GCE MARKING SCHEME

PHYSICS
AS/Advanced

JANUARY 2014

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2014. 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)*			A quantity which has magnitude [accept size] and direction.	[1]
	(b)			[Resultant] Force (1) Acceleration (1) (award 1 mark only if both symbols identified correctly)	[2]
	(c)	(i)		$2T$ (1) x cos 37° (1) [= 8 000 N]	[2]
		(ii)		F_{drag} = 6 000 [N]	[1]
	(d)			F = 6 000 N (1) **ecf** from *(c)*(ii) d = 2.5 x 60 (1) W = 6 000 x 2.5 x 60 = 9 x 10^5 J (1) **UNIT mark**	[3]
				Question 1 total	**[9]**
2	*(a)*			n- number of free/conducting electrons (charge carriers) per unit volume (1) accept free electron density v- drift velocity (1)	[2]
	(b)			LHS: C s^{-1} (1) RHS: m^{-3} x m^2 x m s^{-1} x C (1) Clear manipulation to show/state LHS = RHS (1)	[3]
	(c)	(i)		$v = \frac{I}{nAe}$ (1) (or correct substitution) v = 1.30 x 10^{-4} m s^{-1} (1) (-1 for slips in powers of 10) $t = \frac{5.0}{1.30\text{x}10^{-4}}$ = 3.85 x 10^4 [s] (1) **ecf** for incorrect value of v	[3]
		(ii)		Reduced CSA (or diameter) **<u>and</u>** n,e constant...... (1) ...Increased v ...... (1) .....Hence reduced t (1)	[3]
				Question 2 total	**[11]**

Question				Marking details	Marks Available
3	*(a)*	(i)		Displacement (don't accept distance)	[1]
		(ii)		Shaded area = ½ tv (1) u = 0 shown or implied (1) $v = at$ and clear substitution (1)	[3]
	(b)	(i)		2.2 [s]	[1]
		(ii)		Valid substitution into $v = u + at$ (e.g. $0 = u - g$ x 1.1 or $2u = 2.2g$ etc) Or any other valid kinematic equation (**ecf** on t from (i)) Correct algebra/manipulation (1) u = 10.8 [m s^{-1}] (1)	[3]
		(iii)		Correct substitution into $x = ut + ½ at^2$ (i.e. x = 10.8 x 0.3 – ½ x 9.81 x 0.3^2) (**ecf** on 10.8 m s^{-1}) (1) x = 2.8 [m] (1)	[2]
	(c)			Reasonable scales on both axes (1) Diagonal straight line from (0, ±10.8 (**ecf**)) to (1.1 (**ecf**), 0) (1) Diagonal line continued to (2.2, ±10.8) (1)	[3]
	(d)			Two vertical downwards arrows shown during upward motion (1) Single vertical downwards arrow shown at max height (1) Vertical upwards and vertical downwards arrows shown during downward motion (1) All labels correct (weight or force due to gravity, air resistance or force due to air) (1)	[4]
				Question 3 Total	**[17]**

Question				Marking details	Marks Available
4	*(a)*	(i)		Metal wire at constant temperature - straight diagonal line. Filament of lamp - curved line.	[1]
		(ii)		Straight line: R constant throughout [or V/I constant] as... (1) ....T constant throughout (1) Curve: Initially R constant [or V/I constant] as....(1) Then T increases (1) so R increases - accept explanation in terms of particles (1)	[5]
	(b)	(i)		$I = 2$ [A]	[1]
		(ii)	(I)	Voltage across X = 12 [V]	[1]
			(II)	12 V - 6 V = 6 [V] **ecf** from (I)	[1]
			(III)	$R_2 = \frac{6}{4} = 1.5[\Omega]$ **ecf** from (II)	[1]
			(IV)	V across $R_1 = 3$ [V] (1) I through $R_1 = 6$ [A] (1) $R_1 = \frac{3}{6}$ (**ecf** on I and/or V) = 0.5[Ω] (1)	[3]
				Question 4 Total	**[13]**

