

Lecture 5 CH101 A1 (MWF 9:05 am) Fall 2017 Copyright © 2017 Dan Dill dan@bu.edu

**[TP]** Ethanol,  $\text{CH}_3\text{CH}_2\text{OH}$ , and dimethyl ether,  $\text{CH}_3\text{OCH}_3$ , are constitutional isomers. This means that their mass spectra ...

20% 1. must have the same molecular ion peak

20% 2. must contain the same number of peaks at the same places (m/z), but with different heights

20% 3. must contain the same number of peaks but at different places (m/z)

20% 4. 1 and 2

20% 5. 1 and 3

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Friday, September 15, 2017

For today ...

- Begin ch3: Naming things
- Molecular mass spectra

Next lecture: Molecular mass spectra; mass spectra of compounds with Br (or Cl); light; infrared (IR) spectra

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Naming things

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Common **monoatomic** ions and patterns

Figure 3.7 (p 57)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
$\text{H}^+$	$\text{Li}^+$	$\text{Na}^+$	$\text{Mg}^{2+}$	$\text{Ti}^{4+}$	$\text{Cr}^{2+}$	$\text{Mn}^{2+}$	$\text{Fe}^{2+}$	$\text{Co}^{2+}$	$\text{Ni}^{2+}$	$\text{Cu}^+$	$\text{Zn}^{2+}$	$\text{Al}^{3+}$	$\text{P}^{3-}$	$\text{S}^{2-}$	$\text{Cl}^-$	$\text{H}^-$	
$\text{K}^+$	$\text{Ca}^{2+}$				$\text{Cr}^{3+}$	$\text{Fe}^{3+}$	$\text{Co}^{3+}$		$\text{Ni}^{2+}$	$\text{Cu}^{2+}$	$\text{Zn}^{2+}$			$\text{Se}^{2-}$	$\text{Br}^-$		
$\text{Rb}^+$	$\text{Sr}^{2+}$									$\text{Ag}^+$	$\text{Cd}^{2+}$			$\text{Te}^{2-}$	$\text{I}^-$		
$\text{Cs}^+$	$\text{Ba}^{2+}$									$\text{Hg}_2^{2+}$	$\text{Hg}^{2+}$	$\text{Pb}^{2+}$	$\text{Bi}^{3+}$				

Legend:

- Metals (light blue)
- Transition metals (medium blue)
- Metalloids (green)
- Non-metals (yellow)

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## Common **monoatomic** ions

Figure 3.8 (p 59)

3-	2-	1-
		H <sup>-</sup> hydride ion
N <sup>3-</sup> nitride ion	O <sup>2-</sup> oxide ion	F <sup>-</sup> fluoride ion
P <sup>3-</sup> phosphide ion	S <sup>2-</sup> sulfide ion	Cl <sup>-</sup> chloride ion
	Se <sup>2-</sup> selenide ion	Br <sup>-</sup> bromide ion
	Te <sup>2-</sup> telluride ion	I <sup>-</sup> iodide ion

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## Common **polyatomic** ions, Table 3.2 (p 59)

Formula	Name	Formula	Name
<b>CATION: Positive Ion</b>			
NH <sub>4</sub> <sup>+</sup>	ammonium ion		
<b>ANIONS: Negative Ions</b>			
<b>Based on a Group 14 element</b>		<b>Based on a Group 17 element</b>	
CN <sup>-</sup>	cyanide ion	ClO <sup>-</sup>	hypochlorite ion
CH <sub>3</sub> COO <sup>-</sup>	acetate ion	ClO <sub>2</sub> <sup>-</sup>	chlorite ion
CO <sub>3</sub> <sup>2-</sup>	carbonate ion	ClO <sub>3</sub> <sup>-</sup>	chlorate ion
HCO <sub>3</sub> <sup>-</sup>	hydrogencarbonate ion (or bicarbonate ion)	ClO <sub>4</sub> <sup>-</sup>	perchlorate ion
<b>Based on a Group 15 element</b>		<b>Based on a transition metal</b>	
NO <sub>2</sub> <sup>-</sup>	nitrite ion	CrO <sub>4</sub> <sup>2-</sup>	chromate ion
NO <sub>3</sub> <sup>-</sup>	nitrate ion	Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup>	dichromate ion
PO <sub>4</sub> <sup>3-</sup>	phosphate ion	MnO <sub>4</sub> <sup>-</sup>	permanganate ion
HPO <sub>4</sub> <sup>2-</sup>	hydrogenphosphate ion		
H <sub>2</sub> PO <sub>4</sub> <sup>-</sup>	dihydrogenphosphate ion		
<b>Based on a Group 16 element</b>			
OH <sup>-</sup>	hydroxide ion		
SO <sub>3</sub> <sup>2-</sup>	sulfite ion		
SO <sub>4</sub> <sup>2-</sup>	sulfate ion		
HSO <sub>4</sub> <sup>-</sup>	hydrogensulfate ion (or bisulfate ion)		

