



**General Certificate of Education (A-level)
June 2013**

Physics

PHA/B6T

(Specification 2450/2455)

**Unit 6: Investigative and practical skills in A2
Physics**

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Marking Guidelines Explanatory Notes

The marking guidelines should be considered a working document. A version of the marking guidelines will be placed on the Secure Key Materials Website in September. This is to allow centre's to undertake ISA practicals as soon as they wish. Centres can use this version of the marking guidelines to mark candidates work. However this version of the marking guidelines may be subject to amendments. An updated version of the marking guidelines to be used during the present academic year will be placed on the Secure Key Materials Website by **31st October**. Examinations Officers must ensure that Teachers receive the final version of the marking guidelines. **Centres should ensure that their marking is in line with the updated version of the marking guidelines.**

The marking guidelines have been devised by a team of experienced examiners. They have tried to anticipate all possible responses worthy of credit. In order to establish consistency it is essential that all centres mark exactly to this scheme.

For ease of use the mark scheme has been presented in tabular form. Concise answers are given in the left-hand column. More detailed explanatory notes for some questions are included in the right-hand column.

Marking of Stage 1 of the ISA – student data and graph – should ideally be completed before the ISA written test to ensure that candidates do not change any data. (Alternatively, centres should take other steps to ensure that candidates do not change any information on their data script/graph). The marking of this section should be annotated with a red tick at the point where the mark has been awarded together with the letter referring to this mark scheme, eg '✓b'. **No other comments or feedback should be written on the candidates' scripts.** The total mark for this section should be written at the top of the paper. This will be transferred to the grid on the front page of the ISA test booklet.

Marking of the ISA test should be done using a red tick to represent each mark awarded. Further annotated comments **can** be added where necessary as an explanation as to why a particular point has been awarded which will greatly aid the moderation process. The total mark for each question should be entered on the grid on the front cover of the ISA booklet and the total mark calculated.

Assessment Advisers are allocated to each centre and they can advise on the marking process. You should receive the contact details for the Assessment Advisor through the post. If you have not received them, please contact the AQA subject team.

ISA (P) Gas Laws

Stage 1		Mark	Additional guidance notes
(a)	Table with column headings and units ✓ Must include columns for M , L , F , $\log_{10}(F/N)$ and $\log_{10}(L/m)$.	1	(Also allow L and $\log(L)$ in cm or mm, but logs must be written in the correct form given in the task sheet ie $\log_{10}(L/cm)$). Allow log instead of \log_{10} . Column headings can either be in words or standard symbols.
(b)	Correct sf on all raw distance measurements taken ✓	1	Should be to nearest mm.
(c)	At least one repeat reading for each length measurement and correct computation for mean length and $\log_{10}(L)$. Check 2 nd and 4 th data line ✓	1	The mark is awarded if 2 nd and 4 th data lines are correct. No sf penalty.
(d)	Correct computation of F and $\log_{10}(F/N)$ ✓ Check 2 nd and 4 th data lines	1	No sig fig penalty on these values. (Eg typical values of F in range 20 to 9 N, and $\log_{10}(F)$ 1.30 to 0.95).
(e)	Suitably large graph scale (do not award if scale on either axis could have been doubled) ✓ Scale must be 'sensible' divisions which can be easily read, eg scales in multiples of 3, 6, 7, 9, etc are unsatisfactory.	1	The plotted points should occupy at least half of each axis, with the scale(s) starting at non zero values if necessary.
(f)	Axes labelled with quantity and unit Must be $\log_{10}(F/N)$ for y axis and $\log_{10}(L/m)$ for x axis ✓	1	Allow log instead of \log_{10} . Do not award mark if axes wrong way around. (Also allow L/cm or L/mm). Ecf for incorrectly written log value already penalised in (a) column headings.
(g)	Points accurately plotted to within 1 mm Check the 1 st and 5 th point which must both be correctly plotted to award the mark Straight line of best fit drawn ✓	1	The line of best fit should be a straight line with an approximately even distribution of points on either side of the line. This mark is independent of mark (f), ie if candidates have used an unsuitable scale they can still achieve a mark for accurately plotting the points and drawing the line of best fit.
	Total	7	

