**2024 PU3 H2 Physics Prelim Paper 2 Suggested Answers**

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| **1** | **(a)(i)** | The <u>vertical acceleration of the ball is constant in magnitude (9.81 ms$^{-2}$) and directed downwards throughout the path</u>.<br><br>Hence as the ball moves from the ground to the highest point, <u>vertical velocity decreases at a constant rate till vertical velocity reaches zero.</u><br><br>As the ball moves from the highest point towards the ground, <u>vertical velocity increases at constant rate.</u> | B1<br><br>B1<br><br>B1 |
| | **(a)(ii)** | The <u>horizontal acceleration of the ball is zero throughout the path</u>.<br><br>Hence the <u>horizontal velocity is constant in magnitude</u>. | B1<br><br>B1 |
| | **(b)(i)** | Considering the ball just after it leaves the ground to the point just before it hits the ground,<br><br>$v_y = u_y + a_y t$<br>$15\sin 20^o = (-15\sin 20^o) + (9.81)t$<br>$t = \frac{30\sin 20^o}{9.81}$<br><br>$s_x = u_x t = (15\cos 20^o)\frac{30\sin 20^o}{9.81}$<br><br>= 14.7 m | <br><br><br><br>C1<br><br>C1<br><br>A1 |
| | **(b)(ii)** | Considering the ball just as it drops down the cliff to just before it hits the ground.<br>$s_y = u_y t + \frac{1}{2}a_y t^2$<br>$70 = -15\sin 20^o t + \frac{1}{2}(9.81)t^2$<br>t = - 3.29 (NA) s or 4.34 s<br><br>$s_x = u_x t - 14.7 = (15\cos 20^o)(4.34) - 14.7$<br>$= 46.4\ m$ | <br><br><br>C1<br>C1<br><br>C1<br>A1 |

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| **2** | **(a)** | Gravitational field strength is defined as the force per unit mass acting on a small mass placed at a point in the gravitational field. | A1 |
| | **(b)** | For the same difference in gravitation potential, the distance between the potential lines is increasing as the distance from the surface of Mars, show that gravitation field strength is decreasing. | A1 |
| | **(c)** | Loss in gravitational potential energy = gain in kinetic energy of the satellite<br>$(90)(-6.0 - (-8.0)) \times 10^6 = (1/2)(90)v^2$<br>$v = 2000\ ms^{-1}$ | <br>C1<br>A1 |
| | **(d)(i)** | Centripetal force of the satellite is provided by the gravitation force.<br>$mr(\frac{2\pi}{T})^2 = \frac{GMm}{r^2}$<br>$T = \sqrt{\frac{4\pi^2 r^3}{GM}}$<br>$= \sqrt{\frac{4\pi^2(3.4\times10^6+1.7\times10^7)^3}{G(6.4\times10^{23})}}$<br>= 88607 s = 24.6 h | <br>C1<br><br>C1 (correct radius)<br>A1 |
| | **(d)(ii)** | KE = $\frac{1}{2}mr^2\omega^2$<br>$= \frac{1}{2}(90)(3.4\times10^6 + 1.7\times10^7)^2\left(\frac{2\pi}{88607}\right)^2$<br>= 9.42 x $10^7$ J<br><br>Alternative<br><br>KE = $\frac{GMm}{2r}$<br>$= \frac{G(6.4\times10^{23})(90)}{2(3.4\times10^6+1.7\times10^7)}$<br>= 9.42 x $10^7$ J | <br>C1<br>A1 |
| | **(d)(iii)** | Due to work done against friction, total energy of the satellite decreases, causing the satellite to fall towards Mars (or radius of orbit decreases).<br><br>As the satellite fall towards Mars, it experiences a loss in gravitational potential energy and an increase in kinetic energy. (Or Since KE = GMm/2r as radius decreases, KE increases) | B1<br><br>B1 |

