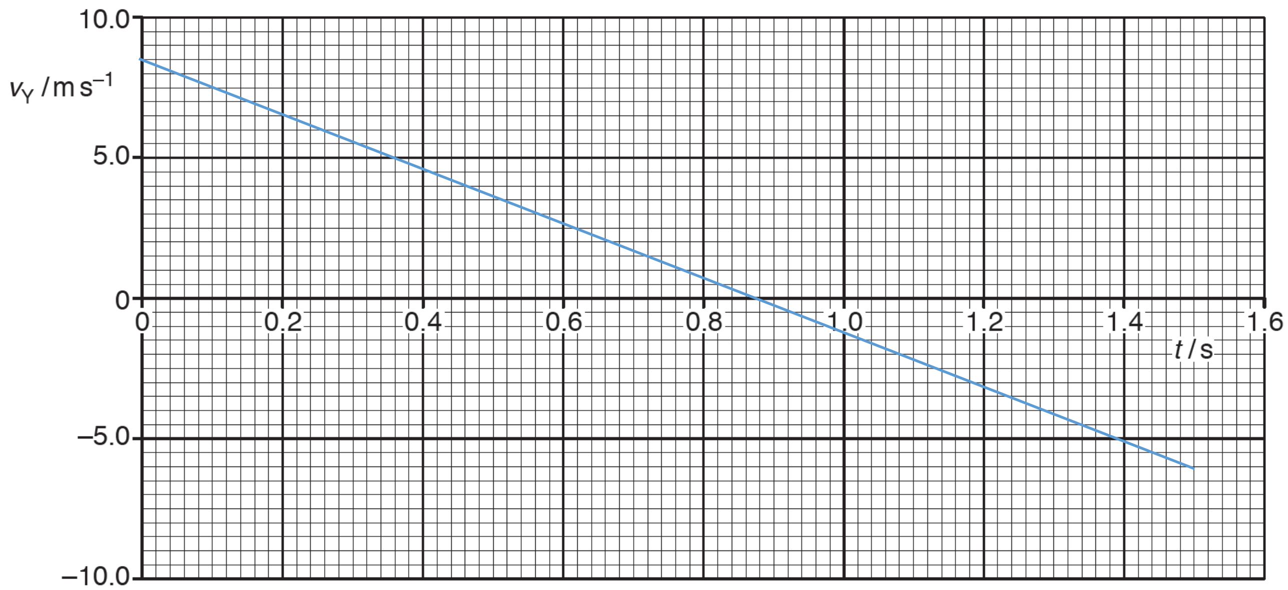
Anderson Serangoon Junior College 2025 H2 Physics Prelim P3 Mark Scheme

Paper 3 (80 marks) **E – Easy, A – Average, D – Difficult**

ECF	Error carried forward	**SF**	Significant figures error	**M0**	No A marks awarded
AE	Arithmetic error	**BOD**	Benefit of doubt	**^**	More is needed in answer
POT	Power of ten error	**CON**	Contradictory response	**XP**	Wrong physics
TE	Transcription error	**IR**	Irrelevant (part) response		

1a	$s_x = v_x t$ $v_x = 24 / 1.5 = 16$ m s^{-1} $\tan 28° = v_Y / v_X$ or $v_X = v \cos 28°$ **and** $v_Y = v \sin 28°$ $v_Y = 16 \tan 28°$ or $v_Y = 16 \times (\sin 28° / \cos 28°)$ so $v_Y = 8.507 = 8.5$ m s^{-1} <u>Examiner's comments:</u> Most students were able to solve. Some workings did not show complete substitution of values to meet the demand of a “Show” question. There were still some students who did not show more s.f. before final answer which was required in a “Show” question.	**A**	 C1 C1 A0
1b	Taking upwards as positive $v_Y = u_Y + at$ $t = (0 – 8.5) / (– 9.81)$ = 0.87 s <u>Examiner's comments:</u> Students did not substitute the sign of the direction correctly in their Kinematics questions which resulted in wrong answer. Some students wrongly assumed initial velocity as zero.		 C1 A1
1c	straight line from positive v_Y at t = 0 to negative v_Y at t =1.5 s line starts at (0, 8.5) and crosses t-axis at (0.87, 0) and does not go beyond t = 1.5 s.		M1 A1



