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.

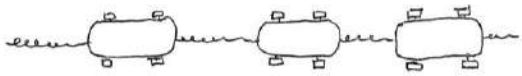
WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

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)		*ut* **shown** to have units: $m\,s^{-1}$ x s→ [m] (1) (½)at^2 **shown** to have units: $m\,s^{-2}$ x s^2 → [m] (1) Comment: **all terms** have same units or equivalent e.g. LHS=RHS (1)	[3]
		(ii)	(I)	$u = 8\,m\,s^{-1}$ **UNIT MARK**	[1]
			(II)	½ a = 3 $a = 6\,[m\,s^{-2}]$	[1]
			(III)	Substitution and answer x = 115[m]	[1]
			(IV)	Equation (1) Substitution (1) **ecf** for *u*, *a* and *x* $v = 38\,[m\,s^{-1}]$ (1)	[3]
				Question 1 total	**[11]**
2.	*(a)*	(i)		[electric] current	[1]
		(ii)		I = 6 [A]	[1]
	(b)	(i)		Parallel combinations calculated: 4 Ω (1); 2 Ω (1) Series addition: 6 [Ω] (1) [**ecf**]	[3]
		(ii)		XY→ ⅔ x 12 =8 [V] (1) **or** I = 12/6 = [2 A] (1) YZ→ ⅓ x 12 =4 [V] (1) V_{xy} = 8 [V] **and** V_{yz} = 4 [V] (1) **ecf**	[2]
		(iii)		No Change (1) Correct explanation in terms of: Either: Ratio of resistances stays the same } (1) **ecf** Or: New current calculated (1⅓ A) and used }	[2]
		(iv)		R = 12/1.5 = 8 [Ω] (1) S_1 open **and** S_2 closed (1)	[2]
		(v)		$P = (12)^2/9$ **or** P = 1⅓ x 12 **or** $P = (1⅓)^2$ x 9 (1) P = 16 [W] (1)	[2]
		(vi)		Strategy - various switch settings and corresponding powers calculated e.g Close S_1: R = 7 Ω **or** Close S_2: R = 8 Ω } (1) P = 20.6 W P = 18 W } Close both: R = 6 [Ω] (1) and P = 24 [W] (1) e.g. $P = V^2/R$ (1) largest P when R smallest or smallest R identified as 6 [Ω] [must be linked to $P = V^2/R$] (1) S_1 and S_2 closed (1) e.g. $P = I^2R$ (1) largest P when I greatest when R smallest [must be linked to $P = I^2R$] (1) S_1 and S_2 closed (1) (N.B. $P=IV$ could be used here) In both of the above the 3rd mark can be awarded as a standalone mark provided some sensible reasoning is given.	[3]
				Question 2 total	**[16]**

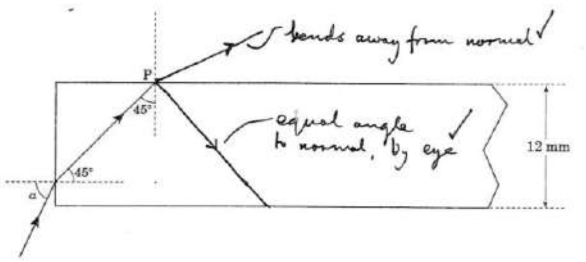
Question			Marking details	Marks Available
3.	*(a)*		[Electrical] energy [or work done] transferred to whole of circuit [or through cell] (1) per coulomb [or unit charge] (1)	[2]
	(b)		Sensible scale and axes labelled with units (1) All points correct ± ½ small square division (1) Line of best fit (1) (no requirement → *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 x 60 [1 200 s] (1) Q = 0.22 **(ecf)** x 1 200 (**ecf**) = 264 [C] (1)	[4]
			Question 3 Total	**[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) ρ = grad x area or substitution into $\rho = RA/l$ (1)	[3]
	(b)		Vol = Al = ⅓A x 3l (CSA reduced to ⅓ original) (1) $R = \frac{\rho 3l}{A/3}$ (1) ρ = constant stated (or implied) (1) **OR**: A = vol/l so $R = \rho l^2$/vol (1) $R \propto l^2$ (1) New $R \propto (3l)^2$ so new R = 9R (1)	[3]
			Question 4 Total	**[10]**

