GCE A LEVEL MARKING SCHEME

SUMMER 2024

A LEVEL
PHYSICS – UNIT 3
1420U30-1

About this marking scheme

The purpose of this marking scheme is to provide teachers, learners, and other interested parties, with an understanding of the assessment criteria used to assess this specific assessment.

This marking scheme reflects the criteria by which this assessment was marked in a live series and was finalised following detailed discussion at an examiners' conference. A team of qualified examiners were trained specifically in the application of this marking scheme. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners. It may not be possible, or appropriate, to capture every variation that a candidate may present in their responses within this marking scheme. However, during the training conference, examiners were guided in using their professional judgement to credit alternative valid responses as instructed by the document, and through reviewing exemplar responses.

Without the benefit of participation in the examiners' conference, teachers, learners and other users, may have different views on certain matters of detail or interpretation. Therefore, it is strongly recommended that this marking scheme is used alongside other guidance, such as published exemplar materials or Guidance for Teaching. This marking scheme is final and will not be changed, unless in the event that a clear error is identified, as it reflects the criteria used to assess candidate responses during the live series.

GCE A LEVEL PHYSICS

UNIT 3 – OSCILLATIONS AND NUCLEI

SUMMER 2024 MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (except for the extended response question).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statement.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)			(236.052595 – 235.866563) u = (1) i.e. attempt at LHS-RHS 0.186032 [u] can be implied (1) × 931 (1) Energy released = 173.20 M[eV] (1)	1	1 1 1		4	4	
	(b)			Number of nuclei in 1.2 kg i.e. number method $= \frac{6.02\times10^{23}}{235\times10^{-3}}$ x $1.2 = 3.074 \times 10^{24}$ **or** $\frac{1.2}{(235 \text{ x } 1.66 \text{ x } 10^{-27})}$ (1) Energy released by 1.2 kg i.e. 1(a) **ecf** × number $= (3.074 \times 10^{24})(173.20) = 5.32 \times 10^{26}$ MeV (1) Conversion and answer i.e. $= (5.32 \times 10^{26})$ x $(1.6 \times 10^{-13}) = 8.52 \times 10^{13}$ (1) **Alternative:** $\frac{0.186032}{235}$ x 1.2 (1) $\times c^2$ (1) = 8.56 $\times 10^{13}$ (1)		3		3	3	
	(c)			Use of 3600 factor e.g. Energy required for 1 light bulb for 1 hour $= 11 \times 60 \times 60 = 39600$ J (1) Correct use of energy, power equation e.g. Number of bulbs $= \frac{8.52\times10^{13}}{39600}$ [method, ecf for energy 1] $= 2.15 \times 10^{9}$ so her claim is correct (1) Accept other numbers e.g. 7.92 × 10^{13} [J] 11.8 [W], 3863 or 3868 [s], 2.36 × 10^{10} [W]			3	3	2	
				Question 1 total	**1**	**6**	**3**	**10**	**9**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)			[An acceleration that applies to] motion on a circular [path] (1) [is directed] towards the centre [of the circle] (1)	2			2		
	(b)	(i)		Period, $T = 24 \times 60 \times 60 = 86400$ s (1) $\omega = \frac{2\pi}{T} = \frac{2\pi}{86400}$ (1)[= 7.27×10^{-5} rad s^{-1}]		2		2	2	
		(ii)		$a = \omega^2 R_E = (7.27 \times 10^{-5})^2 (6370 \times 10^3)$ (1) **ecf** $= 0.0337$ [m s^{-2}](1) [**alternatively** could use $a = \frac{v^2}{r}$] Accept 0.0312 [m s^{-2}] if 7×10^{-5} used	1	1		2	2	
		(iii)	I	$v = \omega r = 7.27 \times 10^{-5} \times 6370 \times 10^3$ (1) $= 463$ [m s^{-1}](1) Accept 446 [m s^{-1}] if 7×10^{-5} used	1	1		2	2	
			II	Speed is irrelevant / velocity changes slowly / velocity can't be felt (1) {Acceleration / force} is small (1) Don't accept acceleration = 0			2	2		
				Question 2 total	**4**	**4**	**2**	**10**	**6**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)			**Indicative content:** **<u>Experimental set-up</u>** Source clear in diagram or description Detector clear in diagram or description Distance clear in diagram or description. Blocking alpha and beta [with aluminium]. **<u>Data collection</u>** Vary distance. Measure counts for set time / long time / repeats Check for background With no source present **<u>Analysis</u>** Adjust for the background intensity (or nothing if they have said that the source is a strong source / lead container). Correct plot chosen e.g. intensity vs r^{-2}, or $(\text{count})^{-1/2}$ vs r $\ln(\text{intensity or count})$ vs $\ln r$ Correct expected shape i.e. straight line Added detail e.g. error bars, intercept etc	6			6		6

