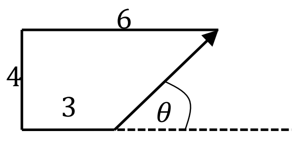
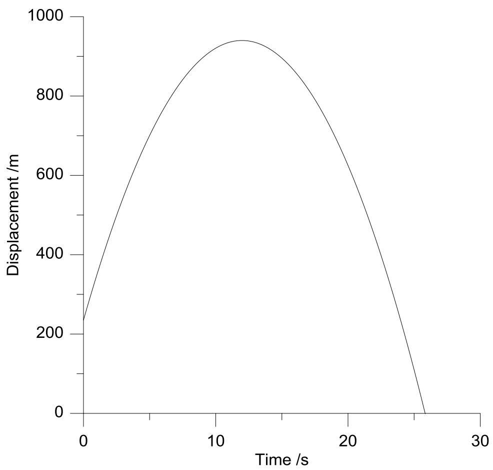
Advanced Level Physics – May 2016 – Paper 1

Mark schemes are prepared by the Examination Board and considered, together with the relevant questions. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Examination Board.

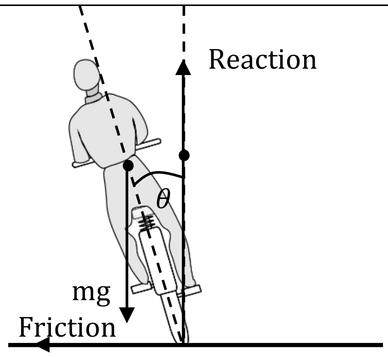
It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

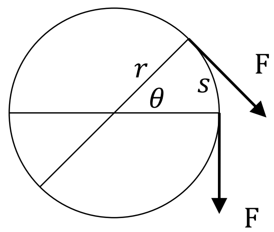
Section A

Question	Part	Subpart		Mark	Additional Guidelines
1.					
	a)		*Base Units* $LHS: \frac{V}{t} \rightarrow \mathrm{m^3\ s^{-1}}$ $RHS: \frac{\pi r^4 \Delta p}{8\eta l} \rightarrow \frac{\mathrm{m^4\ kg\ m\ s^{-2}\ m^{-2}\ m^{-1}}}{\eta}$ $Units\ of\ \eta \rightarrow \frac{\mathrm{m^4\ kg\ m\ s^{-2}\ m^{-2}\ m^{-1}}}{\mathrm{m^3\ s^{-1}}} = \mathrm{kg\ m^{-1}\ s^{-1}}$	2 2 2	
	b)	i.		2	
		ii.	Displacement magnitude $= \sqrt{3^2 + 4^2} = 5$ units Direction given by $\tan\theta = \frac{4}{3} \rightarrow \theta = 53.13°$	2 1	Accept the 3-4-5 triangle. Accept the complementary angle of theta as well.
		iii.	Total distance travelled is 13 units	1	
				12	

Question	Part	Subpart		Mark	Additional Guidelines
2.					
	a)		$v = u + at$ $v = 0 + 29.4 \times 4 = 117.6 \text{ m s}^{-1}$ $s = ut + \frac{1}{2}at^2$ $s = 0 + \frac{1}{2} \times 29.4 \times 4^2 = 235.20 \text{ m}$	2 2	
	b)		$v^2 = u^2 + 2as$ $0 = 117.6^2 - 2 \times 9.81 \times s$ $s = 704.88 \text{ m}$ $Max\ Height = 704.88 + 235.2 = 940.80 \text{ m}$	3 1	
	c)		$v^2 = u^2 + 2as$ $v^2 = 0 + 2 \times 9.81 \times 940.80 \rightarrow v = 135.86 \text{ m s}^{-1}$	2	
	d)		Time to reach max height from when the fuel runs out $v = u + at$ $0 = 117.6 - 9.81t \rightarrow t = 11.99\ s$ Time to fall to ground from max height $s = ut + \frac{1}{2}at^2$ $940.80 = 0 + \frac{1}{2} \times 9.81 \times t^2$ $t = 13.85\ s$ 	1 1 2	Do not award marks if the working is missing. Award 1 mark if the graph is a parabola but starting/ending from/at the wrong co-ordinates.
				14	

