decimaltutoring

Mark Scheme

Q1.

A

[1]

Q2.

A

[1]

Q3.

D

[1]

Q4.

B

[1]

Q5.

C

[1]

Q6.

C

[1]

Q7.

B

[1]

Q8.

C

[1]

Q9.

D

[1]

Q10.

D

[1]

Q11.

D

[1]

Q12.

D

[1]

Q13.

(a) work done per unit charge

Allow V=W/Q if W and Q defined

1

(b) Voltmeter reading / terminal pd drops
Battery has internal resistance
pd occurs within battery / 'lost volts' within battery / emf is shared between internal and external resistances

3

[4]

Q14.

(a) $V = -Ir + \epsilon$ **(1)**

1

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

2

(c) ϵ : intercept on voltage axis **(1)**
r: gradient **(1)**

2

[5]

Q15.

(a) the (total) energy transferred/work done when one unit/coulomb of charge

B1

is moved around a circuit/provided by the supply

B1

2

(b) work is done inside the battery/there is resistance inside the battery

B1

so less energy is available for the external circuit/someoltage is lost between the terminal/mention of lost volts

B1

2

(c) (i) 9.00 V

c.a.o.

B1

(ii) lost voltage = E - V or E = I(R + r)

C1

0.82r = 0.59

C1

5

internal resistance = 0.720 Ω

A1

(iii) because the battery has to provide more energy/power

B1

[9]

Q16.

(a) 15(.0) (Ω) ✓

Only acceptable answer

Must be on answer line or clearly identified as (largest) R

by R *= 15 (.0) (Ω) seen.*

Allow an answer just above (or below) the answer line in cases where a previous answer has been crossed out.

If not on the answer line, units must be stated.

1

(b) 1.4(1) (Ω) ✓✓

Only selects 2.2 Ω and 3.9 Ω in parallel ✓

Accept evidence from working or a clear labelled sketch of 2.2 Ω and 3.9 Ω in parallel

Possible allowed combinations include:

$$(\frac{1}{R} =)\frac{1}{2.2} + \frac{1}{3.9}$$

$$\text{Condone } R = \frac{1}{2.2} + \frac{1}{39}$$

$$(R =)\frac{1}{\frac{1}{2.2} + \frac{1}{3.9}}$$

$$(R =)(\frac{1}{2.2} + \frac{1}{3.9})^{-1}$$

$$(\frac{1}{R} =)\frac{5}{11} + \frac{10}{39}$$

$$(R =)\frac{2.2 \times 3.9}{2.2 + 3.9}$$

Accept 1.407 Ω but not >4 sf

Must be on answer line or clearly identified as (smallest)R

by R = 1.4 (1) (Ω) seen.

Allow an answer just above (or below) the answer line in cases where a previous answer has been crossed out.

Common wrong answer = 0.71 (Ω) is worth one mark with correct supporting working

2

(c) Any of the following statements:

Power supply is on open circuit (so current is zero)

OR

Voltmeter has a (very) large resistance (so current is zero)

OR

No current (load) (so no lost volts)

OR

(Current is zero) so no lost volts

Accept 'negligible' current for zero current

Accept 'very large' resistance; don't penalise 'voltmeter has very large internal resistance'

Do not allow:

Resistance is zero

Only resistance is the internal resistance

No other component (this implies that the internal resistance is zero)

1

(d) (Current through power supply leads to)

lost volts (across the internal resistance)

OR

(Current through power supply leads to)

voltage drop across the <u>internal resistance</u>

OR

(Current through power supply leads to)

Some of the emf is used in the <u>internal resistance</u>

OR

Voltage is shared between the internal and external resistances

Allow correct 'energy transfer in the internal resistance' arguments

Must refer to a voltage across the internal resistance or r except when the term "lost volts" is used.

Do not allow:

The current decreases

1

(e) $\varepsilon - V$ = (1.62 – 1.14 =) 0.48(0) (V)

and

$\frac{V}{R} = \left(\frac{1.14}{9.0} = \right) = 0.13(V\Omega^{-1})$ ✓

Both results required for ✓; accept 0.127 or 0.1267 for $\frac{V}{R}$

Do not allow answers expressed in terms of unknown variables

Answers must be on answer line or clearly identified as answer by using correct subject and equals sign

Allow an answer just above (or below) the answer line in cases where a previous answer has been crossed out.

1

(f) Point correctly plotted to nearest 1 mm (half a grid square)

and

continuous ruled best fit line for the 5 (originally printed) points ✓

Withhold mark if point is hidden or if best fit line is of variable thickness or has discontinuities.

Data point should be marked with a cross. Both × and + marks are acceptable.

Do not allow *points plotted as dots / dots in circles*

If point is wrongly calculated in Part 1.5 allow CE for an accurate plot of this but this should then be treated as anomalous when judging the best fit line.