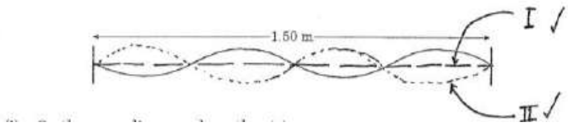
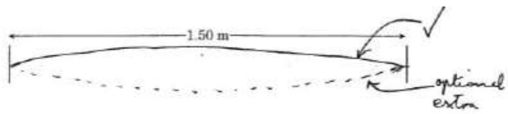
Question			Marking details	Marks Available
5.	*(a)*		Energy cannot be created or destroyed, only converted to other forms.	[1]
	(b)	(i)	½ $mv^2 = mgh$ shown **or** use of $v^2=u^2+2ax$ (1) (no mark for $E_k = E_p$ only) Clear manipulation (1)	[2]
		(ii)	v = 48.5 [m s^{-1}]	[1]
	(c)	(i)	Air resistance /drag (1) Friction between bobsleigh and ice or surface or track or on surface /ice/snow (1)	[2]
		(ii)	Actual v = [48.5 – 20% x 48.5] = 38.8 m s^{-1} (1) **(ecf)** Actual E_k = 210 762 [J] (1)	[2]
		(iii)	**Either** [½ x 280 x (48.5)^2 – 210 762] **or** [280 x 9.8 x 120 – 210 762] (**ecf** on 48.5 or 210 762) (1) Work done against resistive forces = 118 500 J (1) =F x 1 400 (1) **ecf** F = 85 [N] (1) **ecf** for use of 1.4 km	[4]
			Question 5 Total	**[12]**
6.	*(a)*	(i)	cos 40º (1); 600 cos 40º = 460 [N] (1)	[2]
		(ii)	386 [N] no **ecf** if sin or cos mixed up	[1]
	(b)		(90 x 9.8) – 386 (1) (**ecf**) N.B. if 10 used **-**1 mark) = 496 [N] (1)	[2]
	(c)		0.8 x 496 = 397 N (1) **ecf** $\Sigma F_{\text{horizontal}}$ = (460 – 397) = 63 N (1) (**ecf**) a = 0.7 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)		$wx + F_2x_2$	[1]
	(c)	(i)	1.2 [m] **and** 2.8 [m] – correctly labelled	[1]
		(ii)	w x 0.8 = 90 x 1.2 + 100 x 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 [N m] **or** ∑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]**

