

PH4

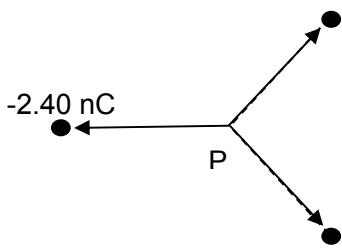
Question		Marking details	Marks Available
1	(a)	<p>The total momentum (of a system) is constant (must have total, sum, vector sum etc.) (1)</p> <p>Provided no <u>external</u> [resultant] force (1)</p> <p>e.g. - The momentum before and after a collision is the same - 0</p> <p>When two particles collide the sum of momentum stays the same as long as no forces are involved - 1</p>	2
	(b)	<p><math>\lambda = \frac{c}{f}</math> i.e. rearranged or <math>E = hf = 2.13 \times 10^{-13}</math> [J] (1)</p> <p><math>p = \frac{h}{\lambda}</math> <b>used</b> or <math>p = \frac{E}{c}</math> <b>quoted</b> (1)</p> <p>Final evidence  <math>p = \frac{6.63 \times 10^{-34}}{9.35 \times 10^{-13}}</math> or <math>p = \frac{2.128 \times 10^{-13}}{3 \times 10^8}</math> (= <math>7.09 \times 10^{-22}</math>) (1)</p>	3
	(c)	<p>Reasonable attempt at cons of mom  e.g. initial <math>p</math> of Ni = final <math>p</math> of Ni <math>\pm p</math> of photon (1)</p> <p><math>2440 \times 9.95 \times 10^{-26} = 7 \times 10^{-22} - 9.95 \times 10^{-26} v</math> (1)</p> <p>Answer = <math>4700</math> [<math>\text{m s}^{-1}</math>] or slightly different dependent on (b) (1)  <b>ecf</b> on <math>p</math></p>	3
<b>Question 1 Total</b>			<b>[8]</b>

Question		Marking details	Marks Available
2	(a)	$\frac{1}{3}\rho\overline{c^2}V = nRT$ i.e. some sort of combining both equations (1)  Realising $\rho = \frac{Nm}{V}$ (any mistakes in $N$ and $m$ means max of 1/3) (1) (or equivalent steps)  <b>Clear</b> algebra with no mistakes leading to $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ or $\frac{1}{2}m\overline{c^2} = \frac{3}{2}\frac{R}{N_A}T$ (if it's difficult to follow don't award the mark - needs to be clear) (1)	3
	(b) (i)	Mass of argon molecule = $6.3(08)\times 10^{-26}$ (1)  Algebra or equivalent method $T = \frac{m\overline{c^2}}{3k}$ or $T = \frac{N_A m\overline{c^2}}{3R}$ (1)  Answer = 605 [K] (1) <b>ecf</b>	3
	(ii)	$\sqrt{\overline{c^2}} \propto \sqrt{T}$ or correct substitution of 1 210 K ( <b>ecf</b> ) and algebra (1)  Answer = $630 \times \sqrt{2}$ or 891 [m s <sup>-1</sup> ] (1)	2
<b>Question 2 Total</b>			<b>[8]</b>

Question			Marking details	Marks Available
3	(a)	(i)	Graph is straight line through origin [hence proportional] (1) (accept acceleration is proportional to displacement) Negative gradient [hence direction ok] (1)	2
		(ii)	Gradient calculated correctly i.e. $\frac{1}{0.028}$ or 36 (or $k$ calculated from $ma = kx$ i.e. $7.14 \text{ N m}^{-1}$ ) (1) Gradient = angular velocity squared i.e. method <b>explained</b> Or $f = \left(2\pi\sqrt{\frac{m}{k}}\right)^{-1}$ i.e. equation for $T$ <b>and</b> $f = 1/T(1)$ Answer = $\frac{5.98}{2\pi} = 0.95 \text{ [Hz]}$ (1)	3
		(iii)	$1 \text{ m s}^{-2}$ read off graph Or $6^2 \times 0.028 = 1 \text{ [m s}^{-2}\text{]} \text{ etc.}$	1
		(iv)	Max speed = $\omega A$ or implied (= 0.167) (1) KE = $\frac{1}{2}mv^2$ or implied (1) Answer = 2.8 [mJ] (1) <b>ecf</b>	3
		(v)	$v = A\omega\cos\omega t$ used or $\varepsilon = 0$ stated (1) Rearrangement e.g. $\omega t = \cos^{-1}\frac{v}{A\omega}$ or implied (1) Correct answer = 0.156 [s] (1) <b>ecf</b>	3
	(b)		KE to PE <b>or</b> PE to KE (1) PE is both GPE and EPE (1) Energy gradually lost due to friction or air resistance or internal energy of spring/air etc. Not sound, not heat by itself - needs more e.g. lost as heat to the air ok (1) Detail of energy loss e.g. internal energy of air, KE of air particles	4
<b>Question 3 total</b>				<b>[16]</b>

