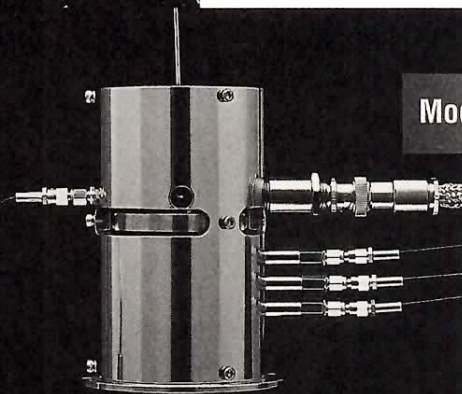


# VICI

**Valco Instruments Co. Inc.**

## **Pulsed Discharge Detector**

**ECD  
HID  
PID**



**Model D-1**

▶ Non-radioactive

▶ Mode-selectable

▶ Sub-picogram sensitivity

▶ No lamps or windows

▶ Capillary or packed columns

*The spark within*

**Electron Capture**

**Helium Ionization**

**Photoionization**

## NEW! Non-radioactive detector

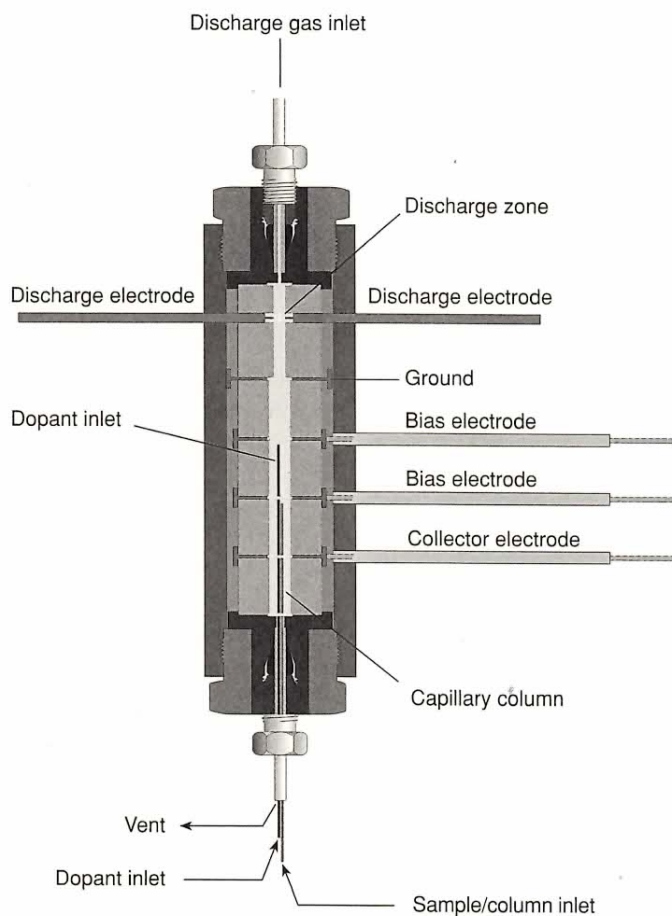
Finally, an alternative to radioactive ECDs and HIDs! Our pulsed discharge detector (PDD) utilizes a stable, low powered, pulsed DC discharge in helium as an ionization source. The resulting chromatograms are as good as or better than those obtained with conventional radioactive sources.

In the **electron capture** mode, the PDECD is a selective detector for monitoring high electron affinity compounds such as freons, chlorinated pesticides, and other halogen compounds. The minimum detectable quantity (MDQ) for this type of compound is at the femtogram ( $10^{-15}$ ) or picogram ( $10^{-12}$ ) level. Our PDECD is similar in sensitivity and response characteristics to a conventional radioactive ECD, and can be operated at temperatures up to  $400^{\circ}\text{C}$ . For electron capture operation, He and  $\text{CH}_4$  are introduced between the pulsed discharge and the sample inlet.

