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RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE

Unit **G485:** Fields, Particles and Frontiers of Physics

Mark Scheme for January 2011

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Question			Expected Answer	Mark	Additional Guidance
1	(a)	(i)	$E = \frac{V}{d} = \frac{2400}{9.4\times10^{-3}}$ $E = 2.55 \times 10^{5}$ (V m^{-1}) force = $E \times Q = 2.55 \times 10^{5} \times 1.60 \times 10^{-19}$ force = 4.09×10^{-14} (N)	C1 A1	**Allow** 1 mark for 4.1×10^{-n}, $n \neq 14$ **Allow** 2sf answer of 4.1×10^{-14} (N) Alternative: $F = \frac{Ve}{d} = \frac{2400\times1.60\times10^{-19}}{9.4\times10^{-3}}$ C1 force = $4.08(5) \times 10^{-14}$ (N) A1 [Allow: 4.08×10^{-14} (N)]
		(ii)	KE = $e \times V$ or KE = $F \times d$ KE = $1.6 \times 10^{-19} \times 2400$ or KE = $4.09 \times 10^{-14} \times 9.4 \times 10^{-3}$ KE = 3.84×10^{-16} (J)	C1 A1	**Allow** 2 sf answer Possible ecf if answer from **(a)(i)** is used
		(iii)	KE = $\frac{1}{2}mv^2$ $v = \sqrt{\frac{2\times3.84\times10^{-16}}{9.11\times10^{-31}}}$ speed = $2.9(0) \times 10^{7}$ (m s^{-1})	B1	Possible ecf if answer from **(a)(ii)** is used
	(b)		There is no change (to the gain in KE) work done or KE = Fd, F or E is halved and d is doubled or work done or KE = VQ and V is the same or work done or KE = VQ and this does not depend on distance	M1 A1	
			Total	7	

Question			Expected Answer	Mark	Additional Guidance
2	(a)		coulomb <u>per</u> volt	B1	**Allow**: 1 F = 1 $\underline{CV^{-1}}$
	(b)	(i)	<u>Electrons</u> flow 'clockwise' / negative to positive These are deposited on (plate) **A** (and hence becomes negatively charged) or These are removed from (plate) **B** (and hence become positively charged)	B1 B1	**Not**: **A** becomes negative / **B** becomes positive
		(ii)1	$Q = C \times V = 5.4 \times 10^{-9} \times 12$ charge = 6.48×10^{-8} (C)	B1	
		(ii)2	energy = $\frac{1}{2}V^2C = \frac{1}{2} \times 12^2 \times 5.4 \times 10^{-9}$ energy = 3.89×10^{-7} (J)	B1	Possible ecf if Q used from **(ii)1**
	(c)	(i)	$R = \frac{12}{3.24 \times 10^{-6}}$ resistance = 3.7×10^6 (Ω)	M1 A0	**Allow**: 'R = 12/3.24μ' (= 3.7 MΩ)
		(ii)	time constant = CR = $5.4 \times 10^{-9} \times 3.7 \times 10^6$ or 0.02 (s) $I = I_0 e^{-t/CR} = 3.24 \times e^{-(0.080/0.020)}$ current = 0.059 (μA)	C1 A1	**Allow**: ecf for time constant **Allow**: 1 mark for 5.9×10^{-n}
	(d)		(Total) resistance of circuit <u>halved</u> / time constant is <u>halved</u> Rate of discharge is <u>doubled</u> / (initial) current is <u>doubled</u>	B1 B1	
			Total	10	

