



GCE A LEVEL MARKING SCHEME

SUMMER 2019

**A2
PHYSICS - UNIT 4
1420U40-1**

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.

A2 UNIT 4 – Fields AND Options

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.

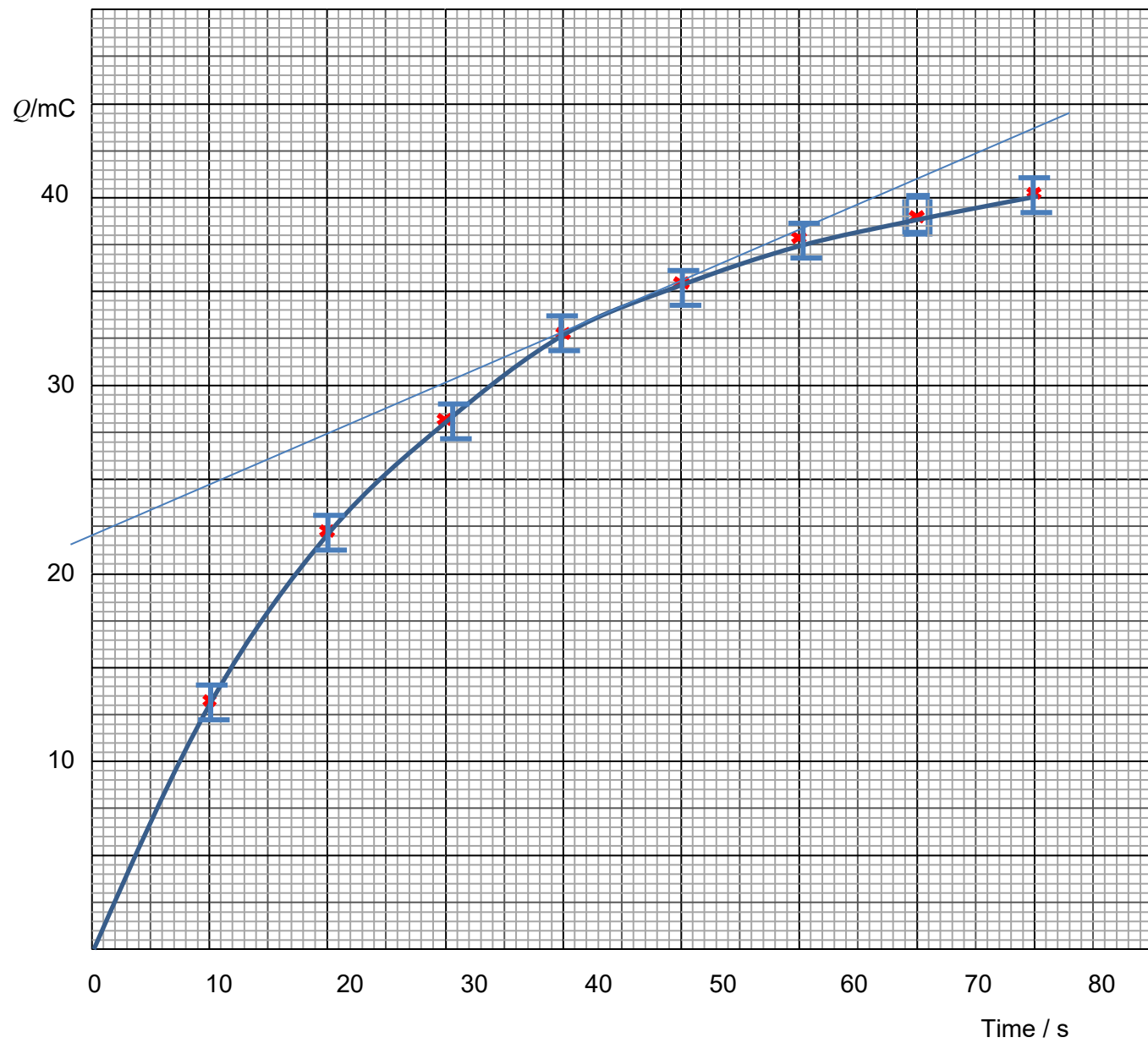
Marking abbreviations

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)	Use of $C = \frac{\epsilon_0 A}{d}$ [73.6 pF] [1] Use of $E = \frac{1}{2} CV^2$ or combination of $E = \frac{1}{2} QV$ and $Q = CV$ [1] Rearrangement $\left(\frac{2Ed}{\epsilon_0 A} \right)$ OR substitution in both equations [1] Correct answer = 833 [V] [1]	1 1	 1 1		 4	 3	
		(ii)	[Pd supplies/leads to] charges on plates (1) accept electric field set-up [This set-up] can do work / [electrostatic] PE stored / energy stored <u>in field</u> (1) accept can provide current after pd removed	2			2		
		(iii)	Any 3 (× 1) valid points e.g. • Repeat experiment / more tests / repeatability • Repeats by other research groups / industry / reproducibility • Tests for safety [of dielectric] • Tests for lifetime [of dielectric] • Cost effectiveness / availability • Environmental impact • Check for charge leakage			3	3		
	(b)	(i)	2.2 mF × 0.5 V seen or clear % usage shown		1		1		1
		(ii)	28.2 (1) 37.6 (1)		2		2		2
		(iii)	Numbers on y-axis i.e. 10, 20, 30, 40 (1) Both points plotted correctly ecf < small square (1) y-error bars correct < small square (1) Good curve of best fit ecf (2) If flawed but valid attempt at best fit e.g. hairy line, not smooth, missing one of the bars award 1 mark only		5		5		5

