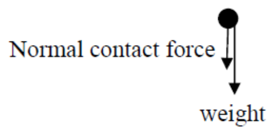
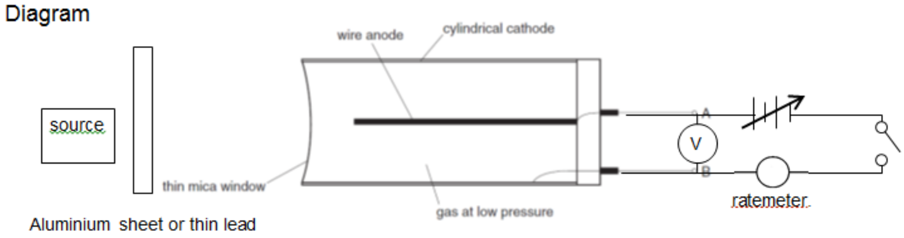
2013 H2 Physics Prelim 2 Exam – Paper 2 Solutions

1	(a)	(i)	$V_H = 13 \cos 50^o = 8.36$ m s^{-1}. (Horizontal line around 8.5) [C1]	
		(ii)	$V_V = 13 \sin 50^o = 9.96$ m s^{-1}. (straight line passing through coordinates (0, 9.96) & (1.02, 0) Using v = u + a t, 0 = 9.96 + (–9.81) t, t = 1.02 s [C1 for negative gradient straight line graph], [C1 for acceptable coordinates points on graph]	
	(b)		Maximum height is the area under the straight line graph, s = ½ (9.96)(1.02) = 5.06 m [A1] Accept answers between 4.96 and 5.16 m	
	(c)		The value in (b) will be <u>smaller</u> [A1] due to a smaller value of gravitational potential energy as there will be <u>work done against air resistance</u>. [M1] Or, the resultant downwards acceleration will be higher, stone will not be able to travel as high.	
2	(a)		gravitational force provides the centripetal force [B1] $GMm / r^2 = m r \omega^2$ (must be in terms of ω) [B1] $T^2 = (4\pi^2 / GM) r^3$ = <u>and</u> $(4\pi^2 / GM)$ is a constant [B1]	
	(b)	(i)	$(9.39 \times 10^6)^3 / (7.65)^2 = (1.99 \times 10^7)^3 / T^2$ [C1] T = 23.6 hours [A1]	
		(ii)	Almost 'geostationary' or satellite would take a long time to cross the sky or the moon has the same angular speed as the rotation of the planet. [B1]	
	(c)	(i)	1. $\dfrac{GM_1M_2}{(R_1+R_2)^2}$ [A1]	
			2. $M_1R_1\omega^2$. [A1]	
		(ii)	M_1 has a slower speed due to its smaller orbital radius and hence has a smaller acceleration. [M1] By Newton's second law, for the same gravitational force between M_1 and M_2, [M1] M_1 must be of a bigger mass. [A0] Alternatively, since both masses experience the same gravitational force (N3L) → same centripetal force → since R1 is smaller than R2, M1 has to be larger than M2.	
3	(a)		Any <u>**increase**</u> **in the internal energy** of a system is the <u>**sum**</u> [B1] of the **heat <u>supplied to</u>** the system and the **work done <u>on</u> the system**. [B1] The **internal energy** of a system **depends** only on its <u>**state**</u>. (bonus mark)	
	(b)	(i)	$\dfrac{p_1V_1}{p_1V_1} = \dfrac{T_1}{T_2}$ $or \dfrac{p_1}{p_1} = \dfrac{T_1}{T_2} or \dfrac{p_1}{p_1} = \dfrac{V_1}{V_2}$ or calculate n = 0.053 and substitutes in $pV = nRT$	

