Question number	Answer	Additional guidance	Mark
4(d)	An answer that combines the following points to provide a logical description of the plan/method/experiment: • using a larger group of students/large population of students (1) • and measure how their reaction time varies with age/height (1)	allow any suitable variable	**(2)**

Question number	Answer	Additional guidance	Mark
5(a)	Rearrangement (1) $m = \frac{f}{a}$ Substitution and conversion (1) $m = \frac{1870}{1.83}$ Answer and rounding to 3 s.f. (1) 1020 (kg)	maximum 2 marks if kN not converted to N award full marks for correct numerical answer without working	**(3)**

Question number	Answer	Additional guidance	Mark
5(b)	Rearrangement of $\frac{(v-u)}{t} = a$ (1) $v = u + at$ Substitution (1) $v = 0 + 1.83 \times 16$ Answer (1) 29.3 (m/s)	award full marks for correct numerical answer without working	**(3)**

Question number	Answer	Mark
5(c)	Correctly identifies data points from the graph to calculate areas (1) Calculates area under AB (1) 240 m Calculates area under CD (1) 135 m distance travelled at constant speed = 240 m is greater than distance travelled when slowing down = 135 m (1)	**(4)**

Question number	Answer	Mark
6(a)	B	**(1)**

Question number	Answer	Additional guidance	Mark
6(b)(i)	The time taken for the activity of a radioactive nuclide to halve (1)	accept for nuclide: isotope sample	**(1)**

Question number	Answer	Additional guidance	Mark
6(b)(ii)	Determines number of half-lives and rounds (1) 263/87.7 = 3 Determines that 3 half-lives is 1/2 × 1/2 × 1/2 = 1/8 (1) Determines mass of Pu-238 after 3 half-lives (1) 925/8 = 115.625 (g) Determines average energy released per second (1) 115.625 × 0.54 = 62.4 (J)	 allow repeated division by 2 allow ecf from step 2 for 1 mark (mass of Pu-238 after1 half-life 925/2 = 462.5 (g)) allow ecf from 1 half-life or from step 3	**(4)**

Question Number	Answer	Acceptable answers	Mark
4(e)	An explanation linking the following points • nuclei are positively charged (1) • need enough energy to overcome repulsion (1)	ignore references to high temp and pressure accept same charge accept protons for nuclei accept atoms and will repel each other	**(2)**

Question Number	Answer	Acceptable answers	Mark
5(a)	**A**		**(1)**

Question Number	Answer	Acceptable answers	Mark
5(b)	distance travelled = area under graph (1) substitution (1) ½ x 20 x 2 evaluation (1) 20 (m)	distance = average speed x time = 10 × 2 20 (m) allow (distance) = speed × time or 20 x 2 for 1 mark give full marks for correct answer, no working	**(3)**

Question Number	Answer	Acceptable answers	Mark
5(c)	An explanation linking the following points • velocity is a vector (1) • (whereas) speed is not (1)	velocity has magnitude and direction velocity has direction speed is a scalar speed has {no direction}/{magnitude only} allow for 2 marks velocity is speed in a straight line velocity = $\frac{\text{displacement}}{\text{time}}$ NOTE answers in terms of momentum must still refer to vectors or direction to gain credit	**(2)**

Question Number		Indicative Content	Mark
QWC	***5(d)**	An explanation linking some of the following **Forces acting** • weight down • air resistance up (opposing motion) **Forces during fall** • weight constant • air resistance increases • with speed • resultant force = W − R **Effect on shape of graph** • at start, resultant force is large so acceleration large / gradient steep • mid resultant force decreasing so acceleration decreasing / gradient decreasing • terminal velocity, resultant force is zero so acceleration zero / gradient zero	**(6)**
Level	**0**	No rewardable content	
1	**1 -2**	• a limited explanation linking a few facts from the indicative content. E.g. at terminal velocity, forces are equal so constant speed. • 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 explanation linking some of the indicative content to the shape of the graph e.g At the start weight > air resistance so acceleration and at the end weight = air resistance so no acceleration. • 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 detailed explanation linking most of the indicative content to the complete shape of the graph e.g. At the start weight > air resistance so acceleration. Then air resistance increases (with speed) so acceleration decreases. At the end weight = air resistance so no acceleration. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

Question Number	Answer	Acceptable answers	Mark
6 (a) (i)	C		**(1)**

Question Number	Answer	Acceptable answers	Mark
6 (a) (ii)	acceleration	Recognisable mis-spellings More than one word written scores zero EXCEPT for the phrase Acceleration due to gravity which scores 1 mark	**(1)**

Question Number	Answer	Acceptable answers	Mark
6 (b)	Substitution weight = 0.00008 x 10 (1) evaluation 0.0008 (N) (1)	 8×10^{-4} 1/1250	**(2)**

Question Number	Answer	Acceptable answers	Mark
6 (c)	Substitution speed = 13 / 1.7 (1) evaluation 7.6 (m/s) (1)	An answer which rounds to 7.6 eg 7.647 7.65 7.7	**(2)**

