SUPERIOR
INTERFERENCE REMOVAL
ACCURATE RESULTS

NexION® ICP-MS Series: We're in Our Element

Accurate, reproducible trace elemental analysis is essential to ensuring the quality and safety of our products and our environment. Our award-winning NexION® ICP-MS platform delivers that level of accuracy and repeatability through a host of unique features that provide superior interference removal and outstanding detection limits.

At the forefront is our proprietary Universal Cell Technology™ (UCT) – a unique quadrupole reaction/collision cell with dynamic bandpass tuning. It not only allows the use of pure reaction gases, which are able to deliver reliable and repeatable reactions, but also controls the reaction – a feature unique to quadrupole cells – and eliminates reaction byproducts before they form new interferences.

The UCT can perform two different tasks, depending on the nature of the introduced gases and operational setup. The first task is to operate in Reaction (DRC) mode with reactive gases. The second is to operate in Collision mode, employing kinetic energy discrimination (KED) with nonreactive gases, such as helium and argon.

This work presents color-coded periodic tables with estimated reactivity of six gases (O_2, N_2O, CO_2, CH_4, CH_3F and NH_3) for over 80 elements. Experiments were performed on the NexION 5000 multi-quadrupole ICP-MS, working seamlessly with the UCT.

NexION 1000 ICP-MS

NexION 2200 ICP-MS

NexION 5000 ICP-MS

PerkinElmer
For the Better

Advantages of Reaction (DRC) Mode

The use of pure cell gases in a dynamic reaction cell with scanning quadrupole allows a much higher and more specific interference reduction than kinetic energy discrimination with helium. The sensitivity of the analyte is maintained or even increased by collisional focusing. At the same time, even the highest spectral backgrounds are removed instantaneously by a predictable chemical reaction.

The NexION ICP-MS platform opens several paths to a successful separation of analyte and interferent. The periodic tables in this document are intended to be an initial overview of the chemical alternatives.

Mass Shift Mode

High reactivity of the analyte with the cell gas allows the analyte to be shifted to a higher mass.
In Mass Shift mode, it is crucial that the analyte reacts with the cell gas and the interferent does not.

Typical mass shift reactions with O_2, N_2O and CO_2 shift the analyte by 16 amu from M^+ to MO^+ or by 32 amu to MO_2^+. In the case of CH_3F, there are shifts by 19 amu from M^+ to MF_x^+ as well as shifts by 34 amu to $M(CH_3F)_x^+$ clusters. For CH_4, a 14 amu shift to $M(CH_2)^+$ is usually encountered. For strong reactions with NH_3, clusters of the type $MNH_x(NH_3)_y^+$ (x = 1, 2 and y = 0 - 5) are formed.

The yield of each reaction product can be optimized by the cell gas flow rate and by the RPq parameter.

On-Mass Mode

For analytes that undergo little or no reaction with the selected gas, interference removal can be accomplished by measuring the analyte at its original mass.
In On-Mass mode, it is crucial that only the interferent reacts with the reaction gas and not the analyte.

- Charge transfer reaction of the interferent – Usually, a reactive gas such as NH_3 with a lower ionization energy than the interferent is used for this purpose. By transferring an electron from the neutral gas to the positively charged interferent, the interferent is instantly neutralized and removed from the ion beam. Typical examples are the removal of $^{40}Ar^+$ on $^{40}Ca^+$, $^{40}Ar^{16}O^+$ on $^{56}Fe^+$, $^{40}Ar^{12}C^+$ on $^{52}Cr^+$ or $^{35}C^{16}O^+$ on $^{51}V^+$.
- Mass shift reaction of the interferent – A second pathway of interferent removal is the mass shift of the interferent, changing it into a different ion that does not reside on the analyte mass. Typical examples are the removal of $^{98}Mo^{16}O^+$ on $^{114}Cd^+$ by O_2 or $^{87}Sr^+$ on $^{87}Rb^+$ by N_2O.

