Cambridge Assessment

A Level

Physics A

Session: 2010 June
Type: Mark scheme
Code: H158-H558
Units: G481; G482; G484; G485

OCR
RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE **G481**

Mechanics

Mark Scheme for June 2010

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CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Convention used when marking scripts

WRONG PHYSICS OR EQUATION – indicate by **?** on scoris
No credit is given for correct substitution, or subsequent arithmetic, in a physically incorrect equation.

ERROR CARRIED FORWARD – indicate by **ECF** on scoris
Answers to later sections of numerical questions may be awarded up to full credit provided they are consistent with earlier incorrect answers.

ARITHMETIC ERROR – indicate by **AE** on scoris
Deduct 1 mark for the error and then follow through the working/calculation giving full credit for subsequent marks if there are no further errors. The ruling also includes power of ten (POT).

TRANSCRIPTION ERROR – indicate by ^ on scoris
This error is when there is incorrect transcription of data from the question, formulae booklet or previous answer. For example 1.6×10^{-19} has been written down as 6.1×10^{-19} or 1.6×10^{19}. Deduct the relevant mark and then follow through the working giving full credit for subsequent marks.

SIGNIFICANT FIGURES – indicate by **SF** on scoris
Where more SFs are given than is justified by the question, do not penalise. Fewer significant figures than necessary will be considered within the mark scheme. An error in significant figures is penalised only once per paper.

BENEFIT OF DOUBT – indicate by **BOD** on scoris
This mark is awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done.

RUBRIC INFRINGEMENT
If the candidate crosses out an answer but does not make any other attempt, then the work that is crossed out should be marked and the marks awarded without penalty.

CONTRADICTION – indicate by **CON** on scoris
No mark can be awarded if the candidate contradicts himself or herself in the same response. For example, '… t*he mass of the particle increases and decreases*.'

Q 1	Expected Answers	Marks	Additional Guidance
a	10^6 nano (n) 10^{12}	B1 B1 B1	**Allow**: 1000 000 **Allow**: nano / n / nano (N) as BOD **Allow**: 1000 000 000 000
b	Circled quantities: density and volume	B1	
c	$1.5\times10^{11} = 3.0\times10^{8}\times t$ time = $\frac{1.5\times10^{11}}{3.0\times10^{8}}$ / 500 (s) time = 8.33 (min) ≈ 8.3 (min)	C1 A1	**Allow**: Any subject **Note**: Bald 500 (s) scores 1 mark **Allow**: 2 marks for a bald answer of 8.3 **Allow**: Answer as a fraction – 25/3 (min) / 8 min 20 s **Allow**: 1 mark for '(500/3600 =) 0.139'
d(i)	Mention of weight or drag Net / total / resultant force (on drop) is zero 'upward force = downward force' / 'weight = drag' / 'weight balances drag'	B1 B1	**Allow:** (air) resistance / (air) friction for 'drag' **Not:** 'gravity' for 'weight' **but** 'force of gravity' is fine **Not**: 'acceleration = 0' since question requires answer in terms of forces **Not**: 'All forces are equal' **Note**: 'weight = drag' / 'weight balances drag' scores 2 marks
d(ii)1	A downward line / arrow (from the raindrop) leaning to the right	B1	**Note**: Answer **must** be on Fig. 1.2 Judge by eye – the angle is not important
d(ii)2	$v^2 = 1.5^2 + 4.0^2$ velocity = 4.27 (m s^{-1}) ≈ 4.3 (m s^{-1})	C1 A1	**Allow**: 2 marks for a scale drawing with value in the range 4.1 to 4.5. If value in the range 4.0 to 4.1 or 4.5 to 4.6 then give 1 mark **Allow**: 2 marks for a bald answer of 4.3 (m s^{-1})
	Total	**11**	

Q 2	Expected Answers	Marks	Additional Guidance
a	‘heavy’ and ‘light’ objects / different weights / different masses dropped (from leaning tower of Pisa) / rolled down incline plane Objects have the same <u>acceleration</u> (of free fall) Objects hit ground at same time	B1 B1 B1	**Must use ticks on Scoris to show where the marks are awarded** **Not**: ‘dropping feather’ / ‘vacuum’ / ‘experiment on the Moon’ for this first B1 mark but can score subsequent B1 marks **Not**: ‘fall at the same rate / accelerates at the same rate / same speed’
b(i)	$s = ut + \frac{1}{2}at^2$ <u>and</u> $u = 0$ / $0.600 = \frac{1}{2} \times a \times (0.356)^2$ $a = \frac{2 \times 0.600}{0.356^2}$ $a = 9.47$ (m s^{-2})	C1 C1 A0	**Note**: There are no marks for just an answer, since this is a **‘show’** question **Allow**: 2 marks for correct substitution with ‘a’ the subject or $0.600 = \frac{1}{2} \times a \times (0.356)^2$ followed by $a = 9.469$ (more than 3 sf) **Note:** Using ‘v =.600/0.356’ followed by $a = \Delta v / \Delta t = 4.73$ scores zero. (Watch out for $4.734 \times 2 = 9.47$)
b(ii)	Air resistance or drag / residual magnetism or ‘sticky’ electromagnet / trapdoor takes time to open	B1	**Not**: ‘Experiment is not done in a vacuum’ / ‘friction/resistance’
b(iii)	A ‘parabola shape’ / graph of increasing positive gradient starting from <u>origin</u> and going through 0.356,0.6	B1	Judge the shape of the graph by eye. A horizontal line from 0.6 must cut the graph within the ‘vertical zone provided by 0.356 s ’ on the time axis
	Total	**7**	

Q 3	Expected Answers	Marks	Additional Guidance
a	The (net) force (is a newton) when a 1 kg mass has acceleration of 1 m s^{-2}	B1	**Not**: 1 N = 1 kg m s^{-2} because this is too brief for a definition
b(i)	weight = $1.9 \times 10^6 \times 9.81$ weight = 1.86×10^7 (N)	 B1	**Allow**: 9.8 (m s^{-2}) for *g* but not 10 (m s^{-2}) **Allow**: A bald answer of 1.9×10^7 N, but **not** if 10 (m s^{-2}) is seen
b(ii)	net force = 1.24×10^7 (N) or 1.2×10^7 (N) $a = \frac{F}{m} = \frac{1.24 \times 10^7}{1.9 \times 10^6}$ acceleration = 6.53 (m s^{-2}) or 6.5 (m s^{-2})	C1 A1	**Allow**: The C1 mark for "(net force) = $(3.1 - 1.86) \times 10^7$ (N)" **Allow**: 2 marks for a bald answer **Allow**: Answer of 6.3 (m s^{-2}) if 1.9×10^7 (N) is used for weight or net force of 1.2×10^7 (N) is used **Allow**: 1 mark for '$3.1 \times 10^7 / 1.9 \times 10^6 = 16.3$' **Not:** '$1.86 \times 10^7 / 1.9 \times 10^6 = 9.8$'
b(iii)	The mass / weight (of spaceship) decreases (as it loses fuel)	B1	**Allow**: 'g' / acceleration of free fall / gravitational field strength decreases (but **not** gravity decreases) **Not**: 'less drag / air resistance'
	Total	**5**	