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 <u>and</u> 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 = <u>340 ± 10 m s^{-1}</u> **<u>UNIT</u>** (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 λ = 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)		λ = 1.1 [m] **or** $\lambda > a$ **or** λ > 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)*			Award 3 x (1) of: • 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 α = 1.33 sin 45° (1) **or** equivalent **or** by implication α = 70° (1)	[2]
		(ii)	I	 No need for arrow heads. No penalty if reflected ray doesn't reach the bottom of the fibre.	[2]
		(ii)	II	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]	[3]
	(c)	(i)		*c* = 49° (1) 50° > 49° **or** 50° > *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) I II		[2]
		(ii)	λ = 0.75 [m] (1) **or** by implication f = <u>128 Hz **UNIT**</u> (1)	[2]
	(c)	(i)		[1]
		(ii)	λ = 3.00 [m] **or** by implication **ecf** provided λ consistent with diagram (1) f = 32 [Hz] (1) **ecf**	[2]
	(d)		32 n [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** <u>from metal</u> **or** <u>from material</u>]. (1) No marks for giving meaning of f_0 . So [minimum] *photon* energy needed is ϕ. (1) So $hf_0 = \phi$ **or** $E_{photon} = hf$ (1)	[3]
		(ii)	Award 2 x (1) of: • More photons per second • Individual photon energies unchanged • E_{kmax} depends on energy of individual photon **or** $E_{kmax} = hf - \phi$ 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 $E_{kmax} = eV$ (1)	[3]
	(c)	(i)	Gradient = 6.7 [± 0.2] x 10^{-34} [J s] (1) Mention of Planck's constant and sensible comparison (1)	[2]
		(ii)	ϕ = 4.1 [± 0.2] x 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)	$\Delta E = 1.87 \times 10^{-19}$ [J] (1) $\lambda = \frac{hc}{\Delta E}$ (1) **or** equivalent, including $\lambda = \frac{c}{f}$ **and** $f = \frac{c}{\lambda}$. $\lambda = 1.06 \times 10^{-6}$ m (1) **ecf** on arithmetical slip in ΔE.	[3]
		(ii)	$\lambda = 7.9 \times 10^{-7}$ [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 1.87×10^{-19} 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)	$\lambda_{\text{peak int}}$ = <u>55 nm</u> **and** $T = \frac{W}{\lambda_{peak\,int}}$ or by implication (1) T = 53 000 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 $P = 2.11 \times 10^{33}$ [W] (1) **or** by implication So $P/P_{\text{sun}} = 5.49 \times 10^6$ **or** $5 \times 10^6\, P_{\text{sun}} = 1.9 \times 10^{33}$ [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 $d = 4.0 \times 10^{10}$ [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 weak interaction. (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 1st mark either of these (u or d): - u: [0 +] 1 +2 → 2 + 2 [+0] **or** 3 → 4 - d: [0 +] 2 +1 → 1 + 1 [+0] **or** 3 → 2 For the 2nd mark: the other (i.e. u or d) **and** remark that a d has changed to a u **OR** equivalent N.B. uud + udd → uud + uud is an alternative for the 1st mark.	[2]
		(iv)	Lepton number not conserved.	[1]
			Question 8 Total	**[8]**