Question				Marking details	Marks Available
5	*(a)*			$R = \frac{\rho \ell}{A}$ (1) ρ constant (1) Effect of change in *l* **and** *A* on *R* (1)	[3]
	(b)	(i)		CSA = 2.4×10^{-10} m^2 (1) $l = 6 \times 3.2 \times 10^{-2}$ m (= 0.192 m) (1) Correct substitution into $R = \frac{\rho \ell}{A}$ to show R = 56 [Ω] (1)	[3]
		(ii)		0.1% x 56 = 0.056 Ω (1) $\Delta l = 1.9 \times 10^{-4}$ [m] (**ecf**) (1)	[2]
		(iii)		Zig-zag pattern ensures long length of wire (1) Therefore maximise Δ*l* (or maximise Δ*R* - or equivalent) **or** measure strain in a small region (1)	[2]
				Question 5 Total	**[10]**
6	*(a)*			No net force (1) No net moment (1)	[2]
	(b)	(i)		Downward pointing arrow placed in (approximate) centre of beam	[1]
		(ii)		Clockwise: (10 x 1.5) + (20 x 3) (1) Anti-clockwise: 40*d* (1) *d* = 1.875 [m] (1)	[3]
		(iii)		10 [N] (1) Downwards (1)	[2]
				Question 6 Total	**[8]**

Question				Marking details	Marks Available
7	*(a)*	(i)		Mass of air = $\rho A u$ (1) Convincing substitution into ½ mu^2 (1)	[2]
		(ii)	(I) (II)	4 (1) 8 (1)	[2]
		(iii)		$\frac{1}{2} A\rho(u^3 - v^3)$ (or equivalent)	[1]
		(iv)		Turbines in front will have removed energy from the wind - or equivalent	[1]
		(v)		Substitution into $\frac{1}{2} A\rho(u^3 - v^3)$ (or equivalent) (1) P = 1 644 [W] (1) (- 1 mark for error in A)	[2]
	(b)	(i)		Energy passing through blades insufficient to overcome friction of moving parts.	[1]
		(ii)		Efficiency = 54% ±1% (1) P = 888 W (**ecf** from *(a)*(v)) **UNIT mark** (1)	[2]
	(c)			Density of water much greater than density of air	[1]
				Question 7 Total	**[12]**

Question				Marking details	Marks Available
1	(a)			0.40 [m]	1
	(b)			$v = \frac{0.050}{0.10}, \frac{0.450}{0.10}$ etc **or** $\left(\frac{1}{0.8}\right)$x0.4 or by implication (1) v = 0.50, 4.5 etc [m s^{-1}] (1)	2
	(c)			1.25 Hz **UNIT MARK** [**ecf** on v and λ and T]	1
	(d)			same	1
	(e)			**B** lags **A** (1) by ¼ cycle / 90° / $\frac{\pi}{2}$ accept $\frac{T}{4}$ or $\frac{\lambda}{4}$ (1)	2
				Question 1 total	**[7]**
2	(a)			Direction of wave [or energy] travel and direction of [particle] displacements [or oscillations] are the same [or parallel].	1
	(b)	(i)		diffraction	1
		(ii)		No zeros (or waves spread right round) so $\lambda \geq 0.3$ m (1) λ = 0.9 m for 375 Hz or λ = 0.09 m for 3 750 Hz or if λ = 0.3 m then f = 1 100 Hz (1) 375 Hz more likely with some supporting argument, e.g. the above, or even just "Longer wavelengths [or lower frequencies] spread more."] (1)	3
	(c)			λ = 140 [mm] (1) Any 2 x (1): Interference occurs between [accept superposition of] waves travelling in opposite directions [accept waves from speaker and reflected waves] Board acts as reflector Stationary wave set up	3
				Question 2 total	**[8]**

