GCE A LEVEL MARKING SCHEME

SUMMER 2022

A LEVEL
PHYSICS – UNIT 3
1420U30-1

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INTRODUCTION

This marking scheme was used by WJEC for the 2022 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.

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GCE A LEVEL PHYSICS

UNIT 3 – OSCILLATIONS AND NUCLEI

SUMMER 2022 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.

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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

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	(a)	(i)	[The *activity* is the] rate of decay or [the number of] disintegrations / decays per second (or unit time [of a sample of radioactive nuclei] (1) Accept number of radioactive emissions per second Becquerel or becquerel or Bq (1) Accept s^{-1}	2			2		
		(ii)	$\lambda = \frac{\ln 2}{3.3\times10^5} = 2.1 \times 10^{-6}\ s^{-1}$ (1) $e^{\lambda t} = \frac{A_0}{A}$; $t = \frac{1}{\lambda}\ln\left(\frac{A_0}{A}\right)$ (1) $t = \frac{1}{(2.1\times10^{-6})}\ln\left(\frac{1}{0.2}\right) = 7.7 \times 10^5\ s = [8.9\ day]$ (1) **Alternative:** Taking logs of $A = \frac{A_0}{2^n}$ e.g. $\ln A = \ln A_0 - n\ln 2$ or $n\ln 2 = \ln\frac{A_0}{A}$ (1) Substitution: $n\ln 2 = \ln\frac{100}{20}$ [leads to n = 2.32] (1) Correct answer 7.7×10^5 s = [8.9 day] (1)		3		3	3	
		(iii)	Safe outside the body or stopped by the skin or danger or dangerous if swallowed / inhaled (1) Highly ionising (1) Any reference to damage e.g. damage DNA, kills cells, cause cancer, cause radiation poisoning, causes mutations (1)			3	3		

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(b)		Attempt at masses: LHS – RHS i.e. 0.005 229 [u] or 0.004131 [u] or 0.006327 [u] (1) Attempt at conversion to MeV or mass i.e. × 931 or × 1.66×10^{-27} (1) Attempt at conversion to J i.e. × 1.6×10^{-13} or × c^2 (1) Expect 7.8×10^{-13} [J] Rearrangement and incorporating 98 % **or** statement ignoring 98 % i.e. $v = \sqrt{\frac{2E}{m}}$ (1) N.B. Accept 4 u or 4.0026 u or 4.0015 u 1.52×10^7 or 1.35×10^7 or 1.67×10^7 [m s^{-1}] **ecf** on 98 % and one arithmetic slip (1)	1 1	1 1 1		5	5	
			Question 1 total	**4**	**6**	**3**	**13**	**8**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	(a)	(i)	$n = \frac{pV}{RT} = \frac{1.2 \times 10^5 \times 1.6 \times 10^{-3}}{8.31 \times 293.0}$ = [0.0789 mol] (1) $nN_A = 0.0789 \times 6.02 \times 10^{23} = 4.75 \times 10^{22}$ (1) **Alternative:** $N = \frac{pV}{kT} = \frac{1.2 \times 10^5 \times 1.6 \times 10^{-3}}{1.38 \times 10^{-23} \times 293.0}$ (1) $= 4.75 \times 10^{22}$ (1)		2		2	2	
		(ii)	Valid method e.g. $\frac{1}{2}mv^2 = \frac{3}{2}kT$ (1) Answer = 1 350 [m s^{-1}] **ecf** on N (1)	1	1		2	2	
	(b)	(i)	Combine: $nRT = \frac{1}{3}Nm\overline{c^2}$ (1) Substitution of $N = nN_A$ **or** n = 1 so $N = N_A$ (1) KE [of a molecule] = $\frac{1}{2}m\overline{c^2}$ **or** $U = N\frac{1}{2}m\overline{c^2}$ can be implied if everything is clear (1) So use or implied $k = \frac{R}{N_A}$ and convincing algebra (1) **Common alternative for full marks:** $nRT = \frac{1}{3}Nm\,\overline{c^2}$ (1) $NkT = \frac{1}{3}Nm\,\overline{c^2}$ (1) (implies 1st line if 1st line omitted) KE = $\frac{1}{2}m\overline{c^2}$ (1) (can be implied if everything clear) Algebra leading to KE = $\frac{3}{2}kT$ (1)	4			4	2	

