GCE A LEVEL MARKING SCHEME

SUMMER 2018

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

INTRODUCTION

This marking scheme was used by WJEC for the 2018 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)*	(i)	Velocity [of car] is changing [with time] (1) because its direction is changing [so the car is accelerating] (1) **or** There is a <u>resultant</u> force (1) [towards the centre] due to friction / grip (1)	2			2		
		(ii)	$v = \frac{45 \times 10^3}{60 \times 60}$ = 12.5 m s^{-1} (conversion) (1) $\omega = \frac{v}{r} = \frac{12.5}{80}$ = 0.156 rad s^{-1} substitution and calculation (1)		2		2	2	
		(iii)	$a = \frac{v^2}{r} = \frac{(12.5)^2}{80}$ substitution (**ecf**) (1) [Alt: use $a = \omega^2 r$] = 1.95 m s^{-2} (1) Direction: towards centre (of 'circular' motion) (1)	1 1	1		3	2	
	(b)		Either: Any two × (1) of these points - Appropriate tyre design for friction - Banking of road [for contribution from normal contact force] - Appropriate surface - Suspension set-up - Anti-roll bars. (or any sensible answers, one referring to road and the other to the car) **Or** any one sensible point (1) + explanation of the role of physics (1) [			2	2		
			Question 1 total	**4**	**3**	**2**	**9**	**4**	**0**

Question			Marking details		Marks available				
				AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
2	*(a)*	(i) (ii)	Mass of a molecule [accept: atom or particle] [of the gas] Mean [accept: average] square velocity / speed [of a molecule of the gas]	1 1			2		
	(b)		N_A, [Avogadro's number is] the number of molecules per mole [or in a mole] [of gas] (1) There are n moles [of the gas] (1) So the total number of molecules [in the gas] = $n N_A$ (1)	3			3		
	(c)		Realising that KE = $N_{(A)} \frac{1}{2} m\overline{c^2}$ (1) Substitution of $pV = nRT$ (1) Convincing algebra, e.g handling $\frac{2}{3}\ \frac{1}{3}\ \frac{3}{2}$ (1) Explanation that *n* = 1 [NB. if *M* used need to see molar mass when *n* = 1] (1) **Alternative:** $\frac{1}{2} m\overline{c^2} = \frac{3}{2} kT$ (1) Multiplication by *N* $\rightarrow \frac{1}{2} Nm\overline{c^2} = \frac{3}{2} NkT$ (1) Justification that $R = kN_A$ (1) with justification (1)	4			4	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(d)		$n = \frac{pV}{RT} = \frac{115\times10^{3}\times2.2\times10^{-3}}{8.31\times294}$ = 0.104 [mol] (1) Final temperature, $T = \frac{pV}{nR} = \frac{115\times10^{3}\times2.6\times10^{-3}}{0.104\times8.31}$ = 346.0 K (1) [value depends upon rounding of n. No rounding → 347.5 K] $\Delta U = \frac{3}{2}nR\Delta T = \frac{3}{2}\times0.104\times8.31(346-294)$ = 67.4 J (1) Allow ecf on 1 mol for the last two marks. **Alternative:** $\Delta U = \frac{3}{2}(p_1V_1 - p_2V_2)$ or $\Delta U = \frac{3}{2}p\Delta V$ (for constant pressure) (1) $= \frac{3}{2}115\times10^{3}(2.60-2.20)\times10^{-3}$ (1) = 69 J (1)		3		3	3	
			Question 2 total	**9**	**3**	**0**	**12**	**5**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*		The specific heat capacity is the heat required to increase the temperature of 1 kg [or unit mass] of a material by 1 °C (1 degree K – or one degree/ unit temperature rise). [Alternative: equation with all terms fully defined.]	1			1		
	(b)	(i)	Idea: heat lost by boiling water=heat gained by other water (1) $1.6\left[\times10^{-3}\right]\left(100.0-\theta_f\right)=0.6\left[\times10^{-3}\right]\left(\theta_f-19.5\right)$ (1) θ_f = 78.0 °C (1) **Alternative (for second mark)** If $\Delta\theta$ is temperature rise of water in flask $1.6\left[\times10^{-3}\right]\left(80.5-\Delta\theta\right)=0.6\left[\times10^{-3}\right]\Delta\theta$ (✓)			3	3	2	
		(ii)	Mass of water = $1.6\times10^{-3}\times1000=1.6$ [kg] (1) Application of $m=\rho V$ [even if 0.6×10^{-3} m^3 used → 0.6 kg] [Can be credited from *(b)*(i) Heat lost = 1.6(100.0 – 78.0 **ecf**) × 4200 (1) = 1.48×10^5 J (1) 148 J → 1 mark		3		3	3	
		(iii)	[Work done is negligible as] negligible / no change in volume.			1	1		
			Question 3 total	**1**	**3**	**4**	**8**	**5**	**0**

