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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 6451

Specification A

PA10 The Synoptic Unit

Mark Scheme

2008 examination - June series

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 meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting 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 candidates' 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.

Further copies of this Mark Scheme are available to download from the AQA Website: www.aqa.org.uk

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Instructions to Examiners

1 Give due credit to alternative treatments which are correct. Give marks for what is correct; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors specific instructions are given in the marking scheme.

2 Do not deduct marks for poor written communication. Refer the script to the Awards meeting if poor presentation forbids a proper assessment. In each paper candidates may be awarded up to two marks for the Quality of Written Communication in cases of required explanation or description. Use the following criteria to award marks:

2 marks: Candidates write legibly with accurate spelling, grammar and punctuation; the answer containing information that bears some relevance to the question and being organised clearly and coherently. The vocabulary should be appropriate to the topic being examined.

1 mark: Candidates write with reasonably accurate spelling, grammar and punctuation; the answer containing some information that bears some relevance to the question and being reasonably well organised. Some of the vocabulary should be appropriate to the topic being examined.

0 marks: Candidates who fail to reach the threshold for the award of one mark.

3 An arithmetical error in an answer should be marked AE thus causing the candidate to lose one mark. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks (indicated by ticks). These subsequent ticks should be marked CE (consequential error).

4 With regard to incorrect use of significant figures, normally two, three or four significant figures will be acceptable. Exceptions to this rule occur if the data in the question is given to, for example, five significant figures as in values of wavelength or frequency in questions dealing with the Doppler effect, or in atomic data. In these cases up to two further significant figures will be acceptable. The maximum penalty for an error in significant figures is **one mark per paper**. When the penalty is imposed, indicate the error in the script by SF and, in addition, write SF opposite the mark for that question on the front cover of the paper to obviate imposing the penalty more than once per paper.

5 No penalties should be imposed for incorrect or omitted units at intermediate stages in a calculation or which are contained in brackets in the marking scheme. Penalties for unit errors (incorrect or omitted units) are imposed only at the stage when the final answer to a calculation is considered. The maximum penalty is **one mark per question**.

6 All other procedures, including the entering of marks, transferring marks to the front cover and referrals of scripts (other than those mentioned above) will be clarified at the standardising meeting of examiners.

GCE Physics, Specification A, PA10, The Synoptic Unit

Question 1		
(a)	(rearranging s = ½ (u + v)t with v = 0 gives) $u = \frac{2s}{t} = \frac{2\times 120}{8.0}$ ✓ = 30 m s^{-1} ✓ E_k (= ½ mv^2 = 0.5 × 1600 × 30^2) = 720 kJ ✓	**3**
(b) (i)	any three of the following when the coil generates current, a force acts on side(s) of coil due to motor effect (or reference to F = BIL) ✓ force on opposite sides acts as a couple ✓ couple (or (magnetic) force) acts against direction of motion of coil ✓ due to Lenz's law (or according to the conservation of energy) ✓	
(ii)	electrical energy returned to batteries (= $I\,V\,t$ = 90 × 12 × 8.0) = 8.6 × 10^3 (J) ✓ % initial kinetic energy returned to battery (= $\frac{8.6\times 10^3}{720\times 10^3}$ × 100) = 1.2 % ✓ **alternative for (ii)** electrical power (= 90 × 12) = 1080 W ✓ % initial E_k returned ($\frac{1080}{\left(\frac{720\times 10^3}{8}\right)}$) 100 = 1.2 % ✓	**5**
	Total	**8**