Question			Marking details	Marks Available
1.	*(a)*		Curve for 1st step <u>and</u> line for 2nd step (1) Direction on **both** steps (1) Labelling of state C (1)	3
	(b)	(i)	$V_A = \frac{(0.06)(8.31)(250)}{(8.5\times10^4)} = 1.47\times10^{-3}[\text{m}^3]$	1
		(ii)	$V_B = \frac{(0.06)(8.31)(355)}{(8.5\times10^4)} = 2.08\times10^{-3}[\text{m}^3]$	1
		(iii)	$V_C = \frac{(0.06)(8.31)(355)}{(7.0\times10^4)} = 2.53\times10^{-3}[\text{m}^3]$ (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 = $p\Delta V = (8.5\times10^4)(2.08-1.47)\times10^{-3} \cong 52$ [J] **ecf** Convincing, correct method.	1
		(ii)	Work done = $-\frac{1}{2}(8.5+7.0)\times10^4(2.53-1.47)\times10^{-3} \cong -82$ [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)*		$m = \rho V = 10^3 (1.7 \times 10^{-3}) = 1.7$ [kg]	1
	(b)		**All** points plotted correctly (± half small square division) and straight line (1) Sensible scales on **both** axes (1)	2
	(c)		20 ± 1 [°C]	1
	(d)		3.20 ± 0.05[min] (or 192 ± 3s)	1
	(e)		Heat supplied to water in e.g. 2.5 min (*Q*) $= (3 \times 10^3)(2.5 \times 60) = 4.5 \times 10^5$ [J] (1) e.g. $\Delta\theta = 95.5 - 32.5 = 63$[°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) $c = \frac{4.5 \times 10^5}{(1.7)(63)} = 4.2 \times 10^3$ [J kg^{-1} °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)	3
		(ii)	Gradient of graph shallower or $\Delta\theta$ smaller (1)	
		(iii)	*c* larger (overestimated) (1) No **ecf** within this question part.	
			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 **<u>UNIT</u>** $\frac{(2000)(9.81)}{(0.15)} = 1.31\times10^5$ N m^{-1} (1)	2
	(b)	(i)	$e = \frac{(75+85)g}{(1.31\times10^5)} = 0.012$ [m] = 1.2 [cm] (allow **ecf** for *k*). Correct method. (1) Correct result. (1)	2
		(ii)	$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{2160}{1.31\times10^5}} = 0.81$[s] Substitution into formula. (1) Correct result.(1) Award 2 marks for answer of 0.78 [s]	2
		(iii)	Natural frequency of system is $\frac{1}{0.81} \cong 1.24$ [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 ***<u>quickly</u>*** 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)	$\omega = \frac{45(2\pi)}{60} = 4.71$ [rad s^{-1}] Conversion from rotations to radians, with the '45'. (1) Conversion from minutes to seconds and convincing working. (1)	2
		(ii)	$velocity = \omega r = (4.71)(0.08) = 0.38$ [m s^{-1}] Formula and substitution. (1) Result. (1)	2
		(iii)	$acceleration = \omega^2 r = (4.71)^2 (0.08) = 1.77$ [m s^{-2}] Formula and substitution. (1) Result (1)	2
		(iv)	Towards point Q, or towards centre of circle.	1
	(b)	(i)	$A = 0.080$ [m]	1
		(ii)	$T = \frac{2\pi}{\omega} = \frac{2\pi}{4.71} = 1.33$[s]	1
		(iii)	$a = -1.77\sin(4.71 \times 0.20) = -1.43$ [m s^{-2}] 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) $\frac{6.63\times10^{-34}}{620\times10^{-9}} = -\frac{6.63\times10^{-34}}{620\times10^{-9}} + (1.67\times10^{-27})v$ $v = 1.28$ [m s^{-1}]	2
		(iii)	$E = hf = \frac{hc}{\lambda} = \frac{(6.63\times10^{-34})(3\times10^{8})}{620\times10^{-9}} = 3.2\times10^{-19}$ [J]	1
	(b)	(i)	Equating momenta, rearranging and substitution (1) $mv = \frac{h}{\lambda}$ $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{(1.67\times10^{-27})(1.28)} = 3.10\times10^{-7}$[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)	$\frac{F}{m} = -\frac{GM}{r^2} = -\frac{(6.67\times10^{-11})(1.99\times10^{30})}{(1.50\times10^{11})^2} = [-]5.90\times10^{-3}$ N kg^{-1} formula and substitution (1) result with **<u>UNIT</u>** (1).	2
		(ii)	$-\frac{GM}{r} = -\frac{(6.67\times10^{-11})(1.99\times10^{30})}{(1.50\times10^{11})} = -8.85\times10^{8}$ [J kg^{-1}] formula and substitution (1) result with sign (1) **ecf**	2
	(b)	(i)	$r_1 = \left(\frac{M_2}{M_1+M_2}\right)d = \left(\frac{1.90\times10^{27}}{1.99\times10^{30}+1.90\times10^{27}}\right)(7.79\times10^{11})$ or with approximation (1) $= 7.43\times10^{8}$ [m] (1). $7.43\times10^{8} > 6.96\times10^{8}$ (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) $2\pi\sqrt{\frac{(7.79\times10^{11})^3}{(6.67\times10^{-11})(1.99\times10^{30}+1.90\times10^{27})}} = 3.75\times10^{8}$ [s] or with approximation. $\omega = \frac{2\pi}{T} = 1.68\times10^{-8}$ [rad s^{-1}] (allow **ecf**). (1) $speed = \omega r_1 = (1.68\times10^{-8})(7.43\times10^{8}) = 12.5$ [m s^{-1}] (1)	4
			Question 6 Total	**[11]**