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			Another alternative for full marks: KE = $\frac{1}{2}m\overline{c^2}$ (1) Substituting from $pV = \frac{1}{3}Nm\,\overline{c^2}$ into above e.g. KE = $\frac{1}{2}\frac{3pV}{N}$ (1) Substituting $pV = NkT$ into above e.g. KE = $\frac{1}{2}\frac{3NkT}{N}$ (1) Hence KE = $\frac{3}{2}kT$ (1) **Alternative for a maximum of 3 marks:** Internal energy or $U = \frac{3}{2}nRT$ (1) $U = \frac{3}{2}NkT$ (1) This is for N molecules, hence KE = $\frac{3}{2}kT$ (1)						
		(ii)	$\frac{3}{2}$ x 1.38 x 10^{-23} x 293 = 6.07 × 10^{-21} [J]		1		1	1	
		(iii)	4.75 × 10^{22} **ecf** × 6.07 × 10^{-21} **ecf** = 288 [J]		1		1	1	
	(c)	(i)	Ideal gas – kinetic energy only or no PE (1) Liquid – kinetic energy and potential energy (1) Link PE to intermolecular forces or separation of molecules or intermolecular force / separation mentioned for liquid (1)	3			3		
		(ii)	At absolute zero or 0 [K] or -273 [°C] Do not accept 0 °C OR -273 K (treat as neutral, don't penalise – they may have said something else that is correct e.g. absolute zero)	1			1		
			Question 2 total	**9**	**5**	**0**	**14**	**8**	**0**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)	(i)		Straight line <u>through the origin</u> [shows that acceleration is directly proportional to displacement] (1) Negative slope [shows that the acceleration is always directed towards the fixed point] (1)	2			2		
		(ii)		Calculating gradient i.e. 60 or obtaining suitable point from graph e.g. -0.05, 3.0 (1) Gradient = [-] ω^2 or substitution into equation (1) ω = 7.75 [rad s^{-1}] (1) **Allow 1 mark** for slips such as: $\omega = \sqrt{\frac{3}{0.5}}$ **Allow 2 marks** for $\omega = \sqrt{\frac{3}{0.5}}$ = 2.45 **or** $\omega = \sqrt{\frac{1.5}{0.03}}$ = 7.07 **Allow 3 marks** for Accept $\sqrt{\frac{1.75}{0.03}}$ = 7.64 [rad s^{-1}] **or** $\sqrt{\frac{2}{0.033}}$ = 7.8 [rad s^{-1}] **or** $\sqrt{\frac{2.4}{0.04}}$ = 7.85 [rad s^{-1}] **Allow 1 mark** for: $\omega = \sqrt{\frac{a_{max}}{A}} = 7.7$ i.e. no evidence of data points used or substitution but method ok. **Alternative for full marks:** Using $a = \frac{v^2}{r}$ (which leads to v = 0.39) (1) Using $\omega = \frac{v}{r}$ (1) Convincing correct answer e.g. 7.75 or $\frac{0.39}{0.05}$ (1)		3		3	2	

