CLAIMS

1. A method of transmitting ions in a mass spectrometer maintained in a sub-atmospheric pressure regime, wherein the mass spectrometer has an ion source with an ion exit and a mass analyser, the method comprising:

(a) generating analyte ions in the ion source;

(b) applying extraction voltages for extracting analyte ions through the ion exit, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised and so that a number of extracted analyte ions is maximised;

(c) transmitting the extracted analyte ions through an ion guide to the mass analyser, the ion guide being filled with an interaction gas,
wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide.

~~2. The method of claim 1, wherein, in step (b), the extraction voltages and geometrical dimensions are configured so that a number of extracted analyte ions is maximised.~~

~~3. The method of claim 1, wherein in, step (b), the extraction voltages and geometrical dimensions are configured and wherein the analyte ion energy distribution width in a direction of ion travel is narrowed.~~

2. A method of transmitting ions in a mass spectrometer maintained in a sub-atmospheric pressure regime, wherein the mass spectrometer has an ion source with an ion exit and a mass analyser, the method comprising:

(a) generating analyte ions in the ion source;

(b) applying extraction voltages for extracting analyte ions through the ion exit, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised and wherein the analyte ion energy distribution width in a direction of ion travel is narrowed;

(c) transmitting the extracted analyte ions through an ion guide to the mass analyser, the ion guide being filled with an interaction gas, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide.

43. The method of claim ~~32~~, wherein the analyte ions are thermalized in the ion guide, and wherein the method further comprises exerting a driving force on the thermalized analyte ions to drive them towards the mass analyser.

~~54~~. The method of claim 43, wherein the driving force is exerted by one of a direct current electric field gradient established along an ion path in the ion guide, Coulomb repulsion from analyte ions subsequently entering the ion guide and a drag force produced by movement of the interaction gas from a point along the ion path at which the interaction gas is supplied to the ion guide.

5. A method of transmitting ions in a mass spectrometer maintained in a sub-atmospheric pressure regime, wherein the mass spectrometer has an ion source with an ion exit and a mass analyser, the method comprising:

(a) generating analyte ions in the ion source;

(b) applying extraction voltages between substantially 0 volts and 500 volts for extracting analyte ions through the ion exit, wherein the extraction voltages and

geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

(c) transmitting the extracted analyte ions through an ion guide to the mass analyser, the ion guide being filled with an interaction gas,

wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide.

6. The method of any one of claims 1 to ~~5~~4, wherein step (b) comprises applying extraction voltages between substantially 0 volts and 500 volts.

7. A method of transmitting ions in a mass spectrometer maintained in a sub-atmospheric pressure regime, wherein the mass spectrometer has an ion source with an ion exit and a mass analyser, the method comprising:

(a) generating analyte ions in the ion source;

(b) applying extraction voltages for extracting analyte ions through the ion exit, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

(c) transmitting the extracted analyte ions through an ion guide to the mass analyser, the ion guide being filled with an interaction gas,

wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide with frequencies between about 0.2 and 20 megahertz and amplitudes between substantially 0 volts and 10 kilovolts peak-to-peak, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide.

~~7~~8. The method of any one of claims 1 to 6, comprising applying operating voltages to the ion guide with frequencies between about 0.2 and 20 megahertz and amplitudes between substantially 0 volts and 10 kilovolts peak-to-peak.

9. A method of transmitting ions in a mass spectrometer maintained in a sub-atmospheric pressure regime, wherein the mass spectrometer has an ion source with an ion exit and a mass analyser, the method comprising:

(a) generating analyte ions in the ion source;

(b) applying extraction voltages for extracting analyte ions through the ion exit, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

(c) transmitting the extracted analyte ions through an ion guide to the mass analyser, the ion guide being filled with an interaction gas, wherein the interaction gas is a collision gas with molecules that have non-fragmenting collisions with the analyte ions,

wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide.

~~8~~10. The method of any one of claims 1 to ~~7~~8, wherein, in step (c), the interaction gas is a collision gas with molecules that have non-fragmenting collisions with the analyte ions.

~~9~~11. The method of any one of claims ~~8~~9 to 10, wherein the interaction gas is helium.