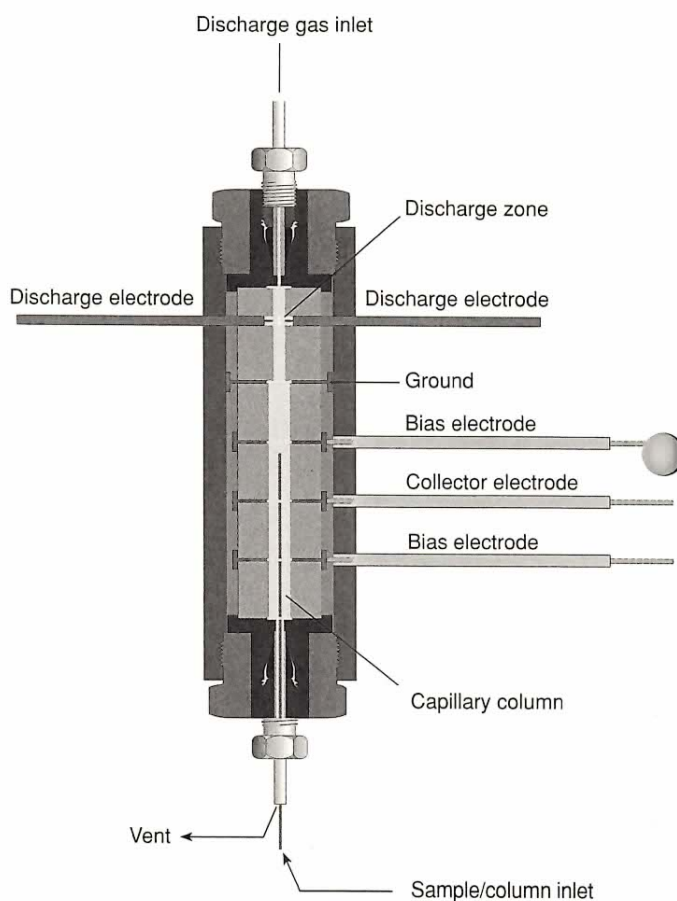
In the **helium ionization** mode, the PDHID is a universal, non-destructive, high sensitivity detector. The response to both inorganic and organic compounds is linear over a wide range. Response to fixed gases is positive (increase in standing current), with an MDQ in the low ppb range.

The PDHID is an excellent replacement for flame ionization detectors in petrochemical or refinery environments, where the flame and use of hydrogen can be problematic. In addition, when the helium discharge gas is doped with a suitable noble gas, such as argon, krypton, or xenon (depending on the desired cutoff point), the PDHID can function as a specific **photoionization** detector for selective determination of aliphatics, aromatics, and amines, as well as other species.

