Model answers for the 2012 Electricity Revision booklet:

SAMPLE ASSESSMENT SCHEDULE

Physics 91173 (2.6): Demonstrate understanding of electricity and electromagnetism

Assessment Criteria

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding involves writing statements that show an awareness of how simple facets of phenomena, concepts or principles relate to a described situation.	*Demonstrate in-depth understanding* involves writing statements that give reasons why phenomena, concepts or principles relate to a described situation. For mathematical solutions, the information may not be directly usable or immediately obvious.	*Demonstrate comprehensive understanding* involves writing statements that demonstrate understanding of connections between concepts.

Evidence Statement

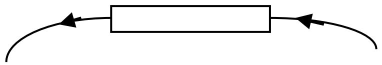
One	Not achieved		Achievement		Achievement with Merit		Achievement with Excellence	
	NØ N1	No response; no relevant evidence ONE correct	A3	ONE correct	M5	ONE correct	E7	ONE correct of E ONE correct of A
	N2	TWO correct	A4	TWO correct	M6	TWO correct	E8	ONE correct of E ONE correct of M
(a)	The electron gains kinetic energy. The electron gains potential energy. Describes that an electron that is free to move is attracted to the positive plate, but no mention of		Describes the electron gains kinetic energy when free to move in an electric field. OR Describes the electron gains potential energy when forced to move against		Demonstrates in-depth understanding by stating the electron loses electric potential energy and gains kinetic energy when moving in the electric field AND			

	the energy changes involved.	the electric field	Demonstrates in-depth understanding by stating the electron loses kinetic energy and gains electric potential energy when forced to move against the electric field.	
(b)	$E = \frac{V}{d}$ $E = \frac{F}{q}$	Solves: $E = \frac{V}{d} = \frac{200}{0.004}$ E = 5.0 $\times 10^4$ Vm^{-1} $F = Eq$ $F = 5.0 \times 10^4 \times 1.6 \times 10^{-19}$ $F = 8.0 \times 10^{-15}$	Solves: $E_p = Fd$ $E_p = 8.0 \times 10^{-15} \times 0.004$ $E_p = 3.2 \times 10^{-17}$ J $E_k = 3.2 \times 10^{-17}$ J	Solves: $3.2 \times 10^{-17} = 0.5 \times mv^2$ $v^2 = 7.1 \times 10^9$ $v = 8.4 \times 10^6$ ms^{-1}
(c)	No force. Force increases or force decreases.	Describes that the force is the same throughout. OR Describes the size of the force being much larger than the weight force of an electron.	Explains the force is the same throughout because the electric field is uniform.	

Two	Not achieved		Achievement		Achievement with Merit		Achievement with Excellence	
	NØ N1	No response; no relevant evidence ONE correct	A3	TWO correct	M5	TWO correct	E7	ONE omission
	N2	TWO correct	A4	THREE correct	M6	THREE correct	E8	ALL correct
(a)	$4+5=9$ $3+2+4+5=14$		$3+2=5\Omega$ $\left(\frac{1}{4}+\frac{1}{5}\right)^{-1}=2.22\Omega$		$\left(\frac{1}{4}+\frac{1}{5}\right)^{-1}=2.22\Omega$ $3+2=5\Omega$ $5+2.22=7.2\Omega$			
(b)	Attempts calculation but uses incorrect value for resistance.		$I=\frac{V}{R}=\frac{9.0}{7.2}$ I = 1.25A		$V_{3\Omega}$ = 3 × 1.25 = 3.75 V $V_{2\Omega}$ = 2 × 1.25 = 2.50 V $V_{5\Omega}$ = 9.0 – (3.75 + 2.50) $V_{5\Omega}$ = 2.75 V OR V = 2.22 × 1.25 = 2.77 V			
(c)	The 5 Ω resistor draws more power. The greater the resistance, the greater the voltage across it for the same current.		Describes power depends on both voltage and current. Describes ONE correct calculation for power. This could be either 3 Ω resistor = 3.75 × 1.25 = 4.69 W		Explains by calculating power drawn by 3 Ω resistor = 3.75 × 1.25 = 4.69 W Explains by calculation power drawn by 5Ω resistor		Explains in detail power depends on both voltage and current. $P = VI$ Voltage across 5 Ω resistor is 2.75 V and the voltage across 3 Ω resistor is 3.75 V. The current through 3 Ω resistor is 1.25 A. Hence power drawn	

		OR power drawn by 5Ω resistor = $\frac{V}{R} \times 2.75 = \frac{2.75^2}{5}$ $= 1.5\ W$ OR Identifies 3Ω resistor as using more power due to it drawing more current OR having a higher voltage across it.	$= \frac{V}{R} \times 2.75 = \frac{2.75^2}{5}$ $= 1.5\ W$ Explains that power depends on voltage and current and the 3Ω resistor draws more current AND has a higher voltage across it.	by 3 Ω resistor is 4.69 W. Power drawn by 5 Ω resistor is 1.5 W. Explains in detail both the voltage across and the current through the 5 Ω resistor is less than that of the 3 Ω resistor. Hence the 3 Ω resistor draws more power from the battery.

