

Activity 5: Ions and the Periodic Table

Why?

- ★ Ions, like atoms, may also be identified by the numbers of protons, neutrons and electrons they contain.
- ★ Ions are particularly important in the formation of “ionic compounds”.
- ★ By understanding the types of ions formed by the elements, it is possible to predict the correct chemical formulas of ionic compounds.

Learning Objectives

- ✓ Be able to identify an element as a metal, nonmetal, or semimetal based on its position in the periodic table
- ✓ Predict the type of ion an element will form
- ✓ Identify the numbers of protons, neutrons, and electrons in an ion

Concepts and vocabulary

- Anion
- Cation
- Metal, nonmetal, semimetal

| 1 H 1.00 | | | | | | | | | | | | | | | | | 2 He 4.00 |
|---|------------------|-----------------------|-------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| ← IA | | | | | | | | | | | | | | | | | VIIIA → |
| | Alkali Metals | Alkaline Earth Metals | Transition Metals | | | | | | | | | | Other Metals | Non-Metals | Halogens | Inert Gases | |
| | | | Lanthanide | | | | | | | | | | | | | | |
| | | | Actinide | | | | | | | | | | | | | | |
| Columns = Groups I – VIII = Number of e ⁻ in Outer Shell | | | | | | | | | | | | | | | | | |
| Rows = Periods 1-7 = Outer Shell Number | | | | | | | | | | | | | | | | | |
| | | III A | IV A | V A | VII A | VII B | VIII B | | | | | | IB | II B | | | |
| 3 Li 6.94 | 4 Be 9.01 | | | | | | | | | | | | | | | | |
| 11 Na 22.9 | 12 Mg 24.3 | | | | | | | | | | | | | | | | |
| 19 K 39.1 | 20 Ca 40.1 | 21 Sc 44.9 | 22 Ti 47.9 | 23 V 50.9 | 24 Cr 52.0 | 25 Mn 54.9 | 26 Fe 55.8 | 27 Co 58.9 | 28 Ni 58.6 | 29 Cu 63.5 | 30 Zn 65.3 | 31 Ga 69.7 | 32 Ge 72.6 | 33 As 74.9 | 34 Se 79.0 | 35 Br 79.9 | 36 Kr 83.8 |
| 37 Ru 85.5 | 38 Sr 87.6 | 39 Y 88.9 | 40 Zr 91.2 | 41 Nb 92.9 | 42 Mo 96.0 | 43 Tc 98 | 44 Ru 101 | 45 Rh 102 | 46 Pd 106 | 47 Ag 108 | 48 Cd 112 | 49 In 115 | 50 Sn 119 | 51 Sb 122 | 52 Te 128 | 53 I 127 | 54 Xe 131 |
| 55 Cs 132 | 56 Ba 137 | 57 La 139 | 72 Hf 178 | 73 Ta 181 | 74 W 184 | 75 Re 186 | 76 Os 190 | 77 Ir 192 | 78 Pt 195 | 79 Au 197 | 80 Hg 200 | 81 Tl 204 | 82 Pb 207 | 83 Bi 210 | 84 Po 209 | 85 At 210 | 86 Rn 222 |
| 87 Fr 223 | 88 Ra 226 | 89 Ac 227 | 104 Rf 267 | 105 Db 268 | 106 Sg 271 | 107 Bh 272 | 108 Hs 270 | 109 Mt 276 | 110 Ds 281 | 111 Rg 280 | | | | | | | |
| | | | 58 Ce 140 | 59 Pr 141 | 60 Nd 144 | 61 Pm 145 | 62 Sm 150 | 63 Eu 152 | 64 Gd 157 | 65 Tb 159 | 66 Dy 162 | 67 Ho 165 | 68 Er 167 | 69 Tm 169 | 70 Yb 173 | 71 Lu 175 | |
| | | | 90 Th 232 | 91 Pa 231 | 92 U 238 | 93 Np 237 | 94 Pu 244 | 95 Am 243 | 96 Cm 247 | 97 Bk 247 | 98 Cf 251 | 99 Es 252 | 100 Fm 257 | 101 Md 258 | 102 No 259 | 103 Lr 262 | |

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Part 1. Introduction to the periodic table

Please use the periodic table on the first sheet, or in your chemistry book to answer these questions.

1. In some periodic tables, the atomic symbols are represented a little differently than in the exercise we have just completed. For example, your text represents sodium as:

11
Na
22.989770

Which number is the atomic number (Z)? The atomic mass?

2. Using your periodic table, how can you be certain that you always pick the "right" number for the atomic number? Come up with a rule to help you distinguish which of the two numbers with the symbols of the elements is the atomic number.

3. