal ball bearing on a string is swung around a pole in a circle of radius 0.8 m. The plane of the circular path is horizontal. The angular velocity of the motion is 4π rad s^{-1}.



What is the magnitude of the centripetal force required to maintain the motion of the ball?

A. 0.7 N

B. 1.9 N

C. 2.4 N

D. 3.0 N

6 A satellite is orbiting a planet at a fixed altitude.

Which row of the table correctly identifies the magnitude of the work done by the forces on the satellite and the reason for this being the case?

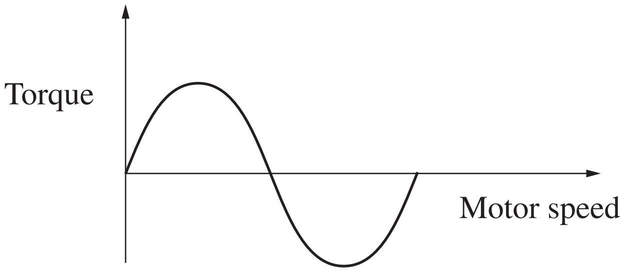
	Magnitude of work done	*Reason*
A.	Zero	The net force on the satellite is zero.
B.	Zero	Gravity acts at 90 degrees to the direction of motion of the satellite.
C.	Greater than zero	The work done equals the kinetic energy of the satellite.
D.	Greater than zero	The work done equals the gravitational force multiplied by the length of the orbital path of the satellite.

Multiple-choice options (A–D) may be presented in different formats, for example text, numbers, tables, graphs, photographs, diagrams.

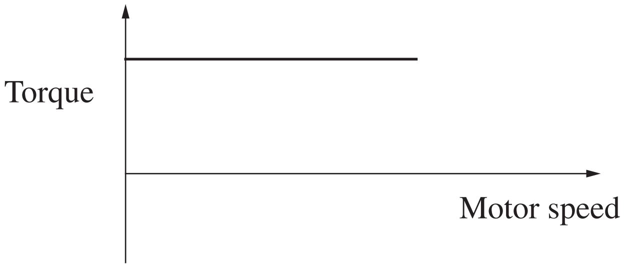
7 An experiment was carried out to investigate the change in torque for a DC motor with a radial magnetic field. The data from start up to operating speed were graphed.

Which graph is most likely to represent this set of data?

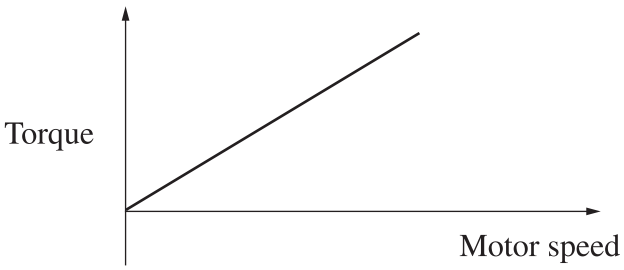
A.



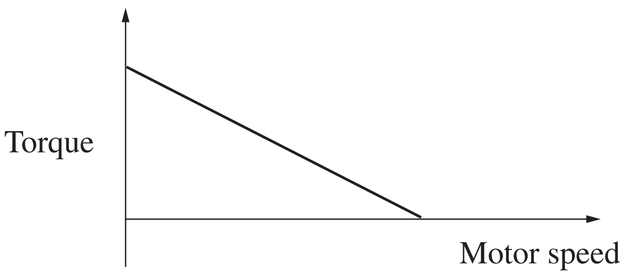
B.



C.



D.



Sample Questions | HIGHER SCHOOL CERTIFICATE EXAMINATION

Questions in Section II may contain parts. There will be 20 to 25 items and at least two items will be worth 7 to 9 marks.

Physics

Section II
Answer Booklet

This is NOT a complete sample examination paper. Six sample questions (eight items) are included in this section.

