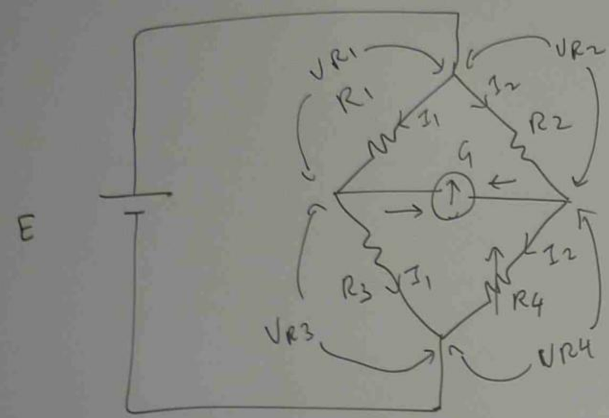
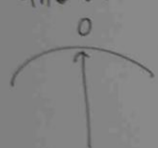
WHEAT STONE BRIDGE



(G) - GALVANOMETER



CENTRE ZERO METER

ADJUST THE VALUE OF VARIABLE RESISTOR "R4" TO BALANCE THE BRIDGE.

AT THE BALANCED CONDITION

$$V_{R_1} = V_{R_2}$$

AND

$$V_{R_3} = V_{R_4}$$

NO CURRENT FLOWS INTO GALVANOMETER

$$V_{R_1} = I_1 R_1 \qquad V_{R_3} = I_1 R_3$$

AND

$$V_{R_2} = I_2 R_2 \qquad V_{R_4} = I_2 R_4$$

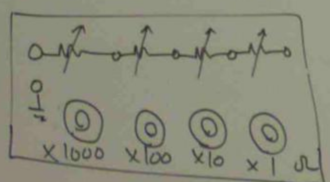
$$I_1 R_1 = I_2 R_2 \quad \text{—}(1)$$

$$I_1 R_3 = I_2 R_4 \quad \text{—}(2)$$

$$\frac{(1)}{(2)} \qquad \frac{I_1 R_1}{I_1 R_3} = \frac{I_2 R_2}{I_2 R_4}$$

$$\frac{R_1}{R_3} = \frac{R_2}{R_4}$$

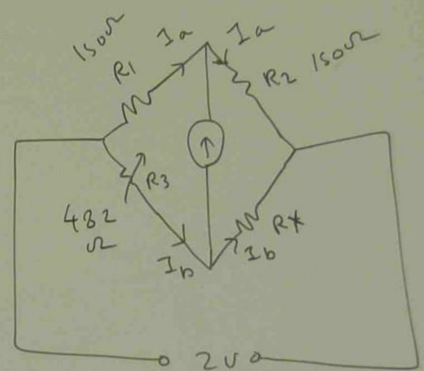
$$\boxed{R_1 R_4 = R_2 R_3}$$



FOUR DECADE STANDARD RESISTANCE BOX

pb (1)

THE CIRCUIT SHOWN IN FIGURE HAS BEEN SET UP TO MEASURE THE RESISTANCE OF R_x. THE BRIDGE IS BALANCED BY VARIATION OF R_3 AND AT BALANCE, ITS VALUE IS FOUND TO BE 482 Ω. IF R_1 AND R_2 BOTH HAVE THE VALUES OF 150 Ω, CALCULATE THE VALUE OF R_x