The best fit line must intersect each of the 5 originally printed X symbols.

Allow no plot where ECF (even as algebraic equation) point won't fit on the grid <u>*and*</u> *student has stated that it can't be plotted.*

If no answer / no plottable answer in 1.5 but student chooses to plot a point then it must be the correct point only (0.13, 0.48)

1

(g) Gradient triangle for **Figure 3**; correct read-offs for points (± 1 mm) from triangle with the $\varepsilon - V$ step at least 0.5 V

Allow $\frac{y2 - y1}{x2 - x1}$ *seen or gradient triangle drawn with* $\frac{\Delta y}{\Delta x}$ *seen, read-offs must be substituted into* $\frac{y2 - y1}{x2 - x1}$ *or* $\frac{\Delta y}{\Delta x}$

Condone one read-off error in four read-offs for gradient method

(common error: candidates miss non-origin on ordinate axis)

(common error: makes a power of 10 error on abscissa)

r in range 3.49 to 3.95 (Ω)

Any correct method other than gradient method (no read-off errors here) allow 1 mark

i.e. allow 1 mark for the accurate use of 1 point from their line

r *must be quoted to a minimum of 2 significant figures*

ecf *for* r *(their gradient from their best fit line)*

r *must be supported by correct working*

2

(h) The **Figure 1** method is better **because** more R values are available ✓

6 values of R (possible) for method (seen) in Fig 4 ✓

Do not allow:

The 2nd method has a wider range

The 2nd method has a larger maximum resistance

The 2nd method has a smaller minimum resistance

The 2nd method only goes up to 8.2 Ω

(resistances available in Fig 4: 2.0 Ω, 3.2 Ω, 4.3 Ω, 4.6 Ω, 5.0 Ω, 5.3 Ω)

2

[11]

Q17.

(a) any **three** from

voltmeter resistance is high B1

current in circuit is 0 or low B1

no (low) energy lost in voltmeter B1

no lost volts/volts lost overcoming internal resistance B1

'load'/voltmeter resistance >> internal resistance B1

voltage across voltmeter >> voltage across int. resistance B1

3

(b) (i) current = 14.5/470 C1

0.031 or 0.0309 (A) amps penalise 1 sf A1

2

(ii) 'lost' pd in cell = 0.5 V C1

internal resistance = 0.5 × 470/14.5 or (0.5/0.031 etc) C1

16 (Ω) (16.2) (16.7) A1

or 13.9(14) using 0.031 A to calculate total circuit resistance

15.4(15) using 0.0309 A1

30 using 0.3

3

[8]

Q18.

(a) (i) the energy provided by a battery **(1)** per unit charge **(1)**
[or when no current flows **(1)** it is the potential difference across the battery **(1)**]

(ii) a potential difference is developed across the internal resistance **(1)**

(3)

(b) $I = \frac{11.5}{10}$ = 1.15(A) **(1)**

12 – 11.5 = 1.15 × r **(1)**

r = 0.43 Ω **(1)**

(3)

[6]

Q19.

(a) (i) joules per coulomb (of charge)/work done per unit charge
(treat reference to force as neutral)

M1

where charge moved (whole way) round circuit

A1

2

(ii) lost volts = 0.1 (V) or 0.1 seen as voltage

C1

r = 0.011 to 1.09×10^{-2} (Ω)

A1

2

(b) brightness decreases

B1

increased current (in circuit/battery)

B1

increased lost volts leading to decreased pd across bulb or decreased terminal pd

B1

3

[7]

Q20.

(a) time base is (switched) off ✓

TO for y-input switched off

not affected by x plates because these plates are not switched on

1

(b) (i) emf (of battery) ✓

not just terminal pd

TO applied for non-emf statements

Allow explanation of emf

1

(ii) (emf = 3 × 2.0 =) 6.0 V ✓

penalise 1 sf

1

(c) Because the pd across the y plates has decreased ✓

there is a current (in the battery) ✓

there is a pd / voltage across the internal resistance **or** there are (now) lost volts ✓

terminal pd decreases **or** terminal pd now less than emf **or** $IR = \varepsilon - Ir$ ✓

3

(d) *V*= 2.5 × 2.0 = 5 V

or (use of V=IR) by I = their incorrect voltage ÷18 ✓

Must see I as subject or their working leading to answer line for use of

I=0.28(A) ✓ cao

2

(e) (use of $\varepsilon = IR + Ir$)

6.0 = 2.5 × 2.0 + 0.28× r

$$r = \frac{\varepsilon - IR}{I}$$

or correct rearrangement to make *r* subject

or sets $R_{(T)} = \frac{\varepsilon}{0.28}$ = 21.2 or 21.4 (ohms) with subject seen

or $\frac{1}{0.28}$ ✓

r = 3.4 to 3.6 Ω ✓

Ecf for I and V $\text{ecf ans} = \frac{6 - \text{their V}}{\text{their I}}$

2

[10]

Q21.