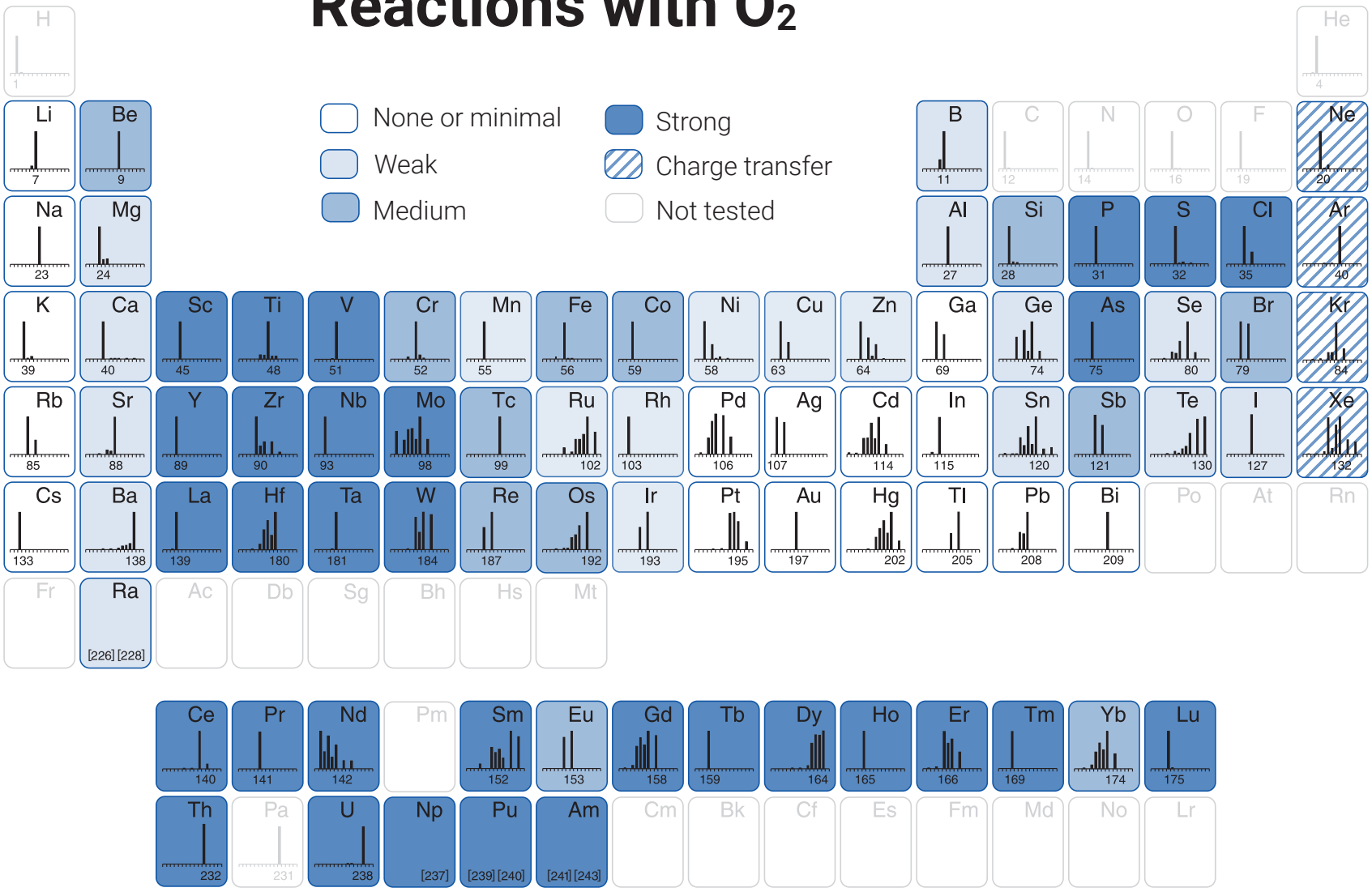
Spectral Library

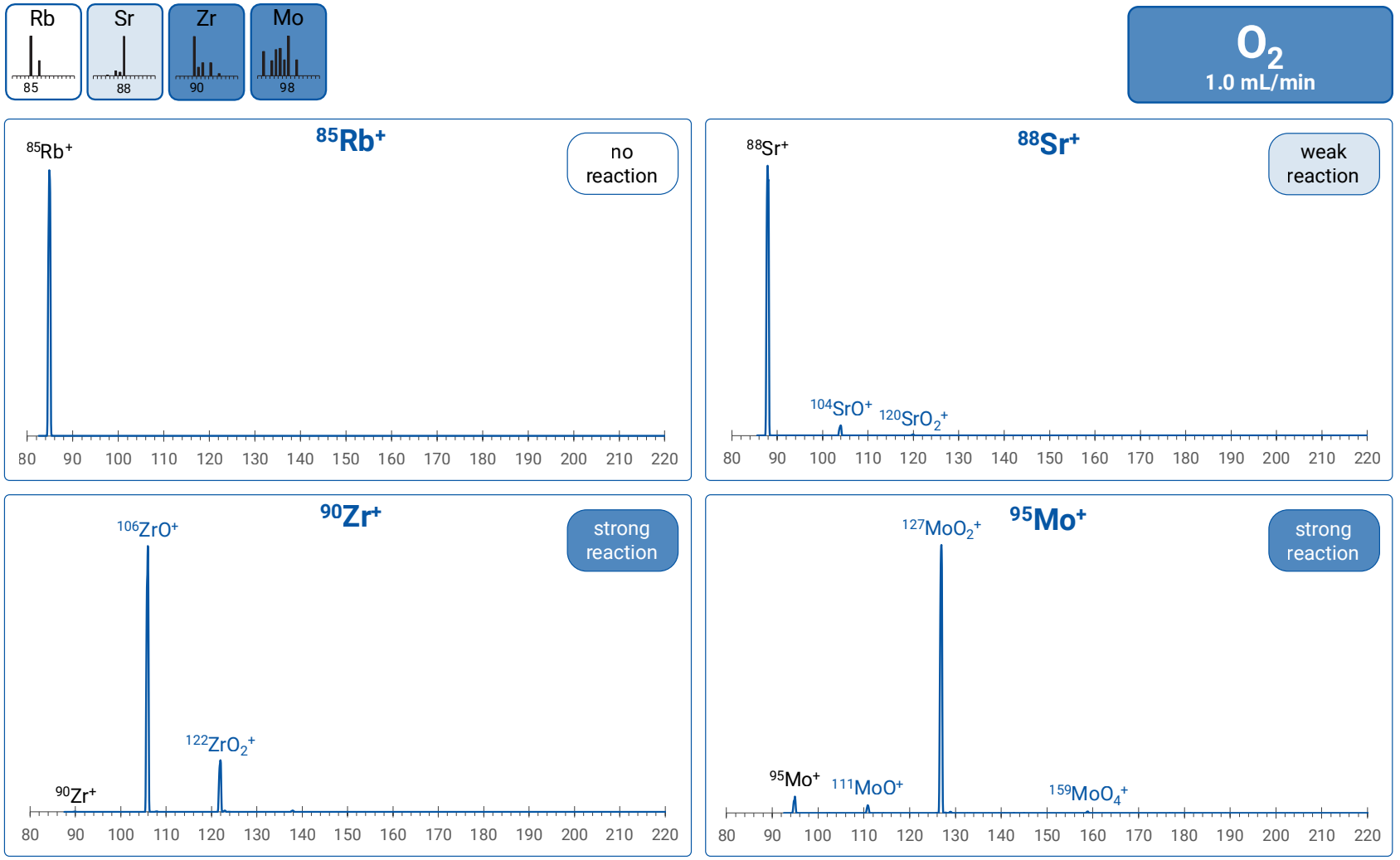
The evaluation of the reactivity of the individual elements with the respective reaction gas is based on > 1,400 product ion scans acquired with the NexION 5000 multi-quadrupole ICP-MS from blanks, 1 µg/L multi-element solutions and single-element solutions of higher concentration.

The product ion scan is the optimal tool for the identification of the reaction products. Samples were scanned with Q1 set at mass of interest M and Q3 measuring all masses from M-2 to 285 amu. Spectral resolution of Q1 and Q2 was 0.7 amu, dwell time was 500 ms/amu. Cell gas flow rates were 1.0 mL/min for O_2, N_2O, CO_2, CH_4, CH_3F, and 0.8 and 1.2 mL/min for NH_3. RPq for all measurements was 0.4.