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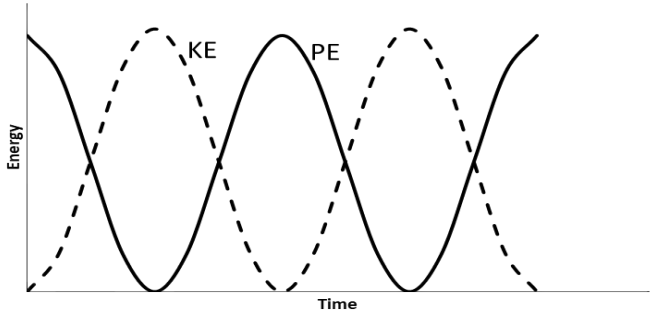
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)	I.	$T = \frac{2\pi}{\omega} = \frac{2\pi}{7.7}$ = 0.82 [s]		1		1	1	
			II.	Substitution: $T = 2\pi\sqrt{\frac{m}{k}}$ so $0.82 = 2\pi\sqrt{\frac{0.30}{k}}$ **or** $ma = kx$ (1) k = 17.8 N m^{-1} **unit mark** (1)	1	1		2	2	
			III.	Substitution: $v = wA$ = 7.7 × 0.05 (1) if $\sin\omega t$ or $\cos\omega t$ used then the angle must be correct v = 0.39 [m s^{-1}] (1) **Alternatives for the first mark:** Substituting into $ma = kx$ e.g. 0.3 × 3 = k × 0.05 (1) **OR** substituting into $\omega = \sqrt{\frac{k}{m}}$ e.g. $7.8 = \sqrt{\frac{k}{0.3}}$ (1)	1	1		2	2	
		(iv)		 Shape and start point of PE sketch (1) Shape KE sketch and starting at zero (1) KE out of phase with PE and same size peaks and one complete cycle i.e. 2 KE peaks (1)		3		3	1	

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			**Indicative content:** **<u>Damping:</u>** Damping linked to resistive force. It dissipates energy or linked to energy loss. Amplitude decreases with time. Link to energy loss to surroundings. Critical damping. **<u>Resonance</u>**: Periodic force. Happens when frequency is equal to the natural frequency. Amplitude of oscillation becomes large. Damping lowers the resonance peak. Reasonable resonance graph. **<u>Real systems</u>:** Any sensible real system e.g. bridges / structural /swings, tuning circuit Example of damping e.g. car suspension With a description of the driving force Explanation of whether resonance is good or bad.	6			6		

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				5-6 marks All 3 areas answered well. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** 2 areas answered well or limited answers to all 3 areas. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** 1 area answered well or limited answers to 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.*						
				Question 3 total	**10**	**9**	**0**	**19**	**8**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	(a)		Angle where (1) accept diagram showing angle arc length equals the radius **or** approximately 57.3° or $2\pi = 360^{o}$ (1)	2			2		
	(b)		Period, $T = 105 \times 60 = 6300$ [s] or 105 [min] (1) Substitution (regardless of unit): $\omega = \frac{2\pi}{T} = \frac{2\pi}{6300}$ (1) $= 9.97 \times 10^{-4}$ [rad s^{-1}](1)	1	1 1		3	3	
	(c)		$m\omega^2 R = \frac{GM_E m}{R^2}$ (1) Accept $\frac{mv^2}{r} = \frac{GM_E m}{R^2}$ $R^3 = \frac{GM_E}{\omega^2}$ [so: $R = \sqrt[3]{\frac{GM_E}{\omega^2}}$] (1)		2		2	1	
	(d)		Substitution: $R = \sqrt[3]{\frac{(6.67\times10^{-11})\,(6.0\times10^{24})}{(9.97\times10^{-4})^2}}$ **ecf** (1) R = 7 380 k[m] (1) Altitude above the surface of the Earth = 7 380 – 6 400 = 980 k[m] (1)	1	1 1		3	3	
	(e)		$R = \sqrt[3]{\frac{(6.67\times10^{-11})\,(7.3\times10^{22})}{(9.97\times10^{-4})^2}}$ **ecf** (**1**) R = 1 698 k[m] (1) Correct conclusion based on candidate's answer e.g. not possible since inside Moon (1) **Alternative:** Substituting into equation to calculate period or to calculate mass (1) Correct answer e.g. to period (1) Correct conclusion based on period / mass e.g. period longer so not possible, mass smaller so not possible (1)			3	3	1	

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			Alternative: Can also work centripetal acceleration (1.7) (1) Calculate gravitational acceleration (1.6) (1) Not possible (since gravity too weak) (1)						
			Question 4 total	**4**	**6**	**3**	**13**	**8**	**0**

