



GCE MARKING SCHEME

**PHYSICS
AS/Advanced**

SUMMER 2013

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2013 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were 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 conferences was to ensure that the marking schemes were 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' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

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GCE Physics - PH1

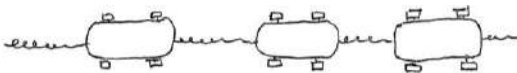
Question			Marking details	Marks Available
1.	(a)	(i)	[A quantity with] magnitude / size and direction.	[1]
		(ii)	Any suitable quantity (e.g force) other than velocity or acceleration.	[1]
	(b)	(i)	<i>ut shown</i> to have units: $\text{m s}^{-1} \times \text{s} \rightarrow [\text{m}]$ (1) $(\frac{1}{2})at^2$ shown to have units: $\text{m s}^{-2} \times \text{s}^2 \rightarrow [\text{m}]$ (1) Comment: all terms have same units or equivalent e.g. LHS=RHS (1)	[3]
		(ii)	(I) $u = 8 \text{ m s}^{-1}$ UNIT MARK	[1]
			(II) $\frac{1}{2} a = 3$ $a = 6 [\text{m s}^{-2}]$	[1]
			(III) Substitution and answer $x = 115[\text{m}]$	[1]
			(IV) Equation (1) Substitution (1) ecf for u, a and x $v = 38 [\text{m s}^{-1}]$ (1)	[3]
			Question 1 total	[11]
2.	(a)	(i)	[electric] current	[1]
		(ii)	$I = 6 [\text{A}]$	[1]
	(b)	(i)	Parallel combinations calculated: 4Ω (1); 2Ω (1) Series addition: $6 [\Omega]$ (1) ecf	[3]
		(ii)	$XY \rightarrow \frac{2}{3} \times 12 = 8 [\text{V}]$ (1) or $I = 12/6 = [2 \text{ A}]$ (1) $YZ \rightarrow \frac{1}{3} \times 12 = 4 [\text{V}]$ (1) $V_{xy} = 8 [\text{V}]$ and $V_{yz} = 4 [\text{V}]$ (1)	[2]
			ecf	
		(iii)	No Change (1) Correct explanation in terms of: Either: Ratio of <u>resistances</u> stays the same } (1) ecf Or: New current calculated ($1\frac{1}{3}$ A) and used }	[2]
		(iv)	$R = 12/1.5 = 8 [\Omega]$ (1)	[2]
		(v)	S_1 open and S_2 closed (1) $P = (12)^2/9$ or $P = 1\frac{1}{3} \times 12$ or $P = (1\frac{1}{3})^2 \times 9$ (1) $P = 16 [\text{W}]$ (1)	[2]
(vi)	Strategy - various switch settings and corresponding powers calculated e.g. Close S_1 : $R = 7 \Omega$ or Close S_2 : $R = 8 \Omega$ } (1) $P = 20.6 \text{ W}$ $P = 18 \text{ W}$ } Close both: $R = 6 [\Omega]$ (1) and $P = 24 [\text{W}]$ (1) e.g. $P = V^2/R$ (1) largest P when R smallest or smallest R identified as $6 [\Omega]$ [must be linked to $P = V^2/R$] (1) S_1 and S_2 closed (1) e.g. $P = I^2 R$ (1) largest P when I greatest when R smallest [must be linked to $P = I^2 R$] (1) S_1 and S_2 closed (1) (N.B. $P=IV$ could be used here) In both of the above the 3 rd mark can be awarded as a standalone mark provided some sensible reasoning is given.	[3]		
		Question 2 total	[16]	

Question		Marking details	Marks Available
3.	(a)	[Electrical] energy [or work done] transferred to whole of circuit [or through cell] (1) per coulomb [or unit charge] (1)	[2]
	(b)	Sensible scale and axes labelled with units (1) All points correct $\pm \frac{1}{2}$ small square division (1) Line of best fit (1) (no requirement \rightarrow y axis)	[3]
	(c)	(i) $E = 1.48$ [V] (± 0.01 V) ecf from graph	[1]
		(ii) Gradient attempted or $r = \frac{E - V}{I}$ (by implication) (1) $r = 0.83$ [Ω] (1) ecf from graph	[2]
	(d)	$I = \frac{E}{R + r} \left\{ \frac{1.48}{6 + 0.83} \right\}$ (1) (ecf on E and r) $I = 0.22$ A (1) $t = 20 \times 60$ [1 200 s] (1) $Q = 0.22$ (ecf) \times 1 200 (ecf) = 264 [C] (1) Question 3 Total	[4] [12]
4.	(a)	(i) Ruler and wire (1) Moving pointer (or crocodile clip shown) (1) Ohmmeter connected correctly with no power supply or voltmeter and ammeter positioned correctly with power supply (1)	[3]
		(ii) Straight line through origin	[1]
		(iii) Gradient = R/l or pair of R and l values from graph (1) Measure diameter to calculate area (1) $\rho = \text{grad} \times \text{area}$ or substitution into $\rho = RA/l$ (1)	[3]
	(b)	$\text{Vol} = Al = \frac{1}{3}A \times 3l$ (CSA reduced to $\frac{1}{3}$ original) (1) $R = \frac{\rho 3l}{A/3}$ (1) $\rho = \text{constant}$ stated (or implied) (1) OR: $A = \text{vol}/l$ so $R = \rho l^2/\text{vol}$ (1) $R \propto l^2$ (1) New $R \propto (3l)^2$ so new $R = 9R$ (1) Question 4 Total	[3] [10]

