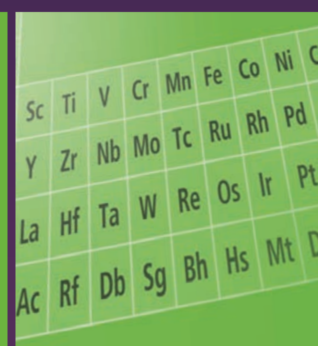
WORLD LEADER IN

AA, ICP-OES AND ICP-MS



Atomic Spectroscopy

A Guide to Selecting the Appropriate Technique and System

PerkinElmer®

For the Better

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WHAT IS ATOMIC SPECTROSCOPY?

Atomic spectroscopy is the technique for determining the elemental composition of an analyte by its electromagnetic or mass spectrum. Several analytical techniques are available, and selecting the most appropriate one is the key to achieving accurate, reliable, real-world results.

Proper selection requires a basic understanding of each technique since each has its individual strengths and limitations. It also requires a clear understanding of your laboratory's analytical requirements.

The following pages will give you a basic overview of the most commonly used techniques and provide the information necessary to help you select the one that best suits your specific needs and applications.

Primary Industries

Many industries require a variety of elemental determinations on a diverse array of samples. Key markets include:

- Agriculture
- Biomonitoring
- Chemical/Industrial
- Environmental
- Food
- Geochemical/Mining
- Nanomaterials
- Nuclear Energy
- Petrochemical
- Pharmaceutical
- Renewable Energy
- Semiconductor
- Single Cell Analysis

For more details, see page 12.

COMMONLY USED ATOMIC SPECTROSCOPY TECHNIQUES

There are three widely accepted analytical methods – atomic absorption, atomic emission and mass spectrometry – which will form the focus of our discussion, allowing us to go into greater depth on the most common techniques in use today:

- Flame Atomic Absorption Spectroscopy (Flame AA)
- Graphite Furnace Atomic Absorption Spectroscopy (GFAA)
- Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES)
- Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

Flame Atomic Absorption Spectroscopy

Atomic Absorption (AA) occurs when a ground state atom absorbs energy in the form of light of a specific wavelength and is elevated to an excited state. The amount of light energy absorbed at this wavelength will increase as the number of atoms of the selected element in the light path increases. The relationship between the amount of light absorbed and the concentration of analytes present in known standards can be used to determine unknown sample concentrations by measuring the amount of light they absorb.

Performing atomic absorption spectroscopy requires a primary light source, an atom source, a monochromator to isolate the specific wavelength of light to be measured, a detector to measure the light accurately, electronics to process the data signal and a data display or reporting system to show the results. (See Figure 1.) The light source normally used is a hollow cathode lamp (HCL) or an electrodeless discharge lamp (EDL). In general, a different lamp is used for each element to be determined, although in some cases, a few elements may be combined in a multi-element lamp. In the past, photomultiplier tubes have been used as the detector. However, in most modern instruments, solid-state detectors are now used. Flow Injection Mercury Systems (FIMS) are specialized, easy-to-operate atomic absorption spectrometers for the determination of mercury. These instruments use a high-performance single-beam optical system with a low-pressure mercury lamp and solar-blind detector for maximum performance.

Whatever the system, the atom source used must produce free analyte atoms from the sample. The source of energy for free-atom production is heat, most commonly in the form of an air/acetylene or nitrous-oxide/acetylene flame. The sample is introduced as an aerosol into the flame by the sample-introduction system consisting of a nebulizer and spray chamber. The burner head is aligned so that the light beam passes through the flame, where the light is absorbed.

The major limitation of Flame AA is that the burner-nebulizer system is a relatively inefficient sampling device. Only a small fraction of the sample reaches the flame, and the atomized sample passes quickly through the light path. An improved sampling device would atomize the entire sample and retain the atomized sample in the light path for an extended period of time, enhancing the sensitivity of the technique. Which leads us to the next option – electrothermal vaporization using a graphite furnace.

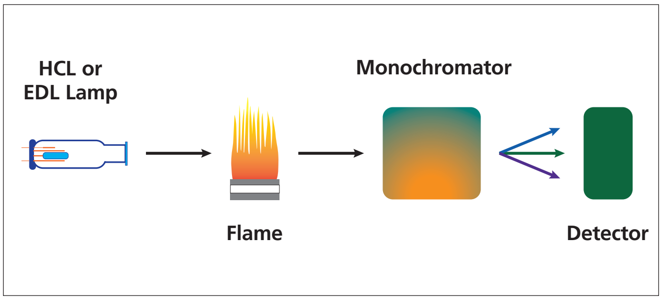


Figure 1. Simplified drawing of a Flame AA system.

Graphite Furnace Atomic Absorption Spectroscopy

With Graphite Furnace Atomic Absorption (GFAA), the sample is introduced directly into a graphite tube, which is then heated in a programmed series of steps to remove the solvent and major matrix components and to atomize the remaining sample. All of the analyte is atomized, and the atoms are retained within the tube (and the light path, which passes through the tube) for an extended period of time. As a result, sensitivity and detection limits are significantly improved over Flame AA.

Graphite Furnace analysis times are longer than those for Flame sampling, and fewer elements can be determined using GFAA. However, the enhanced sensitivity of GFAA, and its ability to analyze very small samples, significantly expands the capabilities of atomic absorption.

GFAA allows the determination of over 40 elements in microliter sample volumes with detection limits typically 100 to 1000 times better than those of Flame AA systems.