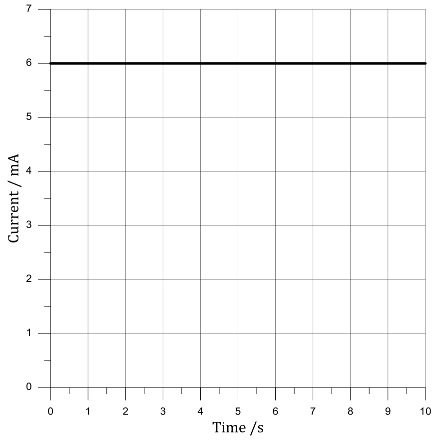
Question	Part	Subpart		Mark	Additional Guidelines
3.					
	a)		$W = Fs = \tau\theta = 4.8 \times 1.9 \times 2\pi$ $W = 57.30$ J	2 1	
	b)		$W = Fs = 45 \times 9.81 \times 0.012$ $W = 5.30$ J	2 1	Deduct 1 mark for missing/incorrect unit.
	c)		Some of the energy is lost as work done against friction between the screw threads and supporting material.	2	
	d)		$Efficiency = \frac{Useful\ Output\ Work}{Total\ Input\ Energy} \times 100$ $Efficiency = \frac{5.30}{57.30} \times 100 = 9.24\%$ Efficiency can be improved by oiling.	2 2	Do not accept: 'Higher pitch of screw' as this would be referring to a different system/machine; 'Longer lever' as this would be referring to a different system/machine; Accept: 'Less friction'.
				12	

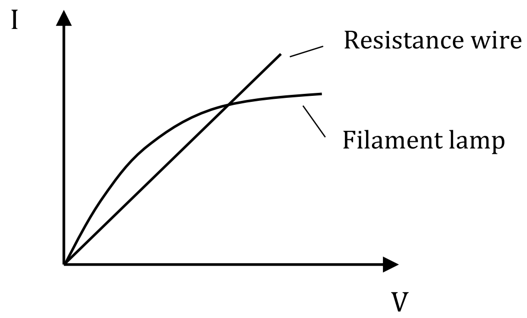
Question	Part	Subpart		Mark	Additional Guidelines
4.					
	a)			3	Award 1 mark for each correct positioning and indication of the three forces.
	b)		Friction	2	
	c)		$R - mg = 0$ $R = mg$ $F = \frac{mv^2}{r}$ Taking moments about centre of gravity $R \times h \sin\theta = F \times h \cos\theta$ $mg \sin\theta = \frac{mv^2}{r} \cos\theta$ $\tan\theta = \frac{v^2}{rg}$	1 1 2 1 1	Do not accept the derivation for banked tracks.
	d)		$\tan\theta = \frac{v^2}{rg} = \frac{4.5^2}{6.7 \times 9.81} = 0.31$ $\theta = 17.12°$	1 1	
				12	

Question	Part	Subpart			Additional Guidelines
5.					
	a)	i.	A couple consists of two parallel forces that are **equal in magnitude**, **opposite in sense** and **do not share a line of action**.	1	Do not award marks if any of the phrases in bold is missing.
		ii.			

			$Work\ Done\ W\ by\ forces\ is$ $W = 2Fs$ But $s = r\theta \rightarrow W = 2Fr\theta$ $\tau = F \times 2r$ $\rightarrow W = \tau\theta$	1 1 1	
	b)	i.	No; because the forces are not opposite each other.	1 1	
		ii.	Taking moments about the pivot, $kxL\sin\theta = \frac{mgL\cos\theta}{2}$ $x = \frac{mg}{2k\tan\theta}$	1 1	
		iii.	Let R be the reaction at the pivot. $R = \sqrt{(mg)^2 + (kx)^2}$ $R = \sqrt{m^2g^2 + \frac{m^2g^2}{4\tan^2\theta}} = \frac{mg}{2\tan\theta}\sqrt{4\tan^2\theta + 1}$	1 1	
		iv.	$\tan\theta = \frac{mg}{2kx} = \frac{5 \times 9.81}{2 \times 15 \times 0.5} = 3.27$ $\theta = 73.00°$	1 1	
				12	

