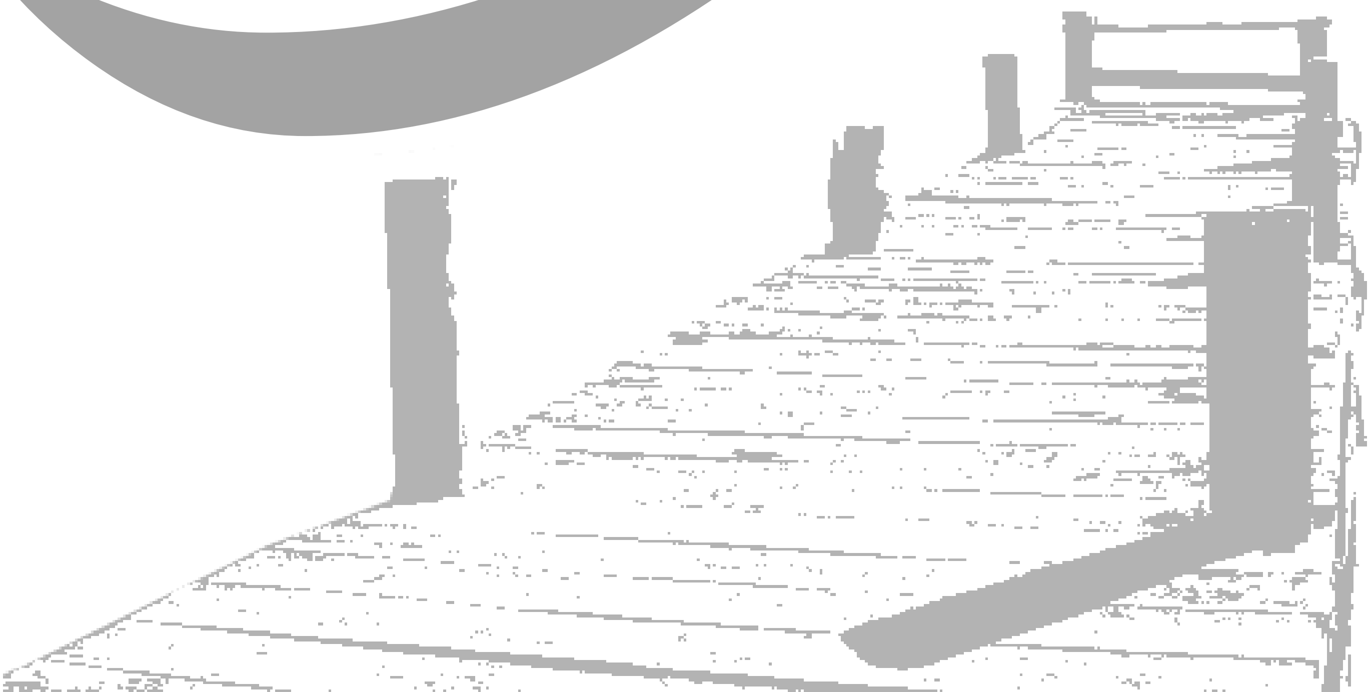
GCE
AS and A Level

Physics A

AS exams 2009 onwards
A2 exams 2010 onwards

Unit 5: Approved specimen mark scheme

Version 1.1



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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 2451
Specification A

PHYA5 Nuclear and Thermal Physics

Mark Scheme

The specimen assessment materials are provided to give centres a reasonable idea of the general shape and character of theplanned question papers and mark schemes in advance of the first operational exams.

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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PHYA5: Nuclear and Thermal Physics

Question 1			
(a)		graph passes through $N = 100$ to 130 when $Z = 80$ ✓ and $N = 20$ when $Z = 20$ ✓	**2**
(b)	(i) (ii) (iii)	**W** at $Z > 60$ just below line ✓ **X** just above line ✓ **Y** just below line ✓	**3**
(c)		fission nuclei (or fragments) are neutron-rich and therefore unstable (or radioactive) ✓ neutron-proton ratio is much higher than for a stable nucleus (of the same charge (or mass)) ✓ β^- particle emitted when a neutron changes to a proton (in a neutron-rich nucleus) ✓	**3**

