Question Number	Answer	Acceptable answers	Mark
1(a)(i)	1260 W		**(1)**

Question Number	Answer	Acceptable answers	Mark
1(a)(ii)	substitution (1) 5040 = 240 × 10 × height transposition (1) height = $\frac{5040}{240 \times 10}$ evaluation (1) 2.1 (m)	substitution and transposition in either order give full marks for correct answer, no working	**(3)**

Question Number	Answer	Acceptable answers	Mark
1(b)	no movement (in direction of force) / (work done=) weight x 0 = 0	stationary it is not changing height is in same position ignore ref to terminal velocity, force and acceleration	**(1)**

Question Number	Answer	Acceptable answers	Mark
1(c)	substitution (1) 240 × 6.4 evaluation (1) 1500 Unit (1) kg m/s independent mark	1536 give (2) marks for correct answer, no working Ns	**(3)**

Question Number	Answer	Acceptable answers	Mark
2(a)	Description including 3 of the following: • (Gravitational) potential energy (transferred) to KE(1) • Idea of energy transfer to heat/sound whilst descending (1) • Chemical energy is transferred to heat energy in Andrew (1) • Idea of energy dissipated on stopping (1)	(G)PE (transferred) to KE Allow gravitational energy for GPE Energy transferred to heat because of air resistance/ friction The energy goes to heat as he stops. Energy is transferred to the surroundings	**(3)**

Question Number	Answer	Acceptable answers	Mark
2(b)(i)	substitution (1) 67 × 31 evaluation (1) 2077 (kg m/s)	 2080, 2100 working backwards using 2000 (v=) 29.85, 30 (m=) 64.52, 65 67 X 31=2000 scores only one mark	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(b)(ii)	substitution (1) 2000 ÷ 2.3 evaluation (1) 870 (N)	 answer to (b)(i)) ÷ 2.3 900, 869.6, 869.5 903	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(b)(iii)	an explanation linking two of the following • Force on Andrew is quite small (1) • Because impact time is long (1) • The acceleration/deceleration is quite small (1) • Because impact distance is far (1)	 force is reduced/ less /not as strong slows down/changes momentum gradually acceleration = 1.35 'g' or 13.5 m/s^2 slows down (rate of) change of momentum scores 2 marks	**(2)**

Total question 2 = 8 marks

Question Number	Answer	Acceptable answers	Mark
3(a)(i)	D 23 m		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(a)(ii)	A the driver is tired		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(b)	substitution (1) 800 x 3 evaluation (1) 2400 (kg m/s)	Give full marks for correct numerical answer, even if no working bald 2.4 x 10^n gains 1 mark (BOD for correct substitution) eg bald 240 = 1 mark In all calculations if the candidate gives two different methods and writes the wrong answer in the answer space award no marks If the candidate writes correct answer they will gain full marks.	**(2)**

Question Number	Answer	Acceptable answers	Mark
3(c)(i)	substitution (1) 600 x 15 evaluation (1) 9000 (J)	bald 9.0 x 10^n gains 1 mark eg bald 900 = 1 mark (BOD for correct substitution) give full marks for correct numerical answer, 9000 (J) even if no working	**(2)**

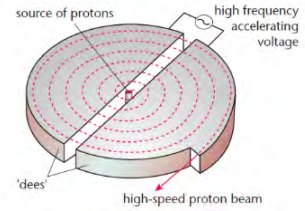
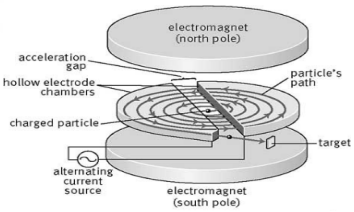
Question Number	Answer	Acceptable answers	Mark
3(c)(ii)	A the energy transferred		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(a)(i)	D towards the centre of the circle		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(a)(ii)	centripetal (force)	reject centrifugal force accept misspellings where meaning is clear e.g. centripedal	**(1)**

