GCE A LEVEL MARKING SCHEME

SUMMER 2019

A2
PHYSICS - UNIT 3
1420U30-1

INTRODUCTION

This marking scheme was used by WJEC for the 2019 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.

A2 UNIT 3 – OSCILLATIONS AND NUCLEI

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

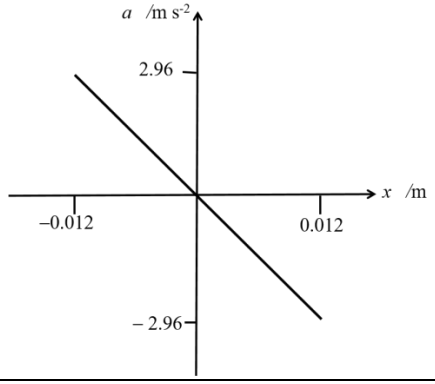
The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

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)*		Award 1 mark for ± 0.1 [cm] **or** measure to resolution of ruler Award 2 marks for ± 0.2 [cm]	1	1		2	1	2
	(b)	(i)	$V = \pi\left(\frac{d}{2}\right)^2 l = \pi\left(\frac{1.5\times10^{-3}}{2}\right)^2 \times 11.5\times10^{-2}$ (subst and convincing change of units for l and d) (1) = 2.03×10^{-7} m^3 **or** 0.2 cm^3 **or** 203mm^3 (1) **unit mark**	1	1		2	2	2
		(ii)	$p_V = 2p_d + p_l = 2\frac{0.1}{1.5}(1) + \frac{0.2}{11.5}(1)$ (or by impl.) = 0.133 + 0.017 = 0.150 (1) allow **ecf** for this mark, on the use of 0.1 instead of 0.2 only Hence p_V = 15 % (**Alternative:** use percentages throughout)	1	1 1		3	3	3
	(c)	(i)	From intercepts with x-axis, mean = – 270 [°C] (1) Uncertainty = 20 [°C] (1) Award 1 mark only if 270 used		2		2	1	2
		(ii)	**Any 4 ×(1) from:** -Straight line -Intercept is consistent i.e. –273 °C / line would go through the origin if temp plotted in K -Passes through all error bars -Volume linked to length -$V \propto T$ **or** $l \propto T$			4	4	1	4
	(d)		Kinetic or internal energy (or velocity) approaches minimum / zero. Accept very little KE / stopped moving / molecules stop / stops vibrating Don't accept KE decreases greatly / superconduct or superfluid	1			1		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(e)		**Any 2 ×(1) from:** -Meniscus or equivalent linked to liquid pellet -Moving readings -Expansion of glass -Gas not ideal -Variation in atmospheric pressure -Gas and liquid at different temperatures -Friction / viscosity of liquid pellet -Parallax / looking at eye level -Ruler not parallel to tube don't accept just ruler vertical Accept inaccuracy of thermometer Don't accept resolution of thermometer			2	2		2
			Question 1 total	**4**	**6**	**6**	**16**	**8**	**15**

