Candidate 2 evidence

DETERMINING INTERNAL RESISTANCE OF AN ELECTRICAL SUPPLY

AIM: TO DETERMINE THE INTERNAL RESISTANCE OF A D BATTERY.

UNDERLYING PHYSICS

ALL ELECTRICAL COMPONENTS HAVE RESISTANCE. RESISTANCE IS THE OPPOSITION TO CHARGE PASSING THROUGH A COMPONENT. RESISTANCE IS MEASURED IN OHMS (Ω) & IS REPRESENTED AS R IN EQUATIONS.

ELECTROMOTIVE FORCE (emf) IS A PROPERTY OF ELECTRICAL SUPPLY COMPONENTS. emf IS DEFINED AS THE ENERGY ... SUPPLIED PER COULOMB OF CHARGE (1) PASSING THROUGH IT. TO MEASURE emf A VOLTMETER MUST BE CONNECTED ACROSS SUPPLY, MEANING emf IS THE POTENTIAL DIFFERENCE (p.d.) OF AN OPEN CIRCUIT. emf IS MEASURED IN VOLTS (V) AND IS REPRESENTED BY $\mathcal{E}$ IN CALCULATIONS.

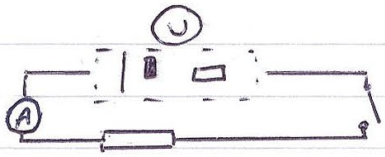
WHEN A CURRENT IS DRAWN FROM SUPPLY THE VOLTMETER READING DECREASES. THIS IS DUE TO A PROPERTY OF SUPPLY COMPONENTS CALLED INTERNAL RESISTANCE. INTERNAL RESISTANCE CAUSES VOLTS FROM SUPPLY TO BE TRANSFORMED AND LOST FROM THE CIRCUIT. THIS DECREASED VOLTMETER READING IS CALLED TERMINAL POTENTIAL DIFFERENCE (t.p.d.) THIS IS REPRESENTED AS V_{tpd} AND IS MEASURED IN VOLTS. TO FIND V_{tpd} ONE CAN USE $V_{tpd} = Ir$ WHERE V_{tpd} IS THE TERMINAL POTENTIAL DIFFERENCE (V), I IS THE CURRENT (AMPS, A), AND r IS THE INTERNAL RESISTANCE OF SUPPLY (Ω)

THE DIFFERENCE BETWEEN EMF & TPD IS 'LOST VOLTS' VOLTS LOST FROM THE CIRCUIT DUE TO INTERNAL RESISTANCE.

THIS GIVES RISE TO THE EQUATION:
$\epsilon = V_{LOST} + V_{TPD}$ WHERE ϵ IS EMF MEASURED IN VOLTS (V), V_{LOST} IS LOST VOLTS MEASURED IN VOLTS (V) & V_{TPD} IS tpd MEASURED IN VOLTS (V)

EXPERIMENT ① METHOD:

- ~~VOLTAGE~~ TERMINAL POTENTIAL DIFFERENCE WAS MEASURED USING VOLTMETER IN CLOSED CIRCUIT.
- CURRENT THROUGH RESISTOR WAS MEASURED USING AMMETER.
- CURRENT WAS ALTERED BY CHANGING RESISTOR THAT WAS IN SERIES.
- SET UP THIS CIRCUIT:



EXPERIMENT ① RESULTS:

~~TERMINAL POTENTIAL DIFFERENCE (V)~~ TERMINAL POTENTIAL DIFFERENCE (V)						~~CURRENT THROUGH RESISTOR (A)~~ CURRENT THROUGH RESISTOR (A)					
1	2	3	4	5	MEAN	1	2	3	4	5	MEAN
0.67	0.76	0.74	0.73	0.68	0.72	0.58	0.69	0.68	0.67	0.63	0.65
0.74	0.86	0.85	0.82	0.78	0.81	0.48	0.55	0.55	0.53	0.51	0.52
0.93	1.03	1.02	0.99	0.96	0.99	0.33	0.36	0.36	0.35	0.34	0.35
1.02	1.09	1.09	1.07	1.04	1.06	0.26	0.28	0.28	0.27	0.27	0.27
1.11	1.17	1.18	1.14	1.11	1.14	0.20	0.21	0.21	0.20	0.20	0.20
1.18	1.22	1.23	1.20	1.17	1.20	0.14	0.15	0.15	0.14	0.14	0.14

