Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	More electrons in higher energy level [E_2] compared to lower energy level [E_1]	1			1		
		(ii)	Population inversion ensures stimulated emission [rather than spontaneous emission] (1) Produces 2 photons for 1 incoming photon (1)	2			2		
	(b)		Conversion of eV to J correct (1) Wavelength = 1.00×10^{-5} m (1) Wavelength lies in the infra-red (1)	1 1	1		3	2	
	(c)		Converting 2 290 km^2 to 2.29×10^9 m^2 (1) Force on the crater (= pressure × area **ecf**) = 1.38×10^{12} [N] (1) Momentum of each molecule calculated = 4×10^{-23} [N s] (1) Momentum change per collision = 8.03×10^{-23} [N s] **or** realisation that momentum change = initial – (-final) (1) Number of molecules = 1.71×10^{34} (1)		5		5	5	
			Question total	**5**	**6**	**0**	**11**	**7**	**0**

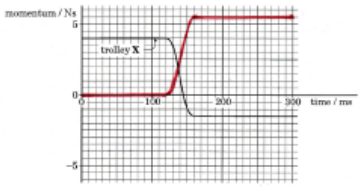
#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	(a)		$E = [2\times] 9.11 \times 10^{-31} \times c^2$ or $m = \frac{9.11 \times 10^{-31}}{1.66 \times 10^{-27}}$ [= 0.000549 u] [1] Conversion to eV i.e. dividing by 1.6×10^{-19} or × 931 [1] 1.025 MeV seen or $2 \times 9.11 \times 10^{-31} \times \frac{(3 \times 10^8)^2}{1.6 \times 10^{-19}}$ or $2 \times 0.000549 \times 931$ [1]		3		3	3	
	(b)		Excess energy or 0.01 MeV [1] Equal amounts shared by electrons & positron due to equal (light) masses [1]		2		2		
	(c)		$0.5 \times 9.11 \times 10^{-31} \times v^2 = 0.005 \times 10^6 \times 1.6 \times 10^{-19}$ seen or equivalent: $(0.5 \times 9.11 \times 10^{-31} \times (4.2 \times 10^7)^2$ giving 0.005 MeV or 4.19×10^7 seen [1] Momentum of gamma ray [= $\frac{E}{c}$] = 5.49×10^{-22} [N s] [1] Momentum of electron or positron = $9.11 \times 10^{-31} \times 4.2 \times 10^7$ = 3.8×10^{-23} or 7.6×10^{-23} [1] $5.49 \times 10^{-22} - 2 \times 4.2 \times 10^7 \times 9.11 \times 10^{-31}$ seen [1]		4		4	3	
	(d)		KE calculated (3.35×10^{-19} J or 2.1 eV) [1] Correct conclusion – negligible [1] **No ecf**			2	2	1	
			Question 5 total	**0**	**9**	**2**	**11**	**7**	**0**

#3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	(a)		Energy cannot be created or destroyed only changed from one form to another	1			1		
	(b)	(i)	Length from top of pendulum = 2 cos 48° = 1.34 [m] (1) Height pendulum rises = 2.00 – 1.34 = 0.66 [m] (1)		2		2	2	
		(ii)	$\frac{1}{2}mv^2 = mgh$ (1) v = 3.60 [m s^{-1}] (1)		2		2	2	
	(c)	(i)	The vector sum of momentum before a collision equals the vector sum of momentum after collision / Accept total for vector sum of (1) provided no external forces act (1)	2			2		
		(ii)	$m_b v_b$ = 1.91 × 3.6 **ecf** (1) v = 687(.6) or 688 [m s^{-1}] (1)		2		2	2	
	(d)		**Any 2 × (1) from:** - Students over the age of sixteen - Legitimate reason for scientific learning - Needs to be transported through school play ground -Possible dangers in transporting - Risk assessment made			2	2		
			Question 2 total	**3**	**6**	**2**	**11**	**6**	**0**

#4

Question				Marking details		Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
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 [Ns]		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 [Ns] [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 Ns and 40 ms [1]		2		2	2	
				Question 3 total	**2**	**8**	**0**	**10**	**6**	**0**

#5

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)		Mean KE = $\frac{3}{2} \times 1.38 \times 10^{-23} \times 1500$ [J] **or by impl** [1] = 3.11×10^{-20} [J] [1]	1	1		2	1	
		(ii)		$c^2_{rms} = \frac{3.11 \times 10^{-20}}{\frac{1}{2} \times 3.82 \times 10^{-26}}$ [i.e. transposed] **or by impl** [1] $c_{rms} = 1275\ m\ s^{-1}$ [1]		2		2	2	
	(b)	(i)		Any statement that shows knowledge of gas molecules [at a given temp] having a range of speeds [1] 6.40 km s^{-1} is a few [5] times greater than rms speed [1] Molecule could have acquired this speed through a succession of 'lucky' collisions [1]		3		3		
		(ii)		$m \times 6.40 + 0 = m \times 4.39 + m \times v$ **or equiv or by impl** [1] $v = 2.01\ km\ s^{-1}$ **to the East** [1]		2		2	2	
		(iii)		KE before = 7.82×10^{-19} [J] [1] KE after = 3.68×10^{-19} J + 0.77×10^{-19} J [1] [= 4.45×10^{-19} J] or equivalent (no need to include the $\frac{1}{2}m$ or 10^3] Inelastic as KE [= 3.37×10^{-19} J] has been lost [1] **Alternative** Considering relative velocities of approach and separation [1] $6.40 \times 10^3 > 4.39 \times 10^3 - 2.01 \times 10^3$ **or equiv** [1] Therefore KE lost **or** inelastic [1]		3		3	2	
		(iv)		The molecules exert equal and opp forces on each other	1			1		
		(v)		Photon momentum = $\frac{6.63 \times 10^{-34}\ J\ s}{589 \times 10^{-9}\ m}$ or by implication [1] = 1.1×10^{-27} **N s UNIT mark** [1] << either molecule's momentum, so insignificant effect [1]			3	3	1	
				Question total	**2**	**11**	**3**	**16**	**8**	**0**