ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 6451
Specification A

PHA7/W Applied Physics

Mark Scheme

2005 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.

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.

PHA7/W: Section A Nuclear Instability

Question 1			
(a)		graph passes through N = 10/11 when Z = 10 and N increases as Z increases ✓ N = 115 → 125 when Z = 80 and graph must bend upwards ✓	**2**
(b)	(i)	**W** at $Z > 60$ just (within one diagonal of a square) below line ✓	
	(ii)	**X** just (within one diagonal of a square) above line ✓	**3**
	(iii)	**Y** just (within one diagonal of a square) below line ✓	
(c)		working showing the change due to emission of four α particles ✓ four β^- particles ✓	**2**
(d)		Any **two** from the following list of processes: β^+ describe the changes to *N* (up by 1) and *Z* (down by 1) [or allow p change to n] α move closer to line of stability [or state the proton to neutron ratio is reduced] p only if nuclide is **very** proton rich [or electrostatic repulsion has to overcome the strong nuclear force] [or highly unstable] [or rare process] e^- capture describe the changes to *N* (up by 1) and *Z* (down by 1) allow p changes to n marking: listing **two** processes ✓ discussing **each** of the two processes ✓✓	**3**

PHA7/W: Section B Applied Physics

Question 2		
(a) (i)	energy: kinetic energy = $\frac{1}{2}I\omega^2$, → small stored energy [or less work/energy needed to produce change] power = rate of energy change, fast change → high power torque: $T = I\alpha$, α large so large torques needed unless I small, momentum , impulse: $L = I\omega$, impulse = ΔL so unless I small, large angular impulses are needed *marking*: for any **one** of the above: for correct consideration ✓ for mathematical justification ✓	**4**
(ii)	explanations based on $I = mr^2$ ✓ low **mass**, small diameter ✓	
(b) (i)	$\alpha = \frac{\omega_1 - \omega_2}{t} = \frac{120+120}{50\times10^{-3}} = 4.8\times10^3$ rad s^{-2} ✓	**4**
(ii)	$T = I\alpha = 4.4\times10^{-5}\times4.8\times10^3 = 0.21(1)$ N m ✓ (allow C.E. from incorrect value of α from (i))	
(iii)	impulse = torque × time = $0.21\times50\times10^{-3} = 1.1\times10^{-2}$ N m s ✓ (1.05×10^{-2} N m s) (allow C.E. for value of T from (ii)) [or $\Delta L = I(\omega_2 - \omega_1) = 4.4\times10^{-5}\times240 = 1.1\times10^{-2}$ N m s]	
(iv)	$\theta = \left(\frac{\omega_1+\omega_2}{2}\right)t = \left(\frac{120+0}{2}\right)25\times10^{-3} = 1.5$ rad ✓	

Question 3		
(a) (i)	110 rpm = $\left(\dfrac{110\times 2\pi}{60}\right)$ = 11.5 (rad s^{-1}) ✓ kinetic energy = ½$I\omega^2$ = 0.5 × 150 × 11.5^2 = 9.9(2) kJ ✓ (use of 12 for conversion above gives 10.8 kJ)	
(ii)	average useful $P_{out} = \dfrac{9.92\times 10^3}{15}$ = 660 W ✓ (661 W) (use of k.e. = 10.8 kJ gives 720 W)	**5**
(iii)	$P_{av} = T_{acc}\omega_{av}$ gives $T = \left(\dfrac{661}{11.5/2}\right)$ = 115 N m ✓ ✓(for ω_{av}) (use of P_{out} = 720 W gives 125 N m)	
(b)	work done against friction = $T_r\theta$ and $T_r = \dfrac{9.95\times 10^3}{35\times 2\pi}$ ✓ = 45(.2) N m ✓ [or use of $\omega_2^{\ 2} = \omega_1^{\ 2} + 2\alpha\theta$, $T = I\alpha$ i.e. 0 = 11.5^2 + (2α × 2π × 35 gives α = 0.301 (rad s^{-2}) T (= $I\alpha$) = 150 × 0.301 = 45(.1) N m]	**2**

Question 4		
(a)	$p_1V_1^{\ \gamma} = p_2V_2^{\ \gamma}$, two points chosen on section BC, e.g. at B and C, $p_1V_1^{\ \gamma} = 29$ and $p_2V_2^{\ \gamma} = 29$ ✓	**1**
(b)	(use of $pV = nRT$ gives) $n = \left(\dfrac{pV}{RT}\right) = \dfrac{2.0\times 10^6\times 3.5\times 10^{-4}}{8.3\times 350}$ ✓ = 0.24(1) (moles) ✓	**2**
(c)	(use of $pV = nRT$, gives) $T = \left(\dfrac{pV}{nR}\right) = \dfrac{0.9\times 10^6\times 6.2\times 10^{-4}}{0.24\times 8.3}$ = 280 K ✓ (7°C) (allow C.E. for value of n from (b))	**1**
(d)	work done = area under curve A → C = 1050 ± 100 J ✓ satisfactory method of finding the area e.g. counting squares ✓	**2**

Question 5		
(a)	P_{in}(= calorific value × fuel flow rate) $= \frac{36\times10^6\times9.6}{3600}$ ✓ ✓ (for conversion to 3600 s) (= 96 kW)	**2**
(b)	$\eta\left(=\frac{T_H - T_C}{T_H}\right) = \frac{1400-360}{1400}$ = 0.74 or 74% ✓	**1**
(c)	η claimed in (a) = $\frac{80(\text{kW})}{100(\text{kW})}$ = 0.80 or 80% ✓ [or $\frac{80(\text{kW})}{96(\text{kW})}$ = 0.83 or 83%] which is > 74%, so claim 1 is unjustified ✓ heat rejected from engine = $P_{in} - P_{out}$ ✓ real mechanical P_{out} must be < 0.74 × 100 i.e. < 74 kW ✓ so claim 2 is justified as $P_{in} - P_{out}$ > 20 kW ✓ [alternative for (c): **maximum** *P*out = 71 kW (0.74 × 96) or 74 kW (0.74 × 100) ✓ which is < 80 kW, so claim 1 is unjustified ✓ heat rejected from engine is 25 kW (96 − 71) or 26 kW (100 − 74) ✓ **actual** wasted power must be > 25 kW ✓ claim 2 is justified as 25 kW > 20 kW ✓]	**Max 4**

Quality of Written Communication : Q1 (d) and/or Q5 (c)	**2**