GCE MARKING SCHEME

SUMMER 2016

PHYSICS PH4
1324/01

INTRODUCTION

This marking scheme was used by WJEC for the 2016 examination. It was finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conference was held shortly after the paper was taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conference, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about this marking scheme.

GCE PHYSICS PH4
SUMMER 2016 MARK SCHEME

Question			Marking details	Marks Available
1	*(a)*	(i)	The *rate of change of momentum of an object is (directly) proportional to the* <u>*resultant / net / total / overall*</u> *(1) force acting on it* (1) [and *is in the direction of that force]* Award 1 mark for stating $F = ma$ with all terms correctly identified	2
		(ii)	The [*vector sum of the] momenta of bodies in a system stays constant* (1) [even if forces act between the bodies], *provided there is no [net] external [resultant] force* / *isolated system* (1)	2
	(b)	(i)	Conservation of momentum: idea of (1) $m_A u_A + m_B u_B = m_A v_A + m_B v_B$ $(0.12)(2.40) + (0.24)(-1.70) = (0.12)(-2.24) + (0.24)v_B$ correct substitution (1) $(0.24)v_B = 0.1488$ $v_B = 0.62$ [m s^{-1}] (1)	3
		(ii)	Energy considerations $\text{Energy lost} = \text{Initial kinetic energy} - \text{Final kinetic energy}$ $= \left(\frac{1}{2}m_A {u_A}^2 + \frac{1}{2}m_B {u_B}^2\right) - \left(\frac{1}{2}m_A {v_A}^2 + \frac{1}{2}m_B {v_B}^2\right)$ idea and formulation of energy lost (1) $= \frac{1}{2}(0.12 \times 2.40^2 + 0.24 \times 1.70^2)$ $- \frac{1}{2}(0.12 \times 2.24^2 + 0.24 \times 0.62^2)$ correct substitution, allow **ecf** from (i) (1) $= 0.6924 - 0.3472$ $= 0.3452$ [J] (1)	3
		(iii)	Consider mass m_A $\text{Force} \times \Delta t = \text{change of momentum}$ idea (1) $\text{Force} \times (0.3) = \text{final momentum} - \text{initial momentum}$ $\text{Force} \times (0.3) = m_A(-2.24 - 2.40)$ $\text{Force} = \frac{(0.12)(-4.64)}{0.3} = -1.856$ N Force of 1.86 [N] (1) to the left accept – sign or arrow (1)	3
			Question 1 Total	**[13]**

Question			Marking details	Marks Available
2	(a)	(i)	The maximum value of the platform's displacement [from its equilibrium (central) position]. Don't accept reference to height	1
		(ii)	The number of cycles / oscillations / vibrations [completed by the platform] per second / rate.	1
	(b)	(i)	$v = \omega A = (2\pi f)A = \big(2\pi(0.5)\big)0.03$ substitution (1) $v = 0.094$ [m s^{-1}] (1)	2
		(ii)	$x = A\sin(2\pi ft)$ use of $\omega = 2\pi f$ $0.02 = 0.03\sin(2\pi(0.5)t)$ substitution (1) $t = 0.232$ [s] or 0.768 [s] (1) $v = (2\pi f)A\cos(2\pi ft)$ $v = \big(2\pi(0.5)\big)(0.03)\cos(2\pi(0.5)(0.232))$ $v = 0.070$ [m s^{-1}] or - 0.070 [m s^{-1}] (1)	3
		(iii)	$\text{max acceleration} = (2\pi f)^2 A = \big(2\pi(0.5)\big)^2(0.03)$ subs (1) $= 0.30$ [m s^{-2}] (1)	2
	(c)		Contact will be lost when the maximum downward acceleration is equal (or greater) to the acceleration due to gravity, g i.e. when $\text{acceleration at top of oscillation} = g$ explanation (1) $g = (2\pi f)^2 A$ (implies 1st mark) $9.81 = (2\pi f)^2(0.03)$ $f = \left(\frac{1}{2\pi}\right)\sqrt{\frac{9.81}{0.03}} = 2.88$ [Hz] (1) As frequency is incrementally increased, contact will be lost at $f = 3.00$ [Hz] answer (1) [Alternatively for the 2nd and 3rd marks, substitute values and find acceleration for different frequencies. Indicate 2.50 Hz is on lower side of g (1) and 3.00 Hz on higher side.(1)]	3
			Question 2 Total	**[12]**

