GCE A2

Physics

January 2010

Mark Schemes

Issued: April 2010

NORTHERN IRELAND GENERAL CERTIFICATE OF SECONDARY EDUCATION (GCSE) AND NORTHERN IRELAND GENERAL CERTIFICATE OF EDUCATION (GCE)

MARK SCHEMES (2010)

Foreword

Introduction

Mark Schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of 16- and 18-year-old students in schools and colleges. The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes therefore are regarded as a part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

The Council hopes that the mark schemes will be viewed and used in a constructive way as a further support to the teaching and learning processes.

CONTENTS

ADVANCED
General Certificate of Education
January 2010

Physics

Assessment Unit A2 1

assessing

Module 4: Energy, Oscillations and Fields

[A2Y11]

MONDAY 18 JANUARY, AFTERNOON

MARK SCHEME

Subject-specific Instructions

In numerical problems, the marks for intermediate steps shown in the mark scheme are for the benefit of candidates who do not obtain the correct final answer. A correct answer and unit, if obtained from a valid starting-point, gets full credit, even if all the intermediate steps are not shown. It is not necessary to quote correct units for intermediate numerical quantities.

Note that this "correct answer" rule does not apply to formal proofs and derivations, which must be valid in all stages to obtain full credit.

Do not reward wrong physics. No credit is given for consistent substitution of numerical data, or subsequent arithmetic, in a physically incorrect equation. However, answers to later parts of questions that are consistent with an earlier incorrect numerical answer, and are based on a physically correct equation, must gain full credit. Designate this by writing **ECF** (Error Carried Forward) by your text marks.

The normal penalty for an arithmetical and/or unit error is to lose the mark(s) for the answer/unit line. Substitution errors lose both the substitution and answer marks, but 10^n errors (e.g. writing 550 nm as 550×10^{-6} m) count only as arithmetical slips and lose the answer mark.

AVAILABLE MARKS

1 **(a)** **(i)** $\sigma = \dfrac{F}{A}$ [1]

(ii) $\varepsilon = \dfrac{x}{L}$ [1] [2]

(b) **(i)** Area = $1.77 \times 10^{-6}\,\text{m}^2$ [1]

Subs into $E = \dfrac{FL}{Ax}$ $\qquad 128 \times 10^9 = \dfrac{468\,(2.7)}{1.76 \times 10^{-6} x}$ [1]

5.6 mm [1] [3]

(ii) $\frac{1}{2} \times$ stress $\times$ strain or $\frac{1}{2} Fx$ divided by volume + subs [1]

$275\,\text{kJ}\,\text{m}^{-3}$ [1] [2] 7

2 **(a)** **(i)** Labelled diagram identifying fixed mass of gas [1]

water bath [1]

(ii) Water bath temperature varied and measured and corresponding length of gas column measured (or gas syringe arrangement) [1]

(iii) Graph T (in K) against volume or length [1]

Verified if straight line through origin [1] [5]

Quality of written communication [1]

(b) **(i)** Subs into $pV = nRT$ (with $T = 290$) [1]

$n = 0.768$ [1]

$N = nN_A = 4.62 \times 10^{23}$ [1] [3]

(ii) rms speed = $\sqrt{\dfrac{3kT}{m}}$ or $\sqrt{\dfrac{3pV}{Nm}}$ [1]

Correct subs [1]

$423\,\text{m}\,\text{s}^{-1}$ [1] [3] 12

3 **(a)** angular velocity constant [1]

Since same angle moved through per unit time or equivalent statement [1]

linear velocity increases [1]

r is increasing

$v = r\omega$ if ω constant, v proportional to r [1] [4]

(b) knows 2π radians or 360° in 24 hours [1]

$\omega = 7.27 \times 10^{-5}$ [1]