Question			Expected Answer	Mark	Additional Guidance
3	(a)		Perpendicular out of plane of paper	B1	**Allow**: 'out of paper' **Not**: 'up the paper'
	(b)		$\frac{mv^2}{R} = BQv$ hence $v = \frac{BQR}{m}$	M1 A0	**Allow**: Use of *r* instead of *R* and *e* instead of *Q*
	(c)		speed = $\frac{2\pi \times 0.18}{2.0 \times 10^{-8}}$ or 5.66×10^7 (m s^{-1}) $5.66 \times 10^7 = \frac{B \times 1.60 \times 10^{-19} \times 0.18}{1.67 \times 10^{-27}}$ (Any subject) *B* = 3.28 (T)	C1 C1 A1	**Allow** : ecf for incorrect value for speed *v* Alternative : $t = (\frac{2\pi R}{v} =) \frac{2\pi m}{BQ}$ C1 $B = \frac{2\pi \times 1.67 \times 10^{-27}}{2.0 \times 10^{-8} \times 1.60 \times 10^{-19}}$ C1 *B* = 3.28 (T) A1
	(d)		The force / acceleration is perpendicular to the motion / velocity No work is done	B1 B1	**Allow**: 'speed' instead of 'velocity'
			Total	7	

Question			Expected Answer	Mark	Additional Guidance
4	(a)		The speed of recession of a galaxy is proportional to its distance (from Earth / observer)	B1	
	(b)	(i)	$v = \frac{\Delta\lambda}{\lambda} \times c$ $v = 0.15 \times 3.0 \times 10^8$ speed = 4.5×10^7 (m s $^{-1}$)	M1 A0	**Allow**: '15% of $3.0 \times 10^8 = 4.5 \times 10^7$ (m s $^{-1}$)' **Not**: '0.15*c*'
		(ii)	distance = v / H_0 (Any subject) distance = $\frac{4.5 \times 10^7 \times 3.1 \times 10^{22}}{65 \times 10^3}$ distance = 2.15×10^{25} (m)	C1 A1	 Possible ecf from **(b)(i)** **Allow**: 1 mark for 2.15×10^n, $n \neq 25$
		(iii)	$H_0 = \frac{65 \times 10^3}{3.1 \times 10^{22}}$ (= 2.10×10^{-18} s^{-1}) age = $1/H_0 = 4.77 \times 10^{17}$ (s) age = 1.49×10^{10} (y)	C1 A1	 **Allow**: 1 mark for 1.49×10^n, $n \neq 10$
	(c)		Any two from: 1. Spectra from galaxies show shift to longer wavelengths (suggests galaxies are moving away from the Earth) 2. The more distant galaxies are moving faster (than the ones closer to our galaxy) 3. Existence of microwave background radiation (which is the same in all directions) / The temperature of universe is 3 K (after cooling due to expansion) / gamma (radiation) became microwaves (as the universe expanded) 4. Existence of primordial helium (produced in the early stages of the universe) 5. Temperature fluctuations (predicted and observed)	B1 × 2	**Not** 'red-shift' for 1. **Allow**: Reference to CMB (radiation) in 3. **Not** bald 'ripples' for 5.
			Total	8	

Question			Expected Answer	Mark	Additional Guidance
5	(a)		Diagram showing (star,) 1 AU, 1 pc and angle of 1 arc second Distance from a base length of 1 AU that subtends an angle of 1 (arc) second or Parsec is a distance that gives a (stellar) parallax of 1 second (of arc) / 1/3600°	B1 B1	**Allow**: 1 pc is the distance calculated using: 1 AU/tan(1/3600°) **Not**: 1 pc = 3.26 ly **Not**: 1 pc = 3.1×10^{16} m
	(b)	(i)	distance (pc) = 1 / 0.275 distance = 3.64 (pc)	B1	
		(ii)	distance in m = $3.1 \times 10^{16} \times 3.64 = 1.127 \times 10^{17}$ (m) distance in ly = $1.127 \times 10^{17} / 9.5 \times 10^{15}$ distance in ly = 11.9	C1 A1	Possible ecf from **(b)(i)** **Alternative**: 1 pc = 3.26 ly C1 distance = 3.26×3.64 distance 11.9 (y) A1
			Total	5	