Three	Not achieved		Achievement		Achievement with Merit		Achievement with Excellence	
	NØ N1	No response; no relevant evidence TWO correct	A3	ONE correct	M5	ONE correct	E7	ONE omission
	N2	THREE correct	A4	TWO correct	M6	TWO correct	E8	BOTH correct
(a)	The electrons feel a force. This causes the electrons to move.		Describes that the electrons feel a magnetic force and so move to one end of the wire leaving the other end positive. OR Describes that the electrons feel a magnetic force and states correct direction of the force (to the left).		Explains the separation of charge causes an electric field to be formed. The electrons will also experience a force due the formation of the electric field.		Explains in detail that the force due to the electric field is opposite to the force due the magnetic field as experienced by the electrons. AND Charge separation continues until the magnetic force is equal and opposite to the electric force.	
(b)	$B = BvL$ $V = 0.80 \times 12 \times 65$		Calculates: $V = 0.80 \times 12 \times 0.65$					

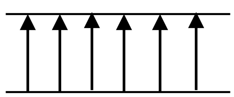
		$V = 6.24$ V (*or consequential error accepted for M in 3 (c))*		
(c)	Current is anticlockwise**.**	Calculates the current correctly. OR Shows OR states that the current is anticlockwise: $V = IR$ 	Calculates: $I = \frac{6.24}{4.5}$ $I = 1.39$ A AND Shows/states correct direction.	

QUESTION 4: ELECTROSTATIC SWING *(NCEA 2011, Q1)*

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	The left hand plate, A. Field lines go from positive to negative. OR Field lines show the direction a positive test charge would move.	[1] ONE part correct.	[1] BOTH parts correct.	
(b)	The field lines are equally spaced.	[1] Correct answer.		
(c)	$E = \frac{V}{d}$ $V = Ed$ $V = 3.33 \times 10^{6} \times 0.12$ $V = 399\,600 = 4.0 \times 10^{5}\ \text{V} = 400\ \text{kV}$	[2] Correct working except for ONE error.	[2] Correct answer.	
(d)	$V = \frac{\Delta E}{q}$ $\Delta E = Vq$ $\Delta E = 4 \times 10^{5} \times 1.5 \times 10^{-10}$ $\Delta E = 6 \times 10^{-5}\ \text{J}$ $E_K = \frac{1}{2} mv^2 = 6 \times 10^{-5}\ \text{J}$ $v = \sqrt{\frac{2 \times 6 \times 10^{-5}}{2.5 \times 10^{-2}}} = \sqrt{4.8 \times 10^{-3}} = 0.069\ \text{m s}^{-1}$	[2] Correct calculation of energy change. OR $F = 4.995 \times 10^{-4}$	[2] Correct working with ONE error. $a = 0.01998$	[2] Correct working and answer.

(e)	When the ball touches the negative plate, it will gain electrons until it has an overall negative charge. It then experiences a force in the opposite direction to the field (OR is attracted to the positive plate OR is repelled from the negative plate). When the ball touches the positive plate, it loses electrons until it has an overall positive charge. It then experiences a force in the same direction as the field (OR is attracted to the negative plate OR is repelled from the positive plate).	1 ONE correct idea. Eg moves towards positive plate	1 TWO correct ideas. Moves towards + and attraction/force/ repulsion	1 Full explanation linking the charging process and the force due to the field. M+ **Electron** movement and repetition

QUESTION 5: STATIC ELECTRICITY *(NCEA 2010, Q1)*

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
ONE (a)		1 Upward arrow (.		
(b)	$E = \frac{V}{d}$ $E = \frac{20.0}{3.0 \times 10^{-3}} = 6.667 \times 10^{3}\ \text{V m}^{-1}$	2 Correct working and answer without the unit.	2 Correct answer including correct alternate unit N C^{-1}.	
(c)	Alternate unit is NC^{-1}	1 Correct answer		

(d)(i) (ii)	At the negative plate, the electron has electric potential energy. As it goes towards the positive plate electric potential energy is changed to kinetic energy. The electron accelerates towards the positive plate.	1 Idea of EITHER the electron possessing electric potential energy at the negative plate. OR Electron gaining kinetic energy as it approaches the positive plate. OR Electron accelerating towards positive plate.	1 Potential to kinetic + accelerating down/towards positive plate.	
(e)	As it reaches the positive plate, $E_p = E_k$ $E_p = Eqd$ $E_p = 6.667 \times 10^3 \times 1.6 \times 10^{-19} \times 3.0 \times 10^{-3}$ $E_p = 3.20 \times 10^{-18}$ $3.20 \times 10^{-18} = \frac{1}{2} \times 9.0 \times 10^{-31} \times v^2$ $v = 2.67 \times 10^6 \text{ m s}^{-1}$	2 Recognition that $E_p = E_k$ OR 2 Finds $F = 1.07 \times 10^{-15}$	2 Correct except for one error. Eg finds $a = 1.19 \times 10^{15}$ OR uses $d = 3$	2 Correct answer for speed of electron.

QUESTION 6: SPRAY PAINTING *(NCEA 2005, Q1)*

Q	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(a)	Right to left (chair to spray gun).	[1] Correct answer.		
1(b)	Charge = no. of electrons × charge of each electron $= 3.0 \times 10^{6} \times 1.60 \times 10^{-19}$	[2] Correct factors using data are shown (ignore presence or absence of –ve sign on charge).		
1(c)	$F = Eq \qquad E = \frac{V}{d}$ $F = \frac{Vq}{d}$ $F = \frac{110 \times 10^{3} \times 4.8 \times 10^{-13}}{0.65}$ $F = 8.1 \times 10^{-8}$ N	[2] Evidence of electric field calculation and a substitution $E = \frac{V}{d} = \frac{110 \times 10^{3}}{0.65}$ (ignore × 10^{-3})	[2] Equations are combined correctly. [2] Force is calculated using correct E or q $F = Eq$ $F = 1.69 \times 10^{5}$ $\times\ -4.8 \times 10^{-13}$ ($q = -1.6 \times 10^{-19}$)	[2] Merit ***plus*** correct answer.
1(d)	The force will increase. If the length of the field decreases, and the voltage remains the same, the field strength will increase. ($E = \frac{V}{d}$) A stronger field causes a greater force. ($F = Eq$)	[1] Force increases. [1] Electric Field increases [1] $F = \frac{V}{d}q$ given.	[1] TWO correctly linked ideas [1] Electric field correctly linked to distance [1] Force vs $\frac{1}{d}$ given.	[1] THREE ideas linked correctly. Correct statement linking less distance, more Electric Field and more Force. [1] Force increases as distance decreases if V & q constant.
1(e)	$V = \frac{\Delta E_p}{q} \qquad \Delta E_p = Eqd$ $\Delta E_p = F.d$ $\Delta E_p = Vq$ $= 110 \times 10^{3} \times 4.8 \times 10^{-13}$ $= 5.28 \times 10^{-8}$ J $= 5.3 \times 10^{-8}$ J	[2] Valid equation and a substitution (ignore × 10^{3}) (force from 1c)	[2] Correct answer.	
1(f)	**Rate** of flow of charge / electrons.	[1] Correct answer, or indication of Coulomb per second.		
1(g)	$I = \frac{Q}{t}$ $I =$ $\frac{6.5 \times 10^{5}}{60}$ drops / s $\times 8.0 \times 10^{-13}$ C / drop $= 8.7 \times 10^{-9}$ C/s (A)	[2] $\frac{8 \times 10^{-13}}{60}$ [2] $\frac{6.5 \times 10^{5} \times 8 \times 10^{13}}{1}$ (Ignore presence or absence of –ve sign on charge).	[2] Correct equation, substitution and answer. (Ignore presence or absence of –ve sign on charge).	

QUESTION 7: MASS SPECTROMETER *(NCEA 2009, Q1)*

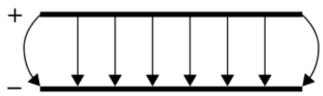
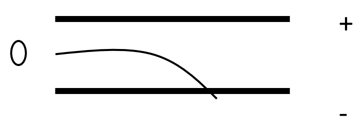
Q	Evidence	Achievement	Merit	Excellence
ONE (a)	Arrow towards top of page.	[1] Correct answer.		
(b)	$I = \frac{Q}{t}$ $Q = I \times t = (3.5 \times 10^{-6}) \times 60$ $Q = 2.1 \times 10^{-4}\ \text{C}$ $N = \frac{2.1 \times 10^{-4}}{1.6 \times 10^{-19}} = 1.3 \times 10^{15}\ \text{ions}$	[2] Correct charge.	[2] Correct answer.	
(c)	The force remains constant because the electric field strength is constant ($F = Eq$).	.	[1] Correct answer	
(d)	If the voltage increases, the force on the ion increases. Greater force means greater acceleration, which means greater maximum velocity. OR If the voltage increases, the ion gains more kinetic energy, and therefore has a greater velocity.	[1] Greater velocity. Except if based on V=Bvl,	[1] Achievement plus partial explanation.	[1] Correct answer and full and **concise** explanation.
(e)	$F = Eq$ $E = \frac{F}{q} = \frac{3.2 \times 10^{-15}}{1.6 \times 10^{-19}} = 2.0 \times 10^{4}\ \text{N C}^{-1} (\text{or V m}^{-1})$	[2] Correct answer.		
(f)	$KE = \frac{1}{2}mv^2$ $\Delta E = Eqd = 2.0 \times 10^{4} \times 1.6 \times 10^{-19} \times 0.04$ $\Delta E = 1.28 \times 10^{-16}\ \text{J}$ $\frac{1}{2}mv^2 = 1.28 \times 10^{-16}$ $\frac{1}{2} \times 5.31 \times 10^{-26} \times v^2 = 1.28 \times 10^{-16}$ $v^2 = \frac{2 \times 1.28 \times 10^{-16}}{5.31 \times 10^{-26}} \Rightarrow v = 69\,434\ \text{m s}^{-1}$ $v = 6.9 \times 10^{4}\ \text{m s}^{-1}$	[2] Correct KE.	[2] Correct working except for one error.	[2] Correct working and answer.

QUESTION 8: THE PARTICLE ACCELERATOR *(NCEA 2007, Q1)*

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
ONE (a)	Left to right.	[1] Correct answer.		
(b)	Electrical/potential to kinetic.	[1] Correct answer. Electrical to kinetic Potential to kinetic		
(c)	$\Delta E_{\mathrm{k}} = \frac{1}{2}m\Delta v_{\mathrm{f}}^{2} - \frac{1}{2}m\Delta v_{\mathrm{i}}^{2}$ $\Delta E_{\mathrm{k}} = \frac{1}{2}\times 1.67\times 10^{-27}\times((8.8\times 10^{5})^{2} - (6.2\times 10^{5})^{2})$ $\Delta E_{\mathrm{k}} = 3.25\times 10^{-16}\ \mathrm{J}$ $E = \frac{\Delta E_{\mathrm{k}}}{qd} = \frac{3.25\times 10^{-16}}{1.6\times 10^{-19}\times 0.02} = 1.0\times 10^{5}\ \mathrm{V\ m^{-1}}$ **Or** $v_{f}^{2} = v_{1}^{2} = 2ad$ gives $a = 9.75\times 10^{12}$ $F = ma$ *and* $F = Eq$ *give* $E = \frac{1.67\times 10^{-27}\times 9.75\times 10^{12}}{1.6\times 10^{-19}}$ $= 101\,765 = 100\,000$	[2] Calculates **a** kinetic energy. [2] Attempts to use or states $\Delta E = Eqd$ [2] Finds a	[2] Calculates the gain in energy **OR** correctly uses $\Delta E = Eqd$ [2] uses $F = ma$	[2] Correct working and answer.
(d)	N $\mathrm{C^{-1}}$	[1] Correct unit.		
(e)	$V = Ed = 100\,000\times 0.02 = 2000\ \mathrm{V}$	[2] Correct answer.		
(f)	Towards the top of the page.	[1] Correct answer. Upward.		
(g)	$F = Bvq$ $F = 3.5\times 10^{-3}\times 8.8\times 10^{5}\times 1.6\times 10^{-19}$ $F = 4.9\times 10^{-16}$ Unrounded is 4.928×10^{-16}	[2] Correct answer [2] Accept correct substitution into formula.		

