GCE A LEVEL MARKING SCHEME

SUMMER 2019

A LEVEL
PHYSICS - COMPONENT 3
A420U30-1

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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.

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A LEVEL COMPONENT 3 – LIGHT, NUCLEI AND OPTIONS

MARK SCHEME

GENERAL INSTRUCTIONS

The mark scheme should be applied precisely and no departure made from it.

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (except for the extended response questions).

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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SECTION A

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*		Transverse – <u>oscillations / vibrations</u> 90° or perpendicular to energy transfer/wave direction [1] Longitudinal – oscillations / vibrations parallel/same direction to energy transfer / wave direction [1] Penalise missing oscillations / wave direction only once	2			2		
	(b)	(i)	4 [cm]	1			1	1	
		(ii)	0.8 [m]	1			1	1	
		(iii)	Period = 0.3 [s] [1] $f = \frac{1}{T}$ and $v = f\lambda$ used **or** $v = \frac{\lambda}{T}$ [1] **ecf** on T Answer = 2.67 [m/s] [1] don't accept 2.6 [m/s]	1	1 1		3	1	
	(c)	(i)	Arrow radially outward (accept inward) based on point S	1			1		
		(ii)	S and T only	1			1		
			Question 1 total	**7**	**2**	**0**	**9**	**3**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*	(i)	Answer = 2a [1] Diffraction pattern is narrower / smaller central maximum / brighter [1]	2			2		
		(ii)	Make slit width approximately one wavelength or similar to one wavelength Don't accept smaller or smaller than one wavelength	1			1		
	(b)		Sound, sodium & microwaves only give interference [2] (or only 2 lasers don't) Only 1 incorrect - allow 1 mark		2		2		
	(c)		Use of equation: $n\lambda = d\sin\theta$ [1] Max possible n = 5 **or** min = 4 [1] λ = 600 n[m] [1] λ = 480 n[m] [1]	1	1 1 1		4	2	
			Question 2 total	**4**	**5**	**0**	**9**	**2**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*	(i)	Stimulated emission also happens [1] Decreasing the upper population (accept 50 % population is greatest possible **or** equal probability of absorption / dropping) [1]	2			2		
		(ii)	Greater efficiency or requires less energy / small pumping voltage / larger population inversions / less pumping / cheaper and mass produced [1] Don't accept lower current CD / DVD / Blu ray / pointers / laser fusion / anything sensible [1]	2			2		
	(b)		**3-level system** Pumping E1-E3 E3-E2 quick E2 metastable E2-E1 laser output E1-E2 population inversion **4-level system** Pumping E1-E4 E4-E3 quick E3 metastable E3-E2 laser output E2-E3 population inversion E2-E1 quick **Advantages / Disadvantages** E1 ground so usually full in 3-level More than 50% pumping required in 3-level E2 normally empty in 4-level Minimum pumping required in 4-level	6			6		

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			5-6 marks Comprehensive description of how a 3-level works, how a 4-level works and its advantages. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Comprehensive description of 2 from: how a 3-level works, how a 4-level works and its advantages or limited description of all 3. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** Comprehensive description of 1 from: how a 3-level works, how a 4-level works and its advantages or limited description of 2. *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**	**0**	**0**	**10**	**0**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*		Diagram of radiation in B-field or E-field (or description) [1] α, β deviate in opposite directions [1] α, β and γ radiation all go correct directions [1]	1	1 1		3		
	(b)	(i)	Decay constant obtained 1.51×10^{-7} [s^{-1}] **or** 0.013 [day^{-1}] **or** $1.58 T_{½}$ [1] $3.5e^{-0.013 \times 84}$ **or** equivalent e.g. $2^{1.58}$ [1] Answer = 1.169 [cps] (no more required) [1]		3		3	3	
		(ii)	Subtracting background radiation from initial (3 cps) [1] Calculating correct cps after 84 days (i.e. 1.002 cps) [1] Adding background radiation (i.e. 1.502) [1] Valid conclusion: close to expected or okay / due to randomness and low numbers **ecf** [1]			4	4	2	
			Question 4 total	**1**	**5**	**4**	**10**	**5**	**0**