Question	Part	Subpart			Additional Guidelines
6.					
	a)		**Kirchhoff's junction rule** states that the sum of the currents that flow into a junction— any electric connection—must equal the sum of the currents that flow out of the same junction. **Kirchhoff's loop rule** states that if a closed path is followed in a circuit, beginning and ending at the same point, the algebraic sum of the potential changes must be zero.	2 2	
	b)	i.	An electromotive force (e.m.f.) is the net quantity of work W done in carrying a charge q around a closed path in which no current is flowing. Electric potential difference between any two points in a circuit is the difference in electric potential as a result of work done on a charge in moving it against the electric field between the two points.	1 1 1	
		ii.	When a circuit is closed, current flows through the external circuit and through the internal resistance of the cell. The e.m.f. equals the sum of the p.d. dropped across the external circuit and the internal resistance.	1	

			Thus the p.d. across the terminals of the battery/external circuit is always less than the e.m.f.	1	
		iii.	Mathematically, $V = \varepsilon - Ir$ $V + \frac{Vr}{R} = \varepsilon$ $V\left(1 + \frac{r}{R}\right) = \varepsilon$ For, $R \gg r, \varepsilon = V$	1 1	Accept also the qualitative treatment and description of the solution.
	c)	i.	The current I can be obtained from the gradient $\frac{dQ}{dt}$ of the charge against time graph.	1	Do not accept $I = Q/t$. Accept also 'Calculate the gradient'.
		ii.	$\frac{dQ}{dt} = \frac{0.06}{10} = 0.006 = 6$ mA 	1 1	
				14	

Question	Part	Subpart			Additional Guidelines
7.					
	a)	i.	The <u>potential difference (voltage) across a conductor is proportional to the current through it</u>, provided that its physical conditions such as <u>temperature remains constant</u>. The constant of proportionality is called the "resistance", R.	1 1	
		ii.		4	Award full marks even if the graphs are drawn on separate axis. 2 marks for each correct sketch. Deduct 1 mark when axes labels were missing.

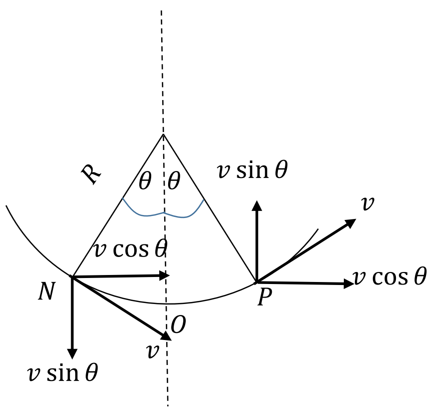
		iii.	The resistance wire obeys Ohms law and hence the current increases linearly with the potential difference across it. As the potential difference across the filament lamp increases, the resistance increases and less current flows through the lamp per unit increase in voltage.	1 1	Do not award marks if the justification is missing.
	b)	i.	$V_{AX} = \frac{2.2}{100} \times 70 = 1.54\text{ V}$	1	
		ii.	$\varepsilon = 1.54\text{ V}$	1	
		iii.	$V_{terminal} = V_{AX} = \frac{2.2}{100} \times 63 = 1.39\ V$	1	
		iv.	$V_{terminal} = \varepsilon - Ir$ $1.39 = 1.54 - \left(\frac{1.39}{18}\right) r$ $r = 1.94\ \Omega$	2 1	
				14	

Question	Part	Subpart			Additional Guidelines
8.					
	a)		The graph shows that <u>when electrons are emitted</u>, the <u>current they produce is directly proportional to the light intensity</u>.	1 1	Accept also 'Photoelectric current is directly proportional to light intensity'.
	b)	i.	$hf = \phi + KE_{max}$ $KE_{max} = eV_{stopping}$ $eV_{stopping} = hf - \phi = \frac{hc}{\lambda} - \phi$ $\frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{3.6 \times 10^{-7}}$ $\phi = (2 \times 1.602 \times 10^{-19})$ $V_{stopping} = 1.45\text{ V}$	1 1 1 1	
		ii.	$KE_{max} = eV_{stopping}$ $KE_{max} = e \times 1.45 = 1.45\text{ eV}$ $\text{KE}_{\text{max}} = 2.32 \times 10^{-19}\text{J}$	1 1	
		iii.	$KE_{max} = \frac{1}{2} mv^2 \rightarrow v = \sqrt{\frac{2 \times KE_{max}}{m}}$ $v = 7.15 \times 10^{5}\text{ m s}^{-1}$	1 1	
				10	