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iv)	Obtaining $Q_0 = 19.1 \times 2.2 \text{ mF} = 42 \pm 2 \text{ m[C]}$ (1) Using 63 % of fully charged OR substituting values into $Q = Q_0 \left(1 - e^{-\frac{t}{RC}}\right)$ OR taking logs correctly (1) T or $RC = 27 \pm 2 \text{ [s]}$ (no marks for 26.4 s) OR Q value correct after substituting (1)		3		3	3	3
		(v)	Good tangent drawn at 45 s ecf (1) Gradient = 0.27 m[A] ecf (1)		2		2		2
	(c)		Any 5 × (1) from: - Shape of graph is good - Line of best fit goes through error bar(s) - $RC = 26.4 \text{ s}$ - RC in good agreement with 27 s (ecf available) - $I_0 = \frac{19.1}{12\,000} = 1.59 \text{ m[A]}$ - Gradient of graph decreases / gradient is the current - So current equation is in good agreement – only award mark if current decreasing implied - Substitution into either equation for confirmation			5	5	2	5
			Question 1 total	4	15	8	27	8	18



Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	(a)		Field lines radial minimum of 3 (1) Field lines / arrows towards the Earth (1) Equipotentials are spheres minimum of 1 (circular cross-section) (1)	3			3		
	(b)	(i)	Use of $V = [-] \frac{GM}{r}$ (1) Answer = 1.16×10^6 or 1.29×10^5 (1) Answer = -1.29×10^6 *** J kg ⁻¹ *** unit mark (1)	1	1 1		3	1	
		(ii)	Use of $g = [-] \frac{GM}{r^2}$ (implied by 0.0034) (1) Evidence of cancelling fields e.g. $\frac{597}{342^2} - \frac{7.37}{38^2}$ or $0.0034 - 0.0034$ or difference in fields = 1.71×10^{-7} or checking ratio of fields is equal to 1 (1)	1	1		2	1	
		(iii)	Definition of SHM or force / acceleration proportional [& opposite] to displacement (can be implied through logical argument) (1) Force is in same direction as displacement / space craft will accelerate towards Moon or Earth (1) Hence, Dafydd is wrong consistent with argument and ecf (1)			3	3		
			Question 2 total	5	3	3	11	2	0