Question				Marking details	Marks Available
3	(a)	(i)		Same point in cycle at same time **or** equivalent	1
		(ii)		$S_2P - S_1P$ **or** equivalent. [Accept $S_1P - S_2P$]	1
		(iii)	(I)	Path difference = 36 mm (1) which is 3λ, so constructive. (1) Award 1 mark only for : $S_1Q = 28\lambda$, $S_2Q = 25\lambda$ therefore arrive in phase so constructive interference	2
			(II)	[Path difference doesn't change], so always constructive (1) but signal strength will decrease as we move further from sources. (1)	2
		(iv)		$y = \frac{12\text{x}360}{36}$ even if units inhomogeneous (1) y = 120 mm **UNIT** (1)	2
	(b)			correct insertion of 12 [mm] and 30 [mm] into grating equation or by implication (1) 24° (1) 53° (1) award 1 mark if both angles wrong because of arithmetic error Either 0° **or** ± 24°**and** ± 53° **or** equivalent. (1)	4
				Question 3 total	**[12]**
4	(a)	(i)		incident ray **and** angle *c* marked **and** grazing refracted ray	1
		(ii)		$n_1 \sin c = n_2 \sin 90°$ (1) $\sin 90° = 1$ **or** $n_1 \sin c = n_2$ (1)	2
	(b)	(i)		$\sin c = \frac{x}{s}$ **and** *c* marked on diagram (1) convincing algebra (1)	2
		(ii)		$v = 2.0 \times 10^8 \text{ m s}^{-1}$ [**or** by implication] (1) t = 6.00 μ[s] [**or** t = 4.00 μs, in which case first mark not gained] (1)	2
		(iii)		time via zigzag = 6.00 μs x $\frac{1.500}{1.485}$ [= 6.06 μs] or $\frac{1212}{2\text{x}10^8}$ (1) [**ecf** on t = 6.00 μs **or** by implication] Δt = 0.06 μ[s] [ecf on 6.00 μs] (1)	2
		(iv)		[$\frac{1}{6.00\text{x}10^{-6}}$] = 17×10^6 [s^{-1}] [Accept $(18 \pm 2) \times 10^6$] (1) assumes negligible pulse duration [**or** assumes angles of incidence range from 0 to *c* or longest path is 1 212 m] (1)	2
				Question 4 Total	**[11]**

Question				Marking details	Marks Available
5	(a)	(i)		[minimum] energy needed to eject an electron from the metal [**or** surface **or** solid **not** atom]	1
		(ii)		6.9 x 10^{14} [Hz]	1
		(iii)		Photon energy not high enough [< work function] (1) Electrons can't escape (1)	2
	(b)			$f = \frac{(E_{k\max} + \phi)}{h}$ **or** correct transposition at any stage **or** by implic(1) = 1.0 x 10^{15} [Hz] (1)	2
	(c)	(i)		3.2 x 10^{-19} [J] (1) This uses the higher energy [**or** the higher frequency] photons, or produces the higher energy electrons, **or** photons don't co-operate **or** equivalent (1)	2
		(ii)		2.0 [V] **ecf**	1
				Question 5 Total	**[9]**
6	(a)	(i)		$\lambda = \frac{hc}{\Delta E}$ **or** [$\lambda = \frac{c}{f}$ **and** $E = hf$] or f = 2.8 x 10^{14} [Hz] (1) λ = 1.06 x 10^{-6} [m] (1)	2
		(ii)		*up* arrow from L to U (1) Photon's energy given to atom **or** electron (1)	2
		(iii)	(I)	[Incident] photon causes electron to drop from U to L. (1) Incident photon must have energy $E_U - E_L$ or equivalent (1) Photon emitted so now 2 photons present; accept by implic from emitted photon in phase.(1)	3
			(II)	Need more electrons in U than L. *Accept*: need pop'n inversion (1) Electrons pumped to P and drop to U (1) Electrons drop from L to ground [helping to keep L depopulated].(1)	3
	(b)			Any 2 x (1): monochromatic [or equivalent e.g. long wave-trains] photons in phase (don't accept waves in phase) light in phase (or wavefronts continuous) across width of beam	2
				Question 6 Total	**[12]**

