Internal Resistance (1 of 2) AS Physics

1. Starting your car. (need a current of 50A or more)

Car starter motors operate from nominally "12V" supplies, and need a current of 50A or more.

A Physics student needs a new car battery (cost £24.99 at cheapo-mart.), and thinks "I can use 8 zinc cells, and buy some Physics text books..."

8 Zinc cells
each:- E = 1.5V, r = 0.4Ω

6 lead cells
each: E = 2.0V, r = ? Ω

a) What is the total emf, and total internal resistance of 8 zinc cells in series? (2)

b) How much current would these cells deliver if short circuited ($R_{ext} = 0\ \Omega$)? (2)

c) What would be the terminal voltage across the 8 cells? (2)

d) Would the zinc cells start the car? Explain your answer. (2)

e) The student buys a new car battery, and investigates. She measures that while starting the engine.....:

battery p.d. = 10.8 V and current through motor = 60A.

Calculate the resistance of the motor (3)

f) Calculate the total internal resistance of the battery. (3)

g) If the motor needs a minimum of 50A to start the engine, what is the maximum internal resistance the battery can have? (3)

Q... [1] [2]

TRN /17 /14

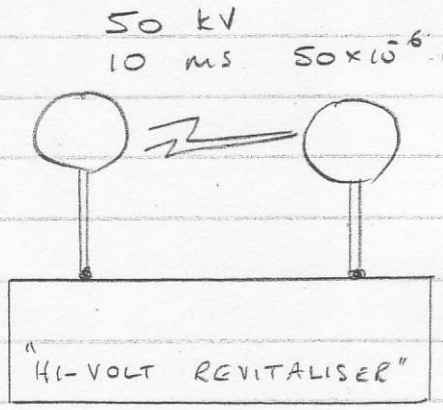
12.00 +11.04

Internal Resistance

2 of 2

AS Physics

1. The Spark of Life



Baron Frankenstein is building his mark IV spark vitaliser. It delivers a spark at 50 kV lasting 10 milliseconds (10 ms).

a) What are the voltage and time duration of the spark in V and s ? (2).

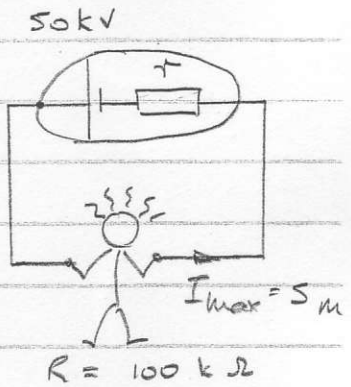
b) Calculate the current flowing in the spark (2)

c) How many electrons is this ? (1)

electron charge $e = -1.6 \times 10^{-19}$ C

d) The Baron is concerned for the safety of his assistant Igor, in case he touches the terminals. He knows that body resistance is about 100 kΩ, and the maximum safe current is 5 mA

What internal resistance r should the Baron put in his machine to limit the current to 5 mA ? (3)



e) The Baron has two resistors; one of 3.3 MΩ (3.3×10^6 Ω) and the other of 8.2 MΩ.

What is their combined resistance ... in series ?

... in parallel ? (2)

f) What is the current through Igor with the resistors used ..... in series ? (2)

... in parallel ? (2)

Q.. [1] [2]

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Internal Resistance answers

AS Physics

1 

(a) $E_{total} = 8 \times 1.5 = 12\ V$ ① and $r_{total} = 8 \times 0.14 = 3.2\ \Omega$ ①

b) Short circuit $R_{ext} = 0\ \Omega$ so $E = IR + Ir$ ①

$12 = 0 + I \times 3.2 \rightarrow I = 3.75\ A$ ① /2

c) Since $R = 0$ .... $IR = 0$ ① ... $V_{terminal} = 0\ V$ ① !! /2

d) Nope ① ... current too small ① .... (limited by internal resistance) /2

e) look at the motor ... p.d. across motor = 10.8 ① $I = 60\ A$

So $R_{motor} = V/I$ ① $= 10.8/60 = 0.18\ \Omega$ ① /3

f) use $E = IR + Ir$ ① $\rightarrow 12 = 10.8 + 60r$ ①

(V_{ext})

So ... $r_{int} = (12 - 10.8)/60 = 0.02\ \Omega$ ① /3

g) use $E = IR + Ir$ ① $= I(R + r)$

So $12 = 50(0.18 + r_{max})$ (A) $\rightarrow 12/50 = 0.24 = 0.18 + r_{max}$ ①

$\rightarrow r_{max} = 0.24 - 0.18 = 0.06\ \Omega$ ① max

(

$12 = (50 \times 0.18) + 50 \times r \rightarrow 12 - 9 = 3 = 50r \rightarrow r_{max} = 0.06\ \Omega$) /1

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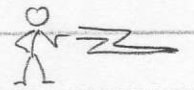
2. 

(a) $50\,000\ V$ ① and $10/1000 = 10 \times 10^{-3}\ s$ ① /2

b) $I = Q/t$ ① $= 50 \times 10^{-6} / 10 \times 10^{-3} = 0.005\ A$ ① (5 mA) /2

c) no. electrons $= 50 \times 10^{-6} / 1.6 \times 10^{-19} = 3.1 \times 10^{14}$ ① /1

d) use $E = IR + Ir$ ① $\rightarrow 50\,000 = 0.005 \times 100\,000 + 0.005 \times r_{int}$

(I_{gov})

So ... $50\,000 = 500 + 0.005r$ ① $\rightarrow r = 49500/0.005$

$= 9\,900\,000\ \Omega$ ① (9.9 M

e) series  $R_t = 11.5\ M\Omega$ ① the windmill! ✗ /1

parallel  $R_t = \frac{3.3 \times 8.2}{3.3 + 8.2} = 2.35\ M\Omega = 2.35 \times 10^6\ \Omega$

f) series .... $E = IR + Ir = I(R + r)$ use the exp key!

$50 \times 10^3 = I(100 \times 10^3 + 11.5 \times 10^6)$ ①

So $I = 50 \times 10^3 / 11.6 \times 10^6 = 0.0043$ ① A (4.3 mA)

parallel ... $E = IR + Ir$

$50 \times 10^3 = I(100 \times 10^3 + 2.35 \times 10^6)$ ①

So $I = \frac{50 \times 10^3}{2.45 \times 10^6} = 0.020\ A$ ① (20 mA

Sorry Igor!!  oops.

TN

12.00

Q 1! /17 2 /14