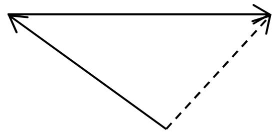
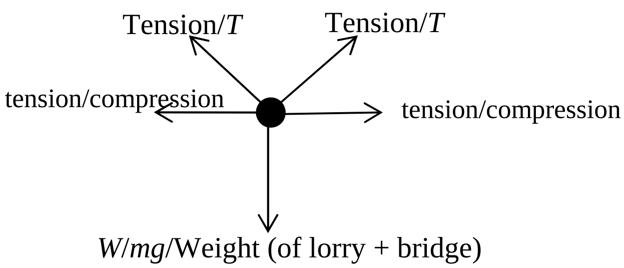
Question Number	Answer	Mark
1(a)	Construction of a vector triangle or parallelogram (labels not required but arrows must be included and in the correct direction) **(1)** Magnitude = 13 N to 14 N **(1)** Direction to 16 N force = 47 ° to 48° **(1)** <u>Example of diagram</u> 	**3**
1(b)(i)	(A quantity with both) magnitude/size **and** direction **(1)**	**1**
1(b)(ii)	**Any 2 from** Displacement Velocity Acceleration Momentum **(1)** (Do not award this mark if additional quantities that are not vector are also given or for any examples of forces e.g. upthrust or weight)	**1**
	Total for Question	**5**

Question Number	Answer	Mark
2(a)	Both upward tensions labelled **(1)** Weight labelled **(1)** (allow 2 separate arrows for the weight of the bridge and the lorry) Tension **and/or** compression labels for the horizontal force **(1)** (-1 for any additional forces and all lines must touch the dot)  	**3**
2(b)	(Diagonal) beams create a upward/vertical force **(1)** The idea that the beams support/distribute/share the weight **Or** to prevent the bridge from sagging **Or** to reduce the tension/compression in the horizontal section of the bridge **(1)**	**2**
	Total for Question	**5**

Question Number	Answer		Mark
3(a)	Variable resistor in series Ammeter in series and voltmeter in parallel with cell (If there are extra fixed resistances they can be ignored, as long as the terminal p.d. is being measured. Assume the ammeter has zero resistance, so its precise placement doesn't matter as long as it is in series)	**(1)** **(1)**	**2**
3(b)	Best fit straight line drawn Substitution of values from student's line for gradient using at least half current axis ($\Delta I \geq 80$ mA) $\mathcal{E}$ = 3.9 V to 4.1 V r = 1.6 Ω to 2.5 Ω <u>Example of calculation</u> gradient = (3.7 V – 4.0 V) / 0.16 A = – 1.9 Ω	**(1)** **(1)** **(1)** **(1)**	**4**
3(c)	Start *y*-axis at 3.0 V (accept reference to points from 3.0 to 3.75 V) This will allow plots to be made more accurately **Or** This will allow intercept and change in *V* to be determined to more sf **Or** this will allow read-offs to be made with more precision (Only award this mark if first mark awarded)	**(1)** **(1)**	**2**
	Total for Question		**8**

Question Number	Answer		Mark
4(a)	Negative gradient (accept curve)	**(1)**	
	Straight line (dependent on first marking point)	**(1)**	
	Reference to terminal p.d. = e.m.f. – 'lost volts' **Or** $V = \varepsilon - Ir$	**(1)**	
	Intercept on V axis = ε **Or** Intercept on y axis = ε **Or** ε **=** value of V on graph when $I = 0$ (accept from labelled graph)(mark not awarded if line passes through origin)	**(1)**	
	Gradient = $-r$ **Or** magnitude of gradient is r (accept gradient = $-r$ marked on graph)	**(1)**	**5**
***4(b**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Ammeter explanation:**		
	If ammeter has resistance, current decreased	**(1)**	
	but doesn't affect the determination because current through cell/r is measured **Or** doesn't affect the determination because the voltmeter measures the terminal p.d. for that current	**(1)**	
	OR		
	The resistance of the ammeter contributes to the load/circuit/total resistance	**(1)**	
	Values of p.d. corresponding to given values of current will be unchanged	**(1)**	
	Voltmeter explanation:		
	If voltmeter has smaller resistance it would draw current	**(1)**	
	measured current not current through cell/r	**(1)**	**4**
	Total for question		**9**