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3				**5-6 marks** A comprehensive account of all 3 areas is provided. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** A comprehensive account is given for 2 out of the 3 areas i.e. experimental set up, data collection and analysis or a limited account of all 3 areas is provided. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** A comprehensive account is given for 1 out of the 3 areas i.e. experimental set up, data collection and analysis or a limited account of 1 or 2 areas is provided. *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.* **0 marks** *No attempt made or no response worthy of credit.*						
	(b)	(i)	I	Substitution: $E = hf = h\frac{c}{\lambda}$ $E = (6.63 \times 10^{-34})\left(\frac{3\times10^{8}}{1\times10^{-12}}\right)(1)$ $= 2.0 \times 10^{-13}[\text{J}](1)(\text{or } 1.24 \text{ MeV})$	1	1		2	2	
			II	$E = (6.63 \times 10^{-34})(1.8 \times 10^{9}) = 1.2 \times 10^{-24}[\text{J}]$		1		1	1	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		**For the 1st mark:** Lots of further research / data collected **For the 2nd mark either of:** – Brain cancer vs mobile phone usage i.e. targeting brain cancer victims or high mobile phone usage – Carry out statistical analysis e.g. look for correlations between usage (in phone bills) and cancer occurrence. Don't accept carry out experiments on humans or any reference to ionisation or testing what comes out of mobile phones			2	2		
				Question 3 total	**7**	**2**	**2**	**11**	**3**	**6**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	(a)		Reasonable attempt at sinusoidal curve (1) Accurate curve drawn with maximum and minimum at correct points (1) N.B. Look out for points being missed, trough in the right place, starting too low		2		2	1	2
	(b)		Period – the time taken for one complete cycle of the oscillations (1) 0.9 ± 0.01 [s] (1)	1	1		2		2
	(c)		$y = 1.5\cos\left(\frac{2\pi}{0.9\ [1]}t \pm \pi\ (1)\right)$ cm **ecf** on period Don't accept 180		2		2	1	1
	(d)	(i)	Good tangent (1) Substitution of values for the gradient **ecf** (1) Max velocity i.e. 10.5 ± 1.0 [cm s^{-1}] (1) **ecf**	1 1	1		3	2	3
		(ii)	Max velocity of 10 [cm s^{-1}] **ecf** (1) [Sinusoidal curve with] appropriate period **ecf** (1) Appropriate phase for starting point i.e. sin curve (1)		3		3	2	3
	(e)	(i)	Acceleration is [directly] proportional to displacement (1) And is directed towards a fixed point (1)	2			2		
		(ii)	Substitution: $T = 2\pi\sqrt{\frac{m}{k}}$ i.e. $0.9 = 2\pi\sqrt{\frac{0.030}{k}}$ (1) **ecf** Rearrangement: $k = \frac{4\pi^2 \text{x} 0.030}{0.81}$ (1) Answer = 1.46 N m^{-1} ****unit mark**** (1)	1	1 1		3	2	3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(f)		Attempt at ½ mv^2 i.e. $0.5\ m\ v_{\max}^2 = 0.5\ (0.030)\ (0.1)^2 (1)$ $= 1.5 \times 10^{-4}$ J(1) Extension at equilibrium ($= \frac{mg}{k} = \frac{(0.030)(9.81)}{1.46} = 0.20$ m (1) Adding 1.5 cm [= 0.215 m] (1) Attempt at ½ kx^2 i.e. $= 0.5\ k\ x^2 0.5\ (1.46)(0.215)^2 [1$ **ecf**$]$ $= 0.034$ [J] so therefore claim is correct (1)			6	6	6	6
			Question 4 total	**6**	**11**	**6**	**23**	**14**	**20**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)			Air resistance or resistive forces or friction or drag	1			1		1
	(b)			Substitution (1) Taking logs (1) Answer for $\lambda = 1.53 \times 10^{-3}$ or 1.18×10^{-3} or 1.93×10^{-3} or 0.071 or 0.092 or 0.116 (1) Second value for λ correct or 20% + 6.7% = 26.7% (1) Value for absolute uncertainty to 1 or 2 sig figs and consistent dps with λ e.g. 0.4×10^{-3} (1)	1	1 1 1 1		5	5	5
	(c)			Suitable example e.g. car suspension system, push-tap light switches, soft close toilet seats, swing	1			1		1
				Question 5 total	**3**	**4**	**0**	**7**	**5**	**7**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	(a)		$\lambda = \frac{\ln 2}{T_{1/2}} = \frac{\ln 2}{5730} = 1.2097 \times 10^{-4}$ [yr^{-1}] **or** 3.84 × 10^{-12} [s^{-1}] (1) Correct use of 70% i.e. 0.7 (1) Taking logs (1) so $t = \frac{1}{\lambda} \ln\left(\frac{N_0}{N}\right) = \frac{1}{1.2097\times10^{-4}} \ln\left(\frac{1}{0.7}\right) = 2948$ [yr] **or** 9.29 × 10^{10} [s] (1) Award 3 marks for 9950 years **Alternative:** Correct use of 70% i.e. 0.7 (1) Substitution e.g. $0.7 = \frac{1}{2^n}$ (1) Taking logs e.g. $\ln 0.7 = -n \ln 2$ (1) Correct answer (1)	1 1 1	1 1		4	4	