Q 4	Expected Answers	Marks	Additional Guidance
a	✍work done = force × distance <u>moved</u> / <u>travelled</u> (in direction of force) **The term *distance* / *displacement* to be included and spelled correctly to gain mark**	B1	**Note**: Must have reference to 'distance moved / travelled' **Allow**: 'work done = force × displacement' **Must use tick or cross on Scoris to show if the mark is awarded**
b(i)	<u>gravitational</u> potential ✍ kinetic **The term *kinetic* to be included and spelled correctly to gain the second B1 mark**	B1 B1	**Not**: 'potential' on its own **Note**: Ignore any reference to sound **Must use ticks on Scoris to show where the marks are awarded**
b(ii)	(GPE =) $4000 \times 9.81 \times 110$ / (GPE =) 4.32×10^6 **or** (KE =) ½ × 4000×20^2 / (KE =) 8.0×10^5 Work done = $(4000 \times 9.81 \times 110) - (\frac{1}{2} \times 4000 \times 20^2)$ force = $\frac{3.516 \times 10^6}{510}$ force = 6.9×10^3 (N)	C1 C1 A1	 **Allow**: 2 marks if second line is written or $3.5(16) \times 10^6$ (J) is quoted **Allow**: 3 marks for a bald answer of 6.9×10^3 (N)
	Total	**6**	

Q 5	Expected Answers	Marks	Additional Guidance
a	The distance travelled (by the car) whilst the brakes are applied and the car stops (wtte)	B1	**Note**: The answer must have reference to car stopping
b	Any <u>two</u> factors from: mass, brakes, tyres / tread, road (surface) and 'slope' of road Correct description for each factor; see below: 1. Greater mass increases distance / distance ∝ mass 2. Worn brakes increases distance 3. Bald tyres increases distance (when wet) 4. Wet / icy /gravel road increases distance 5. An uphill road will decrease the distance (ora)	B1×2 B1×2	**Must use ticks on Scoris to show where the marks are awarded** **Allow:** Reference to just 'distance' since '<u>braking</u> distance' is in the question **Note**: For point 3, allow 'less tread increases (braking) distance (when wet)'.
c	Any <u>three</u> from: 1. Prevent collision with steering wheel / windscreen /dashboard 2. Time for stopping is more / distance for stopping is more / seat belt 'stretches' 3. Smaller deceleration / acceleration (of person) 4. Reference to '$KE = Fs$' or '$\frac{1}{2}mv^2 = Fs$'	B1×3	**Must use ticks on Scoris to show where the marks are awarded** **Allow**: Smaller 'rate of change of momentum' for the third B1 point **Not**: Less pressure (on driver because of larger area of belt)

Q 5	Expected Answers	Marks	Additional Guidance
d(i)1	thinking distance = 0.50 × 20 thinking distance = 10 (m)	B1	
d(i)2	braking distance = 30 (m) stopping distance = (30 + 10 =) 40 (m)	C1 A1	 **Allow**: 2 marks for a bald answer of 40 (m) **Allow**: 1 mark for 'answer to **(d)(i)1** + candidate's braking distance' if braking distance ≠ 30 (m) Possible ecf from **(d)(i)1**
d(ii)	$\frac{s}{32^2} = \frac{30}{20^2}$ / 'k = 0.075' / 'k = 13.3' (distance =) 77 (m) ---------- Or ---------- At speed of 16 (m s^{-1}), distance = 19 (m) (distance = $2^2 \times 19$ =) 76 (m)	C1 A1 ------- C1 A1	**Allow**: For the C1 any other equivalent and correct substitution into similar equation **Allow**: An answer in the range 76 - 78. Note bald answer in this range can score 2 marks **Allow**: distance in the range 19 to 19.5 (m) Possible ecf
	Total	**13**	

Q 6	Expected Answers	Marks	Additional Guidance
a(i)	torque = 4.0×0.03 torque = 0.12 (N m)	C1 A1	 **Note**: An answer of 12 scores 1 mark (because cm not converted into m) **Allow**: Full marks for if the centi prefix added; that is 12 N cm **Allow**: 2 marks for a bald 0.12 (N m)
a(ii)	 (total moment =) $(x + 0.03) \times 4.0 - 4.0x$ (total) moment = 0.12 (N m) It is the same as the torque (of the couple) / same as **(a)(i)**	 M1 A1 B1	**Condone** the use of 'N cm' in **a(ii)** **Allow**: Equation with x value of 0.06 (m) or 6 cm **Special case**: 1 mark for (anticlockwise moment =) $4.0x$ or (clockwise moment =) $[x + 0.03] \times 4.0$ seen anywhere on the script **Not**: '0.12 (N m)'
b	Net / total / resultant force = 0 Net / total torque / moment = 0	B1 B1	**Not**: 'forces are balanced' or 'force up = force down' **Allow**: clockwise moment(s) = anticlockwise moment(s)
c(i)	$\rho = \frac{M}{V}$ / density = $\frac{45}{0.600 \times 0.600 \times 0.050}$ density = 2.5×10^3 (kg m^{-3})	C1 A1	 **Allow**: 2 marks for a bald answer of 2.5×10^3 (kg m^{-3})
c(ii)	clockwise moment = anticlockwise moment **or** (weight =) 45×9.81 / (weight =) 441.45 $(45 \times 9.81) \times 0.150 = F \times 0.600$ F = 110 (N)	C1 C1 A1	 **Allow**: 3 marks for a bald 110 (N) **Allow**: 2 marks for 11.25 – mass of 45 kg not changed to N
	Total	**12**	