$a = 0.034\,\text{m}\,\text{s}^{-2}$ [1] [3] 7

					AVAILABLE MARKS
4	**(a)**	acceleration is proportional to displacement	[1]		
		acceleration acts towards equilibrium position	[1]	[2]	
	(b)	$a = -\omega^2 x$	[1]		
		$\omega = \dfrac{2\pi}{T}$	[1]		
		$\omega = 10.9$ (rad s^{-1})	[1]		
		$T = 0.57$ (s)	[1]	[4]	
	(c)	Prose to indicate:			
		$t = 0$ to $t = t_1$ amplitude remains constant	[1]		
		$t = t_1$ to time $t = t_2$ amplitude decreases with time	[1]		
		decreases exponentially	[1]	[3]	
		Quality of written communication		[1]	10
5	**(a)**	**(i)** Region (area) where an object experiences a force	[1]	[1]	
		(ii) One similarity e.g.: both obey inverse square law field strengths defined similarly both depend on two bodies	[1]		
		One difference e.g.: gravitational always attractive, electric attractive or repulsive	[1]	[2]	
	(b)	**(i)** 0.0226 or 0.023 N	[1]	[1]	
		(ii) Equation + subs: $F = \dfrac{160 \times 3.4 \times 10^{-6}}{9.0 \times 10^{-2}}$	[1]		
		$F = 6.0 \times 10^{-3}$ (N)	[1]	[2]	
		(iii) Straight line with components down and right	[1]	[1]	7

						AVAILABLE MARKS
6	**(a)**		attractive force	[1]		
			proportional to the product of masses	[1]		
			inversely proportional to the square of the separation	[1]	[3]	
	(b)	**(i)**	equates $\frac{GMm}{r^2}$ and $mr\omega^2$ or $\frac{mv^2}{r}$	[1]		
			uses $\omega = \frac{2\pi}{T}$ or $v = \frac{2\pi r}{T}$	[1]		
			Subs and rearrange	[1]	[3]	
	(c)	**(i)**	One in which the satellite is always above the same point on earth or period = that of the earth	[1]	[1]	
		(ii)	$T = 24 \times 3600\,\text{s}$	[1]		
			subs into equation leading to $r = 4.224 \times 10^7\,\text{m}$	[1]		
			height $= 35.9 \times 10^6\,\text{m}$	[1]	[3]	
		(iii)	subs into $v = 2\pi r/T$	[1]		
			$3072\,\text{m}\,\text{s}^{-1}$	[1]	[2]	12
7	**(a)**	**(i)**	exponential	[1]	[1]	
		(ii)	e.g. radioactive decay, discharge of capacitor through resistor	[1]	[1]	
		(iii)	correct curve	[1]		
			cutting n axis but asymptotic to h axis	[1]	[2]	
	(b)	**(i)**	$\frac{n_0}{2} = n_0 e^{\frac{-mg\rho h}{kT}}$	[1]		
			$\log_e \frac{1}{2} = -\frac{mg\rho h}{kT}$ or $\log_e 2 = \frac{mg\rho h}{kT}$	[1]		
			rearranges correctly	[1]	[3]	
		(ii)	Converting units of kT to base units ($\text{kg}\,\text{m}^2\,\text{s}^{-2}$)	[1]		
			Converting units of $mg\rho$ to base units ($\text{kg}\,\text{m}^0\,\text{s}^{-2}$)	[1]		
			Showing units as m	[1]	[3]	

AVAILABLE MARKS

(c) **(i)** Increases [1] [1]

(ii) Consequence: more at bottom, fewer higher up [1] [1]

(iii) exponent becomes more negative [1]
n decreases [1] [2]

(d) **(i)** 188 3 significant figures [1]
56 2 significant figures [1] [2]

(ii) takes ln of Equation 7.1 and compares to $y = mx + c$ [1]
m, g, ρ, k and T are all constants so gradient constant [1]
$c = \ln n_0$ i.e. not = 0 [1] [3]

(iii)

