



**Assessment of Student Knowledge of Gas
Chromatographic Instrumentation
Before Its Use**

**Scott Donnelly
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Yuma, AZ**

Colorado River



Las Vegas



Grand Canyon

Glen Canyon Dam

San Juan River

Flagstaff



Little Colorado River

Colorado River



Phoenix

ARIZONA

NEW MEXICO



AWC

MEXICO



Tucson

Presentation Topics

- **GC Pre-labs and Activities: An Overview**
- **Examples of GC Pre-lab Questions**
- **Compilation of Student Answers to GC Pre-labs**

GC pre-lab and labs carried out in the following classes:

- *Organic Chemistry 1*
- *General Chemistry 2*
- *Analytical Methods in Environmental Science*

GC Pre-lab & Lab Activities: An Overview

GC Pre-lab (Speculation)

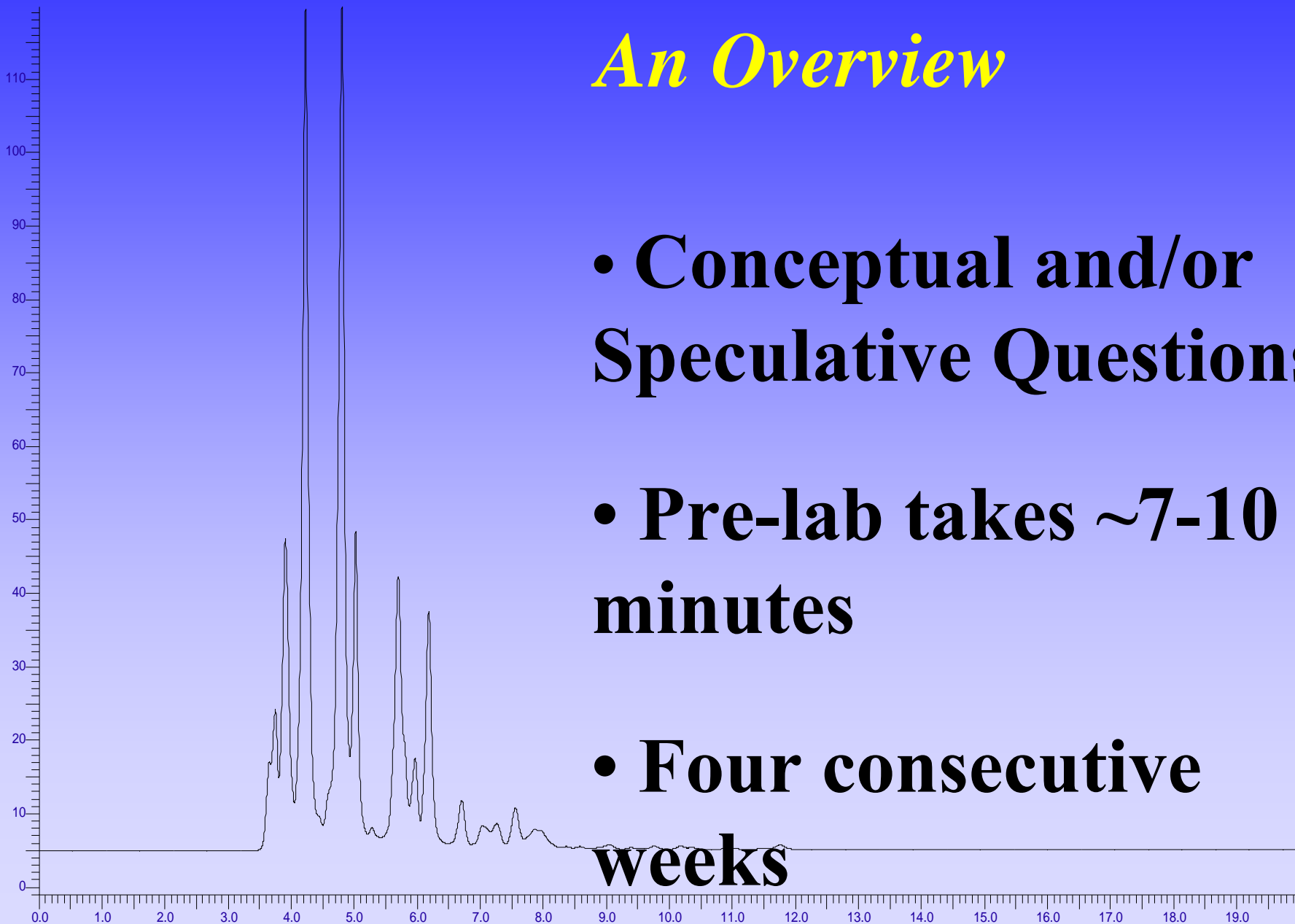


**GC Minilab
(Experimentation)**



Post-lab Assessment

GC Pre-lab & Lab Activities: An Overview



- **Conceptual and/or Speculative Questions**
- **Pre-lab takes ~7-10 minutes**
- **Four consecutive weeks**

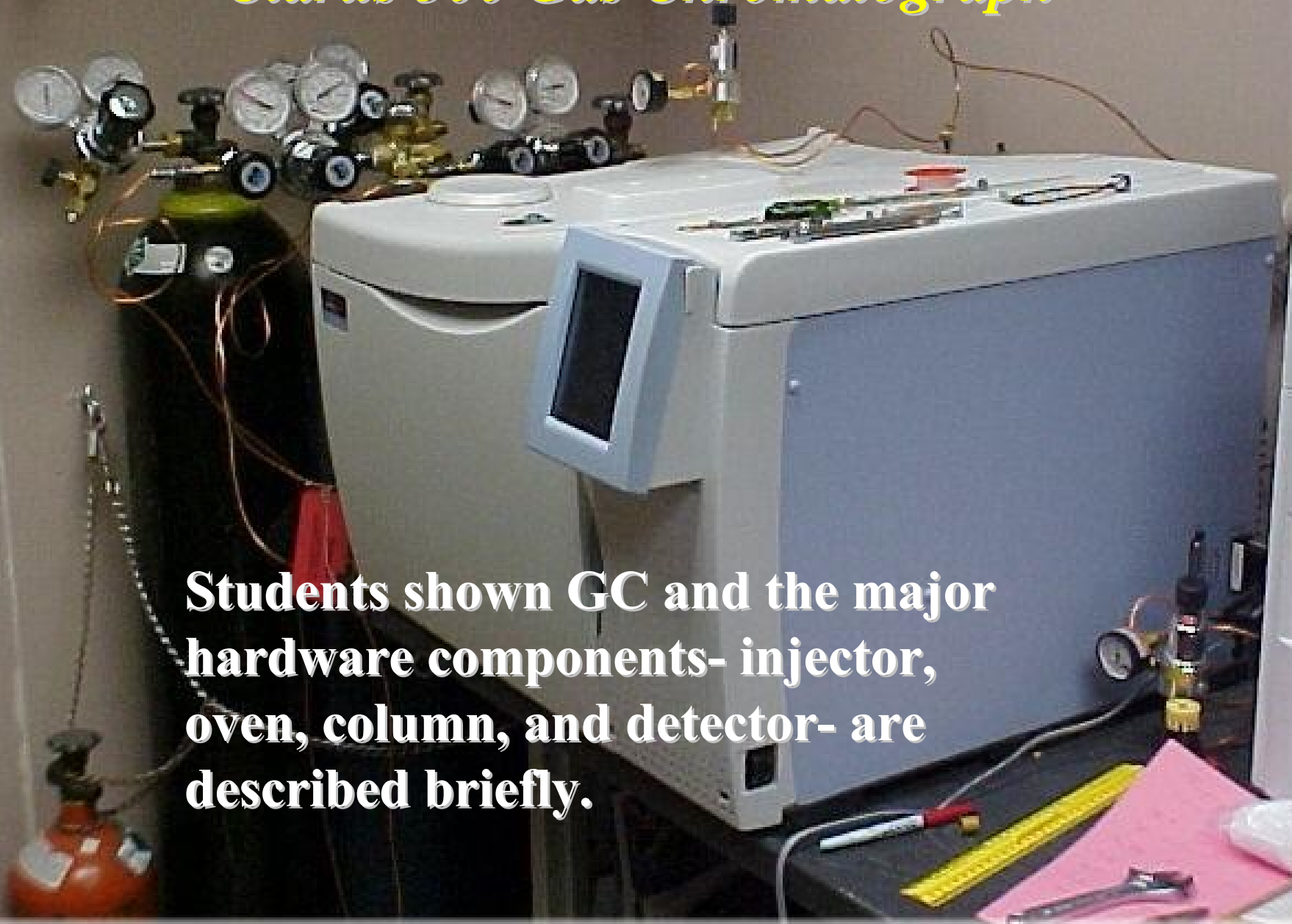
GC Labs: Potential Factors Affecting Retention Time, R_t