AT BALANCE

$$V_{R_1} = V_{R_3}$$

$$V_{R_2} = V_{R_x}$$

$$I_a R_1 = I_b R_3 \quad -(1)$$

$$I_a R_2 = I_b R_x \quad -(2)$$

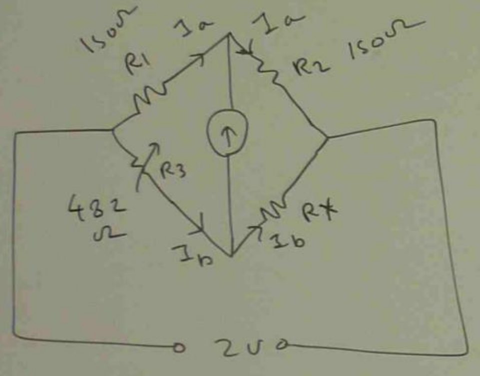
$$\frac{(1)}{(2)} \qquad \frac{I_a R_1}{I_a R_2} = \frac{I_b R_3}{I_b R_x}$$

$$\frac{R_1}{R_2} = \frac{R_3}{R_x}$$

$$R_1 R_x = R_2 R_3$$

pb ①

THE CIRCUIT SHOWN IN FIGURE HAS BEEN SET UP TO MEASURE THE RESISTANCE OF R_x. THE BRIDGE IS BALANCED BY VARIATION OF R_3 AND AT BALANCE, ITS VALUE IS FOUND TO BE 482 Ω. IF R_1 AND R_2 BOTH HAVE THE VALUES OF 150 Ω, CALCULATE THE VALUE OF R_x



AT BALANCE

$$V_{R_1} = V_{R_3}$$

$$V_{R_2} = V_{R_x}$$

$$I_a R_1 = I_b R_3 \quad -①$$

$$I_a R_2 = I_b R_x \quad -②$$

$$\frac{①}{②} \quad \frac{I_a R_1}{I_a R_2} = \frac{I_b R_3}{I_b R_x}$$

$$\frac{R_1}{R_2} = \frac{R_3}{R_x}$$

$$R_1 R_x = R_2 R_3$$

$$R_x = \frac{R_2 R_3}{R_1}$$

$$= \frac{150 \times 482}{150}$$

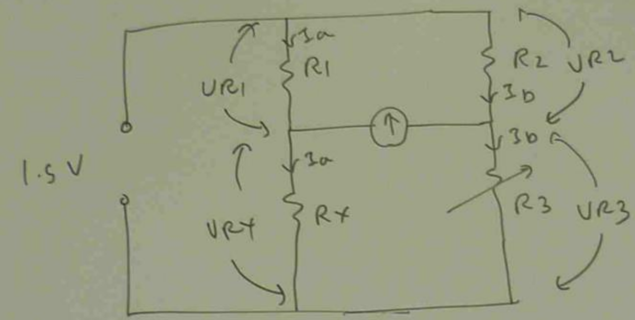
$$= 482\,\Omega$$

pb 2

THE FOLLOWING BRIDGE CIRCUIT HAS THE FOLLOWING VALUES AT BALANCE.

$R_1 = 1000\,\Omega$, $R_2 = 1000\,\Omega$, $R_3 = 27.15\,\Omega$.

CALCULATE THE VALUE OF THE UNKNOWN RESISTOR R_X.



BALANCED

$V_{R_1} = V_{R2}$ AND $V_{RX} = V_{R3}$

$I_a R_1 = I_b R_2$ — ① & $I_a R_X = I_b R_3$ — ②

$$\frac{①}{②} \qquad \frac{I_a R_1}{I_a R_X} = \frac{I_b R_2}{I_b R_3}$$

$$\frac{R_1}{R_X} = \frac{R_2}{R_3}$$

$R_1 R_3 = R_2 R_X$

$$R_X = \frac{R_1 R_3}{R_2}$$

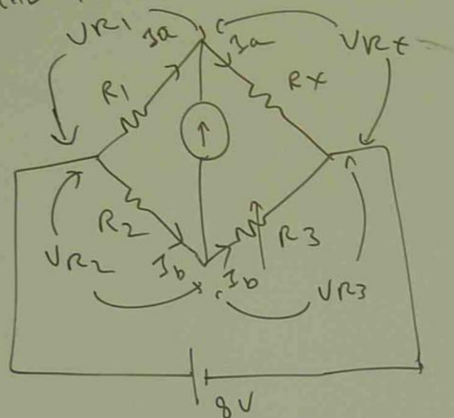
$$= \frac{1000 \times 27.15}{1000}$$

$$= 27.15\,\Omega$$

pb (3)