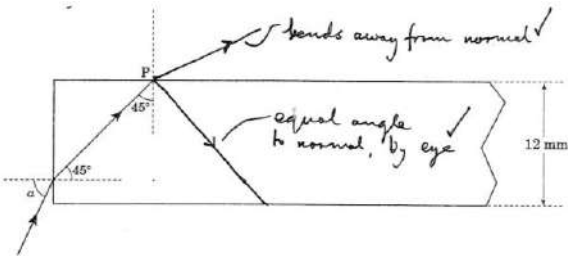
Question		Marking details	Marks Available	
5.	(a)	Energy cannot be created or destroyed, only converted to other forms.	[1]	
	(b)	(i) $\frac{1}{2}mv^2 = mgh$ shown or use of $v^2 = u^2 + 2ax$ (1) (no mark for $E_k = E_p$ only)	[2]	
		(ii) Clear manipulation (1) $v = 48.5 \text{ [m s}^{-1}\text{]}$	[1]	
	(c)	(i) Air resistance /drag (1) Friction between bobsleigh and ice or surface or track or on surface /ice/snow (1)	[2]	
		(ii) Actual $v = [48.5 - 20\% \times 48.5] = 38.8 \text{ m s}^{-1}$ (1) (ecf) Actual $E_k = 210\,762 \text{ [J]}$ (1)	[2]	
		(iii) Either $[\frac{1}{2} \times 280 \times (48.5)^2 - 210\,762]$ or $[280 \times 9.8 \times 120 - 210\,762]$ (ecf on 48.5 or 210 762) (1) Work done against resistive forces = 118 500J (1) $= F \times 1\,400$ (1) ecf $F = 85 \text{ [N]}$ (1) ecf for use of 1.4 km	[4]	
	Question 5 Total			[12]
	6.	(a)	(i) $\cos 40^\circ$ (1); $600 \cos 40^\circ = 460 \text{ [N]}$ (1)	[2]
			(ii) 386 [N] no ecf if sin or cos mixed up	[1]
		(b)	$(90 \times 9.8) - 386$ (1) (ecf) N.B. if 10 used -1 mark) $= 496 \text{ [N]}$ (1)	[2]
(c)		$0.8 \times 496 = 397 \text{ N}$ (1) ecf $\Sigma F_{\text{horizontal}} = (460 - 397) = 63 \text{ N}$ (1) (ecf) $a = 0.7 \text{ m s}^{-2}$ (1) UNIT MARK	[3]	
(d)		gravitational pull of tree trunk on earth	[1]	
Question 6 Total			[9]	

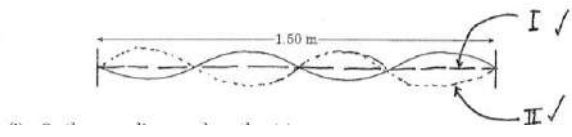
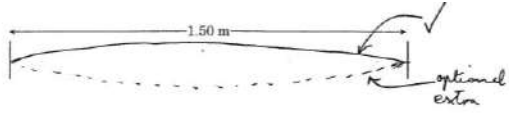
Question		Marking details	Marks Available	
7.	(a)	No net force / all forces acting on the body are balanced / $\sum F=0$	[1]	
	(b)	$w x + F_2 x_2$	[1]	
	(c)	(i)	1.2 [m] and 2.8 [m] – correctly labelled	[1]
		(ii)	$w \times 0.8 = 90 \times 1.2 + 100 \times 2.8$ (1) (ecf on 1.2 and 2.8) $w = 485$ [N] (1)	[2]
		(iii)	$R = 675$ [N] (ecf on w)	[1]
		(iv)	Anticlockwise and clockwise moments calculated correctly (even as ecf) (1) Both = 2 160 [Nm] or \sum moments about Q shown=0 (1)	[2]
		(v)	To the left (or towards P) (1) Increased clockwise moment needed to counteract increased anti-clockwise moment or sensible statement related to weight and distance (1)	[2]
Question 7 Total			[10]	

GCE Physics - PH2

Question 1		Marking details	Marks Available
1.	(a)	(i) 0.40 [m]	[1]
		(ii) 0.20 [s]	[1]
		(iii) $f = 5.0$ [Hz] (1) or $v = \frac{\lambda}{T}$ or by implication $v = 2.0$ [m s ⁻¹] (1) ecf on T and λ	[2]
	(b)	F and J	[1]
	(c)	(i) Direction of oscillations or trolley motion (accept particle vibration or wave oscillations) and direction of [wave] travel (1) are at right angles. (1)	[2]
	(ii)		[1]
Question 1 total			[8]

Question 2		Marking details	Marks Available
2.	(a)	Use of $v = \frac{d}{t}$ even if factor of 2 is omitted, or powers of 10 adrift (but not both these faults). (1)	
		$v = 340 \pm 10$ m s ⁻¹ UNIT (1) Answer must be seen to be derived. No marks for gradient attempt.	[2]
	(b)	(i) I $\lambda = \frac{0.30 \times 0.16}{1.2}$ [m] (1) or by implication $\lambda = 0.040$ [m] (1) [0.080 m, arising from $y = 0.32$ m, loses 1 mark]	[2]
		II $v = 332$ [m s ⁻¹] ecf	[1]
	(ii)	I Dot nearest A should be marked 'M'.	[1]
	II Waves [from S_1 and S_2] arrive in phase at M Accept constructive interference <u>and</u> whole number of wavelengths path difference.	[1]	
(iii)	$\lambda = 1.1$ [m] or $\lambda > a$ or $\lambda > 0.3$ [m] or $\lambda > S_1 S_2$ (1) Maximum path difference possible [for waves from S_1 and S_2] is [the slit separation, which is only] 0.30 m or path difference can never be large enough (1) Or [Young's fringes equation gives] 'first' maximum at 4.4 m from central dot. Accept fringes too far apart.	[2]	
Question 2 total			[9]

Question 3		Marking details	Marks Available	
3.	(a)	<p>Award 3 x (1) of:</p> <ul style="list-style-type: none"> • Refraction is change in direction of travel as waves change medium / air to glass (or equivalent). • AB, CD are wavefronts (or peaks or crests). • AB goes to CD. • Waves travel more <u>slowly</u> in 2 than in 1. • Hence $BD < AC$ Accept wavelength less in medium 2. • Direction of travel of waves is normal to wavefronts. 	[3]	
	(b)	(i)	[1.00] $\sin \alpha = 1.33 \sin 45^\circ$ (1) or equivalent or by implication	
	(ii)	I	$\alpha = 70^\circ$ (1) 	[2]
	(ii)	II	<p>No need for arrow heads. No penalty if reflected ray doesn't reach the bottom of the fibre.</p> <p>6 reflections needed [including that at P] (1) Light travels 12 mm parallel to rod axis between successive reflections. (1) or by implication Light has to travel 60 [mm] beyond P (1) Accept 72 [mm] Award 2 marks for 17 mm x 5 = 85 [mm] Award 1 mark for 17 mm x 6 = 102 [mm]</p>	[3]
	(c)	(i)	$c = 49^\circ$ (1) $50^\circ > 49^\circ$ or $50^\circ > c$ AND so refraction not possible / TIR / no power loss (1)	[2]
	(ii)		Total internal reflection	[1]
Question 3 Total			[13]	

