GCE A LEVEL MARKING SCHEME

SUMMER 2017

A LEVEL (NEW)
PHYSICS - UNIT 3
1420U30-1

INTRODUCTION

This marking scheme was used by WJEC for the 2017 examination. It was finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conference was held shortly after the paper was taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conference, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about this marking 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)		Diagram showing source, absorber and detector or equivalent stated in words (1) I. Take measurement with no source and no paper/aluminium – [to measure the background radiation] or show awareness of background. II. Measure count rate with no paper/aluminium. **(1 for both I and II)** III. Insert [a few sheets of] paper between the source and receiver and take measurement. If reduction from count in II then alpha particles present. (1) IV. Insert [a few mm of] aluminium between the source and receiver and take measurement. If reduction in the count from that in III then beta particles are also present **and** if count is still above the background level, then gamma radiation is present – this penetrates the aluminium. (1)	4			4		4
	(b)	(i)	$\lambda = \frac{\ln 2}{T_{\frac{1}{2}}} = \frac{\ln 2}{(11.4 \times 24 \times 60 \times 60)}$ Substitution (1) $7.037 \times 10^{-7}\ \mathrm{s}^{-1}$ **unit** (1) **Alternative solution:** $\lambda = \frac{\ln 2}{T_{\frac{1}{2}}} = \frac{\ln 2}{11.4}$ substitution (1) $= 0.0608$ days^{-1} **unit** (1)	1	1		2	2	
		(ii)	$\frac{57.0}{11.4} = 5$ so 5 half lives (1) Activity $= \frac{1}{2^5}A_0 = \frac{1}{32}A_0$ (1) **Alternative solution:** $A = A_0 e^{-\lambda t}$; $t = 5T_{\frac{1}{2}}$ and $\lambda = \frac{\ln 2}{T_{\frac{1}{2}}}$; substitution $A = A_0 e^{-5 \ln 2}$(1) $= A_0 \frac{1}{2^5} = \frac{1}{32}A_0$(1)	1	1		2	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iii)	Let the initial number of particles be N_0, so number of particles remaining after 57 days $= \frac{1}{32}N_0$ i.e. $A \alpha N$(1) Decrease in the number of nuclei in 57 days = $\left(1 - \frac{1}{32}\right) N_0$ i.e. decrease (1) Percentage decrease = $\frac{\left(1-\frac{1}{32}\right)N_0}{N_0}\quad 100\% = 96.875\%$ i.e. percentage (1) Answer only of 3% award 2 marks only	1	1 1		3	3	
			Question 1 total	**7**	**4**	**0**	**11**	**7**	**4**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	(a)		The most stable nuclei (or reference to elements near to peak i.e. Fe, Ni Ca) are therefore where the curve (or binding energy per nucleon) reaches its maximum. (1) Nuclei of small atomic mass number (lhs of graph) can combine to produce species of larger atomic mass number, [hence larger binding energy per nucleon. Energy is released]. Fusion. (1) Nuclei of large atomic mass number (on rhs of graph) break down to produce species of smaller atomic mass number, [hence larger binding energy per nucleon. Energy is released]. Fission. (1) Reference anywhere to there being energy released, when a reduction in mass occurs i.e. mass converted to energy. (1)	4			4		
	(b)		Mass defect = 4 (1.00728) + 2(0.00055) (1) – 4.00151 = [0.02871 u] (1) Energy: 0.02871 $\times$ 931= 26.7 [MeV] (1)		3		3	3	
	(c)		**Benefit:** routine supply of energy (i.e. does not depend on weather) or jobs or no CO_2 emission (1) **Issue:** needs secure storage of radioactive waste (products) over a extended time period or reference to long half-lives or long build time or building extra transmission power lines (1) **Reasoned conclusion** (1)			3	3		
			Question 2 total	**4**	**3**	**3**	**10**	**3**	**0**

