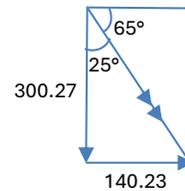


RVHS JC2 H2 Physics Preliminary Examinations Paper 3 Mark Scheme

Questions		Answers	Marks
1	(a)	Systematic errors are constant deviations of the readings of a physical quantity, either consistently higher, or consistently lower, than its true value.	[B1]
		Random errors are deviations of readings of a physical quantity, randomly scattered about the mean reading.	[B1]
	(b)	(i) 21.150 cm 20.980 cm Half the smallest division for read-off	[B1]
		(ii) 0.005 cm (half smallest division)	[B1]
	(iii)	$A = \pi(D/2)^2 = \pi D^2/4$ $\Delta A/A = 2\Delta D/D$ Using $\Delta D = (0.005 + 0.005) = 0.01$ $= 2(0.01)/(21.15 - 20.98) = 11.76 \sim 12\%$ (max 2 s.f.)	[M1] [A1]

Questions		Answers	Marks
2	(a)	Using $v^2 = u^2 + 2as, u = 0$ or $\frac{1}{2}mv^2 = mg\Delta h$ to arrive at $v = \sqrt{2 \times 9.81 \times 1.96}$	M1
		$v = 6.20(12) \text{ m s}^{-1}$	A1
	(b)	unchanged Normal contact force on ball is vertical	B1 B1
	(c)	$v^2 = u^2 + 2as, v = 0$ or $\frac{1}{2}mv^2 = mg\Delta h$ to obtain rebound speed $v = \sqrt{2 \times 9.81 \times 0.98} = 4.38 (49) \text{ m s}^{-1}$	B1
		impulse = change in momentum $m(v_f - v_1)$ impulse = $0.034(4.3849 - (-6.2012)) = 0.36 \text{ N s}$ or kg m s^{-1}	A1

Questions		Answers	Marks
3	(a)	The torque of a force about an axis is the <u>product</u> of that force and the <u>perpendicular distance</u> from the line of action of the force to the axis.	B1
	(b)	<p> $T_y = T \cos 20 = 410 \cos 20 = 385.7 \text{ N}$ $T_x = T \sin 20 = 410 \sin 20 = 140.2 \text{ N}$ </p> <p>Sum of forces in horizontal direction = 0, $R_x = T_x = 140.23 \text{ N}$</p> <p>Sum of forces in vertical direction = 0, $R_y = T_y - 65 - 20 = 300.27 \text{ N}$</p> <p>Resultant force at elbow $= (R_x^2 + R_y^2)^{0.5}$ $= 331 \text{ N}$</p> <p>$\tan^{-1}(140.23/300.27) = 25^\circ$ Direction = 65° below the positive x-axis</p>	<p>M1</p> <p>A1</p> <p>C1 / A1</p>
	(c)	<p>Using Newton's 2nd law of motion, the large change in momentum and the <u>short time</u> duration of impact will result in greater force.</p> <p>Using Newton's 3rd law, the force on hand is equal in magnitude and opposite in direction to the force on wooden boards.</p>	<p>B1</p> <p>B1</p>



Questions		Answers	Marks
4	(a)	There is no further gain in KE as the acceleration of the metal sphere reaches zero, leading to a constant velocity.	[B1]
		The acceleration reaches zero as the viscous (resistive) force increases with velocity of the sphere, until the viscous force equals to the weight of the sphere.	[B1]
	(b)	<p>According to Newton's second law, this force results in an acceleration a where</p> $F = ma$ <p>The work done by the constant force F is</p> $W = F \cdot s = mas$ <p>But $v^2 = u^2 + 2as$</p> $\rightarrow as = \frac{1}{2}(v^2 - u^2)$ $\therefore W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$ <p>= final kinetic energy – initial kinetic energy = ΔE_k</p> <p>If the object start from rest ($\frac{1}{2}mu^2 = 0$),</p> $\therefore W = \frac{1}{2}mv^2 \text{ (derived)}$	<p>[B1]</p> <p>[B1]</p> <p>[B1]</p> <p>[A0]</p>
		Constant acceleration is necessary for the derivation	[B1]