Question 4		Marking details	Marks Available
4.	(a)	Interference between or superposition of or sum of two [progressive] waves [of equal amplitude and frequency] (1) Travelling in opposite directions or reflect (1)	[2]
	(b)	(i) 	[2]
		(ii) $\lambda = 0.75$ [m] (1) or by implication $f = 128$ Hz UNIT (1)	[2]
	(c)	(i) 	[1]
		(ii) $\lambda = 3.00$ [m] or by implication ecf provided λ consistent with diagram (1) $f = 32$ [Hz] (1) ecf	[2]
	(d)	$32n$ [Hz] or equivalent	[1]
		Question 4 Total	[10]

Question 5		Marking details	Marks Available
5.	(a)	(i) ϕ is [minimum] energy needed to release an electron <u>from surface</u> [or from metal or from material]. (1) No marks for giving meaning of f_0 . So [minimum] <i>photon</i> energy needed is ϕ . (1) So $hf_0 = \phi$ or $E_{\text{photon}} = hf$ (1)	[3]
		(ii) Award 2 x (1) of: <ul style="list-style-type: none"> • More photons per second • Individual photon energies unchanged • $E_{k\text{max}}$ depends on energy of individual photon or $E_{k\text{max}} = hf - \phi$ does not include intensity. Accept: Photons don't co-operate [in releasing electrons].	[2]
	(b)	Increase / adjust pd until nano-ammeter shows zero current [or equiv.] (1) Read voltmeter (1) or by implication $E_{k\text{max}} = eV$ (1)	[3]
	(c)	(i) Gradient = $6.7 [\pm 0.2] \times 10^{-34}$ [J s] (1) Mention of Planck's constant and sensible comparison (1)	[2]
		(ii) $\phi = 4.1 [\pm 0.2] \times 10^{-19}$ [J] (1) barium but only award mark if some reasoning given e.g. correct reference to intercept (1)	[2]
		Question 5 Total	[12]

Question 6			Marking details	Marks Available
6.	(a)	(i)	$\Delta E = 1.87 \times 10^{-19} \text{ [J]}$ (1) $\lambda = \frac{hc}{\Delta E}$ (1) or equivalent, including $\lambda = \frac{c}{f}$ and $f = \frac{c}{\lambda}$. $\lambda = 1.06 \times 10^{-6} \text{ m}$ (1) ecf on arithmetical slip in ΔE .	[3]
		(ii)	$\lambda = 7.9 \times 10^{-7} \text{ [m]}$	[1]
	(b)	(i)	More electrons [accept atoms, ions] in <u>U than in L</u>	[1]
		(ii)	PI ensures stimulated emission (1) more likely [frequent] than absorption [for photons of energy $1.87 \times 10^{-19} \text{ J}$] (1) Stimulated emission needed for light amplification because in each stimulated emission event 2 photons out for 1 in or implied by “in phase”. (1)	[3]
		(iii)	Electrons drop from L [to ground state] leaving L depopulated. (1) Making it easier to have more electrons in U than L or making a PI easier to establish or needing less pumping. (1)	[2]
Question 6 Total			[10]	

Question 7			Marking details	Marks Available
7.	(a)	(i)	Ultraviolet [or u-v]	[1]
		(ii)	$\lambda_{\text{peak int}} = \underline{55 \text{ nm}}$ and $T = \frac{W}{\lambda_{\text{peak int}}}$ or by implication (1) $T = 53 \text{ 000 K}$ (1) ecf on 50 or 60 nm	[2]
		(iii)	In tail of curve [or equivalent] greater intensity at smaller λ . Accept blue end of visible nearer peak than red end.	[1]
	(b)	(i)	$I = \frac{P}{4\pi r^2}$ (1) or equivalent so $P = 2.11 \times 10^{33} \text{ [W]}$ (1) or by implication So $P/P_{\text{sun}} = 5.49 \times 10^6$ or $5 \times 10^6 P_{\text{sun}} = 1.9 \times 10^{33} \text{ [W]}$ (1)	[3]
		(ii)	$A = \frac{P}{\sigma T^4}$ with A as subject ecf on P and T (1) or by implication $r = \sqrt{\frac{A}{4\pi}}$ (1) or $d = \sqrt{\frac{A}{\pi}}$ or by implication $d = 4.0 \times 10^{10} \text{ [m]}$ (1) [one mark lost for factor of 2 or 10^n adrift.]	[3]
Question 7 Total			[10]	

Question 8		Marking details	Marks Available
8.	(a)	(i) They interact by the <u>weak interaction</u> . (1) Interactions [very] infrequent compared with strong or e-m. (1) [or other correct and relevant comment e.g. no charge]	[2]
	(b)	(i) Combination of 3 quarks	[1]
		(ii) Lepton no: $1 + 0 = 0 + 0 + 1$ (1) or equivalent Charge: $0 + e = e + e + (-e)$ (1) or equiv. e.g. $0 + 1 = 1 + 1 - 1$	[2]
		(iii) For the 1 st mark either of these (u or d): - u: $[0 +] 1 + 2 \rightarrow 2 + 2 [+0]$ or $3 \rightarrow 4$ - d: $[0 +] 2 + 1 \rightarrow 1 + 1 [+0]$ or $3 \rightarrow 2$ For the 2 nd mark: the other (i.e. u or d) and remark that a d has changed to a u OR equivalent N.B. $uud + udd \rightarrow uud + uud$ is an alternative for the 1 st mark.	[2]
		(iv) <u>Lepton</u> number not conserved.	[1]
		Question 8 Total	[8]

