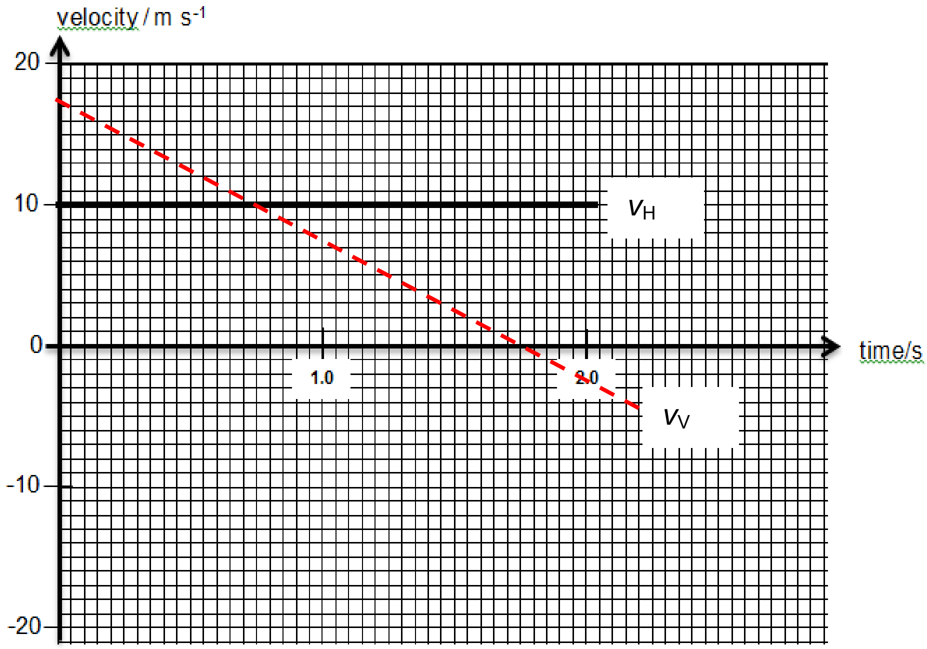
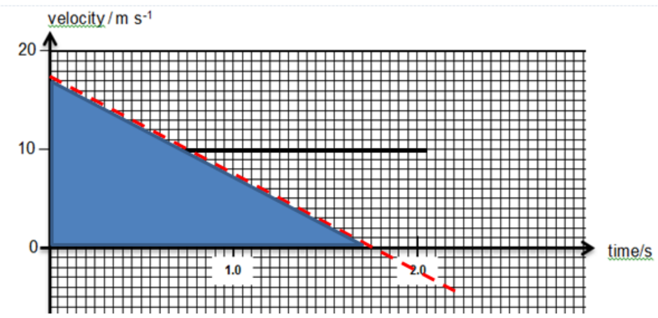
JURONG JUNIOR COLLEGE
JC2 Preliminary Exam 2013
H2 Physics Paper 3 solutions

Qn	Suggested solution	Remarks
1(a)(i) & (a)(ii)	 Applying $v_y = u_y + at$ and substituting $v_y = 0$ at maximum vertical height, $0 = (20.0 \sin 60°) + (-9.81)t$ $t = 1.77$ s or $t = \frac{17.3}{9.81} = 1.77$ s	**(a)(i)** **[1]** v_H is horizontal and equal to 10.0 m s^{-1} **(a)(ii)** **[1]** v_V is sloping and straight **[1]** *v-intercept* = 17.3 m s^{-1} **[1]** *t*-intercept between 1.7 and 1.8 s or gradient = 9.81 m s^{-2}
(b)	Object reached maximum vertical height *h* at *t* = 1.77 s. maximum vertical height *h* = area under *v-t* graph from *t* = 0 s to *t* = 1.77 s (= area of blue triangle below) = ½ (1.77)(17.3) = 15.3 m  *Comments: Many candidates did not use data from the graph (as requested by the question*	**[1]** equating area under graph to *h* **[1]** ans Note: **Max [1]** for candidates who did not consider area under graph in arriving at answer

<table>
<tr><th>Qn</th><th>Suggested solution</th><th>Remarks</th></tr>
<tr><td>(2a)</td><td>Gravitational Potential Energy is the energy possessed due to the <u>relative position of 2 masses</u> whereas Electric Potential Energy is the energy possessed due to the <u>relative position of 2 charges</u>.
Comments:
Most candidates, who try to state the definition of gravitational and electric potential energy, define them wrongly as “work done per unit mass in moving...” or “work done per unit positive charge in moving…”</td><td>1
1</td></tr>
<tr><td>(bi)</td><td>dm/dt = ρ(dV / dt)
= 1000 x 1.4
= 1400 kg s^{-1} (Shown)
Comments:
Most candidates did not explain properly the product of 1000 and 1.4.</td><td>1</td></tr>
<tr><td>(ii)</td><td>Rate of change in GPE = (dm/dt)gh