Question				Marking details	Mark Available
7	(a)	(i)		λ_{peak} = 430 n[m] [± 10 nm] (1) T = 6 700 [K] **ecf** on λ_{peak}, provided it's not 1 200 nm (1)	2
		(ii)		T = 5 400 [K] [± 250 K]	1
		(iii)		bluer or whiter at maximum T **or** redder at minimum T	1
	(b)			$A = \frac{P}{\sigma T^4}$ (transposition at any stage) **or** by implication (1) $A = \frac{1.46\text{x}10^{30}}{5.76\text{x}10^{-8}\text{x}6700^4}$ [= 1.3 x 10^{22}m^2] **ecf** on T (1) use of $A = 4\pi r^2$ **or** $A = \pi d^2$ (1) d = 6.4 x 10^{10} [m] **ecf** on T if value from *(a)*(i) used (1) Slips of factors of 2 or 10 lose 1 mark each.	4
	(c)			$\left(\frac{P_{min}}{P_{max}}\right) = \left(\frac{T_{min}}{T_{max}}\right)^4$ **or** P_{min} = 6.2 x 10^{29} W **ecf** (1) $\frac{P_{min}}{P_{max}} = 0.42$ **ecf** **or** $P_{max} - P_{min}$ = 8.4 x 10^{29} W **ecf** (1) $\left(\frac{P_{max} - P_{min}}{P_{max}}\right) = 0.58$ [accept] = 58% (1)	3
				Question 7 Total	**[11]**
8	*(a)*			+2, 0 (1) ūd, –1, 0 (1) [blank], 0, 1 [Accept 'none' instead of cell left blank.] (1)	3
	(b)	(i)		Sun **or** stars	1
		(ii)		e-m **and** γ **or** photon involvement	1
		(iii)		In stage 1: 0 + 0 goes to 0 – 1 + 1 [or equivalent] (1) In stages 2 and 3, zeros throughout or equivalent (1)	2
		(iv)	(I)	uud + uud goes to uud + udd accept d: 2→3, u: 4→3 (1) A u is lost and a d is gained [or a u changes to a d]. (1)	2
			(II)	Neither involves weak force or equivalent e.g. only strong [and em] force involved.	1
				Question 8 Total	**[10]**

Question				Marking details	Marks Available
1	(a)			The total momentum (of a system) is constant (must have total, sum, vector sum etc.) (1) Provided no external [resultant] force (1) e.g. - The momentum before and after a collision is the same - 0 When two particles collide the sum of momentum stays the same as long as no forces are involved - 1	2
	(b)			$\lambda = \frac{c}{f}$ i.e. rearranged or $E = hf$ = 2.13x10^{-13} [J] (1) $p = \frac{h}{\lambda}$ **used** or $p = \frac{E}{c}$ **quoted** (1) Final evidence $p = \frac{6.63\times10^{-34}}{9.35\times10^{-13}}$ or $p = \frac{2.128\times10^{-13}}{3\times10^{8}}$ (= 7.09 x 10^{-22}) (1)	3
	(c)			Reasonable attempt at cons of mom e.g. initial *p* of Ni = final *p* of Ni ± *p* of photon (1) 2 440 x 9.95 x 10^{-26} = 7 x 10^{-22} - 9.95 x 10^{-26} v (1) Answer = 4 700 [m s^{-1}] or slightly different dependent on (b) (1) **ecf** on *p*	3
				Question 1 Total	**[8]**

