3. Dynamics

3.3 Linear momentum and its conservation

Paper 2

Marking Scheme

Q1.

(a)	sum / total momentum before (a collision) = sum / total momentum after (a collision) **or** sum / total momentum (of a system) is constant	**M1**
	if no (resultant) external force (acts) / for an isolated system	**A1**
(b)	along direction of motion: $10m = 2mv \cos 30° + 3mw \cos 30°$	**C1**
	perpendicular to direction of motion: $2mv \cos 60° = 3mw \cos 60°$ $(v = 3w / 2)$	**C1**
	$v = 2.9\ \text{m s}^{-1}$	**A1**
	$w = 1.9\ \text{m s}^{-1}$	**A1**

Q2.

(c)(i)	$212(\text{u}) \times 1.3 (\times 10^5) \sin 68°$ **or** $4(\text{u}) \times 150 (\times 10^5) \sin \theta$	**C1**
	$4(\text{u}) \times 150 (\times 10^5) \times \sin \theta = 212(\text{u}) \times 1.3 (\times 10^5) \times \sin 68°$	**C1**
	$\sin \theta = 0.426$ $\theta = 25°$	**A1**

Q3.

(b)	(total) momentum before decay is zero **or** X has zero / no momentum	**B1**
	(total momentum after decay must be zero so) Y must have equal (and opposite) momentum to α-particle (so cannot be stationary / must have speed/velocity)	**B1**

Q4.

(b)(ii)	$(0.25 \times 0.48) + (0.75 \times 0.12) = (0.25\ v) + (0.75 \times 0.30)$ **or** $(0.48 - 0.12) = (0.30 - v)$ **or** $(½ \times 0.25 \times 0.48^2) + (½ \times 0.75 \times 0.12^2) = (½ \times 0.25 \times v^2) + (½ \times 0.75 \times 0.30^2)$	**C1**
	$v = (-)0.060\ \text{m s}^{-1}$	**A1**
	direction: to the left / from the right / opposite to (its) initial velocity / opposite to (initial / final) velocity of B	**B1**
(c)	sketch: horizontal line from (0, 0.48) to (0.15, 0.48)	**B1**
	horizontal line from (0.35, –0.06) to (0.5, –0.06)	**B1**
	straight line between (0.15, 0.48) and (0.35, –0.06)	**B1**

Q5.

(a)(i)	component of momentum $= 0.25 \times 3.7 \times \sin 27°$	**C1**
	$= 0.42$ N s	**A1**
(a)(ii)	$m_{(Z)} \times 5.5 \times \sin 44° = 0.42$ **or** $m_{(Z)} \times 5.5 \times \sin 44° = 0.25 \times 3.7 \times \sin 27°$ $m_Z = 0.11$ kg	**A1**
(b)	$4 + 6 = 2 + v$ $v = 8$ m s^{-1}	**A1**

Q6.

(a)	sum/total momentum before = sum/total momentum after **or** sum/total momentum (of a system of objects) is constant	**M1**
	if no (resultant) external force/for a closed system	**A1**
(b)(i)	$(3.0 \times 4.0 \times \cos\theta)$ **or** $(2.5 \times 4.8 \times \cos\theta)$ **or** (5.5×3.7)	**C1**
	$(3.0 \times 4.0 \times \cos\theta) + (2.5 \times 4.8 \times \cos\theta) = (5.5 \times 3.7)$	**C1**
	$\theta = 32°$	**A1**
(b)(ii)	(initial $E_K = \frac{1}{2} \times 3.0 \times 4.0^2 + \frac{1}{2} \times 2.5 \times 4.8^2 =$) 53 (J) **or** (final $E_K = \frac{1}{2} \times 5.5 \times 3.7^2 =$) 38 (J)	**C1**
	values of initial E_K and final E_K both correct **and** inelastic stated	**A1**

Q7.

(a)	(total) momentum before (decay) is zero **or** P has zero momentum	**B1**
	(total momentum after decay must be zero so) α-particle and Q have momenta in opposite directions (and therefore velocities are in opposite directions)	**B1**
(b)	$p = 239$ (u) $\times v$ **or** 4 (u) $\times 1.6 \times 10^7$	**C1**
	239 (u) $\times v = 4$ (u) $\times 1.6 \times 10^7$ $v = 2.7 \times 10^5$ m s^{-1}	**A1**

Q8.

