Question number	Answer	Notes	Marks
1 (a) (i)	force = mass x acceleration;	in words or in accepted symbols e.g. F=ma	1
(ii)	substitution; evaluation; e. 38 x 1.5 57 (N)	 57000 (N) scores 1 mark	2
(iii)	any suitable suggestion; e.g. friction between snow/ground and sledge ground is not level towing rope/direction at an angle to the ground/direction of movement	allow air resistance/drag	1
(b) (i)	acceleration = **change** in velocity; time (taken)	in words or in accepted symbols e.g. $a=\frac{\Delta v}{t}$ $a=\frac{v-u}{t}$ not 's' for 'v'	1
(ii)	*working must be shown* rearrangement of equation OR substitution; evaluation to at least 2SF; e. $t=\frac{2.8}{1.5}$ = 1.9 (s)	Calculation of velocity or acceleration scores 1 mark max. allow 1.87 no unit required	2

(c) (i)	MP1. statement of total distance = area under graph; MP2. any 1 correct distance for a segment of journey; e.g. calculation of distance during acceleration (½ x 3.25x 2.5 = 4.1 m) calculation of distance during constant speed (3.25x 8 = 26 m) calculation of distance during deceleration (½ x 3.25x 4 = 6.5 m) MP3. correct total distance 36.6 (m);	may be assumed by an attempt at sum of the areas allow range of 36-37 (m)	3
(ii)	(average) speed = distance (moved) / time (taken) ;	in words or in accepted symbols e.g. v=s/t condone s=d/t	1
(iii)	substitution; evaluation; e.g. 36.6/14.5 2.52 (m/s)	allow ecf from (c)(i) for distance ignore s.f. allow answers that round to 2.5 or 2.6 (m/s)	2

Total 13 marks

Question number	Answer	Notes	Marks
2 a	any FIVE from: MP1. Object has weight or there is a downward force (due to gravity on the object); MP2. So it accelerates (downwards); MP3. there is (a force of) drag (upwards or to oppose movement); MP4. drag increases as speed increases; MP5. eventually drag = weight ; MP6. (hence) resultant force is zero; MP7. (hence) object travels at constant speed;	allow: gravity pulls it down the speed/velocity increases oil resistance / water resistance / air resistance for drag oil friction / water friction / air friction for drag 'drag increases as it accelerates' forces are equal / forces are balanced accept 'no acceleration' DO NOT ALLOW • (The drag) slows it down MP2 • upthrust for drag MP3 • resistance = acceleration for MP5 • terminal velocity for constant speed for MP7	5

b	<u>Measuring instruments</u> MP1. Timer / stop-clock/ light gate (and data logger); MP2. Ruler / scale; <u>Measurements made</u> MP3. Take time for ball to pass between two points; MP4. determine the distance apart; MP5. Repeat readings lower down; **OR** MP6. For a set time (e.g. for 1 s); MP7. measure distance travelled (in this time); MP8. Repeat readings lower down; **OR** MP9. measure velocity using light gate with data logger; MP10. at two different places; <u>Using measurements</u> MP11. Use speed = distance / time; MP12. How results indicate terminal velocity achieved;	Ignore ticker-timer measurement of mass condone tape measure if the measurements are from top to bottom then only give MP3 or MP4 not both allow velocity for speed	5

(Total for Question 2 = 10 marks)

Question number	Answer	Notes	Marks
3 (a)	any two from : a balance/scales; metre rule or measuring tape; stopwatch or stop-clock;	 allow newtonmeter	2
(b)	dependent = time (taken for fall);	accept speed (of cupcake cases)	2
	independent = mass (of cupcake cases);	accept number/weight (of cupcake cases)	
(c)	Any ONE of • (constant) height; • still air/no (cross) wind; • from rest/zero force at launch; • identical (cupcake) cases;		1
(d)	time in s; mass in g;	accept in either order accept mass in kg weight in N number of cupcake cases in numbers/no units	2

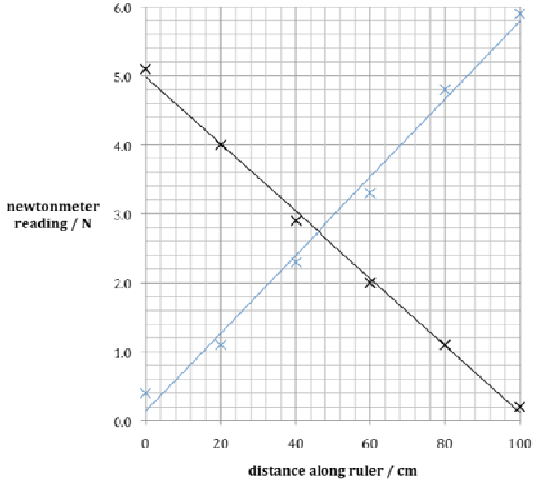
(e)	Any one of • detail of any sensible and valid procedure; e.g. repeat readings for time and then average readings • detail of more suitable conditions e.g. measure over a larger fall work indoors/reduce draughts ;	allow more accurate timing methods;	1