Questions		Answers	Marks
5	(a)	Angular velocity is the <u>rate of change of angular displacement</u> . Unit is rad s^{-1}	[B1] [B1]
	(b)	From forces p.o.v., $mg + T = \frac{mv^2}{L}$ Analyzing FBD of string just taut, when the particle reaches C Hence $T = 0 \text{ N}$ $mg = \frac{mv^2}{L}$ $v = \sqrt{gL}$	[M1] [B1] [A0]
	(c)	From energy p.o.v., initial KE = Gain in GPE + final KE $\frac{1}{2}mV^2 = mg2L + \frac{1}{2}mv^2$ $\frac{1}{2}mV^2 = mg2L + \frac{1}{2}mgL$ $V^2 = g4L + gL$ $V^2 = g4L + gL$ $V = \sqrt{5gL} = 7.0$	[M1] [A1]

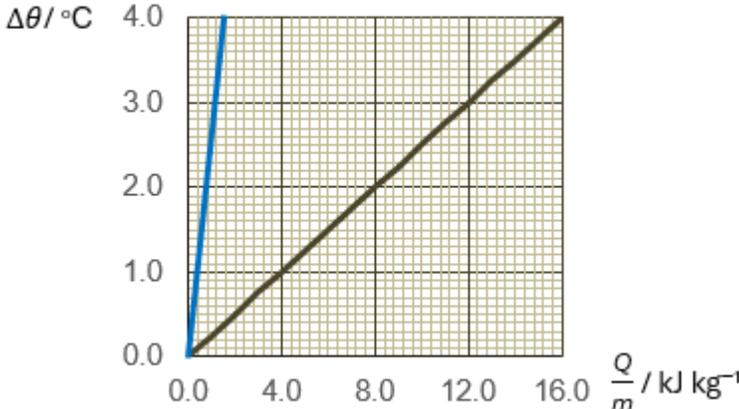
Questions		Answers	Marks
6	(a)	(i) The electromotive force (e.m.f.) of a source is defined as the <u>amount of energy transferred from non-electrical forms of energy to electrical energy per unit charge as the charge passes through a complete circuit</u> .	B1
		(ii) Potential difference = $[4.5 / (4.5 + 0.5)] \times 3$ = 2.7 V	A1
	(b)	Voltage across XP = $(L_{xp}/L_{xy}) \times 2.7$ = $(0.8/1.5) \times 2.7$ = 1.44 V At balanced point, $V_{EF} = V_{XP} = 1.44 \text{ V}$ Current = $1.44 / 3 = 0.480 \text{ A}$	M1 A1
	(c)	(i) L_{xp} decreases Since $R = \rho L/A$, when A decreases, R increases. V_{xy} increases so L_{xp} decreases	B1 B1
		(ii) Since balance length decreases to potential difference $V_{xp} = V_{EF}$, at balance length, there are no changes for the ammeter reading.	B1

Questions			Answers	Marks
7	(a)	(i)	<p>Longest wavelength \rightarrow lowest energy photon Therefore emission transition must be between two closest levels, <u>5 to 4</u></p> <p>Do not accept 4 to 5</p>	[B1]
		(ii)	<p>Energy</p> <p>Level number</p> <p>6.02 \times 10⁻¹⁹ J 5 5.81 \times 10⁻¹⁹ J 4 5.12 \times 10⁻¹⁹ J 3 3.38 \times 10⁻¹⁹ J 2 0 1 (GROUND STATE)</p> <p>10</p>	[B1]
		(iii)	<p>Converting 3.6 eV into joules, 5.76 \times 10⁻¹⁹ J is available from the bombarding electrons</p> <p>5.76 is larger than 5.12, but smaller than 5.81, so maximum absorption of energy will be up to 5.12</p> <p>Therefore, observed transitions will be between Level 3 and Level 1, i.e. 3</p>	[M1] [M1] [A1]
	(b)		<p>Energy</p> <p>Level number</p> <p>6.02 \times 10⁻¹⁹ J 5 5.81 \times 10⁻¹⁹ J 4 5.12 \times 10⁻¹⁹ J 3 3.38 \times 10⁻¹⁹ J 2 0 1 (GROUND STATE)</p> <p>For transitions to be visible to human eye, consider extreme values of 400 nm and 700 nm</p> <p>400 nm: Using $E = hc/\lambda = (6.63 \times 10^{-34})(3.00 \times 10^8)/(400 \times 10^{-9}) = 4.9725 \times 10^{-19} \text{ J}$</p> <p>700 nm: $(6.63 \times 10^{-34})(3.00 \times 10^8)/(700 \times 10^{-9}) = 2.8414 \times 10^{-19} \text{ J}$</p> <p>From energy levels in Fig. 7.1, only 1 (one) visible line (from Level 1 to Level 2)</p>	[M1] [A1]