Q 7	Expected Answers	Marks	Additional Guidance
a	<table><tr><th>X</th><th>Y</th></tr><tr><td>✓</td><td></td></tr><tr><td></td><td>✓</td></tr><tr><td>✓</td><td></td></tr></table>	B1	All 3 ticks correctly placed for 1 mark
b(i)	Material is permanently deformed / longer when stress / force is removed (wtte)	B1	**Note**: The answer must make reference to stress or forces removed
b(ii)1	(stress = force/area) force = $3.00 \times 10^{9} \times 1.02 \times 10^{-7}$ force = 306 (N) or 310 (N)	C1 A1	**Allow**: Any subject **Allow**: 2 marks for a bald 306 (N) or 310 (N)
b(ii)2	(E = stress/strain) strain = $\frac{1.20\times10^{9}}{1.30\times10^{11}}$ / strain = 9.23×10^{-3} extension = $9.23 \times 10^{-3} \times 0.500$ extension = $4.6(15) \times 10^{-3}$ (m)	C1 A1	 **Allow**: 4.6×10^{-3}, 4.61×10^{-3}, 4.62×10^{-3} **Allow**: 2 marks for a bald $4.6(15) \times 10^{-3}$ (m) **Allow**: 1 mark for using breaking stress of 3.0×10^{9} Pa; this gives an extension of 0.0115 (m) **Alternative answer:** $x = (1.20 \times 10^{9} \times 0.500)/1.30 \times 10^{11}$ C1 (Any subject) extension = $4.6(15) \times 10^{-3}$ (m) A1
	Total	**6**	

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OCR
RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced Subsidiary GCE **G482/01**

Electrons, Waves and Photons

Mark Scheme for June 2010

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Question			Expected Answers	M	Additional Guidance
1					
	a		current moves from + to – (of battery in circuit) **and** electrons move from – to +	B1	
	b		$C\ s^{-1}$ $V\ \Omega^{-1}$	B1 B1	2 correct 2 marks; 1 correct 1 mark, withhold a mark for each additional answer given
	c	i	statement of Kirchhoff's first law or conservation of charge	B1	**accept** wires are in series or current is the same (at every point) in a series circuit/AW **not** current in = current out
		ii1	R = ρl/A calculation to justify R = 72 Ω	B1 A1	accept R α l and R α 1/A **or** similar method/argument must be convincing **accept** 3/½ x12 but **not** 3 x 2 x 12
		ii2	R = sum of Rs R = 84 Ω	C1 A1	**accept** Rs in series **ecf (c)(ii)1**
		iii	select I = nAev $v = 4.0 \times 10^{-5}$ (m s^{-1})	B1 B1	**allow** v α 1/A **accept** 4×10^{-5} (m s^{-1}) **no** SF error
			Total question 1	**10**	

Question			Expected Answers	M	Additional Guidance
2					
	a	i	When connected/using/AW to the 230 V supply the power/energy per second from supply/output/dissipated/AW is 25 W	B1 B1	**accept** when working normally/AW **not** 230 V (going) through/into lamp/AW **accept** transferred from electrical (into other) form(s) is 25 W
		ii	$25 = 230^2/R$ R = 2100 Ω **or** 2.1 kΩ	C1 A1	**accept** I = 25/230 = 0.11 A R = 230/0.11 = 2100 Ω (2116 Ω)
		iii	Using the equation in the form P = VI, for larger P need larger I so 60 W	M1 A1	accept $P = V^2/R$, for larger P need smaller R so larger I; do **not** allow any argument using 880 Ω unless this value is calculated here
		iv1	1/R = 1/2100 + 1/880 R = 620 Ω	C1 A1	substitution into formula for Rs in parallel **ecf (a)(ii)**
		iv2	I = 230/620 I = 0.37 (A)	C1 A1	**ecf (a)(iv)1** using 1/R gives 143 kA accept total P = 85 W so I = 85/230 ;= 0.37 (A)
	b		the resistivity/resistance (of a metal) increases with temperature **or** R is greater when hot(ter) at 6V/low I little heating effect **or** at 230 V/high I large heating effect	B1 A1	**ora** less when colder **QWC mark**: explanation linked to observations
	c	i	(a unit of) energy equal to 3.6 MJ **or** 1 kW for 1 h/AW	B1	**eg** 1000 W for 3600 s or similar
		ii	0.06 x 8 = 0.48 (kWh) or 60 x 8 = 480 (Wh) 0.48 x 21 = 10(.1) p	C1 A1	no marks for using s instead of h POT error e.g. 100 or 10000 p
			Total question 2	**15**	

Question			Expected Answers	M	Additional Guidance
3					
	a	i	correct symbols (variable) R in series with ammeter and cell voltmeter correctly in parallel with variable R	B1 B1 B1	variable R and voltmeter needed **ecf** variable resistor symbol **accept** voltmeter in parallel with cell
		ii1	V decreases as I increases caused by R decreasing V is large when R is large **or** V is small when R is small V = e.m.f. when R is infinite/open circuit **or** V = 0 when R = 0 3.14 Ω at A; 0.88 Ω at B and 0.19 Ω at C any correct reference to internal resistance of cell	B1 B1 B1	**max 3 marks** with 2 marks for first two or second two marking points or three numbers and 1 mark for reference to r **allow** as R increases (decreases) V increases (decreases) for 1 mark but **not** as V increases R increases; **award 0/2** if reason given as V α R or I is constant
		ii2	at A I is small or V is much bigger than I/AW at C V is small or I is much bigger than V/AW product of V. and I is largest when the values of both quantities are about equal/half of the maximum value	B1 B1 B1	**accept** numerical answers, e.g. 0.39 W at A, 0.33 W at C 0.56 W at B for 2 marks comment on values for third mark
		ii3	1.4 (V)	B1	
		ii4	appreciating V against I is a straight line graph with gradient –r; giving r = 0.88 ± 0.02 Ω	C1 A1	**accept** using V = E – Ir **not** just quoting formula **allow** 0.8 ± 0.02 for calculation using any point on line N.B. can also have **ecf(ii)3**
	b	i	intensity is the (incident) energy <u>per</u> unit area <u>per</u> second	B1	**accept** power per unit area or power per m^2 or (total) power/(surface) area
		ii	efficiency = power out/power in = 0.25/(800 x 2.5 x 10^{-3}) = 0.125 or 12.5%	C1 C1 A1	**not** energy out/energy in **accept** 13%
			Total question 3	**16**	

