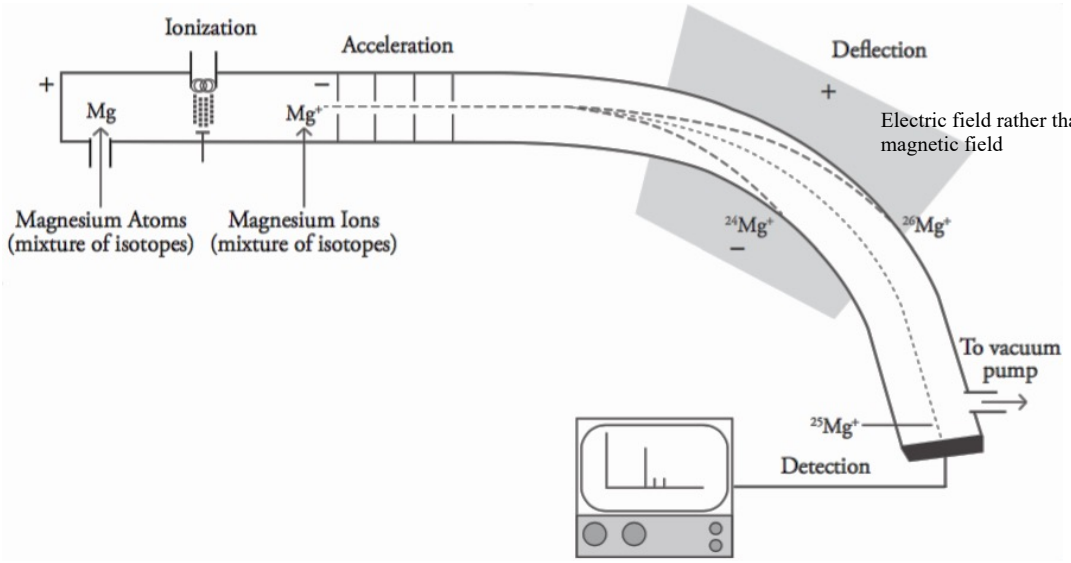
WKS 4-3
Mass Spectrometry

Name _____
Period _____ **Date** _____

The Mass Spectrometer



1) Match each of the four processes indicated above on the model of the mass spectrometer with its description below:

detection	Ions collide with a metal plate. Electrons are transferred from the metal to the ion, producing a current and thus a signal to a computer.
deflection	Ions are attracted to the negative side of an electromagnetic field causing separation of the mixture based on mass and charge.
ionization	Electrons are knocked off sample particles to form (mostly) +1 ions.
acceleration	Ions move through a series of charged plates to form a narrow beam of high speed particles with equal kinetic energy.

2) Why must the sample atoms be ionized—what separates them?
The sample atoms must be ionized so they will be attracted/repelled by an electric or magnetic field. The attraction of the positive ions to the negative side of the electromagnetic field in the deflector separates them.
3) Which ions are deflected the most? Why is this the case?
$^{24}Mg^{+}$ ions. They have the highest charge/mass ratio (are lightest), so they respond most to the electromagnetic field.

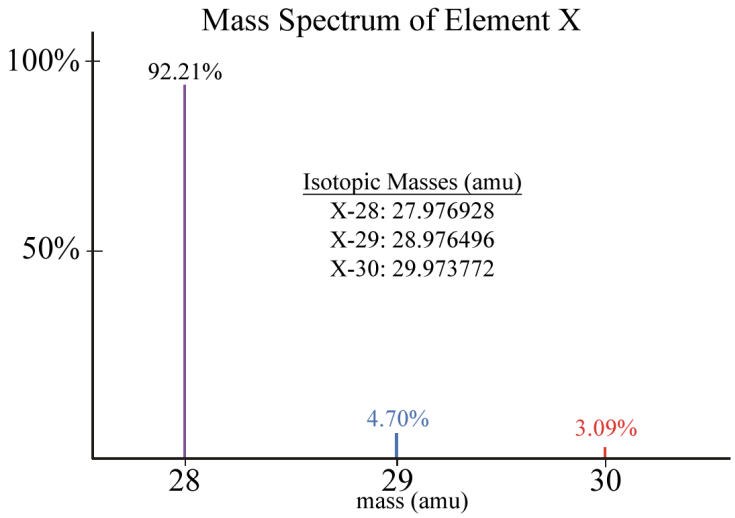
The key to mass spectrometry is that all of the particles go into the deflection chamber with the same kinetic energy. They do not, however, have the same **charge/mass ratio (q/m)**. Although most of the ions formed are +1 ions, their masses are different. Therefore, the amount of deflection they experience by the electromagnet is different. The strength of the electromagnet can be varied so only particles with a particular mass/charge ratio can make it to the detector. Other particles collide with the metallic sides of the instrument, are neutralized, and then removed by the vacuum pump. The machine is calibrated using carbon-12 isotopes which are, by definition, exactly 12 amu (12.0000000...amu).