Question Number		Indicative Content	Mark
QWC	***6(d)**	A explanation including some of the following points • drops near the top are accelerating • due to force of gravity • travel a greater distance in given time • there is air resistance on the drops as they fall • this increases with velocity • resultant force is downward • this reduces resultant force • eventually resultant force is zero • drops have reached terminal/ maximum velocity • drops near bottom are all travelling at terminal velocity • so travel same distance in given time	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited explanation such as one which correctly addresses either why the drops at the bottom are evenly spaced or why the drops at the top are not e.g. drops at bottom are all going at the same speed OR drops at top are speeding up • 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 explanation such as a correct comparison of the motion of the drops at top and bottom e.g. drops at bottom are travelling at terminal velocity whereas drops at top are still accelerating. **Or** a complete explanation of motion at either top or bottom e.g.at the bottom, air resistance and gravity forces are balanced so they travel at constant speed • 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 detailed explanation such as one which explains why the motion of the drops at top and bottom are different e.g. The drops were initially accelerating due to a resultant force downwards. The acceleration decreased as they fell and eventually reached zero. With no acceleration their velocity was constant and so equal distance travelled in given time at the bottom. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

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

Question Number	Answer	Acceptable answers	Mark
3(b)(i)	12 (m/s) (1)	Range from 11(m/s) to 14 (m/s)	**(1)**

Question Number	Answer	Acceptable answers	Mark
3(b)(ii)	Substitution (1) $\frac{20-0}{5}$ evaluation (1) 4 (m/s^2)	$\frac{20}{5}$ Full marks for correct answer with no working Allow answers between 3.6 and 4.7 for 2 marks to reflect readings taken from the graph	**(2)**

Question Number	Answer	Acceptable answers	Mark
3b(iii)	• velocity/ speed (measured in) m/s (1) • <u>divided</u> by time in s (1)	velocity/ speed (measured in) ms^{-1} acceleration is rate of change of velocity m/s/s m per s per s [accept per for divide] do not accept m/s <u>times</u> time	**(2)**

Question Number	Answer	Acceptable answers	Mark
3b(iv)	at constant vel • distance = 60 (m) (1) slowing down • distance = ½×2×20 (1) • = 20 (m) (1)	correct answer scores 2 marks	**(3)**

Total for question 3=10 marks

Question Number	Answer	Acceptable answers	Mark
5(a)(i)	force (1)	If than one word given then 0 marks.	**(1)**

Question Number	Answer	Acceptable answers	Mark
5 (a)(ii)	B 0.07kg		**(1)**

Question Number	Answer	Acceptable answers	Mark
5 (a)(iii)	Arrow pointing (vertically) upwards (1) Value of 1.2 (N) (written near to arrow) (1)	 Marks are independent of each other	**(2)**

Question Number	Answer	Acceptable answers	Mark
5(b)(i)	Substitution $\frac{90}{1000}$ x 3.3 (1) evaluation 0.30 (N) (1)	 A value which rounds to 0.30 eg 0.297 Give full marks for correct answer with no working Ignore power of ten error until evaluation Allow 1 mark for 297 even with no working shown	**(2)**

Question Number		Indicative Content	Mark
QWC	***5(b)(ii)**	An explanation demonstrating some of the following: Descriptions of the graph • Accelerates upwards during stage1 • Maximum velocity is reached at the end of stage 1 • Accelerates downwards / decelerates during stage 2 • Accelerates during stage 3 • Comes to rest during stage 4. Interpretations of the shape of the graph • Fuel is burnt creating thrust in stage • Thrust is upwards in stage 1/ • Gravity/weight (is always) a downward force • Fuel runs out at end of stage 1/ has ran out by stage 2 • Still going up during/ max height at end of stage 2 • Starts to fall at start of stage 3 • Negative velocity during stage 3 because it is falling. • Rapid deceleration / collision with the ground during stage 4/end of stage 3 Explanations for changes in velocity • Resultant force upwards/ thrust greater than gravity force during stage 1 • Acceleration non-linear because mass is decreasing / resultant force is increasing • Linear deceleration in stage 2/3 because force of gravity is constant • Resultant downward force/only gravity/ weight is acting during stage 2 and 3 • Large resultant force of impact during stage 4	**(6)**

Level	0	No rewardable content
1	**1 - 2**	• A limited explanation involving descriptions of the graph. • E.g. The rocket gets faster as it goes up during stage 1. The rocket slows down during stage 2 • 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 explanation involving interpretations of the shape of the graph e.g. The rocket's velocity increases during stage 1 because the burning fuel provides a force. The rocket accelerates downwards during stage 3 • 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 detailed explanation which includes descriptions and interpretations for the shape of the graph including an explanation. E.g. The rocket's acceleration during stage 1 is increasing because it is losing mass as the fuel is burnt. It then slows down until it reaches maximum height at the end of stage 2 • 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	Answer	Acceptable answers	Mark
4 (a)	B 		**(1)**

Question Number	Answer	Acceptable answers	Mark
4 (b)	**A –** 0 N		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(c)(i)	Substitution (1) 1.2 = (20 – 13) / t Transposition (1) t = (20-13)/1.2 Evaluation 5.8 (s) (1) substitution and transposition can be in either order	1.2 = 7 / t t = 7/1.2 5.833 (etc) Give full marks for correct answer, no working	**(3)**

Question Number	Answer	Acceptable answers	Mark
4(c) (ii)	Substitution 1400 x 1.2 (1) Evaluation 1700 (N) (1)	1680 Allow full marks for correct answer with no working shown	**(2)**

Question Number	Answer	Acceptable answers	Mark
4 (c) (iii)	An discussion to include three of the following points The tow rope does not have to support the weight of the car (1) Tension is caused by accelerating force (plus frictional forces) (1) Tension is 5700 N (in this situation)(1) Forces could be kept below 12,000N (1) If acceleration is kept small (1) Numerical justification using f = m x a (1)	forces are horizontal not vertical / only needs to overcome friction Force is needed to accelerate / resultant force is 0 at constant velocity Force to accelerate is 1700N Forces could be kept small If truck is driven gently/slowly	**(3)**

(Total for Question 4 = 10 marks)