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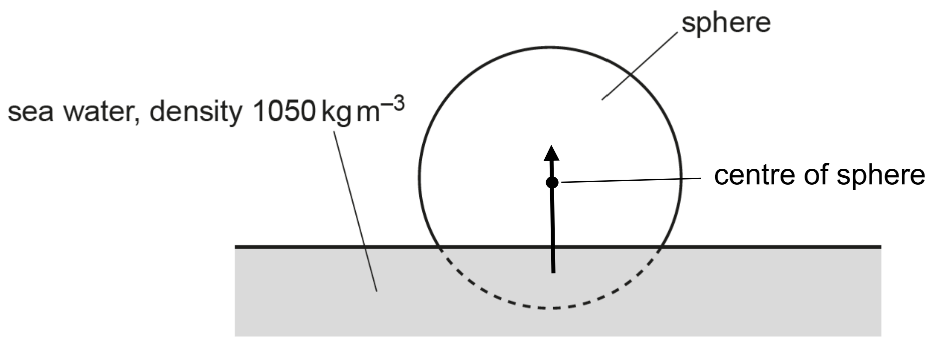
	Examiner's comments: Those who drew a straight line graph often did not ensure the x-intercept was within half smallest square and extended line beyond t = 1.5 s.		
1d	acceleration (of freefall) is unchanged / not dependent on mass, and so no effect (on maximum height and time taken) Examiner's comments: Many did not pinpoint acceleration as the quantity that was unchanged / independent of mass. Even though net force (= weight) was larger, the acceleration of free fall remained as *g*, so this showed it was independent of mass.	**E**	B1
1e	Since air resistance acts downwards, net downward force is larger hence, shorter time taken Examiner's comments: Students need to be explicit about the direction of the net force / net deceleration as **downwards**. Stating AR is directed opposite to the motion of the object was too generic and not contextualizing. Students need to illustrate their awareness about the net deceleration or net force is **greater** than before. Many students used inappropriate term such as "increases" to illustrate greater / larger. Some did not conclude for the time taken.	**D**	M1 A1

2ai	Use $R = \frac{\rho l}{A}$ $= \frac{(5.5 \times 10^{-8})(2.0)}{\left(\frac{\pi(0.020 \times 10^{-3})^2}{4}\right)}$ $= 350\ \Omega$ power dissipated = $I^2R = (0.42)^2(350) = 62$ W *Examiner's comments:* Most students performed the correct calculation and obtained the correct answer.	**A**	C1 A1
2aii1	Mthd 1 Common current in both wires, so *nAv* for tungsten= *nAv* for copper. $v_{tungsten} = \frac{n_{copper} A_{copper} v_{copper}}{n_{tungsten} A_{tungsten}}$ $= \frac{(8.0)(1.4^2)(0.021 \times 10^{-3})}{(3.4)(0.02^2)}$ $= 0.24\ m\ s^{-1}$ Mthd 2 Use $I = nAve$ $v_{tungsten} = \frac{I}{n_{tungsten} A_{tungsten}\, e}$ $= \frac{0.42}{(3.4 \times 10^{28})(\pi \frac{(0.02 \times 10^{-3})^2}{4})(1.60 \times 10^{-19})}$ $= 0.25\ m\ s^{-1}$ *Note that v is the drift speed and not the actual speed of the electrons.* *Examiner's comments:* This was commonly correct.	**A**	C1 A1