THE CIRCUIT GIVEN IN THE FIGURE IS TO BE USED TO CONFIRM THE VALUE OF THE RESISTOR R_3 WHICH HAS VALUES FROM 0 TO 10 KΩ IN 10Ω STEPS. $R_x = 8.25\,m\Omega$

STANDARD RESISTORS WITH VALUES OF 10Ω, 100Ω, 1KΩ AND 100 KΩ ARE AVAILABLE FOR USE AS RATIO ARMS SUGGEST THE COMBINATION TO GIVE THE BEST RESULTS FOR THE REQUIRED MEASUREMENT.



BALANCED

$V_{R1} = V_{R2}$ — (1)

$V_{Rx} = V_{R3}$ — (2)

$I_a R_1 = I_b R_2$ — (1)

$I_a R_x = I_b R_3$ — (2)

$\frac{(1)}{(2)}$ $\quad \frac{R_1}{R_x} = \frac{R_2}{R_3} \Rightarrow \frac{R_x}{R_1} = \frac{R_3}{R_2}$

$R_x = 8.25\,m\Omega$

Assume $R_1 = 10K\Omega$

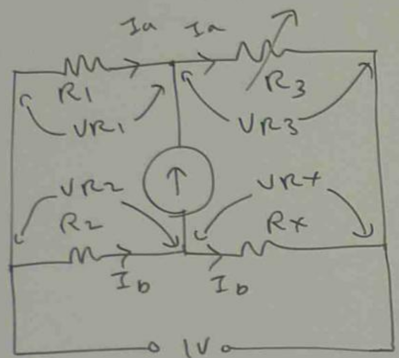
$R_2 = 10K\Omega$

$\frac{8.25 \times 10^{3} K}{10K} = \frac{R_3}{10K}$

$R_3 = 8.25\,m\Omega$

pb (4)

A WHEATSTONE BRIDGE IS ARRANGED AS SHOWN IN FIGURE. THE RATIO ARMS R_1 AND R_2 HAVE VALUES OF $1000\,\Omega$ AND $10\,\Omega$ RESPECTIVELY. AND AT BALANCE, THE VARIABLE R_3 IS FOUND TO BE SET AT $154\,\Omega$. CALCULATE THE VALUE OF THE UNKNOWN RESISTOR "R_x".



$R_1 = 1000\,\Omega$, $R_2 = 10\,\Omega$

$R_3 = 154\,\Omega$, $R_x = ?$

AT BALANCED CONDITION

$V_{R_1} = V_{R_2}$ — (1)

$V_{R_3} = V_{R_x}$ — (2)

$I_a R_1 = I_b R_2$ — (1)

$I_a R_3 = I_b R_x$ — (2)

$\dfrac{(1)}{(2)}$ $\qquad \dfrac{R_1}{R_3} = \dfrac{R_2}{R_x}$

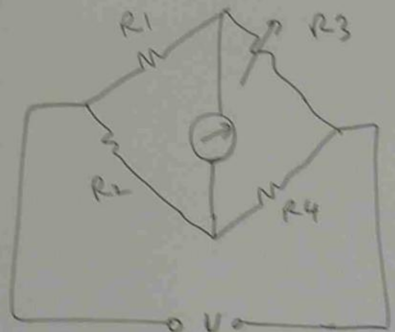
$R_1 R_x = R_2 R_3$

$$R_x = \frac{R_2 R_3}{R_1}$$

$$= \frac{10 \times 154}{1000} = \frac{1540}{1000} = 1.54\,\Omega$$

EXERCISE

1. THE CIRCUIT FOR A WHEATSTONE BRIDGE IS SHOWN IN FIGURE. IF $R_1 = R_2 = 1k\Omega$ AND R_3 AT BALANCE IS 1537Ω, THE VALUE OF R_4 WILL BE