= 1400 (9.81)(750)

= -10.3 MJ s^{-1} (Loss)
Comments:
Most candidates forgot that the change of GPE was a loss and did not put a negative sign.</td><td>1 for eqn

1-sub

1 – end answer with negative sign</td></tr>
<tr><td>3(a)(i)</td><td>ΔU is the <u>increase in internal energy</u> of system
q is the <u>thermal energy/heat supplied to</u> system
w is the <u>work done on</u> system
Comment :Many candidates wrote ΔU as change in internal energy.</td><td>[1] with all underlined points</td></tr>
<tr><td>(a)(ii)</td><td>
<table>
<tr><th></th><th>Solid which expands on melting</th><th>Solid which contracts on melting</th></tr>
<tr><td>ΔU</td><td>+ (3)</td><td>+/- (4)</td></tr>
<tr><td>q</td><td>+ (2)</td><td>+/- (2)</td></tr>
<tr><td>w</td><td>- (1)</td><td>+ (1)</td></tr>
</table>
(1) Expansion implies <u>work done by</u> system and w is negative by definition. Vice versa for contraction.
(2) Thermal energy has to be <u>supplied to</u> the system for melting to occur.
(3) Expansion implies intermolecular separation larger than the equilibrium intermolecular separation (where potential energy is minimum), resulting in greater potential energy.
(4) Apply 1st law of thermodynamics. Contraction implies intermolecular separation smaller than the equilibrium intermolecular separation (where potential energy is minimum), resulting in greater potential energy.
For (3) and (4), random kinetic energy remains constant since melting occurs at constant temperature. Hence internal energy increases.
</td><td>[1] for every two correct signs