Patents: 5,153,519; 5,317,271; 5,394,092; 5,394,090; 5,394,091



**Electron capture mode**  
Cross section

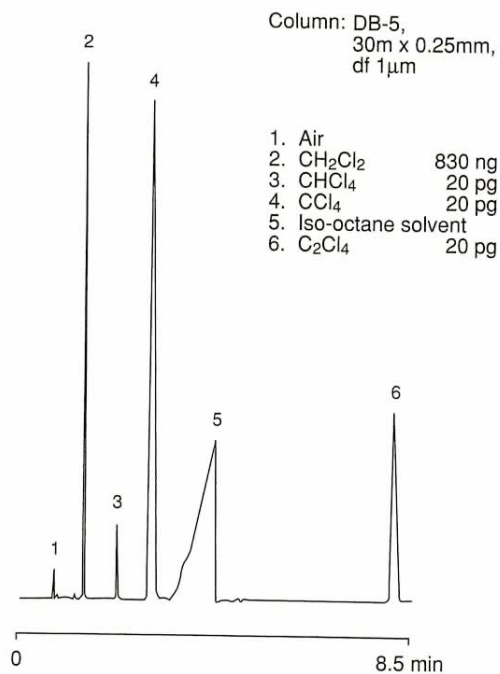


**Helium ionization mode**  
Cross section

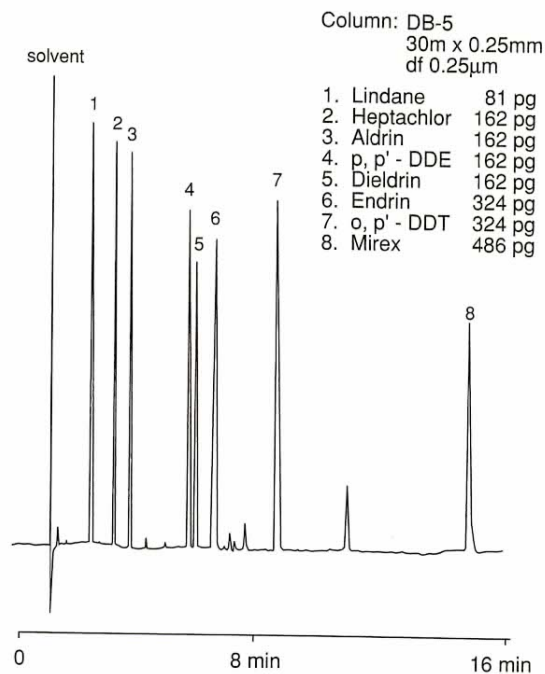


# Electron Capture

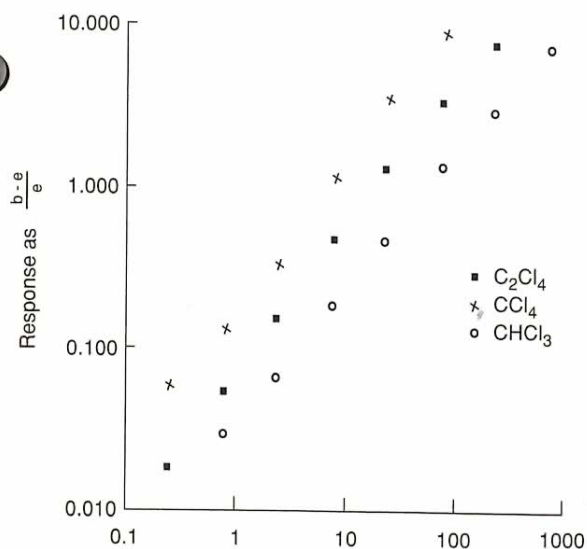
## Analysis of Halocarbons



## Analysis of Pesticides



## Linear Range for Chloro Compounds



## Minimum Detectable Quantities

### Pesticides

$\alpha$ - BHC	0.33 pg
$\gamma$ - BHC	0.32 pg
$\beta$ - BHC	0.57 pg
Heptachlor	0.40 pg
$\delta$ - BHC	0.39 pg
Aldrin	0.40 pg
Heptachlor epoxide	0.40 pg
Endrin	0.53 pg
p p' - DDT	0.80 pg
Endrin Aldehyde	0.90 pg

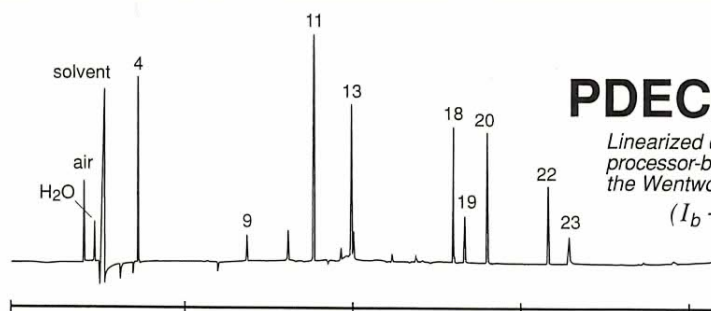
### Halocarbons

CH <sub>2</sub> Cl	0.7 ng
CHCl <sub>3</sub>	59 fg
CCl <sub>4</sub>	35 fg
C <sub>2</sub> Cl <sub>4</sub>	69 fg

