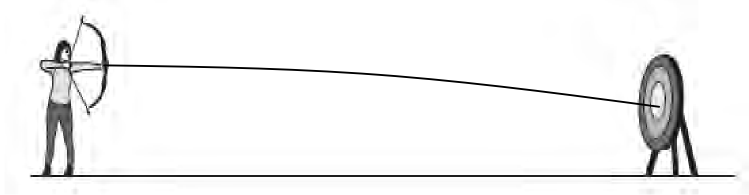
Question Number	Answer	Mark
1(a) (i)	Show that the initial horizontal component of velocity for the drop is about 1 m s^{-1}. Shows a correct, relevant trigonometrical relationship Correct answer for horizontal component (1.2 (m s^{-1})) <u>Example of calculation</u> $v_h = v \cos\theta$ = 3.5 m s^{-1} x cos70° = 1.2 m s^{-1}	 **(1)** **(1)**
1(a)(ii)	Calculate the vertical distance to the insect if the shot is successful. Use of equation of motion suitable for time Calculates time (allow 1/3) Use of trigonometry or Pythagoras suitable to find vertical component of speed Use of equation of motion suitable to find distance Correct answer (0.55 m) If using $v^2 = u^2 + 2as$: Use of trigonometry or Pythagoras suitable to find vertical component of speed(1) Use of equation of motion suitable to find distance (1) Substitute v = 0 (1) Substitute g negative (1) Correct answer (1) Answers based on $mgh = 1/2\ mv^2$ coincidentally giving correct answer are not credited as $v^2 = u^2 + 2as$ unless conservation of energy fully described, i.e. ke at bottom using u = 3.5 m s^{-1} and ke at top due to only horizontal motion accounted for <u>Example of calculation</u> $t = s/v$ = 0.4 m / 1.2 m s^{-1} = 0.33 s $v_v = v \sin\theta$ = 3.5 m s^{-1} x sin 70° = 3.3 m s^{-1} $s = ut + 1/2\ at^2$ = 3.3 m s^{-1} x 0.33 s - 1/2 x 9.81 m s^{-2} x $(0.33\ s)^2$ = 0.55 m	 **(1)** **(1)** **(1)** **(1)** **(1)**
1(b)	Sketch the path of the water droplet Any section of an approximate parabolic path	 **(1)**
	Total for question 13	**8**

Question Number	Answer	Mark
2(a)	Show that the work done on the cork is about 4 J. Use of work = force x distance (1) Correct answer [3.75 (J)] (1) [no ue] Example of calculation work = force x distance = 150 N x 2.5 x 10^{-2} m = 3.75 J	**2**
2(b)	Calculate the speed of cork Use of ke = 1/2 mv^2 (1) Correct answer [32 m s^{-1}] (1) [allow ecf] Or Use of $a = F/m$ **and** $v^2 = u^2 + 2as$ (1) Correct answer (1) Example of calculation 3.75 J = 1/2 x 0.0075 kg x v^2 v^2 = 1000 m^2 s^{-2} v = 31.6 m s^{-1} [4 J then ke = 32.7 m s^{-1}]	**2**
2(c) (i)	Show that the vertical component of the velocity is about 20 m s^{-1}. Correct answer [21 (m s^{-1})] [no ue] *Example of calculation* $v_v = v \sin \theta$ = 32 m s^{-1} x sin 40° = 20.6 m s^{-1}	**1**
2(c) (ii)	Calculate distance travelled by cork Horizontal component (1) Use of appropriate equation of motion, e.g. $v = u + at$ (1) Time of flight (1) Use of velocity = distance / time (1) Correct answer [103 m] (1) [allow ecf for vertical component] [missing factor of 2 for time of flight → max 3 marks] *Example of calculation* $v_h = v \cos \theta$ = 32 m s^{-1} x cos 40° = 24.5 m s^{-1} Time to max height, $t = (v - u)/a$ = 20.6 m s^{-1} / 9.81 m s^{-2} = 2.1 s Total time = 2 x 2.1 s = 4.2 s range = v x t = 24.5 m s^{-1} x 4.2 s = 103 m	**5**
2(d)	Explain difference to world record	

	If previous answer is larger than 53 m: Air resistance/friction on cork as it leaves the bottle (1) Work done → energy dissipated OR air resistance decelerates cork / reduces speed of cork OR friction with bottle reduces acceleration/launch speed OR reduces ke of cork(1) Accept different angle (1) greater than 50°/ less than 40° reduces range (1) Accept different pressure (1) Lower pressure reduces initial force (1) Accept wind blowing against cork (1) Decelerate cork (1) Accept different cork mass (1) larger mass gives smaller initial speed (1) BUT if start off saying 45° / higher pressure / smaller mass – no marks out of 2 because these would increase range ETC. If previous answer is smaller than 53 m: Accept different angle (1) between 50° and 40° (or 45°) increases range (1) Accept different pressure (1) higher pressure increases initial force (1) Accept wind blowing behind cork (1) Accelerates cork (1) Accept different cork mass (1) smaller mass gives higher initial speed (1)	**2**
	Total for question	**12**

