GCE A LEVEL MARKING SCHEME

SUMMER 2017

A LEVEL (NEW)
PHYSICS - UNIT 4
1420U40-1

INTRODUCTION

This marking scheme was used by WJEC for the 2017 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.

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)	Capacitor equation rearranged $\frac{Cd}{\varepsilon_0} = A$ (1) Area = x^2 used (1) Correct answer = 42.5 [cm] (1)	1	1 1		3	3	
		(ii)	Logical method employed e.g. eliminating 1, 2 etc.(can be implied by correct calculation for 4) (1) Evidence of a correct capacitor in series calculation (1) Evidence of a correct capacitor in parallel calculation (1) Number 4 chosen (1)			4	4	2	
		(iii)	Dielectric / increase the permittivity Accept a named dielectric	1			1		
		(iv)	Valid method e.g. $\frac{q^2}{2C} = U$ or 2 other valid equations (1) Accept use of 3 equations Rearrangement or algebra (1) Answer = 9.96×10^{-8} [C] (accept 1×10^{-7} C) (1)	1	1 1		3	3	
	(b)	(i)	RC used as the time constant (1) Answer = 1.94 M[Ω] (1)	1	1		2	2	
		(ii)	2 time constants interpreted or substitution into: $q = q_0e^{-t/CR}$ (1) 0.37^2 or rearrangement of equation **ecf** (1) Answer = 0.135 or 13.5% or $\frac{27}{200}$ (1)		3		3	3	
	(c)	(i)	Correct shape (starting from 0,0 increasing with decreasing gradient (1) 50-75% charged at 15.5 ms or 8-15 ms half-life (1)	1	1		2	2	2
		(ii)	Correct shape (starting from I_0, 0 decreasing and decreasing negative gradient) (1) 50-75% discharged at 15.5 ms or 8-15 ms half-life (1)	1	1		2	2	2
			Question 1 total	**6**	**10**	**4**	**20**	**17**	**4**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*		Arrow at C going left (1) Arrow at C going up (1)	2			2		
	(b)		Use of the equation $\frac{kq}{r^2}$ (1) 52 500 000 **or** 39 400 000 correct (1) Applying Pythagoras $(52.5M^2 + 39.4M^2)^{0.5}$ (1) Method for obtaining angle correct e.g. $\tan^{-1}\left(\frac{525}{394}\right)$ (1) Correct answers 65.6 MV m^{-1} **unit mark** and 53 or 37[^{o}] or 0.93 or 0.64 [rad] (1)	1	1 1 1 1		5	5	
	(c)		Use of the equation $\frac{kq}{r}$ (1) $\frac{28}{8}$ - $\frac{21}{6}$ or equivalent seen to be zero (1)	1	1		2	2	
	(d)		Conservation of energy applied e.g. $eV = ½\ mv^2$ or E_k calculated to be 1.34×10^{-15} [J] (1) 8 300 [V] (1) Negative sign (1) i.e. 8 300 [V] gets 2 marks, (-8 300 [V] 3 marks)		3		3	2	
			Question 2 total	**4**	**8**	**0**	**12**	**9**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*	(i)	Use of the equation $\frac{M_2 d}{(M_1 + M_2)} = x$ even if wrong M_2 (1) $\frac{9.2 \times 10^{24} \times 5.3 \times 10^{10}}{(9.5 \times 10^{29} + \{9.2 \times 10^{24}\})}$ seen (1) ({ $+9.2 \times 10^{24}$ } can be omitted from the above equation) **or** 513 263 [m] seen etc.	1 1			2	2	