			555 to 580 K (567 K) depending on data used from the graph	
		(ii)	Attempt to find area enclosed. Number of squares = 80 ± 6 small squares (3 to 3.4 large squares) Energy per square = 0.50 J Work done ON the gas = 40 J (± 3 J)	
		(iii)	increase in internal energy = 0 J [B1] Net work done on the gas = + 40 J By first law of thermodynamics, $Q_{net} = -w_{net} = -40$ J [A1]	
4	(a)	(i)	Check: Using COE: Total Energy at C = Total Energy at A $\frac{1}{2}mv_c^2 + mgh = \frac{1}{2}mv_A^2$ $\frac{1}{2}v_c^2 + gh = \frac{1}{2}v_A^2$ $h = \frac{v_A^2 - v_c^2}{2g} = \frac{5^2 - 3^2}{2(9.81)} = 0.81549 \text{ m}$	
		(ii)	$\therefore r = \frac{h}{2} = 0.408 \text{ m (3sf)}$	
		(iii)	 At point C, both the normal contact force and the weight are acting downwards. To calculate the minimum speed at C, the contact force at C is zero. $N + mg = m\frac{v_C^2}{r}$ $mg = m\frac{v_C^2}{r}$ $v_C = \sqrt{gr}$	
	(b)		Speed of the 8M mass = squareroot [½ M $(5)^2$ / (8M/2)] = 1.776 m s^{-1} [M1] Since this speed is less than the min speed required in (a)(iii), [M1] the 8M mass will not reach point C. [A1]	
5	(a)	(i)	When the magnet is approaching the coil, there is an increase in magnetic flux threading through the coil. When the magnet is leaving the coil, there is a decrease in the magnetic flux threading through the coil. [B1 with the previous statement]	

			According to Lenz's law, the direction of the current induced in the coil is such as produce an effect to oppose the change in magnetic flux threading through the coil, the deflections are therefore in opposite directions. [B1]	
		(ii)	The magnet accelerates (increases in speed) as it falls through the coil and hence the rate of change of magnetic flux linkage is larger. [B1] According to Faraday's law, the rate of change of magnetic flux linkage is proportional to the magnitude of the e.m.f. induced. A larger e.m.f. induced gives a larger deflection and hence the second deflection is larger than the first. [B1]	
	(b)	(i)	Change in magnetic flux linkage	
		(ii)	1.0 Wb s^{-1}	
6	(a)	(i)	For n = 1 → 4, $\lambda_3 = \dfrac{hc}{6.0 - 0\ \text{eV}} = \dfrac{(6.63\times10^{-34})(3.00\times10^{8})}{6.0(1.6\times10^{-19})}$ [C1] = 210 nm [A1]	
		(ii)	UV: 210 nm	
	(b)	(i)	Spectrum A is the emission spectrum and B is the absorption spectrum.	
		(ii)	Almost all the time, absorption transitions will start from the ground state, so the number of absorption lines are more limited and fewer than emission lines. On the other hand, there are many possible transitions for an excited atom to de-excite. So the emission lines are more numerous.	
	(c)		Line spectrum A has unique/discrete/quantized wavelengths. [B1] These quantized wavelengths must come from quantized energy levels. [B1]	
7	(a)	(i)	350 to 750 nm. A letter "V" should be indicated along the axis of Fig. 7.2	[A1]
		(ii)	From the graph for T = 1100 K, it is observed that there is a higher intensity of emitted radiation of higher wavelengths within the visible range. Hence, object would glow with a red colour.	[B1]
	(b)	(i)	<table><tr><th>T /K</th><th>λ_{max} /nm</th><th>$T\lambda_{max}$ /nmK</th></tr><tr><td>600</td><td>4830</td><td>2.898×10^6</td></tr><tr><td>700</td><td>4140</td><td>2.898×10^6</td></tr><tr><td>800</td><td>3610</td><td>2.888×10^6</td></tr><tr><td>900</td><td>3210</td><td>2.889×10^6</td></tr><tr><td>1000</td><td>2900</td><td>2.900×10^6</td></tr><tr><td>1100</td><td>2630</td><td>2.893×10^6</td></tr></table>Compute at least 3 values of the product $T\lambda_{max}$. Since values are all close to 2.9 x 10^6 nm K, hence the product $T\lambda_{max}$ is constant. Value of constant = average value = 2.89 x 10^6 or 2.9 x 10^6 nm K	[C1] [B1] [A1]
		(ii)	Using $T\lambda_{max}$ = 2.89 x 10^6, 1200 x λ_{max} = 2.89 x 10^6 λ_{max} = 2408 nm = 2.41 x 10^{-6} m (1M for conversion to m)	 [C1] [A1]
	(c)	(i)	Drawing of BFL Calculation of gradient of BFL:	[M1]