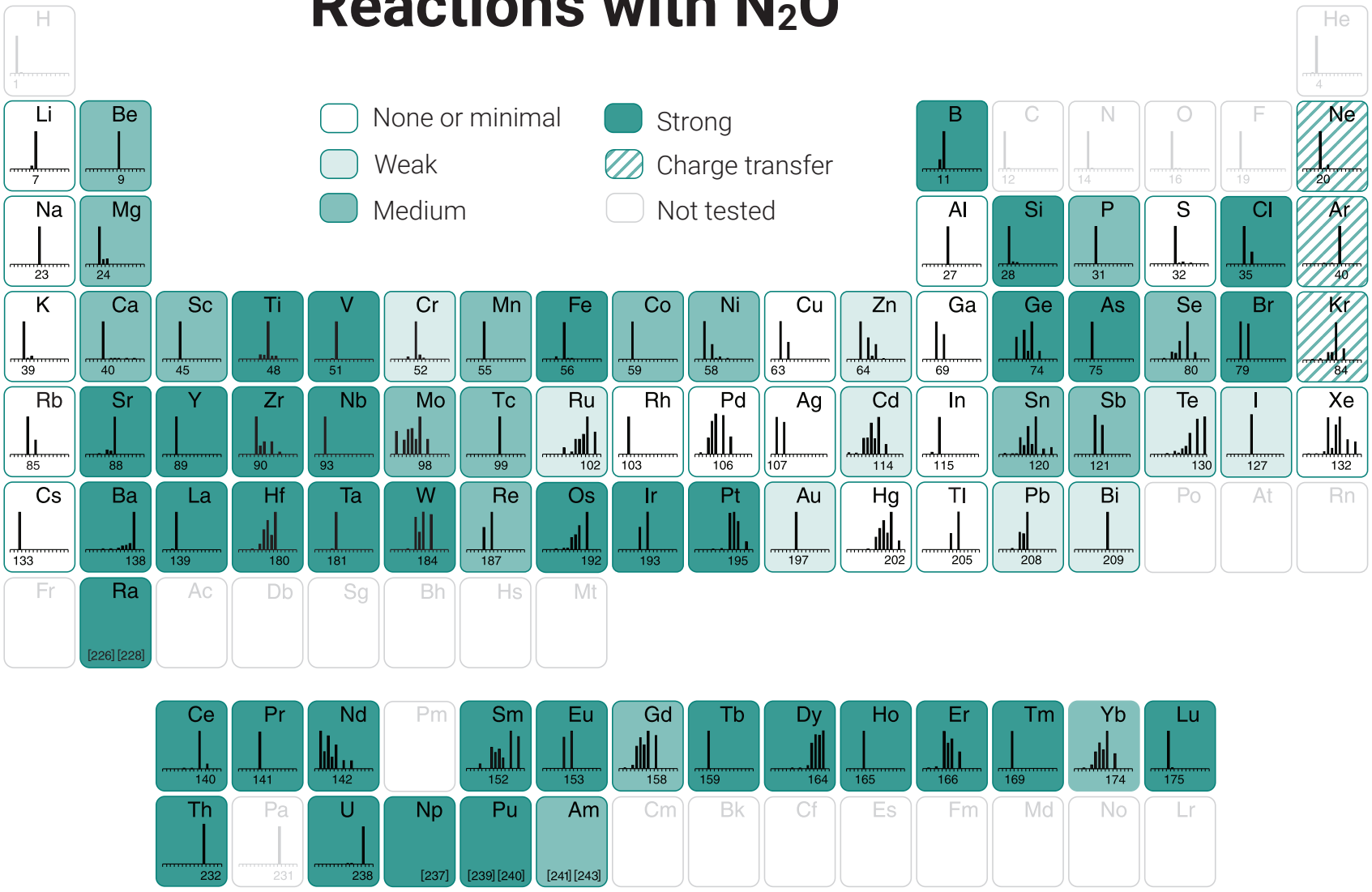
The scans shown have no analytical background and are intended only as an example to compare the different reaction patterns of a gas. Therefore, the cell conditions were neither optimized with respect to the reactivity of the analyte nor with a view to the reaction products.