(c)		[B1]
(d)	<p>Accelerated <u>incident electron 'collides' with an electron from the innermost shell</u> (step 1) <u>kicking it out of the K-shell</u> (step 2). The atom is excited due to the vacancy in the K-shell. <u>An electron from the M-shells transits to the vacancy in the K-shell</u> (step 3), emitting a photon in the x-ray frequency, <u>corresponding to the peaks</u></p>	[B1] [B1]
	<p>Alternate: The <u>high energy incident electrons colliding with the metal target</u> give the <u>innermost shell electrons sufficient energy to be removed</u> from the metal or transited to higher energy levels. The <u>peaks correspond to the characteristic X-rays that are emitted when M-shell electrons electrons transit to the lower energy shells.</u></p>	[B1] [B1]
(e)	<p>With <u>higher accelerating voltage there will be greater number of electrons that can be removed and accelerated from the filament.</u> Also, generally <u>electrons with higher kinetic energy undergoing deceleration should be able to produce more photons.</u> Hence the higher intensity of the broad spectra with higher accelerating voltage</p>	[B1] [B1]
(f)	<p>The <u>peak frequencies are dependent on the energy transition of the other higher energy shell electrons to the lower energy shells,</u> in which discrete quanta of energy are emitted, <u>depending on energy level structure of the metal.</u> This is independent of applied voltage.</p>	[B1] [B1]

Questions		Answers	Marks	
8	(a)	beta (minus) decay	B1	
		charge / proton number need to be conserved so with increase in proton number <u>and</u> a particle of negative charge must be emitted. Alternative Also accept nuclear equation	B1	
	(b)	(i)	Use to kill cancer cells (by implanting it near the tissues)	M1
			half-life is short so duration of powerful radiation will not be too long or beta particles do not travel far in tissue, so surrounding cell will not be damaged.	A1
		(ii)	1. Using $A = \lambda N$, $64\,000 = \frac{\ln 2}{2.69 \times 24 \times 60 \times 60} N$ to get $N = 2.14(60)$	B1
			$N = \frac{6.02 \times 10^{23}}{198} \times \text{mass in gram}$ $m = 7.06 \times 10^{-12} \text{ g}$	A1
			2. $A = 64\,000 e^{-\frac{\ln 2}{2.69} \times 13.5} = 64\,000 \times 0.03085$	M1
			$A = 1.97 \text{ kBq}$	A1

Section B

Questions			Answers	Marks
9	(a)	(i)	No net heat transfer between A and B	B1
			A and B have same temperature	B1
		(ii)	gradient of graph = $\frac{1}{c}$	M1
			$c = \frac{1}{\text{gradient}} = \frac{1}{4/16} = 4 \text{ kJ kg}^{-1} \text{ K}^{-1}$	A1
		(iii)	$m_A c_A \Delta\theta_A = m_B c_B \Delta\theta_B$ gives $c_A = \frac{1.5}{5.0} \times \frac{20}{60} \times 4000$	M1
			$c_A = 400 \text{ J kg}^{-1} \text{ K}^{-1}$	A1
		(iv)	 <p>straight line through origin, <u>10 times as steep</u>.</p>	B1
	(b)	(i)	Δu : <u>increase</u> in internal energy q : heat <u>supplied</u> to the system w : work done <u>on</u> the system M1: definition of quantity A1: direction of change (<u>underlined words</u>)	M1 A1