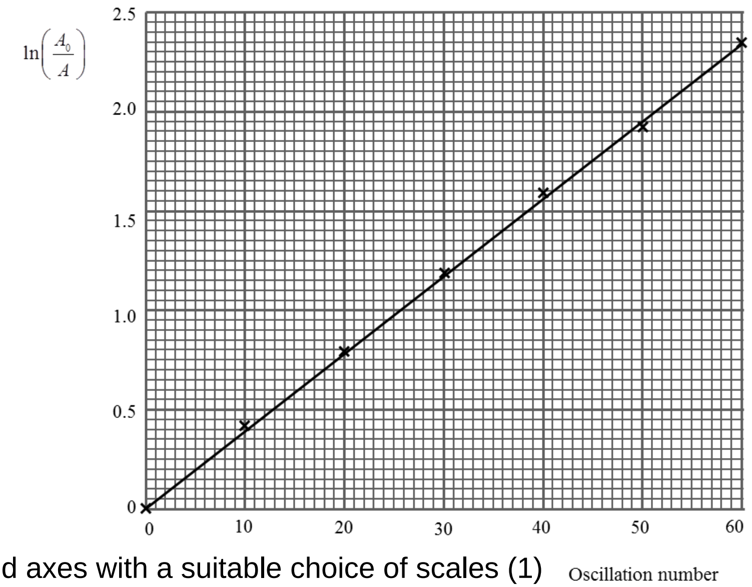
Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*		Mass defect = $((235.01+1.01)-(91.90+140.89+3(1.01)))$ u [or $(235.01-(91.90+140.89+2\times 1.01))$] = 0.20 u (1) Energy released = $0.20\times 931=186$ MeV [190 MeV] (1) (Accept 3.0 × 10^{-11} J) **UNIT**		2		2	2	
	(b)		**General (G)** G1:General shape of curve [correct asymmetry] & axes labelled G2:Maximum around nucleon number 60 / iron / nickel G3:Stability linked to BE/nuc to stability G4:Nucleons react to move towards maximum (on curve) G5:In doing so there is a loss / reduction in mass G6: Mass loss linked to energy released $= \Delta m\ c^2$ **Fusion (Fu)** Fu1: Smaller nucleon number nuclei combine Fu3: Larger nucleons of larger nucleon number formed: energy released, BE/nuc increases, stability increases, lower mass **Fission (Fi)** Fi1: Larger nucleon number split Fi3: Smaller nucleons of smaller nucleon number formed energy released, BE/nuc increases, stability increases, lower mass Additional point: gradient of curve larger in fusion region than fission resulting in more energy release (per nucleon) **5-6 marks** At least 6 G points (6-8 G) 8 – 11 points *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.*	6			6		

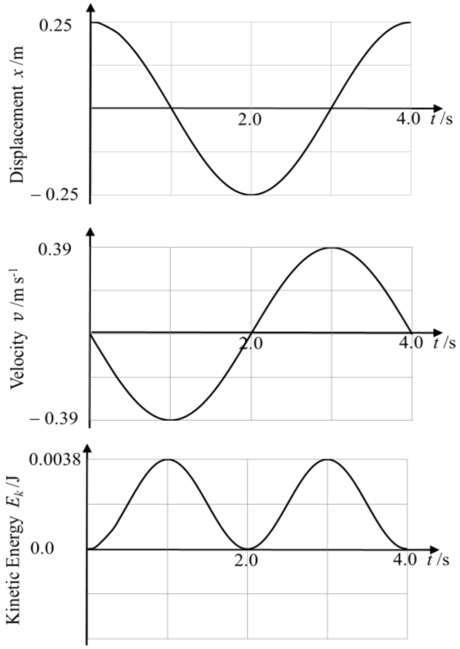
			3-4 marks 5 – 7 points *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** 1 – 4 points *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.* **0 marks** *No attempt made or no response worthy of credit.*						
			Question 4 total	**6**	**2**	**0**	**8**	**2**	**0**