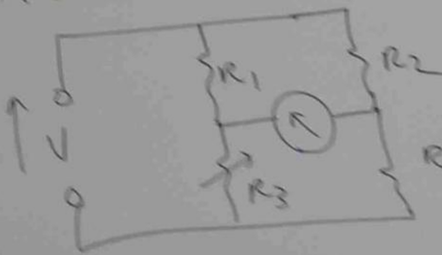
(a) 1.537Ω

(b) $1.537\ m\Omega$

(c) 537Ω

(d) 1537Ω

2. THE BALANCE EQUATION FOR THE GIVEN BRIDGE CIRCUIT WILL BE



(a) $R_x = \frac{R_1}{R_2 R_3}$

(b) $R_x = \frac{R_1 R_2}{R_3}$

(c) $R_x = \frac{R_2 R_3}{R_1}$

(d) $R_x = R_1 R_2 R_3$

ELECTRO CHEMISTRY

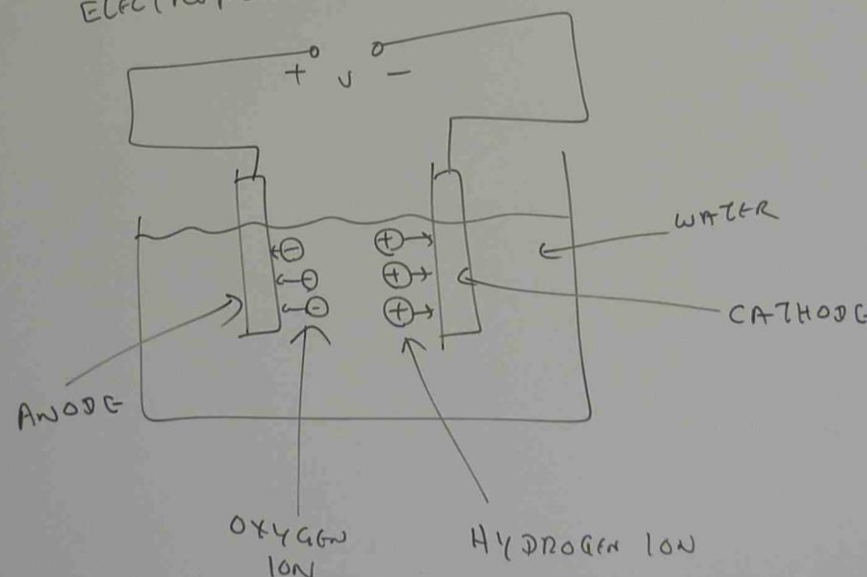
ELECTROLYSIS

ELECTRICITY → CHEMICAL ACTION

ELECTRIC CELL

CHEMICAL ACTION → ELECTRICITY

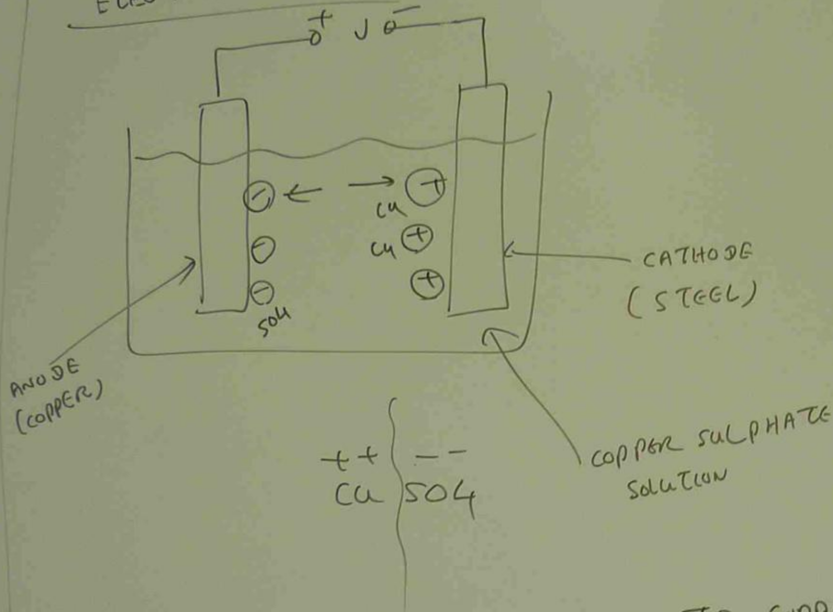
ELECTROPLATING



ELECTRIC CURRENT FLOWS INTO WATER.

WATER MOLECULE IS DISSOLVED INTO − OXYGEN AND + HYDROGEN IONS.

ELECTROPLATING