2aii2	The higher speed of the electrons in tungsten means that they have <u>a much greater kinetic energy</u> than those in copper. As the electrons <u>collide</u> with the fixed atoms, energy is <u>lost</u> to these atoms, resulting in a rise in temperature. <u>Examiner's comments:</u> This question proved challenging. Many students did not use the values of drift speed calculated from the previous part. E1: did not explain in microscopic terms; diameter/current/power is macroscopic E2: did not associate kinetic energy of an electron with its drift speed. E3: did not mention electrons transfer energy to lattice during collisions. E4: misconception, e.g: higher drift speed does not, by itself, mean electrons collide more often. The collision rate is set mainly by the material, impurities, and temperature, not by the small drift speed.	**D**	M1 A1
2bi	resistance of thermistor at 0 °C = 3900 Ω using potential divider, $\left(\frac{R}{R+3900}\right) x1.50 = 1.00$ R = 7800 Ω resistance of thermistor at 30 °C = 1250 Ω using potential divider, $\text{voltmeter reading} = \left(\frac{7800}{7800+1250}\right) x1.50$ $= 1.29 \text{ V}$ *<u>OR</u>* p.d. across thermistor = 1.50 – 1.00 = 0.50 V resistance of thermistor at 0 °C = 3900 Ω common current in circuit = $\frac{1.00}{R} = \frac{0.50}{3900}$ R = 7800 Ω resistance of thermistor at 30 °C = 1250 Ω common current, I in circuit = $\frac{1.50}{R+1250} = \frac{1.50}{7800+1250} = \frac{1.50}{9050}$ voltmeter reading = IR = 1.29 V *<u>Examiner's comments:</u>* It is advisable to use potential divider method instead of using current method which is longer. The current in the circuit is not the same when temperature changes.	**A**	C1 A1
2bii	resistance of thermistor at 0 °C = 3900 Ω effective resistance of R and voltmeter, X = 7800/2 = 3900 Ω (same as thermistor's) voltmeter reading = p.d. across X = 1.50/2 = 0.750 V *<u>Examiner's comments:</u>* The answer should be written to 3 s.f. because all data are given as 3 or more s.f.	**A**	C1 A1

3ai	gravitational force provides the centripetal force $GMm / R^2 = mv^2 / R$ $E_K = ½mv^2$ and clear algebra leading to $E_K = GMm / 2R$ *<u>Examiner's comments:</u>* *Answers need to be clear in presentation flow, since this is a "show" question. Any symbols that are not found in the question must be defined.*	**A**	B1 M1 A1
3aii	$E_T = E_K + E_P$ $= GMm / 2R – GMm / R$ $= – GMm / 2R$ *<u>Examiner's comments:</u>* *The concept of total energy must be shown, as this is a "show" question.*	**A**	M1 M1 A0
3b	As the satellite gradually loses energy, i.e. its <u>total energy E_T decreases</u> (i.e. more negative), its <u>radius of orbit R decreases.</u> As the satellite radius of orbit R decreases, its <u>kinetic energy E_k increases</u>, i.e. its <u>speed v increases</u>, and it would also move nearer or into the Earth's atmosphere. The satellite's increasing speed gives rise to <u>increase of resistive forces</u> which results in <u>increasing</u> rate of conversion of its energy to <u>thermal energy</u>, and so the satellite could eventually 'burn up'. *<u>Examiner's comments:</u>* *The question started with "small resistive forces". Good answers need to show how this transitioned into increasing severity of the satellite eventually "burning up".*	**D**	B1 B1 B1
3c	advantage: • Continuous coverage: They orbit at the same speed as the Earth's rotation, appearing stationary over one location, providing constant monitoring of a specific area. • Ideal for communications: They are well-suited for broadcasting and communication services due to their fixed position. • Weather monitoring: They can provide continuous weather observations and imagery of a particular region. • **Surveillance:** Their constant visibility makes them useful for surveillance applications. Any 1 of the points above or other suitable advantages. disadvantage: • Their high altitude (about 35,786 km above Earth's surface) leads to longer signal transmission times. • Limited polar coverage: Due to the curvature of the Earth, they have limited coverage of the polar regions. • Lower detail: Their high altitude results in lower-resolution images compared to polar-orbiting satellites. Any 1 of the points above or other suitable disadvantages. *<u>Examiner's comments:</u>* *Good answers require not only the characteristics of a geostationary satellite, but how that characteristic leads to an advantage/disadvantage.*	**D**	B1 B1

