Internal Resistance MS

M1. (a) (i) (use of $V = IR$)

R_{total} = 1 (ohm) ✓

$V = 1 \times 1 = 1.0$ V ✓

2

(ii) (use of $V = IR$)

$R = 9.0/1.0 = 9.0\ \Omega$ ✓

$r = 9.0 - 1.0 - 6.0 = 2.0\ \Omega$ ✓

or use of ($E = I(R + r)$)

$9.0 = 1(7 + r)$ ✓

$r = 9.0 - 7.0 = 2.0\ \Omega$ ✓

2

(iii) (use of $W = VIt$)

$W = 9.0 \times 1.0 \times 5 \times 60$ ✓

$W = 2700$ J ✓

2

(iv) energy dissipated in internal resistance = $1^2 \times 2.0 \times 5 \times 60 = 600$ (J) ✓

percentage = $100 \times 600/2700 = 22\%$ ✓ CE from part aii

2

(b) internal resistance limits current ✓

hence can provide higher current ✓

or energy wasted in internal resistance/battery ✓

less energy wasted (with lower internal resistance) ✓

or charges quicker ✓

as current higher or less energy wasted ✓

or (lower internal resistance) means higher terminal pd/voltage ✓

as less pd across internal resistance or mention of lost volts ✓

2

[10]

M2. (a) (i) energy changed to electrical energy per unit charge/coulomb passing through
[or electrical energy produced per coulomb or unit charge]
[or pd when no current passes through/or open circuit] **(1)**

(ii) $I = \frac{6}{2.4}$ = 2.5 A **(1)**

(iii) (use of $\epsilon = I(R + r)$ gives) $\epsilon = V + Ir$ and $8 = 6 + Ir$ **(1)**

substitution gives 8 – 6 = 2.5r **(1)** **(**and r = 0.8 Ω)

4

(b) (i) (use of $P = I^2R$ gives) $P_R = 2.5^2 \times 2.4 = 15$ W

[or $P = VI$ gives $P = 6 \times 2.5 = 15$ W] **(1)**

(allow C.E. for value of I from (a))

(ii) $P_T = 15 + (2.5^2 \times 0.8)$ **(1)**

= 20 (W) **(1)**

(allow C.E. for values of P_R and I)

(iii) $E = 5 \times 2 \times 60 = 600$ J **(1)**

(allow C.E. for value of P from (i) and P_T from (ii))

4

[8]

M3. (i) (V = IR gives) 12 = (30 + 30 + 2)I (1)

$I = \left(\frac{12}{62}\right)$ = 0.19 A **(1)** (0.194 A)

(ii) V_{PQ} = 12 – (0.19 × 2) **(1)**
= 11.6 V **(1)**

(allow C.E. for incorrect *I* in (i))

[or V_{PQ} = 0.19 × 60 = 11.6 V] (*I* = 0.194 A gives 11.6 V)

[or $V_{PQ} = 12 \times \frac{60}{62}$ = 11.6 V

(iii) ($P_A = I^2R$ gives) $P_A = (0.19)^2 \times 30$ = 1.08 **(1)** W **(1)**

[or $P_A = \frac{V^2}{R}$]

(allow C.E. for incorrect *I* in (i) or incorrect *V* in (ii))

(iv) ($E = P_A t$ gives) *E* = 1.08 × 20 **(1)**

= 21.6 J **(1)**

(allow C.E. for incorrect P_A in (iii))

[8]

M4. (a) (i) work (done)/energy (supplied) per unit charge (by battery) **(1)**

(or pd across terminals when no current passing through
cell or open circuit)

1

(ii) when switch is closed a **current flows** (through the battery) **(1)**

hence a pd/lost volts develops across the internal resistance **(1)**

2

(b) (use of ε = *V* + *Ir*)

I = 5.8/10 = 0.58 (A) **(1)**

6.0 = 5.8 + 0.58*r* **(1)**

r = 0.2/0.58 = 0.34 (Ω) **(1)**

3

(c) need large current/power to start the car **(1)** (or current too low)

internal resistance limits the current/wastes power(or energy)/reduces terminal pd/increases lost volts **(1)**

2

[8]

M5. (a) (use of $E = V + Ir$)

$12 = V + 420 \times 0.0095$ **(1)**

$V = 8.0(1)$V **(1)**

2

(b) $\rho = RA/l = 1.6 \times 10^{-3} \times 7.9 \times 10^{-5}/0.75$ **(1)**

$R = 1.7 \times 10^{-7}$ **(1)** Ωm **(1)**

3

[5]