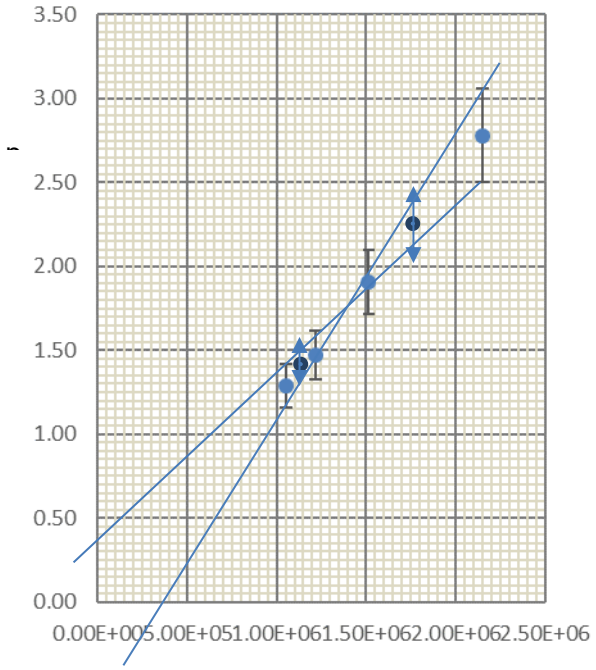
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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*		E = [2×] $9.11 \times 10^{-31} \times c^2$ **or** $m = \frac{9.11 \times 10^{-31}}{1.66 \times 10^{-27}}$ [= 0.000549 u] [1] Conversion to eV i.e. dividing by 1.6×10^{-19} **or** $\times 931$ [1] 1.025 MeV seen **or** $2 \times 9.11 \times 10^{-31} \times \frac{(3 \times 10^8)^2}{1.6 \times 10^{-19}}$ **or** $2 \times 0.000549 \times 931$ [1]		3		3	3	
	(b)		Excess energy **or** 0.01 MeV [1] Equal amounts shared by electrons & positron due to equal (light) masses [1]		2		2		
	(c)		$0.5 \times 9.11 \times 10^{-31} \times v^2 = 0.005 \times 10^6 \times 1.6 \times 10^{-19}$ seen **or** equivalent: $(0.5 \times 9.11 \times 10^{-31} \times (4.2 \times 10^7)^2$ giving 0.005 MeV **or** 4.19×10^7 seen [1] Momentum of gamma ray [= $\frac{E}{c}$]= 5.49×10^{-22} [N s] [1] Momentum of electron or positron = $9.11 \times 10^{-31} \times 4.2 \times 10^7$ = 3.8×10^{-23} **or** 7.6×10^{-23} [1] $5.49 \times 10^{-22} - 2 \times 4.2 \times 10^7 \times 9.11 \times 10^{-31}$ seen [1]		4		4	3	
	(d)		KE calculated (3.35×10^{-19} J **or** 2.1 eV) [1] Correct conclusion – negligible [1] **No ecf**			2	2	1	
			Question 5 total	**0**	**9**	**2**	**11**	**7**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*		$-\frac{2}{3}-\frac{2}{3}-\frac{2}{3}=-2$ seen or statement that this is the only way to get a charge of -2(e)		1		1		
	(b)		$\overline{\mathrm{uuu}} \rightarrow \overline{\mathrm{uud}}+\ \overline{\mathrm{ud}}$ **or** $\overline{\mathrm{uuu}}+\mathrm{u}\overline{\mathrm{u}}$ **or** $\overline{\mathrm{uuu}}+\mathrm{d}\overline{\mathrm{d}}$ [1] [any order of quarks in the baryon and meson] Anti-proton **or** anti- Δ^{+} and π^{-} **OR** anti- Δ^{++} and π^{0} [1]			2	2		
	(c)		Strong force [1] **no ecf** Short time **or** conservation of u and d **and** no photon **or** accept ONLY quarks / hadrons involved **or** no neutrinos **and** no photons **or** no flavour change **and** no photons [1]			2	2		
	(d)		**Any 3 × (1) valid points:** -contradicts current theories (relativity) or can't travel faster than the speed of light ✓ -current theories well established ✓ -further experiments ✓ -by other groups / scientists / peer review ✓ -due to instrument problems (timing delay) / systematic errors ✓			3	3		
			Question 6 total	**0**	**1**	**7**	**8**	**0**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*	(i)	1.76 **and** 1.12 [1] 0.23 **and** 0.14 [1]			2	2	2	2
		(ii)	 Both points correct ± ½ small square division [1] Both error bars correct [1]		2		2	2	2
		(iii)	Line of maximum gradient correct [1] Line of minimum gradient correct [1] Allow **ecf** on plots and error bars for 1 mark only if imperfect		2		2		2