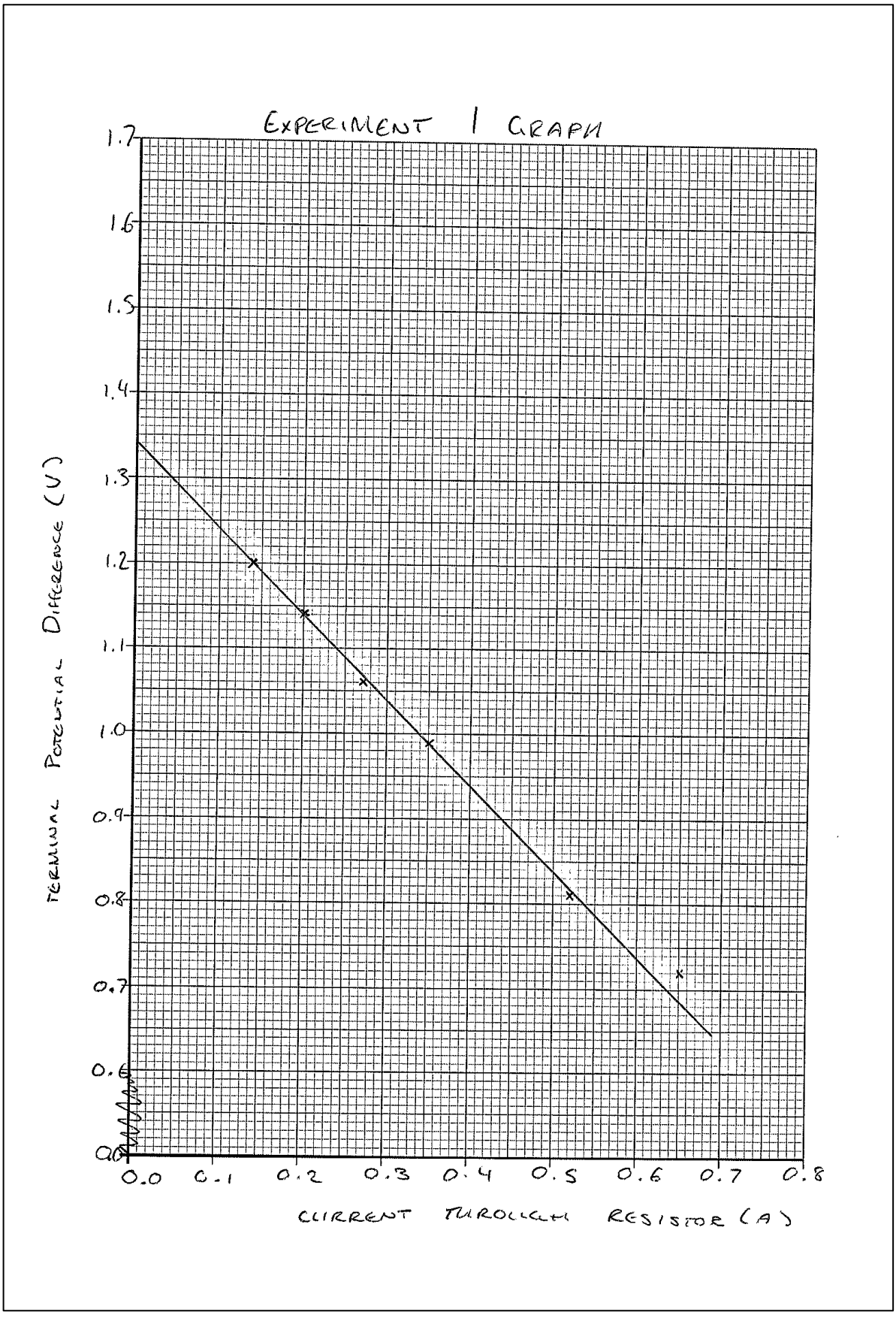
EXPERIMENT ① UNCERTAINTIES.

SCALE READING UNCERTAINTIES: VOLTMETER : ±0.01V

AMMETER : ±0.01A

RANDOM UNCERTAINTIES:

MEAN t.p.d. (V)	RANDOM UNCERTAINTY FOR MEAN t.p.d (V)	MEAN I THROUGH R (A)	RANDOM UNCERTAINTIES FOR MEAN I THROUGH R (A)
0.72	$\frac{0.76-0.68}{5} = 0.016$	0.65	$\frac{0.69-0.58}{5} = 0.022$
0.81	$\frac{0.86-0.74}{5} = 0.024$	0.52	$\frac{0.55-0.48}{5} = 0.014$
0.99	$\frac{1.03-0.93}{5} = 0.020$	0.35	$\frac{0.36-0.33}{5} = 0.030$
1.06	$\frac{1.09-1.02}{5} = 0.014$	0.27	$\frac{0.28-0.26}{5} = 0.004$
1.14	$\frac{1.18-1.11}{5} = 0.014$	0.20	$\frac{0.21-0.20}{5} = 0.002$
1.20	$\frac{1.23-1.17}{5} = 0.012$	0.14	$\frac{0.15-0.14}{5} = 0.002$


EXPERIMENT 1 GRAPH
TERMINAL POTENTIAL DIFFERENCE (V)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.0
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
CURRENT THROUGH RESISTOR (A)

ANALYSIS OF EXPERIMENT (1)

$y = mx + c$ $E = V + IR$

IN TERMS OF EQUATION OF A STRAIGHT LINE.

