Answers to examination-style questions

Answers	Marks	Examiner's tips
1 **(i)** three resistors drawn in series	**1**	The largest resistance is when the resistors are all connected in series.
(ii) $R = 3.0 + 4.0 + 6.0 = 13\ \Omega$	**1**	
(iii) three resistors drawn in parallel	**1**	Adding resistors in parallel creates extra paths for the current and thus lowers the total resistance.
(iv) $\frac{1}{R} = \frac{1}{3.0} + \frac{1}{4.0} + \frac{1}{6.0} = \frac{9}{12}$	**1**	
gives $R = 1.3\ \Omega$	**1**	Don't forget to invert ($1/R$) in parallel circuit calculations.
2 **(a)** circuit resistance is now only $30\ \Omega$	**1**	Connecting a wire of negligible resistance in parallel with a component provides the easiest possible path for the current. All of the current is now in the short circuit and none in the $60\ \Omega$ resistor (which is therefore effectively missing from the circuit).
current $I = \frac{V}{R} = \frac{6.0}{30} = 0.20$ A	**1**	
(b) two resistors in parallel give $\frac{1}{R} = \frac{1}{60} + \frac{1}{30} = \frac{1}{20}$	**1**	The $60\ \Omega$ resistor and the new $30\ \Omega$ resistor now form a parallel combination. Find the resistance of this combination and add it to the original $30\ \Omega$ (which is connected in series) to find the total resistance of the circuit.
and $R = 20\ \Omega$	**1**	
total resistance $= 20 + 30 = 50\ \Omega$	**1**	
current $I = \frac{V}{R} = \frac{6.0}{50} = 0.12$ A	**1**	
3 **(a)** resistance is defined by $R = \frac{\text{potential difference}}{\text{current}}$ **or** $R = (V/I)$, with all three symbols defined	**2**	If you stated the equation $R = (V / I)$ without giving the meaning of R, V and I you would be awarded 1 mark only.
(b) two resistors in parallel give $\frac{1}{R} = \frac{1}{3.0} + \frac{1}{6.0} = \frac{1}{2}$	**1**	Find the resistance of the parallel combination first. You then know that it is equivalent to a single $2.0\ \Omega$ resistor that is connected in series with the $9.0\ \Omega$ resistor.
and $R = 2.0\ \Omega$	**1**	
total resistance $= 2.0 + 9.0 = 11\ \Omega$	**1**	
(c) **(i)** pd across parallel resistors $V = I\,R = 2.4 \times 2.0 = 4.8$ V	**1**	The total current in the two parallel resistors must be equal to that in the $9.0\ \Omega$ resistor. The pd across them is this current multiplied by their effective resistance, which you calculated at the start of **b**.
current in $3.0\ \Omega$ resistor $I = \frac{V}{R} = \frac{4.8}{3.0} = 1.6$ A	**1**	
(ii) total power $P = I^2 R = 2.4^2 \times 11$	**1**	This is the power dissipated in **all** the resistors, so the resistance required is that of the complete arrangement. From part **(b)** this is $11\ \Omega$. The current in the $9.0\ \Omega$ resistor, and in the parallel combination of $2.0\ \Omega$, is 2.4 A.
$= 63$ W	**1**	