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(b)	(i)	Correct gradients (expect 1.73×10^{-6}, 0.98×10^{-6} but allow **ecf** on lines, just check for consistency) [2] Correct value of h obtained expect 7.2×10^{-34} [J s] (regardless of method, allow **ecf** but check consistent with lines) [1] Correct % uncertainty (expect around 27%) **or** $2 \times$ correct values of h obtained e.g. 9.1 and 5.3 [1] (just check that these are consistent with the drawn lines) Final expression consistent with sig figs only 1 or 2 sig figs for uncertainty (allow **ecf**) e.g. $(7.2 \pm 1.9) \times 10^{-34}$ [J s], $(7.2 \pm 1.8) \times 10^{-34}$ [J s], $(7.2 \pm 2.0) \times 10^{-34}$ [J s], $(7 \pm 2) \times 10^{-34}$ [J s] [1]			5	5	4	5
		(ii)	**Any 4 × (1) from:** • Straight line ✓ • Through all error bars ✓ • Straddles origin / best fit line goes through origin ✓ • Value of h consistent (with data booklet) / gradient = $\frac{hc}{e}$ accept h is slightly large ✓ • Large uncertainty or scatter in data ✓			4	4	4	4
	(c)		Eye sensitivity changes with wavelength or long/some wavelengths invisible Don't accept reference to human error			1	1		

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(d)	(i)	Method correct (obtaining gradient or substituting values) e.g. $\frac{6.6 \times 10^{-19}}{10 \times 10^{14}}$ **or** $h \times 10 \times 10^{14} = 4.6 \times 10^{-19} + 2 \times 10^{-19}$ [1] $h = 6.6 \times 10^{-34}$ [J s] or other consistent value [1]		2		2	2	2
		(ii)	$h \times 6.9 \times 10^{14} = 4.57 \times 10^{-19}$ J **OR** y-intercept $= 4.6 \times 10^{-19}$ J [1] Photon energy is too low [1] to release electrons [1]	1 1	1		3	1	3
			Question 7 total	**2**	**7**	**12**	**21**	**15**	**21**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*		122.4 eV obtained [1] $\times 1.6 \times 10^{-19} = 1.96 \times 10^{-17}$ [J] [1]		2		2	1	
	(b)		30.6 – 13.6 seen or implied [1] λ = 73 n[m] or equivalent [1] UV [1]		3		3	1	
	(c)		Energy levels in atoms/for electrons [1] Drops give emission **and** up gives absorption [1] Linking the same energy [transitions] to the same wavelengths [1]		3		3		
			Question 8 total	**0**	**8**	**0**	**8**	**2**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
9	*(a)*		Force on charge carriers/electrons in mag field [1] [Force right] so left face becomes +ve [1] Electric field/voltage linked to charge movement [1] Electric force balances magnetic force / $V_H \propto B$ also constant I [1]	4			4		
	(b)		Correct application/substitution into equation $I = nAve$ [1] Answer = 0.204 [m s^{-1}] [1]		2		2	2	
	(c)		$eE = Bev$ used **or** equivalent e.g. $V = Bvd$ **or** $V = \frac{BI}{nte}$ [1] Correct comparison to get k e.g. $k = vd$ **or** $\frac{I}{nte}$ etc. [1] Correct answer = 6.13×10^{-4} V T^{-1} **or** m^2 s^{-1} **or** A m^2 C^{-1} **unit mark, ecf** on v [1]		3		3	3	
			Question 9 total	**4**	**5**	**0**	**9**	**5**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
10	*(a)*		Flux linkage, $N\Phi = NBA\cos\theta$ [1] All values substituted correctly e.g. $270 \times 0.042 \times 0.114\cos 5°$ [1]	2			2	1	
	(b)		Change in flux is zero **or** flux is constant Accept no lines being cut		1		1		
	(c)		$\frac{0.22}{5.8}$ or similar seen [1] Correct answer = 37.9 [V] [1]		2		2	1	
			Question 10 total	**2**	**3**	**0**	**5**	**2**	**0**