- **Molecular Weight**
- **Boiling Point**
- **T_{oven} and T_{injector}**
- **Column diameter**
- **Sample Volume Injected**

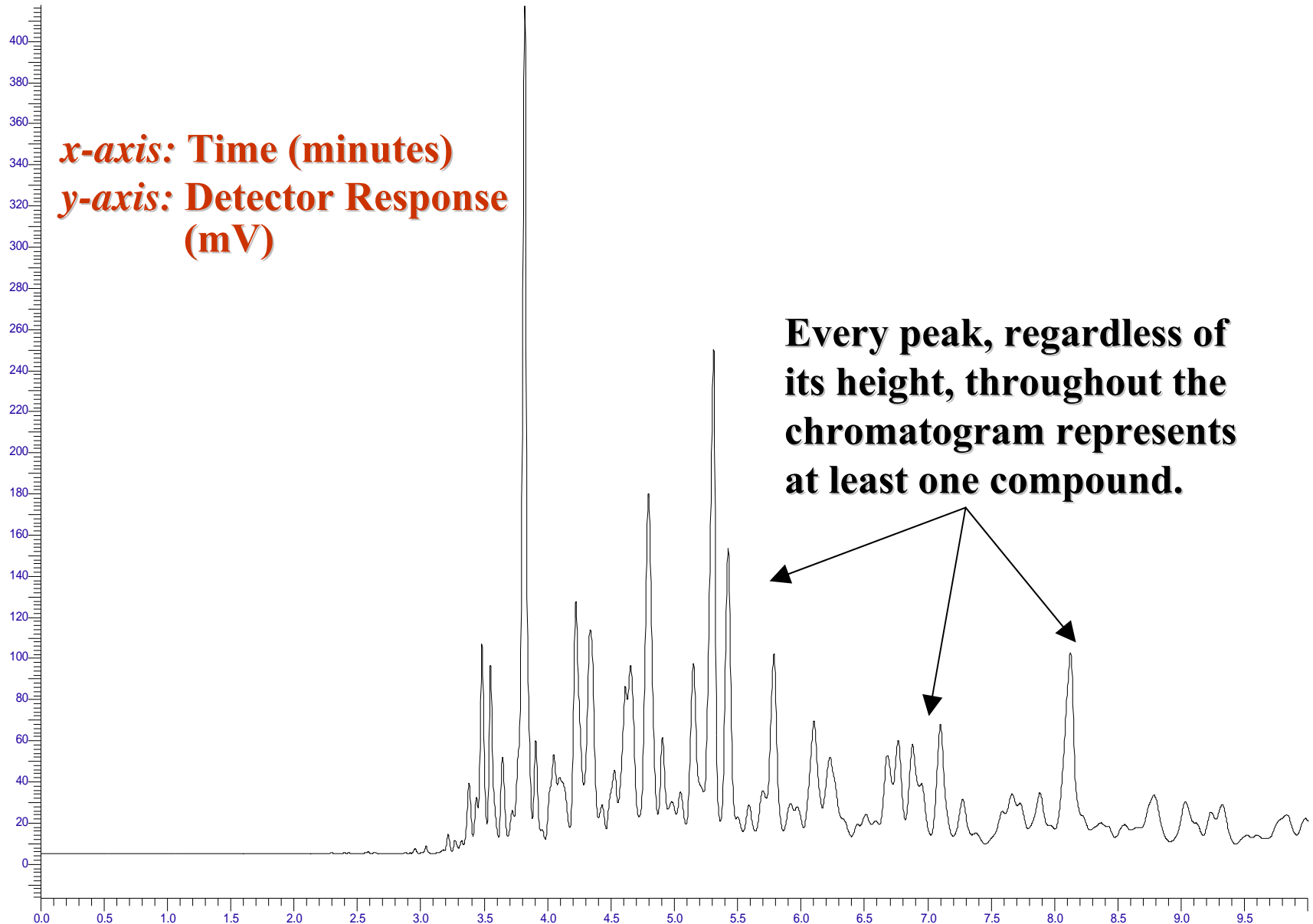


Clarus 500 Gas Chromatograph

Students shown GC and the major hardware components- injector, oven, column, and