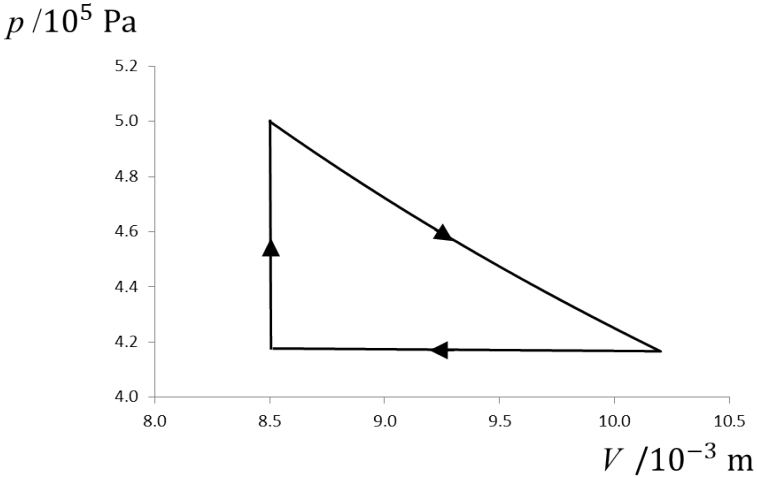
Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*		Angle when arc [length] equals radius Accept about 57.3° **or** angle when 2π = 360° or cycle / circle	1			1		
	(b)	(i)	Use of $T = \frac{1}{f}$ (1) Answer = 1.67 [s] (1) Accept $\frac{5}{3}$ **or** 1.66 **or** $1.\dot{6}$ **or** 1.7 [s] Don't accept 1.6 [s]	1	1		2	1	
		(ii)	Substitution into $\omega = \frac{2\pi}{T}$ or $2\pi f$ or **and** $v = \omega r$ (1) **ecf** on T or f v = 10.6 [m s^{-1}] (1) (Accept 10.5 m s^{-1} if 1.67 s used)		2		2	2	
	(c)		$N = \frac{mv^2}{r}$ or $mr\omega^2$ or implied (1) $N = \frac{66.2 \times (10.6)^2}{2.8}$ = [2 634] [N] (1) **ecf** on v and ω accept approximately 2 657 [N] F = 66.2 × 9.81 = [649.4 [N]] (1) Vertical forces are balanced or equivalent e.g. $F = W$ (1)	1 1	1 1		4	2	
	(d)	(i)	650 ≤ **or** = **or** < $\mu \times$ 2 600 (1) So $\mu >$ **or** = 0.24 or 0.25 (1) **Alternative:** 2 600 × 0.25 (1) = 650 (1)	1	1		2	2	
		(ii)	Friction = 650 [N] or implied (1) $\frac{650}{0.45}$ = 1 444 [N] (1) Equating to centripetal (1) ω = 2.8 [rad s^{-1}] (1) Answer of 2.51 [rad s^{-1}] award 1 mark only		1	1 1 1	4	2	
			Question 2 total	**5**	**7**	**3**	**15**	**9**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*		a = acceleration ω = angular velocity or angular frequency or pulsatance x = displacement **All 3 correct** (1)	1			1		
	(b)	(i)	$\omega = \frac{2\pi}{0.4}$ (1) [= 15.7 s^{-1}] $a_{max} = \omega^2 A = (15.7)^2 \times 0.012$ (1) = 2.96 [m s^{-2}] (1)	1	1 1		3	2	
		(ii)	 One value of a on graph (1) **ecf** from *(b)*(i) Any straight line (1) Correct position of line (1)		3		3	2	
	(c)		$x =$ [0.012] $\cos\left($[15.7] $t +$ [$\frac{3\pi}{2}$]$\right)$ (1 × 3 – one mark for each box) (alternative for angle: $-\frac{\pi}{2}$) Accept 5π for 15.7. **ecf** on ω		3		3	1	
	(d)	(i)	Example e.g. microwave ovens **or** swing (1) Oscillator and driving force named e.g. water molecules and microwaves **or** swing and person pushing (1)	2			2		
		(ii)	Example and consequence e.g. bridge and falling **or** something in the dashboard and buzzing (1) Driving force e.g. wind / soldiers marching **or** engine (1) Resonance explained i.e. both frequencies are the same (1)	3			3		
			Question 3 total	**7**	**8**	**0**	**15**	**5**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4			**<u>Measurement:</u>** Diagram to assist answer Measure length of string Measure time for several oscillations Use of fiducial point Repeat for each length Repeat for several lengths of string **<u>Analysis and theory</u>:** Small angle / amplitude Use of $T = 2\pi\sqrt{\frac{l}{g}}$ Plot T^2 vs l **or** T vs $\sqrt{l}$ Is a straight line [through the origin] Gradient is $\frac{4\pi^2}{g}$ or $\frac{2\pi}{\sqrt{g}}$ respectively Use the gradient or points to calculate g	6			6		6