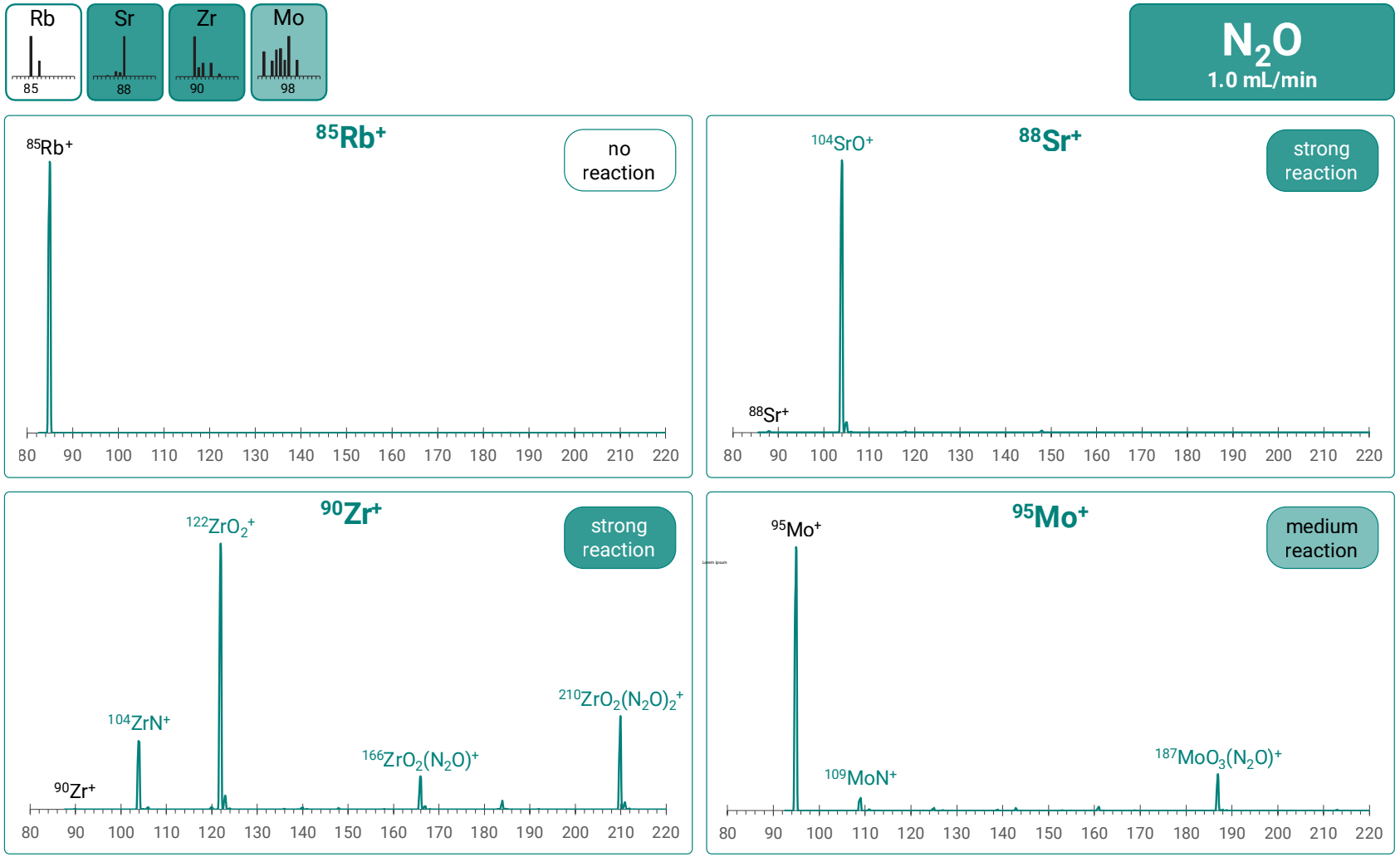
Reactions with O_2



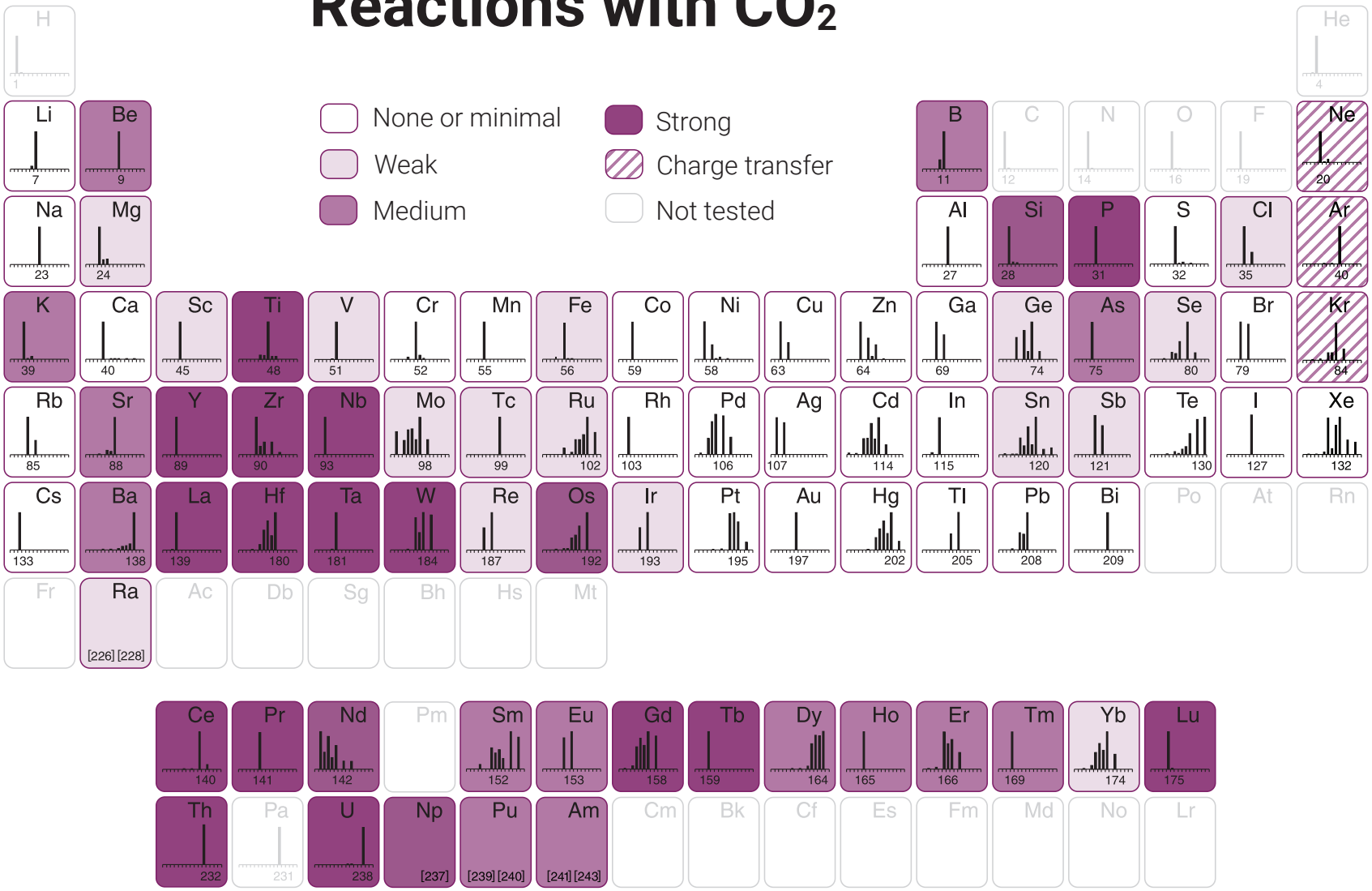

Rb
Sr
Zr
Mo
85
88
90
98
O2
1.0 mL/min
85Rb+
no reaction
85Rb+
88Sr+
weak reaction
88Sr+
104SrO+
120SrO2+
90Zr+
strong reaction
106ZrO+
122ZrO2+
90Zr+
95Mo+
strong reaction
127MoO2+
95Mo+
111MoO+
159MoO4+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220