4a	directed vertically upwards, line of action passing through centre of sphere from centre of submerged part of sphere.  *Examiner's comments:* *Candidates need to use a ruler to properly draw a straight line.*	**A**	B1 B1
4b	Due to pressure difference at varying depths of seawater. *Examiner's comments:* *This question was generally answered well.*	**A**	B1
4c	Equal in magnitude but opposite in direction to the weight of sphere. It acts through the c.g of the sphere. *Examiner's comments:* *Most answers missed out on the rotational equilibrium part (acting through the c.g.). A few erroneously thought upthrust as action-reaction pair of weight.*	**A**	B1 B1
4d	weight of fluid displaced = weight of sphere $\rho_w g V_w = \rho_s g V_s$ $1050 \times 9.81 \times 0.21V = \rho_s \times 9.81 \times V$ $\rho_s = 220.5 \text{ kg m}^{-3} = 220 \text{ kg m}^{-3}$ *Examiner's comments:* *Many correctly answered this part.*	**A**	C1 A1
4e	F = Upthrust - weight of sphere $2000 = (1050 - 220.5) \times 9.81 \times \frac{4}{3}\pi(\frac{d}{2})^3$ d = 0.777m = 0.78 m *Examiner's comments:* *While many started with the correct concept, fewer successfully calculated the final answer. Others incorrectly omitted the value of g in the calculation.*	**A**	C1 A1

5a	$E = \frac{1}{2}kx^2$ or $E = \frac{1}{2}Fx$ and $F = kx$ $E = \frac{1}{2} \times 29 \times (8.0 \times 10^{-2})^2$ or $E = \frac{1}{2} \times 2.32 \times 8.0 \times 10^{-2}$ $E = 9.3 \times 10^{-2}$ J	**E**	C1 A1

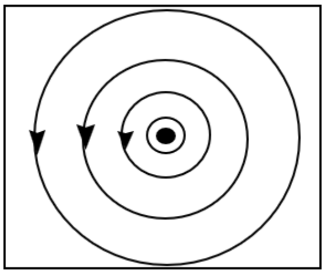
	Examiner's comments: Many answer were correct except a significant number of students omitted the factor half or power square.		
5b	$(\Delta)Ep = mg(\Delta)h$ $= 4.5 \times 10^{-2} \times 9.81 \times 8.0 \times 10^{-2} \sin 15°$ $= 9.1 \times 10^{-3}$ J Loss in EPE = gain in KE + gain in GPE and $E_k = ½mv^2$ $(9.3 \times 10^{-2} – 9.1 \times 10^{-3}) = ½ \times 4.5 \times 10^{-2} \times v^2$ $v = (2 \times 8.4 \times 10^{-2} / 4.5 \times 10^{-2})^{0.5}$ $= 1.9$ m s^{-1} *Examiner's comments:* Many did not consider the ball had gained GPE.	**D**	C1 C1 A1
5c	The speed will be lower, as the spring will possess some KE (or GPE). *Examiner's comments:* There was a need be clear about the **spring** possessed some KE or GPE. Often, students missed out stating the spring possessing some of the energy.	**D**	B1

6ai	$V_s/V_p = N_s/N_p$, $V_s/9.0 = 20/1$ $V_s = 20 \times 9.0 = 180$ V (r.m.s.) *Examiner's comments:* *This question was generally answered well.*	**E**	 A1
6aii	$I_p V_p = P_{mean}$ $I_p \times 9.0 = 30$, $I_p = 30/9.0 = 3.33$ A (r.m.s) *Examiner's comments:* *Some students did not read the question carefully and calculated the output current.*	**A**	A1
6aiii	From graph, T = 20 ms, $w = 2\pi/T = 314 = 310$ Hz $V_{rms} = \frac{V_0}{\sqrt{2}}$, $V_0 = 180\sqrt{2} = 254.6$ V = 250 V $V = V_o \sin (2\pi/T)t$ $= 250 \sin 310t$ Examiner's comments: Many students were not able to determine the period correctly from the graph given. Some who determined the period correctly made POT error. Some confused peak output voltage with input voltage or confused between peak and rms value.	**A**	 C1 A1
6bi	Peak power = 2 x mean power = 60 W Examiner's comments: A significant number of students were not able to gain credit. Many did not realise the peak power is the same for the input and output.	**E**	A1