(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 $\varepsilon = V + Ir$)

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

$6.0 = 5.8 + 0.58r$ **(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]

Q22.

(a) (i) $1 / R_1 + 1 / R_2 = 1 / R_T$ **or** $\frac{R_1R_2}{R_1R_2} = R_t$ **C1**

correct substitution using total resistance of 5 Ω **C1**

7.5 Ω **A1**

(3)

(ii) 3 V or 3.0 V

(no significant figure penalty) **B1**

(1)

(iii) power in 15 Ω resistor = V^2R **or** I^2R **or** IV **C1**

power = 0.6 or 0.60 W *allow e.c.f. from (ii)* **A1**

(no significant figure penalty)

(2)

(iv) 4 Ω resistor is too small (for maximum power to be delivered) **C1**

placing a resistor in parallel will reduce the load resistance further **A1**

or $\frac{1}{5} = \frac{1}{4} + \frac{1}{R}$ leading to $R = -20$ Ω **B1**

negative resistance needed which is impossible **B1**

(2)

(b) (i) $R = \frac{\rho l}{A}$ **or** $\rho = \frac{RA}{l}$ **or** numerical evidence **C1**

area = $\pi(1.5 \times 10^{-4})^2$ **or** $\frac{\pi}{4}$ $(3 \times 10^{-4})^2$ **or** 7.1×10^{-8} (m^2) **C1**

4.6×10^{-7} m c.a.o. **A1**

(3)

(ii) correct curvature, convex to origin, not intersecting diameter axis **M1**

inverse square law shown **A1**

(check one point eg 6×10^{-4} m, 3.5 → 4.0 Ω; 4×10^{-4} m, 8.5 Ω)

(2)

[13]

Q23.

(a) (i) energy provided by the battery **(1)**
per unit charge **(1)**
[or potential difference across battery **(1)** when no current flows **(1)**]

(ii) when current flows, work is done inside the battery
to overcome the resistance (hence $V < \epsilon$) **(1)**
(or any correct alternative)

(3)

(b) (i) suitable scale for I **(1)**
four correct points **(1)** **(1)**
best straight line **(1)**

(ii) ($\epsilon = Ir + V$ gives) $V = -rI + \epsilon$ **(1)**
intercept = ϵ = 5 V **(1)**
gradient = $(-)r$ **(1)**

$= \frac{5}{0.35} = 14.(2)\ \Omega$ **(1)**

(8)

[11]

Q24.

(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]

Q25.

(a) (i) 124 kW

B1

(1)

(ii) efficiency = useful power output/power input

C1

power needed = (100 / 15) × 124 = 827 kW

A1

area needed = 1270 m

(2)

B1

(3)

allow this mark only for 124 000 / 650 or (their power) / 650 (i.e. area for 100% efficient system)

B1

(1)

(iii) any good reason:
e.g. since the value is only an average so more needed sometimes
since little power is used at night more than the average is needed during the day
since some parts may be in shade (due to cloud)
since cloud may reduce intensity of radiation on the cells
since there will be less light in winter

(iv) there is no power at night

B1

the power fluctuates according to the weather conditions / cloud

B1

seasonal changes

B1
Max 2

(b) (i) power = VI or numerical substitution

C1

326A

A1

(2)

(ii) resistance = V/I in any form
or $V = E - Ir$

C1

p.d. across internal resistance = 16.3 V (e.c.f.)
or correct substitution in $V = E - Ir$

C1

p.d. at consumer 214 V (e.c.f. from (b)(i)

A1

(3)

[12]

Q26.

(a) $R = \frac{V^2}{P} = \frac{6.2^2}{4.5} = 8.5(4)(\Omega)$ ✓

Condone use of W for P.

1

(b) Calculation of current in lamp (0.73 A)

OR

Calculation of current in 12 Ω resistor (0.52 A)

OR

Calculation of parallel pair resistance (5.0 Ω) ✓

Allow ecf from ***(a)***

Allow alternative methods

Calculation of total circuit current (1.2(4) A)

OR

Calculation of total circuit resistance (7.5 Ω)

OR

Expression of potential divider arrangement

$$\frac{\varepsilon - 6.2}{r} = \frac{6.2}{\text{external } R} \text{ OR}$$

$$\frac{\varepsilon}{\text{total circuit restance}} = \frac{6.2}{\text{external R}}$$

Give full credit to answers that use 9Ω :

Expected values for this method are

Lamp current = 0.69 A

Current in 12 Ω resistor = 0.52 A

Parallel pair resistance = 5.1(4) Ω

Total circuit resistance = 7.6(4) Ω

Total circuit current = 1.2(1) A

emf = 9.2(1) V

(emf = terminal pd + Ir = 6.2 + (1.24 × 2.5))

9.3(1) V ✓

3

(c) Evidence of calculation of A (= π (d / 2)^2 = 2.84 × 10^{-8}) ✓

Use of their A in the resistivity equation = RA/l ✓

To give 5.1 × 10^{-8} (Ω m) ✓

Allow POT errors in MP1 and MP2

Allow answers that round to 5.10 × 10^{-8} (Ω m)

3

(d) Resistance increases ✓

Reduces current through lamp

and lamp dimmer ✓

OR

Greater pd across plugs as potential divider

and lamp dimmer ✓

Do not condone explanations that confuse current and potential difference.