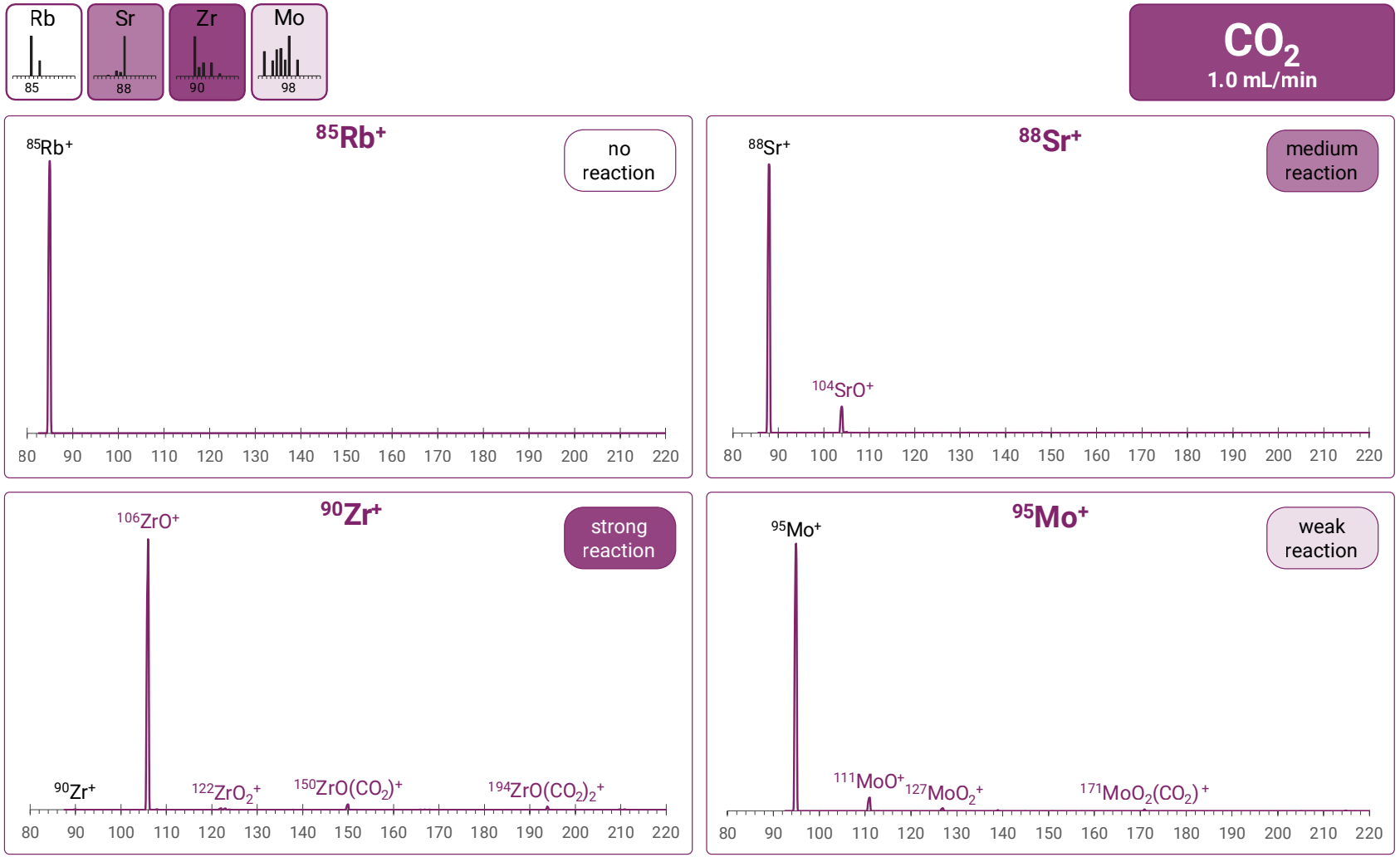
Reactions with N_2O



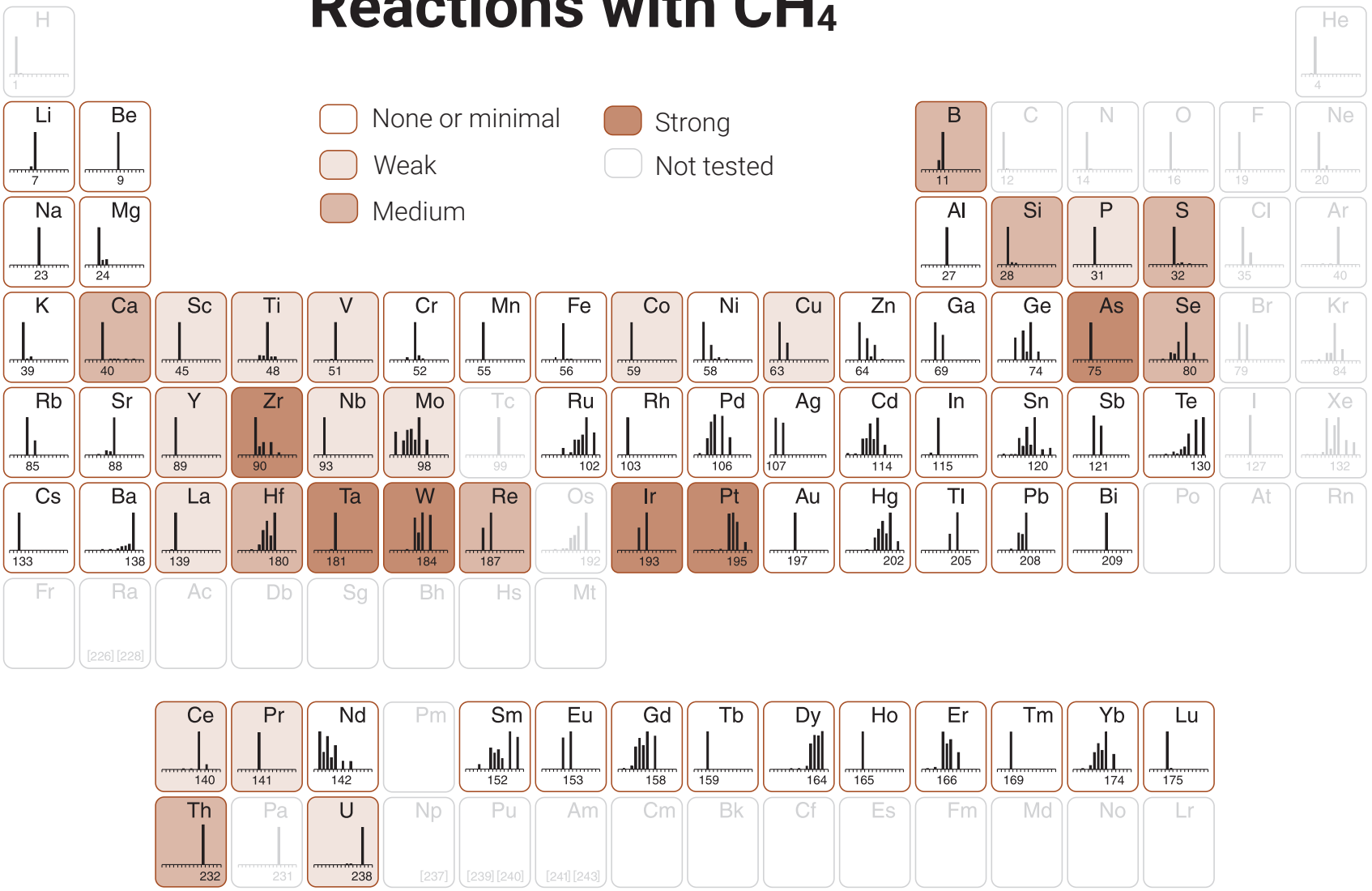

Rb
85
Sr
88
Zr
90
Mo
98
N2O
1.0 mL/min
85Rb+
no reaction
85Rb+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
88Sr+
strong reaction
104SrO+
88Sr+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
90Zr+
strong reaction
122ZrO2+
104ZrN+
166ZrO2(N2O)+
210ZrO2(N2O)2+
90Zr+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
95Mo+
medium reaction
95Mo+
109MoN+
187MoO3(N2O)+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220

