RVHS JC2 H2 Physics Prelim Examination 3 Mark Scheme

1	**(a)**	**(i)**	time = 0.43 / 1.1 = 0.39(1) s	A1
		(ii)	$s = ut + \frac{1}{2}at^2$ $= \frac{1}{2}(9.81)(0.39)^2$	C1
			= 0.75(0) m	A1
		(iii)	vertical velocity: $v = u + at$ $= (9.81)(0.39)$ = 3.8259 m s^{-1}	M1
			$\theta = tan^{-1}\frac{v_y}{v_x} = tan^{-1}\frac{3.8259}{1.1}$ = 74(.0)°	A1
		(iv)	1. Horizontal line at a non-zero value of *a*.	B1
			2. Curved line from origin with increasing gradient	B1
	(b)		acceleration of free fall is unchanged / not dependent on mass <u>and</u> so no effect (on time taken)	A1

2	**(a)**		$\left.\begin{array}{l}T_1 \text{ and } T_2 \text{ : down} \\ T_3 \text{ : up}\end{array}\right\}$ All 3 must be correct.	B1
	(b)		By Principle of Moments, $\left.\begin{array}{l}\text{Taking moment about the pivot at the base of wire 1,} \\ \text{sum of clockwise moments = sum of anti-clockwise moments} \\ (14.5)(m_p g) = (10.0)T_3\end{array}\right\}$	M1
			$T_3 = \frac{14.5}{10.0}(m_p g)$ $= \frac{14.5}{10.0}(350 \times 10^{-3})(9.81)$ $= 4.98$ N	A1
	(c)		P is in vertical translational equilibrium, R adds additional downward force. T_3 is only upward force and so must provide additional tension, more likely to snap.	B1

			If method involves principle of moments, reference to a pivot must be made known before a mark can be awarded together with the reasoning.	

3	**(a)**		loss in GPE = gain in elastic PE $mgh = \frac{1}{2}kx^2$ $m = \frac{kx^2}{2gh} = \frac{(25)(0.050)^2}{2(9.81)(0.110)} = 0.028959$ kg $= 0.029$ kg(shown)	M1
	(b)		When the spring first compresses, the magnitude of the <u>force from the spring is less than weight</u>. Hence, there is still a <u>downward resultant force</u> that causes the marble to continue accelerating.	B1 B1
	(c)		Max speed of marble happens when force from spring = weight $kx = mg$ $x = \frac{mg}{k} = \frac{(0.028959)(9.81)}{25} = 0.01136$ m $gain\ in\ EPE = \frac{1}{2}kx^2 = \frac{1}{2}(25)(0.01136)^2 = 0.001614$ J $loss\ in\ GPE = mg(0.060 + 0.01136)$ $= (0.028959)(9.81)(0.060 + 0.01136) = 0.02027$ J $gain\ in\ KE = loss\ in\ GPE - gain\ in\ EPE$ $= 0.02027 - 0.001614$ $= 0.019$ J (2sf)	M1 M1 M1 A1

4	**(a)**		When a charged particle is travelling in a magnetic field, it experiences a <u>magnetic force that is always perpendicular to its velocity</u> (and the magnetic field lines). Since the charged particle is travelling perpendicular to the uniform magnetic field, and that the <u>resultant force only consists of the magnetic force</u>, the particle travels in a circular path.	B1 B1
	(b)		centripetal force provided by magnetic force	M1 M1

			$mr\omega^2 = Bqv$ $m\omega^2 = Bq\left(\frac{v}{r}\right)$ $m\omega^2 = Bq\omega$ $\omega = \frac{Bq}{m}$ $\frac{2\pi}{T} = \frac{Bq}{m}$ $T = \frac{2\pi m}{Bq}$	A1
	(b)		magnetic force provides for centripetal force $Bqv = \frac{mv^2}{r}$ $q = \frac{mv}{Br} = \frac{(4.5\times10^{-26})(4.8\times10^{5})}{(0.15)\left(\frac{0.60}{2}\right)}$ $= 4.8\times10^{-19}C$	M1 A1