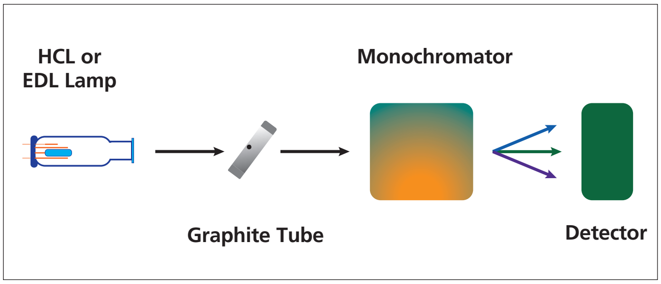
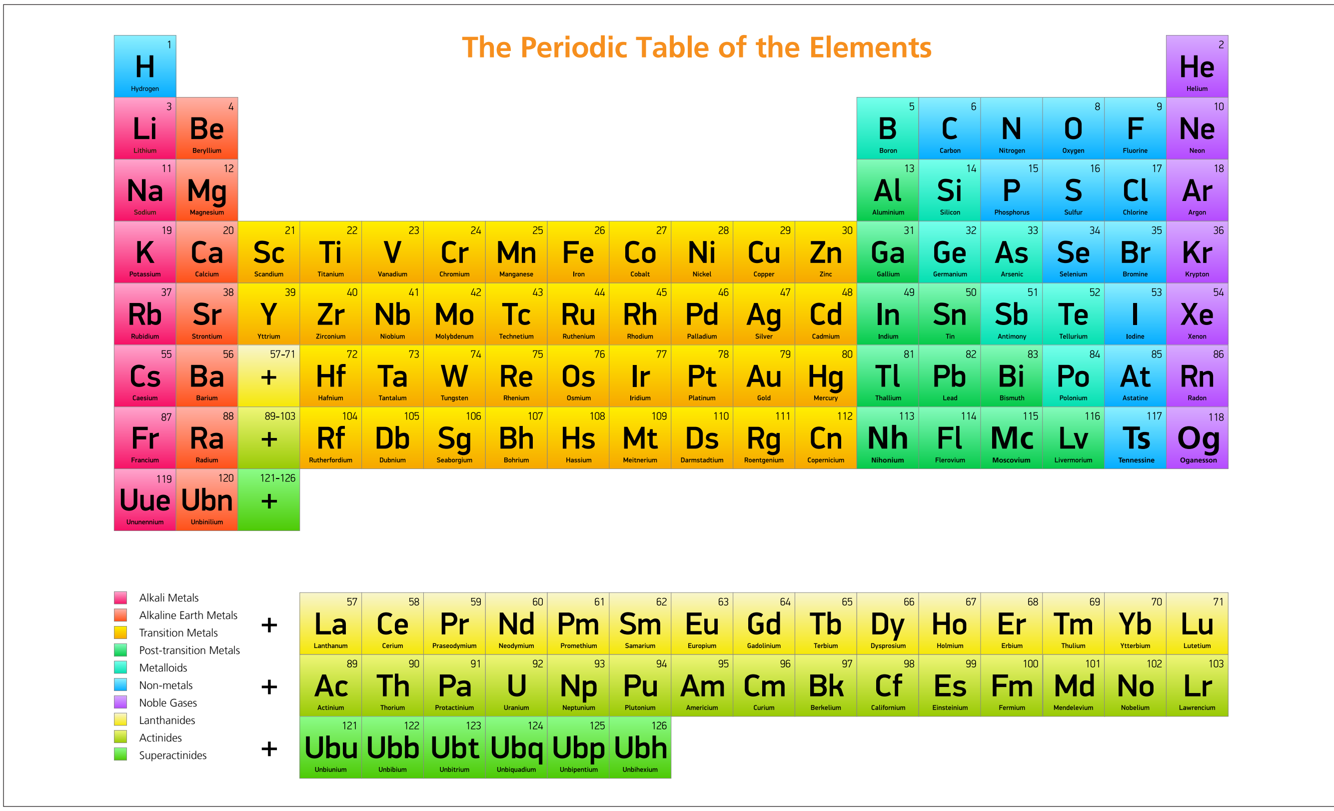


Figure 2. Simplified drawing of a Graphite Furnace AA system.



The Periodic Table of Elements – See page 11 for a listing of detection limits for all elements using the different atomic spectroscopy methods.

Inductively Coupled Plasma Optical Emission Spectroscopy

ICP is an argon plasma maintained by the interaction of an RF field and ionized argon gas. The plasma can reach temperatures as high as 10,000 ˚K, allowing the complete atomization of the elements in a sample and minimizing potential chemical interferences.

Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) is the measurement of the light emitted by the elements in a sample introduced into an ICP source. The measured emission intensities are then compared to the intensities of standards of known concentration to obtain the elemental concentrations in the unknown sample.

There are two ways of viewing the light emitted from an ICP. In the classical ICP-OES configuration, the light across the plasma is viewed radially (Figure 3a), resulting in the highest upper linear ranges. By viewing the light emitted by the sample looking down the center of the torch (Figure 3b) or axially, the continuum background from the ICP itself is reduced and the sample path is maximized. Axial viewing provides better detection limits than those obtained via radial viewing by as much as a factor of 10. The most effective systems allow the plasma to be viewed in either orientation in a single analysis, providing the best detection capabilities and widest working ranges.