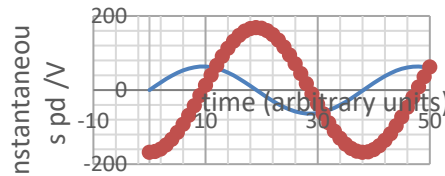
Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	(a)	(i)	Planets / masses orbit in ellipses (with the Sun at a focus) (1) [Line from planet to Sun] sweeps equal area(s) in equal time(s) or sweeps area at a constant rate (1) Sun at a focus & line from planet to Sun (or radius vector) (1)	3			3		
		(ii)	$\frac{GMm}{r^2} = \frac{mv^2}{r} \text{ or } mr\omega^2 \text{ (1)}$ Substitution of $\omega = \frac{2\pi}{T}$ or equivalent i.e. $v = \frac{2\pi r}{T}$ (1) Intermediate step seen e.g. $\frac{GMm}{r^2} = m \frac{4\pi^2}{T^2} r$ (1) Alternative: $T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}} \text{ (1)}$ $M_2 = 0$ or implied (1) $d = r$ and $M_1 = M_E$ (1)	3			3	3	
	(b)		Period of geostationary = 1 day (24 hr etc.) (1) Use of Kepler e.g. $\frac{T_1^2}{r_1^3} = \frac{T_2^2}{r_2^3}$ [accept substitution with 5.97×10^{24}] (1) Correct answer = 27.2 [days] (2.35×10^6 s) (1) Alternative: Substitution into period equation (1) Algebra (1) Correct answer = 27.2 [days] (2.32×10^6 s) (1)	1 1		1	3	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		Assumption - Radius cannot be less than r_E (or inside Earth's surface etc.) or ignore mountains/air resistance accept no atmosphere or Earth is totally smooth (1) Use of Kepler or accept equation use again (1) Correct answer = 1.42 h, $\frac{1}{16.9}$ of a day, 5 100 s etc. (accept slightly larger due to, e.g. $r_E = 6470$ km to be above atmosphere etc. which gives 1.45 h) (1)		3		3	2	
			Question 3 total	8	4	0	12	7	0

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	(a)		Align probe for max signal / perpendicular to field (at known distance) (1) Put probe at a fixed/known distance (1) Current calculated from equation $B = \frac{\mu_0 I}{2\pi a}$ (1)	3			3	1	1
	(b)		Use of $F = BIl$ (1) Use of $B = \frac{\mu_0 I}{2\pi a}$ (1) $\left[\text{or } \frac{F}{l} = \frac{\mu_0 I^2}{2\pi a} \text{ for 2 marks} \right]$ Answer = $0.336[4 \text{ N m}^{-1}]$ (1) Repulsive force (or equivalent) (1)	1 1	1 1		4	3	
	(c)	(i)	Use of Bqv [i.e. $F = 2.15 \times 10^{-14} \text{ N}$] (1) $\frac{mv^2}{r}$ or $m\omega^2 r$ used (1) Radius calculated $r = 3.56 \text{ c[m]}$ or $F = 3.06 \times 10^{-14} \text{ [N]}$ or $v = 2 \times 10^7 \text{ [m s}^{-1}\text{]}$ (1) Not circular or radius too large or field not uniform or force not large enough or speed too large (1)			4	4	2	
		(ii)	Starts in correct direction (1) Curving downward or clockwise (1)		2		2		
	(d)		Equation $F = Eq$ used (1) $F = Bqv$ used (1) Note $Eq = Bqv$ or $E = Bv$ scores both marks Substitution of $E = \frac{V}{d}$ (1) (use of $V = Bvd$ gets 3 marks) Final correct calculation(s) e.g. forces = $(2.15 \text{ \& } 2.16) \times 10^{-14} \text{ N}$ or confirmation of V , B , v or d from the other values (1) Final conclusion consistent with answer ecf - true (accept not true because 2.15 different from 2.16) (1)			5	5	3	
			Question 4 total	5	4	9	18	9	1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	(a)		[Induced] emf (or pd or voltage) equal to (or proportional to) the rate of change (or cutting) of flux [linkage] (1) The emf [tends to] oppose the <u>change</u> [to which it is due] (1)	2			2		
	(b)		Indicative content: Flux in pipe(s) changes or flux cut by pipe(s) Emf induced in pipe(s) Pipe P current cannot flow / incomplete circuit Pipe Q current flows [Current] opposes motion (change)(since) magnetic field set up due to (induced) current Uniform acceleration - no opposing force or gravity only Additional useful points – Terminal velocity - magnetic force equal (and opposite) to weight Slow velocity - due to strong magnet or small resistance or large current GPE converted to internal energy or electrical energy or electromagnetic energy Copper is not magnetic		6		6		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			5-6 marks Comprehensive list of observations made. <i>There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.</i> 3-4 marks Some reasonable observations made. <i>There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.</i> 1-2 marks Limited observations made. <i>There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.</i> 0 marks <i>No attempt made or no response worthy of credit.</i>						
	(c)		mgh or $mc\Delta\theta$ used or implied (i.e. $E_p = 2.35 \text{ J}$) (1) Use of $V = Ah$ (1) Use of $m = \rho V$ (1) (i.e. $m = 0.056 \text{ kg}$) Answer = 0.109 [K] (1)		4		4	4	
			Question 5 total	2	10	0	12	4	0