GCE Physics - PH4

Question		Marking details	Marks Available
1.	(a)	Curve for 1 st step <u>and</u> line for 2 nd step (1) Direction on both steps (1) Labelling of state C (1)	3
	(b)	(i) $V_A = \frac{(0.06)(8.31)(250)}{(8.5 \times 10^4)} = 1.47 \times 10^{-3} [\text{m}^3]$	1
		(ii) $V_B = \frac{(0.06)(8.31)(355)}{(8.5 \times 10^4)} = 2.08 \times 10^{-3} [\text{m}^3]$	1
		(iii) $V_C = \frac{(0.06)(8.31)(355)}{(7.0 \times 10^4)} = 2.53 \times 10^{-3} [\text{m}^3]$ (alternatively use $\frac{V_B}{V_A} = \frac{T_B}{T_A}$ and $\frac{V_C}{V_B} = \frac{P_B}{P_C}$ allowing ecf)	1
	(c)	(i) Work done = $p\Delta V = (8.5 \times 10^4)(2.08 - 1.47) \times 10^{-3} \cong 52 [\text{J}]$ ecf Convincing, correct method.	1
(ii) Work done = $-\frac{1}{2}(8.5 + 7.0) \times 10^4 (2.53 - 1.47) \times 10^{-3} \cong -82 [\text{J}]$ ecf 1 for: Evidence for “finding area”. 1 for: Convincing algebra.		2	
(d)	1 for: Remaining block in column 1: C to A = -79 1 for: All of column 3: A to B = +131; B to C = +34; C to A = -161	2	
Question 1 Total			[11]

Questions		Marking details	Marks Available
2.	(a)	$m = \rho V = 10^3(1.7 \times 10^{-3}) = 1.7 \text{ [kg]}$	1
	(b)	All points plotted correctly (\pm half small square division) and straight line (1) Sensible scales on both axes (1)	2
	(c)	$20 \pm 1 \text{ [}^\circ\text{C]}$	1
	(d)	$3.20 \pm 0.05 \text{ [min]}$ (or $192 \pm 3 \text{ s}$)	1
	(e)	Heat supplied to water in e.g. 2.5 min (Q) $= (3 \times 10^3)(2.5 \times 60) = 4.5 \times 10^5 \text{ [J]}$ (1) e.g. $\Delta\theta = 95.5 - 32.5 = 63 \text{ [}^\circ\text{C]}$ (1) (or equivalent for second and third marks provided consistent for substitution that follows) Rearranging formula for $c = \frac{Q}{m\Delta\theta}$ Substitution of values and result (1) $c = \frac{4.5 \times 10^5}{(1.7)(63)} = 4.2 \times 10^3 \text{ [J kg}^{-1} \text{ }^\circ\text{C}^{-1}]$ ($\pm 0.1 \times 10^3$)	3
	(f)	(i) [All] temperature measurements lower [because heat taken by container (heat lost) i.e. some reference to heat going elsewhere or lost] (1) (ii) Gradient of graph shallower or $\Delta\theta$ smaller (1) (iii) c larger (overestimated) (1) No ecf within this question part.	3
		Question 2 Total	[11]

Question		Marking details	Marks Available
3.	(a)	Rearranging Hooke's Law $k = \frac{F}{e} = \frac{mg}{e}$ (1) Substitution and correct result with UNIT $\frac{(2000)(9.81)}{(0.15)} = 1.31 \times 10^5 \text{ N m}^{-1}$ (1)	2
	(b)	(i) $e = \frac{(75 + 85)g}{(1.31 \times 10^5)} = 0.012 \text{ [m]} = 1.2 \text{ [cm]}$ (allow ecf for k). Correct method. (1) Correct result. (1)	2
		(ii) $T = 2\pi \sqrt{\frac{m}{k}} = 2\pi \sqrt{\frac{2160}{1.31 \times 10^5}} = 0.81 \text{ [s]}$ Substitution into formula. (1) Correct result. (1) Award 2 marks for answer of 0.78 [s]	2
		(iii) Natural frequency of system is $\frac{1}{0.81} \cong 1.24 \text{ [Hz]}$; the frequency of driving force is essentially equal to this; so resonance occurs. (1) (need all three points) Accept 1.28 [Hz]. Amplitude of oscillation becomes large/maximum (1)	2
	(c)	Any 3x(1): - return quickly to equilibrium - critical damping - avoid resonance / large amplitude - reduce oscillations - dissipating energy Accept: - comfortable ride - braking better on rough surfaces	3
		Question 3 Total	[11]

Question		Marking details	Marks Available	
4.	(a)	(i) $\omega = \frac{45(2\pi)}{60} = 4.71 \text{ [rad s}^{-1}\text{]}$ Conversion from rotations to radians, with the '45'. (1) Conversion from minutes to seconds and convincing working. (1)	2	
		(ii) $velocity = \omega r = (4.71)(0.08) = 0.38 \text{ [m s}^{-1}\text{]}$ Formula and substitution. (1) Result. (1)	2	
		(iii) $acceleration = \omega^2 r = (4.71)^2(0.08) = 1.77 \text{ [m s}^{-2}\text{]}$ Formula and substitution. (1) Result (1)	2	
		(iv) Towards point Q, or towards centre of circle.	1	
	(b)	(i) $A = 0.080 \text{ [m]}$	1	
		(ii) $T = \frac{2\pi}{\omega} = \frac{2\pi}{4.71} = 1.33 \text{ [s]}$	1	
		(iii) $a = -1.77 \sin(4.71 \times 0.20) = -1.43 \text{ [m s}^{-2}\text{]}$ Substitution of time (1). Result with minus sign (1)	2	
		(iv) A body moves with SHM if its acceleration - is directly proportional to its displacement from a fixed point - is always directed towards that [fixed] point 1 for: each statement	2	
		(v) $a = -\omega^2 A \sin(\omega t)$; $x = A \sin \omega t$ so substitution gives: $a = -\omega^2 x$ convincing manipulation. (1) final expression linking to SHM.(1)	2	
	(c)	$x = 0.06 \sin\left(4.71t - \frac{\pi}{2}\right)$. 1 for: each correct parameter inserted.	3	
	Question 4 total			[18]

Question		Marking details	Marks Available
5.	(a)	(i) The [vector] sum of the momenta of bodies [in a system] stays constant [even if forces act between the bodies] provided there is no external [resultant] force.	2
		(ii) Idea of conservation of momentum i.e. expression or statement of $p_i = p_f + m_e v$ (1) No need to specify here that momentum of the hydrogen atom is initially zero. Substitution of values and convincing manipulation. (1) $\frac{6.63 \times 10^{-34}}{620 \times 10^{-9}} = -\frac{6.63 \times 10^{-34}}{620 \times 10^{-9}} + (1.67 \times 10^{-27})v$ $v = 1.28 \text{ [m s}^{-1}\text{]}$	2
		(iii) $E = hf = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34})(3 \times 10^8)}{620 \times 10^{-9}} = 3.2 \times 10^{-19} \text{ [J]}$	1
	(b)	(i) Equating momenta, rearranging and substitution (1) $mv = \frac{h}{\lambda}$ $\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{(1.67 \times 10^{-27})(1.28)} = 3.10 \times 10^{-7} \text{ [m] (= 310 nm)}$ Correct value of wavelength (1) (allow ecf if substitution incorrect but calculation consistent)	2
		(ii) Ultraviolet. ecf	1
Question 5 total			[8]