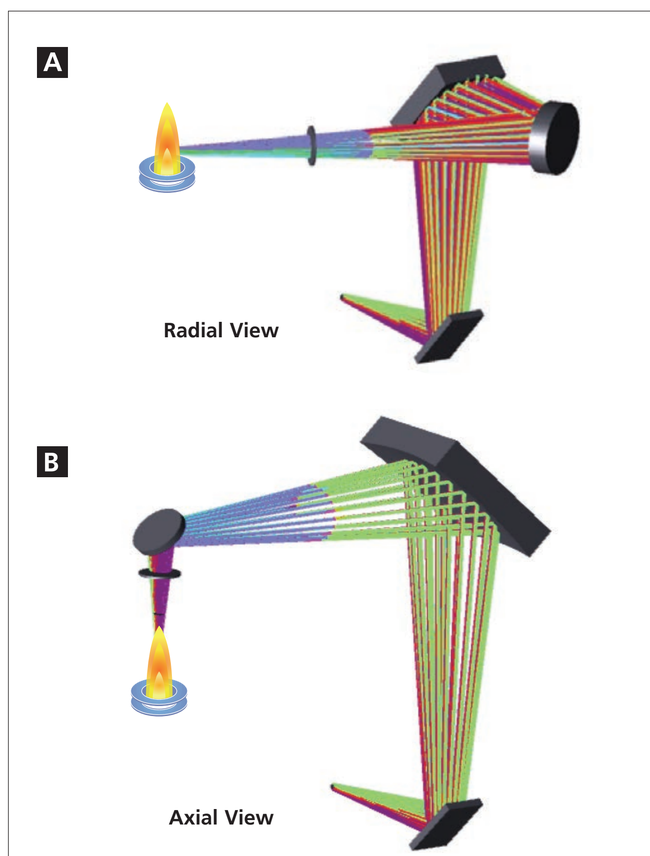


Figure 3. (A) Radially viewed plasma with a vertical slit image in the plasma. (B) Axially viewed plasma with a circular slit image in the plasma.

The optical system used for ICP-OES consists of a spectrometer that is used to separate the individual wavelengths of light and focus the desired wavelengths onto the detector (Figure 4). Older, "direct reader" types of ICP-OES systems used a series of photomultiplier tubes to determine pre-selected wavelengths. This limited the number of elements that could be determined as the wavelengths were generally fixed once the instrument was manufactured. Sequential-type systems can select any wavelength and focus it on a single detector. However, this is done one element at a time, which can lead to longer analysis times.

In today's modern ICP-OES systems, solid-state detectors based on charge-coupled devices (CCD) are used, providing very flexible systems and eliminating the need for large numbers of single photomultiplier detectors.

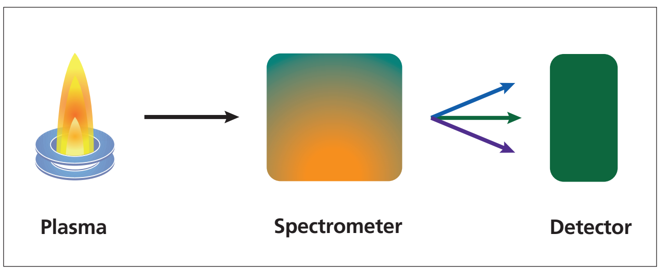


Figure 4. Simplified drawing of a basic ICP system.

Inductively Coupled Plasma Mass Spectrometry

With Inductively Coupled Plasma Mass Spectrometry (ICP-MS), the argon ICP generates singly charged ions from the elemental species within a sample that are directed into a mass spectrometer and separated according to their mass-to-charge ratio. Ions of the selected mass-to-charge ratio are then directed to a detector that determines the number of ions present (Figure 5). Typically, a quadrupole mass spectrometer is used for its ease-of-use, robustness and speed. Due to the similarity of the sample-introduction and data-handling techniques, using an ICP-MS is very much like using an ICP-OES system.

ICP-MS combines the multi-element capabilities of ICP techniques with exceptional detection limits equivalent to or below those of GFAA. It is also one of the few analytical techniques that allows the quantification of elemental isotopic concentrations and ratios, as well as precise speciation capabilities when used in conjunction with HPLC or GC interfaces. This feature enables the analytical chemist to determine the exact form of a species present – not just the total concentration.

However, due to the fact that the sample components are actually introduced into the instrument, there are some limitations as to how much sample matrix can be introduced into the ICP-MS. In addition, there are also increased maintenance requirements as compared to ICP-OES systems. Generally, ICP-MS systems require that the total dissolved solids content of a sample be below 0.2% for routine operation and maximum stability. There are several items, such as the interface cones and ion lens, located between the ICP torch and the mass spectrometer, that need to be cleaned on a periodic basis to maintain acceptable instrument performance.

Recent developments have led to new technologies to increase the robustness and stability of ICP-MS. Orthogonal ion lens systems increase the ability of the ICP-MS to handle higher total dissolved solids content and dramatically improve long-term stability for high matrix solutions. Interference control has been made even easier by using universal cell technologies that include both collision (using Kinetic Energy Discrimination KED) and Dynamic Reaction Cell (DRC) in a single instrument, allowing the analyst to choose the best technique for their samples.