Question Number	Answer	Acceptable answers	Mark
4(a)(iii)	Any two of the following :- ball slows down (1) ball / it drops (down) / circles at a lower height (1) go in smaller circles (1)	 less **<u>kinetic</u>** energy / momentum any lowering / less **<u>potential</u>** energy stops going in circles the ball/it would not make complete circles (not just 'stops')	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(a)(iv)	An explanation linking: • the idea that momentum (of the closed system) would stay the same (1) • the idea that kinetic energy would not be conserved (1)	 momentum **<u>of the ball</u>** decreases / changes (direction) / passed to wall must specify which momentum; do not credit 'momentum decreases' by itself kinetic energy → heat/sound/wall ignore 'KE decreases / is lost' without qualification allow 'KE is lost because it's not elastic' (i.e. qualified)	**(2)**

Question Number		Indicative Content	Mark
QWC	**4(b)**	A description including some of the following points :- Cyclotron • two D-shaped halves • gap between the Dees • (alternating) voltage across the gap • magnetic field (at right angles to the moving particles) • vacuum enables free movement of particles Particle movement • accelerate • start at the centre • move in a circular path • spiral outwards • exit in a straight line Examples of labelled diagrams which would give Level 3 by themselves (not all labels / details needed)   Level 2 if no labels but Dees AND particle path shown. Level 1 if no labels but either Dees OR spiral of particle shown Ignore uses of cyclotron	**(6)**

Level		No rewardable content
1	**1 - 2**	• a limited description of either particle movement OR cyclotron e.g. The particles move in a circle OR Cyclotrons have two Dees OR Cyclotrons are particle accelerators OR there's a vacuum • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	**3 - 4**	• a simple description of particle movement AND cyclotron OR a more detailed description of one e.g. A cyclotron has two D-shaped halves and the particles inside accelerate OR A cyclotron has a magnetic field and a voltage across the gap OR Charged particles increase in speed as they spiral outwards OR vacuum allows free movement of particles • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	**5 - 6**	• a description of particle movement AND cyclotron with a detailed description of one of them e.g. the charged particles get faster as they accelerate across the gap in the Dees **OR** the magnetic field (of the cyclotron) causes the particles to move in a circle • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

(Total for Question 5 = 12 marks)

Question Number	Answ		Mark
5(a)(i)	Circular/spiral/circle		**(1)**

Question Number	Answer	Acceptable answers	Mark
5 (a)(ii)	An explanation linking three of the following. • (fast moving) <u>protons</u> (1) • absorbed by (1) • nuclei (1) • (produces)unstable nuclei (1)	bombard / hit /strike / collide with stable atoms / stable element	**(3)**

Question Number	Answer	Acceptable answers	Mark
5 (b)(i)	B momentum		**(1)**

Question Number	Answer	Acceptable answers	Mark
5 (b)(ii)	(Momentum/it)equals mass x <u>velocity</u>	p = m x v kilograms / kg is the mass and metres per second / m/s is the <u>velocity</u> Accept “times” for x	**(1)**

Question Number		Indicative Content	Mark
QWC	***5(b)(iii)**	An explanation including some of the following points Diagram 1 • Moving in opposite directions before collision • inelastic collision • stationary after collision • momentum zero after collision • (therefore) total momentum must have been zero before collision • (therefore) cars were moving at the same speed in opposite directions (assuming cars have equal mass) • both cars had kinetic energy before the collision • KE zero after collision • KE converted into heat, sound, elastic potential energy etc. Diagram 2 • Elastic collision / almost elastic collision • Momentum conserved • Momentum transferred from first to last sphere • KE conserved / almost conserved • (because)last sphere reaches same height as first sphere • Three spheres always have zero momentum • Small amount of energy transferred to sound/heat	**(6)**

Level		No rewardable content
1	**1 - 2**	• A limited analysis of ONE collision which is given by a correct statement e.g. In collision 1, kinetic energy has been lost OR In collision 2 momentum is transferred from the first to the last sphere. • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	**3 - 4**	• a simple analysis of BOTH collisions considering BOTH momentum AND kinetic energy correctly for each one e.g. In collision 1, momentum is conserved and the kinetic energy of the cars changes. In collision 2, momentum and the kinetic energy is conserved. • answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	**5 - 6**	• a detailed analysis of BOTH collisions considering momentum AND kinetic energy for each collision correctly for each AND detailed reference to EITHER diagram. e.g. In collision 1, the momentum before and after the collision is zero because momentum is always conserved, but the KE is lost. In collision 2, all the momentum and KE is transferred to the last sphere because it gets to the same height as the first one. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

(Total marks for question 6 = 12 marks)