Question			Marking details	Marks Available
3	*(a)*	(i)	$pV = nRT$ $n = \frac{pV}{RT} = \frac{(3\times10^5)(1.2\times10^{-3})}{(8.31)(275)} = 0.1575$ mol (1) $\text{mass}, m_n = n \times M_r \times 10^{-3} = (0.1575)(4 \times 10^{-3})$ $= 6.30 \times 10^{-4}$ kg or 0.63 g (1) **unit mark**	2
		(ii)	density $\rho = \frac{m_n}{V} = \frac{6.30\times10^{-4}}{1.2\times10^{-3}} = 0.525$ kg m^{-3} (1) $p = \frac{1}{3}\rho\overline{c^2}$ rms $\sqrt{\overline{c^2}} = \sqrt{\frac{3p}{\rho}} = \sqrt{\frac{3(3\times10^5)}{(0.525)}} = 1\,309$ [m s^{-1}] (1) Allow 1 mark for 41.4 [m s^{-1}] and allow **ecf** from (i). [Alternatively $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ where $m = \frac{M_r\times10^{-3}}{N_A} = \frac{4\times10^{-3}}{6.02\times10^{23}}$ (1) $\sqrt{\overline{c^2}} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3(1.38\times10^{-23})(275)(6.02\times10^{23})}{(4\times10^{-3})}} = 1\,309$ [m s^{-1}] (1)]	2
	(b)	(i)	Increase in volume $\Delta V = (1.8 - 1.2) \times 10^{-3} = 6 \times 10^{-4}$ m^3 (1) Work done by gas $= p\,\Delta V = (3 \times 10^5)(6 \times 10^{-4}) = 180$ [J] (1)	2
		(ii)	Final temperature $T_f = \frac{p\,V_f}{n\,R} = \frac{(3\times10^5)(1.8\times10^{-3})}{(0.1575)(8.31)} = 412.584$ K (1) Increase in internal energy of gas $\Delta U = \frac{3}{2}nR\,\Delta T = \frac{3}{2}(0.1575)(8.31)(412.584 - 275.0) = 270.110$ J (1) Heat flowing into gas $Q = \Delta U + W = 270.110 + 180 = 450$ [J] (1) Allow **ecf** from part (i)	3
			Question 3 Total	**[9]**

Question			Marking details	Marks Available
4	*(a)*		If two (or more) systems are in thermal equilibrium then the *systems are in thermal contact* (1) but there is *no* (*net*) *heat flowing between them* (1). **Alternative** No heat flow between the systems (1) because they are at the same temperature (1)	2
	(b)		[Saucepan and water initially at higher temperature than vegetables], so net heat will flow from the saucepan to the water (1) and from the water to the vegetables (1) Accept heat flows from the saucepan to the vegetables (1) and from the water to the vegetables (1) Eventually **heat transfer will stop** and all three (saucepan, water and vegetables) will be in thermal equilibrium / be at the same temperature (1).	3
	(c)		$\text{Heat lost by saucepan} = (0.9)(92 - T)(500)$ $\text{Heat lost by water} = (1.6)(92 - T)(4\,200)$ heat lost (1) $\text{Heat gained by vegetables} = (1.1)(T - 17)(3\,500)$ (1) Heat lost is equal to the heat gained: understanding of this (1) $\big((0.9)(92 - T)(500)\big) + ((1.6)(92 - T)(4\,200)$ $= (1.1)(T - 17)(3\,500)$ $T\big((3\,500)(1.1) + (500)(0.9) + (4\,200)(1.6)\big)$ $= ((3\,500)(1.1)(17)) + ((500)(0.9)(92))$ $+ ((4\,200)(1.6)(92))$ $T\ (11\,020) = 725\,090$ $T = 65.80\ °\text{C}$ (1)	4
	(d)		**Lower** final temperature (or eventually temperature of surroundings) (1) Heat will be lost to the surroundings from the system [as the temperature of the surroundings is lower] (or temperature gradient between saucepan-water-vegetable system and surroundings is driving transfer of heat) (1)	2
			Question 4 Total	**[11]**

Question			Marking details	Marks Available
5	*(a)*		$g_M = \frac{GM}{{R_M}^2} = \frac{(6.67\times10^{-11})(7.34\times10^{22})}{(1.74\times10^6)^2} = 1.62$ [N kg^{-1}] substitution (1); answer (1)	2
	(b)		Total energy at surface $= -\frac{GMm}{R_M} + \frac{1}{2}mv^2$ m: mass of projectile $= -\frac{(6.67\times10^{-11})(7.34\times10^{22})m}{(1.74\times10^6)} + \frac{1}{2}m(400)^2$ (1) Total energy at highest altitude $= -\frac{GMm}{r_M}$ $= -\frac{GMm}{r_M} = -\frac{(6.67\times10^{-11})(7.34\times10^{22})m}{r_M}$ (1) Conservation of energy: application (1) $-\frac{(6.67\times10^{-11})(7.34\times10^{22})m}{(1.74\times10^6)} + \frac{1}{2}m(400)^2 = -\frac{(6.67\times10^{-11})(7.34\times10^{22})m}{r_M}$ $-\frac{(6.67\times10^{-11})(7.34\times10^{22})}{(1.74\times10^6)} + \frac{1}{2}(400)^2 = -\frac{(6.67\times10^{-11})(7.34\times10^{22})}{r_M}$ $-2\,813\,666.667 + 80\,000 = -\frac{4.89578\times10^{12}}{r_M}$ $-2733666.667\, r_M = -4.89578\times10^{12}$ $r_M = \frac{(4.89578\times10^{12})}{2733666.667} = 1\,790.921\times10^3$ m above surface $h = 1\,790.921 - 1\,740 = 50.9$ [km] (1) [with rounding.: $-2.814\times10^6 + 80\,000 = -\frac{4.896\times10^{12}}{r_M}$ $r_M = \frac{4.896\times10^{12}}{2.734\times10^6} = 1\,790.8\times10^3$m from surface $h = 1790.8 - 1740 = 50.8$ km]	4
	(c)		$\frac{1}{2}mv^2 = mg_M h$ (1) $h = \frac{v^2}{2g_M} = \frac{400^2}{2(1.62)} = 49\,382.716$ m $= 49.4$ [km] (1)	2
	(d)		percentage difference $= \frac{(51-49.4)}{51} \times 100\% = 3\%$ formula for percentage error (1), result (1)	2
	(e)		Yes, as it is likely that the percentage difference is less than the uncertainty because of the measurement of the velocity or suitable alternative. **ecf** for consistency **Answer to (e) must be consistent with answer to (d)**	1
			Question 5 Total	**[11]**