Question			Marking details	Marks Available
7.	*(a)*	(i)	$separation = 2(0.75)\sin 10^\circ = 0.26$ [m] Factor 2 (1) Formula with substitution for one string. (1)	2
		(ii)	$F = \frac{1}{4\pi\varepsilon_o}\frac{(2.55\times10^{-7})^2}{(0.26)^2} = 8.65\times10^{-3}$ [N] Substitution into formula. (1) Result.(1)	2
		(iii)	Method. $PotentialEnergy = \left(-\frac{1}{4\pi\varepsilon_o}\frac{q}{(0.26)}\right)(-q)$(1) Convincing substitution (1) $= \frac{(2.55\times10^{-7})^2}{4\pi(8.85\times10^{-12})(0.26)} = 2.25\times10^{-3}$ [J]	2
	(b)	(i)	$F = T\sin 10^\circ$ (1) Rearranging to $T = \frac{F}{\sin 10^\circ}$ (1) Substitution and result. $T = \frac{8.65\times10^{-3}}{\sin 10^\circ} = 0.050$ [N] (1) (allow **ecf** for force).	3
		(ii)	Convincing use of $mg = T\cos 10^\circ$ to obtain $m = 5.0\times10^{-3}$ [kg]	1
			Question 7 Total	**[10]**

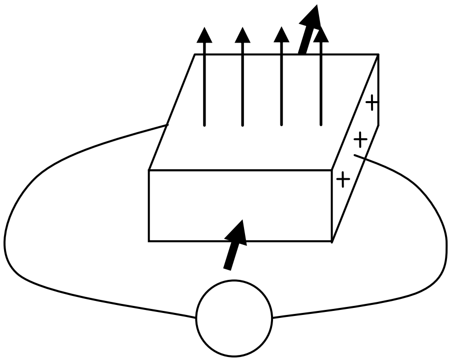
Question			Marking details	Marks Available
1.	*(a)*		Correct α or β absorber (1)	
			If drop after α absorber, then α present (1) (Alpha is stopped by paper – award 2 marks)	
			If **further** drop after β absorber then β present (1)	
			If (significant) count after β absorber then γ present or equivalent (1)	4
	(b)	(i)	19 x 10^{15} [Bq]	1
		(ii)	Use of $\lambda = \frac{ln2}{T_{1/2}}$ (1) e.g. 0.0271 per day or 3.13 x 10^{-7} 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 x 10^{12} [Bq] (1)	4
		(iii)	Attempt at using $A = \lambda N$ e.g. $76 \times 10^{15} = \lambda N$ (1)	
			N = 2.4 x 10^{23} (1)	2
			Question 1 Total	**[11]**

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

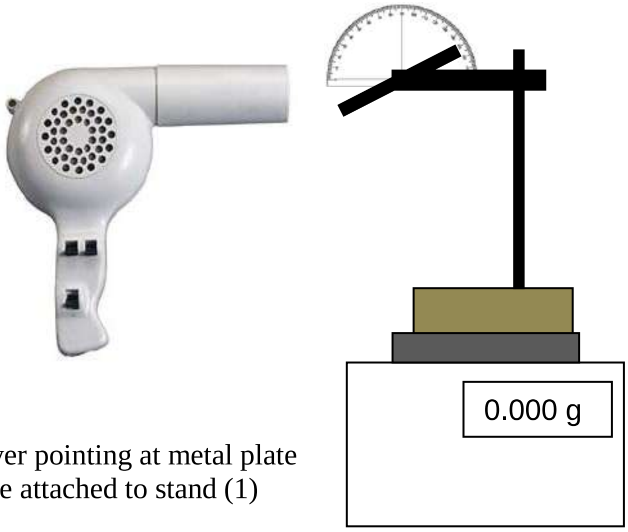
Question			Marking details	Marks Available
3.	*(a)*		$Q = CV$ (1)	
			212 [nC] (1)	2
	(b)		Taking logs e.g. $\ln Q = \ln Q_0 - \frac{t}{CR}$ (1)	
			Algebra e.g. $R = -\frac{t}{C\ln\frac{V}{V_0}}$ (1)	
			Substitution of correct values (1)	4
			Answer = 1.36 [MΩ] (1)	
	(c)		$C = \frac{\varepsilon_0 A}{d}$ used e.g. rearranged (1)	
			A = x^2 (or implied) → $C = \frac{\varepsilon_0 x^2}{d}$ 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)*		$Bev = \frac{mv^2}{r}$ (1) Convincing algebra (minimum of showing *v* cancelling then jumping to answer) i.e. $Bev = \frac{mv^2}{r} \rightarrow r = \frac{mv}{Be}$ (1)	2
	(b)		*r* stays constant (1) (accept to stop *r* from increasing) *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)	2
	(c)		Method e.g. $v = \frac{2\pi r}{T}$ or $v = \omega r$ and $\omega = 2\pi f$ or $v = 2\pi f r$ (1) $v = 3 \times 10^7$ [m s^{-1}] (1) $B = \frac{mv}{re}$ i.e. rearranged (1) *B* = 0.037 [T] (1) **ecf** on *v*	4
	(d)	(i)	*nI* needs to be very large (accept needs very large current) (1) Detail e.g. for *B* = 10 [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.	2
		(ii)	Huge currents achievable or no heat dissipation (accept larger currents or large currents)	1
			Question 4 Total	**[11]**