80 marks
Attempt Questions 21–XX
Allow about 2 hours and 25 minutes for this section

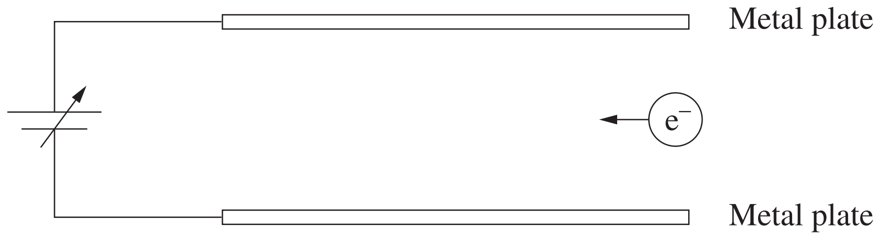
Instructions

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (6 marks)

Negatively charged particles were accelerated from rest between a pair of parallel metal plates. The potential difference between the plates was varied, and the final velocity of the particles was measured for each variation.



The data in the table show the potential difference between the plates and the square of the corresponding final velocity of the particles.

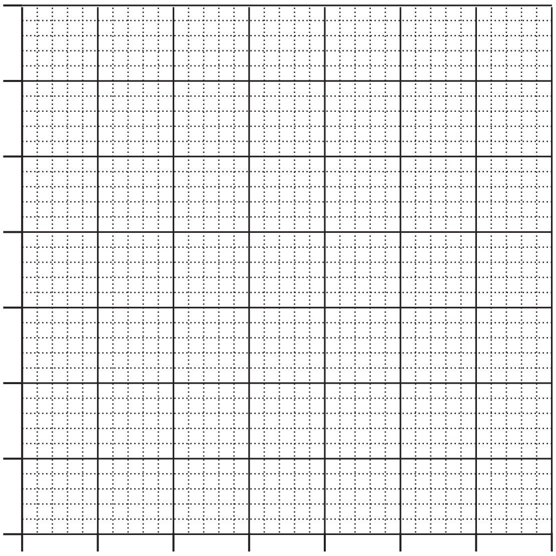
Potential difference (V)	v^2 ($\times 10^9$ m^2 s^{-2})
100	0.8
200	2.1
300	3.1
400	4.1
500	5.2

A variety of stimulus material such as text, diagrams, pictures, graphs, photographs and illustrations may be included in questions in Section II. However, stimulus material will only be included when it is essential for answering the question.

Question 21 continues on page 9

Question 21 (continued)

(a) Plot the data on the grid provided and draw a line of best fit. **3**



Questions in this section may require students to express their responses in a particular format such as text, graphs, tables, diagrams, calculations. In some cases, a combination of formats may be required.

Question 21 continues on page 10

(b) A student hypothesised that the charged particles are electrons. Justify whether the student's hypothesis is correct or not. Support your answer using the data provided and relevant calculations. **3**

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Some questions in this section may specify that the response must be supported with a diagram or other material such as a graph, data and calculations.

In some cases, students may find it useful to support their answer with a diagram or other material even though no specific requirement is made in the question.

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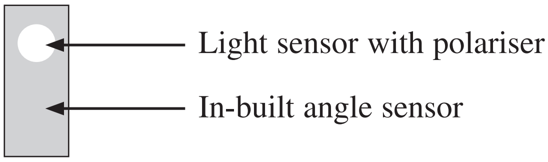
End of Question 21

Question 22 (6 marks)

(a) A student was given a smart phone with a light sensor and an angle sensor, and a computer screen which emitted polarised light. A polariser was fixed over the top of the light sensor in the smart phone. **3**



Smart phone

The student wants to use this equipment to investigate Malus's Law of polarised light. Describe a procedure that is suitable for carrying out this investigation.

