# A Challenge to the Vorticians!

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Mark Hugo issues the challenge Vorticians to determine what is beyond chemical energy output for a flowing calorimetry electrochemical cell: "What flow rate, what delta T, and what length of run would you require to assert that there would be an energy source in a 355 ml Diet Coke can."

Assuming no tricks, we need to identify a chemical source of energy that maximizes J/cc. It appears from the problem definition that utilization of ambient air is OK. The most dense chemical storage I could come up with is Be (10.8 kcal/cc). Second best was pentaborane (B5H9 at 10 kcal/cc). Oxidation of Be to BeO produces 10.78 kcal/cc, so we have room in 355 ml for a max of 3834 kcal, or about 3.8 Mcal. I know this is unrealistic, because where does the ash go?

Now, flow area is 3.14(.5cm)^2 = .785 cm^2. The energy delivered by the current is .5 J/s = (.5 J/s)(.239 cal/J) = .1195 cal/s. So, if we can measure temperature to .01 deg. C, as long as we maintain a flow rate of more than twice .1195 cc/s, or .152 cm/s in our tubing, we will eventually use up the energy stored in the can and measure the result to 1 percent accuracy. Our flow rate must be sufficient to prevent boiling, so it is tied to the rate at which the chemical energy is produced in the can, or vice versa. We can assume any value we want, so let's pick a number out of thin air, say ummmm, 60 watts production rate in the can. We have (60 J/s)(.239 cal/J) = 14.34 cal/sec. This, plus the .1195 cal/s current contribution adds up to a heat production of 14.46 cal/sec. At a flow rate of 3 cc/s, or 3.8 cm/s, the water should heat up about 4.8 deg. C in the can. So it will take (3.83E6 cal)/(14.34 cal/sec) = 2.67E5 sec.= 74 h = about 3 days.

The minimum possible run length would depend on how fast you could pump water through the can at a 100 deg C differential. At 10 cc/s that 1 kcal/s or 3.83E3 s., or about 1 hour.

The longest possible run would be at .4 cc/sec at 1 deg C rise (to get 2 percent accuracy) consuming about .2 cal/s from the can so that's 1.91E7 s = 5.32E3 h = 221 days.