Question				Marking details	Marks Available
2	(a)			$\frac{1}{3}\rho\overline{c^2}V = nRT$ i.e. some sort of combining both equations (1) Realising $\rho = \frac{Nm}{V}$ (any mistakes in *N* and *m* means max of 1/3) (1) (or equivalent steps) **Clear** algebra with no mistakes leading to $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ or $\frac{1}{2}m\overline{c^2} = \frac{3}{2}\frac{R}{N_A}T$ (if it's difficult to follow don't award the mark - needs to be clear) (1)	3
	(b)	(i)		Mass of argon molecule = 6.3(08)x10^{-26} (1) Algebra or equivalent method $T = \frac{m\overline{c^2}}{3k}$ or $T = \frac{N_A m\overline{c^2}}{3R}$ (1) Answer = 605 [K] (1) **ecf**	3
		(ii)		$\sqrt{\overline{c^2}} \propto \sqrt{T}$ or correct substitution of 1 210 K (**ecf**) and algebra (1) Answer = $630 \times \sqrt{2}$ or 891 [m s^{-1}] (1)	2
				Question 2 Total	**[8]**

Question				Marking details	Marks Available
3	(a)	(i)		Graph is straight line through origin [hence proportional] (1) (accept acceleration is proportional to displacement) Negative gradient [hence direction ok] (1)	2
		(ii)		Gradient calculated correctly i.e. $\frac{1}{0.028}$ or 36 (or k calculated from $ma = kx$ i.e. 7.14 N m^{-1}) (1) Gradient = angular velocity squared i.e. method **explained** Or $f = \left(2\pi\sqrt{\frac{m}{k}}\right)^{-1}$ i.e. equation for T **and** $f = 1/T$(1) Answer = $\frac{5.98}{2\pi}$ = 0.95 [Hz] (1)	3
		(iii)		1 m s^{-2} read off graph Or 6^2 x 0.028 = 1 [m s^{-2}]etc.	1
		(iv)		Max speed = ωA or implied (= 0.167) (1) KE = $\frac{1}{2}mv^2$ or implied (1) Answer = 2.8 [mJ] (1) **ecf**	3
		(v)		$v = A\omega\cos\omega t$ used or $\varepsilon = 0$ stated (1) Rearrangement e.g. $\omega t = \cos^{-1}\frac{v}{A\omega}$ or implied (1) Correct answer = 0.156 [s] (1) **ecf**	3
	(b)			KE to PE **or** PE to KE (1) PE is both GPE and EPE (1) Energy gradually lost due to friction or air resistance or internal energy of spring/air etc. Not sound, not heat by itself - needs more e.g. lost as heat to the air ok (1) Detail of energy loss e.g. internal energy of air, KE of air particles	4
				Question 3 total	**[16]**

Question				Marking details	Marks Available
4	(a)			$T = \frac{pV}{nR}$ seen or implied (1) Evidence of 1 correct substitution (1) Evidence of all 3 substituted correctly (1) A - (0.500 ± 0.002, 80 000 ± 2 000) B - (0.260 ± 0.002, 235 000 ± 2 000) C - (0.260 ± 0.002, 80 000 ± 2 000)	3
	(b)			$U = \frac{3}{2}nRT$ used (1) Evidence of ΔT being used or differences in U being calculated (once) (1) AB = 31 500 [J], BC = - 60 500 [J], CA = 29 000 [J] (1)	3
	(c)	(i)		AB approximated as a trapezium (accept triangle gives 19 000 J) (1) AB = - 38 000 [J] (1) AB ≈ (- 32 000 ± 3 000) J due to better method ✓✓✓ e.g. two trapezia or 2 triangles or square counting, or any attempt at integrating pV (unlikely) etc. (i.e. 2 marks for good method 1 mark for correct answer) (1)	3
		(ii)		BC = 0 (independent)	1
		(iii)		CA = 19 200 [J]	1
	(d)	(i)		$Q = \Delta U + W$ i.e. equation used (1) Correct answer with **their** figures e.g. 31 500 – 38 000 = -6 500 (also **ecf** possible for 31 500 + 38 000 = 69 500) (1)	2
		(ii)		No time for heat transfer	1
				Question 4 Total	**[14]**