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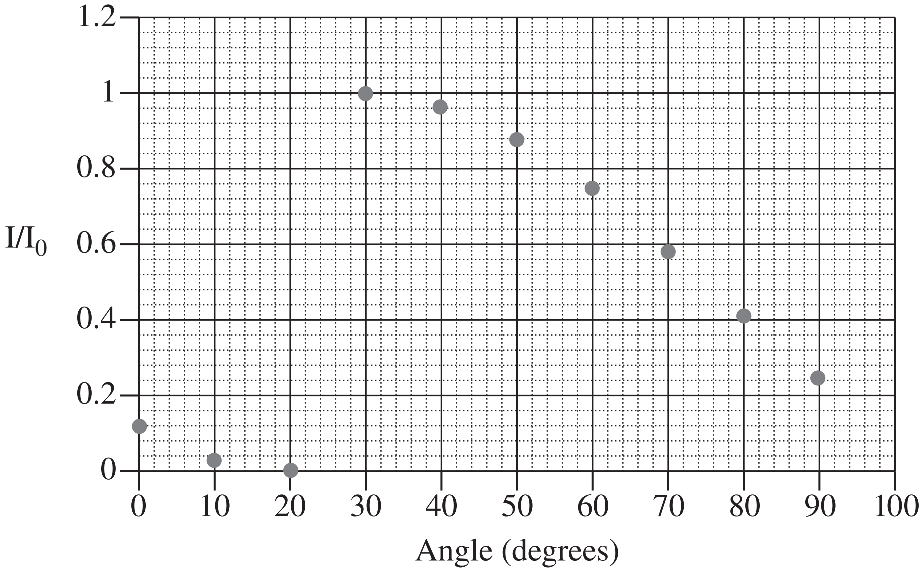
Question 22 continues on page 12

(b) An experiment was conducted to demonstrate Malus's Law for plane polarisation of light. The results are shown in the graph below. **3**



Based on the graph shown, how effective was the experiment in meeting its aim?

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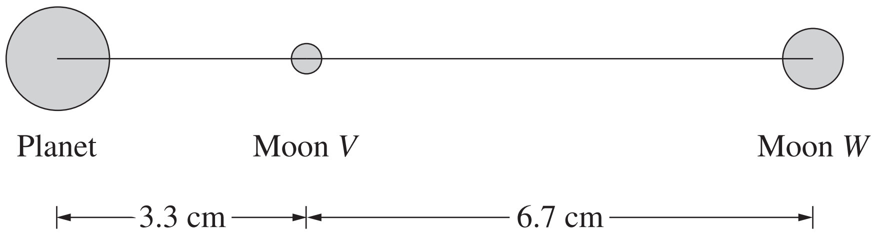
Question 4 is a multiple-choice question using a similar stimulus and demonstrates another method of examining the content area.

End of Question 22

Question 23 (4 marks)

A student used the following scale diagram to investigate orbital properties. The diagram shows a planet and two of its moons, *V* and *W*. The distances between each of the moons and the planet are to scale while the sizes of the objects are not. **4**



Complete the table to compare the orbital properties of Moon *V* and Moon *W*. Show relevant calculations in the space below the table.

	Orbital radius (*W* relative to *V*)	*Orbital period* (*W* relative to *V*)	*Orbital velocity* (*W* relative to *V*)
Quantitative comparison			
Qualitative comparison			

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Question 24 (3 marks)

Applying the law of conservation of energy, explain why $E_k = hf - \Phi$. **3**

Question 25 (6 marks)

An experiment was conducted to model Millikan's oil-drop experiment. In the experiment, different numbers of dominoes were placed inside seven identical boxes. The boxes were then sealed and weighed. The table below shows the mass of each sealed box and some preliminary analysis. **6**

Box number	*Mass of box (including dominoes)* (g)	*Difference in mass between this box and the next box* (g)
1	15.45	17.2
2	32.65	25.8
3	58.45	4.3
4	62.75	8.6
5	71.35	12.9
6	84.25	43
7	127.25	

Analyse this experiment to assess its effectiveness in modelling Millikan's oil-drop experiment.

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Question 25 continues on page 16

Question 25 (continued)

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End of Question 25

Question 26 (9 marks)

Explain how the analysis of quantitative observations contributed to the development of the concept that certain matter and energy are quantised. **9**

Question 26 continues on page 18

Question 26 (continued)

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End of sample questions

Section II extra writing space

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Section II extra writing space

If you use this space, clearly indicate which question you are answering.

