GCE MARKING SCHEME

SUMMER 2016

PHYSICS PH5
1325/01

© WJEC CBAC Ltd.

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.

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
1	(a)		$\lambda = \frac{\ln 2}{T_{\frac{1}{2}}}$ used	1
			answer = 0.516 [s]	1
	(b)		$A = \lambda N$ used	1
			Correct method for finding N (i.e. 1.2×10^{14}) e.g. $n = \frac{4.22\text{x}10^{-11}}{0.211}$ and $N = n \times N_A$	1
			Answer = 1.62×10^{14} [Bq]	1
	(c)		$e^{-1.343\times2.4}$ or $\frac{1}{2^{4.65}}$	1
			Answer = 3.98[%]	1
	(d)		$0.001 = e^{-1.343t}$ (allow factor 10 slips) or ~10 half-lives	1
			Answer = 5.14 [s] (accept 5.1 s -5.2 s)	1
	(e)		[Can be] ingested (accept inhaled) Large activity / short half-life) **and** [alpha highly] ionising Accept high equivalent dose Don't accept high dose only (needs ionising too) and treat reference to daughter nuclei as neutral	1 1
			Question 1 Total	**[11]**

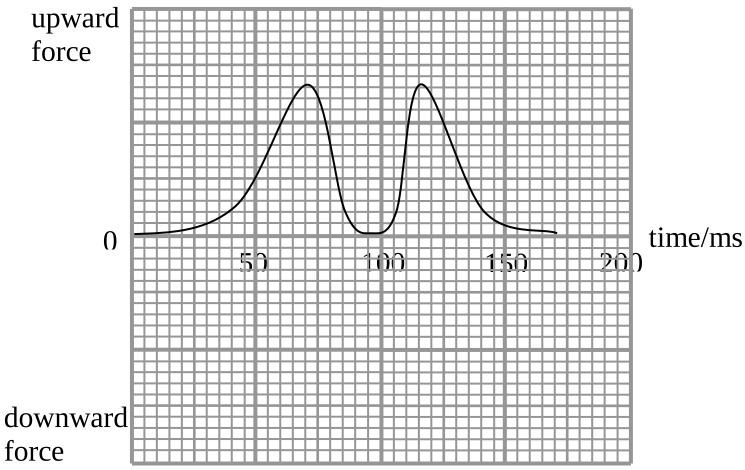
© WJEC CBAC Ltd.

Question			Marking details	Marks Available
2	*(a)*		Attempt at 8n + 8p - mass of oxygen nucleus	1
			$\times$931 and $\div$16 or use of mc^2 and $\div$16	1
			Correct answer = 8.0 [MeV/nucleon] or 1.28 $\times$ 10^{-12} [J]	1
	(b)		Conversion of energy to mass e.g. $\frac{9.594}{931}$ = 0.0103 [u]	1
			Correct application of conservation of mass-energy e.g. (15.9905 $\times$ 2) **–** (4.0015 + 0.0103)	1
			Answer approx correct e.g. 28 u ****unit mark**** or 4.6 $\times$ 10^{-26} kg	1
			27.9692 (accuracy mark, also available for 27.9898 and without unit) Accept 4.64289 $\times$ 10^{-26} [kg]	1
	(c)		The reaction releases [9.594 MeV of] energy or is exothermic (some mention must be made of the energy on the RHS) Don't accept 9.594 MeV is lost or left over	1
			Products are more stable OR mass must have been lost or PE is lost	1
			Binding energy of [RHS / Si and He] greater or converse	1
	(d)		Conservation of momentum **and** energy mentioned	1
			Momentum states the products must be stationary or final momentum equals zero or accept products have KE > 16.5 MeV	1
			but this contravenes conservation of energy or only works if two products are present or 16.5 MeV can't be released or accept KE of product contravenes conservation of momentum	1
			Question 2 Total	**[13]**