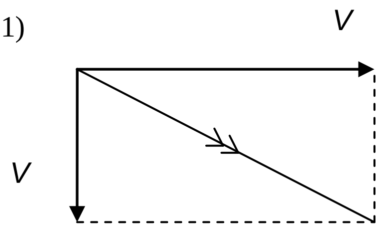
Question			Marking details	Marks Available
5.	*(a)*		The [induced] emf is proportional [or equal] to the rate of change [or cutting] of flux [linkage] or d*BAN*/d*t* and terms defined Nearly correct statements award 1 out of 2 marks e.g. The emf is equal to the change of flux The current is **proportional** 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	2
			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]**

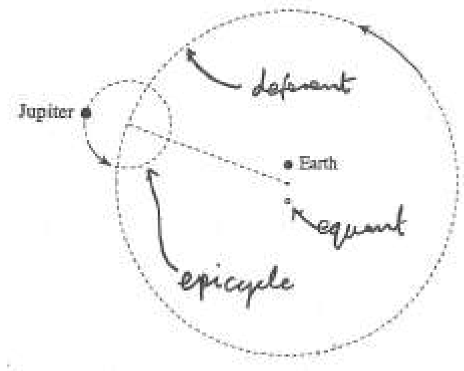
Question			Marking details	Marks Available
6.	*(a)*	(i)	+ve correct	1
		(ii)	voltmeter correct	1
				
	(b)		$V_H = Bvd$ or implied/$eE = Bev$ (1) $v = \frac{0.314\times10^{-3}}{0.168\times0.0043}$ (1) = 0.435 m s^{-1} (1) **or** $E=V/d$ (1) and ans (1)	3
	(c)		Force perpendicular to motion or no motion 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 $n = 1.16\times10^{24}$ m^{-3} *** **UNIT MARK** *** (1) **ecf** on v	3
			Question 6 Total	**[9]**

Question			Marking details	Marks Available
7.	*(a)*		<u>Downward</u> <u>momentum</u> given to air hence a <u>force</u> is applied (1) (N.B. downward can appear next to momentum or force) Newton's 3rd (or implied) force exerted on the plane <u>by the air</u> (1)	2
	(b)		Speed is greater at left side [due to conservation of mass] (1) (accept speed is decreasing) Air is decelerating or acceleration to the left or due to decrease in momentum(1)	2
	(c)		Lift component left is unbalanced (1) i.e. linking to resultant force Vertical component of lift is [slightly] less than weight (1) i.e. linking to direction 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)	2
	(d)		Air has high speed in tornados (1) (accept moving) 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)	2
	(e)		Attempt at pressure difference (1) Pressure difference correct i.e. 155 [Pa] (1) Pressure difference 155 **ecf** x 850 [=130 kN] (1) (No marks for using the lift equation)	3