5	**(a)**	**(i)**	Hypothetical gas obeys equation of state pV = nRT (perfectly at all pressures, temperature s and volume)	B1
		(ii)	Mean-square-speed (of atoms / molecules)	B1
		(iii)	$p = \frac{1}{3}\rho\langle c^2\rangle$	
			$\rho = \frac{Nm}{V}$ with *N* explained (m = mass of a molecule) Or $\rho = \frac{M}{V}$ (*M* = mass of a gas)	B1
			$pV = \frac{1}{3}Nm\langle c^2\rangle$	B1
			$pV = NkT$ with *p, V, T* explained	B1
			So mean kinetic energy $\langle E_k\rangle = \frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$	B1
	(b)	**(i)**	Internal energy *U* of a system is sum of a random distribution of kinetic and potential energies associated with the molecules of a system.	B1
		(ii)	(in ideal gas) no intermolecular forces, hence no potential energy	B1
			Internal energy is (solely) kinetic energy (of particles)	
			Since mean (translational) kinetic energy is proportional to thermodynamic temperature of the gas, the internal energy is directly proportional as well.	B1

	(c)			

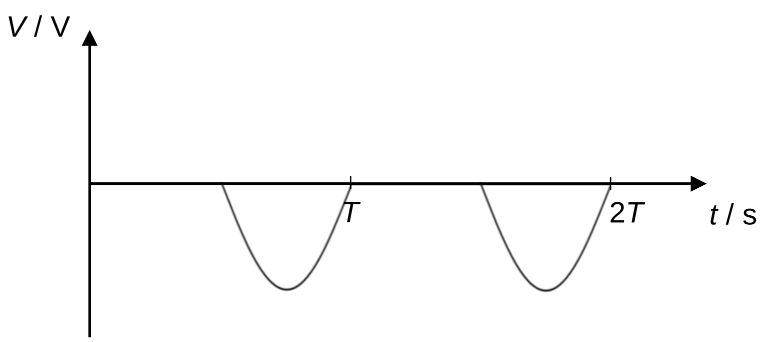
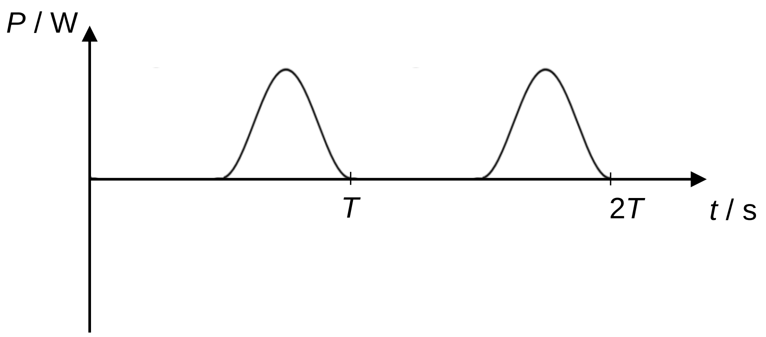
	Increase in internal energy / J	Heat supplied to gas / J	Work done on gas / J
A to B	1200	0	1200
B to C	-1350	-1350	0
C to D	-600	0	-600
D to A	750	750	0

1 if W_{BC} and W_{DA} = 0

1 if ΔU_{DA} calculated correctly.

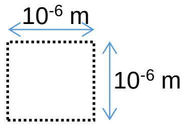
1 if W_{AB} and W_{CD}, Q_{BC} and Q_{DA} calculated correctly

6	**(a)**	**(i)**	PSYV and QRXW	B1
		(ii)	electrons moving in magnetic field deflected towards face QRXW / electrons accumulate on face QRXW	M1
			So face PSYV is more positive	A1
	(b)	**(i)**	Arrow point up the page	B1
		(ii)	$Eq = Bqv$ $v = \frac{E}{B} = \frac{12 \times 10^3}{930 \times 10^{-6}}$	C1
			$= 1.3 \times 10^7 \ m\ s^{-1}$	A1
		(iii)	$Bqv = m v^2/r$ $q/m = (1.3 \times 10^7)/(7.9 \times 10^{-2} \times 930 \times 10^{-6})$	C1
			$= 1.8 \times 10^{11} \ C\ kg^{-1}$	A1