Physics

DATA SHEET

Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^{8} m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2.0×10^{-7} N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	1.097×10^{7} m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^{3} kg m^{-3}
Specific heat capacity of water	4.18×10^{3} J kg^{-1} K^{-1}

FORMULAE SHEET

$\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$

$\vec{v} = \vec{u} + \vec{a}t$

$\vec{v}^2 = \vec{u}^2 + 2\vec{a}\vec{s}$

$\vec{F} = m\vec{a}$

$W = \vec{F}_{\text{net}}\vec{s}$

$\Delta U = m\vec{g}\Delta\vec{h}$

$P = \frac{\Delta E}{t}$

$P = \vec{F}\vec{v}$

$\sum m\vec{v}_{\text{before}} = \sum m\vec{v}_{\text{after}}$

$\sum \frac{1}{2}m\vec{v}^2_{\text{before}} = \sum \frac{1}{2}m\vec{v}^2_{\text{after}}$

$\Delta\vec{p} = \vec{F}\Delta t$

$v = f\lambda$

$f = \frac{1}{T}$

$k = \frac{2\pi}{\lambda}$

$f_{\text{beat}} = \left|f_2 - f_1\right|$

$f' = f\frac{\left(v_{\text{wave}} + v_{\text{observer}}\right)}{\left(v_{\text{wave}} - v_{\text{source}}\right)}$

$n_x = \frac{c}{v_x}$

$n_1\sin(i) = n_2\sin(r)$

$\sin(i_c) = \frac{1}{n_x}$

$I_1 r_1^2 = I_2 r_2^2$

$\Delta Q = mc\Delta T$

$\frac{Q}{t} = \frac{kA\Delta T}{d}$

$\vec{E} = \frac{\vec{F}}{q}$

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

$\vec{F} = \frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_2}{r^2}$

$V = \frac{\Delta U}{q}$

$I = \frac{q}{t}$

$V = \frac{W}{q}$

$R = \frac{V}{I}$

$P = VI$

$E = Pt$

$B = \frac{\mu_0 I}{2\pi r}$

$B = \frac{\mu_0 NI}{L}$

$\vec{a} = \frac{|\vec{v}|^2}{\vec{r}}$

$\sum\vec{F} = \frac{m|\vec{v}|^2}{\vec{r}}$

$\omega = \frac{\Delta\theta}{t}$

$\vec{\tau} = \vec{r}\vec{F}_{\perp}$

$|\vec{\tau}| = |\vec{r}||\vec{F}|\sin\theta$

$\vec{F} = -\frac{GMm}{\vec{r}^2}$

$v_{\text{o}} = \frac{2\pi r}{T}$

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

$\vec{F} = q\vec{v}\vec{B}\sin\theta$

$\vec{F} = \vec{B}I\vec{l}\sin\theta$

$\frac{\vec{F}}{l} = \frac{\mu_0}{2\pi} \times \frac{I_1 I_2}{\vec{r}}$

$\Phi = BA$

$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$

$\frac{V_p}{V_s} = \frac{N_p}{N_s}$

$V_p I_p = V_s I_s$

$\vec{\tau} = n\vec{B}IA\cos\theta$

$d\sin\theta = m\lambda$

$I = I_{\max}\cos^2\theta$

$\lambda_{\max} = \frac{b}{T}$

$E_k = hf - \Phi$

$t = \frac{t_0}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$

$l = l_0\sqrt{\left(1 - \frac{v^2}{c^2}\right)}$

$p_v = \frac{mv}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$

$E = mc^2$

$E = hf$

$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

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

$N_t = N_o e^{-\lambda t}$

$\lambda = \frac{\ln(2)}{t_{\frac{1}{2}}}$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Standard atomic weights are abridged to four significant figures.
Elements with no reported values in the table have no stable nuclides.
Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).
The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.

