GCE A LEVEL MARKING SCHEME

SUMMER 2022

A LEVEL
PHYSICS – UNIT 4
1420U40-1

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.

GCE A LEVEL PHYSICS

UNIT 4 – FIELDS AND OPTIONS

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.

Marking abbreviations

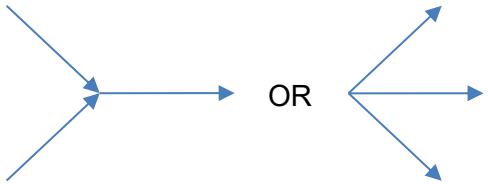
The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

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)	Valid method e.g. $B = \mu_0 nI$ to calculate B **or** I **or** n **or** μ_0 (1) Gives B = 0.0606 [T] **or** I = 7.13 [A] **or** n = 26 972 **or** $\mu_0 = 2.51 \times 10^{-6}$ (1) Correct conclusion based on calculation (with **ecf**) e.g. Lindsay wrong (if B or I calculated), Lindsay wrong because μ_0 too large or real value is 1.26×10^{-6} or Lindsay wrong because n value too large or real value is 13 500 (allow **ecf** on n = 27 000 here) (1) i.e. Calculating B = 0.121 [T] followed by Lindsay correct is 2 marks (1st and 3rd marks)			3	3	1	
		(ii)	Iron / ferromagnetic / steel core Accept increase permeability Don't accept increase permeability of free space	1			1		
	(b)	(i)	Use of $BANcos\theta$ (1) Correct answer = 0.046 Wb **or** Wb turn **or** T m^2 ****unit mark**** (1)	1	1		2	1	
		(ii)	Max when $\theta = 90$ because flux changing / cutting at max rate (accept cutting most lines or similar for max rate) (1) When $\theta = 0$ no emf because flux max or no cutting or rate of change is zero (1) **Alternative for 2nd mark** Min when $\theta = -90, 270$ because flux changing / cutting in opposite direction (1) Allow 1 mark if **both** angles are correct with no explanation Allow 1 mark if angles are wrong but **both** explanations are correct (must refer to flux **changing** or **cutting** but no need to insist on "rate")		2		2		
			Question 1 total	**2**	**3**	**3**	**8**	**2**	**0**