7	**(a)**	**(i)**		A1
		(ii)		A1

		(iii)	$P_{\max} = \dfrac{V_{\max}{}^2}{R} = \dfrac{5.0^2}{2.0} = 12.5\text{ W}$ $P_{average} = \dfrac{P_{\max}}{4} = \dfrac{12.5}{4} = 3.1\text{ W}$	M1 A1
	(b)	**(i)**	When an alternating current source is connected to the primary coil, there would be a <u>changing magnetic flux</u> produced. The <u>iron-core strengthens and links the flux</u> through the secondary coil. In the secondary coil, since the <u>magnetic flux through it changes</u> all the time, there would be an <u>e.m.f. induced</u> (according to Faraday's Law).	B1 B1
		(ii)	emf induced in secondary coil = 230 / 20 = 11.5 V current in secondary coil = V / R = 11.5 / 7.0 = 1.6429 A current in primary coil = 1.6429 / 20 = 0.082 A	 M1 A1

8	**(a)**		The cut-off wavelength corresponds to the most energetic photon that can be produced. That happens <u>when **all the kinetic energy** of an accelerated electron is lost in a single collision/interaction with the target atom in producing one photon.</u>	A1
	(b)		When electrons striking the metal target interact with the crystal lattice, forces experienced by the electrons cause them to be accelerated, decelerated or deflected. When this occurs, <u>their kinetic energies are lost through the emission of *Bremsstrahlung* (or "braking radiation"), which are photons of a range of energies which can lie in the X-ray region</u>. Since <u>the magnitude of the 'deceleration' experienced by the incident electrons is different for all and is not discrete</u>, the wavelengths of the emitted photons have a continuous distribution so the *Bremsstrahlung* produces a continuous spectrum of electromagnetic radiation. OR Bremsstrahlung radiation, which is emitted when high energy external electrons coming close to the nucleus decelerate, accelerate or deflect. This energy lost in terms of photons can be any amount of energy less than the maximum kinetic energy of the electrons, therefore forming continuous spectra.	A1 A1

	(c)	(i)	area = 0.200 m x 0.300 m = 0.0600 m^2 Accept a range of 0.0400 $m^2 \leq$ area $\leq$ 0.200 m^2	A1
		(ii)	Area of a grain:  no of grains = $\dfrac{0.0600}{10^{-6} \times 10^{-6}} = 6.00\times10^{10}$ no of photons = $6.00\times10^{10} \times 10 = 6.00\times10^{11}$ energy = $6.00\times10^{11} \times 10^{-15} = 6.00 \times 10^{-4}$ J Accept a range of 4.00×10^{-4} J $\leq$ energy $\leq 2.00\times10^{-3}$ J	M1 A1

Section B					
9	(a)	(i)	**1.**	Diffraction refers to the bending or spreading out of waves when they travel through a small opening or when they pass round a small obstacle.	B1
			2.	Interference refers to the superposing of two or more coherent waves to produce regions of maxima and minima in space, according to the principle of superposition	B1
			3.	Coherence refers to having a constant phase difference (and same frequency) (between waves/sources/particles).	B1
		(ii)	Any two of the following: 1. The waves must **overlap** to produce regions of maxima and minima. 2. The **sources** must be **coherent**. 3. The waves must have the **same amplitude** or approximately the **same amplitude**. 4. The waves must be **unpolarised** or with the **same plane of polarisation** (for transverse waves).		B1 B1
	(b)	(i)	Since the two radio waves emitters are in phase, along centre-line and path difference is always zero, hence constructive interference always occurs.		B1
		(ii)	Radio waves have long wavelengths, hence the anti-nodal lines will be far apart enough for the ship to differentiate		A1 M1
		(iii)	Since the intensity of each individual wave is inversely proportional to the square of the distance, the intensity of each individual wave will increase as the ship goes nearer, hence the resultant intensity will increase. OR Since the amplitude of each individual wave is inversely proportional to distance, the amplitude of each individual wave will increase as the ship goes nearer, hence the resultant amplitude of		M1