6bii	Input mean P = output mean P = 30 W (ideal transformer) Diode reduces the power by half Mean power in R = 30/2 = 15 W *Examiner's comments:* *Many students were not able to do this part. Some managed to get the answer but presented wrong concept.*	**A**	 A1
6ci	Magnetic flux in the core is changing, causing induced e.m.f. or current in the core. Current in core causes heating effect. *Examiner's comments:* *E1: Did not clearly state the cause (changing magnetic flux) or effect (induced e.m.f or current in the core)* *E2: Referred to the coils rather than the core, ie explaining changing magnetic flux linkage and induced e.m.f. in the coils. The term 'linkage' ($N\phi$) is for coils, for the core we should just use the term 'magnetic flux' (ϕ).* *E3: Wrong understanding of operation of transformer, eg current flow from primary coil to secondary coil through the core. The core doesn't conduct current between the coils.*	**A**	B1 B1
6cii	The iron core is made of laminated sheets to reduce power loss due to induced current. *Examiner's comments:* *E1: Many students did not include "sheets".*	**E**	B1

7a	Diffraction is the spreading of waves when they pass through an opening or round an obstacle. Diffraction effects are the greatest when the width of the opening is **comparable** with the wavelength of the waves. Examiner's comments: Students who memorized the definition well would score full marks. Some unacceptable terms used to illustrate "comparable" included "equal", "similar", "identical".	**A**	B1 B1
7bi	The two stars are considered just distinguishable when the central maximum of the diffraction pattern (of one star) coincides with the first minimum of the diffraction pattern of the other (star). Examiner's comments: Need to contextualize Rayleigh Criterion to the context of the question by relating the objects to stars. Note that those underlined words in the answer were important. Students are strongly discouraged to use the word "resolved" in their explanation as this had been given in the context of the question as "resolution". Instead use "distinguishable" to replace the word "resolved".	**D**	B1 B1 B1 B1
7bii	With smaller aperture, θ (the angular separation of objects when their images are just resolved) increases (since $\theta = \lambda/b$), resulting in decrease in resolving power. Examiner's comments: Many were unable to appreciate that having a greater angular separation meant the need to have a bigger angle to tell the objects apart from one another. This would mean that the resolving power is poor.	**D**	B1

7biii	$\theta \approx \frac{\lambda}{b} = \frac{550 \times 10^{-9}}{0.120}$ = 4.58 × 10^{-6} rad Examiner's comments: Many were able to solve this part. Some made POT error. Note: Those students who used sin θ in your equation, you need to use radian mode in your calculator.	**E**	C1 A1

8ai	 • concentric circles (min 3 lines) centred on the wire • separation of lines increasing with distance from wire • arrows show anti-clockwise direction *Examiner's comments:* *Good answers need to indicate proper concentric circles, else mark was deducted for shape/spacing.*	**A**	B2
8aii1	Current in each wire creates a magnetic field at the other wire Current (in wire) at 90° to magnetic field causes a force *Examiner's comments:* *Some answers did not answer why there is a force.*	**A**	B1 B1
8aii2	By Newton's third law, the pair of forces are equal in magnitude. **or** The force is proportional to product of both currents so they are equal in magnitude *Examiner's comments:* *Correct answers indicate an understanding that the force is a product of both currents.*	**A**	B1
8bi	The force acting per unit current per unit length on a conductor placed perpendicular to the magnetic field. *Examiner's comments:* *Prepared students were able to score full credit.*	**E**	B2
8bii	Into the page *Examiner's comments:* *Most answered correctly.*	**E**	B1
8biii	Magnetic force is always normal to direction of motion of electrons (and force / KE / speed of particle is constant) Magnetic force provides centripetal force Examiner's comments: *If this is a 3-mark question, the second line in brackets will be credited.*	**A**	B1 B1

<table>
<tr><td></td><td>“Magnetic force is normal to current” is not accepted as the focus is on the charged particle (electron) and its motion in a magnetic field.
E1: Dropping the term ‘always’ in the first point (not penalised). This is essential in explaining how magnetic force is able to provide centripetal force.</td><td></td><td></td></tr>
<tr><td>8biv</td><td>$Bqv = mv^2/r$, (so $Bq = mv/r$)
$4.80 \times 10^{-3} \times 1.60 \times 10^{-19} = 9.11 \times 10^{-31} \times 1.70 \times 10^7 / r$
r = 0.02017 m
$d = 2r$ = 0.04033 m ≈ 0.0403 m = 4.03 cm