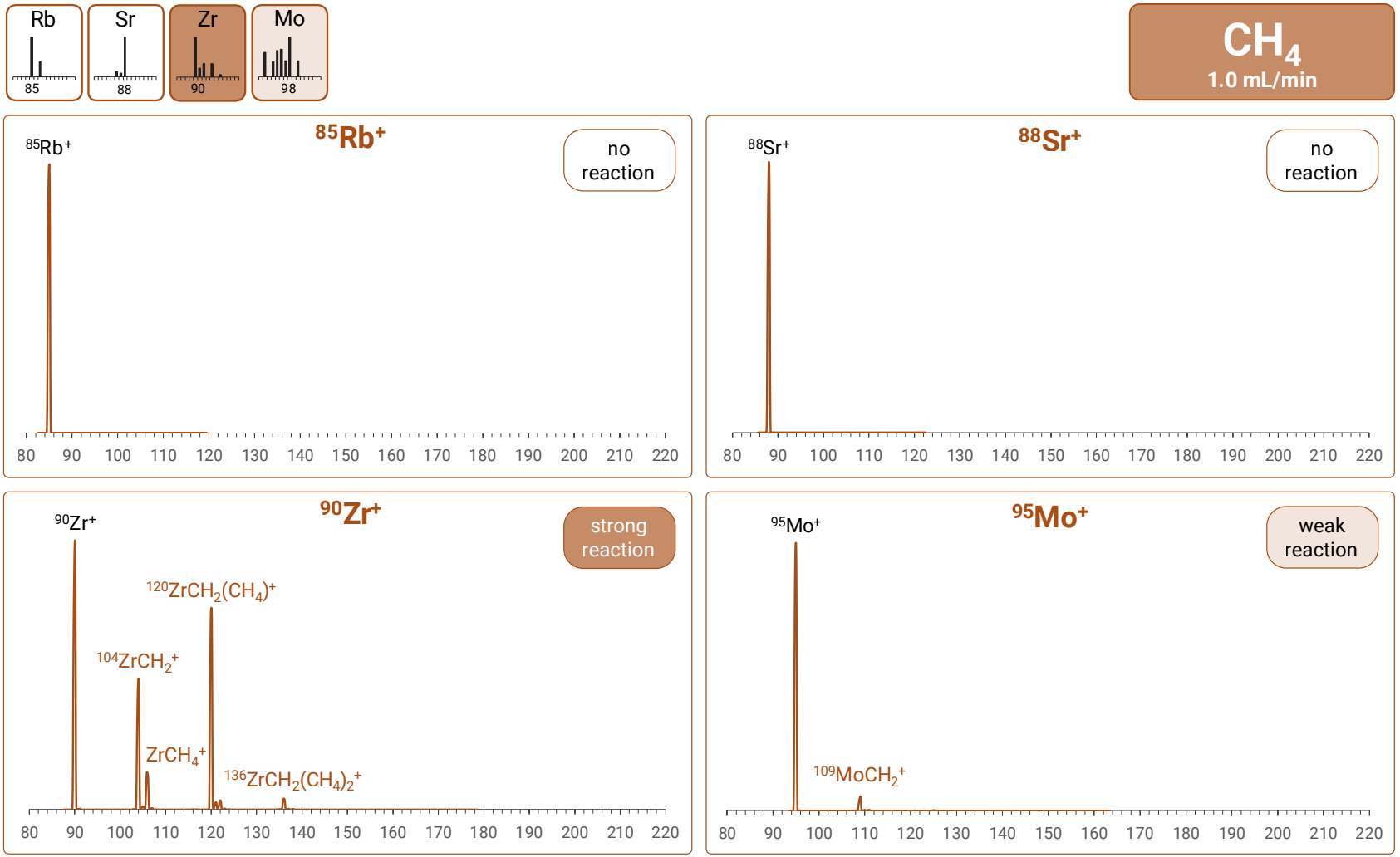
Reactions with CO_2



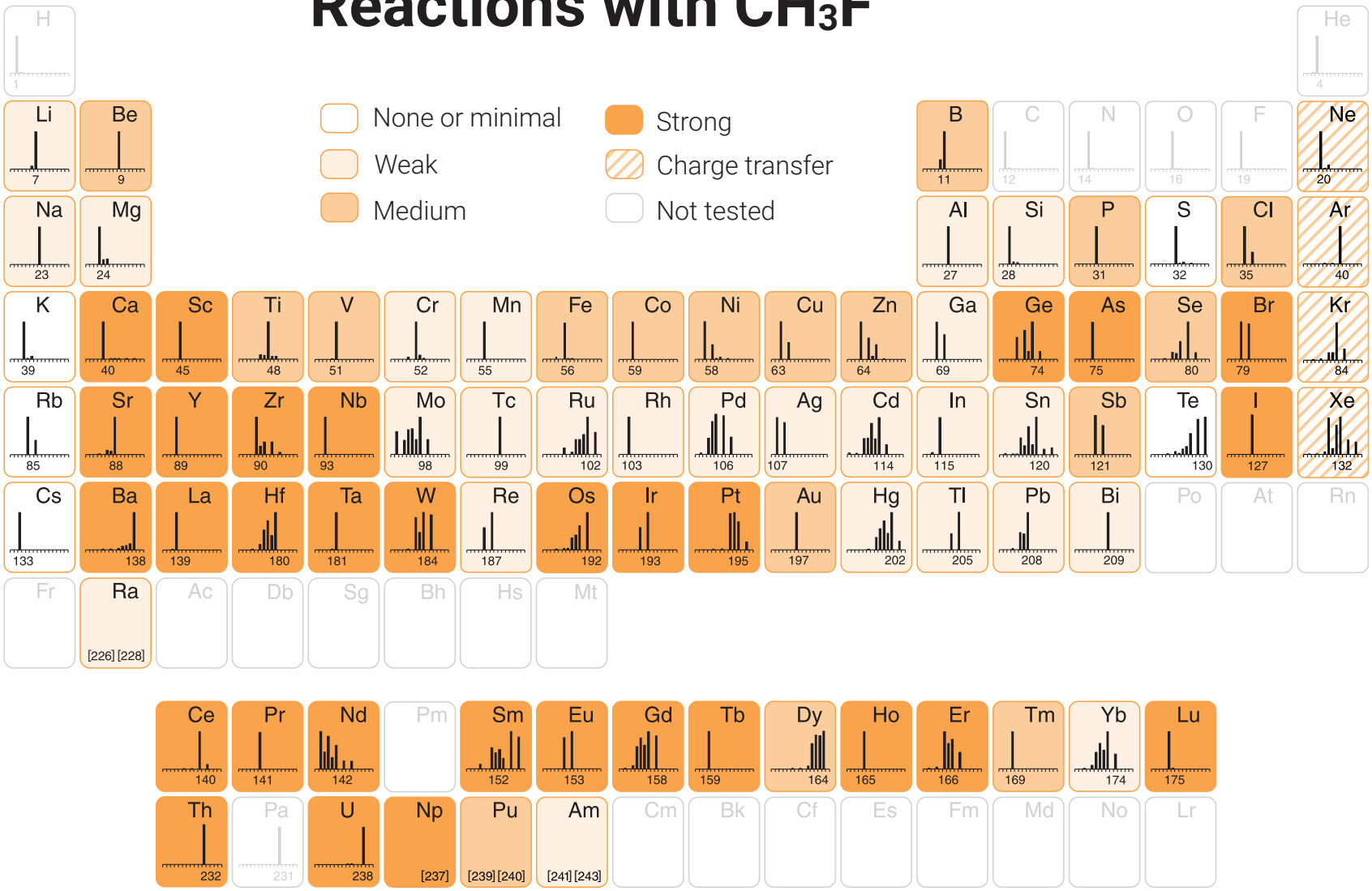

Rb
85
Sr
88
Zr
90
Mo
98
CO2
1.0 mL/min
85Rb+
no reaction
85Rb+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
88Sr+
medium reaction
88Sr+
104SrO+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
90Zr+
strong reaction
106ZrO+
90Zr+
122ZrO2+
150ZrO(CO2)+
194ZrO(CO2)2+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
95Mo+
weak reaction
95Mo+
111MoO+
127MoO2+
171MoO2(CO2)+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220