			<table border="1"> <thead> <tr> <th></th> <th>Δu</th> <th>q</th> <th>w</th> </tr> </thead> <tbody> <tr> <td>process 1 (adiabatic)</td> <td>positive</td> <td>zero</td> <td>positive</td> </tr> <tr> <td>process 2 (constant volume)</td> <td>negative</td> <td>negative</td> <td>zero</td> </tr> <tr> <td>process 3 (isothermal)</td> <td>zero</td> <td>positive</td> <td>negative</td> </tr> </tbody> </table>		Δu	q	w	process 1 (adiabatic)	positive	zero	positive	process 2 (constant volume)	negative	negative	zero	process 3 (isothermal)	zero	positive	negative	
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process 1 (adiabatic)	positive	zero	positive																	
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process 3 (isothermal)	zero	positive	negative																	
		(ii)	first row correct	B1																
		(iii)	second row correct	B1																
			Volume remains unchanged (hence no work done)	B1																
			<p>Since heat is lost to the surrounding to melt ice-water mixture, either</p> <ul style="list-style-type: none"> $q < 0$, and $\Delta u = q + 0$, so $\Delta u < 0$. <p>or</p> <ul style="list-style-type: none"> temperature decreases <u>and</u> internal energy, $u \propto T$ thermodynamic temperature, so $\Delta u < 0$. 	B1																
		(iv)	third row correct	B1																
			<ul style="list-style-type: none"> gas expands, so $w < 0$ <u>and</u> at constant temperature so $\Delta u = 0$ 	B1																
		(v)	for the cycle $\Delta u = 0$, so $0 = q + w$	B1																
			<ul style="list-style-type: none"> $w = -q = -(-100 \times 334) = +3.34 \times 10^4 \text{ J}$ 	A1																
(c)	(i)			M1																
			Gradient = $\frac{0.37}{100} = 0.37$, so $y = 0.37x + 100$	A1																
			When $y = 0$, $x = -\frac{100}{0.37} = -270$																	
			or																	

			Similar triangles give $\frac{ \theta }{100} = \frac{ \theta +100}{137}$ gives $ \theta = 270$ so $\theta = -270$ $\frac{100}{T-(-273.15)} = \frac{37}{100}$, $T = -2.88$, so $\theta = -273.15 - (-2.88) = -270$	
		(ii)	<ul style="list-style-type: none"> at low pressure gases are <u>far apart</u> and seldom interact with one another so intermolecular forces related to distance between molecules) are negligible. 	B1

Questions			Answers	Marks
10	(a)	(i)	Progressive - there is energy transfer Longitudinal - the particle's displacement is parallel to the direction of transfer of energy of wave	B1 B1
		(ii)	$I = P/4\pi r^2$ $I = 20/4\pi(5^2) = 0.0637\text{W/m}^2$	C1 A1
		(iii)	Directional speakers are used in concerts because: <ul style="list-style-type: none"> They focus energy toward the audience, making sound louder and clearer without increasing total power. Energy waste is reduced – less sound spreads in unneeded directions (e.g., behind or upward). Noise pollution is minimized – residential areas outside the beam receive less sound. Better control over reverberation and feedback, especially in open-air environments. 	B1
	(b)	(i)	Since <u>well-formed interference pattern</u> is obtained, the two sources are coherent.	B1
		(ii)	At the centre of the interference pattern, the <u>paths of the waves from both loudspeakers are equal</u> . Now since an <u>intensity minimum is formed (or total destructive interference)</u> there instead, it must mean that the speakers are generating waves in <u>anti-phase</u> .	B1 B1
		(iii)	$x = \frac{\lambda D}{a}$ $0.16 = \frac{\lambda(20)}{0.15}$ $\lambda = 1.2 \times 10^{-3} \text{ m}$ $f = \frac{v}{\lambda} = \frac{343}{1.2 \times 10^{-3}} = 2.86 \times 10^5 \text{ Hz}$	M1 C1