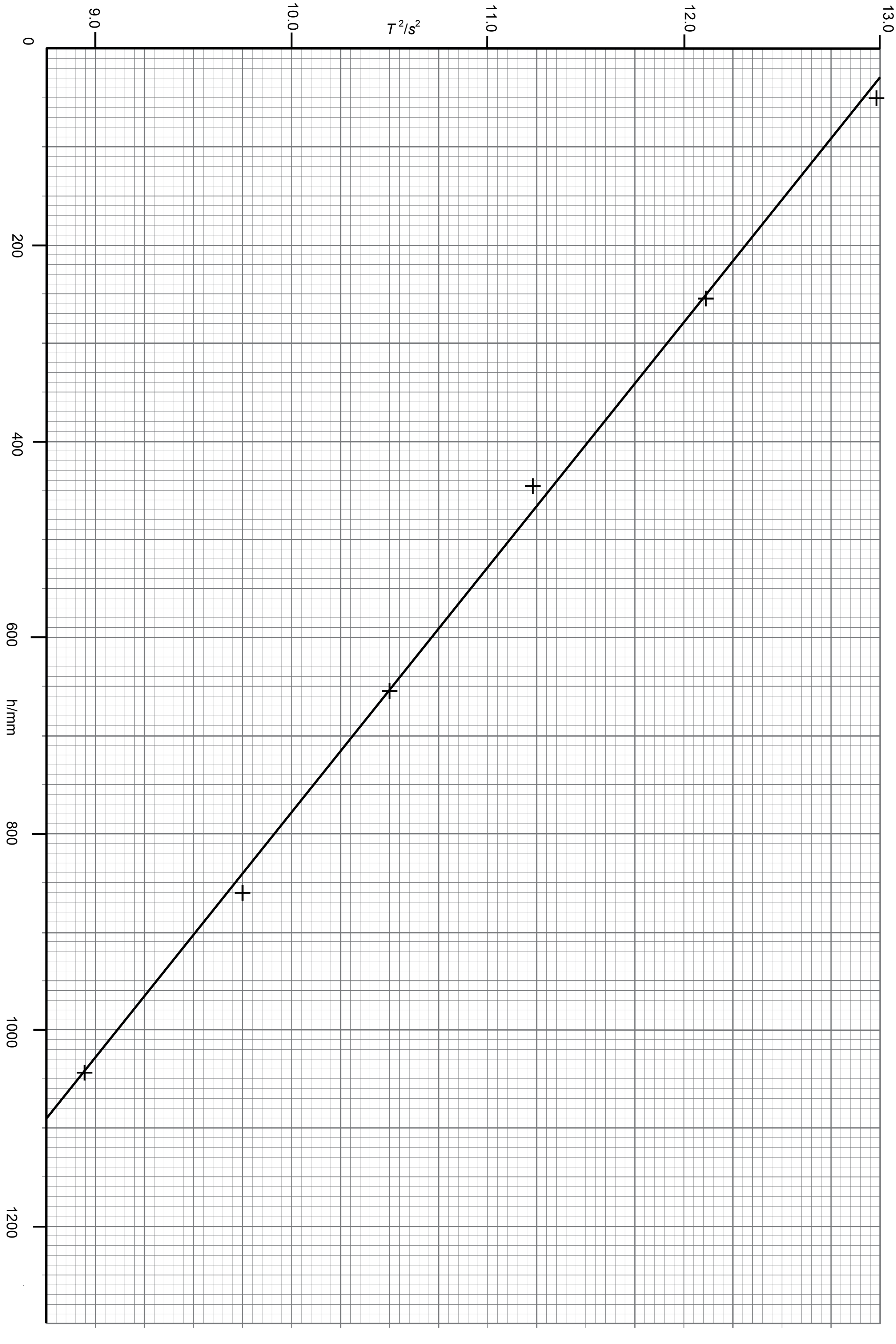
Question 2			
(a)	(i)	$\Delta E = (\frac{1}{2} C V_1^2 - \frac{1}{2} C V_1^2) = 0.5 \times 20 \times 12^2 - 0.5 \times 20 \times 11^2$ ✓ $= 1440 - 1210 \quad = 230$ (J) ✓	3
	(ii)	energy (or heat) dissipated/wasted by current due to circuit wires or resistance (or internal resistance of solar cells or leakage in capacitor) ✓	
(b)	(i)	each grid rectangle represents 360 J (= 0.1 W × 3600 s) ✓ energy supplied represented by area under curve ✓ area under curve = 28 grid rectangles approx ✓ (= 10000 J approx) allow ± 500 J for final value **alternative for (i)** energy supplied represented by area under curve/line ✓ area is equal to that of a triangle of 'height' 0.7 W and 'base' 8 hours ✓ energy supplied = ½ height × base = ½ × 0.7 × 8 × 3600 ✓ (= 10 000 J approx)	6
	(ii)	energy to be supplied (= 230/0.05) = 4600 J ✓ number of grid rectangles for 4600 J = 13 approx ✓ reached by about 13.00 starting at 9.00 so takes about 4 hours ✓ (or for any other start and end time separated by 13 grid rectangles) (**alternative** for last two marks: mean output power = 0.3 W approx ✓ time taken (=4600 J/0.3 W) = 15000 s approx (~ 4 hours) ✓) **general scheme** for correct use of 5 % ✓ for estimate of no. of grid rectangles (= 13 approx) ✓ for estimate of time = 3 – 4 ½ hours (= 10000 – 16000 s) ✓	
		Total	**9**