			the superposed wave will increase. As <u>intensity is proportional to the square of the amplitude</u>, intensity increases. <u>Hence, the intensity of the resultant increases as the ship approached the gate.</u>	A1
	(c)		$\lambda_1 = \dfrac{c}{f_1} = \dfrac{3.0\times10^8}{23.5\times10^6} = 12.77\text{ m}$ Path difference $= \sqrt{(895)^2 + \left(250+\dfrac{95}{2}\right)^2} - \sqrt{(895)^2 + \left(250-\dfrac{95}{2}\right)^2}$ $= 25.527\text{ m}$ $\approx 2\lambda_1$ Since the path difference is approximately $2\lambda_1$, the ship is on an anti-nodal line. Note: using $x = \dfrac{\lambda D}{a}$ will earn no credit.	C1 M1 A1
	(d)	**(i)**	If ship is <u>on the central anti-nodal line</u>, it should detect <u>maximum signals from both frequencies / the maximum signal will be stronger</u>. OR If ship is <u>on wrong anti-nodal line</u>, only <u>one of the frequencies will show a strong signal</u>.	B1
		(ii)	<u>Higher orders of maxima from both frequencies may still coincide/overlap</u>. Hence the ship could still detect maximum signals from both frequencies even though it is not on the central anti-nodal line.	B1
	(e)	**(i)**	Simple harmonic motion	B1
		(ii)	$5.0\text{ km h}^{-1} = 1.39\text{ m s}^{-1}$ $v = r\omega$ $v = \dfrac{2\pi r}{T}$ $T = \dfrac{2\pi r}{v}$ $= \dfrac{2\pi(0.225)}{1.39}$ $= 1.02\text{ s}$	M1 A1
		(iii)	$a_0 = \omega^2 x_0$ $= \left(\dfrac{2\pi}{1.02}\right)^2 (0.225)$ $= 8.57\text{ m s}^{-2}$ (Alternatively, use $a = \dfrac{v^2}{r}$ to solve.)	M1 A1

10	**(a)**	**(i)**	S shown on the peak	B1
		(ii)	Kr and U are right of peak in correct relative positions (Kr on left of U; both on right of S)	B1
		(iii)	Energy released = Binding energy of products – binding energy of reactants $= (144 \times 1.3341 \times 10^{-12} + 90 \times 1.3864 \times 10^{-12})$ $- (235 \times 1.2191 \times 10^{-12})$	C1
			$= 3.0398 \times 10^{-11}\, J$	A1
		(iv)	$E = mc^2$ $m = \dfrac{3.0398 \times 10^{-11}}{(3.00 \times 10^8)^2}$	C1
			$= 3.38\ (3.3776) \times 10^{-28}$	A1
		(v)	The products have <u>greater stability</u> and <u>therefore greater binding energy.</u> OR With a increase in binding energy, <u>the mass of the products will be less than that of the reactants, by the mass-energy equivalence</u> / <u>mass loss</u>, there must be a release of energy.	B1
		(vi)	Neutrons are single particles, they have <u>no binding energy per nucleon.</u>	B1
	(b)	**(i)**	Isotope is one or more forms of the same element, with the <u>same atomic/proton number but with different number of neutrons in their nuclei / different nucleon number</u>	B1
		(ii)	*Y* = 0 *X* = *-1*	B1
			D = *electron* / beta-particle	B1
		(iii)	Radioactive decay is a random process	M1
			thus the time taken to decay by half will fluctuate. / should consider average time taken.	A1
			Or Carbon-14 will decay into Nitrogen-14	M1
			Wrong, to state that the number of nuclei will decay be half / therefore the total number of nuclei in the box remains the same / Should state “number of carbon-14 nuclei”	A1
	(c)	**(i)**	Since carbon-14 will decay into nitrogen 14, the sample from site will have lower concentration <u>as more time has passed for it.</u> Sample from site has <u>undergone more decay</u> as more time.	B1
		(ii)	Calculating of concentrations or number of nuclei.	C1
			$\lambda = \dfrac{ln2}{5700}$	M1
			$\dfrac{1}{8.6 \times 10^{-10}} = \dfrac{1}{3.3 \times 10^{-10}} e^{-\frac{ln2}{5700}t}$	M1
			$t = 7900\ years\ (7880)$	A1
		(iii)	It cannot be used for very old samples.	B1

			As the activity will be very low after a long period of time and the results of the calculation will not be accurate/reliable.	B1
			It cannot be used for things that are still living	B1
			Carbon-14 could have been gained/ lost via other means.	B1
			Activities from other samples.	B1
			Assumes that the wood will have the same concentration of Carbon-14 to Carbon-12.	B1
			Any two of the above, provided explanations are sound.	