GCE A LEVEL MARKING SCHEME

SUMMER 2023

A LEVEL
PHYSICS – UNIT 3
1420U30-1

INTRODUCTION

This marking scheme was used by WJEC for the 2023 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.

GCE A LEVEL PHYSICS

UNIT 3 – OSCILLATIONS AND NUCLEI

SUMMER 2023 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)			ΔU: is the increase in the internal energy of a system (1) accept change Q: is the heat entering (1) the system W: is the work done by (1) the system "system" or "gas" or equivalent needs to be used once correctly for full marks.	3			3		
	(b)			Substitution into $PV = nRT$ (1) $T = \frac{PV}{nR} = \frac{(100\times10^3)(1.4\times10^{-3})}{(0.06)((8.31)}$ = 280.8 K **unit mark** (1)	1	1		2	2	
	(c)	(i)		Work done (by gas) $= P\,\Delta V = (100\times10^3)(2.0-1.4)\times10^{-3}(1)$ $= 60$ [J] (1) Award 1 mark for 200 or 140 [J]	1	1		2	2	
		(ii)		Final temperature: $T = \frac{PV}{nR} = \frac{(100\times10^3)(2.0\times10^{-3})}{(0.06)((8.31)} = 401.1$ [K] (1) Increase in internal energy = $\frac{3}{2}nR\,\Delta T =$ $1.5(0.06)(8.31)(401.1-280.8\mathbf{ecf}) = 90.0$ [J] (1) **Alternative**: Use of $\frac{3}{2}P\,\Delta V$ (1) = 90 [J] (1)		2		2	2	
		(iii)		Heat transferred $Q = \Delta U + W = 90.0\ \mathbf{ecf} + 60.0\ \mathbf{ecf} = 150.0$ [J]		1		1	1	
				Question 1 total	**5**	**5**	**0**	**10**	**7**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)			Is the [resultant] force for circular motion (1) It is directed towards the centre [of the circle] (1)	2			2		
	(b)	(i)		$T = \frac{15}{10} = 1.5$ s **or** $f = \frac{10}{15} = 0.67$ [Hz] (1) $v = \frac{2\pi r}{T} = \frac{2\pi(0.8)}{1.5}$ (1)[$= 3.35\ \text{m s}^{-1}$] **Alternative:** Total distance = $1.6\pi \times 10$ (1) $v = \frac{1.6\pi \text{x } 10}{15}$ (1) [$= 3.35\ \text{m s}^{-1}$]	1	1		2	2	
		(ii)		Substitution: $F = \frac{mv^2}{r} = \frac{(30 \times 10^{-3}) \text{x } 3.35^2}{0.8}$ (1) $= 0.42$ [N] (1) **Alternative:** $F = mr\omega^2 = (30 \times 10^{-3}) \times 0.8 \times \left(\frac{2\pi}{1.5}\right)^2$ (1) $= 0.42$ [N](1)	1	1		2	2	
	(c)			Force $=$ Tension $+ mg$ (1) Tension $=$ Force $- mg = 0.42$ **ecf** $- (30 \times 10^{-3})(9.81) = 0.13$ [N] (1) Award 1 mark for 0.7 [N]		2		2	1	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(d)	(i)		Conservation of energy or implied (1) Full substitution or good algebra e.g. $\frac{1}{2}mv_b{}^2 = mgh + \frac{1}{2}mv^2$ **OR** Initial KE = 0.17 [J] and PE loss = 0.47 [J] (implied by final KE = 0.64 J) **OR** $v_b = \sqrt{2gh + v^2}$ (1) Final velocity $= 6.53$ [m s^{-1}] (1) **Alternative:** Use of $v^2 = u^2 + 2ax$ with u = 3.35 m s^{-1} and a = 9.81 m s^{-2} (1) Correct answer = 6.53 [m s^{-1}] (1) Some statement of why this equation works e.g. due to conservation of energy, we can consider a particle dropping with initial downward speed of 3.35 (1) Accept – this equation shouldn't work but it does! **Alternative:** Use of $v^2 = u^2 + 2ax$ with u = 0 gives v = 5.6 [m s^{-1}] (1) Pythagoras applied i.e. $\sqrt{3.35^2 + 5.6^2}$ (1) Correct answer = 6.53 [m s^{-1}] (1)		3		3	2	
		(ii)		Use of $x = ut + \frac{1}{2}at^2$ for the vertical motion **or** 2 other usable equations (1) $t = \sqrt{\frac{2x}{g}} = \sqrt{\frac{2(1.2+0.8)}{9.81}} = 0.64$ [s] (1) For the horizontal motion: horizontal distance from point of released = vt = 3.35 × 0.64 **ecf** (1) = 2.14 [m] so claim is correct (1) **ecf** Accept 2.14 ≈ 2			4	4	3	
				Question 2 total	**4**	**7**	**4**	**15**	**10**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)			Helium nuclei / 2 protons and 2 neutrons (1) accept $^{4}_{2}\mathrm{He}$ Emitted from the <u>nucleus</u> [at high speeds] (1)	2			2		
	(b)			$\lambda = \frac{\ln 2}{T_{\frac{1}{2}}} = \frac{\ln 2}{432} = 1.60 \times 10^{-3}\ \mathrm{yr}^{-1}$ **or** $5.08 \times 10^{-11}\ \mathrm{s}^{-1}$ (1) **Either:** Substitution: $A = A_0 \exp\left(-(1.60 \times 10^{-3})(30)\right)$ (1) $\frac{A}{A_0}100\% = 95.3[\%]$ (1) $\%\ \text{decrease in activity} = 100 - 95.3 = 4.7[\%]$ (1) **or:** 30 years << ½-life [or by impl.] (1) ∴ Fractional decay in 30 years = 30λ = 0.048 (1) ∴ % decrease in activity = 4.8[%] (1) Accept 5% **Alternative:** 30 years is 30/432 = 0.07 half-lives (1) A = $½^{0.07}$ (1) = 0.95 (1) So activity has decreased by 5[%] (1)	1	1 1 1		4	3	
	(c)			**Any 2 × (1) from:** • Alpha particles pose little risk unless inhaled or ingested. • Very few (or none) make it to the outside of the detector. • If they do, they are stopped by a few cm of air and are unable to penetrate surface of skin. **To award both marks there must be a conclusion present i.e. a minimum of no stated.**			2	2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(d)			**Indicative content:** <u>Absorbers:</u> Explain how absorbers can be used to distinguish between the three radiations – describe set up. Diagram or a clear explanation. Sheet of paper stops alpha. Few mm of aluminium will stop alpha and beta. Gamma penetrates both the paper and aluminium. Reference to background radiation. <u>Magnetic field / Electric field</u>: Explain how a magnetic / electric field can be used to distinguish between the three radiations – describe set up. Diagram and clear explanation. Deflection of alpha particles much smaller than for beta, charge positive. Deflection of beta particles opposite to that of alpha, as charge-negative. No deflection of gamma. Correct direction of alpha or beta in magnetic / electric field. **5-6 marks** Absorbers and magnetic / electric field both covered comprehensively. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Either absorbers or magnetic / electric field covered comprehensively or limited account of both areas. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.*	4	2		6		6