Section B

Question	Part	Subpart			Additional Guidelines
9.					
	a)	i.	The change of momentum per second is proportional to the applied force and the momentum change takes place in the direction of the force.	1 1	Do not accept the formula. Candidates are expected to STATE Newton's Second Law in terms of momentum.
		ii.	According to Newton's Second law: $F = k\frac{m(v-u)}{\Delta t} = k\ ma$ The Newton is defined as the force which when it acts on a 1 kg mass, it produces an acceleration of 1 m s^{-2}. 1 N = k × 1 × 1 → k = 1	1 1 1	
	b)	i.	$Energy\ stored = \frac{1}{2}kx^2 = \frac{1}{2} \times 280 \times 0.098^2$ $Energy\ stored = 1.70$ J	1 1	
		ii.	For a collision occurring between object 1 and object 2 in an isolated system, the total momentum of the two objects before the collision is equal to the total momentum of the two objects after the collision.	1 1	
		iii.	$p_{before} = p_{after}$ $0 = m_1 \times (-v_1) + m_2 \times (v_2)$ $m_1 v_1 = m_2 v_2$ $v_1 = \frac{m_2}{m_1} v_2$	1 1	
		iv.	$Energy\ stored = \frac{1}{2}m_1 v_1^2 + \frac{1}{2}m_2 v_2^2$ $Energy\ stored = \frac{1}{2}m_1 \frac{m_2^2}{m_1^2} v_2^2 + \frac{1}{2}m_2 v_2^2$ $Energy\ stored = \frac{1}{2}m_2 v_2^2 \left(\frac{m_2}{m_1} + 1\right)$ $1.70 = \frac{1}{2} \times 0.95 \times v_2^2 \left(\frac{0.95}{0.60} + 1\right)$ $v_2 = 1.18$ m s^{-1} $v_1 = \left(\frac{0.95}{0.60}\right) \times 1.18 = 1.86$ m s^{-1}	1 1 1 1 1	
	c)	i.	The external forces (***W***) are vertical, while the change in momentum (***Δp***) takes places horizontally. These two vectors are independent of each other since they are perpendicular.	1 1	

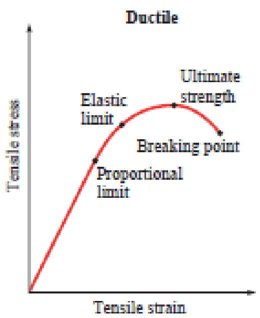
		ii.	$p_{before} = p_{after}$ $(0.018 \times 95) = (1.6 + 0.018) \times v$ $v = 1.06 \text{ m s}^{-1}$	 1 1	
		iii.	$Loss\ in\ KE = Gain\ in\ GPE$ $\Delta h = L - L\cos\theta = 1.15(1 - \cos\theta)$ $\frac{1}{2} \times (1.618) \times 1.06^2 = 1.618 \times 9.81 \times 1.15(1 - \cos\theta)$ $0.0498 = 1 - \cos\theta$ $\theta = 18.2\,°$	1 1 1 1 1	
				25	

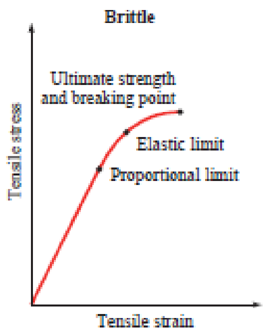
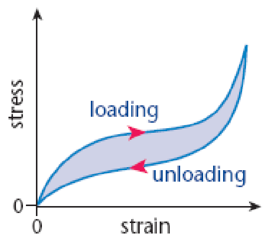
Question	Part	Subpart			Additional Guidelines
10.					
	a)	i.	The angular velocity ω is the change in angle turned per second.	2	
		ii.	 Consider a particle moving at constant speed v along doing an arc NOP. The x-component of the velocity has the same value at N and P, i.e there is no change in velocity along this component and therefore $a_x = \mathbf{0}$ The y-component changes from $v\sin\theta$ to $-v\sin\theta$. $\therefore a_y = \frac{\Delta v}{t} = \frac{v\sin\theta - (-v\sin\theta)}{t} = \frac{2v\sin\theta}{t}$ The speed of the car along the arc is v. $\therefore t = \frac{length\ of\ arc\ NOP}{v} = \frac{2\theta R}{v}$ $\rightarrow a_y = \frac{2v^2\sin\theta}{2\theta R}$ For very small angles $\frac{\sin\theta}{\theta} \cong 1$ $\rightarrow a_y = \frac{v^2}{R}$	2 1 1 1 1 1	Accept the use of similar triangles in the derivation. Deduct 2 marks if the proof that shows the triangles are similar is missing.