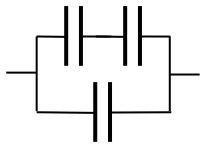
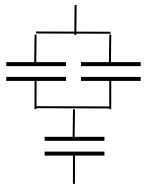
Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	(a)		At least 4 field lines are radial and symmetrical (1) At least 2 equipotentials are circles / spheres (1) Out of positron and into anti-neutron (1)	3			3		
	(b)		**Indicative content:** **Differences** 1. electric fields - charges & grav fields – masses (or force per unit mass, force per unit charge or forces between charges & masses) 2. e-fields – into & out, g-fields only into (direction point – also accept grav forces only attractive, e-forces attractive & repulsive) 3. Gravity is far weaker (on small scale) OR electrical negligible on large scale (i.e. scale point) 4. E potential work done per unit charge & G work done per unit mass 5. E-fields depend on permittivity OR g-fields depend on dark matter **Similarities** 1. Same shape field (for point/spherical masses/charges). Note: this point is **different** from the **same shape graph** which is the next point. 2. inverse square law (applies to both) 3. Both fields lead to (concept of) PE 4. Potential or PE is inversely proportional to distance 5. Both fundamental force laws 6. Both have scalar fields OR both have vector fields (or both!) 7. Anything to do with exchange particles (photon, gluon, bosons) NOTE: some differences can be viewed as similarities and vice versa e.g. energy per unit charge and energy per unit mass could be considered a similarity. Also, the different exchange particles could be considered a difference.	6			6		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			5-6 marks Similarities and differences between electric and gravitational fields covered comprehensively. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Similarities or differences between electric and gravitational fields covered comprehensively or limited description of both. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** Limited description of either the similarities or the differences. *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 2 total	**9**	**0**	**0**	**9**	**0**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	(a)		Vector diagram roughly as shown (1)  Vertical components cancel (1) Accept forces due to +ve charges cancel Field is right OR attractive force towards positives (1) Electron is negative linked to F (or a) left OR repulsive from -ve (1)		4		4	2	
	(b)		Use of $F = \frac{kQq}{r^2}$ **OR** $F = EQ$ **and** $E = \frac{kq}{r^2}$ (1) (expect to see 9.6×10^{-18} [N]) $2E\cos 60 + E$ **or** $2E\sin 30 + E$ **OR** $2F\cos 60 + F$ **or** $2F\sin 30 + F$ (1) (expect to see 1.92×10^{-17} [N] or 120 [N C^{-1}]) Use of $F = ma$ (1) (can be awarded for any valid force ÷ 9.11×10^{-31}) Correct answer = 2.1×10^{13} [m s^{-2}] (no **ecf** for this, must be correct) (1)	1 1	1 1		4	3	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		Substitution into $\mathrm{PE} = \frac{kQq}{r}$ e.g. $\frac{9\times10^{9}\times2.4\times10^{-9}\times1.6\times10^{-19}}{0.6}$ (1) $\frac{9\times10^{9}\times2.4\times10^{-9}\times-1.6\times10^{-19}}{0.6} + \frac{9\times10^{9}\times2.4\times10^{-9}\times-1.6\times10^{-19}}{0.6} + \frac{9\times10^{9}\times2.4\times10^{-9}\times1.6\times10^{-19}}{0.6}$ seen or equivalent or $\frac{9\times10^{9}\times2.4\times10^{-9}\times-1.6\times10^{-19}}{0.6}$ seen with statement that the other 2 potentials cancel (1)	1	1		2	1	
	(d)		Valid method e.g. considering potential energy/potential (1) New PE = $2 \times -5.76 \times 10^{-18} + 2.88 \times 10^{-18} = -8.64 \times 10^{-18}$ [J] **OR** new potential = 54 [V] **OR** PE must be lower because -ve values are the same but the positive is smaller (doesn't need a calculation) **OR** new potential is higher than original because +ve potentials are the same but negative is smaller (36V / 37.5 [V] to 54 [V]) (1) Can travel to lower PE **OR** will gain KE **OR** can travel to higher potential because electron is negative (1) Correct conclusion based on correct physics (yes is sufficient if the explanation is clear) (1) **Alternative based on forces:** Attractive forces (or forces due to +ve charges) are the same/symmetrical for both points OR oscillating with SHM if attractive forces only OR would just reach R with attractive forces only OR force at R is 7.2×10^{-18} [N] (→) (1) Repulsive force / force due to negative charge helps OR repulsive force at end is 2.4×10^{-18} [N] OR force at P is 19.2×10^{-18} [N] (←) (1) Overall of these is to the left (1) Conclusion – yes (1)			4	4	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			Award 3 marks for: Yes it gets there with 16.5 / 18 eV of KE (with no reasoning) Yes it gets there with 2.88 / 2.64 $\times$ 10^{-18} J of KE (with no reasoning) Yes it gets there with a speed of 2.5 $\times$ 10^{6} m s^{-1} (with no reasoning) **Award 2 marks for:** Yes it gets there because the force due to -2.4 nC always repels Yes because acceleration left is greater than acceleration right **Award 1 mark for:** Yes / don't know / No because positive charges provide force to right at the end.						
			Question 3 total	**3**	**7**	**4**	**14**	**8**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	(a)		Substitution into: $C = \frac{\varepsilon_0 A}{d}$ (1) Correct answer = 1.24 n[F] (1)	1	1		2	1	
	(b)	(i)	Combining $0.5QV$ and $Q = CV$ (or using $0.5CV^2$) (1) Correct answer = 20 [V] (1)		2		2	2	
		(ii)	2 capacitors in series all in parallel with another  Allow 1 mark for  Subtract a mark if the symbol for capacitor is wrong			2	2	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)	Either opposite charges **or** attractive force [on plates]		1		1		