$V = -r(I) + E$ $\therefore$ y INTERCEPT = E (emf)

AND y GRADIENT = $-r$ (INTERNAL RESISTANCE

$E = 1.34V$

$-r = \frac{y_2 - y_1}{x_2 - x_1}$ (0.4, 0.94)

$= \frac{1 - 0.94}{0.34 - 0.4}$ (0.34, 1.0)

$= -1$

$r = 1\,\Omega$

METHOD OF EXPERIMENT (2)

- RESISTANCE OF RESISTORS WAS MEASURED USING AN OHMMETER
- CURRENT THROUGH R WAS MEASURED USING AMMETER
- RESISTOR IN SERIES WAS CHANGED & CURRENT THROUGH R WAS RECORDED * IN SAME CIRCUIT AS EXPERIMENT 1.

SOURCE 2 RESULTS

RESISTANCE OF R (Ω)	CURRENT THROUGH R (A)						$\frac{1}{I}$ (A^{-1})
	1	2	3	4	5	MEAN	
1.1	0.54	0.55	0.53	0.53	0.60	0.55	1.82
1.6	0.36	0.45	0.44	0.48	0.51	0.45	2.23
3.0	0.32	0.32	0.31	0.34	0.35	0.33	3.05
4.1	0.26	0.26	0.24	0.27	0.27	0.26	3.85
5.8	0.20	0.20	0.18	0.20	0.20	0.20	5.10
8.4	0.14	0.14	0.13	0.15	0.15	0.14	7.04

EXPERIMENT (2) UNCERTAINTIES

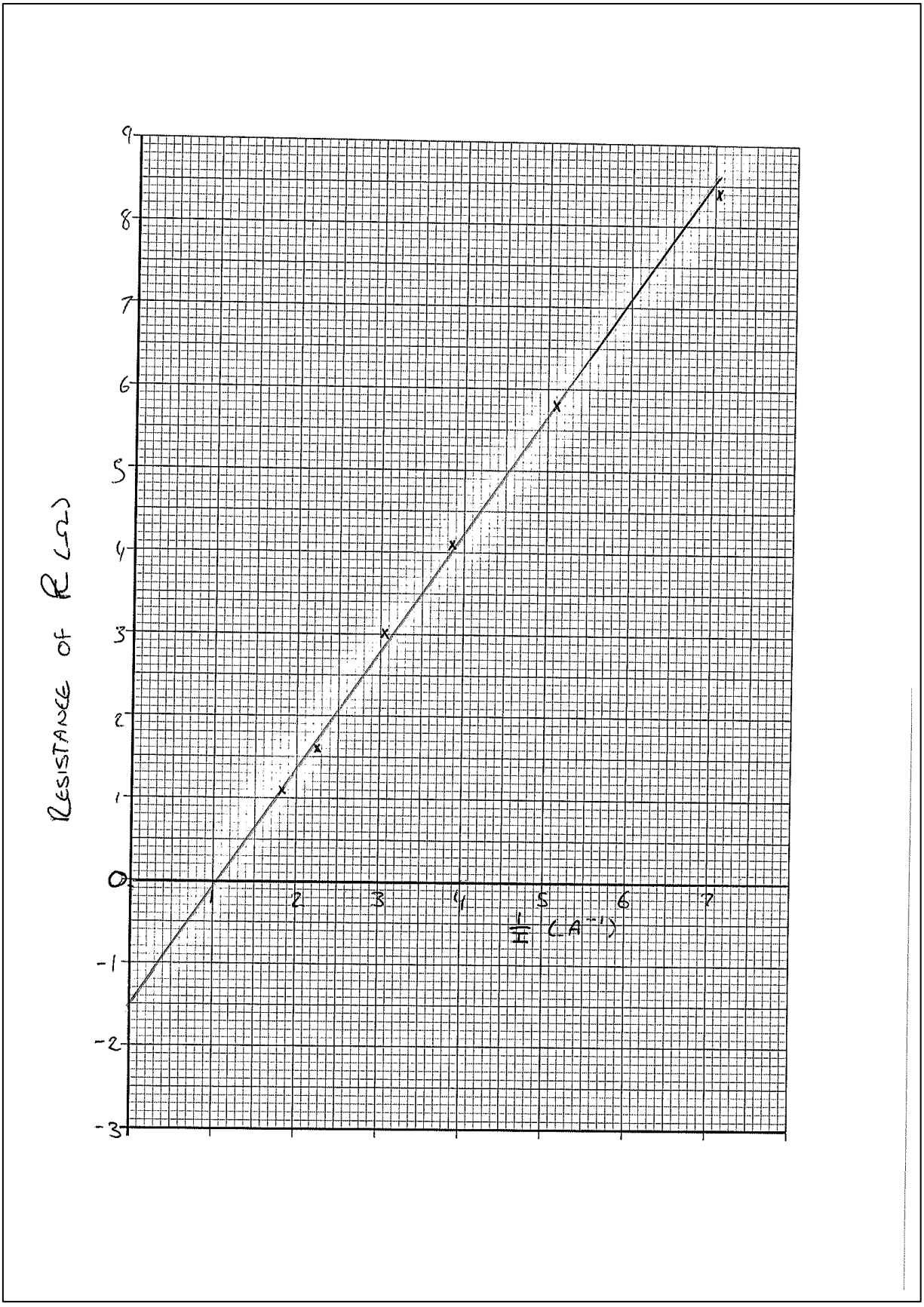
SCALE READING UNCERTAINTIES :