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				1-2 marks Limited account of either absorbers or magnetic / electric field. *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	**7**	**5**	**2**	**14**	**3**	**6**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
4	(a)			The {heat / energy} required to {raise / change} [the temperature of] 1 kg (1) by 1 °C or K (1)	2			2		
	(b)	(i)		Mass of the water = $\text{density} \times \text{volume} = 10^3 \times (1.2 \times 10^{-3}) = 1.2\ \text{kg}$ (1) Heat required to increase temperature = shc × mass × increase in temperature = 4200 × 1.2 × (100 – 18) = [413 280 J] (1) Time required = $\frac{\text{heat required}}{\text{power}} = \frac{413\,280}{3 \times 10^3}$ = 137.8 [s] (1) Or 2 min 18 s		3		3	3	
		(ii)		Use of density equation on milk [expect 0.037 kg] (1) Attempt at conservation of energy (1) e.g. Heat lost by the tea = Heat gained by the milk [expect 11 424 and 11 550 [J]] Correct equation set up (1) e.g. $(95-84)(4200)(0.25) = (84-5)(3900)m_{\text{milk}}$ **or** $(95-\theta)(4200)(0.25) = (\theta-5)(3900)m_{\text{milk}}$ **or** equivalent equation set up to calculate one of the variables **or** 0.25 × 4200 × 95 + 0.03708 × 3900 × 5 = (0.25 × 4200 + 0.03708 × 3900) × T (note that this line also works if temperature is in K) Final answer **and** comment (1) e.g. $V = 3.64 \times 10^{-5}\ \text{m}^3$ and so about right **or** final temperature = 84.1 °C and so about right			4	4	3	
				Question 4 total	**2**	**3**	**4**	**9**	**6**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)			Fusion definition (nuclei join to form larger nucleus and energy release) (1) Fission definition (larger nucleus splits to smaller nuclei and energy release) (1) N.B. energy release only required somewhere once Products are (usually) more stable / have higher BE/N (1) Low A numbers do fusion, high A numbers do fission (might be in diagram with arrows) (1)	4			4		
	(b)	(i)		The Avogadro constant is the {number of / 6.02×10^{23}} {particles / atoms / molecules} in 1 mole of a substance **or** in 12 g of $^{12}_{6}\mathrm{C}$	1			1		
		(ii)		LHS - RHS i.e. (235.04393 + 1.00866) – (97.91273 + 134.91645 + 3 $\times$1.00866) = 236.05259 – 235.85516 = 0.19743 [u] (1) $\times$ 931 or 1.66×10^{-27} (1) Convert from eV into J **or** kg into J i.e. 2.94×10^{-11} [J] (1) Method for number of atoms e.g. $\frac{(6.02\times10^{23})}{235} 1 = 2.56 \times 10^{21}$ **or** $\frac{0.001}{235 \times 1.66 \times 10^{-27}}$ (1) Energy released = 7.5×10^{10} [J] (1)		5		5	5	
				Question 5 total	**5**	**5**	**0**	**10**	**5**	**0**

