Can a microwave oven and some marshmallows measure the speed of light?

Name _____ Date _____

MATERIALS

You supply everything. Tick each item as you gather it.

- ☐ A microwave oven (look for its frequency on the label, usually 2.45 GHz or 2,450 MHz)
- ☐ A microwave-safe plate that you can keep from turning, such as one sitting on an upside-down bowl, with the turntable removed
- ☐ A bar of chocolate, or a layer of marshmallows or cheese, to cover the plate
- ☐ A ruler in millimeters, an oven mitt, and a calculator

SAFETY

Never run a microwave empty, and run it only for the short time given. Melted sugar and chocolate are very hot and can burn. Use an oven mitt and let the plate cool before touching it. Do not stand near the oven when it runs, and do not use metal. Keep the door seal clean and never use a damaged oven.

PROCEDURE

1. Find the frequency on the oven's label. Write it in hertz (2.45 GHz = 2.45×10^9 Hz).
2. Remove the turntable so that the food does not rotate, and set the plate on an upside-down microwave-safe bowl so that the plate stays still. Cover the plate with a single layer of marshmallows or a flat sheet of chocolate.
3. Heat for 15 to 20 seconds, until a few separate spots begin to melt, and no longer, so that the whole layer does not melt. Remove it with a mitt.
4. Measure the distance between the centers of neighboring melted spots in millimeters. Measure at least 5 pairs.
5. Neighboring hot spots are half a wavelength apart, because they are the antinodes of a standing wave in the oven. Compute the wavelength: $\lambda = 2 \times$ (mean spacing).
6. Compute the speed of light with $c = f \times \lambda$, and compare it with 2.998×10^8 m/s. Then compute the energy of a microwave photon, $E = h f$.

RECORD YOUR DATA

Pair	Spacing between hot spots (cm)
1	
2	
3	
4	
5	
Mean	

Also write the oven's frequency, λ, c and your percent error.

LAB REPORT

Write a report that gives your measurements, explains why melted spots are half a wavelength apart, shows the calculation of c and the percent error, and calculates the energy of one microwave photon. Compare it with the energy of a visible-light photon, and explain why microwaves heat food but cannot cause the kind of damage that X-rays can.

Report the numbers you actually got, even when they disagree with the lesson. Write on the lines, or type your report on the website and send it to a teacher there.

Question and hypothesis *State the question in your own words, what you expect to happen, and why you expect it.*

Method *What you changed, what you measured, what you kept the same, and how many trials you ran.*

Observations *Describe what you saw, including anything unexpected. Your data tables are added to the report automatically.*

Calculations *Show each calculation step by step, with units.*

Claim and reasoning *Answer the question using your numbers, then explain why, using the science from the unit.*

Limits and next step *What could have affected your results, and one change you would make next time.*