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SECTION B

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
11	*(a)*		$X_L = X_C$ or impedance cancel or $V_L = V_C$ [1] $\omega L = \frac{1}{\omega C}$ [1] $\omega = 2\pi f$ and reasonable algebra [1]	3			3	1	
	(b)	(i)	$I = \frac{V}{R} = \frac{15}{28} = 0.536$ [A]		1		1	1	
		(ii)	Resonance frequency = 11.35 k[Hz] calculated or implied [1] X_L or X_C calculated e.g. 3 440 [Ω] or 851 [Ω] [1] Total impedance calculated or implied [Z = 2 589 Ω] [1] $I = \frac{V}{Z}$ giving answer = 5.8 m[A] [1]		4		4	4	
		(iii)	$Q = \frac{\omega L}{R}$ or similar used [1] Answer = 61.4 [1]	1	1		2	1	
		(iv)	Shape correct [1] Asymptotes correct [1] I at $2f$ much smaller than I at f [1]	1 1	1		3		
		(v)	Same shape & resonant frequency [1] Peak is half height (by eye or labelled) [1]		2		2		
	(c)		Statement that X_L increases with frequency or vice versa [1] ωL obtained at 82.5 Hz giving 27.99 Ω or 28 Ω [1] Z obtained as 39.6 Ω or realising $\frac{V_0}{\sqrt{2}}$ or equivalent [1] V_{out} confirmed as 4.25 V [1] Correct conclusion stated [1]			5	5	3	
			Question 11 total	**6**	**9**	**5**	**20**	**10**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
12	*(a)*	(i)	Two graphs with skewed normal distributions one always above the other labelled background or continuous [spectra] (1) Line spectra shown on both graphs in the same place and labelled (1) Minimum wavelengths labelled and not at (0,0) and not meeting at the x-axis (1) Higher curve labelled higher voltage (1)	4			4		
		(ii)	$v = \sqrt{\frac{2eV}{m}}$ (1) v = 8.38 [or 8.4] $\times$ 10^7 [m s^{-1}] (1)		2		2	2	
		(iii)	$\lambda = \frac{hc}{eV}$ (1) λ = 6.22 $\times$ 10^{-11} [m] (1)		2		2	2	
	(b)	(i)	A-scans / amplitude scans (1) Only needed to measure depth / moving images not needed (1)			2	2		
		(ii)	Speed in fat / c = 1 450 [m s^{-1}] (1) Distance travelled = 1 450 $\times$ 0.04 $\times$ 10^{-3} = 0.058 [m] or 5.8 [cm] (1) Thickness of fat = $\frac{0.058}{2}$ = 0.029 [m] or 2.9 [cm] or 0.03 [m] **ecf** (1)		3		3	2	

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)	Short half-life [hence small dose] (1) Gamma emitter & less ionising/more penetrating (1)	2			2		
		(ii)	Activity will not change [in a short time] / half-life too long for activity to change / uniform mixing in blood (1) [Dilution factor] = $\frac{160}{0.025}$ or 6 400 (1) [Volume = 6 400 $\times$ 0.8] = 5 120 cm^3] (1)		1 1	1	3	2	
	(d)		They need to precess so $f = \frac{42.6\times10^6\times1.5}{6.39\times10^7}$ [=6.39 $\times$ 10^7 Hz] (1) Wavelength = $\frac{3\times10^8}{6.39\times10^7}$ = 4.7 [m], so [Dr Francis] correct (1) Accept incorrect as 4.7 [m] is not equal to 5.0 [m] **Alternative:** Two frequencies compared with a correct conclusion			2	2	2	
			Question 12 total	**6**	**9**	**5**	**20**	**10**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
13	*(a)*		Anticlockwise moments = $T\sin 18° \times 0.14$ (1) Clockwise moments = $(39 \times 0.35) + (19.6 \times 0.8)$ (1) T = 678 [N] (1)	1	1 1		3	2	
	(b)	(i)	Angular acceleration is rate of change of angular velocity	1			1		
		(ii)	$\omega = 2\pi f = 2\pi \times 2.3$ (1) Angular acceleration = 53 [rad s^{-2}] (1)		2		2	1	
		(iii)	Use of torque $\tau = I\alpha$ (1) Moment of inertia = 0.0121 [kg m^2] (1) τ = 0.648 [N m] (1)	1	1 1		3	2	
	(c)	(i)	Using 24 sin 38° (1) Height = $\frac{u^2}{2g}$ sub into equation (1) Height = 11.1 [m] (1) Maximum height = 12.3 [m] [1]	1 1	1 1		4	2	
		(ii)	Using Bernoulli equation $p = p_o - \frac{1}{2}\rho v^2$ (1) Determining difference in pressure = $\frac{1}{2}\rho(v_1^2 - v_2^2)$ (1) Difference in pressure = 28 [Pa] (1) Force = pA = 1.1 [N] [or weight equivalent pressure = 516 Pa] (1) Horizontal distance will remain approximately unchanged because weight is far greater (1) (accept increase slightly and allow **ecf**)			5	5	2	

