wjec cbac

GCE A LEVEL MARKING SCHEME

SUMMER 2018

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

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 4 – Fields 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.

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 $d = \frac{\varepsilon_0 A}{C}$ (1) Substitution of values (1) Correct answer 1.43×10^{-4} m (0.143 mm) (1) [Accept 1.4×10^{-4} m, not 1×10^{-4}]	1	1 1		3	3	
		(ii)	Adding capacitors in parallel (4 nF) (1) Understanding of 6 nF in series with 4 nF i.e. correct application of physics (1) [even failure to invert to get answer, so 1/4 + 1/6 $\rightarrow$ 2 marks] Correct answer 2.4 n[F] or 12/5 n[F] (1) c.a.o.	1	1 1		3	2	
		(iii)	Any valid *CV* e.g. 2×9, 6×6, 2.4×15 (1) [Accept 2.4×15 or ½ $\times 2.4 \times 15$; **not** 1.2×15 or 2.4×7.5] ½-way explanation: charge split / divided between 2 nFs / 9 V across 2 nF / 6 V across 6 nF (1) Completed explanation: all charge on capacitors in series / justify 9 V or 6V [e.g. $V \propto 1/C$]	1	1 1		3	2	
		(iv)	Correct substitution (into valid equation) e.g.0.5 QV etc. (1) Correct answer (270 nJ or 2.7×10^{-7}J) (1)	1	1		2	2	
	(b)	(i)	Capacitor in series with resistor and cell/battery/psu (1) Properly placed ammeter and voltmeter (1)	2			2		2

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
		(ii)	Emf = 12 V stated [accept V_{max}] (1) Initial current = 2.7 mA (1) $R = \frac{V}{I}$ = 4 444 Ω (1) [4.4 kΩ] [N.B. With incompatible *V* and *I*, 2nd and 3rd marks not accessible] RC ~ 8 s from 37% I_{max} value or 63% V_{max} value or intercept of gradient at the origin with I = 0 (or V = 12 V) **OR** taking logs and rearranging **OR** obtaining Q from total area under current graph around 2.0 × 10^{-2} C (1) $C = \frac{8.0}{4400}$ = 1.8 [± 0.3] mF (1) [No ecf] **Unit** penalty (–1): all 3 units [V, Ω, F] needed **Alternative** Emf = 12 V (1) Find $\frac{dV}{dt}$ **and** I at given t, e.g. at 10 s, 0.411 V s^{-1}, 7.5 mA (1) Hence calculate *C* from $I = C\frac{dV}{dt}$ → 1.8 mF ecf (1) RC ~ 8 s from 37% I_{max} value or 63% V_{max} value or intercept of gradient at *t* = 0 with I = 0 (or V = 12 V) (1) *R* from *C* and *RC* → 4.4 kΩ (1) **Unit** penalty (–1): all 3 units [V, Ω, F] needed		5		5	5	5
			Question 1 total	**6**	**12**	**0**	**18**	**14**	**7**

Question			Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
2	*(a)*	(i)	Kinetic energy and [gravitational] potential energy referred to (1) $\frac{1}{2}mv^2 - \frac{GMm}{r}$ = total [initial] energy **or** ΔKE = [–]ΔPE (1) Final and initial energy are zero and equal [accept final KE = 0 or final PE = 0] (1)	3			3		
		(ii)	Rearrangement / simplification i.e. $v^2 = \frac{2GM}{r}$ (1) [accept *m* = 1 inserted] Substitution e.g. $v^2 = \frac{2 \times 6.67 \times 10^{-11} \times 1.99 \times 10^{30}}{6.96 \times 10^{8}}$ (1) Answer = 618 [or 620] km s^{-1} (1) c.a.o. [accept ~600 km s^{-1} b.o.d.]	1	1 1		3	3	
	(b)	(i)	Applying KE of molecule/atom/particle = $\frac{3}{2}kT$ (or deriving) (1) Rearrangement e.g. accept $v^2 = \frac{3kT}{m}$ (1) Substitution e.g. $v^2 = \frac{3 \times 1.38 \times 10^{-23} \times 5780}{9.11 \times 10^{-31}}$ (1) Answer = 513 km/s (1) [accept just ~500 km s^{-1} only with correct substitution]	1	1 1 1		4	3	
		(ii)	Many electrons have enough KE to escape **(ecf)** or just 'some electrons escape' (1) Because (b)(i) close to (a)(ii) / some electrons have higher velocity / [Boltzmann] distribution / collisions] **(ecf)** (1) Or protons don't escape		2		2		
		(iii)	Valid method employed e.g. electrostatic force & gravitational forces calculated/equated or other (1) Valid calculation carried out correctly e.g. F_E = 2.4 × 10^{-28} N **and** F_g =2.5 × 10^{-28} N or charge = 0.084 C (1) [Or using *GMm* = *kQq* → 1.2 × 10^{-10} [N m^2] and 1.15 × 10^{-10} [N m^2]] Valid conclusion (not independent) e.g. she's quite close (1) **ecf** from calculation of forces [not fields] or alternative above. [Accept: *E* force bigger / *G* force smaller]			3	3	2	