Question		Marking details	Marks Available
6.	(a)	(i) $\frac{F}{m} = -\frac{GM}{r^2} = -\frac{(6.67 \times 10^{-11})(1.99 \times 10^{30})}{(1.50 \times 10^{11})^2} = [-]5.90 \times 10^{-3} \text{ N kg}^{-1}$ formula and substitution (1) result with UNIT (1).	2
		(ii) $-\frac{GM}{r} = -\frac{(6.67 \times 10^{-11})(1.99 \times 10^{30})}{(1.50 \times 10^{11})} = -8.85 \times 10^8 \text{ [J kg}^{-1}\text{]}$ formula and substitution (1) result with sign (1) ecf	2
	(b)	(i) $r_1 = \left(\frac{M_2}{M_1 + M_2} \right) d = \left(\frac{1.90 \times 10^{27}}{1.99 \times 10^{30} + 1.90 \times 10^{27}} \right) (7.79 \times 10^{11})$ or with approximation (1) $= 7.43 \times 10^8 \text{ [m]} (1).$ $7.43 \times 10^8 > 6.96 \times 10^8$ (so centre of mass outside Sun) (1)	3
		(ii) use of formula and substitution (1) (or with approximation) $T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}} =$ result from the substitution (1) $2\pi \sqrt{\frac{(7.79 \times 10^{11})^3}{(6.67 \times 10^{-11})(1.99 \times 10^{30} + 1.90 \times 10^{27})}} = 3.75 \times 10^8 \text{ [s]}$ or with approximation. $\omega = \frac{2\pi}{T} = 1.68 \times 10^{-8} \text{ [rad s}^{-1}\text{]} \text{ (allow ecf). (1)}$ $\text{speed} = \omega r_1 = (1.68 \times 10^{-8})(7.43 \times 10^8) = 12.5 \text{ [m s}^{-1}\text{]} (1)$	4
Question 6 Total			[11]

Question		Marking details	Marks Available
7.	(a)	(i) $separation = 2(0.75)\sin 10^\circ = 0.26 \text{ [m]}$ Factor 2 (1) Formula with substitution for one string. (1)	2
		(ii) $F = \frac{1}{4\pi\epsilon_0} \frac{(2.55 \times 10^{-7})^2}{(0.26)^2} = 8.65 \times 10^{-3} \text{ [N]}$ Substitution into formula. (1) Result.(1)	2
		(iii) Method. $Potential\ Energy = \left(-\frac{1}{4\pi\epsilon_0} \frac{q}{(0.26)} \right) (-q) (1)$ Convincing substitution (1) $= \frac{(2.55 \times 10^{-7})^2}{4\pi(8.85 \times 10^{-12})(0.26)} = 2.25 \times 10^{-3} \text{ [J]}$	2
	(b)	(i) $F = T \sin 10^\circ (1)$ Rearranging to $T = \frac{F}{\sin 10^\circ} (1)$ Substitution and result. $T = \frac{8.65 \times 10^{-3}}{\sin 10^\circ} = 0.050 \text{ [N]} (1)$ (allow ecf for force).	3
		(ii) Convincing use of $mg = T \cos 10^\circ$ to obtain $m = 5.0 \times 10^{-3} \text{ [kg]}$	1
Question 7 Total			[10]

GCE Physics - PH5

Question		Marking details	Marks Available
1.	(a)	Correct α or β absorber (1)	4
		If drop after α absorber, then α present (1) (Alpha is stopped by paper – award 2 marks)	
		If further drop after β absorber then β present (1)	
	If (significant) count after β absorber then γ present or equivalent (1)		
	(b)	(i) 19×10^{15} [Bq]	1
		(ii) Use of $\lambda = \frac{\ln 2}{T_{1/2}}$ (1) e.g. 0.0271 per day or $3.13 \times 10^{-7} \text{ s}^{-1}$ (1) Or $A = \frac{A_0}{2^x}$ quoted Or $A = \frac{A_0}{2^x}$ used Substitutions of values (ignore wrong units or factors of ten slips) (1) Or $x = 14.26$ Correct answer 3.85×10^{12} [Bq] (1)	4
		(iii) Attempt at using $A = \lambda N$ e.g. $76 \times 10^{15} = \lambda N$ (1) $N = 2.4 \times 10^{23}$ (1)	2
		Question 1 Total	[11]

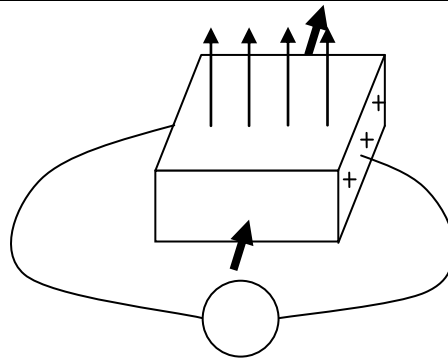
Question		Marking details	Marks Available
2.	(a)	<p>Attempt at LHS – RHS (1) (Difference = 0.0078)</p> <p>Attempt at mass-energy conversion $\times 931$ or $E = mc^2$ used (1)</p> <p>Answer = 7.26 MeV (1.16×10^{-12} J) (1)*** UNIT MARK***</p>	3
	(b)	<p>8.795 x number of nucleons attempted [545.29 MeV] (1)</p> <p>Mass equivalent = 0.5857 [u] (1)</p> <p>28 protons & 34 neutrons stated or implied (1)</p> <p>Mass of 28p & 34n = 62.49828 (1)</p> <p>Answer = 61.913 [u] (1) must be to 5 significant figures</p>	5
		Question 2 Total	[8]

Question		Marking details	Marks Available
3.	(a)	$Q = CV$ (1) 212 [nC] (1)	2
	(b)	Taking logs e.g. $\ln Q = \ln Q_0 - \frac{t}{CR}$ (1) Algebra e.g. $R = -\frac{t}{C \ln \frac{V}{V_0}}$ (1) Substitution of correct values (1) Answer = 1.36 [MΩ] (1)	4
	(c)	$C = \frac{\epsilon_0 A}{d}$ used e.g. rearranged (1) $A = x^2$ (or implied) $\rightarrow C = \frac{\epsilon_0 x^2}{d}$ first two marks (1) Answer = 1.49 [m] (1)	3
	(d)	Dielectric between plates	1
		Question 3 total	[10]