Question			Marking details	Marks Available
	(f)		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) Convincing algebra and method (1)	3
	(g)		Lift = weight or implied (accept 300 x g) (1) C_L = 0.90 (1) **ecf** on incorrect force	2
	(h)		 Hair dryer pointing at metal plate and plate attached to stand (1) Protractor set to measure angle of attack or angle labelled (1) Metal plate & attachment on digital balance (1) Labelling of 4/5 of hair dryer, stand / clamp, protractor, digital balance and metal plate (1)	4
			Question 7 Total	**[20]**

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

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

Question			Marking details	Marks Available
9.	(a)	(i)(I)	2 marks : 3 labels 1 mark : 2 labels  	2
		(II)	Prograde and motion on epicycle and deferent in same direction – or equivalent	1
		(III)	Brightness or size	1
		(ii) (I)	Either $\frac{2\pi}{T_{E/J}}\Delta t$ (1) represents angle swept out by Earth/Jupiter in time Δt (1) **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)	2
		(II)	$\frac{1.092}{1} - \frac{1.092}{T_J} = 1$ (1) $1.092T_J - 1.092 = 1T_J$ $T_J = 11.9$ [years] (1)	2
	(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) $\frac{v^2}{rg_{surf}}$ *or* $\frac{r\omega^2}{g_{surf}}$ =2.78 x 10^{-4} (1)	2
		(ii)	Attempt to evaluate $\left(\frac{r_E}{r_{MO}}\right)^2$ (1) = 2.75 x 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: 7.9×10^{-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)	Greater extension by brass [or smallest extension by iron] (1) $e \alpha 1/E$ (1) [link Young modulus to extension] All other factors same for both wires (1) Ratio 2:1 (1.2 mm:0.6 mm) (1) [Full marks may be obtained by calculation only].	4
	(c)	(i)	Melamine formaldehyde → thermosetting (1) Low density polyethylene → thermoplastic (1)	2
		(ii)	Melamine brittle – low max strain (1) **or** polythene not brittle – high max strain Melamine stiffer – higher Young modulus (1) **or** polythene less stiff – lower Young modulus [or accept low strain for high stress as explanation for stiffness of material]	2
			Question total	**[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)	$eV = \frac{hc}{\lambda}$ (1) $E = \frac{hc}{\lambda}$ 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 *soft tissue* –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 = Density x 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 x 10^3 (1) f = 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. $2.74\text{x}10^{-12}$ and $1.44\text{x}10^{-6}$ J) (1) Comment implying far less energy out than in (1)	3
		(iii)	$7 \text{ x } 1.66 \text{ x } 10^{-27}$ seen (1) Answer $[10^{16} / 7u] = 8.6\text{x}10^{41}$ (1)	2
		(iv)	Answer (iii) x 17.1 MeV (or its J equivalent $2.74 \text{ x } 10^{-12}$) (1) Tolerate slips in powers of 10; answer mark will be lost. previous answer / $5 \text{ x } 10^{20}$ (regardless of mixed units) (1) Answer = $4.7\text{x}10^{9}$ (1)	3

Question			Marking details	Marks Available
	(b)	(i)	Area = 20 mm x 20 mm or implied (1) Including side-faces loses the mark. Temperature difference = 150 [°C] (1) Heat = 2 040 [W] (1) **ecf** on *A*, provided not a volume instead of an area	3
		(ii)	<u>Work</u> is done <u>on</u> the gas (1) 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.	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) 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) Efficiency is greater in equation (not an independent mark i.e. valid earlier argument needed, ignoring °C instead of K) (1)	3
			Question total	**[20]**

WJEC
245 Western Avenue
Cardiff CF5 2YX
Tel No 029 2026 5000
Fax 029 2057 5994
E-mail: exams@wjec.co.uk
website: www.wjec.co.uk