detector- are described briefly.

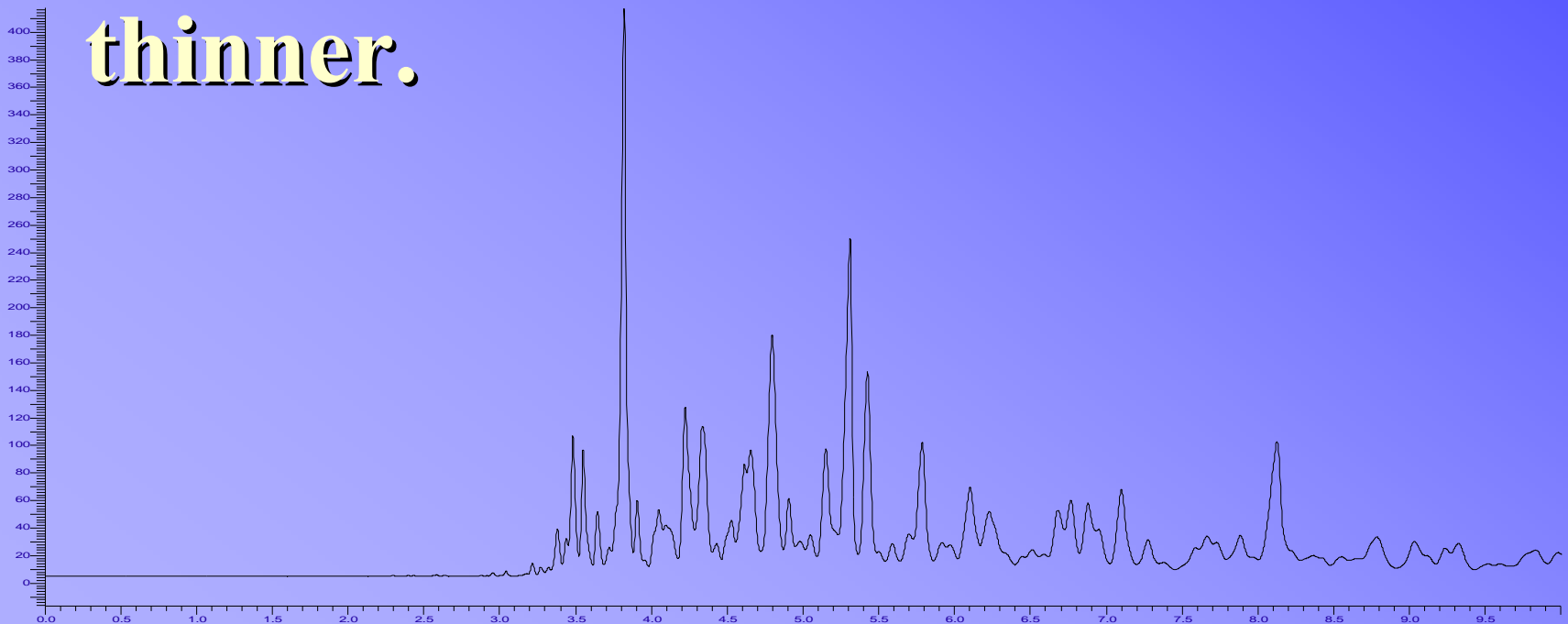


Chromatogram of Paint Thinner



Sample GC Pre-lab 1 Questions

List three physical factors that might influence the separation of different compounds found in paint thinner.