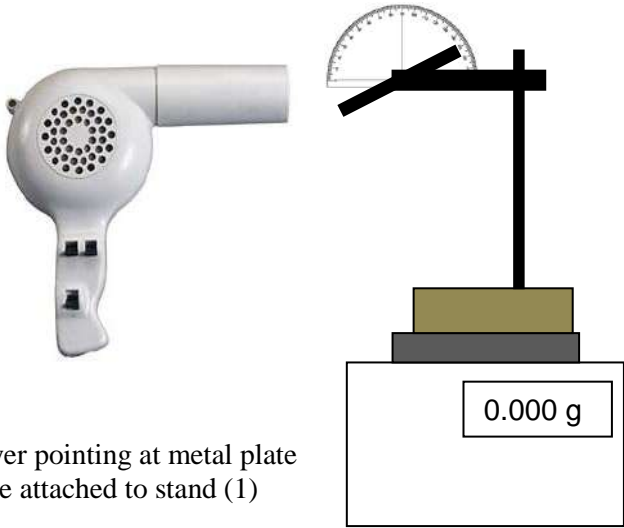
Question		Marking details	Marks Available	
4.	(a)	$Bev = \frac{mv^2}{r} \quad (1)$ <p>Convincing algebra (minimum of showing v cancelling then jumping to answer) i.e. $Bev = \frac{mv^2}{r} \rightarrow r = \frac{mv}{Be} \quad (1)$</p>	2	
	(b)	<p>r stays constant (1) (accept to stop r from increasing)</p> <p>m and e can't be changed (accept $B \propto v$ or $\frac{v}{B} = \text{constant}$ or m increases and e is a constant) (1)</p>	2	
	(c)	<p>Method e.g. $v = \frac{2\pi r}{T}$ or $v = \omega r$ and $\omega = 2\pi f$ or $v = 2\pi fr$ (1)</p> <p>$v = 3 \times 10^7 \text{ [ms}^{-1}\text{]} (1)$</p> <p>$B = \frac{mv}{re}$ i.e. rearranged (1)</p> <p>$B = 0.037 \text{ [T]} (1)$ ecf on v</p>	4	
	(d)	(i)	<p>nI needs to be very large (accept needs very large current) (1)</p> <p>Detail e.g. for $B = 10 \text{ [T]}$, $nI = 8\,000\,000$ (1) (don't accept $n=1$ but accept valid n and I calculation) or wires would melt before high B achieved or n needs thin wires but current needs thick wires etc.</p>	2
	(ii)	<p>Huge currents achievable or no heat dissipation (accept larger currents or large currents)</p>	1	
Question 4 Total			[11]	

Question		Marking details	Marks Available
5.	(a)	The [induced] emf is proportional [or equal] to the rate of change [or cutting] of flux [linkage] or $dBAN/dt$ and terms defined	2
		Nearly correct statements award 1 out of 2 marks e.g. The emf is equal to the change of flux The current is proportional to the rate of change of flux The emf is proportional to the cutting of flux BAN/t and terms defined	
	Wrong statements get 0 The emf is equal/proportional to the flux linkage The current is equal to the rate of change of flux		
	Lenz - the [induced] emf [or current] opposes [or tends to oppose etc.] the change [to which it is due]	1	
(b)	(i)	Clockwise (1) any 1 of FLHR(must have correct direction), FRHR, right hand grip rule (1)	2
	(ii)	Area increases ✓ at an increasing rate ✓ or cutting of flux ✓ inside the loop ✓ or $E=Blv$ ✓ and l is increasing ✓	2
	(iii)	$V = \frac{BAN}{t}$ and $t = \frac{20.1}{31} (= 0.648 \text{ s})$ or $E = Blv$ used (1) $A = \frac{1.8+2.9}{2} \times 20.1 [= 47.2]$ or mean $l = 2.35$ [m] (1) $I = \frac{V}{R}$ (1) Correct answer $I = 77$ [μA] (1)	4
		Question 5 Total	[11]

Question		Marking details	Marks Available
6.	(a)	(i) +ve correct	1
		(ii) voltmeter correct	1
	(b)	$V_H = Bvd$ or implied/ $eE = Bev$ (1) $v = \frac{0.314 \times 10^{-3}}{0.168 \times 0.0043}$ (1) = 0.435 m s ⁻¹ (1) or $E = V/d$ (1) and ans (1)	3
	(c)	Force perpendicular to motion or no motion in direction of E_H or $P = IV$ (or $P = I^2R$) and $I = 0$ in that direction	1
	(d)	Use of $I = nAve$ e.g. $n = \frac{I}{Ave}$ or $V = \frac{BI}{nte}$ (1) Calculation of A or correct substitution (1) Answer $n = 1.16 \times 10^{24} \text{ m}^{-3}$ *** UNIT MARK *** (1) ecf on v	3
		Question 6 Total	[9]

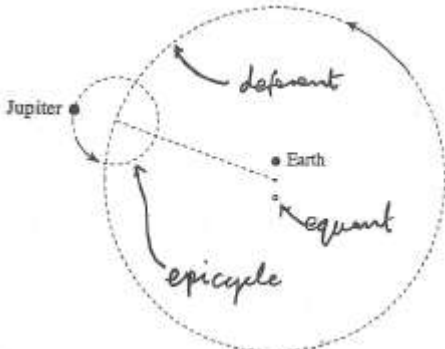


Question		Marking details	Marks Available
7.	(a)	<p><u>Downward momentum</u> given to air hence a <u>force</u> is applied (1) (N.B. downward can appear next to momentum or force)</p> <p>Newton's 3rd (or implied) force exerted on the plane <u>by the air</u> (1)</p>	2
	(b)	<p>Speed is greater at left side [due to conservation of mass] (1) (accept speed is decreasing)</p> <p>Air is decelerating or acceleration to the left or due to decrease in momentum(1)</p>	2
	(c)	<p>Lift component left is unbalanced (1) i.e. linking to resultant force</p> <p>Vertical component of lift is [slightly] less than weight (1) i.e. linking to direction</p> <p>Alternative: Good vector diagram (award 2 marks) The lift and weight added together give a resultant force acting downwards to the left. (award 1 mark only) Or resultant force is down and left (award 1 mark only) Or lift + weight is down and left (award 1 mark only)</p>	2
	(d)	<p>Air has high speed in tornados (1) (accept moving)</p> <p>This means a much lower pressure outside or much higher pressure inside (1) (N.B. much can also be implied by high speed in the 1st mark)</p>	2
	(e)	<p>Attempt at pressure difference (1)</p> <p>Pressure difference correct i.e. 155 [Pa] (1)</p> <p>Pressure difference 155 ecf x 850 [=130 kN] (1) (No marks for using the lift equation)</p>	3

