GCE A LEVEL MARKING SCHEME

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.

WJEC GCE A LEVEL PHYSICS

UNIT 3 – OSCILLATIONS AND NUCLEI

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (apart from the questions where a level of response mark scheme is applied).

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. Award the middle mark in the level if most of the content statements are given and the communication statement is partially met. Award the lower mark if only the content statements are matched.

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
1	(a)		ΔU increase (or change) in internal energy of a system (1) Q heat flowing into the system (1) W work done by the system (1) Reference to system at least once otherwise award a maximum of 2 marks	3
	(b)	(i)	Constant temperature expansion. (1) Use of PV = nRT and note T constant At A PV = 3.6×10^5 x 1 = 3.6×10^5 J (1) At B PV = 1.2×10^5 x 3 = 3.6×10^5 J (1) Check any point on curve (1)	4
		(ii)	Reasonable attempt at calculating area or using pΔV (1) W = 395 500 [± 50 000] [J] (1) Award 1 mark only for 480 000 [J]	2
		(iii)	Work done = 2 x 1.2 x 10^5 (1) Total work = 395 500 - (2 x 1.2 x 10^5) + 0 **ecf** (1) ΔU = 0 (over whole cycle) (1) can't be implied Q = 155 500 [J] (1) allow **ecf** on total work Note: any attempts at ΔU using temperatures can't be credited **Alternative 1** Work done = area enclosed (in cycle) (1) Reasonable attempt at enclosed area (accept triangle at an attempt) (1) ΔU = 0 (1) Correct answer (accept 155 000 ± 50 000) (note there is **ecf** on (b)(i) and on 2nd mark) (1) **Alternative 2** Heat = area enclosed (in cycle) (1) Reasonable attempt at enclosed area (accept triangle as an attempt) (1) ΔU = 0 (1) (note that this will almost certainly be lost if they start from the 1st mark) Correct answer (accept 155 000 ± 50 000) (note that is **ecf** on (b)(i) and on 2nd mark) (1) Penalise bad triangle approximation only once	4

Question			Marking Details	Marks Available
2	(b)	(iii)	**Natalie:** Same KE (beware candidates implying this by using $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ and stating same T) (1) Oxygen slower linked to larger mass (**OR** reverse He faster and lighter) (1) this is an independent mark but does not imply the 1st mark) These 2 marks are implied by rms of O_2 = rms of He /$\sqrt{8}$ **OR** rms of He/$2\sqrt{2}$ etc. **Mona:** KE (or speed) depends on (only) temperature **OR** pressure difference irrelevant (1) Conclusion both wrong (1) **Alternative for Natalie points only:** Calculation of He speed (using same volume even though not quite valid) $\sqrt{\overline{c^2}} = \sqrt{\frac{3p}{\rho}} = \sqrt{\frac{3\times 28000}{0.16}} = 725\ or\ 712$ (1) Using Avogadro's gas law to get oxygen rms speed i.e. $\sqrt{\overline{c^2}} = \sqrt{\frac{3p}{\rho}} = \sqrt{\frac{3\times 28000}{0.16\times 8}} = 256$ OR $\sqrt{\overline{c^2}} = \sqrt{\frac{3p}{\rho}} = \sqrt{\frac{3\times 25000}{0.16\times 8}} = 242$ (1)	4