*Student Responses**

Mass (weight, amount) 14

Temperature (heat) 10

Molecular weight 7

Pressure 4

Viscosities 3

Combustion temperature 2

Melting point 2

Condensation point 1

Electron configuration 1

Composition 1

Absorption of light 1

Boiling point 14

Density 9

Shape (structure) 6

Volume 4

Size 3

Concentration 2

Polarity 1

Smell 1

Time 1

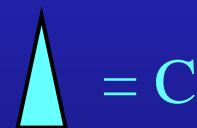
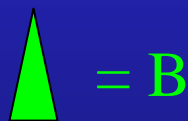
Bonds 1

Color 1

*** General Chemistry 2, Spring 2006**

Pre-lab 1: Molecular Weight

Gas-liquid chromatography, or GC for short, physically separates liquids in a mixture according to a number of factors, one of which is molecular weight (MW). Suppose a mixture of three liquid hydrocarbons- **A**, **B**, and **C** - was injected into a GC with constant oven temperature, T_{oven} . The relative MWs of the three hydrocarbons are $\mathbf{B} > \mathbf{A} > \mathbf{C}$. Based on this information arrange the three compounds in the order that they elute or exit from the column. Then explain your reasoning.



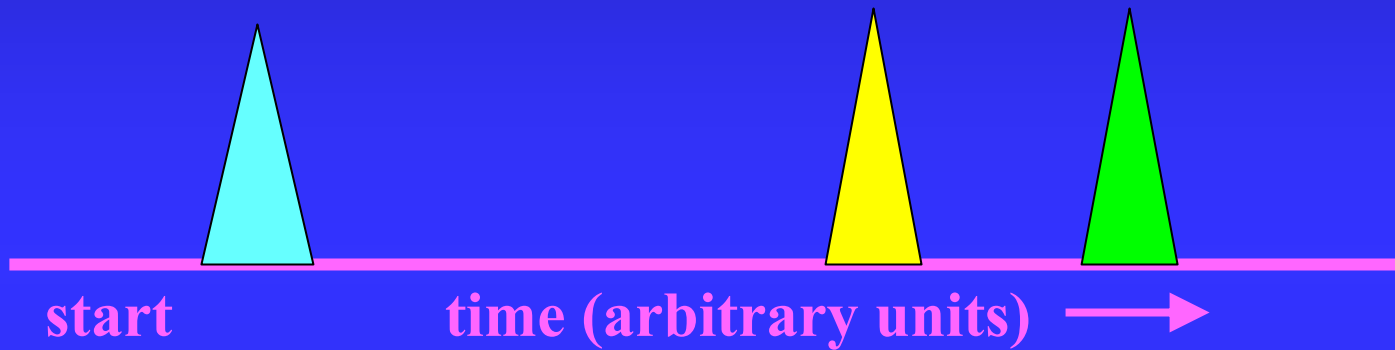
start

time (arbitrary units)