Do not condone "current across" or "pd through".

2

(e) (Resistance increases)

Reduces current in circuit / battery

OR

Increases (external) circuit resistance ✓

Reduces pd dropped across internal resistance of cell / increases terminal pd so lamp brighter ✓

Award MAX 1 for arguments dealing with initial dimming of bulb when wire attached.

Condone "pd across lamp and resistor / parallel section" for "terminal pd".

Condone "lost volts".

2

[11]

Q27.

(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]

Q28.

(a) 12 * 15/25

C1

= 7.2 V

A1

2

(b) total *R* now 32.5

C1

12 * 7.5/32.5 = 2.7[7] V **or** calculates *I* = 0.369 A

C1

terminal p.d. 12 - 2.8 = 9.2 V **or** V = 0.369 × (10 + 15) = 9.2 V

A1

3

[5]

Q29.

(a) idea of maximum voltage between terminals of source or

C1

open circuit p.d. or any W/*Q* or *P*/*I* idea
work done per coulomb in separating a charge internally or
work done per coulomb in moving charge around complete
circuit

A1

2

(b) $E = I(R + r)$ or $E = V + Ir$ or lost volts = 0.16V

B1

I = 0.175(A) or I = 1.4V/8 Ω

B1

r = 0.16 V/ 0.175A = 0.914 Ω or lost volts/I

B1

3

(c) (i) statement or use of parallel formula

C1

6.0 Ω

A1

2

(ii) 0.9 Ω added to (c) (i)

C1

I = 1.56V/6.9 Ω = 0.22 A or 0.23 A e.c.f.

C1

0.22A × 6 Ω = 1.35 V or 1.36 V e.c.f.

(allow 1.56/6.9 = V/6.0 for 2nd C Mark)

A1

3

(iii) voltmeter resistance too similar to circuit or significant p.d. dropped internally or condone significant number of "lost volts"

B1

1

(d) area = 3.1 × 10^{-6} (m^2) or π (condone error in power of 10) or

C1

$\pi d^2/4$ stated or used (not πr^2 stated alone)
$R = \rho l/A$ (or 1.6 × 10^{-3} (condone error in power of 10))

C1

V = (0.2 × R value) or ~ 0.3 mV

C1

~0. 6 mV c.a.o. (unit must be present - extra up)

A1

4

[15]

Q30.

(a) (i) *(use of V=Ir)*

V= 4.2 × 1.5 ✓ = 6.3 (V)

1

(ii) pd = 12 − 6.3 = 5.7 V✓

NO CE from (i)

1

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

I = 5.7 / 2.0 = 2.8(5) A✓

CE from (ii)

(a(ii)/2.0)

accept 2.8 or 2.9

1

(iv) *I* = 4.2 – 2.85 = 1.3(5) A ✓

CE from (iii)

(4.2 −(a)(iii))

accept 1.3 or 1.4

1

(v) *R*= 5.7 / 1.35 =4.2 Ω ✓

CE from (iv)

(a(ii) / (a)(iv))

Accept range 4.4 to 4.1

1

(vi) $\frac{1}{R_{Parallel}} = \frac{1}{4.2} + \frac{1}{2.0} = 0.737$ ✓

CE from (a)(v)

$R_{parallel}$ = 1.35 **Ω**

second mark for adding internal resistance

R_{total} = 1.35 + 1.5✓ = 2.85 Ω

OR

R = 12/4.2 ✓

R= 2.85 Ω ✓

2

(b) (i)

resistor	Rate of energy dissipation (W)
1.5 Ω internal resistance	$4.2^2 \times 1.5 = 26.5$✓
2.0 Ω	$2.85^2 \times 2.0 = 16.2$ (15.68 − 16.82)✓
R	$1.35^2 \times 4.2 = 7.7$ (7.1 − 8.2)✓

CE from answers in (a) but not for first value

2.0: a(iii)²×2

R: a(iv)²×a(v)

3

(ii) energy provided by cell per second = 12 × 4.2 = 50.4 (W) ✓
energy dissipated in resistors per second = 26.5 + 16.2 + 7.7 = 50.4 ✓
(hence energy input per second equals energy output)

if not equal can score second mark if an appropriate comment

2

[12]

Q31.

