



## The Nitrogen Rule

A molecular ion has an odd numbered mass if and only if it has an odd number of nitrogen atoms present.

For example:  $\text{CH}_3\text{CH}_2\text{CH}_3$  ( $M = 44$ )     $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$  ( $M = 59$ )     $\text{NH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$  ( $M = 74$ )



## Mass Spectrum Problems

1. Calculate the molecular ion that would be expected for the following molecules:

$$m/z(\text{H}) = 1 \quad m/z(\text{C}) = 12 \quad m/z(\text{N}) = 14 \quad m/z(\text{O}) = 16$$

- a.  $\text{C}_2\text{H}_6$       30
- b.  $\text{C}_3\text{H}_8\text{O}$     60
- c.  $\text{C}_4\text{H}_9\text{N}$      71
- d.  $\text{C}_5\text{H}_{11}\text{NO}$    101
- e.  $\text{C}_6\text{H}_{12}\text{O}_2$     116
2. a. Use the nitrogen rule to determine which of the following molecular ions are only produced by molecules containing nitrogen (circle your answers):

**A: 87**    **B: 40**    **C: 103**    **D: 84**

- b. Explain why you cannot say for certain whether the other molecular ions have nitrogen or not.  
Even numbered molecular ions have zero or an even number of nitrogens. They may have 0, 2 or 4... nitrogens present. Therefore you cannot say.

3. a. If an amine (containing at least one carbon) has a molecular ion of 60, predict how many nitrogen atoms are present.

As 60 is even, it has an even number of nitrogens and since it is an amine, it has one or more nitrogens. Therefore it has either 2 or 4 nitrogens. As 4 nitrogens have a mass of 56, there is not enough mass for a carbon and therefore the molecule has 2 nitrogens.