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<table>
<tr><th colspan="3" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</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>(i)</td><td>Absorb alpha and beta or only allow gamma through. Accept absorb beta only [due to 40 cm gap]</td><td></td><td></td><td>1</td><td>1</td><td></td><td>1</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Background radiation (1)
To check for consistency / check for variations (1)
Don’t accept for a mean</td><td></td><td></td><td>2</td><td>2</td><td></td><td>2</td></tr>
<tr><td></td><td>(b)</td><td></td><td>
<table>
<tr><th rowspan="2">Distance, r / m</th><th colspan="4">Count</th><th rowspan="2">Uncertainty in mean count</th></tr>
<tr><th>First reading</th><th>Second reading</th><th>Third reading</th><th>Mean count</th></tr>
<tr><td>Without source</td><td>19</td><td>22</td><td>25</td><td>22</td><td>3</td></tr>
<tr><td>1.000</td><td>110</td><td>130</td><td>136</td><td>125</td><td>13</td></tr>
<tr><td>0.800</td><td>195</td><td>165</td><td>178</td><td>179</td><td>15 or 14 or 16</td></tr>
<tr><td>0.600</td><td>270</td><td>316</td><td>300</td><td>295</td><td>23 or 21 or 22 or 24 or 25</td></tr>
<tr><td>0.400</td><td>661</td><td>604</td><td>651</td><td>639</td><td>29</td></tr>
<tr><td>Without source</td><td>20</td><td>20</td><td>25</td><td>22</td><td>3</td></tr>
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1 mark per column.</td><td></td><td>2</td><td></td><td>2</td><td>2</td><td>2</td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td>
<table>
<tr><th>Distance, r /m</th><th>Corrected mean count, N</th><th>Uncertainty in corrected mean count</th></tr>
<tr><td>1.000</td><td>103</td><td>16</td></tr>
<tr><td>0.800</td><td>157</td><td>18</td></tr>
<tr><td>0.600</td><td>273</td><td>26</td></tr>
<tr><td>0.400</td><td>617</td><td>32</td></tr>
</table>
1 mark per column ecf on previous table</td><td></td><td>2</td><td></td><td>2</td><td>2</td><td>2</td></tr>
</table>

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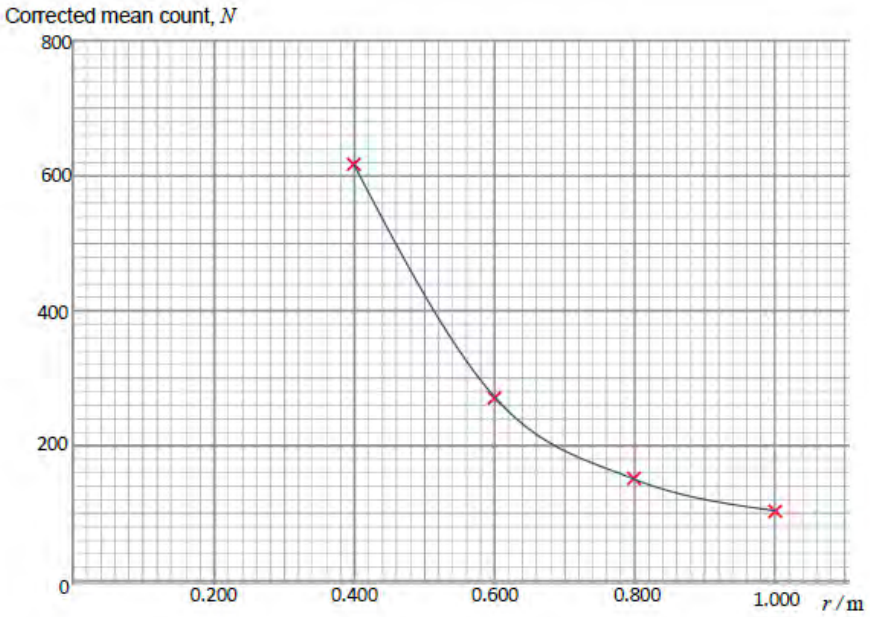
Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(ii)	 All 4 points correct (2) **ecf** 3 points correct (1) One smooth curve passing through all points ± ½ small square (1)		3		3	3	3
		(iii)	Error bars in the corrected mean count are large enough to be shown on the graph [approx. 2 units min], but the uncertainty in r is too small [less than one unit]			1	1		1