Pre-lab MW: Student Answers

$$\text{MW: } \mathbf{B} > \mathbf{A} > \mathbf{C}$$



Correct **Incorrect**

Spring '05

18

9

Spring '06

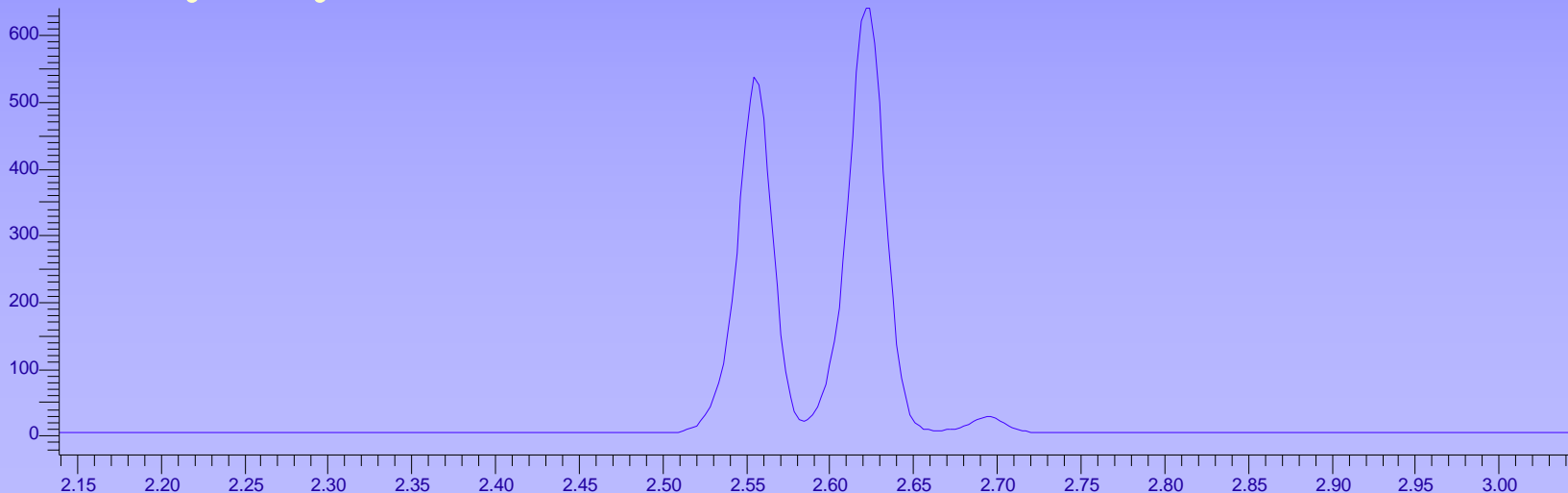
19

11

Most common **incorrect** answer had R_t and MW inversely related.

Pre-lab 2: Boiling Point

The chromatogram below is for a two component liquid mixture containing the alcohols 1-propanol and 2-propanol. Both alcohols have the molecular formula C_3H_8O and hence the same molecular weight (MW). Yet, as shown the two alcohols have different retention times (R_t) under identical GC conditions. Since their MWs are the same, their differences in R_t cannot be explained on account of a difference in MW. So what then is a plausible explanation for why they have different retention times?