COPPER PLATE IS CONNECTED TO COPPER BAR (ANODE)(+) AND CATHODE STEEL IS CONNECTED TO (—) TERMINAL.

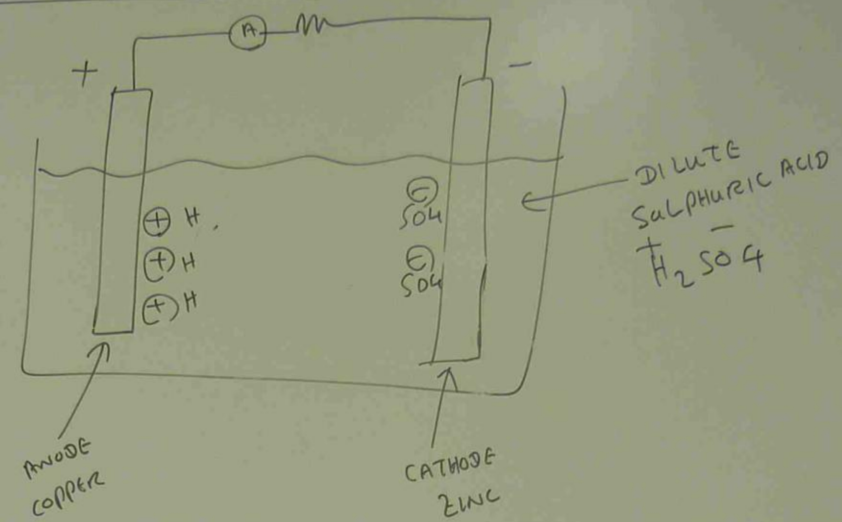
COPPER SULPHATE $\overset{+}{Cu}\,\overset{-}{SO_4}$ IS DISSOLVED INTO POSITIVE COPPER AND NEGATIVE SULPHATE

(+) ANODE ATTRACTS (−) SO_4

(−) CATHODE-STEEL ATTRACTS (+) Cu.

STEEL IS COVERED WITH COPPER.

THE ELECTRIC CELL

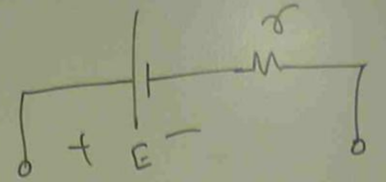


DILUTE SULPHURIC H_2SO_4 IS DISSOLVED INTO + HYDROGEN AND − SULPHATE IONS.

+ HYDROGEN IONS COVER ANODE COPPER BAR AND MAKE + TERMINAL

− SULPHATE IONS COVER CATHODE ZINC BAR AND MAKE − TERMINAL.