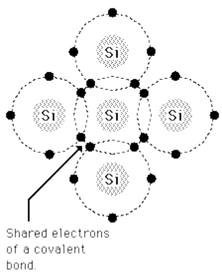
	b)	i.	$r = 0.80 \times \sin 25 = 0.34\ \text{m}$	2	
		ii.	$T\cos\theta = mg$ $T\sin\theta = \frac{mv^2}{r}$ $\tan\theta = \frac{v^2}{rg}$ $\sqrt{rg\tan\theta} = v$ $\sqrt{0.34 \times 9.81 \times \tan 25} = v = 1.24\ \text{m s}^{-1}$	1 1 1 1	
		iii.	$T = \frac{mg}{\cos\theta} = \frac{0.065 \times 9.81}{\cos 25}$ $T = 0.70\ \text{N}$	1 1	
	c)	i.	$Loss\ in\ GPE = Gain\ in\ KE$ $mg\Delta h = \frac{1}{2}mv^2$ $2g(L - L\cos 25) = v^2$ $v = \sqrt{2 \times 9.81 \times 0.80 \times (1 - \cos 25)} = 1.21\ \text{m s}^{-1}$ $\omega = \frac{v}{r} = \frac{1.21}{0.80} = 1.51\ \text{rad s}^{-1}$	1 1 1 1 1	
		ii.	$a = \frac{v^2}{r} = \frac{1.21^2}{0.80} = 1.83\ \text{m s}^{-2}$ The direction of the acceleration is along the string.	2 1	Accept also 'Upwards'.
				25	

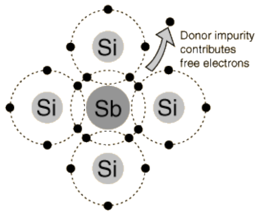
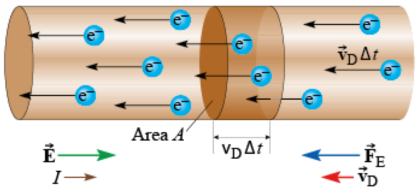
Question	Part	Subpart			Additional Guidelines
11.					
	a)	i.	The moment of inertia of a rigid body is a measure of its opposition to rotate from rest or change its angular speed. or The moment of inertia I is defined as Σmr^2 of all the particles in the body about its rotating axis.	2	
		ii.	If in a body, the distance of the particles from its rotating axis is bigger than that of another body of the same mass, than its moment of inertia is bigger. Considering a disc and a ring of the same mass and radius rotating about an axis through their centres and perpendicular to their planes, the particles of the ring lie at a greater distance from the rotating axis than in the disc. Thus the disc has a smaller moment of inertia I.	1 2	
	b)	i.	$\alpha = \frac{\omega_f - \omega_i}{\Delta t} = \frac{2.2 \times 2\pi - 0}{3.2}$ $\alpha = 4.32\ \text{rad s}^{-2}$	2 1	Deduct 1 mark for a missing or incorrect unit.

		ii.	$3Fr = I\alpha$ $F = \frac{I\alpha}{3r} = \frac{9.2\times10^{-2}\times4.32}{3\times0.15} = 0.88\text{ N}$	2 2	
	c)	i.	$I = \frac{1}{2}MR^2 = \frac{1}{2}\times6\times0.10^2 = 0.03\text{ kg m}^2$	2	Do not deduct marks for missing or incorrect units.
		ii.	$\tau = TR = I\alpha = \frac{Ia}{R}$ $T = mg - ma = \frac{Ia}{R^2}$ $a = \frac{mg}{\frac{M}{2}+m} = \frac{3.0\times9.81}{\frac{6.0}{2}+3} = 4.91\text{ m s}^{-2}$	2 1 2	
		iii.	$mg - T = ma$ $T = mg - ma = 3.0\times9.81 - 3.0\times4.9 = 14.73\text{ N}$	1 1	
		iv.	$KE_{rot} = \frac{1}{2}I\omega_f^2$ $\omega_f = \omega_i + \alpha t = 0 + \frac{4.91}{0.1}\times5 = 245.5\text{ rad s}^{-1}$ $KE_{rot} = \frac{1}{2}\times0.03\times245.5^2 = 904.05\text{ J}$	1 1 2	
				25	