(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]

Q32.

(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]

Q33.

(a) as the temperature of T increases its resistance decreases
/more charge carriers are released

B1

increasing the current in the circuit
/changing the ratio of resistance/reducing pd across T

B1

(so that so that the pd across the resister increases)

2

(b) T/ 20.0 = 1.0/5.0 **OR** 5.0/6.0 = 20/(20+T) **OR** equivalent
(Therefore T = 4.0 ohms)

Note T = (1/5)20 just ok but T = 20/5 not enough

M1

1

(c) Use of $V_{out} = R_1/(R_1 + R_2) \times V_{in}$ **OR** I = 6/44.5 = 0.135 A

C1

V = 2.7 V

A1

2

(d) (i) V/6.0 = 20.0/(20.0+4.0+3.0) **OR** I = 0.222 A

C1

V = 4.4V

A1

2

(ii) The measure temperature would be lower because the pd across the resistor would be less *(ie 2.53V)*

B1

1

[8]

Q34.

(a) Work done in moving 1 C of charge through the cell ✓
1.5 J of work is done in moving 1 C of charge through the cell ✓

OR

Amount of energy converted from other forms to electrical energy per 1 C of charge ✓

1.5 J of energy converted from other forms to electrical energy per unit charge (passing across the emf) ✓

OR

Work done in moving 1 C of charge (whole way) round circuit ✓

1.5 J of work is done in moving 1 C of charge the (whole way) round circuit ✓

2nd marking point obtains both marks

***Max 1 mark** available for the following:*

The emf is the terminal pd when there is no current in the cell (and this equals 1.5 V)

1.5 J of energy per 1 C of charge.

Allow a statement of Kirchhoff's 2nd law for 1 mark. Where the law is in symbol form, the meaning of the symbols must be stated. Need a clear communication of internal and external resistances.

2

(b) P = VI

And

(P) = 0.465 (W) ✓

Seen to more than 2 sf with supporting equation with subject seen in working

1

(c) Use of appropriate power equation to determine wasted power
or
power dissipated in **R** = total power – their wasted power ✓

(P =) 0.40 W ✓

Alternative for 1 mark:

Use of $I = \frac{\varepsilon}{R+r}$

Or

pd across R = 1.5 – 0.65 x 0.31

or

pd across R = 1.2985 (V)

or

total resistance = 1.5/ 0.31

or

total resistance = 4.839 (Ω)

or R = 4.2 (Ω)

or $P = I^2$ *x their* R

or

P = $\frac{V^2}{R}$ *using their V and R* ✓

2

(d) Use of $E = P\,t$

or $E = VI\,t$

Or

$E = QV$ **and** $Q = It$ ✓

Allow use of the equation with their values.

An answer of 3.5 x 10^4 *is worth 1 mark*

(t =) 3.0(1) x 10^4 (s) ✓

2

(e) **MAX 3 from (1 to 4) or (5 to 8)**

It is suitable, because:

(1) Current required in lamp = 0.62 A or use of $I=\frac{P}{V}$ seen

(2) Resistance of lamp = 2.11 Ω or use of $R=\frac{V^2}{P}$ seen ✓

(3) current in each cell = 0.31 A ✓

(4) lost volts = 0.2 V

or

lost volts = 0.65 x 0.31 ✓

Check the diagram in part (e)

Must have the ***correct conclusion to award 4 marks.***

Conclusion: yes, terminal pd = **1.5 – 0.2** seen

or

terminal pd= 1.5 – 0.65 x 0.4 /1.3 ✓

OR

(5) total internal resistance = 0.325 Ω ✓

(6) total resistance in circuit = 2.44 Ω ✓

(7) Resistance of lamp = 2.11 Ω ✓

(8) pd splits in ratio of 0.325:2.11 ✓

Conclusion: yes, pd **across lamp is** $\frac{2.11 \times 1.5}{2.44}$ **(= 1.3 V) seen** ✓

Allow max 3 from a combination of two route [(2) and (7) worth total of 1 mark]

4

(e) (Cells must be added) in parallel ✓

Because:

more energy stored in the bank of cells / less power from each cell ✓

without increasing the voltage across the bulb (above 1.5 V)

or

without increasing the terminal pd (above 1.5V) ✓

Must link the cells being added in parallel to one or both reason to gain three marks.

Alternative:

- *In parallel*
- *Current shared by cells*
- *Takes longer to convert the energy stored in each cell.*

Alternative:

- *In parallel*
- *Less internal resistance*
- *Less power / energy wasted*

Cells in series statement means no marks can be obtained.

3

[14]

Q35.