		(ii)	Either work done (1) and conservation of energy applied (or implied) (1) **OR** energy = $\frac{1}{2}\frac{Q^2}{C}$ (1) and C decreases (1) **OR** $\frac{Q}{V} = \frac{\varepsilon_0 A}{d}$ so $V \propto d$ (1) $E = \frac{1}{2}QV$ hence correct (1) **OR** energy stored in field (1) field has greater volume (1) **OR** increased the potential energy (1) Due to attractive force (1)		2		2		
		(iii)	2 or 3 valid equations **used** e.g. $\frac{1}{2}\frac{Q^2}{C}$ and $C = \frac{\varepsilon_0 A}{d}$ (1) Convincing working leading to $\frac{1}{2}\frac{Q^2 d}{\varepsilon_0 A}$ (if they quote the 2 equations above then simply writing the equation is acceptable) (1)		2		2	2	
		(iv)	Work = force × distance quoted (1) Hence $F = \frac{1}{2}\frac{Q^2}{\varepsilon_0 A}$ or distance = d and Bethan correct **OR** Bethan wrong at large separations or when d = 0 **OR** good conclusion well argued (1)			2	2	1	
			Question 4 total	**1**	**8**	**4**	**13**	**8**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	(a)	(i)	KE + gravitational PE = 0 & **context explained briefly** (also accept KE = gravitational PE and context) (1) Minimum context = conservation of energy **or** mention of galaxy **or** spherical universe **or** uniform universe **or** cosmological principle **or** explaining why $r = D$ or explaining what the mass of the sphere is (accept whole universe or part and mass inside) Reference to universe nor expanding now loses 1st mark $v = H_0D$ substituted for v (1) mass = density × volume of sphere (1) Algebra set out clearly (1)	4			4	3	
		(ii)	Correct substitution into formula (gives 8.66×10^{-27}) (1) Dividing by 1.66×10^{-27} (or 5.2 or 5.22 seen) OR 5 u = 8.3×10^{-27} (1)	1	1		2	1	
	(b)	(i)	Halfway between or correct substitutions into C of M equation leading to 1×10^{11} or simply 1×10^{11} [m]		1		1		
		(ii)	Substitution into period equation (1) 9.73×10^6 s (allow 1 mark for 13.8×10^6 OR 4.87×10^6 OR 3.44×10^6) (1)	1	1		2	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iii)	Use of $v = \frac{2\pi r}{T}$ ecf **or** equivalent with $v = \omega r$ and $\omega = \frac{2\pi}{T}$ (1) (expect 65 000 m s^{-1}) Use of Doppler equation (1) Correct answer = 0.0934 nm (accept 1sf) (1) Note: ecf on previous values gives 0.187 nm, 0.264 nm and 0.066 nm (for full marks unless another clear mistake seen) Allow 2 marks max if d used instead of r (gives 0.187 nm) Allow 1 mark max if $\frac{1}{2}mv^2 = \frac{GMm}{r}$ (also gives 0.187 nm)	1 1	1		3	3	
	(c)		Centre of mass is nearer more massive star (1) Which will give a larger field OR but must be nearer smaller star for fields to match (1) Accept equivalent reverse argument		2		2	2	
	(d)	(i)	Force [due to both stars] are always equal [and opposite] Accept this is the point where the field is zero Accept masses of equal **mass and distance** either side		1		1		
		(ii)	Force due to black hole is 4×greater or 4.17 × 10^{30} [N] (1) Also force from other star (gives factor 5) or 1.04 × 10^{30} [N] (1)		2		2	1	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iii)	Increasing v increases redshift **OR** linking orbital speed to redshift (can be implied by good answers) (1) Correct realisation that factor is $\sqrt{5}$ or that v^2 proportional to force (this implies the 1st mark) (1) Joseff is wrong (based on some valid physics) (1) e.g. red shift increases with orbital speed but they aren't proportional (force and speed) so Jo is wrong (this gets 2 marks – 1st and 3rd) **Also accept for 2 marks:** Red shift increases with orbital speed and orbital speed is proportional to force, so Jo is right **Also accept calculations:** Expected v = 144 000 m s^{-1} (1) Red shift = 0.21 n[m] (1) Joseff is wrong (1)			3	3	2	
	(e)		[More] experiments involving Higgs [decay] (1) Results [need to be] in agreement with theory (1)			2	2		
			Question 5 total	**8**	**9**	**5**	**22**	**12**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	(a)	(i)	Electrons move at right angles to B-field **OR** LHR mentioned **OR** accept Bqv or BIl force (anything to do with magnetic force acting on electrons) (1) Force towards back face or shown clearly in diagram (1) (-ve) charge build (up on back face) (1) Electric field hence voltage (ignore "inducing" = neutral) **OR** accept equilibrium when mag force = electric force **OR** accept charge build-up clearly linked to Hall voltage (1)		4		4		4
		(ii)	$Ee = Bqv$ or similar seen e.g. $Eq = BIl$ or conservation of energy stated (1) $E = \frac{V}{d}$ substituted **OR** $E = \frac{v}{d}$ and $q = It$ and $v = \frac{l}{t}$ substituted or $Vq = Bqvd$ i.e. conservation of energy applied (1) Algebra seen to give correct answer (1)	1	1 1		3	2	
		(iii)	Any 3 numbers substituted to obtain the 4th (1) Correct answer 4th number & conclusion seen (1) (7.26×10^{-5} m s^{-1} is correct drift velocity) 5.4 mm is calculated d, 65.5 nV is calculated Hall pd, 0.187 T is calculated B-field)			2	2	2	2
		(iv)	Rearrangement of $I = nAve$ ($n = \frac{I}{Ave}$) **OR** $V_H = \frac{BI}{net}$ known (1) Correct area method i.e. 5.2×0.4 ($\times 10^{-6}$) **OR** $n = \frac{BI}{V_H et}$ (1) Correct answer (3.28×10^{28} m^{-3}) **OR** 3.4×10^{28} if they use 0.07 mm s^{-1}) (beware **ecf** may be available for a candidate that uses a previously **penalised** value instead of the given values)(1)		3		3	3	3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(b)		1st mark - could be either gold or silver (both required for the mark) 2nd mark either: Inside range **or** reference to uncertainty **or** range is 5.66 – 6.04 **or** check the colour of the metal			2	2		2
			Question 6 total	**1**	**9**	**4**	**14**	**7**	**11**

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	2	3	3	8	2	0
2	9	0	0	9	0	0
3	3	7	4	14	8	0
4	1	8	4	13	8	0
5	8	9	5	22	12	0
6	1	9	4	14	7	11
TOTAL	**24**	**36**	**20**	**80**	**37**	**11**