Question			Expected Answers	M	Additional Guidance
4					
	a		resistance decreases with increase in light intensity	B1	**ora**
	b	i	3.0 (V)	B1	**accept** 3 V, no SF error
		ii	3.0 = I.1.2 x 10^3 giving I = 2.5 x 10^{-3} A 6.0 /2.5 10^{-3} = R = 2400 Ω 2.4 kΩ	C1 C1 A1	**accept** 6 = (R/ R + 1.2 k).9 2R + 2.4 k = 3R or similar R = 2.4 k ;**give** 2 with POT error **accept** ratio of resistors 6/3 x 1.2 good candidates can do this by inspection with no working – full marks **allow** 2400 written on answer line rather than 2.4 if 2400 Ω within body of text
		iii	49 **or** 50 (W m^{-2})	B1	**ecf (b)(ii)** if on R within graph range
	c	i	2.2 (kΩ)	B1	**allow** any value from 2.1 to 2.2
		ii	large(r) changes in R at low light intensities relating change in R to change in V	B1 B1	**allow** greater sensitivity of LDR at low light **or** steeper gradient/AW **e.g.** bigger change in I so in V **or** use of V = R/(R + 1200) V_s **or** bigger change in V ratio across Rs
	d		V across 1.2 kΩ falls so V across LDR rises because ratio of Rs changes in favour of LDR/ potential divider argument **or** total V is constant	B1 B1 B1	**alternative** I increases because total R is less so V across LDR rises do **not** award B marks where there is CON e.g. V across 1.2 k rises so V across LDR rises
	e		continuous record for very long time scale of observation can record very short time scale signals (at intervals) automatic recording/remote sensing data can be fed directly to computer (for analysis)	B1 B1	**allow** any two sensible suggestions which fall within the 4 categories listed for 2 marks
			Total question 4	**14**	

Question			Expected Answers	M	Additional Guidance
5					
	a	i	travel through a vacuum	B1	**allow** travel at c (in a vacuum)
	b	ii	A gamma; C uv; F microwave	B3	**allow** 1 mark for A radio; C ir; F X-ray
	c	i	$3.0 \times 10^8 = 1.0 \times 10^9 \lambda$ $\lambda = 0.30$ m	C1 A1	 **allow** 0.3 no SF error
		ii	aerial length = $\lambda/2 = 0.15$ m	A1	**ecf (c)(i)**
		iii	emitted wave is (plane) polarised detecting aerial will receive weaker signal/cos θ component when it is rotated (through angle θ)/AW signal falls to zero at 90° and then rises to max again at 180°	B1 B1 B1 	**allow** max signal initially/at 0° **max 3 marks** from 4 marking points
	d	i	UV-A causes tanning or skin ageing ; most of (99%) uv light; 400-315 nm UV-B causes damage or sunburn or skin cancer; 315-260 nm UV-C is filtered out by atmosphere/ozone layer; 260-100 nm	B1 B1 B1	accept values within ranges with tolerance of 20 nm **allow** $\lambda_A > \lambda_B > \lambda_C$ for 1 mark **max 3 marks** from 7 marking points
		ii	filters out/blocks/reflects/absorbs UV(-B)	B1	**allow** chemicals prevent sunburn/skin cancer **not** stops UV penetrating skin
	e		energy of the infra-red photon is less than the work function of the metal surface	B1 B1	**accept** frequency and threshold frequency **or** wavelength and threshold wavelength used correctly in place of energy and work function **1 mark** only: energy of the uv photon greater than work function with no mention of ir
			Total question 5	**16**	

Question			Expected Answers	M	Additional Guidance
6					
	a		oscillation/vibration of <u>particles/medium</u> in direction of travel of the wave example: sound wave, etc. oscillation/vibration of <u>particles/medium</u> (in the plane) at right angles to direction of travel of the wave example: surface water waves, string, electromagnetic, etc	B1 B1 B1 B1	**allow** direction of energy transfer of the wave **not** direction of wave motion **allow** direction of energy transfer of the wave **allow** RE mark for weaker descriptions with same omissions as in longitudinal wave
	b		the incident wave is reflected at the end of the pipe <u>reflected</u> wave <u>interferes/superposes</u> with the incident wave to produce (a resultant wave with) nodes and/or antinodes	B1 B1 B1	 **QWC mark** **accept** resultant wave with no energy transfer
	c	i	at 0 oscillation with max amplitude along tube at 0.2 m (oscillation along tube with) smaller amplitude at 0.6 m no motion/node	B1 B1 	**not** displacement (penalise only once) all 4 correct for 2 marks; 2 correct for 1 mark
		ii	oscillation at 3 times the frequency of c(i) at 0 (oscillation with) max amplitude (along tube)/antinode at 0.2 m no motion/node at 0.4 m motion as at 0 (but in antiphase/opposite direction)	B1 B1 	 3 correct for 2 marks; 2 correct for 1 mark
	d	i	λ/2 sketch with zero at 0.3 m	M1 A1	**accept** 1 or 2 lines, solid or dotted
		ii	$2f_0$	B1	**no ecf from d(i)**
			Total question 6	**14**	

Question			Expected Answers	M	Additional Guidance
7					
	a	i	light emitted from (excited isolated) atoms produces a line spectrum a series of (sharp/bright/coloured) lines against a dark background	B1 B1	**max 2 marks** from 3 marking points
		ii	in an absorption spectrum a series of dark lines (appears against a bright background/within a continuous spectrum)	B1	**accept** black
	b	i	$\varepsilon = hc/\lambda$ $= 6.63 \times 10^{-34} \times 3.00 \times 10^{8} / 436 \times 10^{-9}$ $= 4.56 \times 10^{-19}$ (J)	C1 C1 A1	**apply** SF error if all numbers not to 3+ figures 4.54 if use 6.6
		ii	3.64×10^{-19} (J)	A1	**allow** mark if repeated error from **b(i)**
	c	i	correct vertical lines; correct labels arrow(s) downwards	B1 B1 B1	**1 mark** for 1 vertical line + correct label
		ii	$- 8.86 + 4.56 = - 4.3 \times 10^{-19}$ (J) $- 7.94 + 3.64 = - 4.3 \times 10^{-19}$ (J)	B1 B1	**ecf b(i)** **do** calculation for one line only correctly scores 2 marks; give answer as 4.3×10^{-19} **or** -4.3 scores 1 mark **do** calculation for both lines and give answer as 4.3×10^{-19} **or** -4.3 scores both marks
N.B. Before marking 7d check pages 18, 19 and 20 for additional answers by scrolling down. Extra answers MUST be annotated to show that they have been seen and credited back in the relevant question when appropriate. **✓ = 1 extra mark** **x = incorrect; scores 0** **NBOD = no added value or no further action needed; scores 0** **CON = if reference is made to the additional answer in the main text and this answer contradicts the other then deduct the original mark; = if NO reference is made to the additional answer in the main text and this answer contradicts the other then do NOT change the original mark**					
	d		($d \sin\theta = \lambda$) $3.3 \times 10^{-6} \sin\theta = 546 \times 10^{-9}$ $\sin\theta = 0.165$ $\theta = 9.5^{o}$	C1 C1 A1	
			Total question 7	**15**	