<u>Examiner’s comments:</u>
Many answers were correct.</td><td>A</td><td>C1
C1

A1</td></tr>
<tr><td>8bv</td><td>t = distance / speed = $\pi d/2v = \pi \times 0.0403 / (2 \times 1.70 \times 10^7) = 3.723 \times 10^{-9}$ s

<u>Examiner’s comments:</u>
Some responses did not include the pre-rounded values, which is required for all ‘show’ questions. Many used a longer method.</td><td>A</td><td>B1</td></tr>
<tr><td>8bvi</td><td>(Due to electric field directed into the page, electron experiences electric force out of the page.) In the direction out of the page:
$F_{out} = ma_{out} = qE$, so
$a_{out} = qE/m$
$v_{out} = a_{out}t = qEt/m$
$= 1.60 \times 10^{-19} \times 18000 \times 3.723 \times 10^{-9} / 9.11 \times 10^{-31} = 1.177 \times 10^7$ m s^{-1}
$v^2 = v_x^2 + v_{out}^2$ (since resultant v now has 2 components, directed leftwards and out of the page)
$= (1.70 \times 10^7)^2 + (1.177 \times 10^7)^2$
v = 2.068 m s^{-1} ≈ 2.07 m s^{-1}

<u>Examiner’s comments:</u>
Only a minority were able to answer correctly. Due to the uniform electric field, the electron experiences a constant electric force directed out of the page, resulting in uniform acceleration out of the page. Hence, the circular motion due to magnetic field, coupled with increasing velocity out of the page, will result in a helical motion of the electron. The electron will spend the same amount of time inside the fields, completing half a circle. Upon exiting, its velocity will have a leftward component (same magnitude as before) and component out of the page.

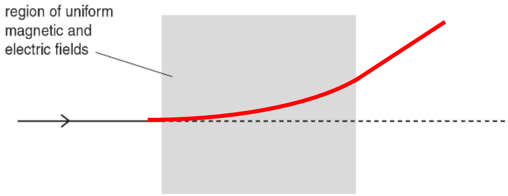
<table>
<tr><td>Wrong approach</td><td>Why it is wrong</td></tr>
<tr><td>F_E provides F_C or ($F_E + F_B$) provides F_C</td><td>A force (or sum of forces) can only provide the centripetal force if it is directed towards the centre of the circular motion. F_E is directed out of the page, not towards the centre of the circular motion.</td></tr>
<tr><td>$F_E = F_B$</td><td>Electric force = qE, magnitude force = Bqv. They are due to different fields.
In the scenario of crossed fields velocity selector, electric force acts opposite in direction to magnetic force, so when the charged particle moves undeflected, the electric force and magnitude force are equal in magnitude. However, this question is unlike the scenario for crossed fields velocity selector.</td></tr>
<tr><td>v = u + at, substituting u = 1.70 × 10^7 m s^{-1}</i></td><td><i>This equation applies for uniform accelerated motion, which is the case for the direction out of the page. However, the initial velocity (upon entry) for this direction is 0. The velocity 1.70 × 10^7 m s^{-1} is directed rightwards upon the electron’s entry into the fields.</td></tr>
</table></td><td>D</td><td>

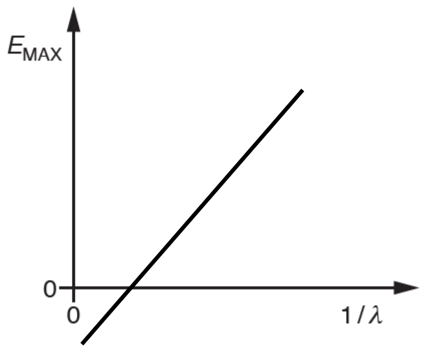
C1

C1

C1

A1</td></tr>
</table>

8c	 smooth curve, deviated upwards straight path after leaving the field Magnetic force on electron is downwards based on Fig 8.4, so magnetic force on proton (Bqv) is upwards. Electric force on proton (qE) is downwards. With higher entry speed, Bqv > qE, so net force upwards. *Examiner's comments:* *E1: Not drawing the path of the electron after it exits the fields, or drawing a path that is not straight, or the path is too short to for marker to assess if it is straight. It is advisable to label the path 'straight'.* *E2: The curve is not smooth.* *E3: The deflection is too large, eg more than 90 degrees. Some drew a semi circle showing the proton exiting from the same side where it entered. As the proton has a significantly larger mass compared to the electron, it will have a much larger radius (see equation in part iv), so any deflection here should not be too large.*	**A**	B1 B1

