Marking Scheme

1.

(a)		[In any interaction] the [vector] sum of bodies' *momenta* [accept 'total momentum'] stays constant (1), provided no [resultant] external force acts [accept: in a closed system] (1) NB. Separate marks but statement of conservation of energy loses both marks.	2
(b)	(i)	$1.67 \times [10^{-27}] \times 3150 \pm 9.98 \times [10^{-27}] \times 225 = 11.6 \times [10^{-27}]v$ (1) [10^{-27} consistently dropped or masses given as 1, 6, 7 ✓] With minus sign (i.e. signs correct) (1) $v = 260$ m s^{-1} (1) [no ecf] Arrow to right (1)	4
	(ii)	Σ KE initially $= 8.54 \times 10^{-21}$ J (1) Σ KE finally $= 3.92 \times 10^{-21}$ J (1) [Correct answer other than powers of 10 → 1 mark]	2
(c)		$\Delta mv = \frac{h}{\lambda}$ or $v = \frac{h}{\lambda m}$ (1) [or $\frac{h}{\lambda} = 3.88 \times 10^{-21}$ [Ns]] $v = 3.3 \times 10^{5}$ m s^{-1} (1) [No penalty for attempts to include initial momentum (which is 3.0×10^{-24} Ns)]	2
			10

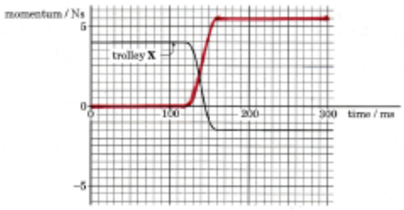
2.

Question			Marking details	Marks Available
4	*(a)*	(i)	Application of conservation of momentum (1) $(0.36 + 0.18)v = (0.36 \times 0.40) + (0.18 \times (-0.10))$ correct eqn(1) $0.54v = 0.126$ $v = 0.23$ [m s^{-1}] to the right (1) – direction may be by implication	3
		(ii)	Initial KE $= \frac{1}{2}(0.36)(0.4)^2 + \frac{1}{2}(0.18)(-0.10)^2 = 0.0297$ [J] (1) Final KE $= \frac{1}{2}(0.36 + 0.18)(0.23)^2 = 0.0143$ [J] (1) KE lost $= 0.0297 - 0.0143 = 0.0154$ [J] as percentage: $\frac{0.0154}{0.0297} \times 100\% = 51.85$[%] (1)	3

3.

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
3	(a)		The (vector) sum of the momenta of bodies in a system stays constant (even if forces act between the bodies) accept overall momentum remains constant [1] provided there is no external / resultant force [1] **Accept**: Total momentum of a system (or bodies) before a collision (or explosion) = total momentum after collision (explosion)... [1] ....provided no external / resultant forces act [1]	2			2		
	(b)	(i)	$600 \times 1.8 \times 10^3 = (500 \times v) + (100 \times 2 \times 10^3)$ [1] v = [+]1 760 [m s^{-1}] [1]		2		2	2	
		(ii)	Use of $\frac{1}{2}mv^2$ [1] Before separation $E_k = 9.72 \times 10^8$ [J] [1] After separation $E_k = 9.74 \times 10^8$ [J] ecf [1]	1	1 1		3	2	
		(iii)	Chemical energy **or** thermal energy **or** internal energy **or** work <u>from explosion</u> [transferred to E_k]	1			1		
	(c)		Substitution into $Ft = mv - mu$ for probe i.e. $F \times 0.002 = 100\ (2 \times 10^3 - 1.8 \times 10^3)$ [1] **Alternative for 1st mark:** Use of $F = ma$ to calculate $a = \frac{(v-u)}{t} = 1 \times 10^5$ m s^{-2} **Alternative for 1st mark:** $F \times 0.002 = 500\ (1.76 \times 10^3$ ecf $- 1.8 \times 10^3)$ [1] F = [-] 1×10^7 N **unit mark** [1]		2		2	2	
			Question 3 total	**4**	**6**	**0**	**10**	**6**	**0**

4.