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RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE **G484**

The Newtonian World

Mark Scheme for June 2010

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Question	Expected Answers	Marks	Additional guidance
1(a)	The magnitude of the impulse on each object is the same Total energy is conserved	B1 B1	For 3 or 4 ticks mark and deduct 1 mark for each error.
(b) (i)	Correct use of ½ mv^2 Loss of KE = 0.03(144-81) = **1.9** (or 1.89) **J**	C1 A1	0.27 J scores 1st mark Do not allow 1.8
(b) (ii)	Change in momentum = (0.06x12)+(0.06x9) = 1.26 (Ns) Average force=rate of change of momentum = 1.26/0.15 = **8.4** (or 8) **N**	C1 A1	Award 1 mark for 1.2 N ignore minus signs
(b) (iii)	**8.4 N** (or - 8.4)	B1	Allow ecf from (ii)
(c) (i)	ANY 3 of the following particles move with rapid, random motion (WTTE) elastic collisions negligible (or zero) volume of atoms (compared with volume of container) no intermolecular forces (except during collisions)/all internal energy is KE collision time negligible (compared to time between collision).	 B1 B1 B1	Allow " gravitational force on molecules is negligible" Do not allow a bare "large number of particles".
(c) (ii)	molecules make collisions with walls/surface (WTTE) (hence) exerts a force on the wall (or each collision has a change of momentum) Pressure = force/area	B1 B1 B1	Do not allow a bare "molecules collide with each other"
	Total	13	

Question	Expected Answers	Marks	Additional guidance
2 (a) (i)	Horizontal <u>component</u> of **L** provides the centripetal force (WTTE) Vertical <u>component</u> of **L** balances the weight (WTTE)	B1 B1	
(a) (ii)	$F = mv^2/r$ correct rearranged into $v = \sqrt{(Fr/m)}$ $v = \sqrt{(1.8\text{x}10^6 \text{ x}2000/1.2\text{x}10^5)} =$ **173** m s^{-1} (or 170)	C1 A1	Allow correct substitution of values into $F = mv^2/r$ for C1 mark
(b)	$mv^2/r = GMm/r^2$ $T = 2\pi r/v$ Correct manipulation of equations to give $T^2 = \frac{4\pi^2 r^3}{GM}$	B1 M1 A1	Do not allow a bare $v^2 = GM/r$ for the first mark – we need to see where this has come from.
(c) (i)	**Equatorial** orbit (WTTE) (<u>QWC mark</u>) Period is 24h/1day/same as Earth **OR** moves from West to East (WTTE)	B1 B1	QWC <u>equatorial</u> or <u>equator</u> must be spelled correctly
(c) (ii)	Correct rearrangement of $T^2 = (4\pi^2 r^3/GM)$ to give $r^3 = T^2GM/4\pi^2$ correct sub. $r^3 = \{6.67\text{ x}10^{-11} \text{ x } 6.0 \text{ x } 10^{24} \text{ x } (8.64\text{x}10^4)^2\}/4\pi^2 = 7.57\text{x}10^{22}$ $r =$ **$4.23 \text{ x } 10^7$ m** (or 4.2 or 4.3 x 10^7)	C1 C1 A1	(1 day = 8.64 x10^4s is given on the data sheet). For those who use $g = GM/r^2$ with g = 9.81 award 1 mark for r= 6.4 x 10^6 m.
	Total	12	

Question	Expected Answers	Marks	Additional guidance
3(a)	Acceleration is (directly) proportional to the displacement/distance (from the equilibrium position/central pt) Acceleration is always directed towards the equilibrium position/central point.	B1 B1	Allow "fixed point" or "point" Allow acc. is in opposite direction to displacement (WTTE) If formula is used: allow a $\propto$ -x for 1st mark and 2nd mark if x is stated as displacement.
(b) (i)	Curve symmetrical about energy axis with maximum at 18 zero at +0.04 and – 0.04	B1 B1	Ignore points where graphs cross Give bod if not labelled **K** but correct
(b) (ii)	Horizontal straight line passing 18	B1	Give bod if not labelled **T** but correct
(c) (i)	0.04 m	B1	
(c) (ii)	$\frac{1}{2}m(v_{max})^2 = 0.018$ $v_{max} = \sqrt{(2x0.018/0.12)} =$ **0.55** ms^{-1} (0.548)	C1 A1	Many will use 18 instead of 0.018. This results in 17.3 and scores 1 mark. Allow ecf for cand's value of max KE. Do not allow 0.54 for second mark.
(c) (iii)	correct use of $v_{max} = 2\pi fA$ $f = (0.55/0.04x2\pi) =$ **2.2** (or 2.19 or 2.18)Hz	C1 A1	Allow ecf for cand's values from (c)(i) and/or (c) (ii). E.g for 17.3 f = 68.8 Hz. This scores 2 marks e.c.f. Do not allow 2.1
(d)	Award first mark for stating the **'driver'** of the oscillations and the second mark for stating what is **'driven'** i.e. oscillating useful applications: e.g. Cooking: **micro waves** cause **water molecules** to resonate Woodwind: **reed** causes **air column** to resonate Brass: **lips** cause **air column** to resonate MRI: **radio waves** (in a magnetic field) cause **nuclei/proton** to resonate Radios: **radio waves** cause **electrons/current** to resonate Person on swing: **intermittent pushes** cause **swing** to resonate problem: Bridges: **wind/walkers** causes **bridge** to resonate Vehicles: **engine vibrations** cause **panels/mirrors** to resonate Earthquakes: **ground vibrating** causes **buildings** to resonate	B1 B1 B1 B1	No marks to be awarded for a bare statement of the example e.g MRI. Please allow any other valid examples.
	Total	14	