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
3	*(a)*	(i)	Adding 1.5 μF	1
			Attempting $\frac{1}{6.0} + \frac{1}{\text{others}}$	1
			Correct answer 2 [μF] (allow 1/3 for 6.75 μF)	1
	(b)		Correct method e.g. using $\frac{Q^2}{2C}$ or $0.5CV^2$ or $0.5QV$	1
			Correct explanation e.g. 1.5 μF has twice the pd but 4× less C Or 1.5 μF has half the charge and a quarter of the C Or 6.0 μF has half the pd but twice the charge Or 3.0 μF has twice the pd, half the charge and energy shared between 2 × 1.5 μF	1
	(c)	(i)	Using $T_{½} = \ln 2 \times RC$ or taking logs correctly e.g. $\ln\frac{Q}{Q_0} = \frac{-t}{RC}$	1
			Algebra i.e. $R = \frac{T_{\frac{1}{2}}}{C\ln 2}$	1
			Answer = 8 420 [Ω]	1
		(ii)	$I_0 = \frac{V_0}{R}$ used	1
			$V_0 = \frac{Q_0}{C}$ used (i.e. V_0 = 12.4 V)	1
			I_0 = 1.47 [mA] **ecf**	1
			Question 3 Total	**[11]**

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
4	*(a)*		Emf is (or proportional to) the rate of change of flux [linkage]	1
			Emf / current opposes (tends to) change to which it is due Accept equation with terms defined	1
	(b)	(i)	Any 3 of:	
			• Emf initially increases as [rate of] flux [linkage increases OR current flows to make top of coil N to oppose motion • Emf decreases when the rate of increase drops • Emf is zero when the flux is max or in middle when no cutting • Emf reverses when S pole due to reversed magnetic field or Lenz • The second peak is higher due to a higher speed	3
		(ii)		
			Upward force only	1
			No force when $V = 0$	1
			Basic shape i.e. two smooth humps, peaks near original max Min & minimum also close to 98 ms	1
		(iii)	Correct attempt at using πr^2 to obtain the radius (7.5 mm)	1
			Use of $2\pi r$	1
			$2\pi \times 0.0075 \times 65$ = 3.1 [m]	1
			Question 4 Total	**[11]**

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
5	*(a)*	(i)	Attempt at $E = mc^2$ or 931 × m_e (with m_e in u)	1
			$2 \times 9.11 \times 10^{-31} \times \frac{9\text{x}10^{16}}{1.6\text{x}10^{-19}}$ seen or $2 \times 931 \times \frac{1}{1836}$	1
		(ii)	<u>KE</u> [of particles]	1
	(b)		$B = \frac{\mu_0 I}{2\pi a}$ used	1
			Realising two 19 A fields cancel (or evident in calculations)	1
			5.56 × 10^{-5} [T] (6.33 × 10^{-5} T only score 1 of first 3 marks)	1
			Out of paper (independent) Don't accept upwards	1
	(c)	(i)	$Bqv = \frac{mv^2}{r}$	1
			Explanation of what this means e.g. equating magnetic force and centripetal force	1
			Must have m_e and e in final equation	1
			Clear algebra leading to correct final version of equation	1
		(ii)	Answer = 5.7 [m]	1
		(iii)	Field not uniform or field changes	1
			Over 5.7 m or even though motion perpendicular to B or reference to the circle being too big	1
			Question 5 Total	**[14]**

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
6	*(a)*		Red shift (accept Doppler) shifts of starlight / galaxies [measured] but not for planets	1
			The further the galaxy the greater the red-shift / velocity (or red-shift is proportional to galaxy distance)	1
			Consistent with initial explosion e.g. expansion is consistent with the Big Bang (or consistent with matter starting from a point)	1
	(b)		Speeds near the speed of light not greater than the speed of light accept velocities are large fractions of the speed of light Don't accept at or greater than the speed of light	1
	(c)		Current content of universe explained clearly i.e. baryons (& leptons) not antibaryons (and anti-leptons)	1
			Argument for symmetry breaking (Violation of Cons of Baryon not enough) - e.g. must have slight excess of baryons etc.	1
	(d)		Smaller mass linked to less energy	1
			Less energy or lower temperature linked to the later time Smaller masses produced at lower temperatures – 1 mark	1
	(e)		Fusion [of nuclei] stated	1
			Due to high T (or velocity or energies) [around 10^{-6} (to 3 min) after Big Bang]	1
	(f)		Universe was cooler or electrons or protons have lower energy	1
			Electrons combined with protons (accept nuclei)	1
			Photon energy too low for atoms/electrons to absorb Accept em radiation was no longer absorbed [by electrons/ions] or em radiation is no longer being scattered	1