		(ii)	$v = \frac{2\pi r}{T}$ applied or $v = \omega r$ and $\omega = \frac{2\pi}{T}$ combined (1) Conversion of 130 days ($130 \times 24 \times 3\,600$) (1) Answer = 0.287 [m s^{-1}] (**ecf** on day conversion) (1)	1	1 1		3	3	
		(iii)	Redshift is small **or** the redshift is proportional to velocity **or** small $\Delta\lambda$ **or** shown using the Doppler equation (1) Small wavelength change is difficult to measure **or** shifted wavelength is too close to the original (1)		2		2		
	(b)	(i)	$F = \frac{GMm}{r^2}$ used (1) Answer = 2.08×10^{23} [N] (1)	1	1		2	2	
		(ii)	Method for obtaining stress i.e. $\frac{F}{A}$ (1) 1.35×10^9 [Pa] (1) Correct conclusion e.g. the steel bar would break **ecf** (1) Theory doesn't work / Newton's grav law used successfully for centuries / won't work for elliptical orbits / would melt (1) **Alternative:** Use of $F = \sigma A$ (1) $F = 6.9 \times 10^{22}$ [N] (1)			4	4	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)	$\mathrm{PE} = -\frac{GMm}{r}$ used N.B. **ecf** if PE = Fr used (1) Answer = [-]1.10 $\times$ 10^{34} [J] (1)	1	1		2	2	
		(ii)	Realising KE is involved (1) Correct variation with distance for KE or velocity **or** as PE increases KE decreases or converse (1)			2	2		
			Question 3 total	**5**	**6**	**6**	**17**	**11**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*	(i)	Force is upward <u>on the magnet</u> (1) [F]LHR quoted **and** application of N3 (1) Force is down on the wire (1)	1	1 1		3		3
		(ii)	Mean calculated = 0.0236 or 0.02355 (1) accept 2.4×10^{-2} Absolute uncertainty calculated or implied (± 0.0012) (1) % uncertainty = 5% (1) accept 1 or 2 sig figs accept range 4 – 5.1%		3		3	3	3
		(iii)	Gradient = Bl used or implied (1) B = 0.295 [T] (no sig fig penalty) (1) Adding % uncertainties **ecf from (a)(ii)** (11%) (no sig fig penalty) (1) accept first principles approach (0.295 ± 0.032)T or (0.30 ± 0.03) **ecf** must have consistency of sig figs either 1 or 2 sig figs in uncertainty + **UNIT** or equivalent in mT (1)		4		4	4	4
	(b)	(i)	Force on charge carriers due to mag field or [F]LHR (1) Charge carriers go to one side of conductor / reference to build-up of charge (1) Electric field set up or top is +ve / -ve depending on carriers (1)	3			3		3
		(ii)	**Indicative content:** 1. Line goes through origin. 2. Graph is a straight line. 3. Line passes through all the error bars. 4. Both values of B compared. 5. Hall probe is more precise or its uncertainty is smaller [accept accurate]. 6. Sensible comment comparing methods e.g. method A is graphical, method B required only one measurement or converse, method A is more prone to human error, method B doesn't confirm $F = BIl$			6	6	3	6