(a) emf is the work done / energy transferred by a voltage source / battery / cell ✓per <u>unit</u> charge✓
OR
electrical energy transferred / converted / delivered / produced✓
per <u>unit</u> charge✓
OR
pd across terminals when no current flowing / open circuit✓✓

not <u>in</u> battery

accept word equation OR symbol equation with symbols defined if done then must explain energy / work in equation for first mark

2

(b) (i) by altering the (variable) <u>resistor</u>✓

1

(ii) reference to correct internal resistance✓

e.g. resistance of potato (cell)

terminal pd = emf ∇ pd across internal resistance / lost volts✓
pd / lost volts increases as current increases OR as (variable) resistance decreases greater proportion / share of emf across internal resistance✓

accept voltage for pd

3

(iii) draws best fit straight line and attempts to use gradient✓
uses triangle with base at least 6 cm✓
value in range 2600 – 2800 (Ω)✓

3

stand-alone last mark

(c) total emf is above 1.6 V✓
but will not work as current not high enough / less than 20 mA✓

2

[11]

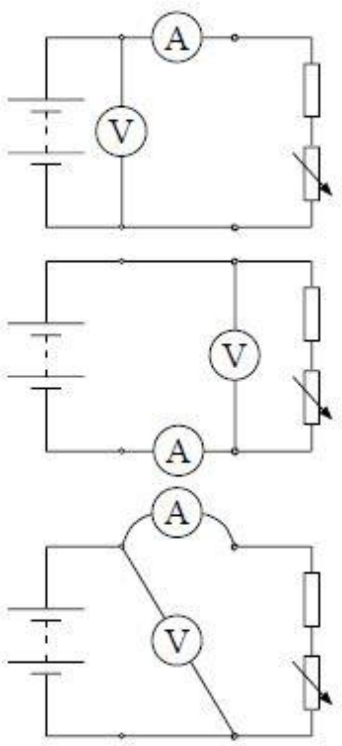
Q36.

(a) valid continuous series circuit that includes ammeter, and one wire link (condone diagonal connections)

and

voltmeter between any two sockets that enable the terminal pd to be measured ✓

all of the following are acceptable:



links and connections

reject broken / dashed lines

tolerate diagrams with diagonal or non-straight connections between sockets if these will produce a valid circuit

don't insist on connection blobs

circuit must be continuous unless a switch is included: otherwise no gaps wider than the thickness of their links

inclusion of a switch is neutral but the length of the open switch must be ≥ length of the gap where the switch is connected: condone the whole gap between terminals *vertically opposite the ammeter to be marked as an open switch*

meters

correct ASE symbol for ammeter and correct ASE symbol for voltmeter are essential

one voltmeter and one ammeter only

meters must not be 'transparent'

positions of meters assume that the ammeter has negligible resistance and voltmeter has infinite resistance

1

(b) (with any switch closed) read ammeter <u>and</u> voltmeter

or

record / measure I <u>and</u> V;

adjust / vary / change resistance / (setting of) variable resistor / Q

and repeat (readings) 1✓

for 1✓ must produce a <u>range</u> of I, V values (>2 sets) and identify how this is achieved; it is not necessary to suggest range or number of sets

plot V (against) I 2✓

mark 2✓ independently of 1✓

2

ε = (vertical / y-axis) intercept 3✓

r = −gradient 4✓

2✓ 3✓ and 4✓ can be awarded for a suitable sketch graph

condone 'use the (variable) resistor to vary current and read I, V'

idea that R can be read from Q is neutral

for 2✓ (and further credit in 3✓ and 4✓) the ordinate and the abscissa must be identified;

allow 'plot V over I' or 'plot V/I'

allow 2✓ for reverse plot 'I (against) V'

then 4✓ for $r = \dfrac{-1}{\text{gradient}}$ *and 3✓ intercept =* $\dfrac{\varepsilon}{r}$

for 3✓ open circuit methods involving ε read directly using voltmeter are neutral

for 4✓ any subject but minus sign essential

2

variation

1✓ as above;

3✓ find R from V divided by I ; disconnect external circuit and measure ε directly;

4✓ plot $\frac{\varepsilon}{V}$ against $\frac{1}{R}$

2✓ gradient = r

(c) gradient calculation seen with Δn^{-1} divided by ΔI^{-1};

ε from 22 × gradient 1✓

for 1✓ do not penalise one read off error, (allow use of 0, 0) or for small steps

expect gradient ≈ 7.2(5) × 10^{-2} leading to ε = 1.594 (V)

do not allow reverse working based on answer to part (e)

1

ε minimum 3 sf; in range 1.58 to 1.61 (V) 2✓

2✓ is contingent on award of 1✓

1

(d) use of **Figure 3** to read off I^{-1} corresponding to n^{-1} = 0.25;

calculates I in range 0.23(2) to 0.24(4) (A) ✓

*do not insist on seeing evidence of working on **Figure 3***

expect I^{-1} = 4.2 ± 0.1 (A^{-1}) leading to I = 0.238 (A)