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
	(g)		Substitution of $v_{esc} = H_0 R$ (or equivalent algebraic step)	1
			$M = \frac{4}{3}\pi R^3 \rho$ (or equivalent)	1
			Clear algebra leading to $\rho_C = \frac{3H_0^2}{8\pi G}$	1
	(h)		Correct substitution of H_0 and G	1
			$\frac{9.21\text{x}10^{-27}}{1.66\text{x}10^{-27}}$ seen or 5.55 seen	1
	(i)		λ_{max} = 0.105 cm	1
			$T = \frac{2.90\text{x}10^{-3}}{0.00105}$ = 2.76 [K]	1
			Question 6 Total	**[20]**

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
7	*(a)*	(i)	Core - avoids flux leakage or extra detail	1
			Low resistance coils - avoids Ohmic heating or WTTE (extra detail low resistivity wires)	1
			Laminations - avoids eddy currents (insulation between laminations)	1
			Suitable alloy - avoids hysteresis losses (named alloy e.g. silicon steel)	1
		(ii)	Valid good comment regarding LN_2 e.g. efficiency gains outweigh LN_2 costs Accept: larger B-fields due to larger currents, Oil free, Lower weight/mass, Smaller volume	1
	(b)	(i)	$\omega L = \frac{1}{\omega C}$ or $f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$ used	1
			Answers shown clearly e.g. $\frac{1}{2\pi}\sqrt{\frac{1}{0.034\times 47\times 10^{-6}}}$ etc. (1 mark each) Or 272.9 [Hz] or 125.9 [Hz]	2
		(ii)	ω decreases (if using $Q = \frac{\omega L}{R}$) or quoting $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$	1
			Or ω decreases less than C increases if using $Q = \frac{1}{\omega CR}$ Q factor decreases (independent)	1
		(iii)	$I = \frac{230}{36}$ or $V_L = V_C$ or all pd across resistor etc.	1
			I = 6.38 [A]	1
			$V_C = \text{I} \times \frac{1}{\omega C}$ or $V_L = \text{I} \times \omega L$ used	1
			V_C = 373 [V]	1
		(iv)	Current is the same (or calculated correctly)	1
			Reactance/impedence of inductor is less (lower frequency) or calculated correctly) or $\frac{1}{\omega C}$ used/calculated correctly	1
			Hence, pd across capacitor is less (not an independent mark) (or calculated correctly) **Alternative:** Q factor smaller (1) same V_R (1) hence smaller V_C (1)	1

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
7	*(c)*		$Z = \sqrt{X_C{}^2 + R^2}$ used or X_C calculated (36 Ω)	1
			Current = $\frac{10}{50.9}$ = 196 mA or correct method e.g. vectors or $\frac{36}{\sqrt{36^2+36^2}} \times 10$	1
			Answer = 7.07[V]	1
			Question 7 Total	**[20]**

