Flame Emission Spectroscopy

Exercise: Self Reversal

There is an excellent match in regards to the energy of the photon given off by $A^*$ and what energy it will take to promote an electron in the ground-state atom, A, to a higher since the energy levels in both atoms are identical.

Arc/Spark

Energy and Momentum of Charged Particles

If a charged particle is accelerated by an electric field over a fixed distance, it will obtain an energy $U = E \cdot d \cdot z \cdot e$, $E =$ electric field in volts/cm, $d =$ distance in cm, $z =$ number of charges the ion carries, and $e =$ electric unit charge. Thus $U$ is naturally expressed in electron volts, the energy of an electron having been accelerated across a total potential difference of 1 volt. Ignoring relativistic corrections, $U = \frac{1}{2} m v^2$, $m =$ mass of the charged particle, $v =$ the particle's speed. Particle momentum $= m v$ (in principle, $v$ is a vector quantity, but for convenience have $v$ directed along a reference axis so we can regard it as speed, a scalar. Key idea: for singly-charged particles accelerated by a fixed potential drop, the energy of the particle is independent of its mass. $v = (2U/m)^{1/2}$. Thus, momentum $= m^* (2U/m)^{1/2} = (2Um)^{1/2}$. So momentum increases as the square-root of ion mass at fixed charge. Since the lightest element, H, has a mass approximately 1836 the mass of the electron, ions have momentum at least $1836^{1/2} = 43$ times that of an electron. For Ar (mass 40 Daltons), the momentum of a singly-charge $Ar^+$ is $(40 \cdot 1836)^{1/2} = 271$ times that of an isoenergetic electron.

Sputtering on Electrodes

The cathode, since cations bombard the cathode and have higher momenta then electrons.

Inductively Coupled Plasma (ICP)

ICP Research

Selecting citations on the ICP is daunting. A Scifinder search on December 22, 2008 gives 30,663 Chemical Abstracts "hits" for "Inductively coupled plasma," limited to books, reviews, journal articles, and letters (thus ignoring e.g. patents, meeting abstracts, and theses). The most prolific author listing was for Joseph Caruso of the University of Cincinnati with 196 "hits," followed by Ramon M. Barnes with 186. Both these authors write on applications as well as discharge fundamentals. A total of 59,020 authors were turned up by Scifinder, although this number is misleading; G. M. Hieftje (54 cites) and Gary M. Hieftje (121 cites) are, in fact, the same individual. There are numerous others with multiple entries, so generation of a consolidated listing is impractical. Furthermore, M. J. Kushner has 49 hits, but these are for chemical vapor deposition plasmas, not analytical plasmas. At one time, the authors contemplated providing hotlinks to
important ICP papers or lists of citations by leading authors. This is not practical without violating Scifinder (or competitors) copyright restrictions. Suffice to say that much important fundamental work was carried out since 1965 by many including (in alphabetical order):


It is manifestly obvious that several tens of thousands of deserving authors have not been listed! The consequences of their work inform much of what is in this module, whether or not specific to the ICP.

Answers

1. This allows for: atomization (and ionization)
2. Elements with low ionization energy: the alkali metals

Microwave Induced Plasma (MIP)

Exercise

If helium is your plasma carrier gas in an MIP, interfacing is straight-forward with a GC that uses helium as a carrier gas. They are most often used as GC detectors! Agilent did sell a GC-AED system, first implemented by Beennakker!

MIP References