		(iv)	Sun electrons ≈ $\frac{1.99\times10^{30}}{1.66\times10^{-27}}$ ≈ 1.2×10^{57} (assumption dependent, allow Sun composed of deuterium) (1) [Accept M_S / 1 u] $\frac{0.08}{e}$ = 5×10^{17} electrons lost **or** charge on Sun's electrons = 1.92×10^{38} [C] (1) % lost ≈ 10^{-38} (1)		3		3	3	
			Question 2 total	**5**	**10**	**3**	**18**	**11**	**0**

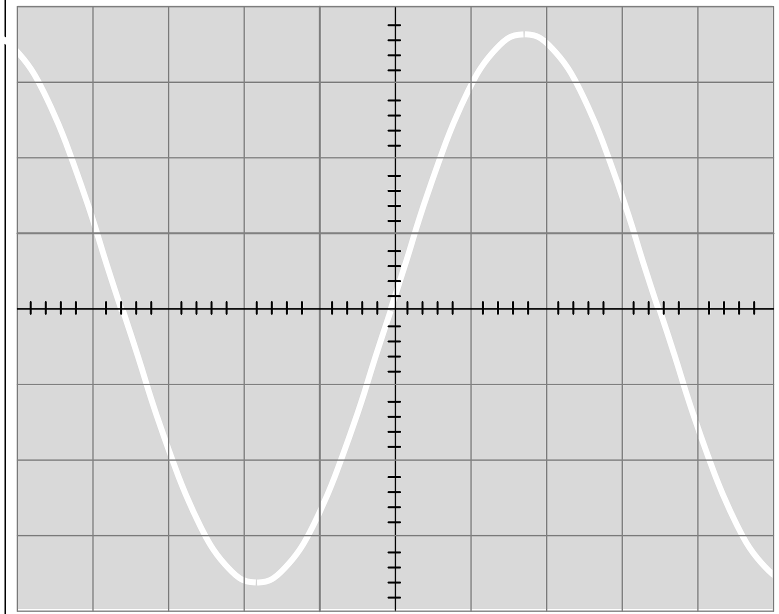
Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*		<u>Constant</u> velocity (1) Substitution of $D = vT$ into Hubble's law and convincing algebra (1)	2			2	1	
	(b)		Substitution of H_0 & 3.09×10^{22} m into Hubble's law (gives 68 000 m/s) (1) Substitution [of at least c and λ] into Doppler equation (1) $\Delta\lambda = \frac{68\,000 \times 486.1 [\times 10^{-9}]}{3 \times 10^{8}}$ seen (1) or 0.11 nm	1 1	1		3	3	
	(c)		Correct method for obtaining velocities e.g. $\frac{c\Delta\lambda}{\lambda}$ (1) Blue shift speed is [-]2v (-136 000) (1) and redshift speed is 6v (407 000 / 408 000) (1) Recessional speed = 2v (136 000) (1) Rotational speed = 4v (272 000) (1) NB Final mark awarded only if recessional speed and rotational speed clearly indentified.		5		5	5	
	(d)		**Collation points** C1 Doppler/red/blue shift measured C2 of [known] lines / wavelengths C3 velocity calculated / measured / linked to $\Delta\lambda$ / $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ C4 for various distances from centre of galaxy [can be credited from good graph] C5 absorption spectrum used C6 mention of [large] telescope / analysis of light / em radiation observed C7 mention of spectrometer / prism / grating / spectral analysis **Theory points** T1 Doppler shift explained e.g. redshift, moving away T2 Doppler equation quoted or shift dependency on velocity mentioned T3 Orbital speed increases with mass / $v = \sqrt{\frac{GM}{r}}$ T4 Orbital speed decreases with radius (theoretically) OR graph	6			6		