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| **3** | **(a)** | Despite both being at 100 °C, <u>steam transfers more (heat or thermal) energy</u> to the skin than boiling water.<br><br>This is because <u>steam releases (heat) energy</u> proportional to the <u>latent heat of vaporisation</u> during condensation in addition to the heat energy released on cooling of condensed water on skin.<br><br>This is much higher than the (heat) energy released by boiling water on contact with the skin. | B1<br><br>B1 |
| | **(b)(i)** | Use state A:<br>$n = \frac{P_A V_A}{R T_A} = \frac{20\times10^5 \times 1.2\times10^{-4}}{8.31\times800}$<br>$= 0.0361$ mol<br><br>If state D is used, $n = 0.0362$ mol. | C1<br><br>A1 |
| | **(b)(ii)1.** | $T_B = \frac{P_B V_B}{R_B n} = \frac{20\times10^5 \times 5.2\times10^{-4}}{8.31\times0.0361}$<br>$= 3467$ K<br><br>If $n = 0.0362$ mol is used, $T_B = 3457$ K.<br><br>OR<br>$\frac{V_A}{T_A} = \frac{V_B}{T_B}$<br>$\frac{1.28}{800} = \frac{5.2}{T_B}$<br>$T_B = 3467$ K | A1 |
| | **(b)(ii)2.** | $\Delta U = \frac{3}{2} nR\Delta T$<br>$= \frac{3}{2}\times0.0361\times8.31\times(3467-800)$<br>$= 1200$ J (allow ecf)<br><br>Accept $\frac{3}{2} p\Delta V = 1200$ J. | C1<br><br>A1 |
| | **(b)(ii)3.** | $W = -P\Delta V = -20\times10^5 \times (5.20-1.20)\times10^{-4}$<br>$= -800$ J<br><br>Award 1 mark for +800 J. | C1<br><br>A1 |
| | **(b)(ii)4.** | From the first law of thermodynamics,<br>$\Delta U = Q + W$<br>$Q = \Delta U - W$<br>$Q = 1200 - (-800) = 2000$ J (allow ecf) | A1 |
| | **(b)(iii)** | From D to A, since Q is zero, $W_{DA} = \Delta U_{DA}$<br><br>$W_{DA} = \frac{3}{2}\times0.0361\times8.31\times(800-226) = 258$ J or <u>259 J</u> if used $n$ 0.0362<br>$W_{\text{net by gas}} = 800 + 390 + 0 - 259 = 932$ J or <u>931 J</u> is used $n$=0.0362<br><br>Allow ecf.<br>Students can also use $W_{DA} = \frac{3}{2}(P_A V_A - P_B V_B) = 258$ J | C1<br><br>C1<br><br>A1 |

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| **4** | **(a)** | In a polarised wave, the vibrations of wave particles are limited to only one axis;<br>whereas an unpolarised wave is not (i.e. no specific axis of vibrations or many different axis of vibrations). | B1 |
| | **(b)(i)** | 0 as no light will be able to pass through the polariser given it is perpendicular. | A1 |
| | **(b)(ii)1.** | $A_3 = A_2 \cos(62°-23°)$<br>$A_2 = A_1 \cos(23°)$<br>thus<br>$A_3 = A_1 \cos(23°) \cos(62°-23°)$<br>$= 0.715 A_1$ | M1<br>M1<br><br><br>A0 |
| | **(b)(ii)2.** | let the initial amplitude (unpolarised light) = $A_0$<br><br>$\frac{1}{2} = (\frac{A_1}{A_0})^2$<br>$A_0 = \sqrt{2}A_1 = 1.41\ A_1$<br>$\frac{I_3}{I_0} = (\frac{A_3}{A_0})^2 = (\frac{0.715A_1}{\sqrt{2}A_1})^2 = 0.256$<br><br>Percentage of intensity reduced = (1 - 0.256) x 100% = 74.4% | <br><br><br>C1<br>C1<br><br>A1 |

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| **5** | **(a)(i)** | $R_R$ = 105Ω<br>$R_{Th}$ = 50 Ω | A1<br>A1 |
| | **(a)(ii)** | $V = \frac{50}{105+50} \times 12$<br>= 3.87 V | C1<br>A1 |
| | **(a)(iii)** | The p.d across resistor and thermistor is equal so this implies that the resistance across each component is equal.<br><br>Hence the temperature is 50 °C. | C1<br><br>A1 |
| | **(b)(i)** | p.d across length x = $\frac{x}{l}E$<br>Since the appliance is parallel to length of x, p.d is the same. Thus<br>p.d across the appliance is x = $\frac{x}{l}E$ | M1<br><br>A1 |
| | **(b)(ii)** | p.d across appliance = 20 / 100 x 5.0 = 1.0 V<br>current = 1/10.0 = 0.10 A | <br>A1 |
| | **(b)(iii)** | $\varepsilon$ = 45.0 / 100 x 5.0 = 2.25 V | A1 |