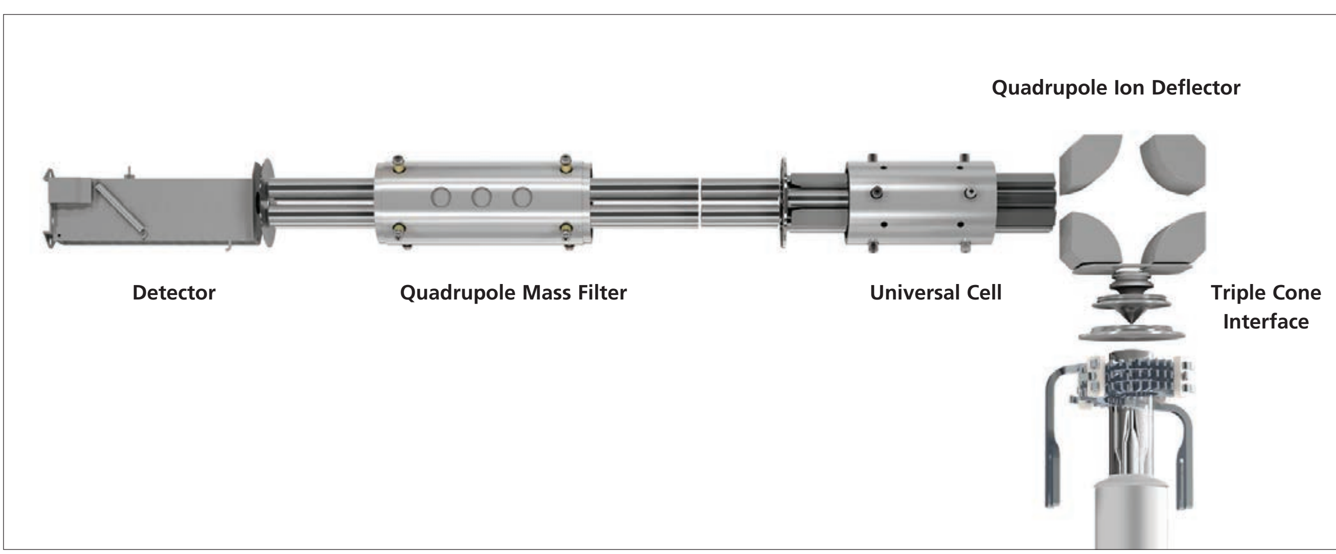


Figure 5. Illustration of ICP-MS system with Universal Cell Technology (UCT).

SELECTING A TECHNIQUE FOR YOUR ANALYSIS

With the availability of a variety of atomic spectroscopy techniques, laboratory managers must decide which of these is best suited to their particular analytical requirements. Unfortunately, because the techniques complement each other so well, it may not always be clear which is the optimum solution for a particular application.

Selecting a technique requires the consideration of a variety of important criteria, including:

- Detection limits
- Analytical working range
- Sample throughput
- Data quality
- Cost
- Interferences
- Ease-of-use
- Availability of proven methodology

In order to help you narrow your selection, many of these criteria are discussed below for Flame AA, Graphite Furnace AA, ICP-OES and ICP-MS. In simple terms, your choice can be guided by answering the four questions in Table 1.

Detection Limits

The detection limits achievable for individual elements are important in determining the usefulness of an analytical technique for a given analytical problem. Without adequate detection-limit capabilities, lengthy analyte concentration procedures may be required prior to analysis.

Typical detection-limit ranges for the major atomic spectroscopy techniques are shown in Figure 6. For a complete listing of detection limits by element for Flame AA, GFAA, ICP-OES (with radial and axial torch configurations) and ICP-MS, see page 11.

Analytical Working Range

The analytical working range can be viewed as the concentration range over which quantitative results can be obtained without having to recalibrate the system. Selecting a technique with an analytical working range (and detection limits) based on the expected analyte concentrations minimizes analysis times by allowing samples with varying analyte concentrations to be analyzed together. A wide analytical working range can also reduce sample-handling requirements, minimizing potential errors.

Table 1. Technique decision matrix.

	Flame AA	GFAA	ICP-OES	ICP-MS
How Many Elements?				
Single	■			
Few		■		
Many			■	■
What Levels?				
PPM	■		■	■
PPB		■	■	■
PPT				■
PPQ				■
How Many Samples?				
Very few	■	■		
Few	■	■	■	■
Many			■	■
How Much Sample?				
> 5 mL	■	■	■	■
< 1-2 mL		■		■

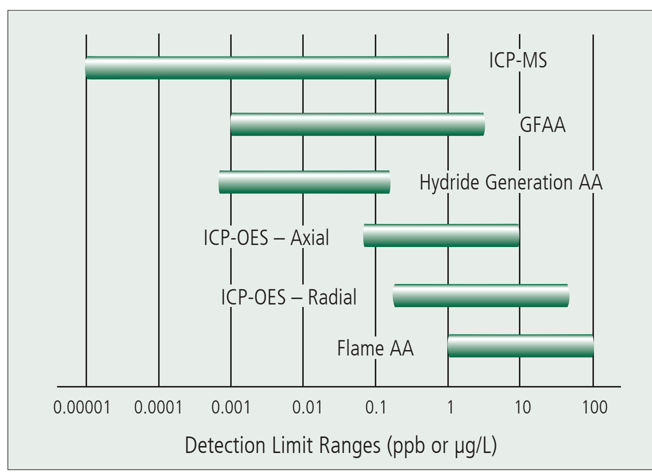


Figure 6. Typical detection limit ranges for the major atomic spectroscopy techniques.

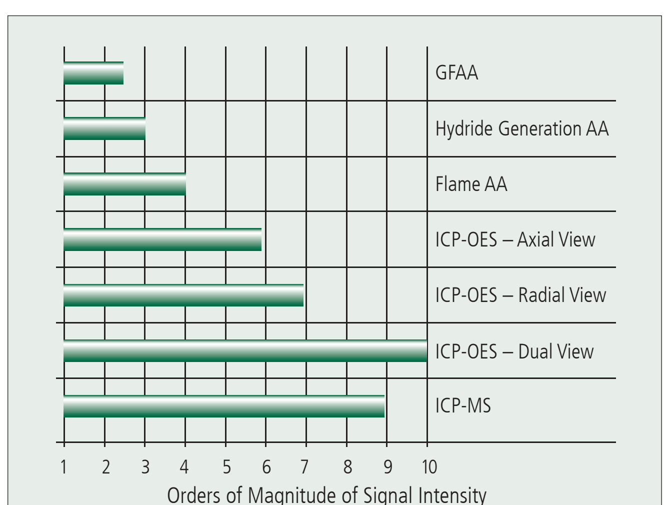


Figure 7. Typical analytical working ranges for the major atomic spectroscopy techniques.