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(d)		$\ln$ 119 = 4.78 **or** $\ln$ 87 = 4.47 (1) $\ln$ 103 = 4.63 **or** the other extreme (1) 4.78 - 4.63 **or** 4.66 - 4.47 = [approx. 0.15] or $\frac{0.31}{2}$ (1) **No ecf** allowed (since 103 and 16 are given) **Award 1 mark** for $\frac{16}{103} = 0.15. 0.155, 0.16$ **Award 2 marks** for statement absolute uncertainty in log = fractional uncertainty in count		3		3	3	3
	(e)	(i)	Taking logs: $\ln(N) = -n\ln(r) + \ln(k)$ (1) (accept $\ln I$ in lieu of $\ln N$) Plotting $\ln(N)$ on the y-axis against $\ln(r)$ on the x-axis or comparison with $y = mx + c$ (1) Gradient $= -n$ (1)			3	3	3	3
		(ii)	Minimum gradient = $\frac{3.94-7.00}{0.50-(-1.30)} = [-]1.69 \pm 0.03$ (1) Maximum gradient = $\frac{3.40-7.00}{0.50-(-1.17)} = [-]2.16 \pm 0.03$ (1) Mean gradient = $[-]1.93 \pm 0.03$ (1) **ecf** Uncertainty = $\frac{1}{2}(-1.69-(-2.16))$ = 0.20 - 0.28 (1) **ecf** accept 0.2 No sig fig penalty		4		4	4	4
			Question 5 total	**0**	**14**	**7**	**21**	**17**	**21**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	(a)		1 clockwise arrow (1) 1, 2, 3, 4 in correct positions 1 (1) 4 2 3		2		2		
	(b)		True because clockwise **OR** process 1 has greatest work than 3 (1) No work done for 2 & 4 (1) Apply ecf if needed			2	2		
	(c)		Attempt made at any area under the graph or enclosed **or** counting squares (1) 9.25ish large squares or 9 × 25 small squares or correct trapezium / enclosed area method (1) Answer = 4 600 ± 400 [J] (1)			3	3	3	
	(d)		Heat flows from gas to surroundings (through piston) **OR** conduction through metal (1) Accept molecules collide with container [Thermal] equilibrium or same temperature as surroundings (1)		1	1	2		
	(e)		**Any 4 × (1) from:** • Volume increases [for expansion part] • Work done by gas [for expansion but not compression] • Internal energy decrease [for expansion but not compression] • Increased PE linked to lower temperature or expansion • KE or internal energy decrease linked to cooling or lower temperature or expansion • [Process] too quick for heat transfer			4	4		

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(f)		Nitrogen boils **OR** heat transferred to LN_2 **OR** high pressure inside bottle. Accept gas expands	1			1		
	(g)		Force on bottle / nozzle is equal and opposite to force on gas / nitrogen (1) Provides [anticlockwise] moment / torque [for rotation] (1) For 2nd mark, do not accept "principle of moments" because this is relevant to equilibrium or adding moments. Don't accept equal and opposite forces acting on the walls	1	1		2		
	(h)		Sound [waves] produced (or implied) (1) Implication of pressure release / molecule or gas release / energy release OR displacement of particles/molecules OR vibration of particles / molecules (1)	1	1		2		
	(i)		Nitrogen escapes from the container OR nitrogen escapes into lift (1) ACCEPT pressure in lift builds up DON'T ACCEPT container explodes OR container acts like rocket Leading to suffocation / anything to do with breathing N_2 (1)			2	2		
			Question 6 total	**3**	**5**	**12**	**20**	**3**	**0**

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SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	4	6	3	13	8	0
2	9	5	0	14	8	0
3	10	9	0	19	8	0
4	4	6	3	13	8	0
5	0	14	7	21	17	21
6	3	5	12	20	3	0
TOTAL	**30**	**45**	**25**	**100**	**52**	**21**

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