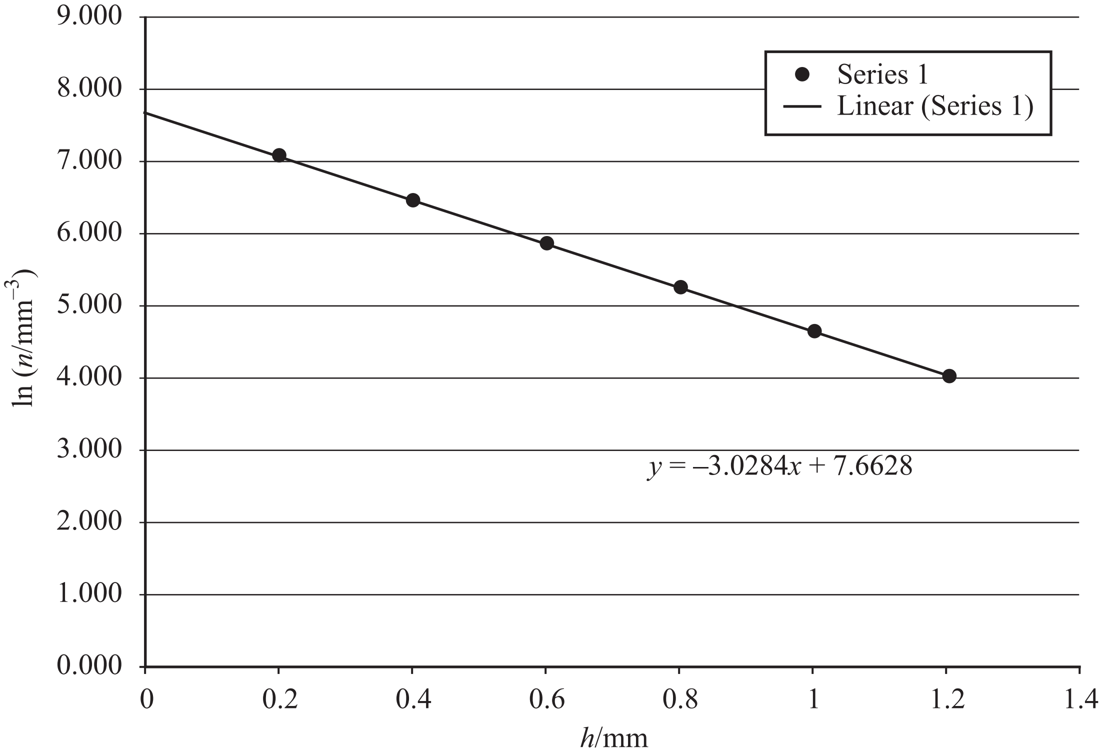
h/mm	n/mm^{-3}	ln (n/mm^{-3})
0.200	1160	7.056
0.400	632.7	6.450
0.600	347.2	5.850
0.800	188	5.24
1.000	103.5	4.640
1.200	56	4.0

Values [1]
To a consistent no of sig figs appropriate to n data [1] [2]

(iv) axes labelled [1]
suitable scale [1]
points correctly plotted ([–1] each error) [2]
best fit line [1] [5]

(v) Uses large triangle [1]
Correct values leading to gradient in range –2.8 – –3.2 [1]
Units mm^{-1} [1] [3]

AVAILABLE MARKS



(vi) Equates gradient to $-\frac{mg\rho h}{kT}$ [1]
Calculates $\rho = 3.988 \times 10^{-3}$ [1]
Correct subs into equation [1]
Value consistent with their gradient (approx 3×10^{-19} kg) [1] [4]

(vii) $\ln n_0$ = intercept or subs point on line into Eq [1]
Consistent value of n_0 (2100 mm^{-1}) [1] [2] 35

Total **90**

Rewarding Learning

ADVANCED
General Certificate of Education
January 2010

Physics

Assessment Unit A2 2

assessing

Module 5: Electromagnetism and Nuclear Physics

[A2Y21]