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[TP] When ionic compounds are dissolved in water, they dissociate into their component ions completely. Which of the following ionic compounds, when dissolved in water, will result in an aqueous solution that contains **the greatest number of ions**?

25% 1. 1 mol of sodium chloride

25% 2. 1 mol of ammonium carbonate

25% 3. 1 mol of potassium phosphate

25% 4. 1 mol of ammonium acetate

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Molecular mass spectra

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[TP] The mass spectrum of ethane,  $C_2H_6$ , has peaks at  $m/z = 14, 15, 27, 28, 29, \text{ and } 30$ .

The peak with the highest relative intensity is at  $m/z = 28$ , and the peak with the lowest relative intensity is at  $m/z = 14$ . Which peak is due to the **molecular ion**?

- 13% 1. The peak at  $m/z = 14$   
 13% 2. The peak at  $m/z = 15$   
 13% 3. The peak at  $m/z = 27$   
 13% 4. The peak at  $m/z = 28$   
 13% 5. The peak at  $m/z = 29$   
 13% 6. The peak at  $m/z = 30$   
 13% 7. None of the above  
 13% 8. All of the above



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## Sketch mass spectrum of ethane

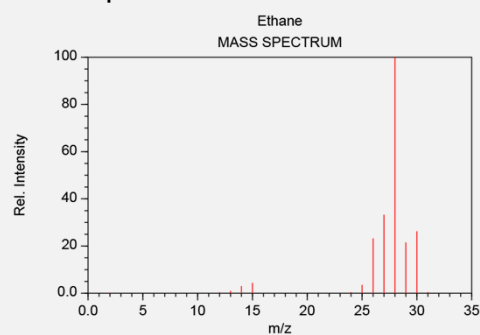


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## Sketch mass spectrum of ethane

NIST Chemistry WebBook (<http://webbook.nist.gov/chemistry>)

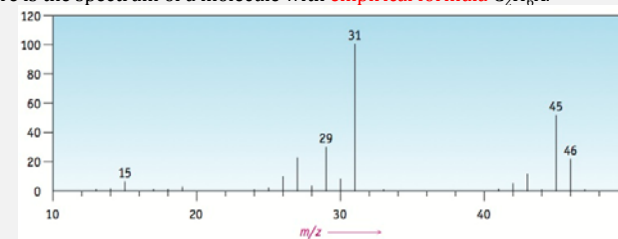
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## Use the molecular ion to analyze mass spectrum

Here is the spectrum of a molecule with **empirical formula**  $C_2H_6X$ .



What element is X?



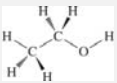
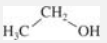
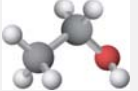
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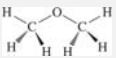

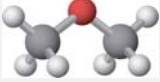
## Important terms to distinguish

- **Constitutional isomers:** Ethanol and dimethyl ether
- **Empirical formula:**  $C_2H_6O$
- **Condensed formula:**  $CH_3CH_2OH$  and  $CH_3OCH_3$
- **Structural formula**

**Ethanol:**

**Dimethyl ether:**

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