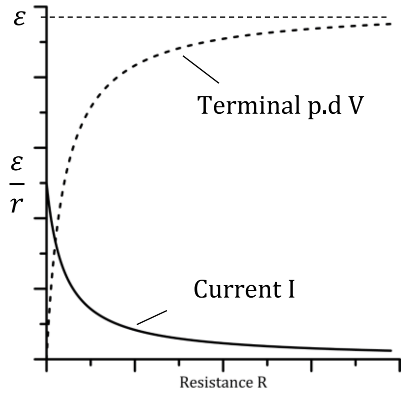
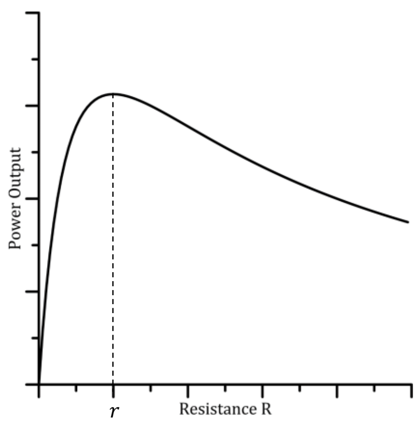
Question	Part	Subpart			Additional Guidelines
12.					
	a)		Tensile strain is a measure of the deformation of a body due to an external tension. It is the ratio of change in length with the original length of a linear material. Tensile stress is a measure of the internal forces a linear body experiences per unit cross-sectional area. It is the ratio of the external force applied to the body with its cross-sectional area. Young's modulus is a measure of the ability of a material to deform in one direction. It is the ratio of stress over strain.	1 1 1	Do not accept formulae as definitions.
	b)	i.	 Copper is a ductile material. Hooke's law is obeyed up to the proportional limit. The elastic limit is the point beyond which there is a permanent deformation of the wire. The maximum stress that can be withstood without breaking	2	1 mark for graph. 1 mark for labelling. 1 mark for description.

			is called the ultimate strength.  The glass fibre is brittle. The difference in the shape of the graph results from the fact that the breaking point occurs at the ultimate tensile stress.  Rubber is an example of an elastomer type polymer, where the polymer has the ability to return to its original shape after being stretched or deformed. The rubber polymer is coiled when in the resting state. The elastic properties arise from the its ability to stretch the chains apart, but when the tension is released the chains snap back to the original position.	1 2 1 2 1	
	c)		$Hooke's\ law \rightarrow F = k\Delta L$ Also $Y = \frac{\sigma}{\varepsilon}$ $\sigma = Y\varepsilon$ $\frac{F}{A} = \frac{Y\Delta L}{L_0}$ $\frac{k\Delta L}{A} = \frac{Y\Delta L}{L_0}$ $k = \frac{YA}{L_0}$	1 1 1 1	
	d)	i.	$Y = \frac{\sigma}{\varepsilon}$ $\sigma = Y\varepsilon = 8.40 \times 10^9 \times 0.45 = 3.78 \times 10^9$ Pa	2	
		ii.	$\sigma = \frac{F}{A} \rightarrow F = \sigma A = 3.78 \times 10^9 \times \pi \times \frac{(3.8 \times 10^{-4})^2}{4}$ $F = 428.70$ N	2 1	
		iii.	$\Delta L = \varepsilon \times L_0 = 0.45 \times 1.60 = 0.72$ m	1	
		iv.	$Energy\ Stored = \frac{1}{2}\sigma\varepsilon = \frac{1}{2} \times 3.78 \times 10^9 \times 0.45$ $Energy\ stored = 8.5 \times 10^8$ J	2 1	
				25	