THURSDAY 28 JANUARY, AFTERNOON

MARK SCHEME

					AVAILABLE MARKS
1	**(a)**	**(i)**	1. $E_1 = \frac{1}{2} CV_1^2$	[1]	
			2. curve through origin increasing gradient terminating at V_{max}	[1]	
		(ii)	$C = Q/V$	eq. or subs [1]	
			Voltage range 3 V to 9 V	[1], [1]	
	(b)	**(i)**	$E = \frac{1}{2} Q^2/C$	[1]	
		(ii)	9 μF capacitor, with explanation:		
			In series, same charge on each capacitor	[1]	
			For constant Q, least E for biggest C	[1]	8
2	**(a)**		For a current carrying wire normal to a magnetic field	[1]	
			carrying a current of 1 A and of length 1 m	[1]	
			experiences a force of 1 N then the flux density is 1 tesla	[1]	
	(b)		$B = \mu_o NI/l$		
			$N/l = B/\mu_o I = 1.0 \times 10^{-2} / (4\pi \times 10^{-7} \times 8)$	eqn [1], subs [1]	
			N/l = 995 turns per metre	[1]	
	(c)		Apparatus: search coil, CRO, ammeter		
			or hall probe, voltmeter, ammeter	[1], [1], [1]	
			Procedure: probe at centre of solenoid	[1]	
			record corresponding current and trace sig/voltage	[1]	
			repeat for different values of current	[1]	
			QWC	[1]	12
3	**(a)**	**(i)**	1. Electron		
			2. Proton or positron or β-particle	[1]	
		(ii)	Quantisation: there is an indivisible quantity of charge		
			Or integral multiples of elementary charge	[1]	

AVAILABLE MARKS

(b) **(i)** battery + to plate B [1]
Potential divider or variable power supply connected to plates [1]

(ii) Potential Difference V (between plates)
Separation d (of plates) [1]

$E = V/d$ [1]

(iii) $F_E = F_G$ [1]

($neE = mg$) [1]

$n = (7.82 \times 10^{-14} \times 9.81)/(6.66 \times 10^4 \times 1.6 \times 10^{-19})$

($n = 72$) [1] 9

4 **(a)** Regularity in an arrangement of atoms = lattice [2]

(b) 1. Pattern of arrangement of atoms or symmetry of crystal [1]
2. Interatomic spacing or side/radius/diameter [1]

(c) 1×10^{-10}m [1]

(d) Adjustable wavelength [1]
can be focused [1]
or suitable alternatives 6

5 **(a)** A Activity
A_o Activity at time t = 0
N Number of radioactive nuclei/atoms
λ Decay constant
(4 × [½] round down) [2]

(b) **(i)** beta particle, electron [1]

(ii) $\lambda = 0.693/4.75 \times 10^{10} = 1.5 \times 10^{-11}$ [1]

$0.88 = \exp(-1.459 \times 10^{-11})t$ [1]

In $0.88 = 1.5 \times 10^{-11}$ t [1]

Age = 8.76×10^9 years [1]

(c) $\triangle m = 59.9322 - 59.9308 = 0.0014\mu$ [1]
$E = mc^2$ or use of $1\mu = 931$ MeV [1]
Energy = 1.33 MeV [1] 10

