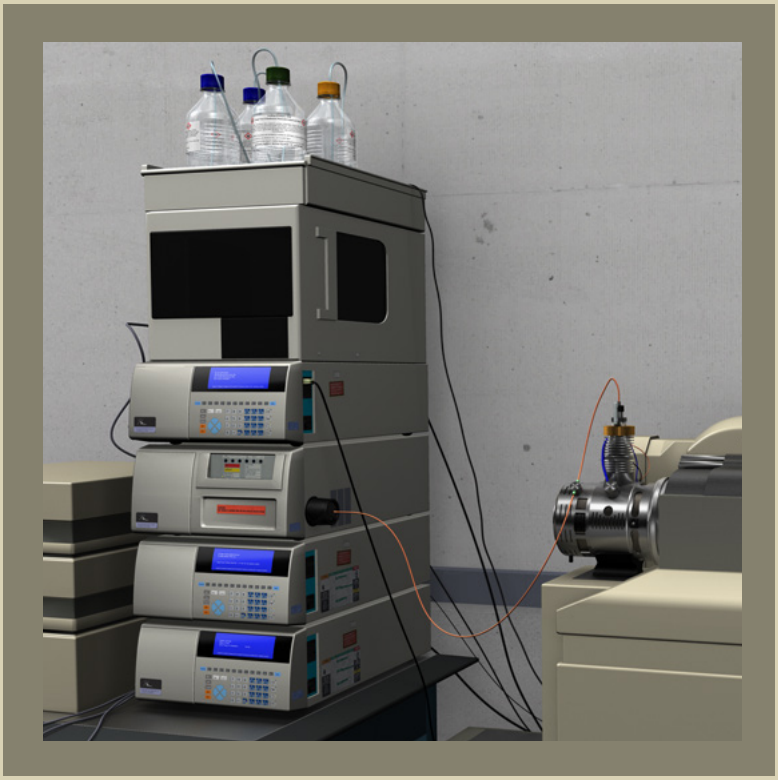
STEM Sims™

Mass Spectrometry



STEM Sims™

Mass Spectrometry

Do you need an idea for a scientific study?
Try out one of our ideas or make one of your own.

Start learning right now about how to determine the chemical formula of a substance using a mass spectrometer. Take the following brief quiz to see how much you already know mass spectrometry. See the bottom of page 4 to check your answers.

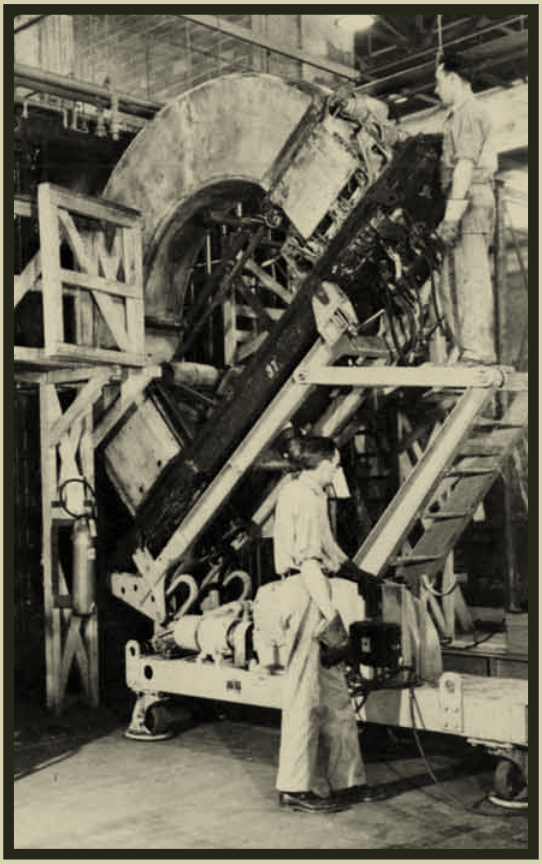
1. Who is most often credited with the invention of the mass spectrometer?
   a. E. Rutherford
   b. J. Chadwick
   c. J. Dalton
   d. J. Thompson

2. In most mass spectrometers, electrons collide with molecules, splitting the molecules into smaller pieces. After the breakup of the molecule, which type of particle does the mass spectrometer usually detect?
   a. anions
   b. cations
   c. radicals
   d. polymers

3. All of the following are common uses of mass spectrometers *except*:
   a. determining the volume of a liquid.
   b. finding pesticides in grocery items.
   c. examining toothpaste for dangerous chemicals.
   d. measuring the size of nanoparticles.