Question	Part	Subpart			Additional Guidelines
13.					
	a)		The most occupied band is the valence band while the band above it is the conduction band. The region between the valence band and the conduction band is free of electrons and is called the forbidden band. In an insulator, the forbidden gap is quite wide and as a result it is very difficult for electrons in the valence band to get enough energy to reach the conduction band. The conduction band for insulators is completely empty. Hence insulators do not conduct electricity. A rise in temperature is not enough for electrons to cross the forbidden band. In the case of a conductor, the forbidden band is either very narrow or almost inexistent. This means that only a small electric field is required to move electrons to the conduction band. This explains why conduction is possible. Intrinsic semiconductors have properties which occur naturally i.e they are intrinsic to the material's nature. Their valence band is full at absolute zero but at higher temperatures some electrons may reach the conduction band after crossing the forbidden band.	2 2 2 2	
	b)	i.	 Silicon atoms form covalent bonds and can crystallize into a regular lattice. This crystal is called an intrinsic semiconductor and can conduct a small amount of current. The main point here is that a silicon atom has four electrons which it can share in covalent bonds with its neighbours.	2	
		ii.	The hole is the absence of an electron in the valence band in a doped semiconductor.	2	
		iii.	The free electron and hole both contribute to conduction about the crystal lattice. That is, the electron is free until it falls into a hole. If an external electric field is applied to the semiconductor, the electrons and holes will conduct in opposite directions. The holes move in the direction of the conventional current, while the electrons move in the opposite direction.	2	

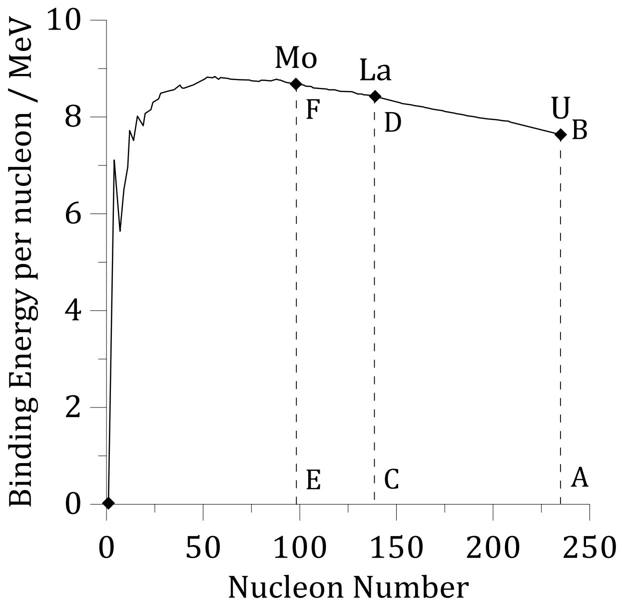
	c)		 The addition of pentavalent impurities such as antimony, contributes free electrons, greatly increasing the conductivity of the intrinsic semiconductor. <u>This happens because four outer electrons from antimony is needed for covalent bonding. The fifth electron from the outer shell of antimony becomes free.</u>	2 2	
	d)	i.	 Volume of section of conductor $= Av_D\Delta t$ Number of charge carriers in the section $nAv_D\Delta t$ Total charge, Q, of material $nAev_D\Delta t$ Current moving through conductor $I = \frac{Q}{\Delta t} = \frac{nAev_D\Delta t}{\Delta t} = nAev_D$ $v_D = \frac{I}{nAe}$	 1 1 1	
		ii.	$R = \frac{\rho L}{A} = \frac{1.04 \times 10^{-6} \times 0.5}{4.54 \times 10^{-9}} = 114.54\ \Omega$ $V = IR \rightarrow I = \frac{V}{R} = \frac{12}{114.54} = 0.105\ \text{A}$	1 1	
		iii.	$v_D = \frac{I}{nAe}$ $v_D = \frac{0.105}{4.57 \times 10^{28} \times 4.54 \times 10^{-9} \times 1.602 \times 10^{-19}}$ $v_D = 0.0032\ \text{m s}^{-1}$	 1 1	
				25	