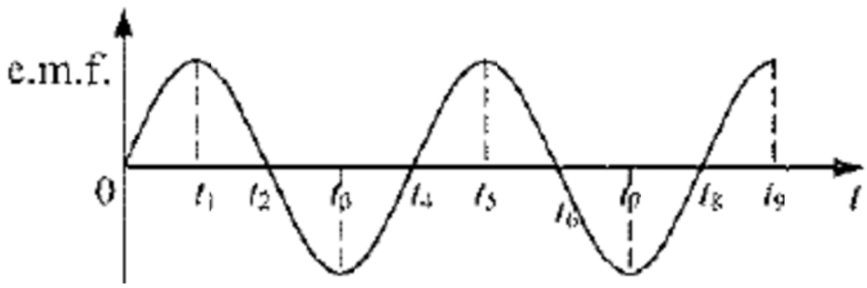
[3] for all correct</td></tr>
</table>

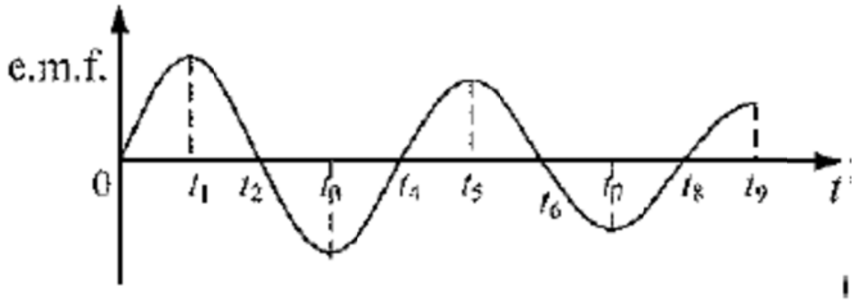
Qn	Suggested solution	Remarks
(b)(i)	At constant temperature, the random kinetic energy of the gas molecules remains unchanged. The internal energy of the gas **which is the sum of the random kinetic energy of its molecules** remains unchanged. Comment : Quite a number of candidates did not mention that internal energy of an ideal only depends on the random K.E. Many of they also did not equate internal energy to temperature directly.	**[2]** for correct reasoning and conclusion **The part in bold must be mentioned in either (b)(i) or (b)(ii), else max [3] of possible 4 marks**
(b)(ii)	The work done on (compressing) the gas increases the random kinetic energy of its molecules. The internal energy of the gas increases. Comment : Many candidates thought that temperature is unchanged since there is no heat exchange.	**[2]** for correct reasoning and conclusion
4a	Newton's law of gravitation states that the gravitational force between 2 point masses is directly proportional to the product of their masses and inversely proportional to the square of their separation, *R.* i.e. $F = \frac{GMm}{R^2}$ $g_M = F/m = \frac{GM}{R^2}$ Where *g* is defined as force per unit mass and m is a test mass.	1 for Newton's Law 1 for definition of g as force per unit mass 1 for mentioning m as a test mass
	Comments: Many students neglected to mention "point masses" while quoting Newton's law of gravitation. The majority also did not distinguish between M and m (i.e. mention that m is a test mass or small mass).	
bi	$g = \frac{GM}{R^2} = \frac{(6.67 \text{ x } 10^{-11})(5.2 \text{ x } 10^{30})}{(1.7 \text{ x } 10^4)^2} = 1.2 \text{ x } 10^{12} \text{ N kg}^{-1}$	1 – sub 1 – answer
	Comments: Generally well done except for a handful of students who forgot to square the denominator while substituting and hence got an incorrect answer.	
bii	The neutron star is assumed to be a point mass.	1
	Comments: Generally well done. Other answers accepted include: star's radius is assumed to be constant, star is a perfect sphere, star has uniform density etc.	
biii	$a = R\omega^2 = R\left(\frac{2\pi}{T}\right)^2 = (1.7 \text{ x } 10^4)\left(\frac{2\pi}{0.21}\right)^2 = 1.52 \text{ x } 10^7 \text{ m s}^{-2}$	1- Sub 1 - answer

Qn	Suggested solution	Remarks
	Comments: Generally well done except for a handful of students who forgot the equation for centripetal acceleration.	
biv	On the surface of the star, the gravitational field strength is much greater (approximately 10^5 times) than the centripetal acceleration of the particle. Hence the gravitational force on the particle is sufficient to provide the centripetal force to maintain the particle in circular orbit on the surface of the star. This is why a particle will not leave the surface of the star.	1 – both points must be mentioned. 1 – correct conclusion only with correct explanation
	Comments: Most students were able to mention the fact that the centripetal acceleration was smaller than the gravitational field strength and hence particles will not leave the surface of the star. However, very few mentioned the crucial detail that because of this, the gravitational force is sufficient to provide the centripetal force to keep the particles in orbit (hence preventing them from flying off). Quite a few misread the question to mean that the particles will leave the surface of the star and thought they were being asked if this was due to the high speed of rotation of the star or not.	
5 (ai)	Resistivity is the proportionality constant relating the resistance of a circuit component to its length and cross-sectional area. It is a property of the material and is dependent on temperature. Comment : Most candidates did not realize that resistivity is a constant of proportionality … (as stated above), but tried to state that resistivity is proportional to the cross-sectional area, and inversely proportional to the length. Students should realize that resistivity, being a property of a material, is independent of the dimensions of the sample/resistor. Many gave incorrect answers such as “resistivity is the resistance per unit length”, or “measure of the ability to conduct electrical current”, which is “conductivity” not “resistivity”. Students should also differentiate the word “material” from “sample”, “resistor” or “conductor”.	1 mark 1 mark
(ii)	$R=\frac{\rho l}{A}=\frac{(1.50\times10^{-6})(1.2)}{2.83\times10^{-9}}=636\,\Omega$	Ans: 1 mark
(bi)	p.d. across 1.2 m of nichrome wire $=\frac{636}{636+500}(18)=10.1\text{V}$ p.d. across 0.050 m of nichrome wire $=\frac{0.050}{1.2}(10.08)=0.421\text{V}$ Comment : A common error is to calculate : V_c = $=\frac{0.050}{1.2}(18V)=0.75V$. Another error is to use the potential ratio method, but with an incorrect denominator. V_c = $=\frac{26.5\Omega}{500+26.5}(18V)=0.906V$.	Working: 1 mark Ans: 1 mark