M6. (a) (i) work done (by the battery) per unit charge **(1)**
or (electrical) energy per unit charge
or pd/voltage when open circuit/no current

(ii) the resistance of the materials within the battery **(1)**
or hindrance to flow of charge **in** battery
or loss of pd/voltage per unit current

2

(b) (i) (use of $E = V + Ir$)

$12 = V + 800 \times 0.005$ **(1)** (working/equation needs to be shown)

$V = 12 - 4 = 8.0$V **(1)**

(ii) (use of $P = I^2r$)

$P = 800^2 \times 0.005$ **(1)** (working/equation needs to be shown)

$P = 3200$ **(1)** W **(1)** **or** J s^{-1}

5

(c) car will probably **not** start **(1)**

battery will not be able to provide enough current **(1)**
or less current
or lower terminal pd/voltage

2

[9]

M7. (a) mention of pd across internal resistance **or** energy loss in internal resistance **or** emf > V ✔

pd across internal resistance/lost volts increases with current **or** correct use of equation to demonstrate ✔

2

(b) (i) *y – intercept* 1.52 V (± 0.01 V) ✔

1

(ii) identifies gradient as *r* **or** use of equation ✔

substitution to find gradient **or** substitution in equation ✔

r = 0.45 ± 0.02 Ω ✔

3

(c) (i) same intercept ✔

double gradient (must go through 1.25, 0.40 ± 1.5 squares) ✔

2

(ii) same intercept horizontal line ✔

1

(d) (i) (use of $Q = It$)

Q = 0.89 × 15 = 13 ✔ C ✔

2

(ii) use of $P = I^2r$ ✔

$P = 0.89^2 \times 0.45$

P = 0.36 W ✔

2

[13]

M8. (a) **battery** has internal resistance **(1)**
current passes through (this resistance) **(1)**
work done/voltage lost, which reduces the value of the emf **(1)**

3

QWC 1

(b) (i) circuit diagram to show:
two **cells** in series **(1)**
two resistors, each labelled *r* **(1)**

(ii) (use of $P = IV$ gives) 1.6 = 2.5 I **(1)** (I = 0.64 (A))
(use of $\in = V + Ir$ gives) 3.0 = 2.5 +0.64 × 2r **(1)** **(1)**
0.5 = 1.28r and r = 0.39 Ω **(1)**
[or $R_{bulb} = 2.5^2/1.6$ = 3.9 (Ω) and 2.5 = 3.9 × I gives I = 0.64 (A)
'lost volts' = (3 – 2.5) = 0.5 (V) i.e. 0.25 (V) per cell
0.25 = 0.64r and r = 0.39 Ω]

5

(c) $\in = V + Ir$ gives $V = -Ir + \in$ (equation of straight line) **(1)**
intercept on y-axis gives $\in$ **(1)**
gradient gives (–)r **(1)**

3

[11]

M9. (a) $V = -Ir + \in$ **(1)**

1

(b) straight line (within 1st quadrant) **(1)**
negative gradient **(1)**

2

(c) $\in$: intercept on voltage axis **(1)**
r: gradient **(1)**

2

[5]

M10. (a) (i) 6.0 (Ω) **(1)**

1

(ii) 4.5 (V) **(1)**

1

(iii) (use of $I = V/R$)

I = 4.5/6.0 = 0.75 (A) **(1)**

current through cell A = 0.75/2 = 0.375 (A) **(1)**

2

(iv) charge = 0.375 × 300 = 112 **(1)** C **(1)**

2

(b) cells C and D will go flat first or A and B last longer **(1)**

current/charge passing through cells C and D (per second) is double/more than that passing through A or B **(1)**

energy given to charge passing through cells **per second** is double or more than in cells C and D **(1)** or in terms of power

3

[9]

M11. (a) (i) electrical energy produced (in the battery) per unit charge **(1)**

[or potential/voltage across terminals when there is no current]

(ii) there is a current (through the battery) **(1)**

voltage 'lost' across the internal resistance **(1)**

Max 2

(b) (i) $\epsilon = V + Ir$ **(1)**

(ii) labelled scales **(1)**
correct plotting **(1)**
best straight line **(1)**
ϵ: intercept on *y* axis **(1)** = 9.2 (± 0.1) V **(1)**

r : (−) gradient = $\frac{9.2}{0.65}$ = 14.2 Ω **(1)** (range 14.0 to 14.3)

8

[10]