				AVAILABLE MARKS
6	**(a)**	**(i)** transport energy by oscillations	[1]	
		(ii) sensible approximation or estimate to nearest power of 10	[1]	
		(iii) energy from one place to another	[1]	
		(iv) number of oscillations per second	[1]	
		(v) periodic disturbance But not simple sine curve	[1] [1]	
		(vi) vector combination of 2 or more waves	[1] [1]	
		(vii) adjustment of frequency to specific value	[1]	
		(viii) undesired signals	[1]	
		(ix) region of very low gas pressure or very few molecules	[1]	
	(b)	e.g. speech, sound, longitudinal, transmit information, 100-1000Hz	[5]	
	(c)	1 parsec = $3.26 \times 365 \times 24 \times 3600 \times 3.00 \times 10^8 = 3.08 \times 10^{16}$m	[1]	
		1 nanometer = 1×10^{-9}m	[1]	
		Ratio = 3.1×10^{25}	[1]	
		To two sig. fig (independent of ratio)	[1]	
	(d)	**(i)** $v = f\lambda$ or $330 = 440\lambda$ $\lambda = 0.75$ m wavenumber = $2\pi/\lambda = 2\pi/0.75$ wavenumber = 8.4 m^{-1}	[1] [1] [1] [1]	
		(ii) frequency = 1760 Hz	[1]	
		(iii) sine or cosine or suiusoidal	[1]	
	(e)	axis labels 1/L $T^{½}$ $M^{-½}$	[3]	
	(f)	**(i)** $L = (2f_o)^{-1}(T/M)^{½}$ $L = (0.5/660)(68/0.38 \times 10^{-3})^{½}$ Length = 0.32 m	 [1] [1]	
		(ii) Stationary traverse vibrations of string Disturb surrounding air Producing longitudinal progressive sound wave	[1] [1] [1]	

				AVAILABLE MARKS
(g)	(i)	Frequencies = 266 Hz and 256 Hz	[1]	
	(ii)	Adjust to higher frequency	[1]	
		Determine new beat frequency	[1]	
		Increased beat frequency means violin playing 256 Hz or Decreased beat frequency means violin playing 266 Hz	[1]	
		or		
		Adjust to lower frequency	[1]	
		Determine new beat frequency	[1]	
		Increased beat frequency means violin playing 266 Hz or Decreased beat frequency means violin playing 256 Hz	[1]	
(h)	(i)	Any **two** from: coherent, monochromatic, narrow beam, very intense, polarised	[2]	
	(ii)	$\Delta\lambda$ required = $0.25 \times 690 \times 10^{-9}$ m	[1]	
		Half this for one length	[1]	
		% change = $(0.5 \times 172.5 \text{ x}10^{-9} \times 100^{o})/220$	[1]	
		$= 3.9 \times 10^{-8}$	[1]	
		QWC	[1]	45
			Total	**90**

Rewarding Learning

ADVANCED
General Certificate of Education
January 2010

Physics

Assessment Unit A2 3A

assessing

Module 6: Particle Physics

[A2Y31]

WEDNESDAY 3 FEBRUARY, AFTERNOON

MARK SCHEME

Subject-specific Instructions

In numerical problems, the marks for intermediate steps shown in the mark scheme are for the benefit of candidates who do not obtain the correct final answer. A correct answer and unit, if obtained from a valid starting-point, gets full credit, even if all the intermediate steps are now shown. It is not necessary to quote correct units for intermediate numerical quantities.

Note that this "correct answer" rule does not apply to formal proofs and derivations, which must be valid in all stages to obtain full credit.

Do not reward wrong physics. No credit is given for consistent substitution of numerical data, or subsequent arithmetic, in a physically incorrect equation. However, answers to later parts of questions that are consistent with an earlier incorrect numerical answer, and are based on a physically correct equation, must gain full credit. Designate this by writing **ECF** (Error Carried Forward) by your text marks.

The normal penalty for an arithmetical and/or unit error is to lose the mark(s) for the answer/unit line. Substitution errors lose both the substitution and answer marks, but 10^n errors (e.g. writing 550 nm as 550×10^{-6} m) count only as arithmetical slips and lose the answer mark.