# Electron Capture

## Comparison of PDECD with Conventional ECD

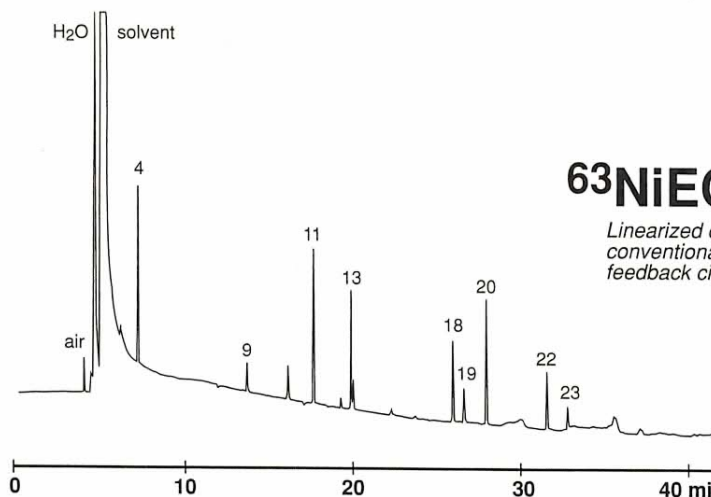
The PDECD exhibits detection limits up to 10 times better than the radioactive Nickel 63 detector, with comparable selectivity.



### PDECD

Linearized output from micro-processor-based linearizer using the Wentworth equation:  
 $(I_b - I_e) / I_e$

The response to the solvent overload in the Nickel 63 detector interferes with the response factors and often obscures components eluting near the solvent, whereas the PDECD recovers quickly from the solvent.