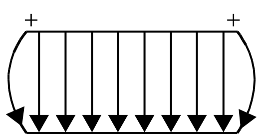
	2 sig figs.	[2] Correct sf. For **any** attempt to find ***F.***		

QUESTION 9: CHARGED PARTICLES *(NCEA 2008, Q1)*

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
ONE (a)		[1] Downward line.	[1] Evenly spaced parallel lines with curved end(s).	
(b)		[1] Curves towards negative plate.		
(c)	The electric force is at right angles to the direction in which the positive particle is moving. This causes the particle to describe a parabolic path.	[1] Force is down. OR [1] Repelled from +. OR [1] Attracted to –.	[1] Achievement plus has link to forward motion **or** constant downwards force and parabolic path	
(d)	Magnetic field **into the page**.	[1] Correct answer.		
(e)	The electric force depends only on the electric field strength and the size of the charge. Hence is not affected by the velocity of the particle. The magnetic force $F = Bqv$ increases as the velocity of the particle increases, as the magnetic force is directly proportional to the velocity, provided the magnetic field strength is a constant.	[1]Electric force is not affected by the velocity OR Magnetic force increases as velocity increases.	[1]Electric force is not affected by the velocity, but the magnetic force increases as the velocity increases.	[1]Merit, plus F depends only on E and q; eg F=E_q AND $F = Bqv$ depends on v.
(f)	$E = \frac{V}{d} = \frac{220\ \text{V}}{0.05\ \text{m}} = 4400\ \text{V m}^{-1}$ $F = Eq \Rightarrow F = 4400 \times 1.6 \times 10^{-19}$ $F = 7.0 \times 10^{-16}\ \text{N}$	[2]**Correct formula** used to find E, but did **not** convert cm to m.(E=44)	[2]Correct value for E (4400) OR **F using cm** [2] F = 7.0×10^{-18} N	[2]Correct answer. 7.0×10^{-18}
		[2] Correct sig figs.		

		Any attempt to find F correct to **2sf**		
(g)	$I = \frac{q}{t}$ $I = \frac{3.5\times10^{15}\times1.6\times10^{-19}}{10}$ $I = 5.6\times10^{-5}\ \text{A}$	2 Correct except for charge, eg $I = \frac{3.5\times10^{15}}{10}$ $= 3.5\times10^{14}$	2 Correct answer. 5.6×10^{-5} A	

QUESTION 10: CATHODE RAY TUBE *(NCEA 2006, Q2)*

2(a)	Upper plate is positive.	1 Top plate positive		
2(b)		• 1 Correct direction • Evenly spaced parallel lines. • Curved ends.	1 Direction and: • Evenly spaced parallel lines. • Curved ends.	• 1 Direction with evenly spaced parallel lines and Curved ends.
2(c)	$E = \frac{V}{d}$ $E = \frac{45}{8.0\times10^{-3}}$	2 $E = \frac{45}{8.0\times10^{-3}}$		
2(d)	$E = \frac{V\ (\text{V})}{d\ (\text{m})}$ $E = \frac{F\ (\text{N})}{q\ (\text{C})} = \text{N C}^{-1}$ $E = \frac{E_P\ (\text{J})}{q\ (\text{C})\ d\ (\text{m})} = \text{J C}^{-1}\text{m}^{-1}$	1 One unit correctly derived. • $E = \frac{V\ (\text{V})}{d\ (\text{m})}$ • $E =$ N C^{-1} • $E =$ J C^{-1} m^{-1}	1 any 2 correct	
2(e)	$F = Eq$ $F = 5625\times1.6\times10^{-19}$ N $F = 9.0\times10^{-16}$ N	2 9×10^{-16}		

2(f)	The electron experiences an electric force and is moving in the same direction as the electric force, hence it is losing electrical potential energy but gaining kinetic energy as it accelerates.	• [1] the electron experiences ***work / attraction / repulsion / force / acceleration***. • the electron ***moves*** in the electric field / to the positive plate. • Velocity or Kinetic energy *increases*.	• [1] any 2 correct linked ideas	• [1] All 3 correct linked ideas.

QUESTION 11: CAMP TORCH *(NCEA 2006, Q1)*

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
1(a)	$V = \frac{E}{q}$ *E* = *Vq* 1.5 J (Can be answered from definition, so does not need to show working.)	[2] Correct. • 1.5		
1(b)	$I = \frac{V}{R}$ $I = \frac{1.5}{5}$ *I* = 0.3 A	[2] Correct • 0.3		
1(c)	• Resistance is the slowing down of electrons as they flow through a conductor	[1] A correct concept. • Slowing electron/		

	when the ends of the conductor are connected to a supply of electrical energy • a measure of how much a component opposes the flow of electrons through itself • ratio of V/I	current flow • Opposing electron/ current flow • **ratio** of V/I • $\Omega = {}^{V}/_{Cs^{-1}}$		
1(d)	$I = \frac{Q}{t}$ $Q = It$ Q = 0.3 × 3 × 60 (**consequential** on 1(b)) Q = 54 C	• [2] Calculated without converting minutes to seconds • 0.3 x 3 = 0.9 • 0.3 x 60	[2] Correct answer with working. • Q = 0.3 × 3 × 60 Q = 54	

QUESTION 12: CLAIRE'S CAR LIGHTS *(NCEA 2011, Q3)*

THREE (a)	When the bulb has 12 V across it, the power output is 5 W.	[1] Correct answer. (Must link power of 5W to 12V)		
(b)	$P = VI$ $I = \frac{P}{V}$ $I = \frac{5}{12} = 0.42 \text{ A}$	[2] Correct answer.		