						AVAILABLE MARKS
1	**(a)**	**(i)**	r_0 = nucleon radius	[1]		
			A = nucleon (mass) number	[1]	[2]	
		(ii)	Spherical		[1]	
	(b)	**(i)**	82 protons	[1]		
			124 neutrons	[1]	[2]	
		(ii)	$r = 1.20 \times 10^{-15} \times (206)^{\frac{1}{3}}$	[1]		
			$r = 7.09 \times 10^{-15}$ (m)	[1]	[2]	7

2	**(a)**	Mass defect	(0.01888 u)	[1]		
		Conversion to kg	(3.134×10^{-29} kg)	[1]		
		Conversion to J	(2.821×10^{-12} J)	[1]		
		Conversion to MeV	(17.6 MeV)	[1]		
		or				
		Mass defect	(0.01888 u)	[1]		
		Recall 1 u = 931 MeV		[2]		
		Answer 17.6 (MeV)		[1]	[4]	
	(b)	**(i)** Overcoming electrostatic repulsion		[1]		
		Requires highly energetic protons/very high temperature		[1]	[2]	
		(ii) No long-lived radioactive waste				
		Almost limitless fuel supply (in seawater)				
		More energy per unit mass (compared to fission)				
		Any two × [1]			[2]	8

3	**(a)**	**(i)**	Diagram showing:			
			Basic: Circular path and bending magnets		[1]	
			Detail: Injector or accelerating cavity or focusing magnets		[1]	
		(ii)	A Strength of B-field adjusted to maintain radius			
			B Particles accelerated at gaps by E-field			
			C Frequency of E-field adjusted to keep particles accelerating			
			D Magnets used to focus the beam			
			Any three from A–D × [1]		[3]	

				AVAILABLE MARKS
(b) **(i)** $mc^2 = hf$ Equation or subs	[1]			
$f = 1.24 \times 10^{20}$ (Hz)	[1]	[2]		
(ii) Total momentum before and after collision = 0	[1]			
Need two photons carrying equal momentum in opposite directions	[1]	[2]	9	

4 **(a)** **(i)**

Particle	Baryon Number
Baryon	+1
Antiparticle of a baryon	–1
Meson	0
Antiparticle of a meson	0

($\frac{1}{2}$ each round down) [2]

(ii) up, down, strange, charm, top, bottom
(–1 each omission or incorrect to 0) [2]

(b) Baryons: quark triplets [1]
Mesons: quark + antiquark [1] [2] 6

5 **(a)** Free electrons gain KE from electricity [1]
Electrons have enough energy to overcome metal work function [1]
Electron KE increases as it's accelerated towards the anode/screen [1]
Electrons lose KE in collision with the screen [1]
Lost energy converted to em photon (X-rays) [1] [5]

(b) Energy level diagram (at least three levels) [1]
Incident electrons transfer all KE to screen electrons [1]
Screen electrons excited to higher energy level [1]
Return to lower level [1]
in two (or more) stages [1]
one of which causes the emission of visible light [1] [6]

QWC Use of appropriate terminology within a suitably structured response [1]

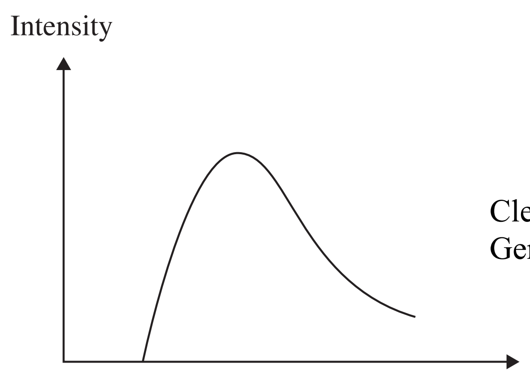
AVAILABLE MARKS

(c) **(i)** $E = qV = 4.00 \times 10^{-15}$ (J) [1]

(ii) All KE converted to em photon [1]
Max photon energy implies minimum photon wavelength [1] [2]

(iii) $eV = hc/\lambda$ [1]
$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8})/(4.00 \times 10^{-15})$ecf(i) [1]
$\lambda = 4.97 \times 10^{-11}$ (m) [1] [3]

(d)



Clear minimum wavelength [1]
General shape [1] [2] 20

Total **50**

Rewarding Learning

ADVANCED
General Certificate of Education
Jaunary 2010

Physics

Assessment Unit A2 3B

assessing

Module 6: Experimental and Investigate Skills

[A2Y32]