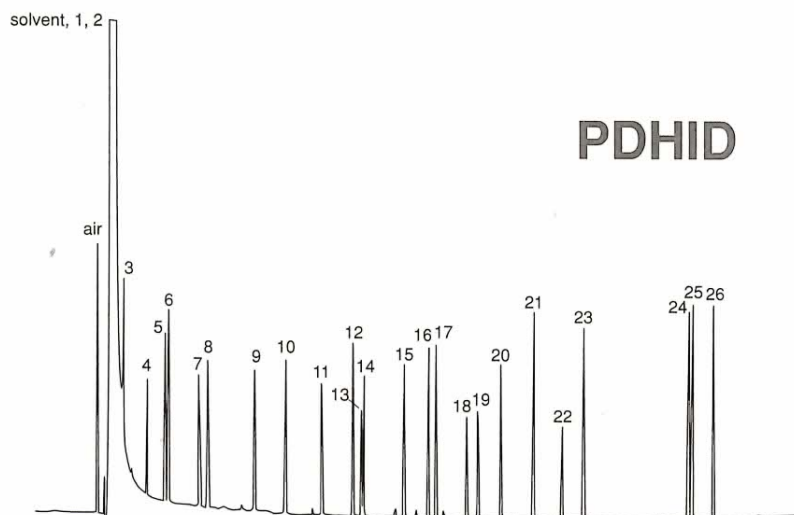


### <sup>63</sup>NiECD

Linearized output using conventional pulsed feedback circuitry

## PDHID Analysis of Mixture used in Comparison Above

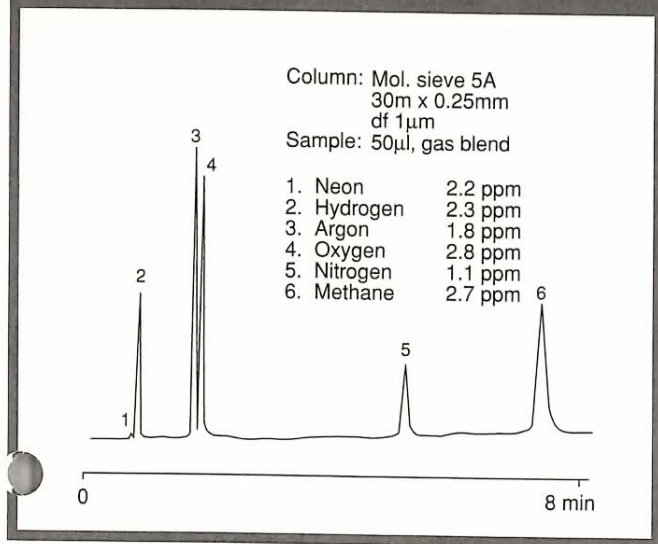
1. Chloromethane
2. Vinyl Chloride
3. Bromomethane
4. Trichlorofluoromethane
5. 1,1-Dichloroethene
6. Methylene Chloride
7. 1,1-Dichloroethane
8. trans 1,2-Dichloroethene
9. Chloroform
10. 1,2-Dichloroethane
11. Carbon Tetrachloride
12. 1,2-Dichloropropane
13. Dichlorobromomethane
14. Trichloroethene
15. cis 1,3-Dichloropropene
16. trans 1,3-Dichloropropene
17. 1,1,2-Trichloroethane
18. Dibromochloromethane
19. 1,2-Dibromoethane
20. Tetrachloroethene
21. Chlorobenzene
22. Bromoform
23. 1,1,2,2-Tetrachloroethane
24. 1,3-Dichlorobenzene
25. 1,4-Dichlorobenzene
26. 1,2-Dichlorobenzene