QUESTION 13: CAMP RADIO *(NCEA 2006, Q1)*

1(a)	1.5 × 3 = 4.5 V	[2] Correct answer. • 4.5		
1(b)	$R = 14 + (4.00^{-1} + 4.00^{-1})^{-1}$	[2] Adds resistors in	[2] Correct	

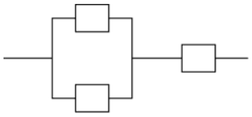
	= 16.0 Ω	parallel • $(4.00^{-1} + 4.00^{-1})^{-1}$ • 2.00 • 14 + 0.5 = 14.5	calculation. 14.0+2.00=16.0	
	Sf = 3	[1] 3 significant figures		
1(c)	Total current = $I = \frac{V}{R}$ $I = \frac{4.5}{16}$ I = 0.281 A Voltage across radio $V = IR$ $V = 0.281 \times 14.0$ V_{radio} = 3.94 V Voltage across lamp = 4.5 – 3.94 = 0.56 V (**consequential** on 1(e),1(f))	• [2] Calculated total current. I = 0.281	• [2] Voltage across radio $V = 0.281 \times 14.0$ V_{radio} = 3.94 • $I_{4\Omega} = ½ \times 0.281$	[2] Working and answer correct. • V_{lamp} = 4.5 – 3.94 = 0.56 • $V_{lamp} = 4 \times .14$ = 0.56 • Voltage across parallel resistance $V_{parallel} = .281 \times 2$ = 0.56 • $\frac{4.5}{16} \times 2 = 0.56$

QUESTION 14: DC ELECTRICITY *(NCEA 2010, Q2)*

TWO (a)	$$R_{\text{parallel}} = \left(\frac{1}{6}+\frac{1}{5}\right)^{-1} = 2.73$$ $$R_T = 3.0 + 2.73 = 5.73\ \Omega$$ $$= 5.7\ \Omega$$	2 Correct substitution. Eg 1/6 + 1/5 OR Correct calculation of effective resistance in series = 6.0 Ω	2 Correct except for one error. Eg finds 2.73.	2 Correct answer.
(b)	$$I = \frac{V}{R} = \frac{12}{5.73} = 2.09\ \text{A} = 2.1\ \text{A}$$	2 Correct answer. OR **Consequential from 2(a).**		
(c)	$$V_{3\Omega} = 2.09 \times 3.0 = 6.27\ \text{V}$$ $$V_{5\Omega} = 12 - 6.27 = 5.73\ \text{V}$$ $$I = \frac{5.73}{5} = 1.15A$$ OR $$I_{5.0\Omega} = \frac{6}{11} \times 2.09 = 1.15\ \text{A}$$	2 Correct answer to voltage across 3 Ω resistor. **6.27**	2 Correct answer to voltage across 5 Ω resistor. **5.73**	2 Correct answer. **1.15**
(d)	The brightness of a lamp depends on its power output. Power depends on the current through and the voltage across the lamp. ($P = VI$ or $P = I^2R$) The 3 Ω lamp will be the brightest because its power output is the greatest. (P = 6.28 × 2.09 = 13.12 W). The current through the branch with the 4.0 Ω resistor is only (2.09 – 1.14) = 0.95 A. Hence the power output of that lamps will be $0.95^2 \times 4.0 = 3.61$ W	1 Recognition that brightness of a lamp depends on its **power** output. OR **Power** depends on the current through and the voltage across a component. OR Shows the calculation for **power** for any one lamp in the circuit.	1 Recognition that brightness of a lamp depends on its power output. AND Power depends on the current through and the voltage across a component. OR Shows the calculation for power for any one lamp in the circuit.	1 Recognition that brightness of a lamp depends on its power output. AND Power depends on the current through and the voltage across a component. AND Shows the calculation for power for the two lamps in the circuit.

QUESTION 15: THE MP3 PLAYER *(NCEA 2007, Q2)*

TWO (a)	$R = \frac{V}{I} = \frac{4.5}{25 \times 10^{-3}} = 180\ \Omega$	[2] Correct except for unit conversion.	[2] Correct answer.	
(b)	$V = 12.0 - 4.5 = 7.5\ V$	[2] Correct working.		
(c)	$I_t = \frac{V}{R} = \frac{7.5}{214} = 0.035\ A$ current through $R = 0.035 - 0.025$ $= 0.010\ A$ $R = \frac{V}{I} = \frac{4.5}{0.01} = 450\ \Omega$ **Or** Circuit *R* = $\frac{12}{0.035} = 342.4$ *R* of parallel branch = 342.4 – 214 = 128.4 And $\frac{1}{R} = \frac{1}{128.4} - \frac{1}{180}$ gives *R* = 450	[2] Calculates total current. **0.035**	[2] Calculates current through R. **0.035 -0.025=0.01** [2] Correct method but makes a computational error [2] **Calculates** $R_t = 342.4$	[2] All working correct. **Needs 4.5/0.01=450 or equiv** **Or** **Evidence of solving R in parallel combination**
(d)	Total resistance increases. (to 664) Total current decreases. (was 0.03 now 0.018) Current through 214 Ω resistor decreases. Voltage across 214 Ω resistor decreases (*V*= *IR*). (was 7.5 now 3.85)	[1] Voltage decreases (across 214) [1] Voltage increases across **R (**450 Ω) [1] Total *R* increases [1] Current decreases	[1] Two ideas [1] Voltage decreases because current decreases	[1] Full and clear explanation clearly linking ideas. (Can have maths but needs written explanation)
(e)	Both resistors are in series, therefore carry same current. 450 Ω resistor has higher resistance therefore higher voltage. ($V = IR$) Therefore higher power output, (P=VI), therefore more heat output in the same time $P = I^2R$ so same current means bigger resistor (450/R) gives more power and more heat.	[1] 450 Ω/**R** resistor produces more heat. [1] Current through both 214 and *R* the same [1] Biggest *V* gives biggest power [1] 214 produces less [1] Now a series circuit [1] links power to heat	[1] Two linked ideas ie [1] same current- higher *V* (gives more heat) [1] same current so higher *R* (gives more heat) [1] *R* as larger	[1] Full and clear explanation clearly linking ideas. Should mention that heat relates to power or (energy and volts)could be explicitly stated or by stating P=IV or $P = I^2R$

(f)		[2] Correct answer.		