Reactions with CH_4

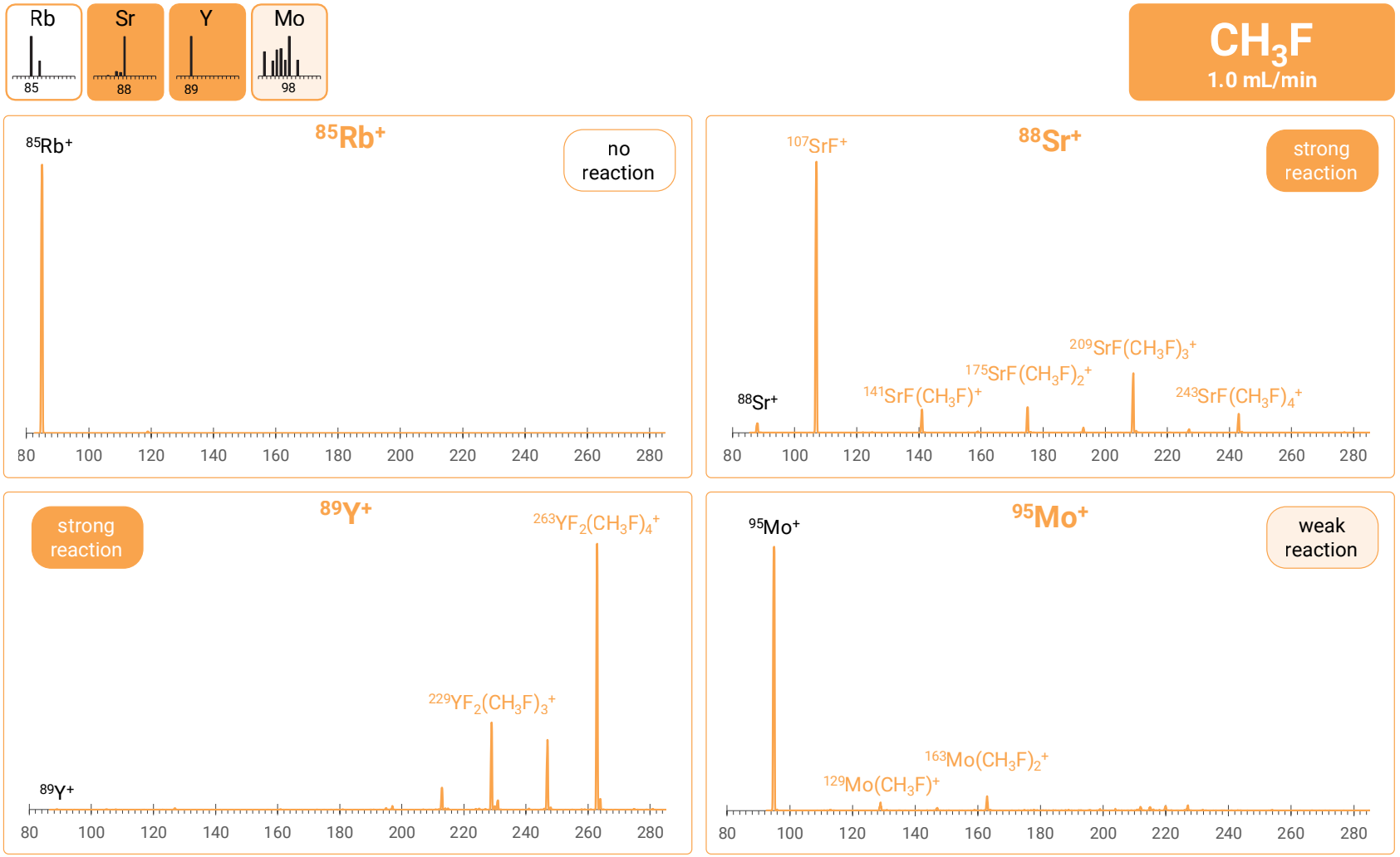



Rb
85
Sr
88
Zr
90
Mo
98
CH4
1.0 mL/min
85Rb+
no reaction
85Rb+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
88Sr+
no reaction
88Sr+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
90Zr+
strong reaction
90Zr+
120ZrCH2(CH4)+
104ZrCH2+
ZrCH4+
136ZrCH2(CH4)2+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
95Mo+
weak reaction
95Mo+
109MoCH2+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220