OHMETER : $\pm 0.10\ \Omega$

AMMETER : $\pm 0.01\ A$

RANDOM UNCERTAINTIES :

MEAN CURRENT THROUGH R (A)	RANDOM UNCERTAINTY OF MEAN CURRENT THROUGH R (A)
0.55	$\frac{0.60-0.55}{5} = 0.010$
0.45	$\frac{0.51-0.36}{5} = 0.030$
0.33	$\frac{0.35-0.31}{5} = 0.004$
0.26	$\frac{0.27-0.24}{5} = 0.006$
0.20	$\frac{0.2-0.18}{5} = 0.004$
0.14	$\frac{0.15-0.13}{5} = 0.004$


RESISTANCE OF R (Ω)
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
1
2
3
4
5
6
7
1/I (A⁻¹)

ANALYSIS OF EXPERIMENT (2)

$y = mx + c$ $\quad E = I(R + r)$

IN TERMS OF EQUATION OF A STRAIGHT LINE

$\frac{E}{I} = R + r$

$R = \frac{E}{I} - r$

$R = E \times \frac{1}{I} - r$ $\quad \therefore$ ~~M = E (emf)~~ E (emf) = GRADIENT (m)

AND $-r$ (INTERNAL RESISTANCE = y INTERCEPT)

$E(\text{emf}) = \frac{6.5 - 4.5}{5.6 - 4.2}$ $\quad (4.2, 4.5)(5.6, 6.5)$

$= 1.43$ V

$-r = -1.5$

$r = 1.5\ \Omega$

CONCLUSION

THE INTERNAL RESISTANCE OF THE D CELL WAS FOUND TO BE: $1\ \Omega$ FROM EXPERIMENT (1) AND $1.5\ \Omega$ FROM EXPERIMENT (2)

EVALUATION

1. THROUGHOUT BOTH EXPERIMENTS ~~Rest~~ THE BATTERY HEATED UP, INCREASING THE INTERNAL RESISTANCE.
   - IF I WERE TO REPEAT THE EXPERIMENT I WOULD ALLOW THE BATTERY TIME, INBETWEEN READINGS, TO COOL DOWN.

2. WIRES USED IN EXPERIMENT ALSO HAVE INTERNAL RESISTANCE THAT WAS NOT ACCOUNTED FOR IN THE LOAD RESISTANCE. MEANING THE y INTERCEPT IS HIGHER THAN IT WOULD BE IF r OF WIRES WAS TAKEN INTO ACCOUNT
   - TO PREVENT THIS ~~III~~ INTERNAL RESISTANCE OF WIRES SHOULD BE MEASURED AND ADDED TO

LOAD RESISTANCE

3. RESISTANCE VALUES ARE ONLY MEASURED TO ONE DECIMAL PLACE MAKING RESISTANCE VALUES LESS PRECISE THAN OTHER MEASURED VALUES.

TO ENSURE VALUES FOR RESISTANCE ARE ~~TAKEN INTO ACCOUNT~~ AS PRECISE AS OTHER MEASURED VALUES ONE SHOULD USE A MORE PRECICE OHMMETER THAT MEASURES TO MORE DECIMAL PLACES.

REFERENCE

BrightRED study guide CfE Higher Physics, TAYLOR JOHN, Pg 64-65 ISBN ~~978-1-906736-67-5~~
978-1-906736-67-5.