QUESTION 16: ELECTRIC CIRCUITS *(NCEA 2009, Q2)*

TWO (a)	$I = \frac{V}{R} = \frac{12}{12} = 1.0\text{ A}$	2 Correct answer.		
(b)	$R_P = 4\ \Omega$ $R_{Tot} = 10\ \Omega$ $I = \frac{V}{R} = \frac{12}{10} = 1.2\ \text{A}$ current through $12\ \Omega$ is $\frac{1}{3} \times 1.2 = 0.4\ \text{A}$ $V = IR = 0.4 \times 12 = 4.8\ \text{V}$ or $\text{V} = \frac{4}{10} \times 12 = 4.8\ \text{V}$	2 One correct step. Eg 10 ohms or 4 from parallel.	2 Correct answer except for one error. Eg 1.2 A	2 Correct answer.
(c)	If the resistance increases, the total resistance increases and the total current decreases. This means the voltage across the two series resistors decreases.	1 One correct idea. Must answer question correctly.	1 Two correct ideas.	1 Correct answer and explanation.

QUESTION 17: ELECTRIC CIRCUITS *(NCEA 2008, Q2)*

TWO (a)	12 J	**Two grades here** 2 Correct number. 2 Correct unit.		
(b)	**This is a "show" question**: $4.5 + \left(\frac{1}{3.4} + \frac{1}{5.2}\right)^{-1}$ = 4.5 + 2.06 = 6.56 Ω	2 States $\frac{1}{R} = \frac{1}{3.4} + \frac{1}{5.2}$	**This is a "show" question**: 2 Correct working.	
(c)	$I = \frac{V}{R} = \frac{12}{6.56} = 1.83A$	2 Correct answer.		

(d)	Effective resistance of 3.4 Ω and 5.2 Ω = 2.06 and V=IR=1.83 × 2.06 = 3.8 V **OR** Voltage across 4.5 Ω resistor is: $V = IR$ = 8.235 V Voltage across the 3.4 Ω resistor is 12 – 8.235 = 3.8 V		[2]Calculates voltage correctly. 3.8 V	
(e)	The voltage across the 5.2 Ω resistor will also be 3.8 V, as it is in parallel with the 3.4 Ω resistor.	[1]Mentions that the voltage is 3.8 V.	[1]Achievement, plus states that this is because it is in **parallel** with the 3.4 Ω resistor.	

QUESTION 18: Mike's MotorBike *(NCEA 2005, Q2)*

2(a)	$I = \dfrac{V}{R}$ = 6.0/1.2	[2] Correct substitution.		
2(b)	P = V × I = 6.0 × 5.0 = 30 W	[2] Correct answer.		
		[1] Correct unit.		
2(c)	When the switch is closed, the current quickly increases, the lamp filament quickly heats up, the resistance increases, so the current will decrease to a steady value. (Must discuss the headlamp only.)	[1] Current increases. [1] Reaches a steady value. [1] Bulb heats up. [1] Resistance increases. [1] Current decreases.	[1] Correctly links TWO ideas. (Changing current qualified.)	[1] Correctly links THREE connected ideas in a clear explanation.

2(d)	The headlamp draws 5.0 A. The tail lamps are in parallel so must draw 1 A. Therefore their combined resistance is: $R = \frac{V}{I}$ $= \frac{6.0}{1}$ $= 6.0\ \Omega$ each tail lamp is therefore 3.0 Ω.	[2] Resistance of each tail light is $\frac{1}{2}$ total resistance of the branch [2]Calculation of correct current (1A) [2] 3 V across each tail light [2] 3 (unjustified)	[2] TWO correct calculations. [2]Calculation of total R in the tail light branch as 6.0 Ω. [2] Correct use of $^{V}/_{I}$ to find $R_{\text{Tail light}}$	[2] Correct answer.
	ALTERNATIVELY $I = 6.0$ A $V = 6.0$ V $R = \frac{V}{I} = \frac{6}{6} = 1.0\ \Omega$ For parallel resistors : $\frac{1}{R_1} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{R_{\text{headlamp}}} + \frac{1}{R_{\text{taillamps}}}$ $\Rightarrow \frac{1}{1.0} = \frac{1}{1.2} + \frac{1}{R_{\text{TLS}}}$ $\Rightarrow \frac{1}{R_{\text{TLS}}} = \frac{1}{1.0} - \frac{1}{1.2} = \frac{1.2 - 1.0}{1.2} = \frac{0.2}{1.2}$ $\Rightarrow R_{\text{TLS}} = \frac{1.2}{0.2} = 6.0$ Each lamp is therefore 3.0 Ω	[2] Calculation of total resistance as 1.0 Ω. [2] Currrent ratio 5:1	[2]Correct substitution in parallel resistors formula. [2] $R_{\text{Tail light}}$ 1:5 1.2 : 6 □	[2] $^{6}/_{2} = 3\ \Omega$

QUESTION 19: ELECTROMAGNETISM *(NCEA 2006, Q3)*

3(a)	The moving electrons would experience a force and move towards A, leaving end B positive.	• [1] ***moving*** charge experiencing a force. • Electrons move up the rod. • End A negative. • End B positive.	[1] ***Moving*** electron experiences an upward force and either A negative or/and B positive.	
3(b)	Since the circuit is now complete, the induced voltage would cause an anticlockwise current in the circuit (or would cause electrons to flow in a clockwise direction).	• [1] Current produced. • Voltage produced. • Electron flow.	• [1] Voltage causes a current/ electron flow. • Anticlockwise current. • Clockwise electron flow.	• [1] Voltage causes an ***anticlockwise current*** in the circuit. • Voltage causes a ***clockwise electron*** flow.