9ai	e.g. no time delay between illumination and emission max. (kinetic) energy of electron dependent on frequency max. (kinetic) energy of electron independent of intensity (any two separate statements, one mark each, maximum 2) *Examiner's comments:* All observations needed to be stated precisely. For example, it is not enough to say that "kinetic energy depends on frequency" when the precise statement is that "the maximum kinetic energy of the emitted electrons depends on the frequency". Similarly, it is not enough to say that "no time delay" when the precise statement is that "no time delay between the illumination of the metal and the emission of electrons".	**E**	B2
9aii1	 $E\text{max} = hf - hf_o$ $= h\frac{c}{\lambda} - h\frac{c}{\lambda_o}$ positive intercept on ($1/\lambda$)-axis (when extrapolated) straight line with positive gradient	**A**	 B1 B1

	Examiner's comments: The most common graph was drawn as a straight line through the origin.		
9aii2	gradient = *hc* where *c* is the speed of light Examiner's comments: Students did not relate the gradient to the Planck constant. The most common response was to simply state the equation for the energy of a photon.	**A**	B1
9aii3	each photon has more energy fewer photons per unit time fewer electrons per unit time / less current Examiner's comments: Some students tried to apply the fact that the intensity affect the number of photons and hence number of electrons emitted.	**D**	M1 M1 A1
9bi	• change in electron energy level emits a single photon / photon energy = difference in energy levels • energy of photon has a corresponding frequency • discrete frequencies (not continuous) must have come from discrete energy levels Examiner's comments: This was a question where many students answered a different question from that which was asked. There were many responses that gave answers to questions asking either for a description of the appearance of an emission spectrum or for an explanation of how an emission spectrum is formed, but where students did not make a connection between the emission spectrum and the idea of discrete energy levels. There was much confusion between the concepts of photon energy, energy transitions and energy levels, with many responses lacking accuracy in the way these technical terms were used.	**A**	B3
9bii	transition (to – 3.400 eV) from X corresponds to 658 nm line $E_2 - E_1 = hc/\lambda$ $E_2 - (-3.400) = \dfrac{6.63\times10^{-34}\times3.00\times10^{8}}{658\times10^{-9}\times1.60\times10^{-19}}$ $= 1.889$ $E_2 = 1.889 - 3.400$ $= -1.511$ $= -1.51$ eV Examiner's comments: Most students were able to identify the correct starting equation and the correct wavelength of the line that corresponds to the transition from level X to the –3.400 eV energy level but a few students were a little confused, and with many random attempts to add and subtract the other energy levels to somehow arrive at a value for X.	**D**	C1 C1 C1 A0
9ci	Electron energy = photon energy $eV = \dfrac{hc}{\lambda}$ $\lambda = \dfrac{6.63\times10^{-34}\times3.00\times10^{8}}{1.60\times10^{-19}\times15000}$ $= 8.3\times10^{-11}$ m	**A**	 C1 A1

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	<u>Examiner's comments:</u> This calculation was generally done well by those who identified the correct starting equation. Common errors included using the accelerating p.d. in place of the electron energy or finding the de Broglie wavelength of the electron rather than the wavelength of the emitted photon.		
9cii	The intensity of entire x-ray will increase, because more energetic electrons produce more x-ray photons The wavelength of highest energy x-ray photon decreases, because the energy of each electron increases when the accelerating potential increases The positions of the k lines remain unchanged (but their intensity increase) because the target metal is not changed <u>Examiner's comments:</u> Candidates were unclear of the difference between the deceleration of the electrons on hitting the target and their acceleration through the applied potential difference. Also all changes needed to be stated precisely. For example, it is not enough to say that "wavelength decreases" when the precise statement is that "the wavelength of highest energy x-ray photon decreases". Similarly, it is not enough to say that "k lines remain changed" when the precise statement is that "the positions of the k lines remain unchanged".	**D**	B1 B1 B1 B1 (B1 B1)