Question			Marking details		Marks available				
				AO1	AO2	AO3	Total	Maths	Prac
			5-6 marks 5 or 6 points clearly described *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** 3 or 4 points clearly described *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** 1 or 2 points clearly described *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	**4**	**9**	**6**	**19**	**10**	**19**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*	(i)	Change in flux linkage or cutting flux (1) Complete circuit or implied (1)	2			2		
		(ii)	These are in the plane of motion/the vertical component is perpendicular to motion/these are not cut		1		1		
	(b)		Use of $\frac{BAN}{t}$ or $V = Blv$ (1) Use of $I = \frac{V}{R}$ (1) Answer = 62 μ[T] (1)	1 1	 1		 3	 3	
	(c)		Current down in resistor [or up in conductor or anticlockwise] (1) [F]RHR or [F]LHR (for electrons) or RH grip rule (1)	 1	1		 2		
	(d)		Other force compared e.g. friction/drag (1) Magnetic force small / resistive force is much bigger (1) Because current small / B small (1) Good calculation e.g. $P = I^2R = 8.8 \times 10^{-7}$ [W] **or** $F = BIL = 1.6 \times 10^{-8}$ [N] **ecf** on B **or** calculated values of B using I (1)			4	4	1	
			Question 5 total	**5**	**3**	**4**	**12**	**4**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*	(i)	Reference to Faraday's law e.g. the emf is the rate of change/cutting of flux/flux linkage (1) The rate of change/cutting of flux (linkage) is proportional to the (angular) velocity (1)	1	1		2		
		(ii)	Agreement since straight line (through origin) or E proportional to A (1) Bad agreement at end (non-linear) (1) Drops off due to non-uniform field or equivalent (1)			3	3	1	
	(b)	(i)	Impedance of the inductor is zero/minimum when f = 0 (1) Short justification e.g. only resistance **or** $Z = R$ **or** hence $Z = \sqrt{X^2 + 82^2}$ is a minimum (1)		2		2	1	
		(ii)	$Z = \sqrt{82^2 + 82^2} = 116$ (1) $I = \frac{V}{Z}$ (1) Answer I = 0.103 [A] (1)	1	1 1		3	3	
	(c)	(i)	Phasors of capacitor and inductor are opposite direction **or** capacitor pd in antiphase cf inductor (1) Cancel when $X_C = X_L$ or equivalent ($V_C = V_L$) (1) Gives minimum impedance / maximum current (1)	3			3		
		(ii)	Understanding impedance = resistance (1) $P = \frac{V^2}{R}$ = 1.76 [W] (1)		2		2	1	
		(iii)	Substitution into $Z = \sqrt{(X_L - X_C)^2 + R^2}$= 244 [Ω] (1) Use of $I = \frac{V}{Z}$ (1) Answer = 49 m[A] (1)	1	1 1		3	3	
		(iv)	Calculation of Q factor (and realisation that this is germane) Q = 1.9 (1) Correct evaluation – not a particularly high Q factor or equivalent (can be obtained without Q factor but needs justification e.g. not sharp because resistance a little high (1)			2	2	1	
			Question 6 total	**6**	**9**	**5**	**20**	**10**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*	(i)	Collisions / deceleration at metal target	1			1		
		(ii)	$\frac{100 \times 10^{-3}}{1.6 \times 10^{-19}}$ (1) 6.25×10^{17} with no units (1)		2		2	2	
		(iii)	Use of $v^2 = u^2 + 2ax$ and $u = 0$ (1) $\frac{(1.5 \times 10^{8})^2}{2 \times 0.03}$ (1) 3.75×10^{17} [$m\,s^{-2}$] (1)		3		3	3	
		(iv)	Greater current (gives more intensity) / more X-rays / photons Ignore reference to power and distance (1) Greater pd (gives larger photon energies) (1)	1	1		2		
	(b)		Disadvantage high exposure to radiation / expensive / longer exposure time (1) Advantage 3D images / show range of tissue types (1) **don't accept** more detailed image	2			2		
	(c)		1.76×10^6 (1) 1.20×10^6 (1) ignore s.f. and units yes there will be a large reflection / will reflect / 0.036 or 3.6% (1) Acoustic impedance (significantly) different (1)			4	4	2	
	(d)	(i)	Cause hydrogen nuclei / protons (1) To flip / precess / change orientation / parallel to antiparallel (1) **don't accept** nuclei moving up energy levels	2			2		
		(ii)	$\frac{64}{x} = \frac{1.5}{1.2}$ (1) x = 51.2 MHz **with units** (1)		2		2	2	