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Question				Marking details	Marks Available
5	(a)	(i)		$g = \frac{GM}{r^2}$ used (1)	
				Answer = 3.7 $m\,s^{-2}$ or $N\,kg^{-1}$ or equivalent (1) **UNIT MARK**	2
		(ii)		$V_g = -\frac{GM}{r}$ used (1)	
				Answer = ± 9.02 [$MJ\,kg^{-1}$] (1) **ecf** on km conversion	2
		(iii)		Negative amount of work bringing mass from ∞ (accept no work done bringing from ∞ or system will do work or work is done in the other direction etc.)	1
	(b)	(i)		$PE = V_g \times m$ or implied (1)	
				$KE = \frac{1}{2}mv^2$ used (1)	
				Answer = 656 kJ - 4.1 MJ = - 3.44 [MJ] (1)	3
		(ii)		$-\frac{GMm}{r} = -3.44$ MJ (1)	
				r = 2 905 km (1)	
				Height = 465 [km] (1) **ecf**	3
				Question 5 Total	**[11]**

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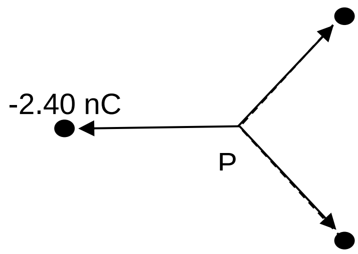
Question				Marking details	Marks Available
6	(a)			Arrows pointing towards charges similar to shown ✓✓ Arrows pointing away from charges similar to shown ✓ 	2
	(b)			$E = \frac{Q}{4\pi\varepsilon_0 r^2}$ used (1) The 2 vertical components cancel or no field into or out of page (1) Pythagoras or trig e.g. $\sqrt{5^2 - 4^2} = 3$ or recognising 3,4,5 triangle (equivalent is to realise cos θ = 3/5 or θ = 53° etc.) (1) 2 nC charge field x2 **and** x3/5 **ecf** (for horizontal components) (1) Calculations all ok e.g. 8 640 = 7 200 x 2 x 3/5 or equivalent shown (1)	5
	(c)			$V = \frac{Q}{4\pi\varepsilon_0 r}$ used (1) Attempt at adding all 3 potentials (1) - 360 -360 - 432 = - 1 152 V or J C^{-1} or equivalent (1) **UNIT MARK**	3
	(d)			Use of PE = $q\Delta V$ must be a change (1) Rearrangement i.e. $v^2 = \frac{2 \times PE}{m}$ allow **ecf** on V (1) Answer = 18.3 x 10^6 [m s^{-1}] (**ecf** only if a ΔV used) (1)	3
				Question 6 Total	**[13]**

Question				Marking details	Marks Available
7	(a)			$T = 2\pi\sqrt{\frac{(1.4\times10^{10})^3}{6.67\times10^{-11}\times(1.6\times10^{29}+\mathbf{3.7\times10^{27}})}}$ (1) Answer = 3.15 x 10^6 [s] or implied (3.19 x 10^6 s if M_2 omitted) (1) 36.5 [days] (1) (36.9 if M_2 omitted gets 2/3)	3
	(b)	(i)&(ii)		$r_1 = \frac{M_2}{M_1+M_2}d$ used or $M_1r_1 = M_2r_2$ used (1) Star orbit radius = 0.032 x 10^{10} [m] (1) Planet orbit radius = 1.37 x 10^{10} [m] (1)	3
	(c)	(i)		$v = \frac{2\pi r}{T}$ or $v = \omega r$ and $\omega = 2\pi f$ (1) $v = \frac{2\pi\times0.032\times10^{10}}{3.15\times10^6}$ (= 631) (1) **ecf**	2
		(ii)		$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ values substituted or not possible (1) Answer = 3.9 [pm] because mean radial speed unknown (1) Don't penalise using 2 x v if explained	2
				Question 7 Total	**[10]**

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