Qn	Suggested solution	Remarks
(ii)	The resistance in the driver circuit is 636 Ω + 500 Ω = 1136 Ω whereas the internal resistance of the driver cell is usually much smaller than 1136 Ω, the assumption is valid. Comments : Students often stated that internal resistance is small, without making comparison to the external resistance. Students should be reminded not to use the word "negligible" or the synonym "insignificant" when answering the question (e.g. the internal resistance is negligible compared to the external resistances") since the question asked why internal resistance was assumed to be "negligible".	1 mark
(ci)	$R=\frac{\rho l}{A}=\frac{(1.50\times10^{-6})(1.2)}{(5)(2.83\times10^{-9})}=127=130\ \Omega$	Sub: 1 mark
(ii)	p.d. across 1.2 m of nichrome wire $=\frac{130}{130+500}(18)=3.71\text{V}$ Comments : Students are advised to use the value of 130 Ω rather than 127 Ω in the calculation, since the value 130 Ω was asked to be shown in part (i) as they would not benefit from e.c.f. if they used other values except 130 Ω from part (i). A significant number of students used *V* = *IR* = (0.036)(130), the value of 0.036 A being the value of current from (b)(i). This indicates an incorrect understanding of circuits as the current has now changed when a new resistance is introduced into the circuit in part (c).	Ans: 1 mark
(iii)	p.d. across 0.10 m of nichrome wire $=\frac{3.71}{12}=0.309\text{V}$ Current $=\frac{0.309}{6.0}=\frac{0.421}{6.0+r}\Rightarrow r=2.17\,\Omega$ Comment : Some candidates calculated the p.d. across the 0.10 m nichrome wire correctly (0.309 V), but thought this was the p.d. across internal resistance. Clearly this should be the p.d. across the 6 Ω resistor.	Working: 1 mark Ans: 1 mark
6(a)(i)	A *progressive wave* is a wave in which the waveform advances and there is a transfer of energy along the direction of propagation of the wave.	[1] [1]
	Comments: Quite poorly done. Many students gave the general definition of a wave instead. Those who tried to explain progressive waves were not able to state the required keywords.	
(ii)	Diffraction is the spreading of waves through an aperture or round an obstacle. It is observable when the width of the aperture is of the same order of magnitude as the wavelength of the waves.	[1] [1]
	Comments: Most students were able to obtain the first mark but neglected to mention when diffraction will be observable.	
(b)(i)1	From Fig. 6.2, Period of the waves = 2.5 x 10^{-10} / 3 = **8.3 x 10^{-11} s**	**[1] - ans**

Qn	Suggested solution	Remarks
	Comments: Many students were not able to obtain the correct value of the period of the waves. Of those who did, a few forgot to consider the power of the x-axis values (10^{-10} s)	
(i)2.	By observing the two waveforms at for example, time t = 0 s, it is apparent that the waveforms are out of phase by a quarter of a period. Hence, phase difference = (1/4)(2π) = **π/2 rad**	**[1] – ans** **(also accept 3π/2 rad)**
	Comments: Many students were not able to obtain the correct phase difference. A spectrum of answers was obtained (0, π, 2π etc).	
(i)3.	Recall that Intensity ∝ Amplitude^2 Hence, ratio of intensities = $\mathbf{3^2/1^2 = 9}$	**[1] – subst** **[1] – ans**
	Comments: Generally well done. A handful forgot to square the ratio of the amplitudes or inverted the ratio.	
(ii)	Using **v = fλ** => v = λ/T λ = $\mathbf{3.00 \times 10^8 (8.3 \times 10^{-11})}$ = 2.5×10^{-2} m = 2.5 cm (shown) [1] – for knowing speed of microwaves is 3.00×10^8 m s^{-1} [1] – subst (practise e.c.f. from part (i)1.)	**[1]** **[1]**
	Comments: Generally well done. Most students were able to state the correct speed of microwaves.	
(iii)	The maximum intensity happens when the waves from S1 and S2 are in phase at that point. At O, both waves from S1 and S2 are in phase (hence maxima). Moving 5 cm away from O to P, both waves are now $\pi/2$ rad out of phase. The next time they are in phase is when the phase difference = 2π rad. Hence approximate distance from O for maxima = 5cm x 4 = 20 cm. → Approximate distance to move from P = 20- 5 = 15 cm.	**[1] – expl** **[1] – expl** **[1] –ans (also accept 1.7 cm)**
	Comments: Not well-attempted. Many students erroneously stated that constructive interference will take place when there is a phase difference of π radians.	
(iv)	Approximating using the double-slit equation, ax = λD a = $(2.5 \times 10^{-2})(3.2)/(20 \times 10^{-2})$ = 0.4 m	**[1] – subst (practise e.c.f. for the value of fringe separation)** **[1] - answer**