Question			Marking Details	Marks Available
3	(a)		A process that occurs without the need for external energy input once it is initiated. (1)	1
	(b)	(i)	Alpha – Deflect upwards (1) Beta – Deflect downwards (1) Gamma – No Deflection (1) **Penalise 1 if beta deflect less than alpha**	3
	(c)	(i)	$A = A_0 e^{-\lambda t}$ when $t = T½$, $A = A_0 / 2$ (1) $\frac{A_0}{2} = A_0 e^{-\lambda T_{\frac{1}{2}}}$ (1) $-ln2 = -\lambda T_{\frac{1}{2}}$. (1)	3
		(ii)	Conversion to seconds 108x24x60x60 = 9331200 (1) ln2 ÷ 9331200 = 7.43×10^{8} s^{-1} (1)	2
	(d)	(i)	⅙ **or** 0.166	1
		(ii)	108, 98, 87, 75, 65, 57, 52, 45, 37, 30, 22, 18, 17, 10, 4, 2, 2, and 0	1
		(iii)	More number of throws, less dice are discarded (1) Number of decay is higher at the start (1) Less dice are thrown at the end (1)	3
		(iv)	Probability of decay is constant (1) Decay is a **random** process (1) So agrees to the assumption (1)	3
	(e)	(i)	6.45×10^{24}	1
		(ii)	λ = ln2 / (5730x60x60x24) (1) $3.84 \times 10^{-12} s^{-1}$ (1)	2
		(iii)	$A_0 = 3.84 \times 10^{-12} \times 6.45 \times 10^{24}$ (1) 2.48×10^{13}Bq (1)	2
		(iv)	$A = 2.48 \times 10^{13} e^{-1.21 \times 10-4*(2400)}$ 1.86×10^{13}Bq (1)	2
		(v)	$150 \times (½)^2$ = 2 half life (1) 37.5 g (1)	2
		(vi)	$A = 0.1A_0 = A_0 e^{-\lambda t}$ (1) 19,000 years (1)	2

Question			Marking Details	Marks Available
4	(a)		$^{236}_{92}\text{U} \longrightarrow {}^{0}_{-1}\text{e}^{-} + {}^{236}_{93}\text{Np}$	1
	(b)		Use of $\lambda = \frac{\ln(2)}{T_{1/2}}$ (1) Correct conversion of MBq → Bq and calculation of initial number of nuclei N_0 using $A_0 = \lambda N_0$, or equivalent method (1) Calculation of the number of half-lives passed (n = 10) (1) Use of $N = N_0 \left(\frac{1}{2}\right)^n$ or equivalent method (e.g., exponential decay formula) (1) Correct final mass calculated (approx. 4.07 × 10-10 kg) with appropriate unit (kg) (1)	5
	(c)		**Indicative content:** **Fusion** Nuclei join together Left of stable region Moving toward higher BE/N Stability linked to BE/N OR also stating moving to higher stability Linked to reduced mass Linked to energy release ($E = mc^2$) Possible numbers would be BE/N increases from 2 to 7 for fusion **Fission** Nucleus splits (into smaller nuclei) Right of stable region Moving toward higher BE/N Stability linked to BE/N OR also stating moving to higher stability Linked to reduced mass Linked to energy release ($E = mc^2$) Possible numbers: BE/N increases from 7.5 to 8.5 for fission **5-6 marks** Comprehensive account of both fission and fusion provided. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Comprehensive account of either fission or fusion provided or limited description of both. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** Limited description of either fission or fusion. *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with little structure.* **0 marks** No attempt made or no response worthy of credit.	6 QER

Question			Marking Details	Marks Available
4	(d)		(92×0.93827) + (144×0.93956) - 219.8750 (1) 1.74 GeV/c^2 (1)	2
	(e)		**Any 3 (x1) from:** No **acid rain** formation (1) Produces a **very large amount of energy** from a small amount of fuel. (1) **Low carbon emissions** during operation, helping to reduce greenhouse-gas output. (1) Provides a **reliable, continuous baseload supply**, not dependent on weather. (1) **Radioactive waste** is produced and must be stored safely for long periods. (1) **High cost** of building, maintaining, and decommissioning nuclear power stations. (1) Risk of **accidents or leaks**, which can have severe environmental and health consequences. (1)	3

Question			Marking Details	Marks Available
5	(a)		Vertical forces are balanced (accept vertical equilibrium) (1) $T\cos\theta$ is vertical component (accept doing trig to show that $T\cos\theta$ is the vertical component) (1)	2
	(b)		$\frac{5}{2}$ = 2.5 and $3.0\sin\theta$ labelled in the diagram (or explained in words) **Accept** radius is 2.5 m and $3.0\sin\theta$ is the component of the displacement horizontally	1
	(c)	(i)	Use of T cos θ = mg (1) $\cos\theta = \frac{mg}{T} = \frac{52.0 \times 9.81}{550} = 0.927$ θ = $\cos^{-1}$(0.927)=22.0° (1)	
		(ii)	r = 2.5 + 3 sin (c)(i) = 4.00 (1) **ecf**	
		(iii)	Use of $\frac{mv^2}{r}$ (1) **ecf** Equating to $T\sin\theta$ (1) **ecf** Answer = 3.8 [m s^{-1}] (1)	3