(should expect 1 more sf than in 0.25 for 'show that' but condone 0.23 and 0.24 since result based on 2 sf data)

do not allow reverse working based on answer to (e)

1

(e) circuit resistance R = 5.5 (Ω) seen in (e) working 1✓

minimum 2sf V from their I × 5.5

or

V from their ε − their I × r 2✓

for 1✓ allow R = $R = \frac{22}{4}$ or $\frac{11}{2}$; allow R^{-1} = $R^{-1} = \frac{4}{22}$ etc

for 2✓ correct R only; expect V = 1.3(1) V; use of I = 0.25 A gives V = 1.38 V

do not allow V ≥ their ε

r using lost volts divided by current; full substitution of their valid data

eg $r = \frac{1.58 - 1.31}{0.238}$ 3✓

or

r using formula for **Figure 3**; full substitution of their valid data

eg $r = \frac{\varepsilon}{I} - \frac{22}{4} = \frac{1.58}{0.238} - 5.5$ 3✓

or

r using either intercept on **Figure 3**; full substitution of their valid data

eg their vertical intercept ×−22 **or**

their horizontal intercept × ε 3✓

use of 'show that' or 2 sf data:

$r = \frac{\varepsilon - V}{I}$ *with* ε *= 1.6 V,* V *= 1.4 V and*

I *= 0.25 A gives* r *= 0.80 Ω*

$\frac{22}{n} = \frac{\varepsilon}{I} - r$ *with* ε *= 1.6 V,* I *= 0.25 A*

and n *= 4 gives* r *= 0.90 Ω;*

(can find r *first, then* V *using* $\varepsilon - Ir$*)*

a vertical intercept must be calculated; result is negative, eg vertical intercept = −0.053:

r *= −1 × −0.053 × 22 = 1.17(Ω)*

horizontal intercept = 0.73:

r *= 1.6 × 0.73 = 1.18(Ω)*

minimum 2 sf result in range 0.80 and 1.3(0) (Ω) 4✓

allow 4✓only if there is clear evidence of a valid method leading to a result in range

4

(f) n = 2 **and** n = 3 1✓

n = 5 **or** n = 6 **or** n = 7 2✓

to improve distribution of points (along the line) or wtte 3✓

for 1✓and 2✓if suggesting more than three values for n *accept only the last three*

for 3✓allow:

'spread out' / 'avoid concentrating' points'

where current / n *is smaller' or wtte 'reduce distance between points (data)' / (add) detail*

'most uniform distribution' / 'most equally spread out' / 'roughly evenly spaced'

reject:

'making points (data) 'equally' / 'evenly-spaced' / 'even spread' (without qualification)

'easier to plot / draw line' / 'line more accurate' / 'easier to see trend' are neutral

3

(h) both points move (by ≥ half a grid square) to the <u>right</u> 1✓

both points move (by ≥ half a grid square) causing the gradient of a straight line between them to be reduced 2✓

allow badly-marked points / use of arrows *ignore any best-fit line added to **Figure 5***

for 1✓ rightwards motion of each point must be parallel to gridlines ± half small square

award of 2✓ mark is independent of 1✓ mark

for 2✓ the points do not need to move in the same direction

2

[17]

Q37.

(a) to limit (maximum) current (when variable resistor is set to zero) ✓

Accept 'so cell is not short-circuited' for 1✓

to prevent overheating (of cell)
OR
to prevent damage to cell
OR
otherwise cell would discharge quickly ✓

'to avoid damaging components' is not enough for 2✓

2

(b) Line ruled through bottom of second error bar and top of ninth (3rd from right) error bar ✓

Ignore unit if given. Allow tolerance of 2 mm inside either error bar.

Determines their gradient, with $\Delta x \geq 0.2$ (A) ✓

(–)1.0 ± 0.1 (/ V A^{-1}) ✓

Expect to see 2 sf in any answer

3

(c) Attempt to calculate mean of their G_{min} and –1.3 ✓

Allow positive G values

1.1 (Ω) ✓

Ecf from (b). 1 mark max if r given as negative

2

(d) States that $\varepsilon = V + Ir$ **OR** calculates R = 0.39 (Ω) ✓

Allow ruled line drawn through (0.94, 0.37) and (0.70, 0.65) ✓

Use of $\varepsilon = V + Ir$ **OR** $\varepsilon = I(R + r)$ ✓

Adds their gradient to read off at I = 1.0 A ✓✓

OR

Use of y=mx+c with their gradient ✓

Intercept (c) determined ✓

1.4 (V) ✓

*Ecf from **(c)**. 3 sf max*

3

[10]

Q38.