Qn	Suggested solution	Remarks
	Comments: Not well-attempted even though most students were able to recall the correct equation. Many left section (iii) blank and hence did not have a value for fringe separation which they could use for substitution.	
(c)(i)1	Distance between 2 nodes = λ/2	**[1] – ans**
(i)2.	Phase angle between adjacent antinodes = π rad	**[1] – ans**
	Comments: Many students were able to answer parts (c)(i)1 and 2 correctly.	
(ii)	Stationary waves are formed by the <u>superposition of 2 progressive waves (of the same type),</u> of equal magnitude and frequency, <u>traveling in opposite directions</u>. For a stationary wave, the <u>product fλ gives the speed of the underlying progressive waves</u>. Because the two waves travel in opposite directions at the same speed, therefore there will be no net transfer of energy for the resultant stationary wave. [1] superposition of 2 progressive waves of the same type [1] traveling in opposite directions [1] relating product fλ to speed of the component progressive waves	**[1]** **[1]** **[1]**
	Comments: Many students neglected to mention that the waves must be progressive. A few also did not mention opposite directions of travel or simply stated that the directions must be "different" ("different" is not specific enough). Only a handful of students were able to deduce that the product fλ was the speed of the underlying progressive waves.	
7(a)i)	Two times at which the magnet is stationary are t_2 and t_4. (t_6 , t_8)	1 mark
(a)ii)	Two times at which the magnet is moving upwards are t_1 and t_5. (t_9)	1 mark
(a)iii)	Two times at which the magnet is moving downwards are t_3 and t_7.	1 mark
(b)i)		1 mark for sinusoidal graph (can also be mirror image about t-axis) [1] correct max. emf, [1] zero e.m.f at the correct time

Qn	Suggested solution	Remarks
(b)ii)	According to Faraday's law, the induced e.m.f. is proportional to the rate of change of the magnetic flux linkage in the coil, which is proportional to the magnet's velocity. When velocity is zero (t=0, t_2, t_4…), induced e.m.f. is zero When velocity is maximum (t_1, t_3, t_5…), induced e.m.f. is maximum. 1. The motion of the magnet is simple harmonic, so the variation of the magnet's velocity with time is also sinusoidal. The variation of the induced e.m.f. with time will therefore be sinusoidal. 2. Since the terminal is connected to a c.r.o of infinite resistance, there is no induced current in the coil to produce any opposing effect as predicted by Lenz's law, thus the amplitude remains constant. 3. Explanation of why the e.m.f. should change direction. Comments : Many did not explain why the shape of the graph should be sinusoidal. Most included Lenz's law, stating that "the direction of induced current…", failing to notice that in this question, the C.R.O. has infinite resistance, and hence, no induced current can flow, thus no opposing effect is predicted according to Lenz's law.	1 mark 1 mark 1 mark 1 mark (for either 1, 2 or 3)
(c)i)	 *Comments:* *Few candidates sketched a damped oscillation and often these showed erratic variations in amplitude and/or large variations in the period of oscillation. In many cases, a sketch was drawn which was similar to that in (b)(i) but of a smaller constant amplitude.*	1 marks for decreasing amplitude 1 mark for same or slightly larger period compared to the previous graph. Allow e.c.f. if the original graph shows oscillatory motion.