Question	Expected Answers	Marks	Additional guidance
4 (a) (i)	**Brownian** (motion) (QWC mark)	B1	QWC Brownian spelled correctly
(a) (ii)	ANY two from the following three: air molecules are moving in different directions/randomly with different speeds mass/size of air molecules is smaller than smoke particles	 B1 B1	Answers that refer to smoke particles only cannot score the marks.
(b) (i)	vol = (4/3) πr^3 = 5.58 x 10^{-3} correct sub into pV = nRT i.e. with T as 290K n = (2.6x10^5x 5.58x10^{-3})/8.31x290 = 0.602 moles mass = n x 0.028 = **0.0169** kg (0.016856)	C1 C1 A1 A1	Allow ecf for wrong volume Allow use of pV = NkT and n = N/N_A Allow ecf for cand's value for n If 17^o C used allow maximum of 2 marks for n = 10.3 moles and m = 0.29 kg
(b) (ii) 1	no net heat flow between objects (WTTE)	B1	Allow "they are at the same temp."
(b) (ii) 2	correct use of P/T = constant: e.g. P = (273/290) x 2.6 x 10^5 P = **2.45 x 10^5** (or 2.4 x 10^5 or 2.5 x 10^5)Pa	C1 A1	Allow correct use of pV=nRT
	Total	10	

Question	Expected Answers	Marks	Additional guidance
5(a) (i)	Initial KE of car = 0.5x970x27^2 = **3.5 x 10^5 J** (353565J)	B1	
(a) (ii)	Work done = Av Force x distance moved Av Force = 3.5 x 10^5 J/40 = **8.8 x 10^3 N** (or 8750 N) (or 353565/40 = 8836.7 N) Assumption: **no air resistance**	C1 A1 B1	If $v^2 = u^2 + 2as$ is used. accept a = 0-27^2/(2x40) = 9.113 ms^{-2} C1 F = ma = 970x9.11 = 8.84 x 10^3 N A1 Allow air friction or drag
(b) (i)	correct use of E = mc$\Delta\theta$: 3.5 x 10^5/4 = 1.2x520x$\Delta\theta$ $\Delta\theta$ = **140^{O}C** (if 353565 is used $\Delta\theta$ = 142^{O}C)	C1 A1	If cand. forgets to divide by 4 allow any value between 560 and 570 for 1 mark.
(b) (ii)	Air resistance will be acting (slowing down the car) (hence) reducing the KE of the car (WTTE) The discs are hotter than the surroundings (hence) energy/heat will be lost from discs/brakes (WTTE)	M1 A1 B1 B1	Do not allow sound since only a tiny proportion of energy is lost in this way. Allow other valid comments as alternative ways of scoring one or both of the 'B' marks: e.g. 'hot spots' on discs; discs are different. Try to credit a well argued case based upon correct physics- e.g. wheels locking.
(b) (iii)	Any valid suggestion: e.g. use a material with a higher s.h.c use a disc with a higher heat capacity Use discs of greater mass put holes in the discs (to increase air flow)	 B1	Confusion between shc and heat capacity should not be penalised.
	Total	11	

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GCE

Physics A

Advanced GCE **G485**

Fields, Particles and Frontiers of Physics

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CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Convention used when marking scripts

WRONG PHYSICS OR EQUATION – indicate by **?** on scoris
No credit is given for correct substitution, or subsequent arithmetic, in a physically incorrect equation.

ERROR CARRIED FORWARD – indicate by **ECF** on scoris
Answers to later sections of numerical questions may be awarded up to full credit provided they are consistent with earlier incorrect answers.

ARITHMETIC ERROR – indicate by **AE** on scoris
Deduct 1 mark for the error and then follow through the working/calculation giving full credit for subsequent marks if there are no further errors. The ruling also includes power of ten (POT).

TRANSCRIPTION ERROR – indicate by **^** on scoris
This error is when there is incorrect transcription of data from the question, formulae booklet or previous answer. For example 1.6×10^{-19} has been written down as 6.1×10^{-19} or 1.6×10^{19}. Deduct the relevant mark and then follow through the working giving full credit for subsequent marks.

SIGNIFICANT FIGURES – indicate by **SF** on scoris
Where more SFs are given than is justified by the question, do not penalise. Fewer significant figures than necessary will be considered within the mark scheme. An error in significant figures is penalised only once per paper.

BENEFIT OF DOUBT – indicate by **BOD** on scoris
This mark is awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done.

RUBRIC INFRINGEMENT
If the candidate crosses out an answer but does not make any other attempt, then the work that is crossed out should be marked and the marks awarded without penalty.

CONTRADICTION – indicate by **CON** on scoris No mark can be awarded if the candidate contradicts himself or herself in the same response. For example, '… t*he mass of the particle increases and decreases*.'

Question			Expected Answers	Marks	Additional Guidance
1	a		Capacitance = charge per (unit) potential difference	B1	Allow: capacitance = charge / potential difference, charge/pd, charge/voltage but not charge / volt, coulomb /pd (no mixture of quantities and units. Allow 'over' instead of per
	b	(i)	Q = CV = 4.5 μ x 6.3 = 28.(35) (μC)	B1	Allow: 28 (≥ 2 sf)
		(ii)	$E = ½ CV^2 = 0.5 \times 4.5 \times \mu \times (6.3)^2$ $= 8.9(3) \times 10^{-5}$ (J) / 89.3 μ(J)	C1 A1	Allow use of E = ½ QV and the Q value from **(b)(i)** Q=28 E= 8.82 and Q=28.4 E=8.946 Allow ecf from **(b)(i)** penalise power of ten error (-1)
	c	(i)	Electrons / they move in an anticlockwise direction Charge on plates decreases / electrons neutralise positive charge p.d. decreases <u>exponentially</u>	B1 B1 B1	Alternatives for anticlockwise: from / lower plate around the circuit, from / lower plate through the resistor to top plate implied Capacitor discharges / loses charge
		(ii)	(dissipated as heat) in the resistor / wires	B1	
	d	(i)	Total capacitance = 1.5 + 4.5 = 6(.0) (μF)	A1	Allow one SF
		(ii)	Original charge on 4.5 μF capacitor is conserved (28.35 μC) V = (28.35 μ) / (1.5 + 4.5) μ = 4.7 (V)	C1 A1	ecf from **(b)(i) and (d)(i)**
			Total	**[11]**	