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HSC Physics Sample Questions Marking Guidelines

Section I

Multiple-choice Answer Key

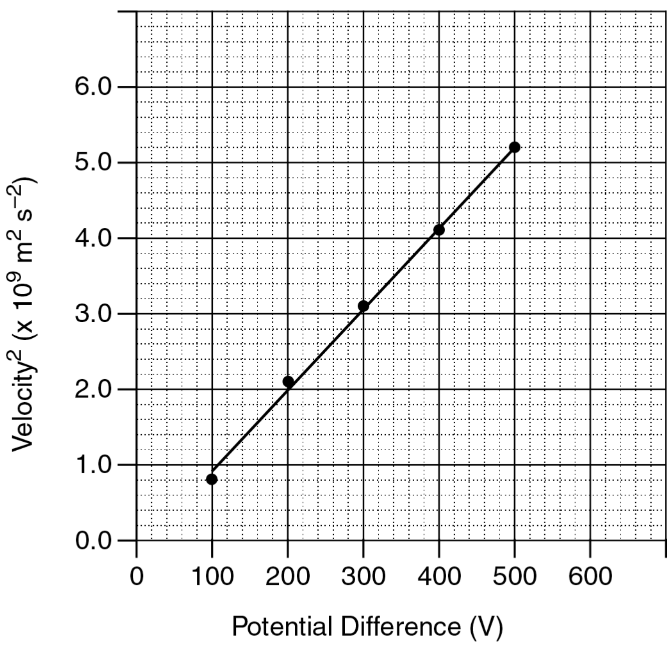
Question	Answer
1	C
2	D
3	B
4	A
5	B
6	B
7	D

Section II

Question 21 (a)

Criteria	Marks
• Uses appropriate scale • Labels axes correctly with units • Plots points accurately • Draws a line of best fit	3
• Provides a substantially correct graph	2
• Provides some basic features of the graph	1

Sample answer:



Question 21 (b)

Criteria	Marks
• Applies an appropriate method to determine if the charged particle could be an electron • Provides relevant data and calculations • Justifies their argument logically	3
• Applies an appropriate method to determine if the charged particle could be an electron • Provides some relevant data and/or calculations	2
• Provides some relevant information	1

Sample answer:

The change in kinetic energy is equal to the work done by the electric field:

$$W = \triangle \mathrm{E_k}$$

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

As $qV = \frac{1}{2}mv^2$, $\frac{v^2}{V} = \frac{2q}{m}$.

The gradient of the line of best fit is equal to the rise divided by the run:

$$\text{gradient } \frac{v^2}{V} = \frac{2q}{m}.$$

$$\text{The gradient of the line of best fit } = \frac{(5.2 - 0.9)\times 10^9}{500 - 100}$$

$$= 1.1\times 10^7\,\mathrm{m^2 s^{-2}} V^{-1}.$$

$$\text{So, } \frac{q}{m} = \frac{gradient}{2}$$

$$= 5.4\times 10^6 C\ \mathrm{kg}^{-1}.$$

But, for an electron:

$$\frac{q}{m} = \frac{1.602\times 10^{-19}}{9.11\times 10^{-31}}$$

$$= 1.8\times 10^{11} C\ \mathrm{kg}^{-1}$$

Therefore, the particles in this experiment cannot be electrons.

Question 22 (a)

Criteria	Marks
• Describes a suitable procedure	3
• Outlines some relevant steps	2
• Provides some relevant information	1

Sample answer:

The computer is set to a constant intensity of light. The distance from the computer screen to the smart phone is measured. The phone is secured in place so that it can rotate but not change its distance from the screen. The smart phone angle sensor is set to zero when its position obtains maximum intensity. The light intensity and angle are then measured and recorded. The phone is rotated and the intensity of light at many different angles is measured. The results are plotted on a graph and the relationship determined via analysis.