			$= (1.82 - 1.22)/(2.95 - 2.8) = 4.00$ Linearization and equating n to gradient: $Lg(I_{tot}) = lg(c) + nlg(T)$ $n = grad = 4.00$	[M1] [A1]
		(ii)	$I_{tot} = cT^n \rightarrow 71 = c(627 + 273)^{4.00}$ $c = 1.082 \times 10^{-10}$ For a temperature of 1200 K, $I_{tot} = 1.082 \times 10^{-10} (1200)^4$ $= 224 \text{ W m}^{-2}$	 [M1] [C1] [A1]
	(d)		Advantage: Temperature can be determined without physical contact Using EM radiation to measure temperature meant that it will be very fast Disadvantage: Range of measurement is limited to higher temperatures for which the peak is sharper. Less distinctive for lower temperatures where the graph is flatter. Not able to measure temperature of objects that only emit low intensity EM radiation.	[B1] [B1]

8			Diagram  *Diagram marks (D1)* *1. Diagram is to show the voltmeter and ratemeter/scalar are connected across AB with correct circuit diagram with variable d.c. supply.*	D1
			Control Mark *1. Set up the apparatus as shown above.* *2. Ensure that the distance between the radioactive source and the mica window is the same (by fixing the positions of the two objects) with a description of method.* *3. Ensure that the activity of the radioactive source is about the same (by using a source with long half-life). Radium-226 or Cobalt-60 are used as the radioactive source as both source has long half-life (thus activity will remain relatively unchanged)*	*(C1)*
			4. Measure the voltage V across AB by using a voltmeter [M1] *5. Remove α-radiation and β-radiation by using aluminium sheet or thin lead. (Alternatively, they can be removed through electric or magnetic deflection) [P1]* *6. Check for background radiation C_0 (when experiment is not carried out yet) or use of screen (to reduce background radiation)[M1]* *7. Start the experiment by directing the radioactive source at the Geiger Muller tube.* *8. Measure the count rate C_1 using ratemeter or scalar connected across AB. Hence the count rate due to source $C = C_1 – C_0$. [M1].* *9. Repeat steps 5 to 9 to obtain another 7 set of values of C with different set of voltage V by adjusting the voltage of the variable d.c. supply [P1].*	
			Analysis Mark (A1) *Plot a graph of lg C against lg V. The relationship of $C = k V^n$ is valid when the plotted points follow a trend of best-fit line [A1].*	
			Additional Detail Mark (can score 2AD or more)	
			Reliability measures *1. Control of an additional variable (stated above).* *2. If lead is used, its thickness should be in the order of mm to cm range.* *3. If aluminium is used, thickness should be in the order of a few cm.* *4. Repeat the count rate measurement to allow for randomness of activity or Carry out the experiment over a long duration to minimise the randomness of activity.* *5. Collect a few readings of count rates and average them over a few minutes at least.*	
			Safety Precautions (at most 2 AD mark) *1. Either (wear protective suit against radiation) Or (store the radioactive source in lead boxes when not in use)* *2. Choose cobalt over radium because radium has too long a half life which would be a safety hazard during disposal or that alpha particles are highly ionizing*	