Question			Expected Answers	Marks	Additional Guidance
2	a		static / homogeneous infinite / infinite number of stars	B1 B1	Uniform (density) Do not allow isotropic or fixed
	b	(i)	gradient of graph = H_0 value $H_0 = 66 \pm 4$ (km s^{-1} Mpc^{-1})	C1 A1	
		(ii)	age = $1 / H_0$ ($H_0 = 2.1 \times 10^{-18}$ s^{-1}) $= (1 / 66 \times 3.2 \times 10^{-20} \times 3.2 \times 10^{7})$ $= 1.5 \times 10^{10}$ (1.48×10^{10}) (year)	C1 C1 A1	ecf from H_0 value Or correct age in seconds (4.7×10^{17} s) Answer will depend on H_0 value in **(b)(i)** Minus one if Mega or kilo omitted
	c	(i)	$\rho_c = 3H_0^2 / 8\pi G$ $= [3 \times (2.1 \times 10^{-18})^2] / (8 \times \pi \times 6.67 \times 10^{-11})$ $= 7.9 \times 10^{-27}$ (kg m^{-3})	C1 A1	If units of H_0 not converted or converted incorrectly then maximum one out of two ecf from H_0 value in **(b)(i)**
		(ii)	if average density of the Universe is less than critical then it will be too small to stop it expanding / it goes on forever if the average density of the Universe is greater than the critical value it will cause the contraction (and produce a big crunch) close to critical value and therefore a universe expands that will go towards a limit / expands at an ever decreasing rate asymptotic	B1 B1 B1	do not allow answers open, closed and flat

2	**d**		galaxies are moving apart / universe is expanding if galaxies have always been moving apart then at some stage they must have been closer together / or started from a point evidence in red shift either optical / microwave further away the galaxy the faster the speed of recession the existence of a (2.7 K) <u>microwave</u> background radiation there is more helium in the universe than expected **MAX 4**	**(B1)** **(B1)** **(B1)** **(B1)** **(B1)** **(B1)** **B4**	Allow stars for galaxies allow from a singularity allow statement that red shift is observed or that blue light becomes red or gamma from big bang has become microwave
			Total	**[16]**	

Question			Expected Answers	Marks	Additional Guidance
3	a	(i)	uniformly spaced, vertical parallel lines must begin and end on the plates with a minimum of three lines arrow in the correct direction down	B1 B1	ignore any edge effects
		(ii)	$E = V / d$ $E = 60 / 5 \times 10^{-3}$ $= 12000$ (V m^{-1})	A1	
	b	(i)	Use of energy qV and kinetic energy = ½ mv^2 $v = [(2qV)/m]^{1/2}$ $v = [(2 \times 3.2 \times 10^{-19} \times 400)/6.6 \times 10^{-27}]^{1/2}$ $v = 1.97 \times 10^5$ (m s^{-1})	M1 M1 A0	
		(ii)	$a = F / m$ $a = Eq / m$ $a = (12000 \times 3.2 \times 10^{-19}) / 6.6 \times 10^{-27}$ $= 5.82 \times 10^{11}$ (m s^{-2})	C1 A1	Both required for the mark
		(iii)	**1** $t = \underline{(16 \times 10^{-3}) / 2 \times 10^5}$ $= 8 \times 10^{-8}$ (s) **2** $s = ½ a \times t^2 = ½ [5.82 \times 10^{11} \times (8 \times 10^{-8})^2]$ $= 1.86 \times 10^{-3}$ (m)	M1 A0 C1 A1	Answer will depend on number of sf used by candidate. Using $u = 2 \times 10^5$ scores 0/2 Allow slight variation in answers that follow from the candidates working

	c		Eq = Bqv B = E / v = 12000 / 2 x 10^5 = 0.060 (T)	**C1** **C1** **A1**	 Allow one sf unless answer is 0.061 when using v =1.97 x 10^5
	d		velocity (produced by p.d / 400 V) is less force due the magnetic field is reduced / Bqv is less / force due to the electric field is unchanged hence beam deflects down	**B1** **B1**	 Allow the resultant force is downward Allow towards the lower plate
			Total	**[15]**	

Question			Expected Answers	Marks	Additional Guidance
4	a		magnetic flux = magnetic flux density x area (perpendicular to field direction)	B1	Allow equation with the symbols identified correctly Do not allow magnetic field or magnetic field strength
	b		Φ = NBA = 500 x 0.035 x 2.5 x 10^{-3} = 0.044 (0.04375) unit: Wb	C1 A1 B1	 [allow for one mark 8.75 x 10^{-5} (Wb) i.e. B x A] Allow: Wb turns and T m^2 and V s
	c	(i)	The component of B perpendicular to the area changes / the idea that the area changes relative to the field direction detail of how it varies / depends on cos θ / maximum when field is perpendicular to B / zero when area is parallel to B	B1 B1	Allow the idea that the direction of the field relative to the area of the coil varies with the orientation of the coil Do not allow reference to cutting of the flux by the coil
		(ii)	Induced / e.m.f is proportional / to <u>the rate</u> of change of (magnetic) flux	B1	Allow the emf produced is equal to the rate of change of flux or flux cutting
		(iii)	e.m.f. **max** when ϕ is **zero** or at 0.005 /0.015 /0.025 s e.m.f **zero** when ϕ is a **max** or at 0.0 / 0.01/ 0.02 s e.m.f. and ϕ have the same frequency allow e.m.f and ϕ out of phase by π/2/ emf follows a sin curve emf is the gradient of the graph **MAX 3**	(B1) (B1) (B1) (B1) (B1) B3	

4		**(iv)**	ε = (change in flux linkage) / time = 0.04375 / 0.005 (8.8 x 10^{-5} x 500) / 0.005 = 8.75 (V)	 **C1** **A1**	 [if N omitted then give one mark (ε = 0.0175)] [if 10^{-5} omitted then minus 1] [reading error from graph is penalised -1 (should be 8.8 and not 8.4)]
		(v)	Max e.m.f. is twice the original value as the rate of flux change is twice the original	**B1** **B1**	Do not allow just larger Allow: the change in magnetic flux occurs in half the time Allow the max gradient will double
			Total	**[14]**	

