Linear Momentum

Mark Scheme 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Dynamics
Sub Topic	Linear Momentum
Paper Type	Theory
Booklet	Mark Scheme 2

Time Allowed: **66 minutes**

Score: **/55**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a (i)** *either* sum / total momentum (of system of bodies) is constant
or total momentum before = total momentum after M1
for an isolated system / no (external) force acts on system .... A1 [2]

(ii) zero momentum before / after decay M1
so α-particle and nucleus D must have momenta in opposite directions .... A1 [2]

(b) (i) kinetic energy = $\frac{1}{2} mv^2$ C1
$1.0 \times 10^{-12} = \frac{1}{2} \times 4 \times \underline{1.66} \times 10^{-27} \times v^2$ M1
$v = 1.7 \times 10^7$ m s^{-1} .... A0 [2

(ii) $1.7 \times 10^7 \times 4u = 216u \times V$ C1
$V = 3.1 \times 10^5$ m s^{-1} .... A1 [2]
(*accept* 3.2×10^5 *m s*$^{-1}$*, do not accept 220 rather than 216*)

(c) $(1.7 \times 10^7)^2 = 2 \times \textit{deceleration} \times 4.5 \times 10^{-2}$ C1
deceleration / a = 3.2×10^{15} m s^{-2} .... A1 [2]
(*accept calculation based on calculating* $F = 2.22 \times 10^{-11}$ *N*
and then use of $F = ma$)

[Total: 10]

2 **(a) (i)** speed = 4.0 m s^{-1} …(*allow 1 s.f.*) .... A1 [1]

(ii) $v^2 = 2gh$
$= 2 \times 9.8 \times 1.96$ M1
$v = 6.2$ m s^{-1} .... A0 [1]
(*use of* $g = 10$ *m s*$^{-2}$ *loses the mark*)

(b) correct basic shape with correct directions for vectors M1
speed = (7.4 ± 0.2) m s^{-1} A1
at $(33 \pm 2)^\circ$ to the vertical .... A1 [3]
(*for credit to be awarded, speed and angle must be correct on the diagram – not calculated*)

(c) (i) *either* $v^2 = 2 \times 9.8 \times 0.98$ *or* $v = 6.2 / \sqrt{2}$ C1
speed = 4.4 m s^{-1} .... A1 [2]
(*allow calculation of* $t = 0.447$ *s, then* $v = 4.4$ *m s*$^{-1}$)

(ii) 1 momentum = mv C1
change in momentum = 0.034 (6.2 + 4.4) C1
= 0.36 kg m s^{-1} .... A1 [3]
(*use of 0.034 (6.2 - 4.4) loses last two marks*)
2 force = $\Delta p / \Delta t$ …….(however expressed) C1
$= \dfrac{0.36}{0.12}$
= 3.0 N ……(*allow 1 s.f.*) .... A1 [2]

[Total: 12]

3 **(a)** ball moving in <u>opposite</u> direction (after collision) .... B1 [1]

(b) (change in momentum = 1.2 (4.0 + 0.8) C2
(*correct values, 1 mark; correct sign {values added}, 1 mark*)
= 5.76 N s …(*allow 5.8*) .... A1 [3]

(ii) force = $\Delta p / \Delta t$ or $m\Delta v / \Delta t$ C1
= 5.76 or 1.2 × 4. .... C1
= 72 N .... A1 [3]

(c) 5.76 = 3.6 × V C1
V = 1.6 m s^{-1} .... A1 [2]

(d) *either* speed of approach = 4.0 m s^{-1} and
speed of separation = 2.4 m s^{-1} M1
not equal and so inelastic A1

or kinetic energy before = 9.6 J and
kinetic energy after collision = 4.99 J M1
kinetic energy after is less / not conserved so inelastic .... A1 [2]

4 **(a)** helium nucleus OR contains two protons and two neutrons B1 [1]

(b) kinetic energy = $\frac{1}{2}mv^2$ C1
$\frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times v^2 = 1.07 \times 10^{-12}$ A1
$v = 1.8 \times 10^{7}$ m s^{-1} A0 [2]

(c) **(i)** sum of momenta (in any direction) is constant
/ total momemtum is constant M1
in a closed system / no external force A1 [2]

(ii) momentum of francium (= 0) = momentum of α + momentum of astatine C1
$204 \times V = 4 \times 1.8 \times 10^{7}$ C1
$V = 3.5 \times 10^{5}$ m s^{-1} A1 [3]
(*nuclei incorrectly identified, 0/3*
nuclei correctly identified but incorrect masses, -1 each error)

(d) another particle / photon is emitted M1
at an angle to the direction of the α-particle A1 [2]
(allow 1 mark for ‘Francium nucleus is not stationary’)

5	**(a)**	**(i)**	(p =) mv	B1	
		(ii)	$E_k = \frac{1}{2}mv^2$	B1	
			algebra leading to	M1	
			$E_k = p^2/2m$	A0	**[3]**
	(b)	**(i)**	Δp = 0.035 (4.5 + 3.5) OR a = (4.5 + 3.5)/0.14	C1	
			= 0.28 N s = 57.1 m s^{-2}		
			force= $\Delta p/\Delta t$ (= 0.28/0.14) OR F = ma (= 0.035 x 575.1) (allow e.c.f.)	C1	
			= 2.0 N	A1	
			Note: candidate may add mg = 0.34 N to this answer, deduct 1 mark		
			upwards	B1	**[4]**
		(ii)	loss = $\frac{1}{2}$ x 0.035 ($4.5^2 - 3.5^2$)	C1	
			= 0.14 J	A1	**[2]**
			(No credit for $0.28^2/(2 \times 0.035)$ = 1.12 J)		
	(c)		e.g. plate (and Earth) gain momentum		
			i.e. discusses a 'syste	B1	
			equal and opposite to the change for the ball		
			i.e. discusses force/moment	M1	
			so momentum is conserved		
			i.e. discusses consequence	A1	**[3]**
			Total		**[12]**