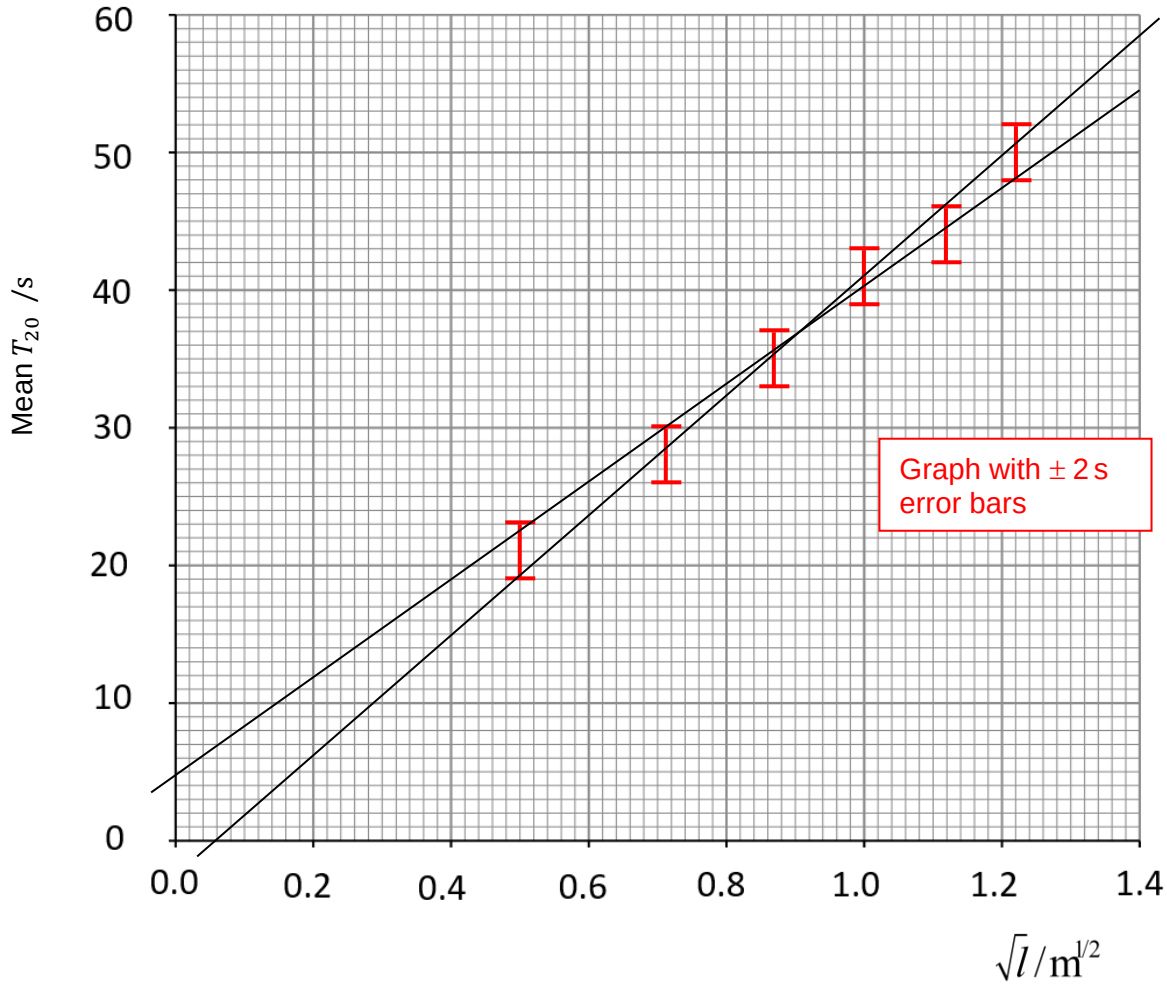
<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>6</td><td>(a)</td><td></td><td></td><td>Is a [light] {string / thread} with a {bob / mass / weight} attached to one end</td><td>1</td><td></td><td></td><td>1</td><td></td><td>1</td></tr>
<tr><td></td><td>(b)</td><td></td><td></td><td>Acceleration is proportional to its {distance / displacement} (1)
and directed towards its {equilibrium / fixed} point (1)</td><td>2</td><td></td><td></td><td>2</td><td></td><td></td></tr>
<tr><td></td><td>(c)</td><td></td><td></td><td>[System A] the angle is too big [for shm to occur] (1)