	(e)	(i)	$55 \times 10^{-3} \times 20$ = 1.1 Sv answer **with units**		1		1	1	
		(ii)	Less than as (a lot) less ionising / interaction with matter /less biological effectiveness – **don't accept** beta is smaller or mass is less			1	1		
			Question 7 total	**6**	**9**	**5**	**20**	**10**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*			Conversion of kg to newtons (1) Application of upward forces = downward forces (1) Force = 62.2 [N] (1)	1	 1 1		 3	 1	
	(b)	(i)		Calculating components of velocity (11.6 hor, 13.8 vert) Calculating time of flight (2.81 s) or **alternative** e.g. $R = \frac{v^2 \sin 2\theta}{g}$ (2 marks) Horizontal range = 32.5 [m] **ecf** on time of flight (1) No, kick would **not** be successful – conclusion (1)			 4	 4	 3	
		(ii)	I.	The (sum of) the products of mass times distance squared (1) from axis (of rotation of the ball) (1)	 2			 2		
			II.	Substitution into $J = I\omega$ (1) Angular momentum = 0.23 [kg m^2 s^{-1}](1)	1	 1		 2	 1	
			III.	Substitution into KE = $\frac{1}{2}I\omega^2$ (1) Rotational KE = 6.3 J [**ecf** on ω](1) Realising speed at greatest height = 18 cos 50^o (1) Total KE = 36(.4) [J] (1)	1	 1 1 1		 4	 4	
	(c)	(i)		$\frac{1}{2}\rho A v^2 C_D$ used (1) Stating $\rho v^2 C_D$ remain constant (can be implied) (1) Drag force [increased] - factor of 5.04 for end over end (1) Or drag force factor 5.04 [less] for spin type kick	1	 1 1		 3	 1	
		(ii)		The values of C_D, speed and A stay the same for different altitude (1) Factor would not change (1)		1	 1	 2		
				Question 8 total	**6**	**9**	**5**	**20**	**10**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	*(a)*	(i)		Use of intensity = $\frac{P}{4\pi R^2}$ or correct substitution (1) Intensity = 1 415 [W m^{-2}] (1)	1	1		2	2	
		(ii)		[Using 1 400 W m^{-2}]: 20% = 280 W m^{-2} 15% = 42 W m^{-2} (1) **for both** efficiency calculations Area = $\frac{8 \times 10^9}{42}$ (**ecf**) = 1.9×10^8 m^2 (1) **(unit)** Accept 190 km^2 or equivalent		2		2	2	
		(iii)		Greater intensity of radiation in Portugal (accept increased/longer sunshine hours throughout year) Do not accept more efficient			1	1		
	(b)	(i)		$\lambda_{max} T$ = constant	1			1		
		(ii)		$\lambda_{max} = \frac{0.0029}{290}$ (1) λ_{max} = 10×10^{-6} [m] so in IR (1)		2		2	2	
		(iii)	I	Surface emits IR in region 5 μm to 20 μm (1) [Partially] absorbed by water vapour (and CO_2) (1) Correct reference to numerical data from graphs e.g. either water: greatest absorption between 5 μm to 8 μm **or** 12 μm to 20 μm) **or** CO_2: (greatest absorption between 10 μm to 20 μm) (1) [IR] re-emitted in all directions (1)	1 1		1 1	4		
			II	Higher temperatures will lead to increased water vapour in atmosphere (1) Leading to further absorption and increase in temperature (1) **Alternative:** As the ice cap melts leaving darker surface (1) which absorbs more visible radiation and increase in temperature (1) **OR** Melting permafrost (1) means more methane in atmosphere (1)			2	2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)		U value = Energy per second / (area × temperature difference) / rate of heat transfer per unit area per unit temperature difference / $U = \frac{P}{A\Delta\theta}$ with symbols correctly identified (1) Thickness of material **or** conductivity of material (1)	2			2		
		(ii)		Energy per second lost = $1.8 \times (5 \times 3) \times (21 - 9)$ (1) for substitution Energy per second = 324 [W] (1)		2		2	2	
		(iii)		$1\,000 = 1.8 \times 15 \times (21 - T)$ (1) T = -16 [°C] (1)		2		2	2	
				Question 9 total	**6**	**9**	**5**	**20**	**10**	**0**

A2 UNIT 4 – Fields and Options

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	6	10	4	20	17	4
2	4	8	0	12	9	0
3	5	6	6	17	11	0
4	4	9	6	19	10	19
5	5	3	4	12	4	0
6	6	9	5	20	10	0
7	6	9	5	20	10	0
8	6	9	5	20	10	0
9	6	9	5	20	10	0
TOTAL	**30**	**45**	**25**	**100**	**61**	**23**