Sample Throughput

Sample throughput is the number of samples that can be analyzed or elements that can be determined per unit of time. For most techniques, analyses performed at the limits of detection or where the best precision is required will be more time-consuming than less demanding analyses. Where these factors are not limiting, the number of elements to be determined per sample and the analytical technique will determine the sample throughput.

- Flame AA – Provides relatively high sample throughput when analyzing a large number of samples for a limited number of elements. A typical determination of a single element requires only 3-10 seconds. Even though it is generally considered to be a single-element technique, Flame AA is frequently used for multi-element analysis.
- Graphite Furnace AA – A highly sensitive technique which provides low detection limits for many elements. As with Flame AA, GFAA is basically a single-element technique. Because of the need to thermally program the system to remove solvent and matrix components prior to atomization, GFAA has a relatively low sample throughput. A typical graphite-furnace determination normally requires 2-3 minutes per element for each sample. With multiple methods in the queue, GFAAS can be left unattended for multi-element analysis.
- ICP-OES – A true multi-element technique with exceptional sample throughput. ICP-OES systems typically can determine more than 73 elements per minute in individual samples. Where only a few elements are to be determined, however, ICP is limited by the time required for equilibration of the plasma with each new sample, typically about 15-30 seconds.
- ICP-MS – Also a true multi-element technique with the same advantages and limitations of ICP-OES. ICP-MS can typically determine more than 73 elements per minute in an individual sample, depending on such factors as the concentration levels and required precision. Although ICP-MS has a wide working range, the upper linear concentration range is generally less than that of ICP-OES systems and may require that some samples be diluted.

Costs

As they are less complex systems, instrumentation for single-element atomic spectroscopy (Flame AA and GFAA) is generally less costly than that for the multi-element techniques (ICP-OES and ICP-MS). There can also be a considerable variation in cost among instrumentation for the same technique. Instruments offering only basic features are generally less expensive than more versatile systems, which frequently also offer a greater degree of automation. Figure 8 provides a comparison of typical instrument price ranges for the major atomic spectroscopy techniques.

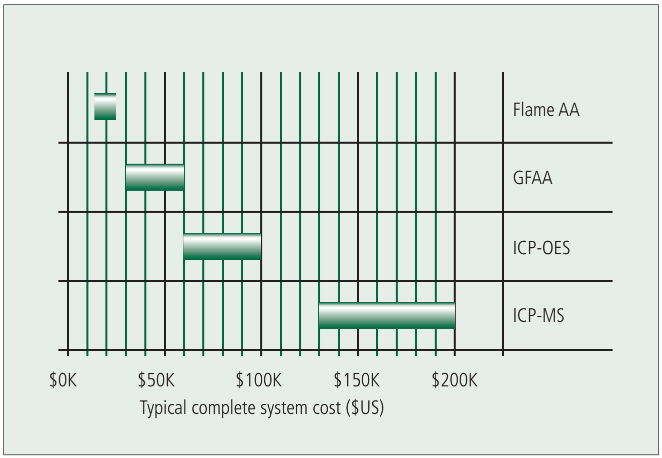


Figure 8. Typical relative purchase prices for atomic spectroscopy systems.

SELECTING A SYSTEM FOR YOUR ANALYSIS

TECHNIQUE	STRENGTHS	LIMITATIONS	APPLICATIONS	SYSTEMS
Flame AA – Flame Atomic Absorption Spectroscopy	• Very easy-to-use • Widely accepted • Extensive application information available • Relatively inexpensive	• Low sensitivity • Single-element analytical capability • Cannot be left unattended (flammable gas)	Ideal for laboratories analyzing large numbers of samples for a limited number of elements and for the determination of major constituents and higher concentration analytes.	**PinAAcle 500/900F AA Spectrometers** 
GFAA – Graphite Furnace Atomic Absorption Spectroscopy	• Exceptional detection limits • Well-documented applications • May be left unattended	• Limited analytical working range • Sample throughput somewhat less than other techniques	Ideal for laboratories analyzing a limited number of elements and requiring excellent detection limits.	**PinAAcle 900 AA Spectrometers** 
ICP-OES – Inductively Coupled Plasma Optical Emission Spectroscopy	• Best overall multi-element atomic spectroscopy technique • Excellent sample throughput • Very wide analytical range • Good documentation available for applications • May be left unatteneded • Easy-to-use	• Higher initial investment	Ideal for laboratories analyzing multiple elements in a moderate or large number of samples.	**Avio 200/500 ICP-OES Spectrometers** 
ICP-MS – Inductively Coupled Plasma Mass Spectrometry	• Exceptional multi-element capabilities • Ability to perform isotopic analyses • Well-documented interferences and compensation methods • Rapidly growing application information • Detection limits equal to or better than GFAA with much higher productivity • May be left unattended	• Highest initial investment • Method development more difficult than other techniques • Limited solids in sample	Ideal for laboratories analyzing multiple elements in a large number of samples and requiring a system capable of determining trace and ultratrace analyte concentrations.	**NexION 1000/2000 ICP-MS Spectrometers** 

Once you have identified the best solution for your particular application, read on for more in-depth product details.