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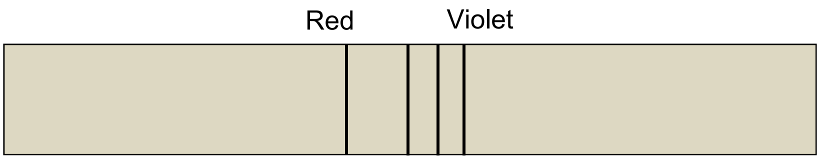
(c)ii)	In the first graph, no electrical energy is generated in the coil, hence the total mechanical energy in the spring system remains constant. (constant amplitude) With a resistor connected across the points, electrical energy is generated in the coil, and is converted from the loss of the mechanical energy (Kinetic/ potential energy) in the spring system . Thus, the amplitude of oscillation reduces over time. *Comments: Most students answered in terms of opposing effect, without reference to energy considerations. Most candidates stated that thermal energy would be dissipated in the resistor but few explained the essential difference between the two cases, i.e. that in the second case, there is a current through the resistor which dissipates-energy as thermal energy at the expense of the energy of the magnet.* *Students should avoid answers such as "Energy is needed to go against the resistive forces" as the comparison is between energy and force, which leads to poor descriptions of energy changes in the process.*	1 mark 1 mark 1 mark
(d)	For a given power *(P = VI)*, using a high voltage implies that the current will be low. Since the heating effect/ power loss *(I^2R)* in transmission cables is proportional to the square of current, energy loss during the transmission will be minimised by using a low current. Comment : Some stated "$P = \frac{V^2}{R}$, thus larger *V* imply larger *P* supplied, and makes the resistance negligible. This increases efficiency". This contradicts the conservation of energy, since power supplied is constant, and the stepping up of the voltage *V* leads to a lower current *I*.	1 mark 1 mark 1 mark
(e)	For many reasons, including safety, generation and consumption of electric power occur at relatively low voltages, so it is essential to be able to change the voltage. During the transmission of electrical energy, we may want to step up or down the voltage due to various reasons such as minimizing energy loss, safety and electrical device power consumption. Transformers can do this efficiently, but they can only operate on alternating current. Comments : Many students did not clearly show in their answers the advantages of using A.C. Many thought that A.C. will allow e.m.f. to continuously be induced as an advantage, not realizing that A.C. is an induced e.m.f. phenomena.	1 mark for each underlined point
8(a)(i)	$\Delta E = \lvert(-13.6-(-0.378)\rvert = 13.222\,\text{eV}$ $\Rightarrow \frac{1}{2}mv^2 = 13.222\times1.6\times10^{-16}$ $\Rightarrow \frac{1}{2}(9.11\times10^{-31})v^2 = 13.222\times1.6\times10^{-16} \Rightarrow v = 6.81\times10^{7}\,\text{ms}^{-1}$	[1] for correct calculation of ΔE. [1]for substitution [1] for answer

Qn	Suggested solution	Remarks
(ii)	 *Comments:* *Only few candidates managed to get this correct.*	[1] for 4 lines Drawn to scale [1] for correct position for red and violet.
(b)(i)	A line of best fit is drawn Since $E_k = hf - \phi$ Gradient of E_k vs f graph is h $h = \frac{(1.2-0)\times1.6\times10^{-19}}{(7.4-4.5)\times10^{14}} \approx 6.6\times10^{-34}$ Js *Comments:* *Some candidates calculated gradient without drawing a best-fit line. Hence they failed to check if the points they used lied on this line.* *Some candidates failed to select points that are more than 50% of the length of the line apart.*	[1] for correct method [1] for final answer
(ii)	$\phi = hf = (6.6\times10^{-34})(4.5\times10^{14}) = 2.97\times10^{-19}$ J	[1] for answer Also accept 2.98×10^{-19} based on 6.63×10^{-34}
(iii)	Graph starts from a minimum frequency. Only radiation of frequency <u>above a minimum (threshold) frequency</u> can cause photoemission. Support particulate nature: Since the energy of a photon is expressed as *hf*, hence the minimum photon energy required to liberate an electron from its surface must be hf_o. Contradict wave nature: Since the energy carried by the wave depends only on the wave amplitude ($I \propto f^2A^2$), <u>emission of photoelectrons from the metal surface should occur at any frequency</u> as long as the amplitude is large enough. This does not happen *Comment:* *Many candidates failed to understand that they were supposed to only identify features only from the graph to explain particulate and wave nature.*	[1] [1] [1]
(c)(i)	$E = hf = h\frac{c}{\lambda} \Rightarrow (1.2\times10^{6}\times1.6\times10^{-19}) = (6.63\times10^{-34})\frac{3\times10^{8}}{\lambda} \Rightarrow \lambda = 1.04\times10^{-12}\,\text{m}$	[1] for correct substitution
(ii)	$p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{1.04\times10^{-12}} = 6.38\times10^{-22}\,\text{kg m s}^{-1}$	[1] for correct answer
(iii)	There is <u>no resultant external force on the system</u> during the radioactive decay, by <u>Newton's 2nd law, there will be no change of momentum with time</u> and hence momentum is conserved.	[1] [1]

Qn	Suggested solution	Remarks
(iv)	$p_i = p_f$ $0 = m_{Ni} v_f + p_{photon}$ $0 = (9.95 \times 10^{-26}) v_f + 6.38 \times 10^{-22}$ $v_f = 6412 \approx 6410\,m\,s^{-1}$	[1] for substitution [1] for answer
(v)	Photons can be absorbed or reflected from the metal surface and hence they experience a change of momentum with time, according to Newton's 2nd law of motion, there is a force acting on these photons. By Newton's 3rd law of motion, there will be an equal and opposite force by the photons on the metal surface. Force per unit area is pressure, so the incident photons would exert a pressure on the surface, known as radiation pressure.	[1] [1] [1]