Question	Marking details	Marks Available
(f)	<p>All units correct award 2 marks 2 or 3 units correct award 1 mark LHS= kg m s^{-2} and kg m^{-3}, m s^{-1} and m^2 on RHS (2)</p> <p>Convincing algebra and method (1)</p>	3
(g)	<p>Lift = weight or implied (accept $300 \times \text{g}$) (1)</p> <p>$C_L = 0.90$ (1) ecf on incorrect force</p>	2
(h)	<div style="display: flex; align-items: center; justify-content: center;">  </div> <p>Hair dryer pointing at metal plate and plate attached to stand (1)</p> <p>Protractor set to measure angle of attack or angle labelled (1)</p> <p>Metal plate & attachment on digital balance (1)</p> <p>Labelling of 4/5 of hair dryer, stand / clamp, protractor, digital balance and metal plate (1)</p> <p>Question 7 Total</p>	4
Question 7 Total		[20]

Question		Marking details	Marks Available
8.	(a)	<p>Alternating current means an alternating B-field (needs a direct link) (1)</p> <p>[alternating] B-field transferred through core to secondary (1)</p> <p>Changing flux inside the secondary coil [gives emf] (1) (accept flux cuts the secondary coil but not flux goes through secondary coil)</p>	3
	(b)	<p>(needs design & loss method)</p> <p><u>Low resistance wires</u> to reduce <u>heat dissipation from wires</u> (or equivalent) (1)</p> <p><u>Laminated core</u> to reduce <u>eddy currents</u> (1)</p> <p><u>Suitable core alloy</u> (or silicon steel etc.) to reduce <u>magnetisation losses</u> (or hysteresis or to reduce leakage flux/stray field etc.) (1)</p>	3
	(c)	<p>(i) $\omega = 2\pi f = 24\,000 \text{ [s}^{-1}\text{]}$ (1)</p> <p>$\omega L = 88.7 \text{ [}\Omega\text{]}$ (1)</p> <p>$\frac{1}{\omega C} = 88.7 \text{ [}\Omega\text{]}$ (1)</p> <p>(ii) Reactances are the same (accept impedances) (this can be stated regardless of a wrong answer to (i))</p> <p>(iii) Answer = 6.5 [mA] (allow ecf if full method followed through)</p> <p>(i.e. using $Z = \sqrt{\left(\omega L - \frac{1}{\omega C}\right)^2 + R^2}$ etc.)</p>	3 1 1

Question	Marking details	Marks Available
8.	<p>(iv) Ignore capacitance (or $\omega L - \frac{1}{\omega C}$ attempted) (1)</p> <p>Correct calculation for impedance e.g.. $\sqrt{887^2 + 2\ 200^2}$ (1)</p> <p>Answer = $\frac{14.4}{2370} = 6.1$ [mA] (1)</p> <p>(d) (i) Attempt at an explanation at low and high frequency (1)</p> <p>Correct variation of X_C with frequency (i.e. large at low frequency or low at high frequency) (1)</p> <p>Correct division of pd with respect to frequency (e.g. at high frequency $R \gg X_C$ so V_{OUT} is large or the opposite at low frequency) (1)</p> <p>(ii) Phasor diagram drawn or implied (1)</p> <div data-bbox="837 1097 1204 1321" data-label="Diagram"> </div> <p>$X_C = R$ or $V_C = V_R$ either derived or quoted (implies diagram correct) (1)</p> <p>Answer = 154 [Hz] (1)</p> <p>Question 8 Total</p>	<p>3</p> <p>3</p> <p>3</p> <p>[20]</p>

Question		Marking details	Marks Available
9.	(a)	(i)(I)	2
		<p>2 marks : 3 labels</p> <p>1 mark : 2 labels</p> 	
		(II) Prograde and motion on epicycle and deferent in same direction – or equivalent	1
		(III) Brightness or size	1
		(ii) Either $\frac{2\pi}{T_{E/J}} \Delta t$ (1) represents angle swept out by Earth/Jupiter in time Δt (1)	2
		OR $\frac{\Delta t}{T_{E/J}}$ (1) represents fraction of a cycle swept out by Earth/Jupiter in time Δt Earth sweeps out extra angle 2π or one extra revolution (1)	
		(II) $\frac{1.092}{1} - \frac{1.092}{T_J} = 1$ (1)	2
		$1.092T_J - 1.092 = 1T_J$	
		$T_J = 11.9$ [years] (1)	
	(b)	(i) Nesting of: sphere of mercury / solid / sphere of Venus/solid (1)	
		Didn't give quite correct orbital radii (1)	2

Question		Marking details	Marks Available
		(ii) Mention of Plato or Pythagoras (1)	
		Nature based on mathematics (or equivalent) (1)	2
	(c)	(i) Path of body acted on by central force [towards S] Accept path of planet. (1)	
		[Central] force applied at [just] these points (1)	2
		(ii) Equal areas in equal times OR area swept out proportional to time	1
	(d)	(i) Use of or by implication : (1)	
		$\frac{v^2}{rg_{surf}} \text{ or } \frac{r\omega^2}{g_{surf}} = 2.78 \times 10^{-4}$ (1)	2
		(ii) Attempt to evaluate $\left(\frac{r_E}{r_{MO}}\right)^2$ (1)	
		= 2.75×10^{-4} (1)	2
		(iii) Either: spherically symmetric OR behaves as if all at centre	1
		Question total	[20]

