Terminal Velocity - Answers

1. When the car starts, the only horizontal force acting on it is the driving force. This causes it to accelerate. As the car moves, it experiences air resistance, which increases with the speed of the car. As the air resistance increases, the forward resultant force decreases. As a result, the acceleration decreases. Therefore, the gradient of the graph decreases. At one point, the air resistance balances the driving force causing the resultant force to become zero. Thereafter, according to Newton's 1st law, the car continues with a constant velocity. Hence the graph eventually becomes horizontal.

2.

(a)
When an object starts falling, initially, the weight causes it to accelerate. Then the drag force increases with the speed and eventually balances the weight, causing the object to continue with a constant velocity (Newton's first law). In the ball-oil experiment, initially the ball experiences only the weight downwards and the upthrust upwards. Since the weight is bigger, the resultant force is downwards and causes the ball to accelerate. While the weight and upthrust remain constant, the ball experiences drag force, which increases with the speed. Eventually, the drag and upthrust balance the weight, causing the ball to continue with a constant velocity (terminal velocity).

(b)
The student could use a ruler, pencil and a stopwatch.

On the bottom half of the tube, the student could mark, using the pencil, at least 4 marks, which are equally spaced.

Then, as the ball falls through the oil, the student could use the stop watch to record the time it takes for the ball to pass between successive pencil marks on the tube.

If the times that the student recorded are the same, that would mean that the ball reached the terminal velocity during the experiment.

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);
	
	independent = mass (of cupcake cases);
		accept speed (of cupcake cases)
		
		accept number/weight (of cupcake cases)
			2

(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
(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 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 MP2. (this unbalanced) force causes acceleration; 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	do not credit repeat of the diagram above there is no upward force at the start weight equals drag	3