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
			Marks available						
			or equation T5 Theoretical speed based on visible/baryonic mass OR graph **Results & Conclusion points** R1 Speed does not decrease with radius / actual speed too large OR graph R2 Hence extra mass R3 Dark matter linked to extra mass R4 Possible link to Higgs boson / WIMPS / CMBR						

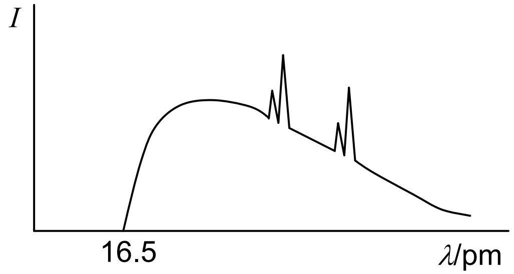
Question			Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
			5 - 6 marks Expect 8-16 points There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. **3 - 4 marks** Expect 5-7 points There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure. **1 - 2 marks** Expect 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 3 total	**10**	**6**	**0**	**16**	**9**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*		Valid method for obtaining gradient (implied if correct) (1) Max = ~0.021 or min = ~0.017 (1) [OK to give 21.0 & 17.5 mT A^{-1}] Mean correct (~0.019) (1) Uncertainty = 8.5 % – 11% (1) [no s.f. penalty]		4		4	4	4
	(b)		Gradient = $\mu_0 n$ used or implied (n =15 200) (1) N = 3 780 (1) N = 3 800 ± 400 (1) [allow 1 or 2 s.f. in uncertainty 1 more s.f. in *N*]			3	3	3	3
	(c)	(i)	5 000 is outside uncertainty range [or equiv.] (1) Straight line (1) Through all error bars (1) Lines straddle the origin (1) [allow ….through origin]			4	4		4
		(ii)	Flux density least accurate/probe not in centre [end effect] /not aligned [90° to axis](1) Get better Hall probe with higher [smaller / better] resolution / put in centre/align properly (1) [not: repeat readings / better apparatus]			2	2		2
			Question 4 total	**0**	**4**	**9**	**13**	**7**	**13**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*	(i)	Use of BA = flux or Faraday's law $\Delta(BA)/t$ (1) [or by impl.] $\frac{2.1\times(610-120)\times10^{-4}}{0.016}$ seen (or similar) (1)	1	1		2	2	2
		(ii)	Anticlockwise (accept words if not in diagram) (1) FRHR or Right hand screw rule or FLHR on electrons (1) **Alternative (for explanation)** Lenz's law: [direction of induced flux must oppose so out of paper.]	1	1		2		2
	(b)		Resistance = $\frac{\rho l}{\pi r^2}$ quoted or used (0.0034 Ω) (1) Use of $I = \frac{V}{R}$ (1) $\frac{6.4\times\pi\times0.0015^2}{2.65\times10^{-8}\times0.91}$ [=1880 A] or equivalent seen (1)	1	1 1		3	3	3
	(c)		$V=\pi r^2 l$ used [= 6.43 × 10^{-6} m^3] (1) Mass = density × volume used [=0.0174 kg] (1) Energy = IVt used (or equivalent 195 J) (1) Energy = $mc\Delta T$ used (1) Answer = 12.5 K so Iestyn wrong(1)			5	5	5	5
	(d)		Any 2 × (1) from • Consent of patient discussed [e.g. volunteers] (1) • possible injury to patient discussed [e.g. long-term effects] (1) • Appropriateness of experiment carried out on model / dead body / animal instead discussed (1) Conclusion Argument is logical and leads to a conclusion (even if a mixed conclusion) (1)			3	3		