Question			Expected Answer	Mark	Additional Guidance
6	(a)	(i)	Any <u>five</u> from: 1. Gas / dust (cloud) drawn together by gravitational forces 2. Loss in (gravitational) PE / KE increases / PE changes KE / temperature increase 3. Fusion of protons / hydrogen <u>nuclei</u> (produces helium nuclei and energy) 4. A stable star is formed when radiation pressure is equal to gravitational pressure 5. When hydrogen runs out the <u>outer layers</u> of the star expands / <u>core</u> shrinks 6. <u>Red giant</u> formed / eventually (the core becomes) a <u>white dwarf</u> QWC mark for '*correct sequencing of the processes from birth to death'*	B1 × 5 B1	**Allow**: 'Gravitational collapse of dust cloud'
		(ii)	Supernova followed by neutron star / black hole	B1 B1	
	(b)		$\Delta E = \Delta mc^2$ energy = $2.0\times10^{30}\times10^{-6}\times(3.0\times10^{8})^2$ or 1.8(0) × 10^{41} (J) time = 1.80 × 10^{41}/3.8 × 10^{26} (= 4.74 × 10^{14} s) time = 4.74 × 10^{14}/3.2 × 10^{7} time = 1.5 × 10^{7} (y)	 C1 C1 A1	**Alternative**: rate = 4.22 × 10^{9} (kg s^{-1}) C1 time = 2.0 × 10^{24}/4.22 × 10^{9} (= 4.74 × 10^{14} s) C1 time = 1.5 × 10^{7} (y) A1

Question			Expected Answer	Mark	Additional Guidance
6	(c)	(i)	Any <u>four</u> from: 1. Protons / hydrogen <u>nuclei</u> to produce He <u>nuclei</u> (positrons and neutrinos) 2. There is electrostatic repulsion (between the protons) / The protons repel (each other because of their positive charge) 3. High temperatures / 10^7 K needed (for fusion) 4. (At high temperatures some of the fast moving) protons come close enough to each other for the strong (nuclear) force (to overcome the electrostatic repulsion) 5. High density / pressure (in the core of the Sun) 6. There is a decrease in mass, hence energy is released / products have greater binding energy	B1 × 4	**Not**: 'heat' in place of temperature in 3.
		(ii)	Kinetic (energy) Electromagnetic / photons	B1 B1	**Not**: heat / thermal (energy) **Not**: 'radiation' / 'wave energy'' **Allow**: Gamma
		(iii)	BE = 4 × 7.2 = 28.8 (MeV) BE = 28.8 × 1.6 × 10^{-13} BE = 4.6 × 10^{-12} (J)	C1 A1	 Possible ecf if BE value is incorrect
			Total	19	

Question			Expected Answer	Mark	Additional Guidance
7	(a)		The application of a p.d. across a material / crystal causes an expansion / contraction / vibration (ora)	B1	**Allow**: reference to 'current' instead of p.d / e.m.f
	(b)		Any <u>two</u> from: • <u>Pulses</u> of ultrasound (sent into the body) • Wave / ultrasound / pulse / signal is <u>reflected</u> (at boundary of tissue) • Time of delay used to determine depth / thickness • The fraction of <u>reflected</u> signal is used to identify the tissue	B1 × 2	**Allow**: The <u>reflected</u> signal / ultrasound /amplitude / intensity is used to identify the tissue
			A-scan in one direction only / range or distance or depth finding	B1	
			B-scan uses a number of sensors or a sensor in different positions / angles (to build up a 2D/3D image)	B1	**Not**: 'B-scan is many A-scans'
	(c)	(i)	$Z = \rho c$; density $\rightarrow$ kg m^{-3} <u>and</u> speed $\rightarrow$m s^{-1} (Hence $Z \rightarrow$ kg m^{-2} s^{-1})	M1 A0	
		(ii)	fraction = $\frac{(7.14-1.72)^2}{(7.14+1.72)^2}$ fraction = 0.37(4)	C1 A1	**Allow**: 37 %
		(iii)	(Acoustic) impedances of media are similar / identical No / reduced reflection (at boundary) Or The gel allows maximum transmission of ultrasound (into the body)	B1 B1	**Allow**: 'The Zs are the same'
		(iv)	$v = f\lambda$ wavelength = $\frac{1590}{1.2\times10^6}$ ($=1.33\times10^{-3}$ m) (Any subject) wavelength = 1.33 (mm)	C1 A1	**Allow**: 1 mark for '4080/1.2 × 10^6 = 3.4 mm'
		(v)	Small wavelength means finer detail can be seen / greater resolution	B1	
			Total	13	