Any × (1) from:
• the shorter length {has a larger [percentage] uncertainty / is less accurate}
• the shorter period {has a larger [percentage] uncertainty / is less accurate}</td><td></td><td></td><td>2</td><td>2</td><td></td><td>2</td></tr>
<tr><td></td><td>(d)</td><td>(i)</td><td></td><td>
<table>
<tr><th>l /m</th><th>$\sqrt{l}$ / m$^{\frac{1}{2}}$</th><th>T_{20} /s</th><th>Mean T_{20} /s</th><th>Uncertainty T_{20} /s</th></tr>
<tr><td>0.250</td><td>0.50</td><td>19, 21, 22, 20</td><td>21</td><td>2</td></tr>
<tr><td>0.500</td><td>0.71</td><td>26, 29, 26. 29</td><td>28</td><td>2</td></tr>
<tr><td>0.750</td><td>0.87</td><td>35, 34, 33, 36</td><td>35</td><td>2</td></tr>
<tr><td>1.000</td><td>1.00</td><td>42, 39, 40, 41</td><td>41</td><td>2</td></tr>
<tr><td>1.250</td><td>1.12</td><td>45, 42, 44, 45</td><td>44</td><td>2</td></tr>
<tr><td>1.500</td><td>1.22</td><td>48, 50, 49, 52</td><td>50</td><td>2</td></tr>
</table>
[1 for each column]
Deduct a maximum of 1 mark overall for inconsistent sig figs in each column</td><td></td><td>3</td><td></td><td>3</td><td>3</td><td>3</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		See example graphs at end of Q6 Award 3 marks for all points and error bars correct Award 2 marks for 5 points and error bars correct Award 1 mark for 4 points and error bars correct Award 0 marks for 3 points or less and error bars correct Correct lines drawn for the maximum gradient and the minimum gradient (1) **ecf**		4		4	4	4
		(iii)		l can be measured to ± 0.001 [m] or resolution is 1 mm (1) [Uncertainty in $\sqrt{l}$] is too small to plot (1)			2	2		2
		(iv)		Both gradients correct (1) Mean gradient correct (1) **ecf** Absolute uncertainty in gradient correct (1) **ecf** implied by % uncertainty Correct g (1) **ecf** Final % correct (1) **ecf No sig fig or unit penalties** $m_{max}\left[=\frac{58.2}{1.40-0.06}\right]=43.4$; $m_{min}\left[=\frac{54.3-4.7}{1.4}\right]=35.4$ $\therefore$ Gradient, m = 39.4 ± {4.0 / 10%} **Either** For 20 oscillations, $T=20\times 2\pi\sqrt{\frac{l}{g}}$ $\therefore \sqrt{g}=\frac{40\pi}{m}$ [or by impl.] [= 3.19 ± 10%] $\therefore$ g = 10.2 m s^{-2} ± 20%		5		5	5	5