4) Consider the following ions formed in a mass spectrometer. Rank the ions in terms of their degree of deflection by the electromagnet from least (1) to greatest (3). Greater deflection means a tighter turn towards the negative pole of the electromagnet.

$^{19}F^{1+}$	$^{16}O^{1+}$	$^{17}O^{1+}$
1	3	2

The Mass Spectrum

Use the mass spectrum of element X below to answer the following questions:



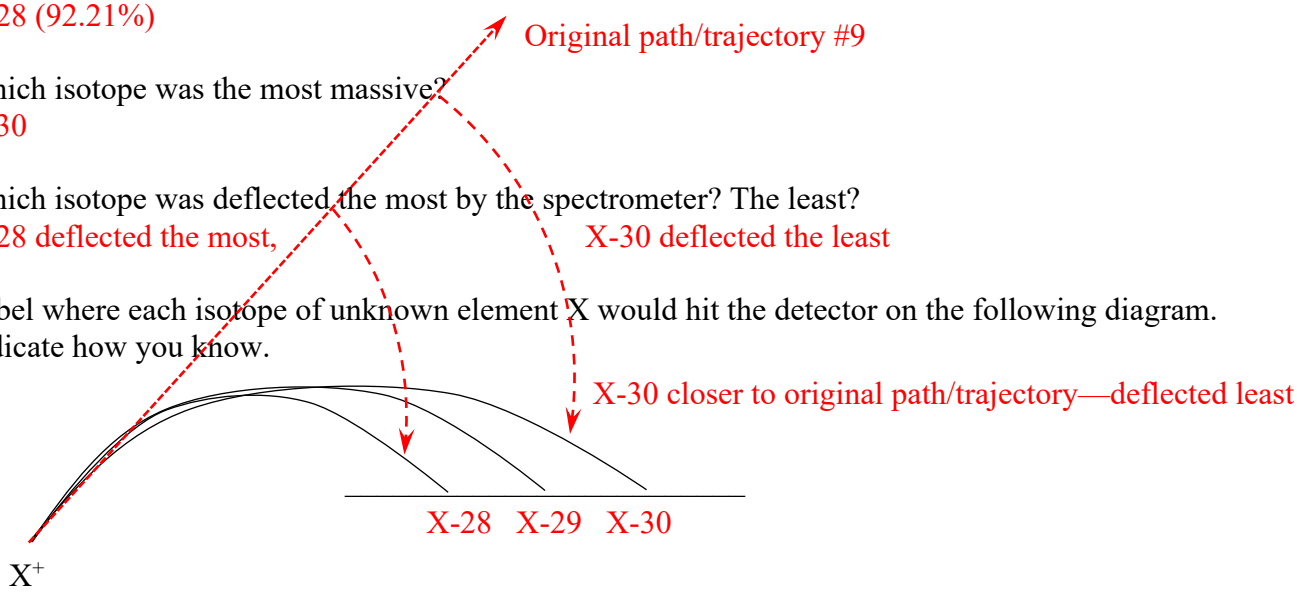
5) What were the masses of the isotopes found to be present in the sample?
28 amu (27.9765928), 29 amu (28.976496) & 30 amu (29.973772)

6) Which isotope was the most abundant in the sample?
X-28 (92.21%)

7) Which isotope was the most massive?
X-30

8) Which isotope was deflected the most by the spectrometer? The least?
X-28 deflected the most, X-30 deflected the least

9) Label where each isotope of unknown element X would hit the detector on the following diagram. Indicate how you know.



10) Calculate the atomic mass of element X, showing all your work, then identify the element.

$$\text{Atomic Mass} = 27.977\ \text{amu} \times \frac{92.21\%}{100\%} + 28.976\ \text{amu} \times \frac{4.70\%}{100\%} + 29.974\ \text{amu} \times \frac{3.09\%}{100\%}$$

$$= 25.798\ \text{amu} + 1.362\ \text{amu} + 0.9262\ \text{amu} = \boxed{28.09\ \text{amu; Silicon (Si)}}$$