### PDHID

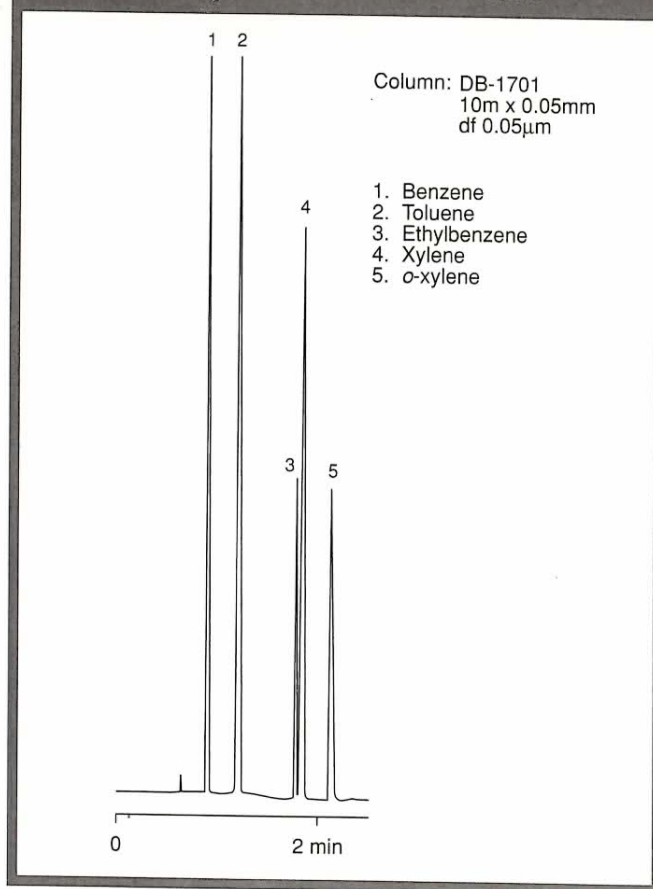
# Helium Ionization

## Analysis of Fixed Gases

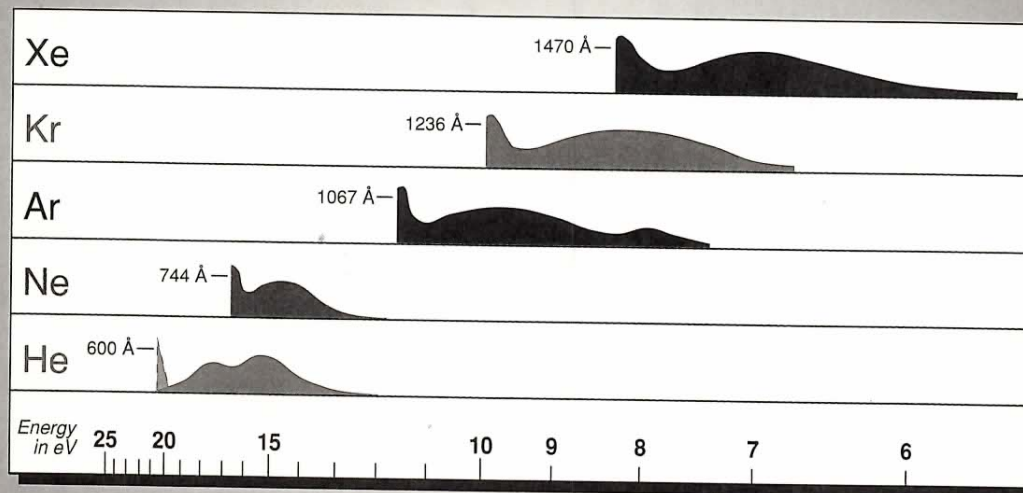


The basic detector functions as a helium ionization detector when pure helium is used as the discharge gas. The extremely high sensitivity is evidenced above. The figure to the right shows that 50 micron columns are a realistic option, due to the fast time constant of the detector. The addition of ~1% of Argon, Krypton, or Xenon to the discharge gas reduces the energy of the pulsed discharge, resulting in response selectivity combined with high sensitivity. The following pages show the detector used in these selective photo-ionization modes.

## Analysis of BTEX Standard



## Schematic Representation of the Rare Gas Continua



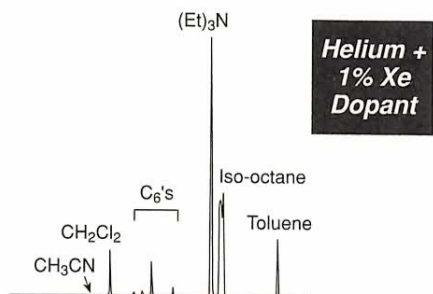
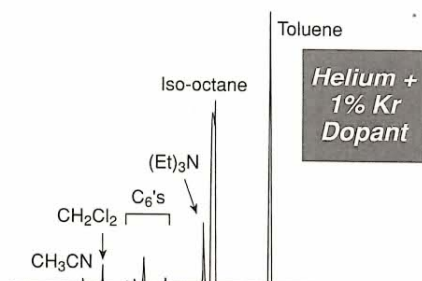
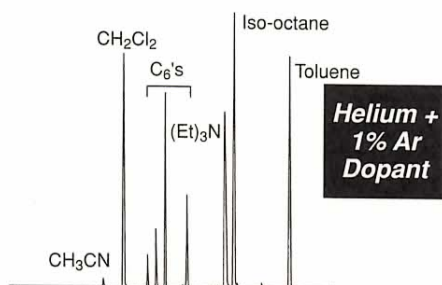
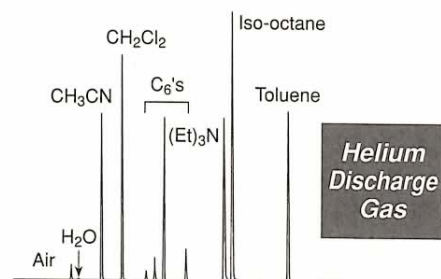
from "Continuous Emission Spectra of Rare Gases in the Vacuum Ultraviolet Region. II. Neon and Helium"  
by Y. Tanaka, A. J. Jurson, and F. J. LeBlanc  
Journal of the Optical Society of America, 48, Number 5, 304 (1958)