3(c)	$V = BvL$ $V = 0.8 \times 4.0 \times 10 \times 10^{-2}$ $V = 0.32$ V $I = \dfrac{V}{R}$ $I = \dfrac{0.32}{2}$ $I = 0.16$ A	[2] Induced voltage calculated (*ignore std form).* • 32	[2] Correct Voltage • 0.32 • 16	[2] Correct current • 0.16
3(d)	Arrow going from N to S. $\longrightarrow$	[1] Correct answer. $\longrightarrow$		
3(e)	Up $\uparrow$	[1] Correct answer $\uparrow$ • Up		
3(f)	When a conducting wire carrying current is placed perpendicularly in a magnetic field, the electrons moving in the wire experience a force causing the wire itself to move in a direction that is perpendicular to both the direction of the magnetic field, and the current. The charge is cutting across the field.	• [1] Charge moving in the magnetic field. • Current in the rod. • Rod perpendicular to the magnetic field. • Magnetic field around the rod.	• [1] Electrons travelling across the magnetic field. • Current carrying rod across the magnetic field. • The magnetic **fields** add / subtract.	• [1] Explanation of the magnetic flux difference.
3(g)	$F = BIL$ $F = 0.90 \times 3.2 \times 0.10$ $F = 0.288$ N = **0.29** N	[2] Correct answer. • 0.288 • 0.29		

	Two sig figs.	[1] 2 sig. figures. = .29		

QUESTION 20: ELECTROMAGNETIC SWING *(NCEA 2011, Q2)*

TWO (a)	Electrons flow from the negative terminal in the direction X→Y These electrons are cutting across a magnetic field that is towards the bottom of the page. Each electron experiences a force in the direction "A" This causes the wire to experience a force and to swing in direction "A" OR can explain in terms of conventional current.	[1] The loop swings in direction "A".	[1] Direction of charge flow and loop movement correct. OR Current direction and wire perpendicular/crossing/cutting (not in) field.	[1] Full explanation. Loop movement + Current flow + perpendicular / cutting / across (not in).
(b)	$V = IR$ $I = \frac{V}{R}$ $I = \frac{6.0}{1.8} = 3.33 \text{ A}$ $F = BIl$ $l = \frac{F}{BI} = \frac{0.25}{2.0 ´ 3.33}$ $l = 0.038 \text{ m}$	[1] ONE correct calculation.	[2] All correct except for ONE error. Stops at 0.038 m.	[2] Correct answer. Must have = 3.8 cm.
(c)	Electron – direction "C" (or left).	[1] Correct answer.		
(d)	$V = Bvl$ $v = \frac{V}{Bl}$ $v = \frac{11 ´ 10^{-3}}{2 ´ 0.0375}$ $v = 0.1467 = 0.15 \text{ m s}^{-1}$	[1] Correct except for one error.	[2] Correct answer.	

QUESTION 21: MAGNETIC FIELDS *(NCEA 2009, Q3)*

THREE (a)	To the right.	[1] Correct answer.		

(b)	$I = \frac{V}{R} = \frac{12}{18} = 0.666\,\text{A}$ $F = BIl = (4\times10^{-4})\times0.66\times8$ $F = 2.1\times10^{-3}\,\text{N}$	[2] Correct current.	[2] Correct answer except for one error. Eg no unit.	[2] Correct answer.
(c)	No. The two wires carry current in opposite direction. The force on the two wires is in the opposite direction. The forces are equal and so they cancel.	[1] No force. Except if because yachts are stationary.	[1] Currents are equal and opposite.	[1] No. Currents opposite, forces equal and opposite.
(d)	Yes there is a voltage induced because the two wires are **cutting** across a magnetic field. This causes an induced voltage.		[1] Correct answer. Must convey **movement** at 90 deg to /across field.	
(e)	$F = Bvq$ $F = 4\times10^{-4}\times3.0\times1.6\times10^{-19}$ $F = 1.9\times10^{-22}\,\text{N}$	[2] Correct answer.		

QUESTION 22: THE MODEL RAILWAY *(NCEA 2007, Q3)*

THREE (a)	Battery causes electrons to flow in axle. These electrons are moving perpendicular to a magnetic field. The electrons experience a force perpendicular to the axle and the field. The electrons are trapped in the axle so the whole axle experiences a force.	[1] one idea [1] Charge moving through a field experiences a force [1] Current flowing makes magnetic field.	[1] Force on charges. moving in magnetic field results in **force** on the **axles**. [1] The two magnetic fields interact and produce force (on axle).	
(b)	In / (arrow indicating left to right)	[1] Correct answer.		