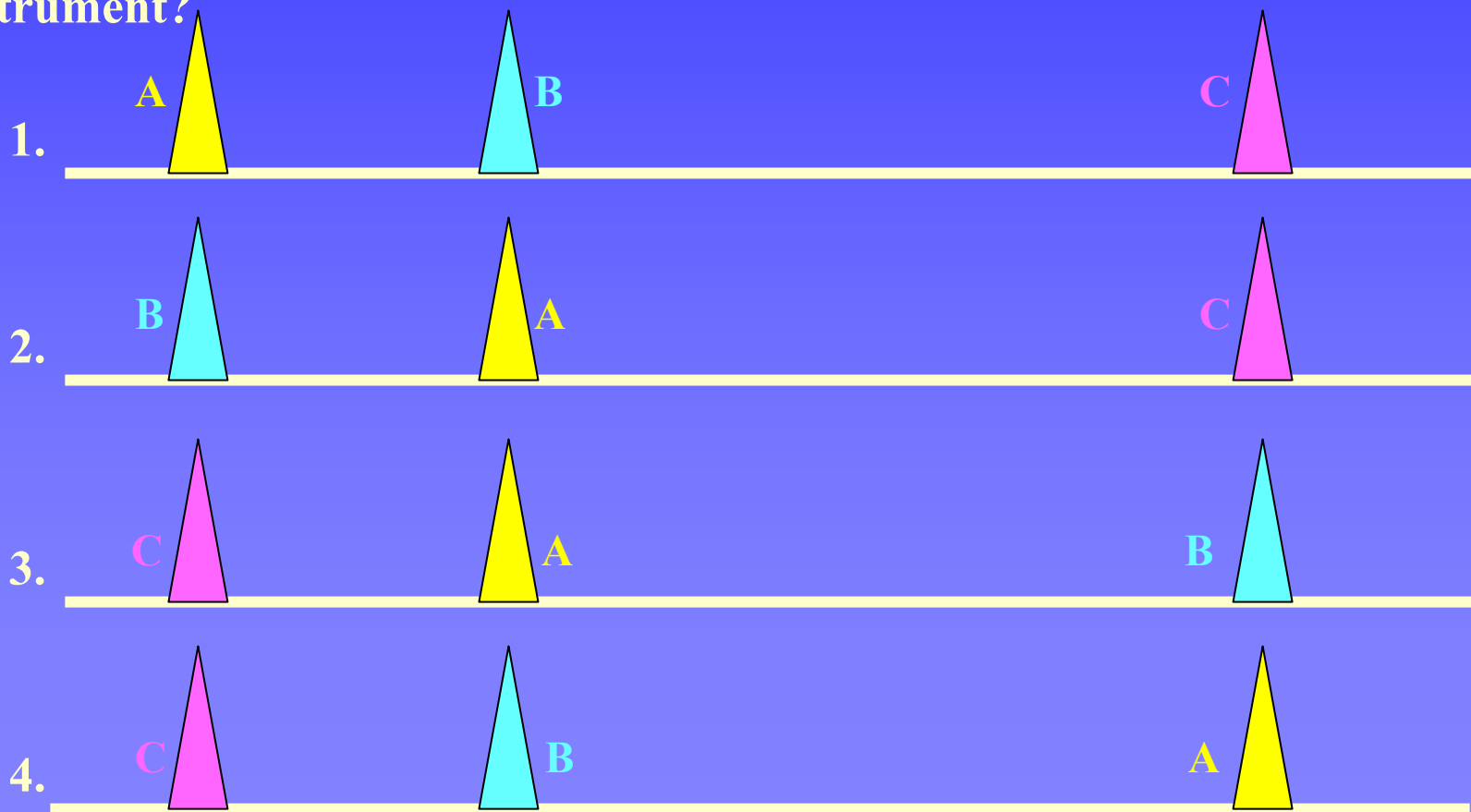
Student Responses

- **Due the structure of the bonds and charges.**
- **It takes more energy to break one compound down than the other; the boiling point.**
- **The shape of the molecules can also be a factor to their separation.**
- **Their boiling points are different.**
- **Each has a different geometric shape. 1-propanol is flatter and exits the chromatograph first.**

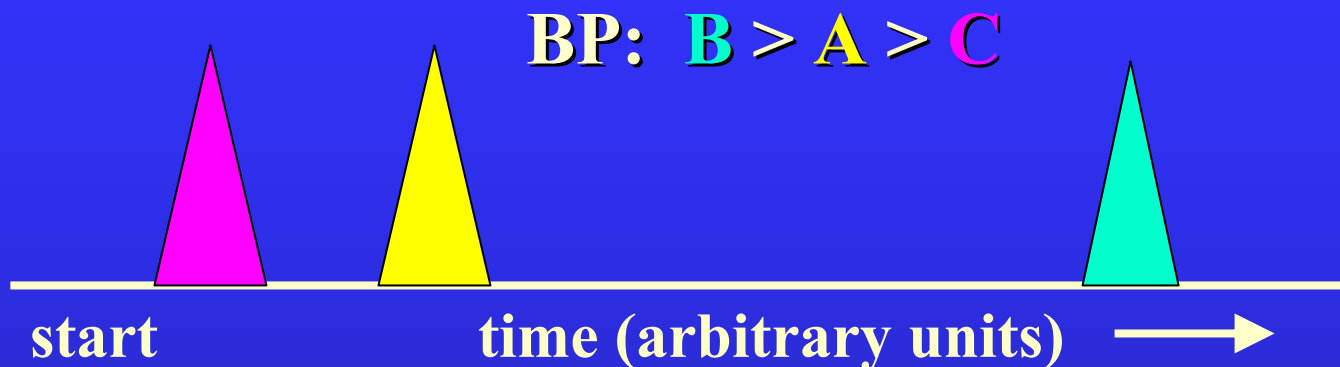
- **Maybe the structure formula of one of the compound makes it more viscous or it could be attracted to the tube in the GC making it go slower.**
- **Different carbon oxide bonds. The retention time will alter depending on what carbon atom the oxide bonds too.**
- **Different molecular structures. They may have the same number of C, H, and O atoms but they're arranged differently.**
- **Molecular structure differs from one to the next. 1-propanol has the O on the first C and 2-propanol has the O on the second C.**