Question 22 (b)

Criteria	Marks
• Provides an informed assessment of the effectiveness of the experiment based on the graph	3
• Outlines strength(s) and/or weakness(es) of the data shown on the graph	2
• Identifies a strength or weakness of the data shown on the graph OR • Shows a basic understanding of Malus's Law	1

Sample answer:

The range of data is good and the points collected give a good indication of the shape of the expected curve according to Malus's Law $\left(I = I_{\max} \cos^2 \theta\right)$. However, the first three measurements seem to be incorrectly taken as the maximum intensity of light should be at 0° (not 30°).

Question 23

Criteria	Marks
• Correctly completes the table • Provides relevant and correct working	4
• Correctly completes most of the table • Applies correct approach to calculate at least two of the ratios	3
• Provides some details of the table • Applies correct approach to calculate at least one of the ratios	2
• Provides some relevant information	1

Sample answer:

	Orbital radius (*W relative to V*)	*Orbital period* (*W relative to V*)	*Orbital velocity* (*W relative to V*)
Quantitative comparison	3.0	5.2	0.58
Qualitative comparison	Larger	Larger	Slower

Radius

$$\frac{r_W}{r_V} = \frac{10.0}{3.3} = 3.0$$

Period

$$\frac{r_W^{\,3}}{T_W^{\,2}} = \frac{GM}{4\pi^2} = \frac{r_V^{\,3}}{T_V^{\,2}}$$

$$\left(\frac{r_W}{r_V}\right)^3 = \left(\frac{T_W}{T_V}\right)^2$$

$$3.0^3 = \left(\frac{T_W}{T_V}\right)^2$$

$$\frac{T_W}{T_V} = \sqrt{3.0^3} = 5.2$$

Orbital velocity

$$v_W = \frac{2\pi r_W}{T_W}$$

$$= \frac{2\pi\left(3.0 r_V\right)}{5.2 T_V} \quad \begin{array}{l}\text{... see radius calculation}\\ \text{... see period calculation}\end{array}$$

$$= \frac{2\pi \times 3.0}{5.2}\;\frac{r_V}{T_V}$$

$$= \frac{3.0}{5.2} \times \frac{2\pi r_V}{T_V}$$

$$= \frac{3.0}{5.2} \times v_V$$

$$v_W = 0.58\ v_V$$

Question 24

Criteria	Marks
• Explains why $E_k = hf - \Phi$ by applying the law of conservation of energy	3
• Shows some understanding of the law of conservation of energy and/or $E_k = hf - \Phi$	2
• Provides some relevant information	1

Sample answer:

The law of conservation of energy states that energy cannot be created or destroyed. It is transferred or transformed. The initial energy of a photon of light is hf. If this photon hits a metal surface, the energy is passed onto an electron, which can be released from the metal surface. For the electron to be released, it will possess kinetic energy (E_k) and some energy to remove the electron from the metal surface (the work function of Φ). Therefore, $hf = E_k + \Phi$ which is $E_k = hf - \Phi$.

Question 25

Criteria	Marks
• Provides an appropriate analysis of the results • Compares the method of analysis to that of Millikan's oil-drop experiment • Makes an informed judgement about the effectiveness of the experiment in modelling Millikan's experiment	6
• Provides an appropriate analysis of the results • Shows a sound understanding of Millikan's oil-drop experiment • Links the analysis of the results to the analysis used in Millikan's oil-drop experiment	5
• Provides an appropriate analysis of the results • Shows some understanding of Millikan's oil-drop experiment	4
• Analyses the results AND/OR • Shows some understanding of Millikan's oil-drop experiment	2–3
• Provides some relevant information	1

Sample answer:

In this experiment, the smallest difference between two boxes is 4.3 g (between box 3 and box 4) and all other differences are multiples of 4.3. These characteristics indicate the quantised nature of the results and that the experiment was done accurately. While it cannot be certain that the smallest difference is the mass of one domino, further tests could improve the probability that this is true. If we assume that the difference is due to one domino, then the mass of a single domino would be 4.3 g, the fundamental quantity of the mass of a domino. This method of analysis is similar to that used in Millikan's oil-drop experiment, in which he sought to determine the charge of an electron. He tested many charged oil drops and found that the value of the charge on an oil drop was always an integer multiple of a certain base value: 1.6×10^{-19} C. Thus, the domino experiment is very effective in demonstrating the analysis of Millikan's oil-drop experiment even though the method and components are completely different. It allows us to think about the assumptions and the problems Millikan must have had, such as whether only one electron was being measured.

