Passage II

The Indian beech tree (*Millettia pinnata*) produces oil-rich seeds. The oil is inedible; however, it can be converted to *biodiesel fuel* in a chemical reaction with methanol (a solvent) and a catalyst. Scientists studied the production of biodiesel fuel from *M. pinnata* oil.

Experiment

In each trial, the following steps were performed:

1. Twenty mL of *M. pinnata* oil was mixed with 80 mL of methanol in a flask to form a solution.
2. A particular mass of a catalyst—either sodium hydroxide (NaOH) or potassium hydroxide (KOH)—was dissolved in the flask.
3. The flask was fitted with a temperature probe, sealed, placed in a microwave oven, and then microwaved until the contents reached 60°C.
4. The flask was maintained at 60°C in the microwave for a particular amount of time (the *microwave time*).
5. The flask was immersed in an ice water bath.
6. The amount of biodiesel fuel produced was measured, and the percentage of the *M. pinnata* oil that had been converted to biodiesel fuel was calculated.

For any given combination of conditions (identity of catalyst, concentration of catalyst, and microwave time), 4 trials were conducted. The table shows, for each set of trials, the experimental conditions and the average percent of the oil that was converted to biodiesel fuel.

Set of trials	Catalyst	Catalyst concentration (percent by mass)	Microwave time (min)	Average percent of *M. pinnata* oil converted to biodiesel fuel
1–4	NaOH	0.5	5	95.0
5–8	NaOH	1.0	5	91.2
9–12	NaOH	1.5	5	N.D.*
13–16	KOH	0.5	5	89.2
17–20	KOH	1.0	5	96.0
21–24	KOH	1.5	5	95.0
25–28	NaOH	1.0	3	93.2
29–32	NaOH	1.0	7	96.4
33–36	KOH	1.0	3	88.6
37–40	KOH	1.0	7	96.5
41–44	KOH	1.0	10	97.3

*N.D.—Not determined.

Table adapted from M. L. Savaliya and B. Z. Dholakiya, "Chemical Transformation of Triglycerides of Fatty Acid of *Pongamia pinnata* Seed to Fatty Acid Methyl Esters by Microwave Irradiation." ©2013 by M. L. Savaliya and B. Z. Dholakiya.

8. Which step was most likely performed to stop the reaction that was occurring in the flask?

F. Step 3
G. Step 4
H. Step 5
J. Step 6

9. According to the table, which of the following combinations of catalyst, catalyst concentration, and microwave time resulted in the *lowest* average percent of *M. pinnata* oil being converted to biodiesel fuel?

	catalyst	catalyst concentration	microwave time
A.	NaOH	1.0%	3 min
B.	NaOH	1.0%	7 min
C.	KOH	1.0%	7 min
D.	KOH	1.5%	5 min

). Consider the results for each combination of catalyst concentration and microwave time that was tested. Compared with the average percent of *M. pinnata* oil converted to biodiesel fuel in the NaOH trials, the average percent of *M. pinnata* oil converted to biodiesel fuel in the KOH trials was:

F. always higher.
G. always lower.
H. always the same.
J. sometimes higher and sometimes lower.

11. Which of the following expressions gives the volume of methanol used in the experiment?

A. $\frac{80 \text{ mL methanol}}{\text{trial}} \times 11 \text{ trials}$

B. $\frac{80 \text{ mL methanol}}{\text{trial}} \times 44 \text{ trials}$

C. $\frac{100 \text{ mL methanol}}{\text{trial}} \times 11 \text{ trials}$

D. $\frac{100 \text{ mL methanol}}{\text{trial}} \times 44 \text{ trials}$

12. The average percent of *M. pinnata* oil converted to biodiesel fuel in Trials 25–28 differed from that in Trials 33–36 because the 2 sets of trials differed with respect to the:

F. identity of the catalyst.
G. concentration of the catalyst.
H. microwave time.
J. temperature at which the flask was maintained.

13. For the trials conducted with 1.0% KOH by mass, as the microwave time increased, the average percent of *M. pinnata* oil converted to biodiesel fuel:

A. increased only.
B. decreased only.
C. increased and then decreased.
D. decreased and then increased.

14. The solution formed in Step 1 of each trial had a mass of 82 g. Based on this information and the table, the mass of the catalyst added to the flask in Step 2 of Trial 5 was closest to which of the following?

F. 0.4 g
G. 0.8 g
H. 4 g
J. 8 g