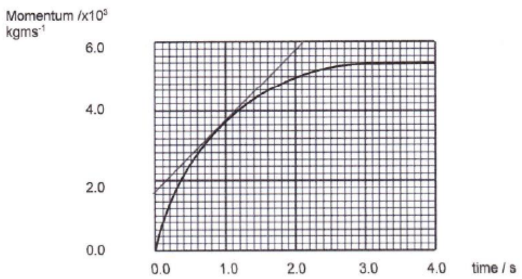
Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
					Marks available				
3	(a)		Vector sum of momenta [or total momentum] of [a number of] bodies is constant [1] provided no forces act from outside [that number] [1]	2			2		
	(b)	(i)	Δp_X = [–] 5.5 [Ns] **or equiv or by imp** [1] Δp_Y = [+] 5.5 [Ns] **or equiv or by imp** [1] **ecf** Y's velocity after collision = [+] 2.3 [m s^{-1}] [1] **ecf** on 5.5 [N s]		3		3	2	
		(ii)	Up to about 120 ms, straight line along time axis [1] After 120 ms upward sloping line followed by horizontal line after 160 ms [1] Horizontal line after 160 ms at 5.5 [N s] [1] 		3		3	2	
		(iii)	Change of momentum in a Δt of 40 ms [**Accept** any Δt between 30 ms and 40 ms] [1] Mean force on X = (–)140 N; **ecf** on (–)5.5 N s and 40 ms [1]		2		2	2	
			Question 3 total	**2**	**8**	**0**	**10**	**6**	**0**

5.	*(a)*		Reasonable attempt at conservation of momentum (1) e.g. $330\,000m = \pm 10\,000m + 6.6 \times 10^{-27} \times v_1$ conservation of momentum applied correctly and values substituted (1) e.g. $330\,000 \times 3.4 \times 10^{-25} = -10\,000 \times 3.3 \times 10^{-25} + 6.6 \times 10^{-27} \times v_1$ correct answer = 1.75×10^7 [m s^{-1}] **(no ecf)** (1)	3
	(b)	(i)	Any valid answer e.g. impulse (or force or acceleration or change in momentum) is vertical, gamma has no momentum in horizontal direction, perpendicular directions are independent etc. Accept: no horizontal force	1
		(ii)	Attempt at using $p = \frac{h}{\lambda}$ (1) $E = hf$ **and** $c = f\lambda$ quoted (or equivalent $E = \frac{hc}{\lambda}$) (1) N.B. $p = \frac{E}{c}$ gains 2 marks Correct momentum = 6.33×10^{-22} (1) Answer = = $\frac{6.33\times10^{-22}}{3.3\times10^{-25}}$ [1 920 m s^{-1}] (1)	4
		(iii)	Method i.e. $\sqrt{10000^2 + 2000^2}$ (1) Answer = 10 200 [m s^{-1}] **ecf on *v* from *(b)*(ii)** (1) Method and correct **indication of angle** e.g. $\tan^{-1}\left(\frac{2000}{10000}\right)$ (1)  Answer = 11.5° **or** 0.2 [rad] (or 90-11.5 for other angle if indicated etc.) (1)	4

6.

(a)		$A = \pi \times 1.8^2$ or implied in numbers (1) Volume per second = $\pi r^2 v$ [or by some method e.g. $m = \rho v$] (1) Mass flow rate = $\pi \times 1.8^2 \times 250 \times 0.4$ [= 1018 kg s^{-1}] (1)	3
(b)		Thrust = Mass / sec × Δv (1) [or equiv.][i.e. *(a)* × Δv] [or by impl.] = 40 [kN] (1)	2
(c)		Aeroplane momentum is constant (1) [this mark is implied if the candidates imply or state that the exhaust air speed = 250 m s^{-1}] No (overall) change in air momentum (1) **Or** (Δ) momentum of air forwards (due to drag etc.) (1) is balanced by (Δ) momentum of exhaust air backwards (1) **Or** equivalents if candidate states momentum of aeroplane is decreasing (due to small decrease in mass i.e. kerosene loss) e.g. momentum of aeroplane is decreasing <u>due to decreasing mass</u> (1) so overall transfer of momentum to air to the right (1)	2

7.