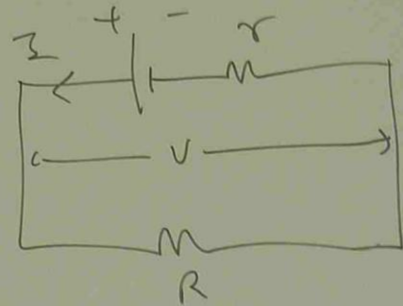
ELECTRICAL CURRENT FLOWS FROM (+) TO (−) TERMINAL



EQUIVALENT DIAGRAM FOR BATTERY

E − ELECTROMOTIVE FORCE (V)

r = INTERNAL RESISTANCE OF BATTERY



V = TERMINAL VOLTAGE

$$E = V + Ir$$

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

NAL

pb 1

A CELL HAS AN Emf OF 1.5V AND INTERNAL RESISTANCE 0.5Ω.

CALCULATE ITS TERMINAL VOLTAGE AT

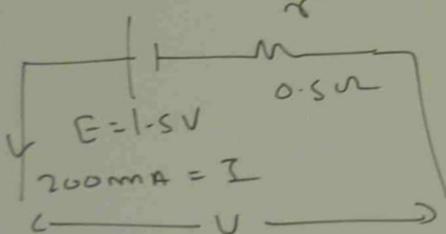
(a) NO LOAD (b) WHEN PROVIDING A CURRENT OF 200mA

(c) WHEN CONNECTED TO A LOAD OF RESISTANCE 8Ω.

(a) $E = V + \cancel{Ir} \to 0$

$E = V = 1.5V$

(b)



$V = E - Ir$

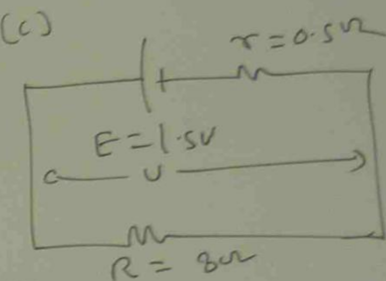
$= 1.5 - 200\times10^{-3} \times 0.5$

$= 1.5 - 0.2 \times 0.5$

$= 1.5 - 0.1$

$= 1.4V$

(c)



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

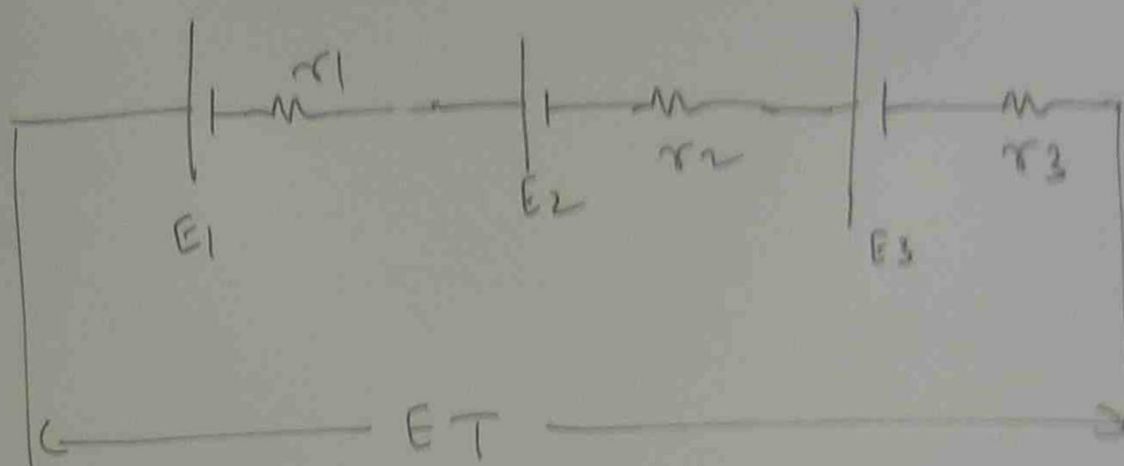
$= \frac{1.5}{8+0.5}$

$= \frac{1.5}{8.5} = 0.176A$

$V = E - Ir$

$= 1.5 - 0.176 \times 0.5$

$= 1.41V$



$$E_T = E_1 + E_2 + E_3 + \cdots$$

$$r_T = r_1 + r_2 + r_3 + \cdots$$

pb(2)