Question			Marking Details	Marks Available
6	(a)	(i)	Potential to kinetic energy (or kinetic to potential energy) (1) This is continuous e.g. potential to kinetic and then potential energy (1) (can be deduced from a diagram)	2
		(ii)	**Any 1 (x1) from:** Energy is lost against air resistance (1) or equiv by collision with air molecules (1) or energy lost due to friction at top of the string (Energy lost due to friction or resistance is not enough) (1)	1
	(b)	(i)	1.18, 1.26, 1.34, 1.41 (1) 50, 52, 56, 59 (1) 2, 2, 2, 2 (1)	3
		(ii)	Rearrange of $T^2 = 4\pi^2 \frac{l}{g}$ (1) Plot a graph of T^2 against *l* (1) g = $4\pi^2$ / gradient (1)	3
		(iii)	Award 3 marks for all points correct Award 2 marks for 3 points correct Award 1 mark for 1 point correct Line of best fit drawn (1) Use more than ½ of the grid (1)	5
		(iv)	Gradient = 394.7 (±5%) (1) 394.7 = $\frac{4\pi^2}{g}$ (1) *g* = 9.99 ms^{-2} (±5%) (1) **ecf**	3
	(c)	(i)	Max gradient between 4.0 and 4.2 [s2 m^{-1}] Min gradient between 3.7 and 3.9 [s2 m^{-1}] **Award 1 mark for both lines correct**	1
		(ii)	T^2 is directly proportional to *l* (1) Straight line passing through origin with positive gradient (1)	2

Question			Marking Details	Marks Available
7	(a)		Use of strain = ΔL/L or equivalent relationship (1) Rearrangement: L = ΔL/strain = $(0.10 \times 10^{-3})/(10^{-21})$ (1) Answer = 1.0×10^{17} [m] or 10 light years (1) [Allow 1 mark for stating 1 part in $10^{21} = 10^{-21}$]	2
	(b)	(i)	Gravitational wave stretches one arm (1) and compresses the other [simultaneously] or changes both arms in opposite ways (1) Accept: interference pattern changes / phase difference changes / allows comparison	2
		(ii)	Use of h = ΔL/L or rearrangement ΔL = hL (1) Answer = 4.8×10^{-18} [m] (1)	2
	(c)		Use of $T = 2\pi\sqrt{(L/g)}$ (1) Answer = 1.4 [s] or 1.42 [s] (1) High frequency vibrations oscillate much faster than the pendulum's natural frequency / pendulum acts as low-pass filter / pendulum cannot respond to high frequencies (1)	3
	(d)		Calculation of ratio: $10^{-18}/(1.7 \times 10^{-15})$ (1) Answer = 5.9×10^{-4} or ≈ 1/1700 or order of 10^{-3} seen with conclusion (1)	2
	(e)		Two masses in the system (1) Each mass causes a compression/disturbance [per orbit] or system has 2-fold rotational symmetry (1) Accept: maximum stretching occurs twice per orbit	2
	(f)	(i)	Correct method: 4.0 × 2 × 280 or 4.0 × 280 × 2 (1) Answer = 2240 [km] or 1120 [km] with explanation that light travels down and back (1) [Accept 1120 km if clearly treating one-way distance]	2
		(ii)	Wavelength = 1064 [nm] or wavelength unchanged in vacuum (1) [If refractive index formula used unnecessarily: $\lambda = \lambda_0/n = 1064/1 = 1064$ nm gets the mark]	1
	(g)	(i)	Centripetal force = Gravitational force or $M\omega^2 r = GM^2/(2r)^2$ (1) Correct rearrangement: $\omega^2 = GM/(4r^3)$ or $\omega = \sqrt{[GM/(4r^3)]}$ (1) Correct substitution with $r = 1.5 \times 10^5$ m (half separation) and answer = 188 rad s^{-1} or 190 rad s^{-1} (1) [Accept 2.7×10^2 rad s^{-1} if full separation used, award 2/3 marks]	3
		(ii)	$f = 2f_{orbital}$ or $f = \omega/\pi$ (1) Answer = 60 [Hz] or 30 Hz if using wrong angular frequency from (i) with **ecf**	1

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