Question 3			
(a)	(i)	amplitude is maximum midway between the bridges (stated or shown on diagram) (or there is an antinode at the centre of the wire (stated or shown on diagram)) ✓ particles vibrate in phase along the wire ✓	3
	(ii)	(fundamental) wavelength (= 2 × length XY = 2 × 0.85 m) = 1.7(0) m ✓	
(b)	(i)	mass of wire (= density × volume = 7800 × 0.85 × ¼ π × $(0.26 \times 10^{-3})^2$) = 3.5×10^{-4} (kg) ✓ mass per unit length = $\frac{\text{mass}}{\text{length}} = \frac{3.5\times10^{-4}\,\text{kg}}{0.85\text{m}}$ ✓ (= 4.1×10^{-4} kg m^{-1}) (or mass per unit length = density × area of cross-section ✓ = 7800 × ¼ π × $(0.26 \times 10^{-3})^2$) ✓ (= 4.1×10^{-4} kg m^{-1}))	4
	(ii)	rearranging $f_0 = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ gives $T = \mu(2\,L\,f_0)^2$ ✓ (= $4.1 \times 10^{-4} \times (2 \times 0.85 \times 150)^2$) = 27 N ✓ (26.7 N to 3 s.f.)	
(c)		breaking force for wire (= breaking stress × area of cross-section) = 1.2×10^9 × ¼ π × $(0.26 \times 10^{-3})^2$ ✓ = 64 N ✓ (as tension T is proportional to f^2), T would need to increase to 110 N (107 N to 3 s.f.) so the wire would break ✓ **alternative method** (as $T \propto f^2$), T would need to increase to 110 N (107 N to 3 sf) ✓ stress at 107 (or 110) N = $\frac{107}{\frac{1}{4}\pi\times(0.26\times10^{-3})^2}$ ✓ = 2(.02) × 10^9 Pa so wire breaks (or could break) ✓	3
		Total	**10**

Question 4		
(a) (i)	distance (= $c\,t$ = 3.0 × 10^8 × 43 × 60) = 7.7(4) × 10^{11} m ✓	
(ii)	(using $g = GM/r^2$ gives) $\frac{\text{distance from Sun to P}, r_1}{\text{distance from P to Jupiter}, r_2}$ = $(1040)^{1/2}$ or 32(.2) ✓ $r_1 + r_2$ = 7.7 × 10^{11} m ✓ $\therefore r_2 = \frac{7.7\times10^{11}}{(1+32.2)}$ = 2.3(2) × 10^{10} m ✓ **alternative method** r_1 = 7.7 × 10^{11} – 2.3 × 10^{10} m = 7.47 × 10^{11} m ✓ $g_1 = GM/r_1^2$ = 6.67 × 10^{-11} × 1040 × $M_J/(7.47 \times 10^{11})^2$ = 1.2(4) × 10^{-31} M_J ✓ $g_2 = GM/r_2^2$ = 6.67 × 10^{-11} × $M_J/(2.32 \times 10^{10})^2$ = 1.2(4) × 10^{-31} M_J ✓	**4**
(b) (i)	V (= $\frac{-GM}{r}$) = (-) $\frac{6.67\times10^{-11}\times1.92\times10^{27}}{7.1\times10^{7}}$ ✓ (= - 1800 MJ kg^{-1})	
(ii)	assume at the surface kinetic energy of comet = loss of potential energy ✓ (or kinetic + potential energy of comet is constant or no loss of comet's energy or no loss of E_k due to atmosphere or negligible initial E_k or E_p) loss of gpe = mV ✓ $\therefore \frac{1}{2} m v^2 = m V$ ✓ (which gives) v = ($\sqrt{2V}$ = $\sqrt{2\times1.8\times10^{9}}$) = 60 km s^{-1} ✓	**5**
	Total	**9**