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
8	*(a)*	(i)	wavelength	1
		(ii)	$\frac{5\lambda}{2}$ or equivalent appears...	1
			... equated to "path difference" or to path difference described in words or to $x - y$ or to $S_1P - S_2P$ even if these symbols not properly explained.	1
			Diagram clearly showing meanings of whatever symbols used in equation.	1
	(b)	(i)	Compass points at right angles to current-carrying wire if Earth's field cancelled out **or** current-carrying wires (or currents) exert forces on each other (1) For currents in same direction, attraction and/or for currents in opposite directions, repulsion (1) **or** [current-carrying] coils behave like magnets (1) either ends of coils attract/repel like poles of magnets, or pivoted coil behaves like compass (1)	1 1
		(ii)	there are [electric] currents inside circulating in [closed] loops.	1 1
	(c)		[Vortex rotation represents] magnetic field. Accept em wave propagating.	1
			Field directions opposite above and below shaded line of idlers.	1
			Suggests field lines to be circles around line of idlers or accept reference to right hand grip rule or equivalent.	1
	(d)	(i)	Correct strategy (i.e. attempt to use Pyth. or a valid trig. method to find light path length, then division by c). Tolerate slips.	1
			Light path length = 26.0 m [accept 26 m, 26.00 m ...]	1
			Time = 86.7 n[s] (accept 86.6 ns. **Ecf** on slips in calculating light path, provided wrong answer (e.g. 43.3 ns) is commented on.	1
		(ii)	80.0 n[s]. No sf penalty. **Ecf** on 40.0 ns if similar penalised in (i) (1)	1
		(iii)	improper time: events in different places; proper time: events in same place. d(i) is improper, OR d(ii) is proper	1 1

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
		(iv)	v = 1.15 × 10^8 m s^{-1} [1.25 × 10^8 m s^{-1} is WRONG]	1
			$\gamma = \frac{1}{\sqrt{(1-\frac{v^2}{c^2})}}$ = 1.08 **ecf** on v	1
			$\frac{\text{time(i)}}{\text{time(ii)}} = 1.08$ + comment on agreement with gamma or by implication if consistency check carried out differently.	1
			Question 8 total	**[20]**

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
9	*(a)*	(i)	No permanent set. Accept: rubber returns to original length (not position) when load is removed or strain returns to origin or no strain after load is removed.	1
		(ii)	At (A) molecules unravel (accept untangle) under the action of a force. At (B) molecules fully stretched/ strong forces between atoms within molecule. Accept – also C-C bond rotates **Either:** Small force (or stress) produces large extension (or strain) hence shallow gradient initially/ or at A **Or:** Large force (or stress) produces small extension (or strain) hence steep gradient finally/ or at B	1 1 1
		(iii)	Hysteresis Area (between loading and unloading curve) represents difference between energy stored in the rubber band when it is stretched and (useful) energy recovered from it when it is unstretched or energy dissipated (lost) in one cycle of loading and unloading. 'Lost' energy transferred to internal energy (accept heat) of molecules	1 1 1
		(iv)	Repeated **large** deformation **increases** energy loss as internal energy (heat) or larger hysteresis curve leads to increasing temperature in tyres.	1
	(b)	(i)	Understanding shown that $W = \frac{1}{2} F (e_P + e_Q)$ $e_P = \frac{FL_0}{2AY}$ and $e_Q = \frac{FL_0}{6AY}$ seen $W = \frac{1}{2} F\left\{\frac{FL_0}{2AY} + \frac{FL_0}{6AY}\right\}$ {award 3 marks if only this seen} Clear mathematical step leading to final equation e.g. Factorisation or fraction addition: e.g. $W = \frac{1}{2} \frac{F^2 L_0}{AY}\left\{\frac{1}{2} + \frac{1}{6}\right\}$ **Alternative:** W in P found W in Q found Addition to find total W – clear mathematical step Leading to final equation	1 1 1 1
		(ii)	$W = \frac{1}{2} \times 2\,800 \times 0.033 \times 10^{-3}$ $= 0.0462$ [J] [No marks for 0.03×10^{-3} used] [-1 for power of 10 slip]	1 1

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
		(iii)	Correct manipulation and substitution $Y = \frac{2800^2 \times 0.3}{3 \times 1.65 \times 10^{-4} \times 0.0462}$ (**ecf** on 0.0462 J)	1
			Use of $A = \pi r^2$ or $\frac{\pi d^2}{4}$ $(1.65 \times 10^{-4}\ \text{m}^2)$	1
			$Y = 1.03 \times 10^{11}$ [N m^{-2}] [0 marks for if area incorrect]	1
		(iv)	3 $Y_Q = 3Y_P$ For same F, L and A	1 1 1
			Question 9 total	**[20]**