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				Or For one oscillation: m = 1.97 ± 10% (1) $\left[T = 2\pi\sqrt{\frac{l}{g}}\right]$, ∴ $\sqrt{g} = \frac{2\pi}{m}$ [or by impl.] [= 3.19 ± 10 %] (1) ∴ g = 10.2 (± 20 %) m s^{-2} **Alternative:** calculate max value of g from min gradient; min value of g from max gradient and hence g ± uncertainty. Gradients of both: 43.284 and 35.357 (1) Mean $T_{20} = \frac{40\pi}{\sqrt{g}}\sqrt{l}$ so gradient = $\frac{40\pi}{\sqrt{g}}$ $g = \left(\frac{40\pi}{43.3}\right)^2 = 8.42$ m s^{-2} **and** $g = \left(\frac{40\pi}{35.3}\right)^2 = 12.67$ m s^{-2} (1) So unc(g) = $\frac{12.67-8.42}{2} = 2.1$ m s^{-2} (1) $g = 10.5$ m s^{-2}[1] ∴ % unc(g) = $\left[= \frac{2.1}{10.5} \times 100\%\right]$ = 20% (1)						

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(e)			Slope $\propto \frac{1}{\sqrt{g}}$ **or** equivalent e.g. gradient = $\frac{2\pi}{\sqrt{g}}$ **or** gradient = $\frac{40\pi}{\sqrt{g}}$ (1) Ratio of slopes = $\frac{1}{\sqrt{0.2}}$ **or** $\sqrt{5}$ **or** new gradient = 89 or two correct expressions for gradients e.g. $\frac{2\pi}{\sqrt{g}}$ **and** $\frac{2\pi}{\sqrt{0.2g}}$ **or** $\frac{40\pi}{\sqrt{g}}$ and $\frac{40\pi}{\sqrt{0.2g}}$ (1) Ratio of gradients = 2.24ish and sensible comment (1)			3	3	3	
				Question 6 total	**3**	**12**	**7**	**22**	**15**	**17**



Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	(a)		Converting ly to m i.e. $200 \times 9.46 \times 10^{15} = 1.892 \times 10^{18}$ [m] (1) Calculating θ in radian i.e. $\frac{1.5 \times 10^{11}}{1.892 \times 10^{18}} = 7.93 \times 10^{-8}$ (1) (can be done by using tan or trig) $\theta = 1.22\frac{\lambda}{d}$ used (whatever the subject) i.e. 7.6 m for visible light **or** 7.625×10^{-8} seen (1) Final calculation leading to suitable conclusion (1) Award full marks for a calculation of 1.45×10^{11} seen and compared with 1 AU	1	1 1 1		4	3	
	(b)	(i)	Substitution into period equation e.g. even $50 = 2\pi\sqrt{\frac{d^3}{G\times3\times2\times10^{30}}}$ (1) Final rearrangement and correct substitution seen **or** 2.93×10^{12} [m] (1)	1	1		2	1	
		(ii)	Substitution into C of M equation (1) can be implied $\frac{1}{3} \times 2.93 \times 10^{12} = 0.977 \times 10^{12}$ or equivalent seen (1)	1	1		2	1	
		(iii)	Use of Stefan's law (1) Use of area proportional to R^2 (1) $\frac{R_A^2 T_A^4}{R_B^2 T_B^4} = \frac{R_A^2}{R_B^2}\frac{1.7^4}{4.3^4} = \frac{25}{1/18}$(1) Answer = $\frac{R_{\text{Sirius A}}}{R_{\text{Sirius B}}}$ = 136 or 140 (1)	1	1 1 1		4	3	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)	Constant intensity when both stars seen **or** gradual drop **or** partial eclipse **or** regular time intervals (1) One star in front of the other, light is “blocked” (1) Different dips depending on which star is “blocked” (1)			3	3		
		(ii)	{Intensity / power / luminosity / brightness} increases with T (1) The same area is blocked regardless of which star is doing the blocking **or** $I = \frac{P}{A} = \sigma T^4$ (1)			2	2		
	(d)		Black hole is not visible [and star orbiting is]			1	1		
	(e)		Reflection method (1) accept the first method of the 3 Black bodies do not reflect **OR** black bodies absorb all em radiation incident (1) Award one mark only for existence of absorption lines in the spectrum			2	2		
			Question 7 total	**4**	**8**	**8**	**20**	**8**	**0**

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	5	5	0	10	7	0
2	4	7	4	15	10	0
3	7	5	2	14	3	6
4	2	3	4	9	6	0
5	5	5	0	10	5	0
6	3	12	7	22	15	17
7	4	8	8	20	8	0
TOTAL	**30**	**45**	**25**	**100**	**54**	**23**