Question 5		
(a) (i)	mean E_k (= $\frac{3}{2}kT$) = 1.5 × 1.38 × 10^{-23} × 3000 ✓ = 6.2 × 10^{-20} J ✓ (or 0.388 or 0.39 eV)	
(ii)	**any 3 points below** the molecules in a vapour have a range of speeds ✓ at 3000 K, the average kinetic energy per molecule is 10 times greater than at 300 K ✓ at 3000 K, molecules have sufficient kinetic energy to cause excitation by collision (but not at 300 K) ✓ excited atoms release photons when they return to the ground state ✓ **alternative for last two marks** correct calculation of photon wavelength for E_{ph} = 6.2 × 10^{-21} J to give 3 × 10^{-5} m (for λ) ✓ this wavelength is not a visible/light photon ✓	**5**
(b) (i)	grating spacing d = 1/600000 = 1.67 × 10^{-6} m ✓ (using d sin θ = n λ gives) λ = $\frac{d\sin\theta}{n} = \frac{1.67\times10^{-6}\sin 45}{2}$ ✓ = 590 nm ✓	
(ii)	photon energy (= $\frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{5.9\times10^{-7}}$) = 3.4 × 10^{-19} J ✓	
(iii)	**max 2 from:** excitation energy needs to be at least equal to the photon energy ✓ at 3000 K, mean kinetic energy of an atom is not much less than the excitation energy needed so excitation is possible ✓ at 300 K, (mean) kinetic energy is much less than the excitation energy needed so excitation doesn't take place ✓ **alternative for last two marks** use of $E_k = \frac{3}{2}$ kT with E_k = 3.4 × 10^{-19} J gives T = 16000 K ✓ vapour at T = 3000 K has (some) atoms with enough E_k for excitation but not at 300 K ✓	**6**
	Total	**11**

Question 6			
(a)		use a fiducial mark at the centre of oscillation ✓ correct statement of 1 oscillation ✓ time at least 10 oscillations and ÷ by 10 to obtain an average time for 1 oscillation ✓	**3**
(b)		(rearranging $T^2 = 4\pi^2 \dfrac{(H-h)}{g}$ gives) $T^2 = \dfrac{4\pi^2 H}{g} - \dfrac{4\pi^2 h}{g} = a - bh$ ✓ where $a = \dfrac{4\pi^2 H}{g}$ ✓ and $b = \dfrac{4\pi^2}{g}$ ✓	**3**
(c)	(i)	T^2/s^2; 12.96, 12.11, 11.22, 10.50, 9.73, 8.94 ✓ for all correct to 2 d.p. (T/s; 3.60, 3.48, 3.35, 3.24, 3.12, 2.99) graph: axes labelled + units shown ✓ suitable scales ✓ at least 5 points plotted correctly ✓ best fit line ✓ graph is a straight line and fits y = mx + c with $y = T^2$ and $x = h$ ✓ with gradient, m = - b and a y-intercept, c = a ✓	**9**
	(ii)	gradient of line (= $\dfrac{-4.25\,\text{s}^2}{1.060\,\text{m}}$) = – 4.0 (± 0.05) s^2 m^{-1} ✓ ($\dfrac{4\pi^2}{g}$ = 4.0 gives) g (= $\dfrac{4\pi^2}{4.0}$) = 9.8 (± 0.1) m s^2 ✓ (or N kg^{-1})	
		Total	**15**


T²/s²
9.0
10.0
11.0
12.0
13.0
h/mm
0
200
400
600
800
1000
1200

Question 7			
(a)	(i)	β^+ (or e^+ or ${}^0{}_1e$) ✓ ν ($_e$) ✓	5
	(ii)	before: (2) p = (2) uud ✓ after: ${}^2{}_1H$ (= p + n) = uud + udd ✓	
	(iii)	change: u → d ✓	
(b)		electrostatic force; repulsive force increases as the protons approach ✓ strong nuclear force; (short-range) attractive force that overcomes the electrostatic force (to cause fusion) ✓ weak interaction; causes u quark to change to a d quark (or p to change/decay to n) ✓ W($^+$) boson decays into a β($^+$) particle and a neutrino ✓	**max 3**
		Total	**8**

Question 8			
(a)	(i)	λ would become smaller ✓ because the momentum or speed/velocity p would become larger and $\lambda = h/p$ (or h/mv) ✓	4
	(ii)	θ_{min} would become smaller ✓ as there would be less diffraction if λ is smaller ✓	
(b)	(i)	volume ∝ A because volume (= $4\pi r^3/3$) = $4\pi r_0^3 A/3$ ✓ mass ∝ A *so* density = $\frac{\text{mass}}{\text{volume}}$ is independent of A ✓	4
	(ii)	density = ($\frac{\text{mass}}{\text{volume}} = \frac{A\,m_u}{4\pi r_0^3\,A/3}$) = $\frac{3\,m_u}{4\pi r_0^3}$ ✓ = $\frac{3\times1.66\times10^{-27}}{4\pi(1.2\times10^{-15})^3}$ = 2(.3) × 10^{17} kg m^{-3} ✓	
		Total	**8**

Quality of Written Communication: Q5 (a)(ii) and/or Q6 (a)	**2**