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
10	(a)	(i)	Voltage for A is higher Smaller minimum wavelength Accept the converse and accept $V_A = 2V_B$ Ignore any reference to intensity	1 1
		(ii)	Line spectra are in the same place Accept peaks for line spectra	1
		(iii)	$h = \frac{eV\lambda}{c}$ / identification of $\lambda_{min} = 15 \times 10^{-12}$ [m] $h = 6.72 \times 10^{-34}$ [J s]	1 1
		(iv)	$V = \frac{hc}{e\lambda}$ (**ecf** on h if wrong h used) / identification of λ_{min} = 30×10^{-12} [m] V = 42 000 V /42 kV / 41.4 kV must have units	1 1
	(b)		Advantage better soft tissue contrast / no exposure to radiation / [good] imaging of the brain Disadvantage Claustrophobia / cost / not with a pacemaker/ Not good for imaging bone Ignore references to time	1 1
	(c)	(i)	Alternating high frequency (MHz) voltage / p.d. applied To piezoelectric crystal Crystal oscillates / vibrates (to produce ultrasound) (because crystal deforms when pd applied)	1 1 1
		(ii)	$v = \frac{\Delta\lambda c}{2\lambda}$ / 1.8 m s^{-1} must have units v = 0.9 m s^{-1} must have units	1 1
	(d)		Axis labelled with units Correct shape graph	1 1
	(e)		Absorbed dose is energy absorbed per unit mass/ kg Dose equivalent = absorbed dose × quality factor Dose equivalent of alpha bigger than gamma / larger Q factor for alpha than gamma) Alpha far more ionising	1 1 1 1
			Question 10 total	**[20]**

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
11	(a)	(i)	Uses energy to pump water to higher reservoir / to raise the water/to give the water GPE	1
			Less than 100% efficient (of pumping or KE→ electric conversion) /not all the stored GPE becomes kinetic/electrical	1
		(ii)	Immediate high output power when increase in demand/at peak times/to cover surges in demand	1
	(b)	(i)	At least 3 good advantages and 1 clear disadvantage	3
			3 good advantages OR 2 advantages & 1 disadvantage	2
			At least 1 good advantage or 1 disadvantage	1
			Advantages: Reliable, High[er] power/output, Easily switched on and off /can adjust to levels of demand/controllable output NOTE: costs are very similar \$64 and \$72 per MWh Disadvantages Changes environment (of waterfall), Difficult to design/construct Dangerous (when dam fails 150 000 deaths in China, 1975) /risk of flooding	
		(ii)	Assumption: efficiency is 50% (accept 20-100) – must be stated	1
			mgh = power × time or equivalent	1
			1 day = 24 × 3 600	1
			Answer = 1.6×10^{12} [kg] (dependent on efficiency) Can get ¾ marks if h = 59 m used, but otherwise correct	1
	(c)	(i)	$P = \sigma A T^4$ used	1
			$A = 4\pi r^2$ used twice	1
			Answer = 1.36 [kW m^{-2}]	1
		(ii)	11 GW divided by 1.12 kW m^{-2}	1
			Factor of daylight hours /efficiency explained (efficiency can be forgiven here)	1
			Answer correct e.g. 1.5×10^8 [m^2] (if 8h and 20% efficient panels)	1
			(wide range acceptable dependent on assumptions)	

© WJEC CBAC Ltd.

Question			Marking details	Marks Available
		(iii)	Attempt at energy of solar panel for 25 years i.e. $1.12 \times 25 \times 365 \times 24$ (**ecf** on efficiency & daylight)	1
			division by kWh or MWh (3.6×10^6 or 3.6×10^9)	1
			Correct cost = e.g £12.50 per MWh if 8h per day and 20% efficient	1
			Correct comparison with **ecf** e.g. £12.50 per MWh considerably cheaper - Accept comments regarding maintenance of panels e.g. moving costs etc	1
			Question 11 total	**[20]**

© WJEC CBAC Ltd.