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iii)	$\frac{1}{2}\rho A v^2 C_D$ stated or $F_D \propto v^2$ (1) Factor increase = 2.25 (1)	1	1		2	1	
			Question 13 total	**6**	**9**	**5**	**20**	**10**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
14	*(a)*	(i)	An energy resource that can be replenished in a relatively short space of time e.g. human life time or equivalent **OR** An energy resource that can be used for a long period of time (1)	1			1		
		(ii)	Mass of LHS 4×1.00728u + 2×0.00055u = 4.03022 Δm=4.03022 - 4.00151= 0.02871 [u] (1) $\frac{0.02871}{4.03022} \times 100$ = [0.71 %] (1)		2		2	2	
		(iii)	Use of $E = mc^2$ i.e. $2 \times 10^{30} \times \frac{0.7}{100} \times (3 \times 10^8)^2 = 1.26 \times 10^{45}$ [J] (1) $t = \frac{E}{P} = \frac{1.26 \times 10^{45}}{3.8 \times 10^{26}}$ = 3.3 $\times$ 10^{18} [s] = 1 $\times$ 10^{11} [years] (1)		2		2	2	
	(b)	(i)	θ used as 10° (1) Manipulation $\rightarrow A = \frac{P}{\mu I \cos\theta} = \frac{150}{0.2 \times 600 \times \cos 10^\circ}$ = 1.27 [m^2] (1)		2		2	2	

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(ii)	**Award (1) mark for calculation and (1) mark for 'suitable' supporting comment** $\frac{3.6\times10^4}{1.27}$ = 28 000 cells ∴ roof has large enough area for recommended no. of cells **OR** $\frac{4\times10^6}{150} = 27000$ cells ∴ power output would be large enough with recommended no. of cells **OR** $\frac{4\times10^6}{27\,500} = 145$ W ∴ power output of each cell (150 W) would be large enough with recommended no. of cells. N.B. Accept alternative suitable calculations **Award (1) mark for 'unsuitable' comment referencing power output affected by other factors** e.g. variable cloud cover / daily change in sun's position / seasonal change in sun's position / etc			3	3	1	
	(c)	(i)	Increase concentration of U-235 (relative to U-238) (1) U-235 is fissile whereas U-238 is not [and absorbs neutrons] (1)	2			2		
		(ii)	$\sqrt{\frac{352}{349}}$ = 1.004 (1) 0.7 %] × 1.004^n = 5 [%] (1) Taking logs to find n to be 492 or 459 if $\sqrt{\frac{352}{349}}$ used (1) [If $0.7\% + 1.004^n = 5\%$ used to give an answer of 365 or 340 award 2 marks out of 3]		3		3	3	
		(iii)	[Gas] centrifuge Accept alternative e.g. Laser isotope/liquid thermal diffusion	1			1		

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(d)	(i)	Allows only positive H ions through it to the cathode meaning negative electrons must travel along external circuit producing power (1) Waste product: Water (1)	2			2		
		(ii)	Electrolysis of water argument dependent on how electrical energy is produced e.g. gas fired power contributes to CO_2 emissions whereas PV cells do not (1) Reforming fossil fuels releases carbon which could in turn be released into atmosphere as CO_2 or comment regarding carbon capture (1)			2	2		
			Question 14 total	**6**	**9**	**5**	**20**	**10**	**0**

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SUMMARY OF ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	7	2	0	9	3	0
2	4	5	0	9	2	0
3	10	0	0	10	0	0
4	1	5	4	10	5	0
5	0	9	2	11	7	0
6	0	1	7	8	0	0
7	2	7	12	21	15	21
8	0	8	0	8	2	0
9	4	5	0	9	5	0
10	2	3	0	5	2	0
11	6	9	5	20	10	0
12	6	9	5	20	10	0
13	6	9	5	20	10	0
14	6	9	5	20	10	0
TOTAL	**30**	**45**	**25**	**100**	**51**	**21**

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