12. A method of transmitting ions in a mass spectrometer maintained in a sub-atmospheric pressure regime, wherein the mass spectrometer has an ion source with an ion exit and a mass analyser, the method comprising:

(a) generating analyte ions in the ion source;

(b) applying extraction voltages for extracting analyte ions through the ion exit, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

(c) transmitting the extracted analyte ions through an ion guide to the mass analyser, the ion guide being filled with an interaction gas wherein the interaction gas is a chemically reactive gas that chemically modifies the analyte ions, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide.

~~10~~13. The method of any one of claims 1 to ~~7~~8, wherein, in step (c), the interaction gas is a chemically reactive gas that chemically modifies the analyte ions.

~~11~~14. The method of claim ~~10~~13, wherein the interaction gas is one of methane and ammonia.

15. A method of transmitting ions in a mass spectrometer maintained in a sub-atmospheric pressure regime, wherein the mass spectrometer has an ion source with an ion exit and a mass analyser, the method comprising:

(a) generating analyte ions in the ion source;

(b) applying extraction voltages for extracting analyte ions through the ion exit, wherein the extraction voltages and geometrical dimensions of the ion exit are

configured so that an energy distribution width of extracted analyte ions is maximised;

(c) transmitting the extracted analyte ions through an ion guide to the mass analyser, the ion guide being filled with an interaction gas,
wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide,
wherein the pressure of the interaction gas in the ion guide reaches a maximum at a position of an inlet through which the interaction gas is supplied to the ion guide, and is reduced at other positions in the ion guide.

~~12~~16. The method of any one of claims 1 to ~~11~~14, wherein the pressure of the interaction gas in the ion guide reaches a maximum at a position of an inlet through which the interaction gas is supplied to the ion guide, and is reduced at other positions in the ion guide.

~~13~~17. The method of claim ~~12~~16, wherein the maximum pressure of the interaction gas is substantially between 10^{-1} and 10 Pascal.

18. A method of transmitting ions in a mass spectrometer maintained in a sub-atmospheric pressure regime, wherein the mass spectrometer has an ion source with an ion exit and a mass analyser, the method comprising:

(a) generating analyte ions in the ion source;

(b) applying extraction voltages for extracting analyte ions through the ion exit, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised and wherein less than ten per cent of the analyte ions are fragmented in the ion guide;

(c) transmitting the extracted analyte ions through an ion guide to the mass analyser, the ion guide being filled with an interaction gas,
wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide.

~~14~~19. The method of any one of claims 1 to ~~13~~17, wherein in, step (b), the extraction voltages and geometrical dimensions are configured and wherein less than ten per cent of the analyte ions are fragmented in the ion guide.

20. A method of transmitting ions in a mass spectrometer maintained in a sub-atmospheric pressure regime, wherein the mass spectrometer has an ion source with an ion exit and a mass analyser, the method comprising:
(a) generating analyte ions in the ion source from analyte molecules entrained in a gas supplied to the ion source from a gas chromatograph;
(b) applying extraction voltages for extracting analyte ions through the ion exit, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;
(c) transmitting the extracted analyte ions through an ion guide to the mass analyser, the ion guide being filled with an interaction gas,
wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide.

~~15~~21. The method of any one of claims 1 to ~~14~~19, wherein step (a) comprises generating the analyte ions from analyte molecules entrained in a gas supplied to the ion source from a gas chromatograph.

22. A method of transmitting ions in a mass spectrometer maintained in a sub-atmospheric pressure regime, wherein the mass spectrometer has an ion source with an ion exit and a mass analyser, the method comprising:

(a) generating analyte ions in the ion source;

(b) applying extraction voltages for extracting analyte ions through the ion exit, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

(c) transmitting the extracted analyte ions through an ion guide to the mass analyser, the ion guide being filled with an interaction gas, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide,

wherein the ion source is maintained in a first pressure area having a pressure between substantially about 10^{-4} and 1 Pascal.

~~16~~23. The method of any one of claims 1 to ~~15~~21, wherein the ion source is maintained in a first pressure area having a pressure between substantially about 10^{-4} and 1 Pascal.