Pre-lab 2: Boiling Point

Suppose there are three colorless liquids- **A**, **B**, and **C**. Their relative boiling temperatures are $B > A > C$. The three component mixture is injected into a GC whose oven temperature is held constant at 120°C . Which chromatogram below best represents the order in which the three liquids exit the GC instrument?



Prelab 2 BP: Student Answers



Correct

Incorrect

Spring '05

21

5

Spring '06

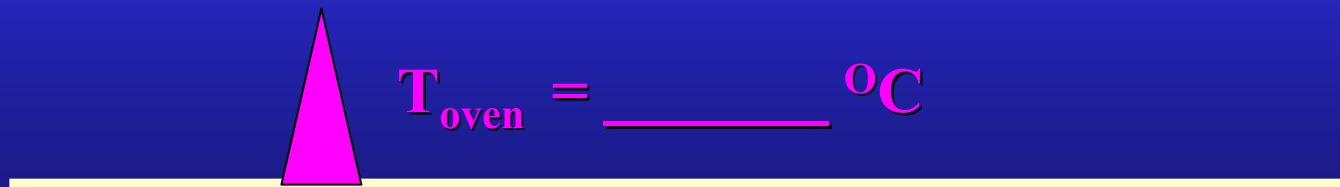
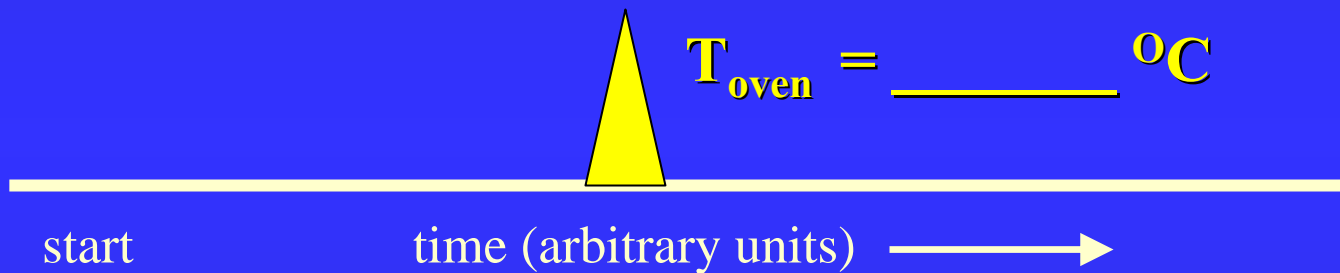
24

6

Most common **incorrect** response had the highest boiling liquid **B** eluting first and the lowest boiling liquid **C** eluting last.

Prelab 3: Oven Temperature, T_{oven}

Three separate $0.2\mu\text{L}$ injections of an unknown colorless liquid were done at three different oven temperatures: 125°C , 100°C , and 75°C . The three separate chromatograms are shown below. Match each chromatogram with one of the three oven temperatures.



Acknowledgements



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WHERE DISCOVERIES BEGIN

- **Course, Curriculum, & Laboratory Improvement (CCLI) grant (DUE-0310264)**
- **My lovely wife & two children**
- **Organizers of this meeting**