# Photoionization

## Analysis of Synthetic Mixes

**Mix 1**  
Sample: 1 ng per



## Ionization Potentials

	eV
Helium	17.7*
N <sub>2</sub>	15.6
CF <sub>4</sub>	> 13.9
O <sub>2</sub>	12.1
H <sub>2</sub> O	12.6
CH <sub>3</sub> CN	12.2

Argon	11.8*
CH <sub>2</sub> Cl <sub>2</sub>	11.3
CH <sub>4</sub> Cl	11.2

Krypton	10.6*
CH <sub>3</sub> Br	10.5
n-C <sub>6</sub>	10.1
CH <sub>2</sub> =CHCl (VCM)	10.0
Acetone	9.7

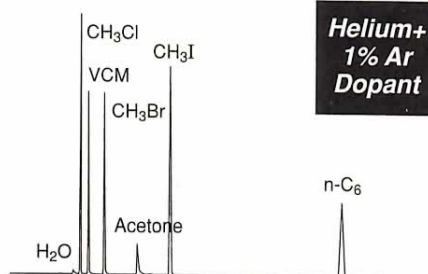
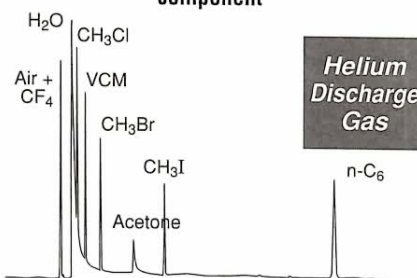
Xenon	9.6*
CH <sub>3</sub> I	9.5
Toluene	8.8
(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub> N ((Et) <sub>3</sub> N)	7.5

These chromatograms show the detector used in various selective ionization modes, accomplished by a simple change of the dopant gas. Many recently developed GCs can do such gas switching automatically via electronic flow controls. Since no lamp or window is used, sensitivity and selectivity *do not* change with time. The chart at left shows the relationship between the ionization potentials of dopant gases and the components in Mixes 1 and 2. When argon, krypton, or xenon is added to the helium carrier, peaks of components with higher ionization potentials are diminished.