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	(a)	(i)	Pd of L and C are opposite signs (antiphase) (or in phasor diag) (1) Pd of L 90° before $\frac{R}{I}$ and C 90° after $\frac{R}{I}$ (or in phasor diag) (1) Pd of supply is the resultant of all 3 (or in phasor diag) (1)	3			3		
		(ii)	Resonance: R pd is power supply pd (1) Pds of L and C are equal and opposite (1)	2			2		
	(b)	(i)	$\frac{119.1}{45} = 2.65$		1		1	1	
		(ii)	$\frac{45}{28} = 1.61$ [A]		1		1	1	
		(iii)	$X_C = \frac{V}{I}$ used [74.1 Ω] or $X_C = \frac{1}{\omega C}$ (1) Answer = 26.2 [Hz] (1)		2		2	2	
		(iv)	$X_L = \omega L$ used with 74.1 (1) ecf Answer = 0.45 [H] (1)	1	1		2	2	
		(v)	Peak V of 168 V (1) Phase as shown (1) 		2		2	1	
		(vi)	Reactance of inductor increases or reactance of capacitor decreases or $X_L > X_C$ (1) Impedance increases because reactances don't cancel (1)		2		2		

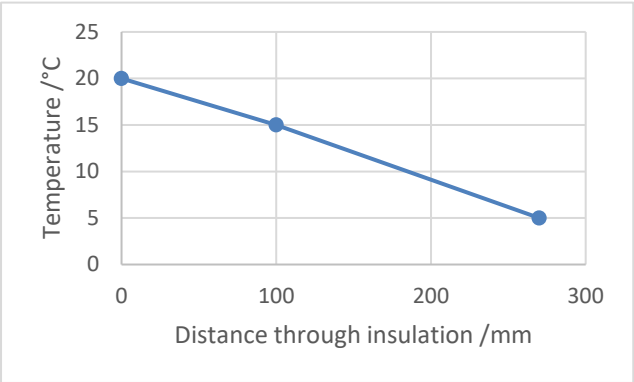
Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		Realising frequency variation of capacitor reactance e.g. decreases with frequency or small at high frequency or large at low frequency or explaining $\frac{1}{\omega C}$ (1) Voltage divider argument or equivalent employed leading to low pd at low f and vice versa (1) Calculating reactance at 20 kHz [43.01 Ω] (1) Realising $\sqrt{V_R^2 + V_C^2} = 12$ and not $6V + 6V = 12V$ (1) Correct conclusion Sam is wrong on pds (or should be 8.5V) but OK on frequency relationship (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)		X-rays penetrate matter or muscle or tissue (1) Denser matter not penetrated as much or absorbed by bone (1) X-rays affect photo film / photo cells (1)	3			3		
		(ii)	I	Rearrange to get $v = \sqrt{\frac{2eV}{m}}$ (1) $v = 7.95$ [or 8.0] $\times 10^7$ [m s ⁻¹] (1)		2		2	2	
			II	$P = 18 \times 10^3 \times 12 \times 10^{-3} = 216$ [W] (1) X-ray power = $0.005 \times 216 = 1.08$ [W] (1)		2		2	2	
	(b)	(i)		$I = \frac{I_0}{2} \rightarrow \frac{I_0}{2} = I_0 e^{-\mu x} \rightarrow \frac{1}{2} = e^{-\mu x}$ or $\frac{1}{2} = e^{-\mu x}$ (1) Logs taken of both sides and convincing algebra (1)		2		2	2	
		(ii)		$\mu = 0.257$ or 0.26 (1) Correct use of logs or $\ln 0.7 = \mu x$ (1) $x = 1.39$ or 1.4 [cm] (1)		3		3	3	
	(c)			Ultrasound B-scan would be very effective [only] form of imaging to give moving images or can monitor blood flow (1) Fluoroscopy also very effective with contrast medium can give a series of rapid images over time / view in real time (1) MRI (would image soft tissue) no moving images (1) X-rays poor at imaging soft tissue (1) CT scans poor at soft tissue imaging [high radiation dose] (1)			5	5		
	(d)		(i)	Absorbed dose is the energy absorbed per kg of tissue (1) Equivalent dose is the absorbed dose multiplied by a weighting factor due to the type of radiation used (1)	2			2		
			(ii)	$4 \times 0.12 = 0.48$ mSv unit mark	1			1	1	
				Question 7 total	6	9	5	20	10	0