(d)	horizontal line from (0, 0.40) to (60, 0.40)	**B1**
	straight line from (60, 0.40) to (100, –0.10)	**B1**
	horizontal line from (100, –0.10) to (160, –0.10)	**B1**

Q9.

(b)(i)	$m_X \times 5v$ **or** $(m_X + m_Y) \times v$	**C1**
	$m_X \times 5v = (m_X + m_Y) \times v$ (so) $m_Y / m_X = 4$	**A1**
(b)(ii)	(E =) $\frac{1}{2}mv^2$	**C1**
	ratio = $[\frac{1}{2} \times (m_X + m_Y) \times v^2] / [\frac{1}{2} \times m_X \times (5v)^2]$	**C1**
	= 0.2	**A1**
(b)(iii)	ratio = 1	**A1**
(c)(ii)	horizontal line from (0 ms, 0 squares) ending at (20 ms, 0 squares)	**B1**
	straight line from (20 ms, 0 squares) ending at (40 ms, 4.0 squares [= 4.0 cm vertically])	**B1**
	horizontal line from (40 ms, 4.0 squares) ending at (60 ms, 4.0 squares)	**B1**

Q10.

(b)(ii)	$p = mv$ **or** $3M \times 0.40$ **or** $M \times 0.25$ **or** $3M \times 0.2$ **or** Mv	**C1**
	$(3M \times 0.40) - (M \times 0.25) = (3M \times 0.2) + Mv$	**C1**
	$v = (3 \times 0.40) - 0.25 - (3 \times 0.2)$ $= 0.35\,\text{m s}^{-1}$	**A1**
(b)(iii)	**1.** relative speed of approach = 0.40 + 0.25 $= 0.65\,\text{m s}^{-1}$	**A1**
	2. relative speed of separation = 0.35 – 0.20 $= 0.15\,\text{m s}^{-1}$	**A1**
(b)(iv)	(relative) speed of separation not equal to/less than (relative) speed of approach **or** answers (to (b)(iii) are) not equal **and** so inelastic collision	**B1**

Q11.

(a)	sum/total momentum (of a system of bodies) is constant **or** sum/total momentum before = sum/total momentum after	**M1**
	for an isolated system **or** no (resultant) external force	**A1**
(b)(i)	(p =) mv **or** $(3.0M \times 7.0)$ **or** $(2.0M \times 6.0)$ **or** $(1.5M \times 8.0)$	**C1**
	$3.0M \times 7.0 = 2.0M \times 6.0 \sin\theta + 1.5M \times 8.0 \sin\theta$	**C1**
	$\theta = 61°$	**A1**
	or (vector triangle method)	
	momentum vector triangle drawn	**(C1)**
	$\theta = 61°$ (*2 marks for* $\pm 1°$, *1 mark for* $\pm 2°$)	**(A2)**
	or (use of cosine rule)	
	$p = mv$ **or** $(3.0M \times 7.0)$ **or** $(2.0M \times 6.0)$ **or** $(1.5M \times 8.0)$	**(C1)**
	$(21M)^2 = (12M)^2 + (12M)^2 - (2 \times 12M \times 12M \times \cos 2\theta)$	**(C1)**
	$\theta = 61°$	**(A1)**

Q12.

(a)	$(p =)\ mv$ **or** 4.0×45 **or** 2.0×85 **or** $89v$	**C1**
	$(4.0 \times 45) - (2.0 \times 85) = 89\ v$ $v = 0.11\ \text{m s}^{-1}$	**A1**
(b)(i)	**1.** speed of approach $= 47\ \text{m s}^{-1}$ **and** **2.** speed of separation = 0	**A1**
(b)(ii)	speed of separation less than/not equal to speed of approach **and** so inelastic collision	**A1**

Q13.

(a)	sum/total momentum (of a system of bodies) is constant **or** sum/total momentum before = sum/total momentum after	**M1**
	for an isolated system **or** no (resultant) external force	**A1**