Question	Part	Subpart			Additional Guidelines
14.					
	a)	i.	$V_{AB} = IR$	1	
		ii.	$P_{gen} = I\varepsilon = I \times I(R + r) = I^2(R + r)$ $P_{out} = I^2R$	1 1	

		iii.	$\eta = \frac{P_{out}}{P_{gen}} = \frac{I^2R}{I^2(R+r)}$ $\eta = \frac{R}{R+r}$	1 1	
		iv.		2 2	Award 1 mark for each correct sketch and 1 mark for labelling.
		v.	The graph of terminal potential difference with increasing load resistance tends to a limit set by the e.m.f of the battery. The second graph intersects the y-axis at the maximum current that can be delivered by the battery in a short circuit. This current is limited by the value of the internal resistance of the battery.	1 1	
		vi.	 Maximum value of power output P_{out} occurs when $R = r$.	3 2	
	b)		$I_1 = I_2 + I_3$ $0.05 = I_2 + I_3$ Loop EBAF $-0.05 \times 2 + \varepsilon - 5I_2 - 1.0 = 0$ $\varepsilon - 5I_2 = 1.1$ V [1] Loop EBCD $-0.05 \times 2 + \varepsilon - I_3 + 1.2 - 4I_3 = 0$ $\varepsilon - 5I_3 = -1.1$ V [2] [1]-[2]	1 2 2	

			$-5I_2 + 5I_3 = 2.2$ V Substituting $I_2 = 0.05 - I_3$ $-5 \times (0.05 - I_3) + 5I_3 = 2.2$ $I_3 = 0.245$ A $\rightarrow I_2 = -0.195$ A $\varepsilon = -1.1 + (5 \times 0.245) = 0.125$ V	1 1 1 1	
				25	

Question	Part	Subpart			Additional Guidelines
15.					
	a)		$\alpha - particle$: It is a doubly ionised helium atom, consisting of two protons and two neutrons. It is stopped by a piece of paper; it has the highest ionisation ability from the 3 mentioned radiations; it is deflected by a magnetic field, showing it has a positive charge; its mass is roughly four times that of a proton; its range in air is only a few centimetres. $\beta - particle$: It is a very fast moving electron that is ejected from the nucleus from the decay of a neutron. It has greater penetrating power than the $\alpha - particle$; stopped by a sheet of aluminium; it is deflected by a magnetic field, showing it has a negative charge; its mass is roughly 1/2000 that of the proton; it has a larger range in air. $\gamma - particle$: It is a radiation obeying an inverse square law; it is very penetrating, being stopped only by thick lead; it is not deflected by a magnetic field; its ionising power is low; it can be diffracted with crystals.	2 2 2	
	b)	i.	Since the majority of α-particles passed straight through means that the gold foil is mostly empty space; Some of the α-particles passed close to the gold nucleus and since both particle and gold nucleus are positively charged, they were slightly deflected. In rare cases, a head on collision between the gold nucleus and the α-particle, made the particle reflect back on its original direction.	1 2 2	
		ii.	$KE_\alpha = 4.0$ MeV Gold Nucleus has 79 protons		

<table>
<tr><td></td><td></td><td></td><td>Let distance of closest approach be x.
$Loss\ in\ KE_\alpha = Work\ Done\ by\ field\ to\ stop\ the\ \alpha$
$KE_\alpha = qV = 2e \times \frac{79e}{4\pi\varepsilon_0 x}$
$4 \times 10^6 \times e = \frac{158e^2}{4\pi\varepsilon_0 x}$
$x = 5.69 \times 10^{-14}\text{m}$</td><td>1
2
1
1</td><td></td></tr>
<tr><td></td><td>c)</td><td>i.</td><td>

Consider disrupting the U-235 completely
$Energy\ needed = 235 \times E_{AB}$
Consider the daughter nuclei
$Energy\ needed = 139 \times E_{CD} + 95 \times E_{EF}$

$Energy\ Rel. = 139 \times E_{CD} + 95 \times E_{EF} - 235 \times E_{AB}$</td><td>1
2
2</td><td></td></tr>
<tr><td></td><td></td><td>ii.</td><td>The release of energy and change of the U-235 nucleus was due to the original neutron absorbed, bringing instability. At the end of the process, 2 neutrons were released. If these were absorbed by other U-235 nuclei, the reaction will continue to grow.</td><td>2
2</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>25</td><td></td></tr>
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