Question Number	Answer	Mark
5(a)(i)	resultant e.m.f. = 15 V – 7.6 V = 7.4 V **(1)**	
5(a)(ii)	Total resistance = 0.65 Ω + 0.050 Ω = 0.70 Ω **(1)**	
5(a)(iii)	Use of $I = V/R$ **(1)** I = 11 A (allow ecf for values from (i) & (ii)) **(1)** (22.6 V gives 32.3 A) <u>Example of calculation</u> I = 7.4 V/ 0.7 Ω I = 10.6 A	**2**
5(b)(i)	Use of p.d. across series resistance = 4.3 A× 0.65 Ω **(1)** Subtraction of calculated p.d. value from 15 V **(1)** Terminal p.d. = 12.2 (V) [no ue] **(1)** **OR** Use of p.d. across internal resistance of battery = 4.3 A× 0.05 Ω **(1)** Addition of calculated p.d. value to 12 V **(1)** Terminal p.d. = 12.2 (V) [no ue] **(1)** <u>Example of calculation</u> p.d. across internal resistance = 4.3 A× 0.65 Ω = 2.8 V Terminal p.d. = 15 V – 2.8 V Terminal p.d. = 12.2 V	**3**
5(b)(ii)	Use of $P = VI$ **(1)** Rate of energy = 65 W **(1)** <u>Example of calculation</u> Power = 15 V × 4.3 A Power = 64.5 W	**2**
5(b)(iii)	Use of $P = I^2r$ (to find wasted power for internal resistance, series resistance or total resistance) (allow ecf from (a)(ii)) **(1)** Subtraction of this value from answer to (b)(ii) (allow ecf) **(1)** Efficiency = 80% (allow ecf) **(1)** **Or** 12 V × 4.3 A (for useful power = 51.6 W) **(1)** Use of ratio of useful power/total power **(1)** Efficiency = 80% **(1)** (efficiency = ratio of emfs leading to 80% scores 3 marks) <u>Example of calculation</u> Wasted power = $(4.3\ \text{A})^2 \times 0.7\ \Omega$ = 13W Efficiency = (65 – 13)/65 Efficiency = 80%	**3**
	Total for question	**12**

Question Number	Answer	Mark
6(a)	Explain the difference between scalar quantities and vector quantities. It must mention direction or give an e.g. with direction. [Vectors have direction 1 mark. Scalars don't have direction 1 mark] scalar – magnitude/size only but vector – magnitude/size and direction (1) (accept vector has direction but scalar doesn't)	1
6(b)	Comment on this statement. (QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) velocity is: a vector / speed in a given direction / = displacement/time / = (total distance in a particular direction)/time [accept references to velocity being postive and negative / changing direction] (1) end and start at the same place / distance in any direction is zero / displacement = 0 (1) so it's true – (ave) vel = zero (1) (consequential on 2nd mark)	3
	Total for question	**4**

Question Number	Answer		Mark
7(a)(i)	4.0 Ω	**(1)**	**1**
7(a)(ii)	Use of $V=IR$ I = 0.75 A (ecf) Example of calculation I= 3 V / 4 Ω I= 0.75 A	**(1)** **(1)**	**2**
7(a)(iii)	Use of $P = I^2R$ **or** $P = VI$ **or** $P=V^2/R$ Power = 2.0 W (ecf) Example of calculation P = (0.75 A)^2 x 3.6 Ω P= 2.0 W	**(1)** **(1)**	**2**
7(b)	Total resistance (of circuit) will increase Current will decrease Reference to $P = I^2R$ to explain power decreasing **Or** $P = VI$ to explain power decreasing **Or** Lost volts increases **Or** Ir increases V across element decreases Reference to $P = VI$ to explain power decreasing **Or** $P=V^2/R$ to explain power decreasing	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
	Total for question		**8**

Question Number	Answer		Mark
8(a)	State (V =) $E - Ir$ Correct substitution p.d. = 1 **OR** Use of (V =) Ir to attempt to find lost volts Subtraction from E p.d. = 1 **OR** Use of $E = I(R+r)$ to attempt to find R Use of $V = IR$ with the value of R calculated p.d. = 11V <u>Example of calculation</u> $V = 12\text{ V} - 3 \times 10^{-3}\ \Omega \times 400\text{ A}$ p.d. = 10.8 V	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
8(b)	To prevent large energy dissipation / wire heating up / wire melting / large pd across the wires OR to allow a large current Resistance of cable low (cross-sectional) area large [Not surface area] [Reverse argument in terms of a thin wire acceptable for all points]	**(1)** **(1)** **(1)**	**3**
	Total for question		**6**

Question Number	Answer	Mark
9(a)	Use of potential divider formula with 40 Ω in numerator and 120 Ω in denominator V = 3.0 V **OR** ohm's law to whole circuit to find current (1) V=IR applied to 40 Ω resistor (1) **Example of answer** p.d. = 40 × 9.0 / (40 + 80) p.d. = 3.0 V	 **1** **1**
(b)	**QOWC** **Work must be clear and organised in a logical sequence** Resistance of parallel combination increases as temperature decreases Total resistance of circuit increases e.m.f./p.d. remains constant therefore current decreases.	 **1** **1** **1**
	Total for question	**5**

Question Number	Answer	Mark
10	p.d. is electrical energy(/coulomb) transferred between two points/electrical energy transformed/converted to other forms (1) e.m.f is the energy(/coulomb) supplied to a circuit/given to the charge/energy output of the cell (1) (full credit if wording implies emf as electrical energy source and pd as electrical energy sink) If neither mark scored but reference to energy/charge is made scores 1 mark only	**2**
	Total for question	**2**