<table>
<tr><th colspan="3" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="4">Marks available</th><th></th><th></th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>3</td><td>(a)</td><td></td><td>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</td><td>3</td><td></td><td></td><td>3</td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td><table>
<tr><th>Process</th><th>Description of process</th><th>Work done on/by gas (if any)</th></tr>
<tr><td>A $\rightarrow$ B</td><td>Increase in pressure at constant volume</td><td>No work done (1) – AO2</td></tr>
<tr><td>B $\rightarrow$ C</td><td>Decrease in volume at constant pressure (1) – AO1</td><td>Work done on gas (1) – AO2</td></tr>
<tr><td>C $\rightarrow$ A</td><td>[Linear] decrease in pressure with increasing volume (1) – AO1</td><td>Work done by gas (1) – AO2</td></tr>
</table></td><td>2</td><td>3</td><td></td><td>5</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Work done on the gas is given by the "area" enclosed
$= \frac{1}{2}(8-4)10^{-3}(2-1)10^{5}$ (1)
$= \frac{1}{2}(4)(1)10^{2} = 200$ [J] (1)</td><td></td><td>2</td><td></td><td>2</td><td>2</td><td></td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td>Use of $PV = nRT$ and note T constant (1)
At A $PV = (1\times10^{5})(8\times10^{-3}) = 800$ [J]
(or at C $PV = (2\times10^{5})(4\times10^{-3}) = 800$ [J]) (1)
Check any point on curve e.g.<table>
<tr><th>If V (m^3)</th><th>P (Pa)</th></tr>
<tr><td>5.0×10^{-3}</td><td>1.60×10^{5}</td></tr>
<tr><td>6.0×10^{-3}</td><td>1.33×10^{5}</td></tr>
<tr><td>7.0×10^{-3}</td><td>1.14×10^{5}</td></tr>
</table>(1)</td><td>1</td><td>1
1</td><td></td><td>3</td><td>3</td><td></td></tr>
</table>

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
		(ii)	Attempt at calculation of area – [accept small square count of between 170 and 280 i.e. 225 $\pm$ ~25%] (1) If 225 i.e. 2.25 large squares, work difference = $2\ \Delta V\ \Delta p\ (\ \Delta V \text{ and } \Delta p \text{ for large square})$ $= 2.25\ (1 \times 10^{-3})(0.2 \times 10^{5}) = 45$ J with uncertainty of 25%, accept a value between 34 and 56 J provided method correct (1)			2	2	2	
			Question 3 total	**6**	**7**	**2**	**15**	**7**	**0**

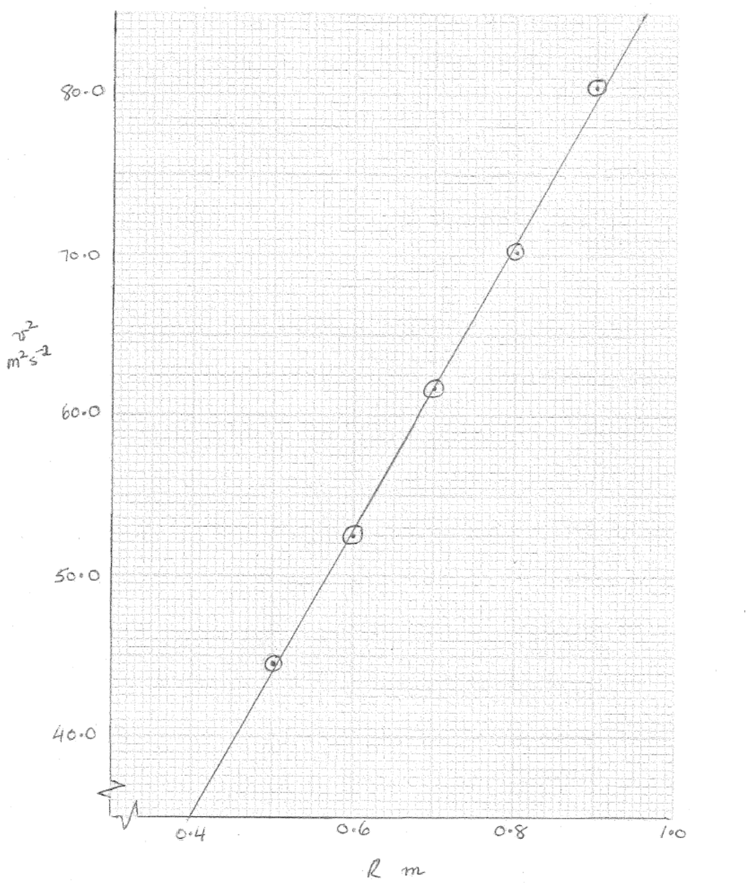
Question			Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
4	(a)		**Increase in temperature - kinetic theory effects** Molecules move randomly Collisions become more frequent [when heat supplied] [No change in volume so heat flowing in] causes increase in U / kinetic energy No work done [as constant volume] T increases with U as temperature proportional to U, or equivalent **Newton's laws of motion** Momentum of molecules increase Force on molecules = rate of change of momentum (during collision with wall) Force on wall is equal and opposite to force on molecules Greater forces during the collisions **Increase in pressure** Molecules collide with walls exerting force on walls and / or pressure Pressure increases with temperature Pressure = force on walls per unit area Mean pressure due to many collisions [and many molecules] **5-6 marks** Comprehensive account including reference to increase in temperature, Newton's laws of motion and increase in pressure. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Comprehensive account including reference to 2 out of 3 of increase in temperature, Newton's laws of motion and increase in pressure or brief account of all 3 areas. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.*	6			6		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			1-2 marks Comprehensive account including reference to one of increase in temperature, Newton's laws of motion and increase in pressure or limited account of 2 areas. *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)	rms $= \sqrt{\frac{400^2+425^2+450^2+550^2+625^2}{5}}$ (1) = 497 [m s^{-1}] (1)		2		2	2	
		(ii)	The expected rms is explained by: $PV = nRT$ so $P = \frac{nRT}{V}$ $\rho = \text{mass}/V = \frac{n\,(M_r \times 10^{-3})}{V}$ use of **both** equations by substitution (1) substitute these into: $P = \frac{1}{3}\rho\overline{c^2}$; $\sqrt{\overline{c^2}} = \sqrt{\frac{3P}{\rho}}$; $\sqrt{\overline{c^2}} = \sqrt{3\frac{nRT}{V}\frac{V}{n(M_r \times 10^{-3})}} = \sqrt{\frac{3RT}{(M_r \times 10^{-3})}}$ $\sqrt{\overline{c^2}} = \sqrt{\frac{3(8.31)(293)}{(32 \times 10^{-3})}} = 478$ [m s^{-1}] (1) Valid conclusion with data i.e. yes, the rms speed of the five molecules is slightly higher [about 4% above the expected rms of the gas] (1) **ecf** **Alternative solution**: Use $m\overline{c^2} = 3kT$ $\sqrt{\overline{c^2}} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3(1.38 \times 10^{-23})(293)}{(32)(1.66 \times 10^{-27})}}$ with sensible substitution (1)= 478 [m s^{-1}] (1)		1	1 1	3	3	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iii)	Density does not change **and** Pressure increases from the original pressure p to $1.2p$ (1) i.e. an increase of 20%. so $\left(\sqrt{\overline{c^2}}\right)_{\mathrm{new}} = \sqrt{\frac{3(1.2p)}{\rho}}$ $\left(\sqrt{\overline{c^2}}\right)_{\mathrm{new}} = \sqrt{1.2}\sqrt{\frac{3p}{\rho}} = \sqrt{1.2}\,(478) = 524\ \mathrm{m\,s^{-1}}$ (1)		2		2	2	
			Question 4 total	**6**	**5**	**2**	**13**	**7**	**0**