			Question 5 total	**3**	**4**	**8**	**15**	**10**	**12**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*	(i)	Rms pd is required or $V_{\text{rms}} = \frac{V}{\sqrt{2}}$ (1) Substitution into $P = \frac{V^2}{R}$ or equivalent e.g. calculating I, $P = IV$ (1)	2			2		
		(ii)	$\frac{18}{5}$ =3.6 squares seen or implied (1) $T = \frac{1}{f}$ used (0.0143 or 14.3 ms) (1) Dividing period by 2 ms (7.1 squares) (1) Period correct in diagram **(ecf)** (1) **accept any phase,** Amplitude correct in diagram **(ecf)** (1) **at least one cycle** 	1	1 1 1 1		5	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(b)	(i)	Reactance of inductor equal and opposite to capacitance (or pds equal and opposite) (1) Minimum impedance (or all pd across resistor) (1) Maximum current (1)	3			3		
		(ii)	Algebra leading to $f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$ (1) Answer = 130 kHz (1)		2		2	2	
		(iii)	X_L = 65 000 [Ω] or X_C = 10 500 [Ω] (1) Substitution into $Z = \sqrt{(X_L - X_C)^2 + R^2}$ = 55 000 Ω (1) Use of $I = \frac{V}{Z}$ leading to Answer = 91 μA (**ecf**) (1)		3		3	3	
		(iv)	Smallest capacitor used (or trial and error) (1) Q factor calculated (533) (or other valid method of getting V) (1) Pd across C or L = $Q \times 5$ (2 700 V) (1) Peak pd this is $\times\sqrt{2}$ (3 800 V) (1) Student is wrong, it's considerably larger (valid conclusion) (1)			5	5	3	
			Question 6 total	**6**	**9**	**5**	**20**	**10**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*	(i)	Background spectra as skewed normal curve and line spectra shown (1) Minimum wavelength labelled /shown as 1.65×10^{-11} m (1) e.g. 	1	1		2	1	
		(ii)	Power = 9 000 W (1) Rate of heat = 8 937 W (1)		2		2	2	
		(iii)	Rearrangement $\mu = \dfrac{\ln\left(\dfrac{100}{60}\right)}{4.1\times10^{-3}}$ **OR** 0.6 × 0.6 (1) μ = 365 m^{-1} answer with unit **OR** 0.36 (1) Substitution into $I = I_0\,e^{-\mu x}$ where $x = 2.8 \times 10^{-3}$ so I = 36% (1)		3		3	3	
	(b)	(i)	Ultrasound hits blood cells (1) Reflected pulse different frequency/wavelength (1)	2			2		
		(ii)	Rearrangement $v = \dfrac{\Delta f c}{2 f_0 \cos\theta}$ (1) v = 0.098 [m/s] (1) Answer of 0.18 [m/s] award 1 mark only for the question part		2		2	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)	**Any 3 of 4** Comment regarding half-life e.g. long enough to enable measurement / short so effect soon disappears (1) Gamma emitter so can be detected out of the body (1) Daughter product stable (1) Low ionisation (1)			3	3		
		(ii)	Gamma rays pass through a <u>collimator</u> (1) Cause scintillations / light flashes on a crystal (1) Collected by a series of photomultiplier tubes OR CCD (1)	3			3		
		(iii)	Mass-energy of electron [or positron] should be equal to the photon energy [because 2e $\rightarrow$ 2γ] (1) $E_{\text{electron}} = mc^2 = 8.20 \times 10^{-14}$ J (1) $\therefore E_{\text{ph}} = \frac{8.20\times10^{-14}[\text{J}]}{1.6\times10^{-13}[\text{J MeV}^{-1}]}$ = 0.512 MeV		1	1 1	3	2	
			Question 7 total	**6**	**9**	**5**	**20**	**10**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*		Angular acceleration is rate of (1) Change of angular velocity (1)	2			2		