Question			Expected Answers	Marks	Additional Guidance
5	a		Magnetic resonance: **some <u>nuclei</u> behave as small magnets / certain <u>nuclei</u> possess a net spin / <u>nuclei</u>** line up in the magnetic field **Need for a strong magnetic field** the frequency of precession is known as Lamor frequency (1) **Application of RF pulses** produces resonance / flip energy states (1) **RF pulse turned off nuclei relax / flip back (and emit RF signal)** RF detected (by coil receiver) and processed (1) Use of non-uniform field / gradient field (1) To locate position of nuclei in body (1) **QWC mark: difference in the relaxation times for hydrogen in different tissues / materials** MAX (3) **MAX 8**	**B1** **B1** **B1** **B1** **B1** **MAX B8**	Allow protons instead of nuclei in the context of hydrogen nuclei or a single proton instead of nuclei There are 5 essential marks **(in bold)** and a maximum of THREE extra marks (1) Maximum of **8 marks** Do not allow 'atoms' for nuclei but penalise once only **Please annotate scripts as follows:** **Essential marks: ✓(ticks) on left hand side of candidate's work** **Extra marks: ✓(ticks) on right hand side of candidate's work**

5	**b**		Advantage: not ionising radiation (as with X-rays) / better soft tissue contrast Disadvantage: heating effect of metal objects /effect on cardiac pacemakers / takes a long time to perform MRI scan	**B1** **B1**	Accept can view soft tissue in brain / skull Do not allow not harmful Do not allow no side effects
			Total	**[10]**	

Question			Expected Answers	Marks	Additional Guidance
6	a	(i)	$A = \lambda N_0 = 4.5 \times 10^{23} \times 0.693 / (12 \times 3600)$ $= 7.22 \times 10^{18}$ (s^{-1})	C1 A1	allow one mark if the 12 hours is not converted into seconds. Answer is 2.6×10^{22} Allow one mark if the 12 hours is converted into minutes Answer 4.33×10^{20}
		(ii)	3 half lives $N = 5.6 \times 10^{22}$	A1	
		(iii)	$N = N_0 e^{-\lambda t}$ $= 4.5 \times 10^{23} \times e^{-(0.693 \times 50/12)}$ or use of 2^n $= 2.5 \times 10^{22}$	C1 A1	use of 2^n 50/12 half lives
	b		material with large λ / short half life have initial high activity hence precautions needed <u>for initial period</u> of disposal OR material with small λ / long half life activity will last for a long period hence need for long term disposal MAX 2	(B1) (B1) (B1) (B1) B2	
			Total	[7]	

Question			Expected Answers	Marks	Additional Guidance
7	a	(i)	e: 0 and –1 N: 15 and 7 + (antineutrino)	B1	
		(ii)	e: 0 and +1 Si: 30 and 14 + (neutrino) correct 'neutrino' <u>in each case</u>	B1 B1	Allow 1 for +1 Correct symbols required for the neutrinos: ν and $\bar{\nu}$ Allow ν_e and $\bar{\nu}_e$
	b	(i)	uud $\rightarrow$ udd	B1	Allow u $\rightarrow$ d
		(ii)	udd $\rightarrow$ uud	B1	Allow d $\rightarrow$ u
	c		weak(nuclear force)	B1	
			Total	[6]	

Question			Expected Answers	Marks	Additional Guidance
8	a	(i)	mass of uranium is greater than (the sum of) the mass of the products $E = \Delta mc^2$ OR binding energy of the products is greater than that of uranium energy available is the difference between the binding energies of uranium and the sum of the products	M1 A1 M1 A1	
		(ii)	kinetic energy	B1	
	b	(i)	the neutron is a single nucleon / cannot be split further / no binding has occurred	B1	The neutron is not bound to anything
		(ii)	binding energy of uranium = 235 x 7.6 =1786 binding energy of products = 141 x 8.3 + 92 x 8.7 = 1170.3 + 800.4 energy available = 184.7 (MeV)	C1 A1	An answer of 9.4 (not using the number of nucleons) scores zero Allow ≥ 2 sf (180, 185, 184.7) Penalise 184 as an AE
			Total	[6]	

Question			Expected Answers	Marks	Additional Guidance
9	a		$F = Q_1Q_2 / 4\pi\varepsilon_0 r^2$ $= (1.6 \times 10^{-19} \times 1.6 \times 10^{-19}) / 4\pi\varepsilon_0 (2 \times 10^{-15})^2$ $= 57.5$ (N)	**C1** **A1**	Allow use of 9×10^9 instead of $1 / 4\pi\varepsilon_0$ (using this gives 57.6) Allow ≥ 2sf (58) If correct formula quoted and then AE (e.g. not squaring r <u>or</u> not squaring Q) then allow ecf in final answer for 2/3
	b		<u>attractive</u> strong (nuclear force)	**B1**	Do not it holds them together
	c		as the proton travels towards the stationary proton it experiences a repulsive force that slows it down. (It needs a high velocity) to get close enough (to the proton) / for the (attractive) <u>short range</u> force to have any effect	**B1** **B1**	
			Total	**[5]**	

Question			Expected Answers	Marks	Additional Guidance
10	a		ANY ONE from X-rays interact with matter by: the photoelectric effect where an (orbital) electron is ejected from atom / atom is ionised Compton scattering where X-ray scattered by the interaction with (orbital) electron Pair production where X-ray photon interacts with the nucleus / atom and an electron and positron are produced [allow one mark for statement and one for explanation] **Max 2**	 **(B2)** **(B2)** **(B2)** **B2**	 Allow electrons ejected from metal surface if reference is made to free electrons Allow: X-ray diffraction **B1** X-ray passes through the 'slits' / atomic gap formed by the atoms **B1**

	b		$I = I_0 e^{-\mu x}$ $0.1 = e^{-\mu 3}$ $0.5 = e^{-\mu x}$ $\ln 0.5 / \ln 0.1 = x/3$ $x = 0.903$ (mm)	**C1** **C1** **A1**	Calculation of μ =0.768 C1 Substitution into second equation C1 Allow 0.9 (1sf) If question misread and 0.9 used for change μ = 0.035 and x = 19.7 (allow 20) give 2/3
10	**c**	**(i)**	Absorption of X-rays by (silver halide molecules) by a photographic film Uses of fluorescent / scintillator/ phosphor Photon releases electron (that is accelerated onto a fluorescent screen) number of electrons increased /multiplied **MAX B2** QWC: Phosphor / Intensifier/ it converts X-ray photon into increased number of 'visible' photons	**(B1)** **(B1)** **(B1)** **(B1)** **B2** **B1**	

		(ii)	Different soft body tissue produce little difference in contrast/attenuation (Contrast media with) high atomic number / Z used / iodine or barium (used to give greater contrast) liquids injected or swallowed into soft tissue areas / or examples of such **MAX B2**	**(B1)** **(B1)** **(B1)** **B2**	This method produces good contrast for soft tissue /for similar Z values
			Total	**[10]**	

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