Question			Marking details	Marks Available
6	*(a)*		Number of electrons removed $= \frac{1.11\times10^{-6}}{1.6\times10^{-19}}$ (1) $= 6.94 \times 10^{12}$ (1)	2
	(b)		Values for graph: **distance /m** | **0.5** | **1.0** | **1.5** | **2.0** E **×10^3 N C^{-1}** | 39.96 | 9.99 | 4.44 | 2.50 V **×10^3 V** | 19.98 | 9.99 | 6.66 | 5.00 Point (or implied from curve) for E approx. (1) Point (or implied from curve) for V approx. (1) Shape of <u>both curves</u> i.e. curves with decreasing magnitudes with increasing distance, [E decreasing faster with distance than V and both curves passing through 10]. (1)	3
	(c)	(i)	$\text{Work} = q\,\Delta V = \frac{q^2}{4\pi\varepsilon_o}\left(\frac{1}{1.2} - 0\right) =$ $(1.11 \times 10^{-6})^2(9.0 \times 10^9)(0.833)$ substitution (1) 9.24×10^{-3} [J] (1)	2
		(ii)	$E\text{ field} = \frac{q}{4\pi\varepsilon_o}\left(\frac{1}{0.5^2} - \frac{1}{0.7^2}\right)$ $= (1.11 \times 10^{-6})(9.0 \times 10^9)\left(\frac{1}{0.5^2} - \frac{1}{0.7^2}\right)$ formula and substitution (1) $= 1.96 \times 10^4$ V m^{-1} or equivalent (1) **unit mark** Direction: to the left accept – sign or arrow (1)	3
			Question 6 Total	**[10]**

Question			Marking details	Marks Available
7	(a)		Star (and companion planet) will both orbit the common centre of mass. Observe star spectral line from Earth. Measure Doppler shift in spectral line. Max wavelength corresponds to star moving away from Earth. Min wavelength corresponds to star moving towards Earth. Doppler shift accept red shift (1) in spectral line (1) Doppler shift $(\Delta\lambda)$ – at max or min - can be used to determine orbital speed (v) as: $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ (1) Orbital period is determined from one cycle of Doppler shift e.g. from one max to the next max. (1)	4
	(b)		Change units $T = 4.23 \text{ days} = 4.23 \times 24 \times 60 \times 60 \text{ seconds} = [365\,472]$ s (1) $T = 2\pi\sqrt{\frac{d^3}{G(M_1 + M_2)}}$ Approximation $M_{\text{star}} \gg M_{\text{planet}}$ (1) so $T = 2\pi\sqrt{\frac{d^3}{GM_{\text{star}}}}$ $d = \sqrt[3]{GM_{\text{star}}\left(\frac{T}{2\pi}\right)^2}$ rearrange(1) $d = \sqrt[3]{(6.67 \times 10^{-11})(2.21 \times 10^{30})\left(\frac{365472}{2\pi}\right)^2}$ substitution (1) $d = 7.93 \times 10^9$ [m] (1)	5
	(c)		use of $v = \omega r$ or equivalent (1) $r_{\text{star}} = \frac{v}{\omega} = \frac{vT}{2\pi} = \frac{(56.0)(365472)}{2\pi}$ $= 3.26 \times 10^6$ [m] (1)	2
	(d)		use of $r_1 = \frac{M_2}{M_1+M_2}d$ or approximation (1) $r_{\text{star}} = \frac{M_{\text{planet}}}{M_{\text{star}}+M_{\text{planet}}}d$ $\left(M_{\text{star}} + M_{\text{planet}}\right)r_{\text{star}} = M_{\text{planet}}d$ $(d - r_{\text{star}})M_{\text{planet}} = r_{\text{star}}M_{\text{star}}$ $M_{\text{planet}} = \frac{r_{\text{star}}M_{\text{star}}}{(d-r_{\text{star}})}$ $M_{\text{planet}} = \frac{(3.26\times10^6)(2.21\times10^{30})}{(7.93\times10^9-3.26\times10^6)}$ substitution (1) $= 9.09 \times 10^{26}$ [kg] (1) **ecf**	3
			Question 7 Total	**[14]**