<table>
<tr><th colspan="3" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="4">Marks available</th><th></th><th></th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>5</td><td>(a)</td><td></td><td>Distance moved by mass P in 1 period, T (i.e. in one rotation) = $2\pi R$ and speed = distance / time = $\frac{2\pi R}{T}$
Alternative:
$\omega = \frac{2\pi}{T}$ and $v = \omega R$</td><td></td><td>1</td><td></td><td>1</td><td>1</td><td>1</td></tr>
<tr><td></td><td>(b)</td><td></td><td>
<table>
<tr><th>R /m</th><th>Time of 10 rot /s</th><th>T /s</th><th>v / m s^{-1}</th><th>v^2 / m^2 s^{-2}</th></tr>
<tr><td>0.50</td><td>4.7</td><td>0.47</td><td>6.68</td><td>44.6</td></tr>
<tr><td>0.60</td><td>5.2</td><td>0.52</td><td>7.25</td><td>52.6</td></tr>
<tr><td>0.70</td><td>5.6</td><td>0.56</td><td>7.85</td><td>61.6</td></tr>
<tr><td>0.80</td><td>6.0</td><td>0.60</td><td>8.38</td><td>70.2</td></tr>
<tr><td>0.90</td><td>6.3</td><td>0.63</td><td>8.98</td><td>80.6</td></tr>
</table>
T column: All values correct (1)
For column v all values correct (1)
For column v^2 all values correct ecf (1)
Consistent use of sig figs in each column and 2 or 3 sig figs (1)</td><td></td><td>4</td><td></td><td>4</td><td>4</td><td>4</td></tr>
</table>

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)	Centripetal force = 0.010 $\frac{v^2}{R}$ (1 for $\frac{mv^2}{R}$; 1 if value inserted for m)	1	1		2	1	2
		(ii)	Forces acting on mass Q: $0.090\ g - \tau = 0 \quad \tau\text{: tension}$ (1) So $\tau = 0.090g$. Substitution for τ into (c)(i) (1) $0.090g = 0.010\frac{v^2}{R}$ $v^2 = \frac{0.090g}{0.010}\ R$ $v^2 = 9g\ \ R$ clear and convincing working (1)		3		3	2	3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(d)	(i)	 Axes, suitable choice scales (no multiples of 3) and labels on both axes (1) – scales to occupy more than half of paper All points plotted correctly to ±½ small square division (2) 4 points plotted correctly to ±½ small square division award 1 mark 1-3 points plotted correctly to ±½ small square division award 0 marks Line of best fit (1)		4		4	4	4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(ii)	gradient = $\frac{50.0}{0.56} = 89.286$ m s^{-2} ; find gradient from best fit line (1) also gradient = $9g$ general method (1) $9g = 89.286$ $g = \frac{1}{9}\,89.286 = 9.92$ m s^{-2} **unit mark** (1) (Accept g = 8.8 to 10.8 m s^{-2} i.e. uncertainty of ~10%.) Use of single data point award a maximum of 2 marks			3	3	3	3
		(iii)	Take measurements for each value of R several times **or** measure time of more rotations **or** use of video capture or increase radius and period Accept repeat readings Don't accept have an assistant			1	1		1
			Question 5 total	**1**	**13**	**4**	**18**	**15**	**18**