Question			Expected Answer	Mark	Additional Guidance
8	**(a)**		Any <u>five</u> from: 1. Intensifier used as X-ray would pass through film 2. Intensifier converts X-ray <u>photon</u> to many visible (light) <u>photons</u> (which are absorbed by film) 3. *Lower exposure / fewer X-rays needed 4. Iodine / barium (used as contrast material) 5. *High Z number / large attenuation coefficient / large absorption coefficient (used to improve image contrast) 6. Contrast media are ingested / injected into the body 7. *Scan shows <u>outline</u> / <u>shape</u> of soft tissue QWC mark is acquired from clear expression of any of the marking points 3, 5 or 7	B1 × 5	
	(b)		X-rays produce visible light or In photoelectric effect electrons are emitted	B1	
	(c)	**(i)**	Any <u>two</u> from: • Simple X-ray is one directional / produces single image • CT image(s) taken at different angles / X-ray tube is rotated • Computer processes data / image constructed from many slices	B1 × 2	
		(ii)	Any <u>two</u> from: 1. X-ray image is 2D / CT scan produces 3D image 2. Greater detail / definition / contrast with CT scan / 'soft tissues can be seen' 3. Image can be rotated	B1 × 2	
			Total	10	

Question			Expected Answer	Mark	Additional Guidance
9	**(a)**	**(i)**	composition for n and p: u d d & u u d charge for n and p: 0 & +1	B1 B1	 **Allow**: charge 'e' instead of '+1' or '1'
		(ii)	up +2/3 (**+1/3**) 0 down -1/3 +1/3 (**0**)	B1 B1	**Allow**: charges in terms of 'e'
	(b)	**(i)**	${}^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e + \bar{\nu}$	A2	**Allow**: '→ proton + electron + <u>anti</u>neutrino' **Note**: -1 for any omission or error. Score = 0 if more than one error
		(ii)	weak (nuclear)	B1	
		(iii)	lepton(s) <u>and</u> hadron(s) / baryons(s)	B1	**Not**: Neutrons are mesons
			Total	8	

Question			Expected Answer	Mark	Additional Guidance
10	**(a)**		**Spontaneous**: the decay cannot be induced / occurs without external influence **Random**: cannot predict when / which (nucleus) will decay next	B1 B1	
	(b)		The probability of decay of a <u>nucleus</u> <u>per</u> unit time	M1 A1	**Allow**: $\lambda = A / N$ (Any subject) C1 A = activity and N = number of <u>nuclei</u> A1
	(c)		Living plants / animals absorb carbon(-14) Once dead, the plant does not take in any more carbon(-14) The fraction of C-14 to C-12 (nuclei) or number of C-14 (nuclei) or activity of C-14 (nuclei) measured in dead <u>and</u> living (sample) $x = x_0 e^{-\lambda t}$ used with data above to estimate the age	B1 B1 M1 A1	
	(d)	**(i)1**	$\lambda = \ln 2 / T_{1/2}$ decay constant = 1.24×10^{-4} (y^{-1})	B1	
		(i)2	$A = A_0 e^{-\lambda t}$ $0.194 = 0.249 \times e^{-(1.24\times10^{-4}\times t)}$ $\ln(0.194/0.249) = -1.24\times10^{-4} t$ time = 2.0×10^3 (y)	C1 A1	
		(ii)	The activity is (very) small / decay is random	B1	
		(iii)	Activity so low that it cannot be differentiated from the background	B1	
			Total	13	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

14 – 19 Qualifications (General)
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

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Facsimile: 01223 552553