PinAAcle 500 Flame AA

The PinAAcle™ 500 offers superior durability, longer life, lower maintenance costs, and the fastest return on investment of any flame atomic absorption (AA) spectrometer. Plus, it's the world's first completely corrosion-resistant flame AA, designed to withstand the harshest environments and most corrosive samples. And with the intuitive and easy-to-use Syngistix Touch™ software, you can start your analysis in only three clicks.

PinAAcle 900 Series AA

The PinAAcle™ 900 series of atomic absorption (AA) spectrometers brings AA performance to new heights. Available in flame, furnace or combination models, PinAAcle instruments offer exactly the level of performance you need with the smallest footprint of any combined flame/graphite furnace AA system on the market.

FIMS 100/400

FIMS are compact, easy-to-operate mercury analyzers with integrated flow injection systems for cold vapor mercury AA. FIMS 100 incorporates a single peristaltic pump while FIMS 400 incorporates two peristaltic pumps. They both include high-performance optics with low-pressure Hg lamp and solar-blind detector for maximum sensitivity.

Avio 200 ICP-OES

The smallest ICP on the market, the Avio® 200 offers high performance, efficient operation, reliable data, and low cost of ownership by delivering: the lowest argon consumption of any ICP, the fastest ICP startup, superior sensitivity and resolution for all elements of interest, and the widest linear range with dual viewing technology.

Avio 500 ICP-OES

The Avio® 500 is a truly simultaneous, dual view, and compact ICP-OES. It utilizes a vertical plasma and is engineered to handle even the most difficult, high-matrix samples without dilution, delivering productivity, performance, and faster return on your investment.

NexION 1000 ICP-MS

The NexION® 1000 is the ideal ICP-MS for high-throughput testing labs running routine, multi-elemental, trace-level analyses that meet regulatory standards - that works within your budget. It provides exceptional speed, operational simplicity, and improved laboratory efficiency.

NexION 2000 ICP-MS

The NexION® 2000 is a very versatile ICP-MS, featuring an array of advanced technologies that combine to offer unique benefits to laboratories, both large and small: the most powerful interference removal for the best detection limits; the highest flexibility regardless of matrix; the lowest-maintenance requirements for ICP-MS.

Syngistix Cross-Platform Software

Designed to offer a harmonized user experience across PerkinElmer's AA, ICP and ICP-MS platforms, Syngistix™ software features a unique icon-based design that simplifies navigation and walks the user through every analysis – from setting up to acquiring data to reporting results. Flexible and intuitive, the Syngistix interface mirrors your workflow with a left-to-right arrangement of analytical steps. Other benefits include built-in methods, Enhanced Security™ option for 21 CFR Part 11 compliance, and application-specific modules for Single Particle and Single Cell ICP-MS, as well as Automated Method Validation for USP <233>.

ATOMIC SPECTROSCOPY DETECTION LIMITS

Element	Flame AA	Hg/Hydride	GFAA	ICP-OES	ICP-MS
Ag	1.5		0.005	0.6	0.00003
Al	45		0.1	1	0.00001*
As	150	0.03	0.05	1	0.0003
Au	9		0.15	1	0.00005
B	1000		20	1	0.0002
Ba	15		0.35	0.03	0.00002
Be	1.5		0.008	0.09	0.00009
Bi	30	0.03	0.05	1	0.000004
Br					0.04
C					
Ca	1.5		0.01	0.05	0.00005*
Cd	0.8		0.002	0.1	0.00006
Ce				1.5	0.00005
Cl					2
Co	9		0.15	0.2	0.000006*
Cr	3		0.004	0.2	0.00005*
Cs	15				0.00005
Cu	1.5		0.014	0.4	0.00003*
Dy	50			0.5	0.0002
Er	60			0.5	0.0001
Eu	30			0.2	0.00007
F					
Fe	5		0.06	0.1	0.0001*
Ga	75			1.5	0.00004
Gd	1800			0.9	0.0003
Ge	300			1	0.0004*
Hf	300			0.5	0.0003
Hg	300	0.006	0.6	1	0.001
Ho	60			0.4	0.00004
I					0.003
In	30			1	0.000003
Ir	900		3.0	1	0.00009
K	3		0.005	1	0.00004
La	3000			0.4	0.00004
Li	0.8		0.06	0.3	0.0000004
Lu	1000			0.1	0.00004
Mg	0.15		0.004	0.04	0.00001
Mn	1.5		0.005	0.1	0.00005*

Element	Flame AA	Hg/Hydride	GFAA	ICP-OES	ICP-MS
Mo	45		0.03	0.5	0.00003
Na	0.3		0.005	0.5	0.00001
Nb	1500			1	0.000009
Nd	1500			2	0.0003
Ni	6		0.07	0.5	0.00006*
Os				6	0.00006
P	75000		130	4	0.6*
Pb	15		0.05	1	0.00001*
Pd	30		0.09	2	0.00008
Pr	7500			2	0.00003
Pt	60		2.0	1	0.00007
Rb	3		0.03	5	0.0002
Re	750			0.5	0.0003
Rh	6			5	0.00003
Ru	100		1.0	1	0.00002
S				10	0.5*
Sb	45	0.15	0.05	2	0.00003
Sc	30			0.1	0.001
Se	100	0.03	0.05	2	0.0003*
Si	90		1.0	10	0.1
Sm	3000			2	0.0002
Sn	150		0.1	2	0.00003
Sr	3		0.025	0.05	0.00002
Ta	1500			1	0.000006
Tb	900			2	0.00003
Te	30	0.03	0.1	2	0.0003*
Th				2	0.00005
Ti	75		0.35	0.4	0.00003*
Tl	15		0.1	2	0.000004
Tm	15			0.6	0.00003
U	15000			10	0.000005
V	60		0.1	0.5	0.00001*
W	1500			1	0.00002
Y	75			0.2	0.00002
Yb	8			0.1	0.0001
Zn	1.5		0.02	0.2	0.0001*
Zr	450			0.5	0.00002

All detection limits are given in micrograms per liter and were determined using elemental standards in dilute aqueous solution. All detection limits are based on a 98% confidence level (3 standard deviations).