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	(a)	(i)	Relative velocity (speed) <u>after</u> a collision = (1) <u>0.55</u> × relative velocity (speed) <u>before</u> a collision (1)	2			2		
		(ii)	At 0 °C $e = 0.55 \times 0.70$ or equivalent (gives 0.39) (1) Use of $e = \sqrt{\frac{h}{H}}$ (1) Rearrangement $h = e^2 H$ Bounce height at 0 °C = 0.074 [m]	1	1 1 1		4	3	
	(b)	(i)	Using $F = \frac{mv - mu}{t}$ (1) $F = 211$ [N] (1)	1	1		2	1	
		(ii)	$34 \sin 8^\circ$ [4.7 m s ⁻¹] as vertical velocity (1) Vertical height calculated correctly = 1.14 [m] (1) No – never goes above 1.20 [m] (1)			3	3	1	
		(iii)	Angular velocity = 88 [rad s ⁻¹] (1) Moment of inertia = 1.23×10^{-4} [kg m ²] (1) Rotational kinetic energy = 0.48 [J] (1)		3		3	3	
		(iv)	At maximum height; there is also linear kinetic energy as well as rotational (1) So Wayne is incorrect - total kinetic energy is higher (1)			2	2		
		(v)	Using Bernoulli equation $p = p_0 - \frac{1}{2} \rho v^2$ (1) Realising difference in pressure = $\frac{1}{2} \rho (v_1^2 - v_2^2)$ (1) [= 87.1 Pa] Force = 87.1 × area = 0.37 [N] (1) Comparing with weight of 1.7 N allow ecf (1)	1 1	1 1		4	2	
			Question 8 total	6	9	5	20	10	0

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)	(i)		Any object [wholly or partially] immersed in a fluid experiences an upwards force equal to the weight of the fluid displaced by the object	1			1		
		(ii)		Sub into $\rho = \frac{m}{V}$ with conversion i.e. 80×10^{-6} and 1 030 (1) Manipulation and answer ($1\,030 \times 80 \times 10^{-6}$) = 0.0824 kg (1)		2		2	2	
		(iii)		Mass of block of ice = 0.0824 kg (can be inferred) (1) Allow ecf from (i) Volume of block of ice = $\frac{0.0824}{920} = 89.6 \times 10^{-6} \text{ [m}^3\text{]} (1)$ Volume of ice above surface = $9.6 \times 10^{-6} \text{ [m}^3\text{]} (1)$	1	1 1		3	2	
		(iv)	I	$\frac{2.2 \times 10^{11} \text{ m}^3 \text{ yr}^{-1}}{3.6 \times 10^{14} \text{ m}^2} [= 6 \times 10^{-4} \text{ m yr}^{-1}]$		1		1		
			II	Melting ice sheets adds to the volume of the sea (1) Melting icebergs replaces volume of sea water already displaced so water level unchanged / change is negligible (1)		2		2		
			III	More radiation absorbed by darker surfaces that is uncovered or less radiation reflected as white reflective surfaces have melted			1	1		
	(b)	(i)		All units correctly identified: Power = W; $[A] = \text{m}^2$; $[\Delta\theta] = \text{K}$; $[\Delta x] = \text{m} (1)$ Convincing algebra e.g. $K = \frac{\Delta Q \Delta x}{\Delta t \Delta \theta A} (1)$	2			2	1	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(ii)	Use of thermal conductivity equation i.e. $\frac{\Delta Q}{\Delta t} = \frac{0.041 \times 72 \times 15}{100 \times 10^{-3}}$ (1) = 443 [Js ⁻¹ / W] (1)	2			2	2	
		(iii)	$\frac{\Delta Q}{\Delta t}$ the same through both layers (1) $\frac{0.041(20 - \theta)}{100} = \frac{0.035(\theta - 5)}{170}$ seen or boundary temp = 15.0 °C (1) $\frac{\Delta Q}{\Delta t} = 148$ [W] (1) Accept thermal resistance in series approach i.e. $\frac{15}{\left(\frac{100 \times 10^{-3}}{0.041 \times 72}\right) + \left(\frac{170 \times 10^{-3}}{0.035 \times 72}\right)} = 148$ [W] > 60% reduction so claim is correct. Allow ecf on $\frac{\Delta Q}{\Delta t}$ values(1)			4	4	3	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iv)	 Negative linear gradient (1) Correct points at (0,20), (100,15 ecf) and (270,5) (1)		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	4	15	8	27	8	18
2	5	3	3	11	2	0
3	8	4	0	12	7	0
4	5	4	9	18	9	1
5	2	10	0	12	4	0
OPTIONS						
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	40	19