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
5	*(a)*		Newton's 2nd Law	1			1		
	(b)	(i)	 Suitable tangent at t = 1.0 [±0.1] s seen [$\Delta t \geq$ 1.0 s] (1) Appropriate [with $\Delta t \geq$ 1.0 s] values taken from tangent and manipulated correctly to show $F_{resultant} \approx$ 2 000 N (1) [**ecf** on tangent in range 1.7 – 2.3 kN]		2		2	2	
		(ii)	m = 2 000 (or own value from (i)) ÷ 0.4 (= 5 000 kg)		1		1	1	
		(iii)	P labelled on line at $t \geq$ 3.0 s	1			1		
	(c)	(i)	The vector sum of the momenta of bodies in a system stays constant (even if forces act between the bodies), ... (1) ....provided there is no external / resultant force / in an isolated system (1) Accept: The total momentum before a collision is equal to the total momentum after a collision....... (1) ....provided there is no external / resultant forces act / in an isolated system (1)	2			2		
		(ii)	Momentum before collision = 5.4×10^3 (N s) (1) [from graph] Momentum after collision = (5 000 or ans to *(b)*(ii)+ 7 000) v (1) v = 0.45 (m s^{-1}) (1) [**ecf** on value from graph, including slips in power of 10]	1	1 1		3	3	
			Question 5 total	**5**	**5**	**0**	**10**	**6**	**0**

Examiner's Comments

1. (mean mark: 7.4/10 = 74 %)

(a) There were many excellent statements of the Principle of Conservation of momentum, but as usual some candidates omitted the no external forces proviso, and some claimed that 'momentum' stayed the same, without explaining that they meant the vector sum of bodies' momenta, (or total momentum).

(b) *(i)* The Principle was usually applied successfully to the colliding particles, with only a few candidates forgetting the minus sign or omitting the requested arrow.

(ii) Most candidates knew how to check that the collision was inelastic, though a few subtracted one initial KE from the other as if KE were a vector, and there were some bizarre algebraic confusions such as: total KE = ½(m1+m2)(v1+v2)2.

(c) Most candidates could calculate the photon's momentum from its wavelength, though hf was sometimes used mistakenly instead of h/λ. Although some did not proceed further, most did go on to calculate the recoil velocity of the nucleus successfully.

*This comment originally referred to question **1** on paper **1324/01 (21/06/2011)***

2. Q.4 (a)*(i)* This part of the question was answered very well by applying the conservation of momentum to find the common velocity of the discs after collision.

(ii) The initial and final kinetic energies were usually calculated correctly, with the very occasional ecf for the answer in part*(i)* . The requirement for the energy lost was sometimes not identified, which resulted in the final mark for the percentage not being awarded.

*This comment originally referred to question **4** on paper **1324/01 (11/06/2015)***

3. There are no examiner comments available for this question

4. There are no examiner comments available for this question

5. (a) Generally answered well but some candidates failed to change the sign of the rebounding nucleus's velocity.

(b) *(i)* Candidates generally understood that the forces in 2 perpendicular directions are independent but it was not always well expressed.

(ii) The method was unclear at times with candidates omitting steps. As this was a 'show that' question candidates should take care to show how they arrived at their answer.

(iii) Magnitude was calculated well. The angle was generally calculated correctly but the direction not always stated. Some candidates tried to describe the direction relative to the vertical/horizontal but candidates who sketched a diagram with a labelled angle tended to secure the mark.

*This comment originally referred to question **1** on paper **1324/01 (11/06/2014)***

6. Question 3: Mean mark: 3.3/7 = 47%

(a) Here, candidates were penalised for not explaining their answers fully. Most candidates who obtained the correct answer set out their proofs very clearly. Nonetheless, there was a significant minority of correct answers that appeared as a jumble of numbers - this was penalised one or two marks depending on whether pr2 was evident.

(b) Generally, not well answered and often not attempted. Common mistakes were to multiply the mass per second by 290 m s-1 instead of the difference in speed

(40 m s-1) or to use kinetic energy.

(c) This was deliberately set as a difficult question and it proved too difficult for the vast majority of the cohort. Very few candidates realised that the increased backward momentum of the air would be countered by air being pushed forward (due to drag).

*This comment originally referred to question **3** on paper **1324/01 (24/01/2012)***

7. There are no examiner comments available for this question