(a) (i) Voltmeter across terminals with nothing else connected to battery / no additional load. ✓

1

(ii) This will give zero / virtually no current ✓

1

(b) (i) $\frac{VI}{\varepsilon I}$

Answer must clearly show power: εI and VI, with I cancelling out to give formula stated in the question ✓

1

(ii) Voltmeter connected across cell terminals ✓

Switch open, voltmeter records ε
Switch closed, voltmeter records V
Both statements required for mark ✓

Candidates who put the voltmeter in the wrong place can still achieve the second mark providing they give a detailed description which makes it clear that:

To measure emf, the voltmeter should be placed across the cell with the external resistor disconnected

And

To measure V, the voltmeter should be connected across the external resistor when a current is being supplied by the cell

2

(c) Vary external resistor and measure new value of V, for at least 7 different values of external resistor ✓

Precautions - switch off between readings / take repeat readings (to check that emf or internal resistance not changed significantly) ✓

2

(d) Efficiency increases as external resistance increases ✓

Explanation
Efficiency = Power in R / total power generated
$I^2R / I^2(R + r) = R / (R + r)$
So as R increases the ratio becomes larger or ratio of power in load to power in internal resistance increases ✓

Explanation in terms of V and ε is acceptable

2

[9]

Q39.

(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]

Q40.

(a) (i) $\epsilon = I(R + r)$ **(1)**

(ii) $V_R = IR$ gives $V_R = \epsilon - I_r$ **(1)**

2

(b) (i) $P = VI$ gives 30 = 120 I **(1)**
I = 0.25 A **(1)**

(ii) I through lamp = 0.25 (A) and p.d. across it = 240 V **(1)**
p.d. due to 1 cell = 1.5 – (0.25 × 1.2) = 1.2 (V) **(1)**

number of cells = $\frac{120}{1.2}$ = 100 **(1)**

[or R_L given by 30 = 0.25^2 R_L and R_L = 480 (Ω) **(1)**
1.5n = 0.25(480 + 1.2n) **(1)**
1.2n = 120 and n = 100 **(1)**]

[or $\epsilon = V + Ir$ gives 1.5n = 120 + 0.25 × 1.2n **(2)**
n = 100 **(1)**]

5

[7]

Q41.

(a) power increases to a maximum / (up) to 3.0 (2.8 -3.4) Ω / / (up)to 3.0 W ✓
then decreases ✓

2

(b) (i) (*use of* $P = I^2R$)
when R = 0.8 Ω power = 1.95 W ✓
1.9 = I^2 × 0.8 ✓
$I = \sqrt{2.375}$ = 1.5(4) (A) ✓

Range
1.9 - 2.0 W for power (first mark)
Current 1.5 – 1.6 A

3

(ii) (*use of* $V = IR$)
V = 1.54 × 0.8 ✓
V = 1.2 V ✓

CE from part (i)

2

(iii) (*use of* $\varepsilon = V + Ir$)

6.0 = 1.2 + 1.54 × r ✓
r = (6.0 – 1.2) / 1.54 = 3.1 (2.9 – 3.2)(Ω) ✓
use of maximum power theorem (quoted) as alternative method can get both marks i.e. read peak maximum from graph

CE from part (ii)

2

(c) power would decrease (as R increased) ✓
pd / voltage across R is now constant / equal to emf ✓
and so power proportional to 1 / R / inversely proportional to R OR
can quote $P = V^2 / R$ but only if scored second mark ✓

3

[12]

Q42.

(a) (i) resistance inside the battery
or
resistance of component/chemicals in the battery
or
resistance of the cell/battery

B1

some pd is used (lost) to pass current/charge through the internal resistance
or **internal** resistance gives rise to lost volts
or terminal pd = emf – current x internal resistance
(lost volts) (no symbolic equations unless terms defined)

M1

in X there is no current /open circuit (so no pd is lost)
or in Y there is a current (so pd is lost)

A1

3

(ii) $V = E - Ir$ or 3.1 = 4.5 – 0.39 r
(n.b. 4.5 = 3.1 – 0.39 r gets 0)

C1

r =3.6 (3.59) Ω

A1

their r/3 (1.2 Ω if correct)

B1

3

(b) (i) Reading on voltmeter in **X** = 1.5 V

B1

1

(ii) Resistance in circuit **Y** = 8.0 + 3.6 = 11.6Ω

C1

their (i) / (8 + their total internal r)
(1.5/11.6 = 0.13 A if correct)

A1

2

or
lost volts = 3.6/11.6 × 1.5 = 0.47 V (allow ecf for r)
terminal pd = 1.5 – 0.47 = 1.03 V (must see working for this mark)

C1

1.03/8 = 0.13 A if correct

A1

[9]

Q43.

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

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

(ii) $V_{PQ} = 12 - (0.19 \times 2)$ **(1)**
= 11.6 V **(1)**

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

[or $V_{PQ} = 0.19 \times 60 = 11.6$ 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) ($E = P_At$ gives) $E = 1.08 \times 20$ **(1)**

= 21.6 J **(1)**

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

[8]