Actual detection limits may vary depending on system configuration, matrices, and laboratory conditions.

All atomic absorption detection limits were determined using instrumental parameters optimized for the individual element, including the use of System 2 electrodeless discharge lamps where available. Data shown were determined on a PerkinElmer AA.

Cold-vapor mercury detection limits were determined with dedicated FIMS 100 and FIMS 400 mercury analyzer. The detection limit of FIAS 100 and FIAS 400 is 0.2 µg/L with a hollow cathode lamp, 0.05 µg/L with a System 2 electrodeless discharge lamp.

Hydride detection limits shown were determined using an MHS-15 Mercury/Hydride system.

GFAA detection limits were determined on a PerkinElmer AA using 50 µL sample volumes, an integrated platform and full STPF conditions. Graphite-furnace detection limits can be further enhanced by the use of replicate injections.

All ICP-OES detection limits were obtained under simultaneous multi-element conditions with the axial view of a dual-view plasma using a cyclonic spray chamber and a concentric nebulizer.

All ICP-MS measurements were performed on a NexION ICP-MS with a quartz sample introduction system using a 1-second integration time and ten replicates in de-ionized water. Detection limits were measured under multi-element conditions in Standard mode, except where denoted by an asterisk (*). Detection limits denoted by * were performed in a Class 1000 Cleanroom using Reaction mode with the most appropriate cell gas and conditions for that element.

ATOMIC SPECTROSCOPY APPLICATIONS BY MARKET

MARKET	TYPICAL APPLICATIONS	COMMONLY USED TECHNIQUES		
		AA	ICP-OES	ICP-MS
Agriculture	Soils	light pink	purple	white
Biomonitoring	Biological fluids	light pink	light pink	purple
Chemical/Industrial	Quality control/Product testing	mauve	purple	mauve
Environmental	Water	mauve	mauve	purple
	Soil	light pink	purple	mauve
	Air	light pink	light pink	mauve
Food	Food safety	light pink	light pink	light pink
	Nutritional labeling	mauve	purple	white
Geochemical/Mining	Exploration	light pink	purple	dark purple
	Research	mauve	purple	dark purple
Nanomaterials	Research	white	white	dark purple
Nuclear Energy	Low-level waste	light pink	mauve	mauve
	Process water	white	mauve	mauve
Petrochemical	Petroleum refining	dark purple	dark purple	purple
	Lubricants and oils	white	dark purple	white
Pharmaceutical	Drug development	white	white	purple
	Quality control	mauve	mauve	dark purple
Renewable Energy	Biofuels	white	purple	purple
	Solar panels	white	purple	mauve
Semiconductor	Wafers	white	white	purple
	High-purity chemicals	mauve	light pink	purple
Single Cell Analysis	Research	white	white	mauve

Frequency of Technique Used → (white, light pink, mauve, purple)

IMPORTANCE OF ATOMIC SPECTROSCOPY TO SPECIFIC MARKETS

Agriculture

Trace metals are essential for plant growth. Atomic spectroscopy also facilitates precise soil analysis to ensure that metals are not at levels that could unduly affect the food source (livestock and/or crops).

Biomonitoring

Instrumentation for accurate measurements of metals in biological matrices is vital when assessing human exposures to natural and synthetic chemicals. Speciation is also becoming increasingly important due to its ability to provide additional information on element valence state or molecular form.

Chemical/Industrial

From the analysis of raw materials and components to finished product testing and quality control, industrial and chemical manufacturers require accurate analytical techniques to ensure the safety and performance of their products.

Environmental

In the environment we live in, understanding heavy-metal contamination is critical. The accurate measurement of concentrations of these metals is imperative to maintain clean air, water and soil for a safer world.

Food

Accurate analysis of food for nutritional content, contamination or authenticity – the exact geographic source of the product – is critical for regulatory and quality assurance.

Geochemical/Mining

With myriad applications from date stamping to precious metals testing, atomic spectroscopy offers a fast, accurate solution for broad geological surveys as well as an invaluable means of testing potential mining areas before incurring the high costs associated with digging.

Nanomaterials

As research science defines more novel applications for nanomaterials, the need to eliminate material uncertainty on a particle-by-particle basis continues to grow. Whether there is a need to solve an environmental issue or apply a manufacturing QA/QC solution to a synthesis or formulation process, there is a growing requirement for sensitivity to conduct accurate, precise work.

Nuclear Energy

Operating under constant scrutiny, the nuclear field is required to monitor and measure the levels of a variety of elements to an exacting degree. Atomic spectroscopy is commonly used to determine trace elements in everything from process water to low-level waste.

Petrochemical

From petroleum refining to a broad spectrum of applications using lubricants and oils, many industries require the determination of metals – particularly analytes that can lead to degradation and contamination – to ensure conformity as well as monitor and control processes.

Pharmaceutical

Drug research, development and production is dependent on elemental analysis, starting with the testing of individual ingredients and continuing through production to final quality control, as impurities can affect drug efficacy and metabolism.

Renewable Energy

As the world continues to move toward ecofriendly technologies and energy sources, there's an ever-increasing need for accurate elemental analysis. Applications include testing biofuels for batch consistency and quality control, as well as trace elemental analysis on solar panels to ensure optimum performance.