~~17~~24. The method of claim ~~16~~23, wherein the ion guide and the mass analyser are located in a second pressure area having a pressure between substantially 10^{-5} and 10^{-1} Pascal.

~~18~~25. A mass spectrometer maintained in a sub-atmospheric pressure regime, comprising:

an ion source for generating analyte ions, the ion source having an ion exit through with the analyte ions are extracted via extraction voltages, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised and a number of extracted analyte ions is maximised;

a mass analyser; and

an ion guide that receives the extracted analyte ions and transmits them to the mass analyser, the ion guide being filled with an interaction gas, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide.

~~19. The mass spectrometer of claim 18, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that a number of extracted analyte ions is maximised.~~

~~20. The mass spectrometer of claim 18,wherein the extraction voltages and geometrical dimensions of the ion exit and at least one of the inner width of the ion guide, the operating voltages applied to the ion guide, the length of the ion guide, and the pressure of the interaction gas are configured such that the analyte ion energy distribution width is narrowed in a direction of ion travel.~~

26. A mass spectrometer maintained in a sub-atmospheric pressure regime, comprising:

an ion source for generating analyte ions, the ion source having an ion exit through with the analyte ions are extracted via extraction voltages, wherein the

extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

a mass analyser; and

an ion guide that receives the extracted analyte ions and transmits them to the mass analyser, the ion guide being filled with an interaction gas, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed in a direction of ion travel and the analyte ions are collimated within the ion guide.

27. A mass spectrometer maintained in a sub-atmospheric pressure regime, comprising:

an ion source for generating analyte ions, the ion source having an ion exit through with the analyte ions are extracted via extraction voltages, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

a mass analyser; and

an ion guide that receives the extracted analyte ions and transmits them to the mass analyser, the ion guide being filled with an interaction gas, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide, wherein the ion guide is a multipole ion guide.

~~21~~28. The mass spectrometer of any one of claims ~~18~~25 to ~~20~~26, wherein the ion guide is a multipole ion guide.

29. A mass spectrometer maintained in a sub-atmospheric pressure regime, comprising:

an ion source for generating analyte ions, the ion source having an ion exit through with the analyte ions are extracted via extraction voltages, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

a mass analyser; and

an ion guide that receives the extracted analyte ions and transmits them to the mass analyser, the ion guide being filled with an interaction gas, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide, wherein the ion guide is curved along a direction of ion travel.

~~22~~30. The mass spectrometer of any one of claims ~~18~~25 to ~~20~~26, wherein the ion guide is curved along a direction of ion travel.

~~23~~31. The mass spectrometer of claim ~~22~~30, wherein the ion guide is curved with an angle of curvature between substantially 30° and 180°.

32. A mass spectrometer maintained in a sub-atmospheric pressure regime, comprising:

an ion source for generating analyte ions, the ion source having an ion exit through with the analyte ions are extracted via extraction voltages, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

a mass analyser; and

an ion guide that receives the extracted analyte ions and transmits them to the mass analyser, the ion guide being filled with an interaction gas, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide, wherein the ion guide is constructed as a tube.

~~24~~33. The mass spectrometer of any one of claims ~~18~~25 to ~~23~~31, wherein the ion guide is constructed as a tube.

34. A mass spectrometer maintained in a sub-atmospheric pressure regime, comprising:

an ion source for generating analyte ions, the ion source having an ion exit through with the analyte ions are extracted via extraction voltages, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

a mass analyser comprises a primary mass filter, a fragmentation cell for collision induced dissociation, and a secondary mass filter; and

an ion guide that receives the extracted analyte ions and transmits them to the mass analyser, the ion guide being filled with an interaction gas, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide.

~~25~~35. The mass spectrometer of any one of claims ~~18~~25 to ~~24~~33, wherein the mass analyser comprises a primary mass filter, a fragmentation cell for collision induced dissociation, and a secondary mass filter.

36. A mass spectrometer maintained in a sub-atmospheric pressure regime, comprising:

an ion source for generating analyte ions, the ion source having an ion exit through with the analyte ions are extracted via extraction voltages, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

a mass analyser; and

an ion guide that receives the extracted analyte ions and transmits them to the mass analyser, the ion guide being filled with an interaction gas, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide, and wherein the portion of the ion guide through which the extracted analyte ions pass has a square cross section.