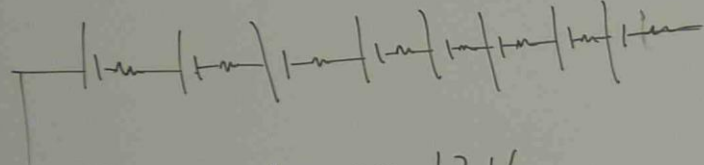
A BATTERY IS MADE BY CONNECTING EIGHT CELLS IN SERIES. EACH OF THE CELLS HAS AN EMF OF 1.5V AND AN INTERNAL RESISTANCE OF 0.35Ω.

CALCULATE (a) THE EMF AND THE INTERNAL RESISTANCE OF THE BATTERY

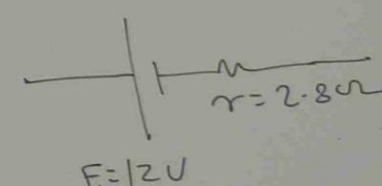
(b) THE TERMINAL VOLTAGE WHEN SUPPLYING A CURRENT OF 300 mA

(c) THE CURRENT AND TERMINAL VOLTAGE WHEN A LOAD OF RESISTANCE 15Ω IS CONNECTED TO THE BATTERY.

(a)



≡

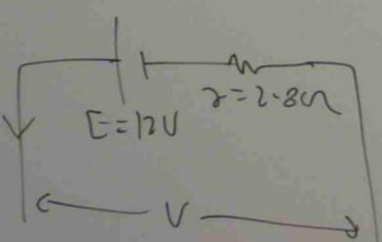


$E = 8 \times 1.5\,V = 12V$

$r = 8 \times 0.35 = 2.8\,\Omega$

(b)

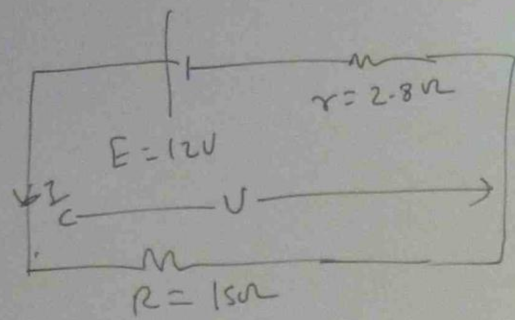
$I = 300$ mA



$V = E - Ir = 12 - 0.3 \times 2.8$

$= 11.16V$

(c)



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

$$= \frac{12}{15 + 2.8}$$

$$= \frac{12}{17.8} = 0.674 \text{ Amp.}$$

$$V = E - I r$$

$$= 12 - 0.674 \times 2.8$$

$$= 10.11V$$

EXERCISE

① A DRY BATTERY INTENDED TO POWER A PERSONAL STEREO IS MADE UP OF SIX SERIES CONNECTED CELLS. EACH WITH EMF 1.5V AND INTERNAL RESISTANCE 0.08Ω. THE EMF AND INTERNAL RESISTANCE OF THE BATTERY WILL BE

(a) 9V, 0.08Ω (b) 6V, 0.48Ω
(c) 9V, 4.8Ω (d) 9V, 0.48Ω

② A BATTERY WITH AN EMF 15V AND INTERNAL RESISTANCE 1.4Ω DELIVERS 350mA TO ELECTRONIC CIRCUIT. TERMINAL VOLTAGE WILL BE

(a) 4.9V (b) 10.1V (c) 14.51V (d) 15.49V

③ A 6V BATTERY WITH INTERNAL RESISTANCE 0.8Ω IS CONNECTED TO A CIRCUIT WITH 8.2Ω. THE DRAIN CURRENT IS

(a) 667mA (b) 732mA (c) 1.5A
(d) 1.33A.