Question		Marking details	Marks Available
10.	(a)	(i) Diameter[accept width/thickness do not accept radius/area]→ micrometer/digital calliper [accept vernier calipers but not vernier only] (1) Original [accept natural] length→ metre rule (1)	2
		(ii) Take (one set of) F and e from graph or Measure gradient [or = $F/\Delta x$] Accept gradient = EA/l (1) Use value of $\pi d^2/4$ or πr^2 [explanation of how A is calculated required – can be awarded from (i)] (1) Insert in relevant equations (1) $Y = \frac{Fl_0}{A\Delta x}$ or $Y = grad \times \frac{l_0}{A}$ etc.	3
	(b)	(i) $[e_{iron}] = \frac{Fl_0}{AE_{iron}}$ [must show $\frac{Fl_0}{A}$]	1
		(ii) Attempt at $e_{brass} + e_{iron}$ (1) Correct manipulation/algebra (1)	2
	(iii) CSA calculated: $7.9 \times 10^{-7} [m^2]$ (1) Substitution (ecf on CSA) (1) $W = 0.042 [J]$ (1) [-1 for slip in power of 10; -1 for use of diameter instead of radius]	3	
	(iv) 1.8 mm UNIT mark	1	

Question		Marking details	Marks Available
	(v)	<p>Greater extension by brass [or smallest extension by iron] (1)</p> <p>$e \propto 1/E$ (1) [link Young modulus to extension]</p> <p>All other factors same for both wires (1)</p> <p>Ratio 2:1 (1.2 mm:0.6 mm) (1) [Full marks may be obtained by calculation only].</p>	4
(c)	(i)	<p>Melamine formaldehyde → thermosetting (1)</p> <p>Low density polyethylene → thermoplastic (1)</p>	2
	(ii)	<p>Melamine brittle – low max strain (1)</p> <p>or polythene not brittle – high max strain</p> <p>Melamine stiffer – higher Young modulus (1)</p> <p>or polythene less stiff – lower Young modulus</p> <p>[or accept low strain for high stress as explanation for stiffness of material]</p> <p>Question total</p>	2
			[20]

Question		Marking details	Marks Available
11.	(a)	(i) Continuous background spectrum (1) Do not accept: a symmetric shape or touching x axis on LHS At least 1 line spectrum (1) Must be part of spectrum not placed on top Minimum wavelength not at 0,0 (1)	3
		(ii) $eV = \frac{hc}{\lambda} \quad (1) \quad E = \frac{hc}{\lambda} \text{ not enough}$ Answer $V = 41\,250$ [V] (1) 41 kV ok but do not accept 41 keV	2
		(iii) Able to penetrate muscle but stopped by denser materials (1) Accept: body/flesh/tissue skin for muscle Accept: bone/harder materials for denser Both needed Expose photographic film (1)	2
		(iv) Any 3x(1) from: –MRI (scan) If X-ray or ultrasound chosen 0 for whole question If PET chosen award maximum of 2 out of 3 marks –[high quality] images of <i>soft tissue</i> –Contrast can be controlled –X-rays are absorbed by bone/skull Accept: MRI not absorbed by skull Accept: X-rays cannot penetrate skull	3

Question		Marking details	Marks Available
	(b)	(i) $Z = \text{Density} \times \text{velocity}$ [of ultrasound in the material] Must be in words as equation is given Do not accept speed of light for velocity	1
		(ii) $Z_1 = 442$ and $Z_2 = 1\,700 \times 10^3$ (1) $f = \text{approx } 1 / 0.995$ (1)	2
		(iii) Almost all ultrasound reflected/ none able to enter the body (1) Need for a coupling gel/medium (1)	2
	(c)	(i) Exposure: amount of radiation incident on the body (1) Do not accept: 'total radiation exposed to' as it is a rewrite of the question. absorbed dose: <u>energy</u> per unit mass absorbed by body (1)	2
		(ii) Dose equivalent = dose x quality factor (1) Do not accept in terms of units Quality factor depends on ionization or alpha $Q = 20$ and gamma $Q = 1$ (1) Greater for alpha than gamma (1)	3
		Question total	[20]

Question		Marking details	Marks Available
12.	(a)	(i) Any 2 x (2) from Easily controllable Accept: no chain reaction (1) Because can switch off protons/hydrogen (1) OR No radioactive by-products or products are alpha particles (1) Any good relevant detail e.g. no storage costs for thousands of years Or alpha particles easily contained etc. (1) OR Fuel cheaper than fuel for fission (1) Detail e.g. per MJ output, H from the sea, no isotope enrichment needed, selling the He would help pay for the fuel (1) OR Fuel supplies would last longer than for fission (1) Detail: sensible remarks about U and H (1)	4
		(ii) 30 000 000 x 300 keV (in whatever units) (1) Conversion so that answer and reaction energy in the same units (i.e. 9 million MeV or equivalent e.g. 2.74×10^{-12} and 1.44×10^{-6} J) (1) Comment implying far less energy out than in (1)	3
		(iii) $7 \times 1.66 \times 10^{-27}$ seen (1) Answer $[10^{16} / 7u] = 8.6 \times 10^{41}$ (1)	2
		(iv) Answer (iii) x 17.1 MeV (or its J equivalent 2.74×10^{-12}) (1) Tolerate slips in powers of 10; answer mark will be lost. previous answer / 5×10^{20} (regardless of mixed units) (1) Answer = 4.7×10^9 (1)	3

Question		Marking details	Marks Available
	(b)	(i) <p>Area = 20 mm x 20 mm or implied (1) Including side-faces loses the mark.</p> <p>Temperature difference = 150 [°C] (1)</p> <p>Heat = 2 040 [W] (1) ecf on A, provided not a volume instead of an area</p>	3
		(ii) <u>Work</u> is done <u>on</u> the gas (1) <p>Internal energy of the gas increases (no heat not required) (1) Freestanding mark i.e. accept if wrongly deduced, but only if link with temperature rise made.</p>	2
		(iii) Efficiency = $1 - \frac{T_2}{T_1}$ accept $\frac{Q_1 - Q_2}{Q_1}$ or $1 - \frac{Q_2}{Q_1}$ (1) <p>T_1 is larger or $\frac{T_2}{T_1}$ is smaller Q_1 is larger or $\frac{Q_2}{Q_1}$ is smaller but these need an explanation e.g. because temperature is higher. If done by putting temperatures into formula, they must be in K. (1)</p> <p>Efficiency is greater in equation (not an independent mark i.e. valid earlier argument needed, ignoring °C instead of K) (1)</p> <p>Question total</p>	3
			[20]



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