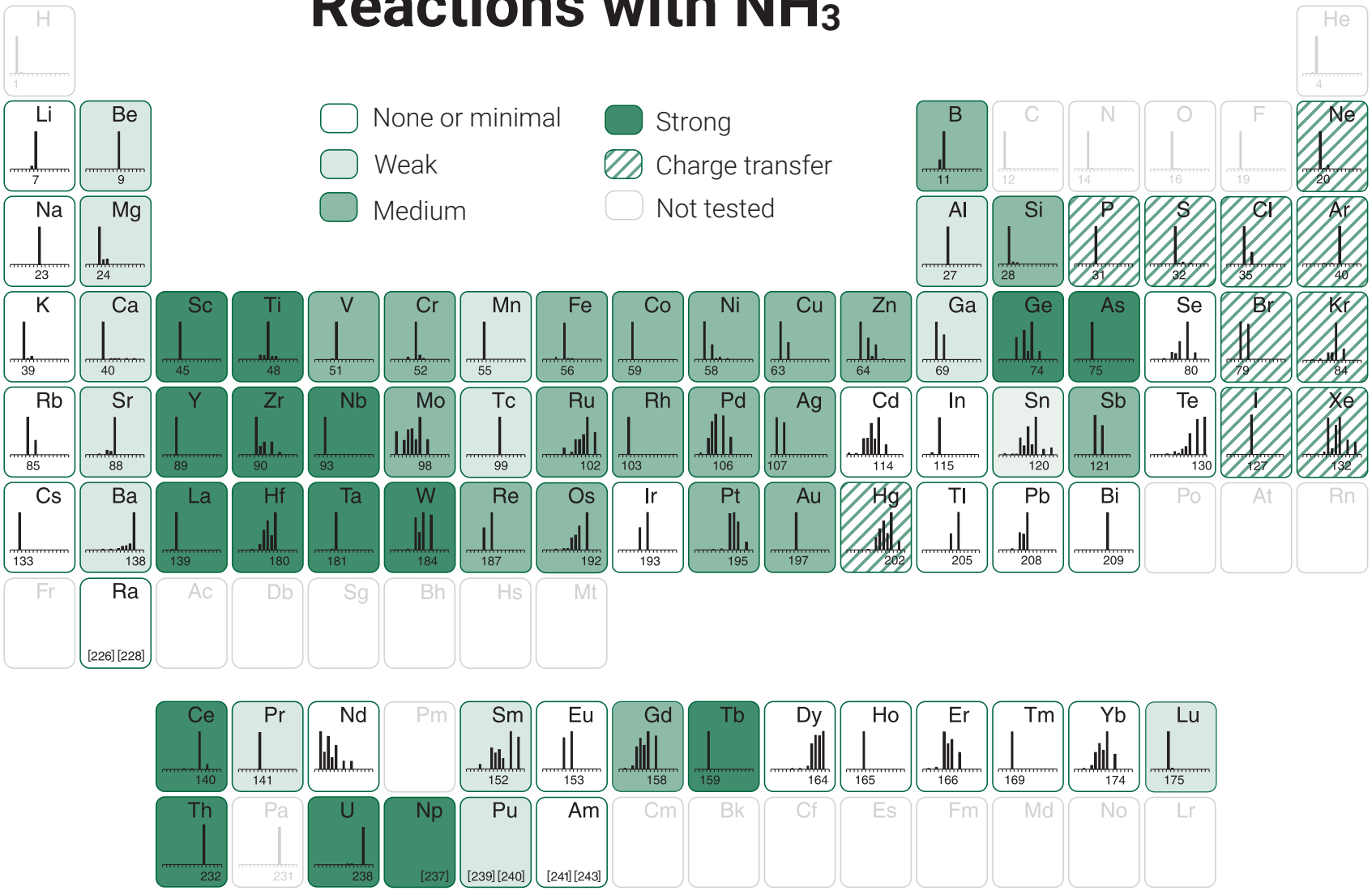
Reactions with CH_3F

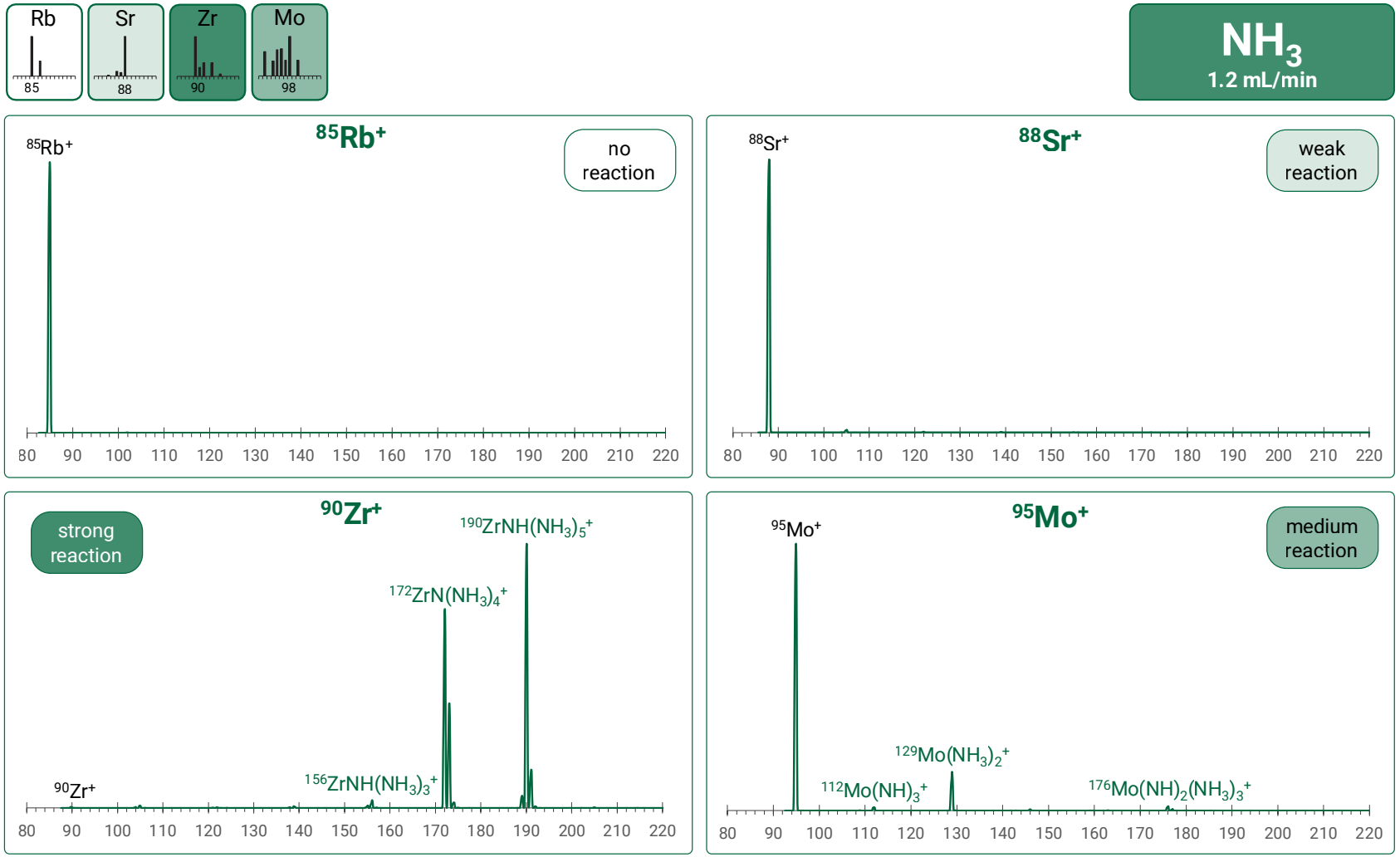


Due to its high reactivity, a low gas flow rate of CH_3F is beneficial for most elements.


Rb
85
Sr
88
Y
89
Mo
98
CH3F
1.0 mL/min
85Rb+
no reaction
85Rb+
80 100 120 140 160 180 200 220 240 260 280
88Sr+
strong reaction
107SrF+
88Sr+
141SrF(CH3F)+
175SrF(CH3F)2+
209SrF(CH3F)3+
243SrF(CH3F)4+
80 100 120 140 160 180 200 220 240 260 280
strong reaction
89Y+
263YF2(CH3F)4+
229YF2(CH3F)3+
89Y+
80 100 120 140 160 180 200 220 240 260 280
95Mo+
weak reaction
95Mo+
163Mo(CH3F)2+
129Mo(CH3F)+
80 100 120 140 160 180 200 220 240 260 280

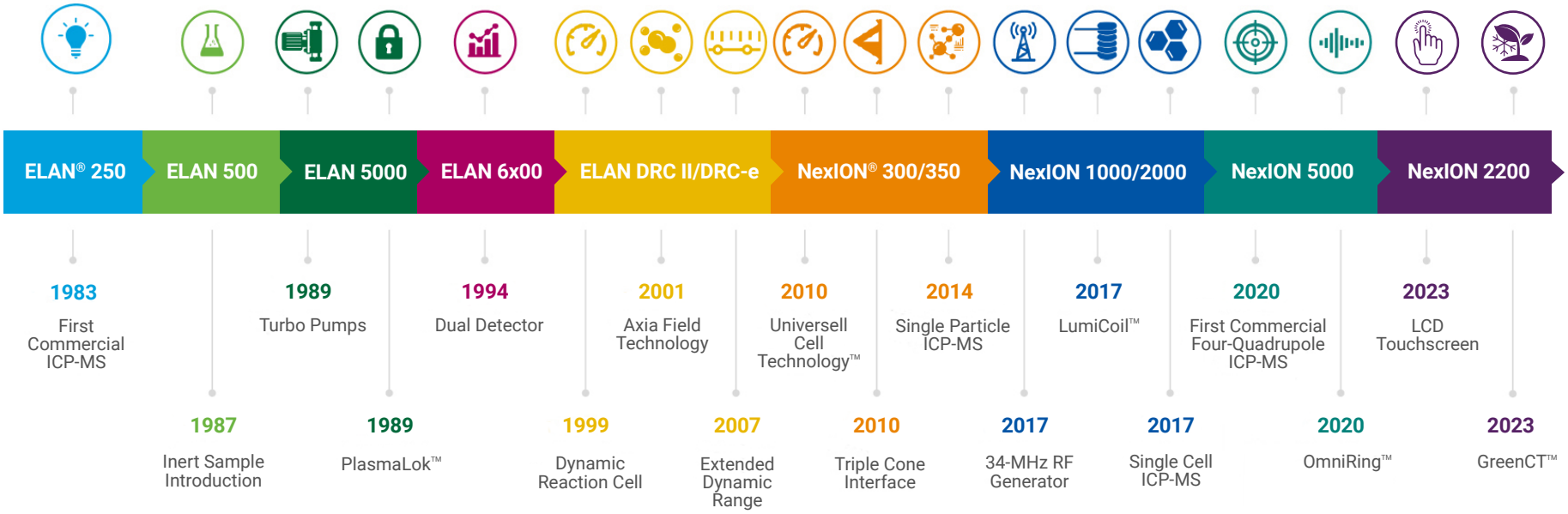
Reactions with NH_3




Rb
85
Sr
88
Zr
90
Mo
98
NH3
1.2 mL/min
85Rb+
no reaction
85Rb+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
88Sr+
weak reaction
88Sr+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
strong reaction
90Zr+
190ZrNH(NH3)5+
172ZrN(NH3)4+
90Zr+
156ZrNH(NH3)3+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
95Mo+
medium reaction
95Mo+
129Mo(NH3)2+
112Mo(NH)3+
176Mo(NH)2(NH3)3+
80 90 100 110 120 130 140 150 160 170 180 190 200 210 220

PerkinElmer and ICP-MS: A History of Innovation

From the introduction of the very first ICP-MS back in 1983 to the industry's first four-quadrupole system today, we've logged four decades of patents, innovations – and accolades.



To learn more about the unique capabilities of the NexION ICP-MS series, visit www.perkinelmer.com/nexion.

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