ISA (P) Gas Laws

Section A		Mark	Additional guidance notes
1(a)	Temperature <u>and</u> mass ✓	1	Allow 'number of moles' or 'quantity' instead of mass.
1(b)	Internal diameter of syringe/diameter of piston/bore diameter ✓ Vernier callipers/callipers ✓	2	Or measured external tube diameter <u>and</u> thickness of tube ✓ With callipers ✓ Only allow micrometer as instrument where student has specifically stated measuring the diameter of the piston.
1(c)(i)	From spread of mean using uncertainty = 0.5 x range And converted to a % ✓	1	No sf penalty no penalty for omitting ± or % sign. If no spread of readings uncertainty is instrument precision, ±1mm
1(c)(ii)	Uncertainty in diameter = 0.8% Uncertainty in area = 1.6% ✓ Allow 1 or 2 sf. Uncertainty in volume = 1.6% + uncertainty in length (3.6%) = 5% (or 5.2%) ✓ Volume 6.4 ± 0.3 ✓ (for both volume and uncertainty value) (cm^3) Appropriate unit and volume given to 2 sf ✓	4	Allow ecf from uncertainty in diameter. Allow ecf from total % uncertainty. Volume in alternative unit acceptable. (NB 3 sf would be inappropriate – uncertainty in value dictates only 1 or 2 sf).
1(c)(iii)	Volume of air in pipe at end of syringe / shape of piston ✓ Systematic error ✓	2	Allow zero error.
1(d)	$\log_{10}F = \log_{10}K - \log_{10}L$ ✓ Gradient should be -1 ✓✓ (one mark for negative sign, one mark for 1) (Just a reference to measuring gradient without specifying it should be -1 should be awarded 1 of the 2 marks above for gradient).	3	Accept log instead of \log_{10} .

ISA (P) Gas Laws

1(e)	Discussion points: <ul style="list-style-type: none"> • Decrease in the area will give a greater uncertainty in the area measurement • Greater lengths hence length measurement more precise/less uncertainty in length measurement. • Smaller area allows greater pressure difference with smaller masses Any 2 of above discussion points ✓✓ 2 marks max	2	
1(f)(i)	Either explanation Turn syringe upside down and add masses pressing downwards on piston. Or Diagram showing the arrangement ✓	1	Any other workable alternative.
1(f)(ii)	$p = p_0 + Mg/A$ ✓	1	Do not allow expression with weight instead of mass.
	Total	17	

ISA (P) Gas Laws

Section B		Mark	Additional guidance notes
2(a)	Mean length: 139,145 Volume :153,160 ✓	1	<p>Candidates would have to have deduced \times sect area to compute volume.</p> <p>Where candidates have kept a 'full quota' of significant figures in their calculations for both area and volume this can lead to different results. Consequently the following combinations are acceptable:</p> <ul style="list-style-type: none"> • Temperature 86 degrees C <ul style="list-style-type: none"> ○ Mean length 139 Volume 152/153/154 • Temperature 98 degrees C <ul style="list-style-type: none"> ○ Mean length 145 Volume 159/160/161 <p>For the 86 degrees C line of data, if a candidate has decided to treat the length of 136 mm as anomalous, the following values are also acceptable:</p> <ul style="list-style-type: none"> • Mean Length 141 Volume 155/156
2(b)	2 points correctly plotted to within ± 1 mm or less from exact position ✓ straight line of best fit drawn ✓	2	Same criteria for the straight line as in stage 1 (j).
2(c)	Triangle drawn with smallest side at least 8 cm <u>And</u> correct values read from graph ✓ Gradient value in range 0.40 to 0.46 (0.395 to 0.464) ✓ Must be to 2 or 3 sf ✓	3	Gradient must lie within limits stated. No ecf from incorrectly read values unless it falls within stated limits. No unit penalty.
2(d)	Appropriate method of calc (eg using similar triangles, or $y = mx + c$) ✓ Temperature = -275°C (must be a negative value) ✓ Allow ecf from gradient value.	2	Unit required for mark. NB <u>no marks</u> for student just quoting a value for the temperature without any supporting calculation.
2(e)	Linear relationship/of form $y=mx + c$ / <u>increase</u> in Volume proportional to <u>increase</u> in Temperature ✓	1	<u>Not</u> Volume proportional or directly proportional to Temperature.