(c)	$F = BIl$ $F = \frac{0.052}{2}$ $I = \frac{F}{Bl} = \frac{0.026}{0.25 \times 35 \times 10^{-3}}$ $I = 2.97\ \text{A}$ $\text{battery current} = 5.94\ \text{A}$ $V = IR$ $V = 5.94 \times 0.55$ $V = 3.3\ \text{V}$	[2] Correct equation and calculation of current. **2.97 or rounded** **OR 5.94**	[2] Correct process for calculating voltage but with one error. Eg does not double = 1.6 / allow incorrect length conversion but **not 35.**	[2] Correct working and answer. **Accept any rounding eg 3.2, 3.27 etc.**
(d)	$V = Bvl$ $V = 0.25 \times 0.29 \times 35 \times 10^{-3}$ $V = 2.5\ \text{mV}$ **Only penalise the same incorrect length conversion once from c and d**	[2] Correct answer except for one error eg for unit conversion of either length or to mV **OR** incorrect length **OR** combining both axles.	[2] Correct answer.	
(e)	As the carriage rolls, the axles (and the electrons) cut across the magnetic field, the electrons in the wire get pushed to one end of the wire. This causes a build-up of negative charge at one end of the axle.	[1] One correct idea. [1] **Force /push** on electrons [1] Charge moving through mag field	[1] Full and clear explanation clearly linking ideas. [1] electrons then move / shift towards one end.	
(f)	The axle has an induced voltage across it, but the connecting wire is also cutting across the magnetic field. It also has an induced voltage. The two voltages oppose each other, so the induced current is zero.	[1] No current flows, [1] Induced voltage in axle [1] Induced voltage in wire	[1] Idea of two induced voltages. [1] lamp does not operate. **Contradictory statements will not negate achievement.**	[1] Full and clear explanation clearly linking ideas. [1] Two opposite induced Voltages cancel. [1] No change in flux as entire circuit / loop in field means no light / current.

QUESTION 23: THE ELECTRIC MOTOR *(NCEA 2010, Q3)*

(a)	$I = \frac{V}{R} = \frac{12}{4.5} = 2.67\ \text{A}$ $F = BIL$ $F = 0.75 \times 2.67 \times 12 \times 10^{-2}$ $F_{1\ \text{turn}} = 0.24\ \text{N}$ $F_{100\ \text{turns}} = 0.24 \times 100 = 24\ \text{N}$	2 Correct answer to current. **2.67** OR Correct use of F= BIL with incorrect value of current.	2 Correct answer for force on a single turn. OR One mistake in calculation, eg missing cm conversion.	2 Correct answer.
(b)	Wire AD is parallel to the magnetic field. OR The wire does not cut the field. Or equivalent.	1 Correct answer.		
(c)	Increase strength of magnetic field. Increase current / voltage / batteries. Increase length of **coil** or have more turns of wire. **Not increase the length.**	1 Any TWO correct answers.		

QUESTION 24: Generator *(NCEA 2008, Q3)*

THREE (a)	$V = BvL = 0.75 \times 0.20 \times 0.146 \times 2$ $V = 0.044\ \text{V}$	2 Correct except for one mistake. Either incorrect unit conversion (4.4) or missing x2 (0.022)	2 Correct answer. 0.044	
(b)	**Stronger magnetic** field, **longer** length of **wire** in the field, **increasing the speed** with which the wire is made to move in the magnetic field.	1 Correct answer.		

QUESTION 25: INDUCTION *(NCEA 2004, Q3)*

3(a)	Current requires a closed circuit/ this set up is not a closed circuit.	[1] Correct answer.		
3(b)(i)	Upward arrow labelled field, or B.	[1] Correct answer.		
3(b)(ii)	Arrow towards right labelled force.		[1] Correct answer.	
3(c)	Voltage from completed circuit causes electrons to move through the rod. Electrons moving, or current, across magnetic field experience a force. Therefore rod experiences a force/moves.	[1] *Any valid single and relevant idea.*	[1] *Some understanding of force produced as electrons move across field, or current carrying wire in a magnetic field experiences a force.*	[1] Correct answer linking current or electron flow at (right) angles/across to the magnetic field and to the force.
3(d)	$I = \frac{V}{R}$ $\quad F = BIL$ $F = B \times \frac{V}{R} \times L$ $F = 0.15 \times 4.8 \times 0.06$ $= 0.043$ N *or consistent selection of $L = 0.08$cm. Nb $v = 0.042$ ms^{-1}.*	[2] *Correct calculation of current.*	[2] *Correct calculation of current, and recognition that $F = BIL$* *or* *incorrect I with correct F for this I.*	[2] Correct method and answer.
3(e)	$V = BvL$ $v = \frac{V}{BL}$ $v = 0.056$ m s^{-1} Nb $\frac{5 \times 10^{-4}}{0.15 \times 0.06}$	[2] *Correct formula and either correct rearrangement.* *or correct substitution.*	[2] Correct method and answer.	
3(f)	Either: Moving rod generates a small current in itself. Current flowing across a magnetic field creates a force. This force opposes the motion of the rod. OR: The moving rod is producing electrical energy. This energy must come from somewhere. It comes from the loss of kinetic energy of the moving rod.	[1] *Any single valid and relevant idea.*	[1] *States that there will be an opposing magnetic force acting on the rod.* [1] *Mention of energy or work to create a current.*	[1] Clear understanding of the link between the induced current and the opposing force created by it. OR: [1] Clear understanding of the link between the conversion of kinetic energy into electric energy.

L2 E+M Matching Answers:

1. ZZ
2. C
3. W
4. WW
5. TT
6. CC
7. Q
8. QQ
9. G
10. J
11. UU
12. S
13. F
14. XX
15. O
16. DD
17. BB
18. PP
19. AAA
20. FF
21. Z
22. RR
23. X
24. I
25. MM
26. SS
27. A
28. B
29. M
30. H
31. VV
32. I I
33. U
34. YY
35. Y
36. FF
37. NN
38. N
39. LL
40. P
41. V
42. CCC
43. KK
44. D
45. AA
46. OO
47. T
48. K
49. L
50. E
51. R
52. GG
53. BBB
54. EE
55. HH