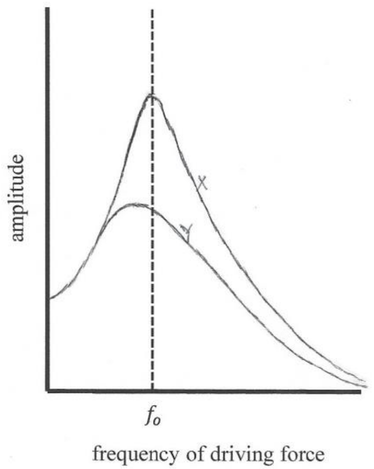
Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*		$\lambda = \frac{\ln 2}{T_{\frac{1}{2}}} = \frac{\ln 2}{3.8}$ day^{-1} [=0.182 day^{-1}] (1) Activity after 12 days $A = A_0 \exp\left(-\frac{12\ln 2}{3.8}\right)$(1) substitution = 0.112$A_0$ (1) $\therefore$ % reduction = 88.8%(1) (Accept variation because of rounding) **Alternative** Number of half-lives, $n = \frac{12}{3.8} = 3.16$ [or by implication] (1) Fraction after 12 days $= 2^{-3.16}$ (1) = 0.112 (1) = 11.2% $\therefore$ Percentage reduction = 88.8% (1)		4		4	4	

	(b)		Any 4 × (1) 1) Counts is reduced significantly (or equivalent alternatives e.g. by almost a half) by the paper, so alpha particles present (✓) 2) Another significant reduction (or alternative e.g. essentially all of the remaining radiation is stopped) by the aluminium, so beta particles present (✓) 3) Count with lead is larger than with aluminium (but almost the same) so no gamma present (✓) 4) The measured counts with aluminium and lead are essentially the same, so this is because of background radiation / the background radiation is approximately 25 counts per minute. (✓) 5) Randomness of nuclear decay is the reason for increased value with lead. (✓)		4		4		4
			Question 5 total	**0**	**8**	**0**	**8**	**4**	**4**

<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>6</td><td><i>(a)</i></td><td>(i)</td><td>$kx = mg$ (1)
$x = \frac{0.150 \times 9.81}{7.5}$ = 0.196 m answer (1)</td><td></td><td>2</td><td></td><td>2</td><td>2</td><td>2</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{0.150}{7.5}}$ substitution (1)
= 0.889 s (1)
NB. No credit for use of $T = 2\pi\sqrt{\frac{l}{g}}$</td><td>1</td><td>1</td><td></td><td>2</td><td>2</td><td>2</td></tr>
<tr><td></td><td><i>(b)</i></td><td></td><td>Drop in amplitude at beginning and end compared, e.g. 0.033 m and 0.005 m over first and last intervals. [Or rates of decrease: 0.0033 m per oscillation and 0.0005 m per oscillation] consider rate of decrease (1)]
Justify by noting the magnitude is larger at the start than at end of experiment. (1)</td><td></td><td></td><td>2</td><td>2</td><td></td><td>2</td></tr>
<tr><td></td><td><i>(c)</i></td><td>(i)</td><td>When n = 0, $A = A_0 e^{-\frac{0}{N}} = A_0 e^0 = A_0$
[Alternative: say $e^0 = 1$, so $A = A_0$.]</td><td></td><td></td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>$A = A_0 e^{-\frac{n}{N}}$; $0.029 = 0.095 e^{-\frac{30}{N}}$ substitution (1)
$N = \frac{-30}{\ln\left(\frac{0.029}{0.095}\right)}$ or equiv → N =25.28 ≅ 25 answer (1)</td><td>1</td><td>1</td><td></td><td>2</td><td>2</td><td>2</td></tr>
<tr><td></td><td><i>(d)</i></td><td>(i)</td><td><table>
<tr><th>Oscillation number (n)</th><th>Amplitude (A) /m</th><th></th></tr>
<tr><td>0</td><td>0.095</td><td>0</td></tr>
<tr><td>10</td><td>0.062</td><td>0.43</td></tr>
<tr><td>20</td><td>0.043</td><td>0.79</td></tr>
<tr><td>30</td><td>0.029</td><td>1.19</td></tr>
<tr><td>40</td><td>0.019</td><td>1.61</td></tr>
<tr><td>50</td><td>0.014</td><td>1.91</td></tr>
<tr><td>60</td><td>0.009</td><td>2.36</td></tr>
</table>
All three values correct (1) [accept 1.6, 1.9, 2.4 if consistent]</td><td></td><td>1</td><td></td><td>1</td><td>1</td><td>1</td></tr>
</table>