<p>2(f)</p>	<p>Gradient lower ✓ Intercept on y axis lower ✓ 3rd mark is for stating gradient halved and intercept on y axis halved (if the 3rd mark is awarded, this automatically achieves 1st and 2nd marks) ✓</p>	<p>3</p>	<p>Full marks can be achieved if candidates have stated their gradient and y- intercept values and halved them.</p>
	<p style="text-align: right;">Total</p>	<p>12</p>	

ISA (P) Gas Laws

Question 3		Mark	Additional guidance notes
3	(a) Volume to be kept constant/ using suitably large volume of gas initially. (b) When temperature changed, adjusting number of weights on piston until volume brought back to same value. (c) Suitable method for providing different temperatures eg water bath. (d) Suggest range of temperatures appropriate for road conditions eg -15 to 90°C (e) Suggest range of weights to use to produce increase in pressure of a few atmospheres (this would require a calculation based on cross sectional area quoted). (f) Suggested method for measuring pressure e.g. monometer, bowden gauge, pressure sensor (g) Method for reducing error eg allowing enough time for temperature of gas to reach temperature of water, repeating both increasing and decreasing temperature. (h) Plot $p - T$ graph.	5	Indicate letter corresponding to marking point awarded (e.g. ✓a).
	✓✓✓✓✓ 5 marks max		
	Total	5	

ISA (Q) Damped SHM

Stage 1		Mark	Additional guidance notes
(a)	Table with column headings showing all recorded results and correct units ✓ Must include columns for number of oscillations, A , $\ln(A/\text{mm})$ and t . Readings for time period measurements should also be given – these will most likely be separate to the table.	1	Column headings can be either in words or standard symbols. Units can be in words or the correct abbreviation, eg time/seconds, t/s . Alternative acceptable labelling includes time(s), time in s etc. Do not award if any of units are in the body of the table. Accept \log_e instead of \ln
(b)	Significant figures correct for all readings ✓	1	Distances quoted to nearest mm, timings quoted to precision of stopclock. 'Readings' refers to raw data, not 'derived data' such as mean values, \ln values etc.
(c)	At least 1 repeat reading for the time period, T and at least 1 repeat reading of amplitude ✓	1	Eg records time for at least 10 oscillations and shows at least one repeat (if a candidate times $T/2$ instead of T penalise this mark).
(d)	Correct computation of t and Correct computation of mean amplitude and in (A/mm) ✓ Check the 2 nd and 4 th data lines	1	The mark is awarded if the 2 nd and 4 th data lines are correct. No sig fig penalty on these values.
(e)	Suitably large graph scale (do not award if scale on axis could have been doubled) ✓ Scale must be sensible divisions which can be easily read. Eg scales in multiples of 3, 6, 7, 9 etc are unsatisfactory.	1	The plotted points should occupy at least half of each axis.
(f)	Graph correctly labelled axes with units ✓	1	Alternative method of labelling axes as in (a) above for table headings. Allow ecf for labels and units already penalised in (a).
(g)	Points accurately plotted to within 1mm. Check 1 st and 5 th points from the y-axis, which must both be correctly plotted to award the mark. Line of best fit drawn ✓	1	This mark is independent of mark (e), ie if candidates have used an unsuitable scale they can still achieve marks for accurately plotting the points. The line of best fit should have an approximately equal distribution of points on either side of the line.
	Total	7	

ISA (Q) Damped SHM

Section A		Mark	Additional guidance notes
1(a)	Number of oscillations or <u>elapsed</u> time ✓	1	
1(b)	Difficulty in judging stationary point of ball/parallax error ✓	1	
1(c)	<ul style="list-style-type: none"> • timing more oscillations • light gate and electronic timer/motion sensor and data logger/video <u>with</u> timing device. • use of fiducial marker at centre of oscillation • shielding from draughts • countdown procedure Any two of above ✓✓	2	Do not accept 'human error'.
1(d)	Calculated by uncertainty in T , based on spread of repeat readings, and then converted to a % by: $\% \text{ uncertainty} = \frac{\text{uncertainty}}{T} \times 100$ ✓	1	No sf penalty. No penalty for omitting \pm or % sign. No mark available if repeat values were not taken.
1(e)(i)	(Take logs so) $\ln A = \ln A_0 - \lambda t$ ✓ $a = \ln A_0$ and $b = -\lambda$ ✓	2	