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4 (a) first two parallel resistors give $\left(\frac{1}{30}+\frac{1}{60}\right)^{-1} = 20\ \Omega$	1	In this instance you are expected to do **all** of the calculation for each of the parallel combinations before being given the marks for them. The parallel combinations are connected in series, so simple addition leads to the third mark.
second two parallel resistors give $\left(\frac{1}{90}+\frac{1}{(15+30)}\right)^{-1} = 30\ \Omega$	1	
total resistance = 20 + 30 = 50 Ω	1	
(b) (i) charge $\Delta Q = I\,\Delta t = 50 \times 10^{-3} \times 4 \times 60$	1	The current in resistor R is the same as that in the ammeter, because they are connected in series.
$= 12$ C	1	
(ii) pd across R, $V = \frac{W}{Q} = \frac{18}{12}$	1	Potential difference is the work done (or energy transferred) per unit charge.
$= 1.5$ V	1	*Alternative approach:* From $W = I\,V\,t$, $V = \frac{W}{It} = \frac{18}{(50 \times 10^{-3} \times 4 \times 60)} = 1.5$ V
(iii) resistance $R = \frac{1.5}{50 \times 10^{-3}} = 30\ \Omega$	1	You calculated the pd across R in **(ii)** above, and (in effect) you were told the current in it in **(i)**.
(iv) emf $\varepsilon = I \times R_{total} = 50 \times 10^{-3} \times (50 + 30)$ $= 4.0$ V	1	When its internal resistance is negligible, the emf of a battery is equal to the total pd across the external resistors.
5 (i) $I = \frac{\varepsilon}{R+r} = \frac{12}{60+2}$	1	Resistors A and B are in series, so the total external resistance is 30 + 30 = 60 Ω.
$= 0.194$ A	1	
(ii) pd across PQ = pd across total external resistance $= I\,R = 0.194 \times 60$	1	You could do this part by other means, such as subtracting the 'lost volts' from the emf of the battery.
$= 11.6$ V	1	
(iii) power $P = I^2 R = 0.194^2 \times 30$	1	The resistance of resistor A is 30 Ω and the current in it is that calculated in **(i)**.
$= 1.13$ W	1	
(iv) energy dissipated $= Pt = 1.13 \times 20$	1	Once you have found the power in **(iii)**, multiplying it by the time will give the energy dissipated.
$= 23$ J	1	
6 (a) current $I = \frac{\varepsilon}{R_{total}} = \frac{12}{10+15} = 0.48$ A	1	Work from first principles by first calculating the current I and then finding V_B by using $V = I\,R$. Alternatively you could write down the potential divider equation and then use it: $V_B = \frac{R_B}{R_A + R_B} \times 12 = \frac{15}{25} \times 12 = 7.2$ V
pd across R_B, $V_B = I\,R_B = 0.48 \times 15 = 7.2$ V	1	

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(b) new total circuit resistance = 25 + 7.5 = 32.5 Ω	1	Because of its internal resistance, cell Y supplies a smaller current than cell X. This reduces the total pd across the external resistors, which is equal to the terminal pd across cell Y, from 12 V to 9.2 V.
new current = $\frac{V}{R} = \frac{12}{32.5}$ = 0.369 A	1	
terminal pd = $\varepsilon - I\,r$ = 12 − (0.369 × 7.5) = 9.2 V	1	
7 (a) (i) zero (0 V), or negligibly small	1	Apply $V = I\,R$ to the shorting lead, for which $R \approx 0$, and $V \approx 0$ (whatever the current). However the current can only ever be small, because it is limited by the 2 MΩ resistor inside the supply unit.
(ii) $I = \frac{\varepsilon}{R_{total}} = \frac{5000}{2 \times 10^6} = 2.5 \times 10^{-3}$ A = 2.5 mA	1	The only resistance in the circuit is that of the 2 M Ω internal resistor. Remember that 1 M Ω = 10^6 Ω.
(iii) minimum power rating = $I^2 R$ = $(2.5 \times 10^{-3})^2 \times 2 \times 10^6$	1	The resistor must be capable of withstanding the heating produced when the EHT supply unit is short circuited and there is a current of 2.5 mA in it.
= 13 W	1	
(b) so that the current supplied by the unit is restricted to a value below danger level	1	An unprotected EHT supply unit could present a lethal danger to a person using it, since the emf of 5000 V could cause a fatal current if its terminals were inadvertently touched. The size of the current presents danger to the human body, rather than the voltage alone. It has been said that 'It's volts that jolts but it's mills that kills'. (mills = mA)

Nelson Thornes is responsible for the solution(s) given and they may not constitute the only possible solution(s).