Question Number	Answer		Mark
3(a)(i)	Correct arched trajectory drawn (arrow may reach the ground before the target) 	**(1)**	**1**
3(a)(ii)	Use of $v = \frac{d}{t}$ time = 0.42 (s) <u>Example of calculation</u> $t = \frac{15\ \text{m}}{36\ \text{m s}^{-1}} = 0.42\ \text{s}$	**(1)** **(1)**	**2**
3(a)(iii)	Use of $s = ut + \frac{1}{2} at^2$ **Or** use of $v = u + at$ **and** $v^2 = u^2 + 2as$ (using vertical data only) $s = 0.87$ m (accept from $s = 0.8$ to 0.9 m) height above ground = 0.63 m (ecf from (a)(ii) for time of flight) <u>Example of calculation</u> $s = 0 + \frac{1}{2} \times 9.81\ \text{m s}^{-2} \times (0.42\ \text{s})^2$ $s = 0.87$ m Height = 1.5 m – 0.87m = 0.63 m	**(1)** **(1)** **(1)**	**3**
3(b)	Arrow hits target higher up **Or** answer to part (a)(iii) would increase (As the) time (of flight) decreases	**(1)** **(1)**	**2**
	Total for Question 14		**8**

Question Number	Answer	Mark
4(a)(i)	Horizontal component of velocity = 7.5 cos 50 = 4.8 (m s^{-1}) (1)	**1**
4(a)(ii)	Vertical component of velocity = 7.5 sin 50 = 5.7 (m s^{-1}) (1) May use Pythagoras or tan for second component calculated	**1**
4(a)(iii)	Use of appropriate equation of motion, e.g. $v = u + at$, leading to time of flight (1) Time of flight OR double distance travelled half way (1) Use of velocity = distance / time (1) Distance = 5.6 m to 6.1 m (1) Correct answer from range formula 4/4, incorrect answer from range formula 0/4 <u>Example of calculation</u> $v = u + at$ 0 = 5.7 m s^{-1} + 9.81 m s^{-2} x t t = 0.58 s to max height time of flight = 1.16 s horizontal distance = horizontal component of velocity x time = 4.8 m s^{-1} x 1.16 s = 5.6 m (Using 'show that' values gives 6.12 m)	**4**
4(b)(i)	Use of $E_k = ½ mv^2$ (1) kinetic energy = 41 J (1) <u>Example of calculation</u> $E_k = ½ mv^2$ m = 2.24 kg – 0.79 kg = 1.45 kg E_k = ½ x 1.45 kg x (7.5 m $s^{-1})^2$ = 40.8 J If answer calculated from difference between 2 kinetic energies, allow first mark only.	**2**
4(b)(ii)	Not all the mass of liquid which left the bottle went that far / 7.5 m s^{-1} is the maximum speed (1)	**1**
4(b)(iii)	Air resistance / friction at neck (1) … could have caused the liquid to lose energy / so the true (initial) velocity is more than the calculated value / so the measured range was less (than it might otherwise have been) (Just 'energy lost' not sufficient – must be linked to some cause) (1)	**2**
	Total for question 17	**11**

Question Number	Answer	Mark
5(a)	Correct the diagram Parabolic path shown (1) [allow for moderate effects of air resistance]	**1**
5b)	Explain why a projectile follows the path you have drawn. state horizontal speed constant / air resistance negligible (1) horizontal motion independent of vertical motion / unaffected by gravity (1) state downwards acceleration / downward force acting / gravity acts on vertical motion (1)	**3**
5(c)	Explain why the balloon follows this path. **QWC – Work must be clear and organised in a logical manner using technical wording where appropriate** Air resistance high (1) so balloon decelerates horizontally also (1) from max height/when speed zero it falls (vertically) (1)	**3**
	Total for question	**7**

Question Number	Answer	Mark
13(a)	Force × distance moved in the <u>direction</u> of the (applied) force **(1)** (An equation with defined terms and the direction stated of the distance can score this mark)	**1**
13(b)	Use of KE = ½mv^2 (with any velocity in m s^{-1}) **(1)** Use of Work done = Fd (with any energy) **(1)** d= 85 m **(1)** **Or** Use of $F = ma$ to find the acceleration **(1)** Use of suitable equation(s) of motion to find the braking distance **(1)** d= 85 m **(1)** <u>Example of calculation</u> KE_{before} = ½ × 1.5 × 10^3 kg × (24.6 m s^{-1})^2 = 4.54 × 10^5 J KE_{after} = ½ × 1.5 × 10^3 kg × (13.4 m s^{-1})^2 = 1.35 × 10^5 J Transfer of KE = 4.54 × 10^5 J – 1.35 × 10^5 J = 3.19 × 10^5 J 3.19 × 10^5 J = 3750 N × d d = 85.1 m	**3**
	Total for question 13	**4**