(d)	The marking scheme for this part of the question includes an overall assessment for the Quality of Written Communication (QWC). There are no discrete marks for the assessment of written communication but the quality of written communication will be one of the criteria used to assign the answer to one of three levels.	
Level	**Descriptor** an answer will be expected to meet most of the criteria in the level descriptor	**Mark range**
Good **3**	- answer supported by an appropriate range of relevant points - good use of information or ideas about physics going beyond those given in the question - argument well structured with minimal repetition or irrelevant points - accurate and clear expression of ideas with only minor errors of spelling, punctuation and grammar	**5-6**
Modest **2**	- answer partially supported by relevant points - good use of information or ideas about physics given in the question but limited beyond this - the argument shows some attempt at structure - the ideas are expressed with reasonable clarity but with a few errors of spelling, punctuation and grammar	**3-4**
Limited **1**	- valid points but clearly linked to an argument structure - limited use of information or ideas about physics - unstructured - errors in spelling, punctuation and grammar or lack of fluency	**1-2**
0	- incorrect, inappropriate or no response	**0**
	examples of the sort of information or ideas that might be used to support an argument: • reduction of greenhouse gas emissions is (thought to be) necessary to stop global warming ✓ • long term storage of radioactive waste is essential because the radiation from it damages (or kills) living cells ✓ • radioactive isotopes with very long half lives are in the used fuel rods ✓ • nuclear power is reliable because it does not use oil or gas from other countries ✓ • radioactive waste needs to be stored in secure and safe conditions for many years ✓ **conclusion** **either** nuclear power is needed; reduction of greenhouse gases is a greater problem than the storage of radioactive waste because 1 global warming would cause the ice caps to melt/sea levels to rise ✓ 2 safe storage of radioactive waste can be done ✓ **or** nuclear power is not needed; storage of radioactive waste is a greater problem than reduction of greenhouse gases because 1 radioactive waste has to be stored for thousands of years ✓ 2 greenhouse gases can be reduced using renewable energy sources ✓	
	Total	**14**

Question 2		
(a)	use of pV = constant or $p_1V_1 = p_2V_2$ ✓ $p = 99 \times 3.50/4.15$ ✓ = 83.5 kPa ✓	**3**
(b)	no. of moles = 99 [× 10] × 3.5 × 10^{-4}/8.31 × **291** ✓ = 1.4(3) × 10^{-2} moles ✓ no. of molecules (= 1.4(3) × 10^{-2} × 6.02 × 10^{-23}) = 8.6 (1) × 10^{-21} ✓	**3**
(c)	molecules/particles have momentum ✓ momentum change at wall ✓ momentum change at wall/collision at wall leads to force ✓ [allow impulse arguments] less air so fewer molecules ✓ so change in momentum per second/rate of change is less [*or* per unit per time] ✓ pressure is proportional to number of molecules (per unit volume) ✓	**max 5**
	Total	**11**

Question 3		
(a) (i)	thermal energy gained by water = 0.45 × 4200 × (35 – 15) = 3.78×10^4 J ✓	
(ii)	(thermal energy loss by copper = thermal energy gained by water gives) $0.12 \times 390 \times \Delta T = 3.78 \times 10^4$ ✓ $\Delta T = \frac{3.78\times10^4}{0.12\times390} = 808\,\text{K}$ flame temperature (= 808 + 35ºC) = 843ºC or 1116 K ✓	**3**
(b) (i)	measure the total mass of the water, beaker and iron lump (to find the mass of water lost) ✓	
(ii)	mass of water lost due to conversion to steam, *m* = mass measured in (b) (i) - initial mass of water, beaker and iron ✓ add the thermal energy due to steam produced, *mL*, to the thermal energy gained by the water ✓ calculated flame temperature would be greater ✓	**4**
	Total	**7**

Question 4		
(a)	number of gamma photons per second = $\frac{3.0\times10^7}{5}$ (= 6.0×10^6) ✓ area of sphere of radius 1.50 m (= $4\pi r^2 = 4\pi \times 1.5^2$) = 28.3 m^2 ✓ number of gamma photons per sec per cm^2 = $\frac{6.0\times10^6}{28.3\times10^4}$ ✓ (= 21(.2))	**3**
(b) (i)	decay constant = ($\frac{\ln 2}{t_{1/2}} = \frac{0.693}{12\times3600}$) = $1.60 \times 10^{-5}\,s^{-1}$ ✓ new no. of gamma photons per sec per cm^2 = 21(.2) $e^{-(1.6\times10^{-5}\times6.0\times3600)}$ ✓ = 15(.0) ✓ (or 6 hours is 0.5 half-lives ✓ source activity decreases to $2^{-0.5}$ of initial activity in this time ✓ new no. of gamma photons per sec per cm^2 = 21(.2) × $2^{-6/12}$ ✓ = 15(.0) ✓)	**5**
(ii)	any **two** of the following points ✓✓ beta particle range in air is less than 1.5 m beta particle absorbed by air beta particles lose energy in air more rapidly than gamma photons beta particles ionise air much more than gamma photons	
	Total	**8**

	Assessment Objectives	
Question No	*Ability tested*	*Marks*
1 (a)	AO1	**2**
(b)	AO2	**3**
(c)	AO2	**3**
(d)	AO1/AO3	**6**
	Question Total	**14**
2 (a)	AO2	**6**
(b)	AO1/AO2	**5**
	Question Total	**11**
3 (a)	AO1	**3**
(b)	AO2	**4**
	Question Total	**7**
4 (a)	AO2	**3**
(b)	AO1/AO2	**5**
	Question Total	**8**
	Total	**40**

	Summary	
Marks	*Ability tested*	*%*
13	AO1 Knowledge and Understanding	33
24	AO2 Application	60
3	AO3 How Science Works	7