FRIDAY 8 JANUARY, MORNING

MARK SCHEME

				AVAILABLE MARKS
1	**(a)** Connecting the circuit		[2]	
	(b)	**(i)** Five lengths with corresponding currents [3] Lengths to 3 dp (-1 once only) voltage to 3 sf (-1 once only)	[3]	
		(ii) Consistent values of V / I [1] unit Ω or VA^{-1} [1]	[2]	
	(c) Relationship showing (V / I) increasing as L increases (or similar) [1] not proportional [1]		[2]	
	(d)	**(i)** (V / I) on y-axis, L on x-axis	[1]	
		(ii) Regular scales (using at least half of each axes) [1] Points (plot to ± 1 square) (-1 each error or omission to 0) [3] Best fit line [1]	[5]	
		(ii) Candidate's intercept (to ± 1 square) and unit (Ω or VA^{-1}) (guide value ~ 5)	[1]	
		(iv) Large triangle (or equivalent) (> 5 cm any one axis) [1] Consistent value (guide value ~ (0.12) 12) [1] and unit (Ωcm^{-1} or VA^{-1} cm^{-1}) [1]	[3]	
	(e)	**(i)** Good extreme-fit line	[1]	
		(ii) Consistent gradient of extreme fit line [1] [Difference in gradients] / [best fit gradient] [1] Consistent % uncertainty [1]	[3]	
	(f) Calculation of area (4.15×10^{-4} cm^2) [1] In range 4×10^{-5} to 6×10^{-5} [1]		[2]	25

2 5 values for L and ≥ 5 [7]
(-1 for L not to 3 sf)
(-1 for 10 T not to 2 dp)
(-1 for fewer than 5 oscillations)
(-1 for no 5 repetitions or mean)
(-1 for shortest length ≥ 250mm) [7]

(a) Calculate 5 values for periodic time T consistent with raw data [2]
(-1 each omission or error to zero) [2]

Guide Values

L / mm		T / s		
400		1.28		
350		1.12		
300		1.07		
250		0.91		
200		0.87		

(b) **(i)** lg T = lg A + B lg L [1]

(ii) Vertical: lg T
Horizontal: lg L [1]

(iii) Calculating 5 consistent values of lg L and lg T [1]
Consistent dp with raw data [1]
Headings eg lg (T/s) and lg (L/mm) [1] [3]

(vi) Axes labelled [1]
Sensible scale [1]
Plotting points (± 1 square) [2]
Best fit line [1] [5]

(v) For B: Large triangle [1]
Measure gradient [1]
Answer in range 0.4 – 0.5 [1] [3]

(vi) For A: sub (L + T values) into equation [1]
sub B value (iv) [1]
answer consistent with values [1] [3] 25

			AVAILABLE MARKS
3 **(a)**	Transmission intensity is zero when sheets are perpendicular [1] Transmission intensity is maximum when sheets are parallel [1]	[2]	
(b)	Light from a filament is definitely unpolarised/ laser light is polarised	[1]	
(c)	Diagram to show: Light detector & voltmeter [1] Lamp & power supply [1] Polaroids between light source & detector [1] Appropriate labels [1]	[4]	
(d)	Initial condition with parallel polarising directions [1] One polaroid fixed, the other rotates [1] Measure angle between filters and corresponding voltage [1] Need protractor and voltmeter [1]	[4]	
	QWC: Fewer than 3 SPG mistakes [1] Logical explanation with appropriate terminology [1]	[2]	
(e)	Plot V against $\cos^2\theta$ [1] Linear graph [1] Through origin [1]	[3]	
(f)	High intensity ambient light conditions [1] Conduct experiment in the dark [1]	[2]	
(g)	Larger angle measured [1] % uncertainty has halved (as measured angle is doubled) [1]	[2]	20
		Total	**70**