Question		Marking details	Marks Available
4	(a)	$T = \frac{pV}{nR}$ seen or implied (1)	3
		Evidence of 1 correct substitution (1)	
		Evidence of all 3 substituted correctly (1) A - (0.500 ± 0.002, 80 000 ± 2 000) B - (0.260 ± 0.002, 235 000 ± 2 000) C - (0.260 ± 0.002, 80 000 ± 2 000)	
	(b)	$U = \frac{3}{2}nRT$ used (1)	3
		Evidence of $\Delta T$ being used or differences in $U$ being calculated (once) (1)  AB = 31 500 [J], BC = - 60 500 [J], CA = 29 000 [J] (1)	
	(c)	(i) AB approximated as a trapezium (accept triangle gives 19 000 J) (1)  AB = - 38 000 [J] (1)  AB ≈ ( - 32 000 ± 3 000) J due to better method ✓✓✓ e.g. two trapezia or 2 triangles or square counting, or any attempt at integrating $pV$ (unlikely) etc. (i.e. 2 marks for good method 1 mark for correct answer) (1)	3
		(ii) BC = 0 (independent)	1
		(iii) CA = 19 200 [J]	1
(d)	(i) $Q = \Delta U + W$ i.e. equation used (1)  Correct answer with <b>their</b> figures e.g. 31 500 – 38 000 = -6 500 (also <b>ecf</b> possible for 31 500 + 38 000 = 69 500) (1)	2	
	(ii) No time for heat transfer	1	
<b>Question 4 Total</b>			<b>[14]</b>

Question			Marking details	Marks Available
5	(a)	(i)	$g = \frac{GM}{r^2}$ used (1) Answer = $3.7 \text{ m s}^{-2}$ or $\text{N kg}^{-1}$ or equivalent (1) <b>UNIT MARK</b>	2
		(ii)	$V_g = -\frac{GM}{r}$ used (1) Answer = $\pm 9.02 \text{ [MJ kg}^{-1}]$ (1) <b>ecf</b> on km conversion	2
		(iii)	Negative amount of work bringing mass from $\infty$ (accept no work done bringing from $\infty$ or system will do work or work is done in the other direction etc.)	1
	(b)	(i)	$PE = V_g \times m$ or implied (1) $KE = \frac{1}{2}mv^2$ used (1) Answer = $656 \text{ kJ} - 4.1 \text{ MJ} = -3.44 \text{ [MJ]}$ (1)	3
		(ii)	$-\frac{GMm}{r} = -3.44 \text{ MJ}$ (1) $r = 2905 \text{ km}$ (1) Height = $465 \text{ [km]}$ (1) <b>ecf</b>	3
		<b>Question 5 Total</b>		

Question		Marking details	Marks Available
6	(a)	<p>Arrows pointing towards charges similar to shown ✓✓</p> <p>Arrows pointing away from charges similar to shown ✓</p> 	2
	(b)	<p><math>E = \frac{Q}{4\pi\epsilon_0 r^2}</math> used (1)</p> <p>The 2 vertical components cancel or no field into or out of page (1)</p> <p>Pythagoras or trig e.g. <math>\sqrt{5^2 - 4^2} = 3</math> or recognising 3,4,5 triangle (equivalent is to realise <math>\cos \theta = 3/5</math> or <math>\theta = 53^\circ</math> etc.) (1)</p> <p>2 nC charge field x2 <b>and</b> x3/5 <b>ecf</b> (for horizontal components) (1)</p> <p>Calculations all ok e.g. <math>8\ 640 = 7\ 200 \times 2 \times 3/5</math> or equivalent shown (1)</p>	5
	(c)	<p><math>V = \frac{Q}{4\pi\epsilon_0 r}</math> used (1)</p> <p>Attempt at adding all 3 potentials (1)</p> <p>- 360 -360 - 432 = - 1 152 V or <math>\text{J C}^{-1}</math> or equivalent (1) <b>UNIT MARK</b></p>	3
	(d)	<p>Use of <math>PE = q\Delta V</math> must be a change (1)</p> <p>Rearrangement i.e. <math>v^2 = \frac{2 \times PE}{m}</math> allow <b>ecf</b> on V (1)</p> <p>Answer = <math>18.3 \times 10^6 \text{ [m s}^{-1}\text{]}</math> (<b>ecf</b> only if a <math>\Delta V</math> used) (1)</p>	3
		<b>Question 6 Total</b>	<b>[13]</b>

Question		Marking details	Marks Available
7	(a)	$T = 2\pi \sqrt{\frac{(1.4 \times 10^{10})^3}{6.67 \times 10^{-11} \times (1.6 \times 10^{29} + 3.7 \times 10^{27})}} \quad (1)$ <p>Answer = <math>3.15 \times 10^6</math> [s] or implied (<math>3.19 \times 10^6</math> s if <math>M_2</math> omitted) (1)</p> <p>36.5 [days] (1) (36.9 if <math>M_2</math> omitted gets 2/3)</p>	3
	(b)	(i)&(ii) $r_1 = \frac{M_2}{M_1 + M_2} d \quad \text{used or } M_1 r_1 = M_2 r_2 \quad \text{used} \quad (1)$ <p>Star orbit radius = <math>0.032 \times 10^{10}</math> [m] (1)</p> <p>Planet orbit radius = <math>1.37 \times 10^{10}</math> [m] (1)</p>	3
	(c)	(i) $v = \frac{2\pi r}{T} \quad \text{or} \quad v = \omega r \quad \text{and} \quad \omega = 2\pi f \quad (1)$ $v = \frac{2\pi \times 0.032 \times 10^{10}}{3.15 \times 10^6} (= 631) \quad (1) \quad \mathbf{ecf}$	2
		(ii) $\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \quad \text{values substituted or not possible} \quad (1)$ <p>Answer = 3.9 [pm] because mean radial speed unknown (1)</p> <p>Don't penalise using <math>2 \times v</math> if explained</p> <p><b>Question 7 Total</b></p>	2
			<b>[10]</b>



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