		(ii)	 Labelled axes with a suitable choice of scales (1) All points plotted correctly including origin (1) **(ecf)** Appropriate line of best fit [not necessarily through origin] ecf (1)	1	1 1		3	3	3
		(iii)	Any two of: 1) It is a straight line, or positive gradient (1) 2) Passes through the origin (1) 3) The measured points lie essentially on a straight line or little scatter(1)			2	2		2
		(iv)	Gradient = $\frac{2.35-0}{60-0}$ (from graph) = 0.039 **ecf** (1) $N = \frac{1}{\text{gradient}}$ (1) = 25.6 (1) Accept answers in range 25 – 26. Use of a point on the line – allow. Use of a data point not on the line → 1st mark not available.			3	3	3	3
		(v)	Expected to be the one from *(d)*(iv) as straight line based on all points [The value in *(c)*(ii) is calculated from only a single point, which may be anomalous.]			1	1		1
			Question 6 total	**3**	**7**	**9**	**19**	**14**	**19**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*	(i)	$T = 2\pi\sqrt{\frac{l}{g}}$ $\omega = \frac{2\pi}{T} = \sqrt{\frac{g}{l}}$ combining formulae (1) $= \sqrt{\frac{9.81}{4.0}}$ = 1.57 rad s^{-1} (1) convincing		2		2	2	
		(ii)	$v_{\text{max}} = \omega A$ (1) v_{max} [= 1.57 × 0.25] = 0.39 m s^{-1} (1)		2		2	1	
		(iii)	$E_{\text{k}} = \frac{1}{2}mv^2$ **and** $v = (-)A\omega\sin\omega t$ / $v = (-)0.39\sin 1.57t$ (1) $E_{\text{k}} = \frac{1}{2}\times 0.05\times(0.39)^2\sin^2 1.57t$ (1) $= 3.8\times10^{-3}\sin^2 1.57t$ [convincing]	1	1		2	1	
		(iv)	 Phase of the velocity graph (1) Period of the kinetic energy graph (1) Kinetic energy curve always ≥ 0 with shape and phase (1)						

			Values on the axes of both graphs (1)		4		4	2	
		(v)	$mgh = 3.8 \times 10^{-3}$ J **ecf** (1) $h = \frac{3.8 \times 10^{-3}}{0.05 \times 9.81}$ = 0.008 m (1) (= 8 mm) Or: using trig: 4 – 4 cos (0.25/4) (1) = 8 mm (1)		2		2	2	
	(b)	(i)	 Sensible curve [X] with label [accept curve to the origin]	1			1		
		(ii)	Resonance	1			1		
		(iii)	Sensible curve with label (see part (b) (i) [cannot cross X – always below, can co-incide at low frequencies] (1) Lower maximum amplitude at the same frequency or to left of maximum of curve **X** (1)	2			2		
			Question 7 total	**5**	**11**	**0**	**16**	**8**	**0**

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*	[Constant] velocity horizontal (1) Accelerating / force downwards [b.o.d. motion under gravity] (1) Projectile motion → 1 mark		2		2		
	(b)	$\phi = \sin^{-1}\left(\frac{1.55}{1.58}\right)$ (1) 78.82°, 78.8° or 79° etc. seen (not just 80) (1) 1.38 [rad] → 1st mark	1	1		2	2	
	(c)	Maximum angle for propagation with TIR (1) Rotational symmetry (about central axis) (1)		2		2		
	(d)	θ_2 = 90 - 80 = 10 degree or similar (11.2 degree etc.) (1) $n_1 \sin\theta_1 = n_2 \sin\theta_2$ used (1) Rearrangement $\theta_1 = \sin^{-1}\left(\frac{n_2}{n_1}\sin\theta_2\right)$ (1) Answer = 17.9° or 15.9° if 10^{o} used (1)	1	1 1 1		4	3	
	(e)	Dispersion increases with length of fibre (1) [Maximum] bit rate and distance proportional [however stated, eg. Accept distance × 10 → bit-rate down by factor of 10] (1) Conclusion consistent with argument (1)			3	3		
	(f)	20 × 0.8 dB or 16 dB seen (1) Correct comparison with table e.g. 15 dB too much (0.03) (1) Correct conclusion: no, signal drops too much / distance too large (1) [NB Either distance for 6% = 15.3 km **or** 20 km → 2.5 % gives the first two marks].			3	3	2	
	(g)	Wavelength is decreased by factor n or $v=c/n$ (1) Wavelength is 820 nm (1) So thickness of around 8.2 μm is required (1) 13 μm student is wrong (1) [Allow Aled correct because 1.3 μm × 10 = 13 μm for 1 mark]			4	4	2	
		Question 8 total	**2**	**8**	**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	4	3	2	9	4	0
2	9	3	0	12	5	0
3	1	3	4	8	5	0
4	6	2	0	8	2	0
5	0	8	0	8	4	4
6	3	7	9	19	14	19
7	5	11	0	16	8	0
8	2	8	10	20	9	0
TOTAL	**30**	**45**	**25**	**100**	**51**	**23**