	(b)	(i)	Torque is rate of change of ang mom used (1) Substitution of data (1) Change in angular momentum = 156.4 kg m^2 s^{-1} (1) Answer = 68 Nm (1)	1 1	1 1		4	3	
		(ii)	Angular Momentum is conserved (1) Adopting tuck position reduces moment of inertia (1) Angular velocity increases (1) Spin completed easier or more spins completed (1)		4		4		
		(iii)	Using $F = \frac{mv - mu}{t}$ (1) F = 1 140 N (1) By N3 gymnast exerts equal & opposite force (1)	1	1 1		3	2	
	(c)	(i)	Centre of gravity directly above [accept: below] rings (1) No (net) moment (1)	1	1		2		
		(ii)	628 = 492 + 136 (1) So no acceleration or no net force (1) Clockwise moment = 492 × 3.1 = 1 525 [N cm] (1) Anticlockwise moment = 136 × 12 = 1 632 [N cm] (1) Will rotate anticlockwise (1)			5	5	5	
			Question 8 total	**6**	**9**	**5**	**20**	**10**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	*(a)*	(i)		Stefan-Boltzman law / Stefan's law (1) Substitution: $P = 4 \times \pi \times (7.0 \times 10^{8})^{2} \times 5.67 \times 10^{-8} \times (5\,800)^{4}$ (1) $P = 3.95 \times 10^{26}$ W seen (1)	1 1	1		3	2	
		(ii)	I	4	1			1		
			II	Positron [accept anti-electron]	1			1		
		(iii)		Production of 1 helium nucleus releases 26. 7 MeV = 4.27×10^{-12} J (1) $\frac{4.0 \times 10^{26}}{4.27 \times 10^{-12}} = 9.4 \times 10^{37}$ s^{-1} produced (1) [or 9.3×10^{37} s^{-1}] [Accept 9.2×10^{37} if 3.95×10^{26} used]		2		2	2	
	(b)			Substitution into $I = \frac{P}{4\pi R^2}$ i.e. $I = \frac{4.0 \times 10^{26}}{4\pi\left(1.5 \times 10^{11}\right)^2}$ (1) I = 1 415 W (approx. 50% of surface intensity) (1) [1397 W using 3.95×10^{26} W]	1	1		2	2	
	(c)	(i)		Application of $P = IV$ to find max P from graph: Max $P = 6.4 \times 20.5 = 128$ W [accept 120 to 135 W] (1) % efficiency = $\frac{128 \times 100}{750}$ (1) % efficiency = 17% [Accept 16% to 18%] (1) [**Alt:** calculate 15% of 750 W and show is less]			3	3	2	
		(ii)		$\frac{1000}{128}$ = 7.8 so 8 panels needed (1) [accept 8 or 9, depending on P output in (i)] [Answer must be whole number] **Mean** power will be less than 750 W (or equivalent) (1) Changing daily/seasonal conditions- need to be specific e.g. less light at night or less light in winter (1)		3		3		

Question				Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
	(d)	(i)		E_k of particles is proportional to Temp (or $E_k = \frac{3}{2}kT$) (1) So particle E_k (or speed, velocity) needs to be high enough to overcome electrostatic (Coulomb) repulsion (1) ...and allow (nuclear) strong force to come into action (1)	1	1 1		3		
		(ii)		$n = \frac{2.2 \times 10^{22}}{75}$ [or $2.9(3) \times 10^{20}$ seen] (1) $2.9 \times 10^{20} \times 120 \times 10^{6} \times 0.8 = 2.8 \times 10^{28}$ Fusion possible (1)			2	2	2	
				Question 9 total	**6**	**9**	**5**	**20**	**10**	**0**

A2 UNIT 4: Fields and Options - SUMMARY OF ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	6	12	0	18	14	7
2	5	10	3	18	13	0
3	10	6	0	16	9	0
4	0	4	9	13	7	13
5	3	4	8	15	10	12
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**	**63**	**32**