~~26~~37. The mass spectrometer of any one of claims ~~18~~25 to ~~25~~35, wherein the portion of the ion guide through which the extracted analyte ions pass has a square cross section.

~~27~~38. The mass spectrometer of claim ~~26~~37, wherein the mass analyser has an inlet with an inlet area, the ion guide has an exit area from which the extracted analyte ions exit the ion guide and wherein the exit area is smaller than the entrance area.

39. A mass spectrometer maintained in a sub-atmospheric pressure regime, comprising:

an ion source for generating analyte ions, the ion source having an ion exit through with the analyte ions are extracted via extraction voltages, wherein the

extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

a mass analyser; and

an ion guide that receives the extracted analyte ions and transmits them to the mass analyser, the ion guide being filled with an interaction gas, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide, wherein the ion guide has an entrance, an exit and an interaction gas inlet centred between the ion guide entrance and the ion guide exit.

2840. The mass spectrometer of any one of claims ~~18~~25 to ~~27~~38, wherein the ion guide has an entrance, an exit and an interaction gas inlet centred between the ion guide entrance and the ion guide exit.

41. A mass spectrometer maintained in a sub-atmospheric pressure regime, comprising:

an ion source for generating analyte ions, the ion source having an ion exit through with the analyte ions are extracted via extraction voltages, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

a mass analyser; and

an ion guide that receives the extracted analyte ions along a path having a length of substantially between 5 and 35 centimetres and transmits them to the mass analyser, the ion guide being filled with an interaction gas, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are

configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide.

~~29~~42. The mass spectrometer of any one of claims ~~18~~25 to ~~28~~40, wherein the extracted analyte ions travel through the ion guide along a path having a length of substantially between 5 and 35 centimetres.

43. A mass spectrometer maintained in a sub-atmospheric pressure regime, comprising:

an ion source for generating analyte ions, the ion source having an ion exit through with the analyte ions are extracted via extraction voltages, the ion exit has a cross sectional area of between 0.25 and 400 mm², wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

a mass analyser; and

an ion guide that receives the extracted analyte ions and transmits them to the mass analyser, the ion guide being filled with an interaction gas, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide.

~~30~~44. The mass spectrometer of any one of claims ~~18~~25 to ~~29~~42, wherein the ion exit has a cross sectional area, through which the analyte ions are extracted, of between 0.25 and 400 mm².

45. A mass spectrometer maintained in a sub-atmospheric pressure regime, comprising:

an ion source for generating analyte ions, the ion source having an ion exit through with the analyte ions are extracted via extraction voltages, the ion exit comprises a tube lens with a tube to which pull voltages are supplied, wherein the extraction voltages and geometrical dimensions of the ion exit are configured so that an energy distribution width of extracted analyte ions is maximised;

a mass analyser; and

an ion guide that receives the extracted analyte ions and transmits them to the mass analyser, the ion guide being filled with an interaction gas, wherein at least one of an inner width of the ion guide, operating voltages applied to the ion guide, a length of the ion guide, and a pressure of the interaction gas are configured so that the analyte ion energy distribution width is narrowed and the analyte ions are collimated within the ion guide.

~~31~~46. The mass spectrometer of any one of claims ~~18~~25 to ~~30~~44 wherein the ion exit comprises a tube lens with a tube to which pull voltages are supplied.

~~32~~47. The mass spectrometer of claim ~~31~~46, wherein the geometrical dimensions of the ion exit include an inner radius and rim contour of the tube.

~~33. A mass spectrometer for analysing samples contained in a continuous gas flow, comprising:~~

~~a first vacuum stage maintained in a first pressure;~~

~~an ion source in the first vacuum stage for generating analyte ions from the samples in the continuous gas flow;~~

~~a second vacuum stage adjacent to the first vacuum stage and being maintained at a second pressure;~~

~~a mass analyser in the second vacuum stage;~~

~~a multipole ion guide located in the second vacuum stage that receives ions from the ion source and transmits the received ions to the mass analyser, the ion guide being filled with an interaction gas that interacts with the analyte ions as they are transmitted to the mass analyser.~~