Question number	Answer	Notes	Marks
3(f)	down arrow labelled weight;	allow gravitational force/pull ignore 'gravity'	2
(i)	up arrow labelled drag;	allow air resistance accept friction, upthrust ignore lift	
(ii)	any three from	do not credit repeat of the diagram above	3
	MP1. idea of **unbalanced** force; e.g. at the start, the only force is weight part way down, the weight is greater than the drag	there is no upward force at the start	
	MP2. (this unbalanced) force causes acceleration;	weight equals drag	
	MP3. idea of balanced forces near the bottom; e.g. near the bottom the forces are equal		
	MP4. therefore no acceleration; e.g. it reaches terminal velocity		

(Total for Question 3 = 13 marks)

Question number	Answer	Notes	Marks
4 (a) (i)	work done = force x distance moved ;	Accept W = F x d Allow rearrangements do not accept eqn in units only	1
(ii)	Substitution into correct equation; Calculation; 170 x 110 19 000 (J)	Accept **18 700** (J)	2
(iii)	exactly same as their answer to (ii);		1

Question number	Answer	Notes	Marks
4 (b) (i)	KE = ½mv^2	Accept word equation	1
(ii)	addition of masses before OR addition of energies after; Substitution into correct equation; Calculation; 1650 + 950 = 2600 (OR 436 425 + 251 275 = 687 700) ½ x 2600 x 23^2 688 000	 Accept for 1 mark - either 436 000 or 251 000 accept for 2 marks - both 436 000 and 251 000 Accept for 3 marks- 687 700	3
(c)	Any **three** of 1. idea that mass and acceleration are inversely related; 2. Idea that (total) mass is less; 3. Idea of less (air) resistance / friction; 4. Idea of less work done/less energy used; 5. Idea of amount work related to amount of (chemical) energy from fuel;	allow F = m x a mentioned weight for mass drag doesn't have to use energy to pull the caravan	3
		Total	**11**

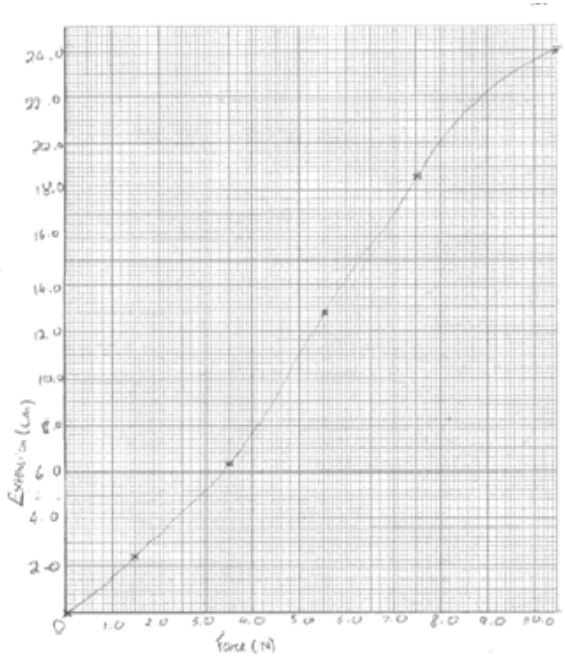
Question number	Answer	Notes	Marks
5 (a) (i)	A – distance A		1
(ii)	D – force D		1
(b) (i)	Force (C) in N; or Force in newtons;	Allow: Reading from newton-meter in N	1
(ii)	Plotting ;; Line of best fit;  0 5.1 20 4.0 40 2.9 60 2.0 80 1.1 100 0.2	To nearest ½ square, penalise errors up to two marks Suited to candidate's plotting (allow a smooth curve) no double lines judge LoBF by balance of points about the line	3
(iii)	Reading from graph to ± 1 cm; e.g.	To nearest ½ small square	1

Question number	Answer	Notes	Marks
5 (c)	weight of ruler;	Accept other valid reasons allow force for weight ignore 'it's got a force acting' 'because of gravity'	1
		Total	**8**

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>6 (a)</td><td>all 3 for both marks;;

any two for 1 mark ;

<table>
<tr><th>item</th><th>Tick if needed</th></tr>
<tr><td>ammeter</td><td></td></tr>
<tr><td>steel spring</td><td></td></tr>
<tr><td>retort stand and clamp</td><td>✓</td></tr>
<tr><td>rubber band</td><td>given ✓</td></tr>
<tr><td>ruler</td><td>✓</td></tr>
<tr><td>thermometer</td><td></td></tr>
<tr><td>mass hanger</td><td>✓</td></tr>
<tr><td>mass</td><td>given ✓</td></tr>
</table>
</td><td>each incorrect tick = -1</td><td>2</td></tr>
</table>

(b)	I	5.5 (in the table)		1
	ii	suitable scale for axes; axes labelled with units; points plotted to nearest mm square (minus one for each plotting, up to max 2 marks);; Line (curve) of best fit acceptable; 	-1 for each incorrect plot Allow (ecf) a balanced straight line of best fit that takes account of any plotting errors and indicated anomalies **Mass in g / Force in N / Extension in cm** 0 / 0 / 0.0 150 / 1.5 / 2.4 350 / 3.5 / 6.3 550 / / 12.8 750 / 7.5 / 18.6 1050 / 10.5 / 24.0	5
	iii	No / yes (no mark) Idea that Hooke's law should show (direct) proportionality; Use of data (from the table or graph) to explain that the results do not show this; e.g. 'line is a curve', '(table shows) rubber band extends unevenly'	Allow (ecf) - converse from <u>straight</u> drawn line, using data from their graph (not the table) e.g. 'Yes' AND 'line is a straigh	2
			Total	10