Question 26

Criteria	Marks
• Shows a comprehensive understanding of the analysis of quantitative observations in relation to quantisation • Clearly relates the analysis to the development of the concept of quantisation	9
• Shows a sound understanding of the analysis of quantitative observations in relation to quantisation • Relates the analysis to the development of the concept of quantisation	7–8
• Outlines analyses of quantitative observations • Links these to the development of the concept of quantisation	5–6
• Outlines some quantitative observations and/or shows some understanding of the concept of quantisation	3–4
• Provides some relevant information	1–2

Sample answer:

Experiments such as the ones testing the photoelectric effect and Millikan's measurement of the fundamental unit of charge have demonstrated that certain quantities measured in physics are quantised. That is, they only appear as exact multiples of some fundamental value, or quantum.

Millikan found that the value of the charge on an oil drop was an integer multiple of 1.6×10^{-19} C, and so he concluded that this was the charge on a single electron. In this situation, quantisation was expected since the electron had been determined to be a particle. However, this result provided critical experimental evidence. This, combined with the Thomson experiment, which determined the charge to mass ratio, allowed for the mass of an electron to be determined. Thus the quantum of mass of an electron was shown through quantitative observations.

The discovery of quantisation of light, and hence energy in the form of electromagnetic radiation, as shown in the photoelectric effect experiments, was much more surprising. The understanding that light was a wave was well supported by experimental evidence, and so it was not expected that the energy would be divided into discrete packets. However, when experiments showed that there was a minimum frequency of light that would produce a photocurrent and that the amount or intensity of light did not affect the ability of electrons to be removed from a metal surface, it was explained by one electron receiving one photon or quantum of energy specific to the frequency of that light ($E = hf$). If a photon did not have enough energy, an electron could not be removed. This could only be adequately explained by a quantum model. In this case, experimental evidence generated a change in physicists' concept of energy, requiring a broader understanding of quantisation in physical processes.

Answers could include:

- spectroscopy and the existence of fixed energy levels in the atom
- cathode ray experiments showing the particle nature of the electron
- radioactivity experiments
- scintillation experiments
- blackbody radiation experiments.

HSC Physics Sample Questions Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes	Targeted performance bands
1	1	Mod 8 Structure of the atom	PH12-15	2–3
2	1	Mod 8 Properties of the nucleus	PH11/12-6, PH12-15	2–3
3	1	Mod 7 Light and special relativity	PH11/12-6, PH12-14	3–4
4	1	Mod 7 Light: wave model	PH11/12-2, PH12-14	3–4
5	1	Mod 5 Circular motion	PH 11/12-6, PH 12-12	3–4
6	1	Mod 5 Circular motion	PH 11/12-6, PH12-12	4–5
7	1	Mod 6 Applications of the motor effect	PH11/12-4, PH12-13	5–6

Section II

Question	Marks	Content	Syllabus outcomes	Targeted performance bands
21 (a)	3	Mod 6 Charged particles, conductors and electric and magnetic fields	PH11/12-4, PH12-13	2–4
21 (b)	3	Mod 6 Charged particles, conductors and electric and magnetic fields	PH11/12-5, PH11/12-6, PH 12-13	4–6
22 (a)	3	Mod 7 Light: wave model	PH11/12-2, PH12-14	2–4
22 (b)	3	Mod 7 Light: wave model	PH11/12-2, PH12-14	2–4
23	4	Mod 5 Motion in gravitational fields	PH12-12	2–6
24	3	Mod 7 The nature of light Mod 7 Light: quantum model	PH11/12-7, PH12-14	3–5
25	6	Mod 6 Light: wave model	PH11/12-4, PH12-14	2–6
26	9	Mod 7 Light: quantum model Mod 8 Structure of the atom	PH12-14, PH12-15	2–6