\*Corresponds to the maximum emission

## Analysis of Synthetic Mixes

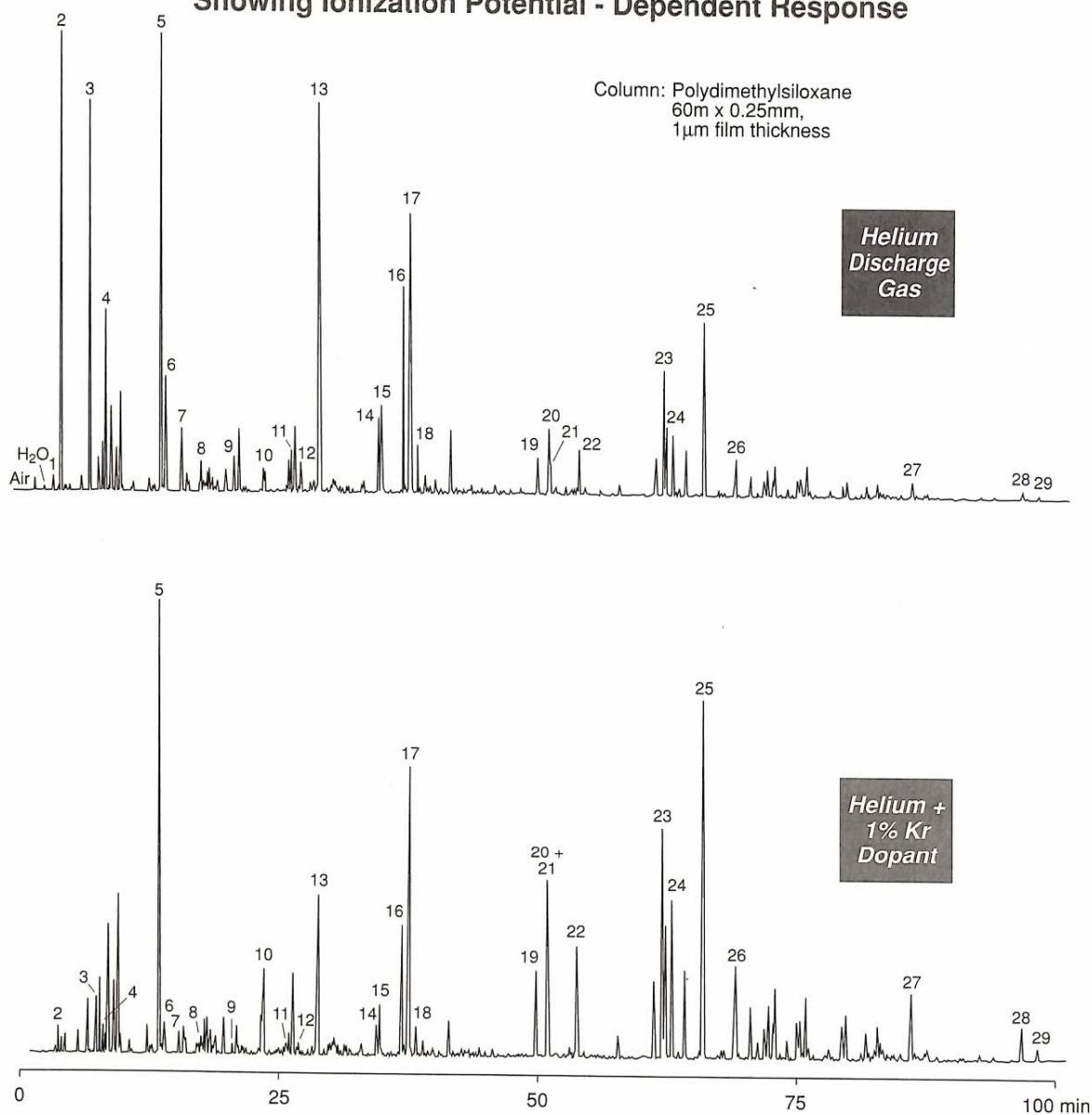
**Mix 2**  
Sample: 10 – 15 pg per component



# Photoionization

## Analysis of Gasoline

### Showing Ionization Potential - Dependent Response



	eV
1. Isobutane	
2. n-Butane	10.5
3. Isopentane	10.4
4. n-Pentane	10.4
5. MTBE	9.24
6. 2-Methylpentane	10.1
7. 3-Methylpentane	10.1
8. n-Hexane	10.1
9. 2,4-Dimethylpentane	
10. Benzene	9.2
11. 2-Methylhexane	
12. 3-Methylhexane	
13. 2,2,4-Trimethylpentane	9.86
14. 2,5-Dimethylhexane	
15. 2,4-Dimethylhexane	

	eV
16. 2,3,4-Trimethylpentane	
17. Toluene	8.82
18. 2,3-Dimethylhexane	
19. Ethylbenzene	8.77
20. m-Xylene	8.56
21. p-Xylene	8.56
22. o-Xylene	8.44
23. 1-Methyl-3-ethylbenzene	
24. 1,3,5-Trimethylbenzene	
25. 1,2,4-Trimethylbenzene	8.27
26. 1,2,3-Trimethylbenzene	8.42
27. Naphthalene	8.14
28. 2-Methylnaphthalene	8.85
29. 1-Methylnaphthalene	7.85



# The practical alternative to radioactive ECDs and HIDs

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**Valco Instruments Co. Inc.**

P. O. Box 5060  
Houston, TX 77255

Sales toll-free (800) FOR VICI  
Technical help (713) 688-9345  
Fax (713) 688-8106

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**Valco Europe**

Untertannberg 7  
CH-6214 Schenkon  
Switzerland

Telephone (041) 925-6200  
Fax (041) 925-6201