Question				Marking details	Marks available				Maths	Prac
					AO1	AO2	AO3	Total		
6	(a)	(i)		T tension in the string **and** mg weight of mass (gravitational force or gravity)	1			1		
		(ii)		T does not have a component tangential to the arc (1) Component of mg tangential to the arc is $mg\ \sin\theta$, (1) this is in the opposite direction to s (or θ) **and** so the negative sign (1)		3		3	1	
		(iii)		$\text{acceleration} = \frac{-mg\sin\theta}{m} = -g\ \sin\theta$ $= -g\theta\ (1)(\text{using the approximation})$ $\theta = \frac{s}{l}\ \text{or}\ \sin\theta = \frac{s}{l}(1) = -\frac{gs}{l}$		2		2	2	
		(iv)		Acceleration $\propto\ \theta\ (\text{or } s)$ measured [from a fixed position] (1) and opposite in direction (-ve) so SHM (1)			2	2		
	(b)	(i)	I	Substitution: $T = 2\pi\sqrt{\frac{l}{g}} = 2\pi\sqrt{\frac{1.2}{9.81}}\ \ (1)$ $= 2.20$ [s] (1)	1	1		2	2	
			II	$f = \frac{1}{T} = 0.45[5]$ [H]z **ecf** (1)		1		1	1	
		(ii)		For maximum distance along the arc $\theta_{\text{max}} = 0.067$, also $\sin\theta_{\text{max}} = 0.067$ As $\theta_{\text{max}} = \sin\theta_{\text{max}}$ (i.e. for the largest value of θ) (1) then $\sin\theta$ is equal to θ for all θ, and approximation holds for SHM. System oscillates with SHM (1)			2	2	1	
				Question 6 total	**2**	**7**	**4**	**13**	**7**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	(a)		Microwave laser or amplifier or equivalent (1) from water [molecules] or water clouds or steam (1) in gas disk around (supermassive) black hole (or quasar) (1) pumping or excitation provided by collisions (accept light) (1) (em radiation) propagates outwards (away from black hole) **or** reference to population inversion (1) Treat as neutral reference to watermaser. (Don't award the individual marks if later contradicted)	1 1 1	1 1		5		
	(b)		Appropriate wavelength or energy or frequency chosen e.g. 400 nm-700 nm or 2-3 eV or 4-8 $\times$ 10^{14} Hz (1) Valid method for obtaining ratio of frequencies, wavelength or energy (1) Answer 35 m[s] – 80 m[s] (1)	1	1 1		3	2	
	(c)		$\frac{3\,300}{68.9}$ (1) 48 [Mpc] (1)		2		2	2	
	(d)		Measure the velocity using Doppler shift or use of Doppler equation (1) at different times (1) acceleration = rate of change of velocity (1) **Alternative:** Measure the velocity using Doppler shift (1) Obtain v_{max} (1) $a = \frac{v^2_{max}}{r}$ or equivalent e.g. use v and r to calculate a (1)			3	3		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(e)	(i)	Use of $r = \frac{v^2}{a}$ (1) Acceleration conversion i.e. /365/24/3600 (1) Answer = 8.8×10^{14} [m] or 8.8×10^{11} k[m] (1)			3	3	3	
		(ii)	Approximation used i.e. $D = \frac{r}{\theta}$ (1) Answer = 7.8×10^{14} [m] (1) Hence consistent (since overlap) i.e. valid conclusion **based on calculations** (1) Comparing e.g. 1.53 ± 0.15 and 1.73 ± 0.17 but also accept combined error = 20% or 8.8×10^{14} is less than 20% bigger than 7.8×10^{14} (1)			4	4	2	
			Question 7 total	**4**	**6**	**10**	**20**	**9**	**0**

A2 UNIT 3 – OSCILLATIONS and NUCLEI

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	7	4	0	11	7	4
2	4	3	3	10	3	0
3	6	7	2	15	7	0
4	6	5	2	13	7	0
5	1	13	4	18	15	18
6	2	7	4	13	7	0
7	4	6	10	20	9	0
TOTAL	**30**	**45**	**25**	**100**	**55**	**22**