	(b)		Substitution (1) $\left(\frac{A}{A_0}\right) = e^{-(1.2097\times10^{-4})(7000)}$ = 0.429 (1) $= 42.9\%$ (1) **Alternative:** Number half-lives = $\frac{7000}{5730}$ = (1.22) (1) Substitution i.e. $A = \frac{A_0}{2^{1.22}}$ (1) Answer = 43% (1)	1	1 1		3	3	
			Question 6 total	**3**	**4**	**0**	**7**	**7**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	(a)		**Any 3 × (1) from:** – Volume of molecules is negligible compared to the size of the gas **or** time between collisions much longer than during – Collisions between the molecules are elastic [on average] – Forces of attraction between molecules are negligible / forces only applied when molecules collide / constant velocity between collisions / molecules have KE but no PE – Gases consist a [large number] of molecules in [rapid], random motion	3			3		
	(b)	(i)	$\text{rms speed} = \text{sqrt}\left(\frac{480^2+521^2+436^2+445^2+503^2}{5}\right)(1)$ $= 478\ [\text{m s}^{-1}](1)$		2		2	2	
		(ii)	$m = \frac{32\times10^{-3}}{6.02\times10^{23}} = 5.316\times10^{-26}$ kg **or** 32 u (1) Use $\frac{1}{2}m\bar{c^2} = \frac{3}{2}kT$ or equivalent and rearrange (1) $T = \left(\frac{m}{3k}\right)\times \text{ rms speed}^2 = \left(\frac{5.316\times10^{-26}}{3(1.38\times10^{-23})}\right)\times 478^2 = 293.4$ [K] (1) **Alternative:** Use $\frac{1}{2}M_r\bar{c^2} = \frac{3}{2}RT$ (1) Rearrange (1) Answer = 293.4 [K] (1)		3		3	3	
	(c)		Method for temperature variation e.g. the $(\text{rms speed})^2 \propto T$ (1) Answer i.e. $\times\sqrt{2}$ + comment e.g. Gareth is incorrect (1) Method for pressure variation e.g. $PV = nRT$ (1) Answer + comment e.g. Gareth is correct (1) Accept $p \propto T$ Gareth is correct for 1 mark only			4	4		
			Question 7 total	**3**	**5**	**4**	**12**	**5**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	(a)	(i)	The energy of the photon becomes (1) PE and KE of electron (accept freeing electron for PE) (1) **Alternative:** Photon energy = KE + workfunction (1) Photon energy = KE + energy to release electron (2)	2			2		
		(ii)	Current / no. of electrons per sec / charge per sec etc. Accept power			1	1		
	(b)		Substituting correctly for r in equation 3 e.g. $p^2 = \frac{m_e e^2}{4\pi\varepsilon_0 \frac{nh}{2\pi p}}$(1) Correct algebra leading to $p = \frac{m_e e^2}{2\varepsilon_0 nh}$(1) (Minimum algebra: $p^{\cancel{2}} = \frac{m_e e^2}{\cancel{4\pi}\varepsilon_0 \frac{nh}{\cancel{2\pi p}}}$ QED i.e. cancelling π and p)		2		2	2	
	(c)	(i)	Minimum of 3 values substituted correctly (1) Answer = 13.55 [eV] or final substitution seen (1)	1	1		2	2	
		(ii)	Explain n = 1 e.g. leaving n = 1 or substituting n = 1 (1) Explain n = ∞ or PE at ∞ (1)		2		2		
	(d)		Valid method adopted e.g. using n = 3 and n = 2 to calculate the wavelength **OR** using 656 nm to confirm energy gap between n = 2 and 3 (1) $E = \frac{hc}{\lambda} = 3.03 \text{ x } 10^{-19}$ [J] **OR** $13.6 \times \left(\frac{1}{4} - \frac{1}{9}\right)$ **OR** 1.89 (1) Final confirmation seen e.g. $3.03 \text{ x } 10^{-19}$J = $13.6 \times \left(\frac{1}{4} - \frac{1}{9}\right) \times 1.6 \times 10^{-19}$ **OR** $\frac{hc}{13.6\times\left(\frac{1}{4}-\frac{1}{9}\right)\times 1.6\times 10^{-19}}$= 656 n[m] (1)			3	3	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(e)		Easier to escape **or** more electrons escaping **or** tunnelling linked to electrons escaping (1) Light at lower V **or** measured V is lower **or** actual barrier is higher (1)		2		2		
	(f)	(i)	Electrons have greater [internal] energy i.e. link between temperature and energy (1) More electrons (1)		2		2		
		(ii)	Use of $\frac{3}{2}kT$ can be implied (1) Conversion to eV (1) Answer = 0.038 [eV] (1) Diode switches on 0.038 V too early or 0.038 V is an uncertainty - any good sensible comment regarding this equivalent pd (1)			4	4	2	
			Question 8 total	**3**	**9**	**8**	**20**	**8**	**0**

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	1	6	3	10	9	0
2	4	4	2	10	6	0
3	7	2	2	11	3	6
4	6	11	6	23	14	20
5	3	4	0	7	5	7
6	3	4	0	7	7	0
7	3	5	4	12	5	0
8	3	9	8	20	8	0
TOTAL	**30**	**45**	**25**	**100**	**57**	**33**