Semiconductor

Determining lower and lower values in a variety of materials – rapidly and affordably – has become necessary in the increasingly competitive semiconductor industry.

Single Cell Analysis

The transfer of analytes in and out of cells is key to many biological processes. Single Cell ICP-MS permits scientists to study the cellular uptake of heteroatom-containing drugs, thereby understanding their efficacy.

ATOMIC SPECTROSCOPY ACCESSORIES

PerkinElmer makes it easy to get the most out of your AA, ICP-OES and ICP-MS system with a full range of accessories designed to optimize performance, streamline your workflow, and generate faster, more accurate results.

S10 Autosampler

A computer-controlled, multi-purpose sampling system for AA, ICP-OES, or ICP-MS, the S10 Autosampler automates standard and sample introduction for instrument calibration and sample analysis, extending your spectrometer's capabilities to those of a fully automated analytical workstation. In addition to the S10, other autosampler options are available to meet your application needs.

Titan MPS Microwave Sample Preparation System

Easy to load and easy to use, the Titan MPS™ delivers simple, safe, cost-effective microwave sample preparation, optimizing performance by constantly monitoring and adjusting digestion conditions during operation. Two configurations are available: 8-position with 100 mL high-pressure vessels; and 16-position one with 75 mL standard pressure vessels.

SPB Preparation Blocks

When conducting routine sample preparation, PerkinElmer's SPB blocks are ideal for any open-vessel digestion/heating method requiring a temperature below 180 °C.

FIAS 100/400

FIAS are fully integrated and automated flow injection mercury/hydride analysis systems that provide automation and sample handling for AA and ICP, dramatically increasing laboratory productivity and capability. FIAS 100 incorporates a single peristaltic pump for carrier, reagent and sample solutions; while FIAS 400 incorporates two peristaltic pumps for carrier, reagent and sample solutions.

MHS-15 Mercury/Hydride System

The MHS-15 Mercury/Hydride System is a manual accessory for high-sensitivity determination of mercury and hydride-forming elements, such as As, Se, Sb, Te, Bi and Sn, by Flame AA spectroscopy. The MHS-15 system includes a reaction assembly and a quartz-cell assembly. The analyzer is free-standing and is placed adjacent to the AA spectrometer's sample compartment.

ATOMIC SPECTROSCOPY CONSUMABLES AND SUPPLIES

Trust the Consumables Engineered for your Instruments

We offer a wide selection of superior quality consumables and supplies designed to work with your PerkinElmer AA, ICP, and ICP-MS instruments. Our precision-designed products deliver the peace of mind that comes from knowing that you'll get the results you need.

AA Graphite Tubes – Engineered to the highest quality specifications, using a high-density base graphite material, exclusive to PerkinElmer.

AA Lamps – Whether Lumina™ HCL or System 2 EDL, they are designed and tested on our AA spectrometers to assure compatibility and the highest performance.

AA Nebulizers – Stainless steel and high-sensitivity, corrosion-resistant options are available, and all manufactured to exacting tolerances to provide maximum sensitivity.

ICP/ICP-MS Injectors – A complete selection in various sizes and materials (alumina, quartz, sapphire) to meet all of your application needs.

ICP/ICP-MS Nebulizers – Available in a variety of materials (glass, quartz, PFA, and HF-resistant) to accommodate your application requirements.

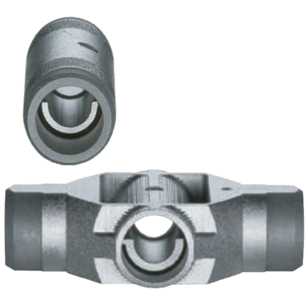
ICP/ICP-MS Spray Chambers – An integral part of the sample introduction system, each type is tested to provide the best performance and analytical results.

ICP/ICP-MS Torches – Manufactured with the best materials for optimal performance and designed specifically for your instrument. Both demountable and fixed torches are available.

ICP-MS Cones – Precision-designed and manufactured for the best analytical results. Large-orifice sampler and skimmer cones provide superior long-term stability.

Reference Materials – From Inorganic Aqueous to Metallo-Organic reference materials, choose from a wide range of standards all certified and tested to provide the quality and reliability you expect.

Sample Preparation – Whether using our Titan MPS Microwave Digestion System, our SPB Sample Preparation Blocks or both, you can benefit from a complete selection of consumables and supplies that ensure sample preparation success.



Graphite Tubes

Lumina™ Hollow Cathode Lamp

MEINHARD® Plus Nebulizer

Spray Chamber

Precision-designed products, along with genuine PerkinElmer consumables and supplies, can be found at www.perkinelmer.com/supplies

THE MOST TRUSTED NAME IN ELEMENTAL ANALYSIS

PerkinElmer has been at the forefront of inorganic analytical technology for over 50 years. With a comprehensive product line that includes Flame AA systems, high-performance Graphite Furnace AA systems, flexible ICP-OES systems and the most powerful ICP-MS systems, we can provide the ideal solution no matter what the specifics of your application.

We understand the unique and varied needs of the customers and markets we serve. And we provide integrated solutions that streamline and simplify the entire process from sample handling and analysis to the communication of test results.

With tens of thousands of installations worldwide, PerkinElmer systems are performing inorganic analyses every hour of every day. Behind that extensive network of products stands the industry's largest and most-responsive technical service and support staff. Factory-trained and located in 150 countries, they have earned a reputation for consistently delivering the highest levels of personalized, responsive service in the industry.

For more information on our atomic spectroscopy solutions, visit www.perkinelmer.com/atomicspectroscopy

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