1(e)(ii)	$-\lambda$ ✓ (or b allowed if correct in (e)(i))	1	Award a mark to any candidate <u>who drew a curve through a curved trend in Stage 1</u> and answers either $-\lambda / b$ (as specified) or gives a valid comment that addresses the difference between the Stage 1 results and the prediction made in the stem of question 1. Eg 'My graph is curved so the theory does not describe my gradient' OWTTE / 'Cannot represent λ as gradient is not constant' or gives valid interpretation of gradient in context of the candidate's results 'Gradient is a measure of how fast the amplitude decreases with time' / 'Gradient is predicted to be $\ln \lambda$ '
1(e)(iii)	$\ln A_0$ ✓ (or a allowed if correct in (e)(i))	1	Also allow $\ln(200/\text{mm})$ but not value calculated. Also allow a and b for (ii) and (iii) for <u>1 mark total</u> where a and b not correctly identified in (e)(i) Award mark for correct answer that arises from a Stage 1 graph whether straight or curved.
1(e)(iv)	<ul style="list-style-type: none"> • points lie close to a straight line (or not) • value of $\ln A_0$ close to intercept on graph • graph is a straight line with a negative gradient • comments on spread of results/uncertainty in readings <p style="text-align: right;">✓✓✓ 3 marks max</p>	3	Where candidates have drawn a smooth curve for their stage 1 graph, credit can be achieved for the following marking points, allowing access to 3 marks:- <ul style="list-style-type: none"> • Graph is a curve/not a straight line, so does not fit predicted theory • Spread of results too great to justify having drawn a straight line / points plotted fit close to the smooth curve drawn • Reference to the fact that had they decided to draw a straight line instead of a curve it would have had a <u>negative gradient</u>.

1(f)	<ul style="list-style-type: none"> • Greater T, hence smaller % uncertainty ✓ • Easier to judge position of amplitude ✓, hence less spread of repeats/smaller uncertainty in amplitude measurements ✓ 	3	Allow less uncertainty in A values because A values larger <u>or</u> greater uncertainty because A values smaller ✓ Comments related to mass of string compared to mass of table tennis ball causing bending of string and error in timing - allow 1 mark.
	Total	15	

ISA (Q) Damped SHM

Section B		Mark	Additional guidance notes
2(a)	correct average $t_{1/2}$ values: 31.2, 38.0 correct log $t_{1/2}$ values: 1.494 (or 1.495), 1.580 correct log λ values: -1.654, -1.740 ✓	1	Exact values only (NB log values quoted are not 4sf the '1' is the mantissa of the log and not part of the sf)
2(b)	Both plotted points to nearest mm ✓ Best line of fit to points ✓	2	The line should be a straight line with approximately an equal number of points on either side of the line.
2(c)	Large triangle drawn (at least 8cm x 8cm) and Correct values read from graph ✓ Correct numerical answer for gradient = (-) 0.96 to 1.04 ✓ Negative sign included <u>and</u> value quoted to 2 or 3 sf ✓	1 1 1	Missing negative sign penalised on 3 rd mark
2(d)	Recognises that gradient is -1 ✓ Indicates that $\lambda t_{1/2} = \text{constant}$ Or λ inversely proportional to $t_{1/2}$ Or λ is proportional $(t_{1/2})^{-1}$ ✓	2	i.e. do not award first mark for +1. Allow ecf for 2 nd mark for use of +1 for gradient value.
	Total	8	

ISA (Q) Damped SHM

Question 3		Mark	Additional guidance notes
3	Determination of $t_{1/2}$ from graph by reading horizontally from half initial value of A to curve and vertically down to find $t_{1/2}$ ✓ Determination of 2 nd value for $t_{1/2}$ from graph ✓ Value of $t_{1/2}$ from 9.8 to 10.85 with 2 or 3 sf and correct unit Value must be correctly computed from a minimum of 2 values ✓	3	
	Total	3	

Question 4		Mark	Additional guidance notes
4(a)	0.2 s ✓ (half the spread) $\% \text{ Uncertainty} = \frac{0.20 \times 100}{38.0} = \pm 0.53$ ✓	2	No sf penalty. No penalty for omission of \pm . No penalty for omission of % sign.
4(b)	$0.2 + 0.53 = 0.73(\%)$ to 1 or 2 sf ✓	1	No penalty for omission of % sign.
	Total	3	

ISA (Q) Damped SHM

Question 5		Mark	Additional guidance notes
5	(a) Method for measuring amplitude (eg marking positions on track and measuring horizontal displacement with metre ruler) Use camera on <u>open shutter</u> OR video must include scale. (b) Method for measuring elapsed time for each corresponding amplitude measurement. (c) Release method to ensure initial velocity is zero. (d) Suggesting measuring at least 6 different amplitude measurements and corresponding elapsed time (e) Repeat readings of time and amplitude to reduce random errors (f) Plotting suitable graph ($A-t$ or $\ln A-t$) (g) How to interpret if graph shows an exponential decrease in amplitude ✓✓✓✓✓5 marks max	5	Indicate the letter corresponding to the marking point awarded (e.g. ✓a).
	Total	5	