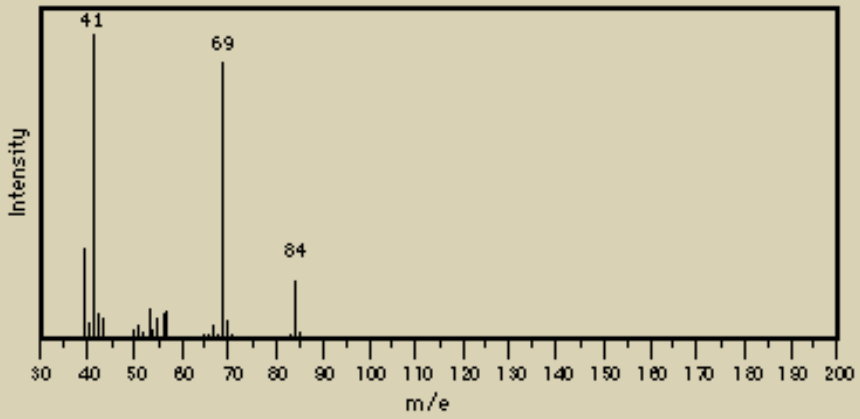
4. Which element was “discovered” using a mass spectrometer?
   a. gold
   b. silver
   c. nitrogen
   d. neon

5. What is/are another name(s) for an anode ray?
   a. positive ray, only
   b. canal ray, only
   c. both canal and positive rays
   d. neither canal nor positive rays



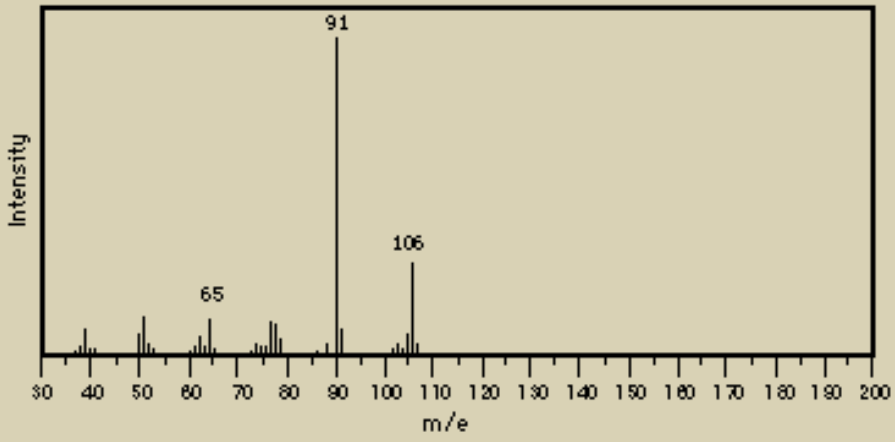
The Number 13 Rules

A mass spectrometer is a device and technique used to determine the molecular mass of an unknown substance that has been ionized. The Rule of 13 is a shortcut method for finding the chemical formula of an alkane once you know the molecular mass. Given the following mass spectrum for an alkane, what is the expected molecular mass of the compound?



Most likely you correctly answered that the molecular mass is equal to 84 daltons. Assuming the compound is an alkane, what is its chemical formula? This is where the Rule of 13 comes into play. First, divide the molecular mass by 13. In this example, 84/13 = 6.46153846. The units position gives the number of carbons in the alkane as 6. Next, multiply the decimal remainder times 13. So here it would be .46153846 × 13 = 6. Add this whole number (6) to the number of carbons (6), which gives the number of hydrogens in the compound (12). And presto chango, you have the chemical formula of the unknown alkane as being C_6H_{12}.

Now it's your turn. Given the following spectrum for an alkane, what is the compound's chemical formula? Please see the bottom of page 4 to check your answer.



Mass Spectrometry

A World of Uses

Mass spectrometry is commonly used to determine the amount and type of elements present in an unknown sample. While this is a common chemistry technique, researchers have adapted the process to applications far beyond the norm. Here are just a few of the novel uses of mass spectrometry.

Toothpaste Detective

Some toothpastes imported to the U.S. from abroad have shown high concentrations of a nasty toxin called DEG, which is used as an artificial sweetener. Detecting DEG has been difficult and an expensive process. However, researchers have successfully demonstrated a way to quickly scan toothpastes for DEG using MS, saving time and money, and most importantly, keeping toxins from entering their bodies when people brush.

Terrorism Fighter

Centers for Disease Control (CDC) scientists have connected 20 mass spectrometers together in an array to serve as an early warning system that detects likely terrorists' biological, radiological, and chemical attacks. These mass spectrometers are able to analyze patients' blood and urine samples to quickly determine the nature and depth of the terrorist attack. The CDC's rapid testing program can reduce the spread of the attack agent throughout the general population by the quick identification of the targeted agent.

Athletic Judge

Sporting news reports have highlighted the abundance of cheating scandals due to athletes taking performance-enhancing drugs. Some bicyclists, track and field participants, baseball players, and football players have been suspended or permanently disqualified from competing due to their use of these drugs. Designer drugs have made detection of these performance enhancers even harder. However, connecting multiple technologies together, like gas and liquid chromatography with MS, has been shown to be highly effective in detecting these drugs and catching the offenders.

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Answers: **Page 2 Answers:** 1) d, 2) b, 3) a, 4) d, 5) c. **Page 3 Answers: Rule of 13:** 1) C_8H_{10}.

The project was supported, in part, by Grant Number DA10394 from the National Institute on Drug Abuse (NIDA). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NIDA or the National Institutes of Health.