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			5-6 marks Comprehensive description of both the method and the analysis. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Comprehensive description of either the method or the analysis **or** limited description of both areas provided. *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 the method or the analysis 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.*						
			Question 4 total	**6**	**0**	**0**	**6**	**0**	**6**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*	(i)	Substitution $n = \frac{pV}{RT} = \frac{(5\times10^5)(8.5\times10^{-3})}{(8.31)(285)}$ (1) $= 1.79$ [mol] (1)	1	1		2	2	
		(ii)	$N = N_A n = (6.02 \times 10^{23}) \times 1.79$ **ecf** $= 1.08 \times 10^{24}$		1		1	1	
		(iii)	Substitution of p and V **or** k and T (1) Correct use of Nm **or** m in either: $p = \frac{1}{3}\rho\,\overline{c^2}$ or $pV = \frac{1}{3}Nm\overline{c^2}$ **ecf** (1) c_{rms} = 471 [m s^{-1}] (1)	1	1 1		3	2	
		(iv)	Force = $pA = (5.0 \times 10^5) \times 0.04$ = 20 000 [N]		1		1	1	
	(b)	(i)	Substitution e.g. $p = \frac{5.0\times10^5 \times 8.5\times10^{-3}}{10.2\times10^{-3}}$ (1) **ecf** on n if $pV = nRT$ used p = 420 k[Pa] (1)	1	1		2	2	
		(ii)	ΔU = 0 (1) So by using the first law of thermodynamics $\Delta U = Q - W$ hence $Q = W$ = 773 [J] (1)	1	1		2	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iii)	Work done = [–]710 [J] **or** area of triangle attempted (1) Total work done by the gas around cycle = 773 – 710 + 0 = 63 [J] **and** $Q = W$ = 63 [J] (1) Axes labelled with units (1) Correct closed triangle as shown (1) Treat arrows as neutral 			4	4	3	
			Question 5 total	**4**	**7**	**4**	**15**	**13**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*			$^{228}_{90}\text{Th} \rightarrow {}^{224}_{88}\text{Ra} + {}^{4}_{2}\alpha$ (1) $^{90}_{38}\text{Co} \rightarrow {}^{90}_{39}\text{Y} + {}^{0}_{-1}\beta$ (1)		2		2		
	(b)			Nucleon mass = 90.727 u **or** nucleon mass +38 e (90.747u) (1) Mass defect attempted with or without electrons 0.84 u or 0.82 u (1) × 931 and division by 90 (1) Answer = 8.69 [MeV per nucleon] (1) If electrons not taken into account answer = 8.47 [MeV per nucleon] award 3 marks 782 or 762 [MeV per nucleon] award 2 marks	1	1 1 1		4	3	
	(c)	(i)		Probability of landing on black face = ¼ **or** 0.25 **or** 25 %		1		1	1	1
		(ii)	I.	Probability of not decaying (i.e. of remaining) after 1 throw = 1 – 0.25 = 0.75 (1) Probability of remaining after 2 throws = 0.75^2 **or** probability of remaining after n throws = $(0.75)^n$ (1)		2		2	2	2
			II.	Number predicted = $N_0 \times (0.75)^n$ = 31.76 = 32 Accept 31 or 31.76		1		1	1	1
			III.	Close to 0.75 for many throws **or** mean close to 0.75 or 32 is close to 35 or fits quite well with $(0.75)^n$ (1) Some further out e.g. 0.90 (1) Random process [these results are to be expected] (1)			3	3		3
				Question 6 total	**1**	**9**	**3**	**13**	**7**	**7**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*		Use of $F = Ap$ **and** $A = \pi r^2$ **or** accept $A = 4\pi r^2$ (1) Correct answer = 3 173 [N] (1) [no **ecf** from use of $A = 4\pi r^2$]	1	1		2	2	
	(b)		Fewer collisions …. (1) …because greater distances between molecules (or smaller density or more free space) (1)		2		2		
	(c)	(i)	Application of conservation of energy i.e. $E_k = \frac{Qq}{4\pi\varepsilon_0 r}$ (1) Conversion of 4.7 MeV → J i.e. $4.7 \times 10^6 \times 1.6 \times 10^{-19} = 7.52 \times 10^{-13}$ J (1) Answer = 4.8×10^{-14} [m] (1)		3		3	3	
		(ii)	Smaller than atomic radius or inside plum pudding (1) So force / PE never great enough (for rebound) or scattering angle too large in experiment (1)			2	2		
	(d)		Use of conservation of energy to get speed or momentum e.g. $p^2 = 2mE_k$ etc. $v = 3.75 \times 10^7$ [m s^{-1}] or $p = 3.41 \times 10^{-22}$ [N s] (1) Calculation of a wavelength using $\lambda = \frac{h}{p}$ (even if incorrect, 1.94×10^{-11} m is the correct value) (1) Comparison of the calculated wavelength with atomic separation (or 10^{-9} to 10^{-11} m) (1) Correct final conclusion **and** correct wavelength (1.94×10^{-11} m) (1)			4	4	3	
	(e)		Proton repulsion or like charges repel etc.	1			1		
	(f)		Photon mom calculated $\left(p = \frac{h}{\lambda}\right)$ = 2.73×10^{-22} [kg m s^{-1}] (1) Electron momentum calculated = 9.11×10^{-26} [kg m s^{-1}] (1) [Initial momentum negligible] so final momenta must cancel (1)			3	3	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(g)		Charge of $\bar{u}d = -\frac{2}{3} - \frac{1}{3}$	1			1		
	(h)		**Either:** Mass = $\frac{172\ \text{G[eV]}}{931\text{M[eV u}^{-1}]}$ = 185 [u] (1) $\therefore$ Mass = 185 [u] $\times$ 1.66 $\times$ 10^{-27} [kg u^{-1}] = 3.07 $\times$ 10^{-25} [kg] (1) **Or:** Mass energy = 172 GeV $\times$ 1.60 $\times$ 10^{-19} J eV^{-1} = 2.75 $\times$ 10^{-8} [J] (1) $\therefore$ Mass = $\frac{2.75\times10^{-8}\ \text{[J]}}{\left(3.00\times10^{8}\ \text{[m s}^{-1}\text{]}\right)^2}$ = 3.06 $\times$ 10^{-25} [kg] (1)		2		2	2	
			Question 7 total	**3**	**8**	**9**	**20**	**12**	**0**

A2 UNIT 3: OSCILLATIONS AND NUCLEI

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	4	6	6	16	8	15
2	5	7	3	15	9	0
3	7	8	0	15	5	0
4	6	0	0	6	0	6
5	4	7	4	15	13	0
6	1	9	3	13	7	7
7	3	8	9	20	12	0
TOTAL	**30**	**45**	**25**	**100**	**54**	**28**