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| **6** | **(a)** | A magnetic field is a region of space in which a magnetic force is experienced by **moving** charges or current-carrying conductors or permanent magnets placed in this field. | A1 |
| | **(b)(i)** | As the positive ion passes into the region of magnetic field, by Flemming's left hand rule, there is a magnetic force on the ion towards the positive plate.<br><br>Due to the electric field, there will be a electric force on the ion towards the negative plate.<br><br>If the magnitude of these two forces are equal, the ion will be able to pass through without deviation.<br><br>(If student state "Electric force is opposite in direction to magnetic force" award only 1 mark out of the first 2 B1 marks). | B1<br><br>B1<br><br>B1 |
| | **(b)(ii)1.** | In the region with B-field only there exist a magnetic force (of constant magnitude) perpendicular to direction of motion causes ions to undergo centripetal acceleration / provides the centripetal force. | A1 |
| | **(b)(ii)2.** | $B'qv = \frac{mv^2}{r}$<br>$\frac{m}{r} = \frac{B'q}{v}$ = constant<br>$\frac{M}{26.2} = \frac{12u}{22.4}$<br><br>$M = 14u$ | C1<br><br>A1 |

<table>
<tr><td>7</td><td>(a)(i)</td><td>Photoelectric effect is the ejection/emission of an electron from a <u>metal</u> surface when the surface is irradiated with electromagnetic radiation of a high enough frequency.</td><td>A1</td></tr>
<tr><td></td><td>(a)(ii)</td><td>Allow 350 nm to 400 nm</td><td>A1</td></tr>
<tr><td></td><td>(a)(iii)</td><td>Threshold frequency is determined when there is no responsivity from photocathode/ no release of photoelectrons.<br><br>From Fig. 7.2, threshold wavelength is approximately 640 mm. Threshold frequency is found by using speed of light divided by threshold wavelength (or 630 nm)</td><td>B1<br><br>B1</td></tr>
<tr><td></td><td>(a)(iv)</td><td>Using hc/λ = work function + $E_{k, max}$,<br>$hc/(450 \times 10^{-9}) = h(4.76 \times 10^{14}) + 0.5(9.11 \times 10^{-31})v^2$<br>$v = 5.27 \times 10^5$ m $s^{-1}$*</td><td>C1<br>C1<br>A1</td></tr>
<tr><td></td><td>(a)(v)</td><td>Using a low work function photocathode will allow electrons to be emitted easily with photons of larger wavelength.</td><td>A1</td></tr>
<tr><td></td><td>(b)(i)</td><td>Current = nq/t<br>$7.8 \times 10^{-4} = (n/t)*(1.6 \times 10^{-19})$<br>$n/t = 4.88 \times 10^{15}$ $s^{-1}$</td><td><br>C1<br>A1</td></tr>
<tr><td></td><td>(b)(ii)</td><td>Number of photons per unit time<br>$= 4.88 \times 10^{15} /(0.01)$<br>$= 4.88 \times 10^{17}$</td><td><br><br>A1</td></tr>
<tr><td></td><td>(b)(iii)</td><td>4.8 mA of current is detected from photocathode when 1 W of power of EM radiation is incident on it.</td><td>A1</td></tr>
<tr><td></td><td>(c)(i)</td><td>Use wavelength = 225 nm, R = 9.0 mA/W and<br>wavelength = 540 nm (or 550 nm), R = 22 mA/W<br>to correctly determine $\eta$ at 5 %.</td><td>B1<br>B1</td></tr>
<tr><td></td><td>(c)(ii)</td><td>Correct computation of values with maximum values of 2sf<br>To deduct one mark for one wrong calculation.<br><br>
<table>
<tr><th>η / %</th><th>λ / nm</th><th>R / mA W<sup>-1</sup></th></tr>
<tr><td>3</td><td>300</td><td>7.2</td></tr>
<tr><td>3</td><td>400</td><td>9.7</td></tr>
<tr><td>3</td><td>500</td><td>12</td></tr>
<tr><td>3</td><td>600</td><td>14</td></tr>
<tr><td>3</td><td>700</td><td>17</td></tr>
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</td><td>A1<br><br>A1</td></tr>
<tr><td></td><td>(c)(iii)</td><td>Correct plotted points<br>with best-fit curve</td><td>B1<br>B1</td></tr>
<tr><td></td><td>(d)(i)</td><td>The voltage used in PMT is higher than 1000V and must be electrically insulated for safety reason.<br>OR Any reasonable answer</td><td>B1</td></tr>
<tr><td></td><td>(d)(ii)</td><td>• Use in eye devices to measure interruption of light. OR<br>• To detect radiation. OR<br>• Measure intensity and spectrum of light emitting materials in laboratory.<br><br>https://en.wikipedia.org/wiki/Photomultiplier_tube#Usage_considerations</td><td>B1</td></tr>
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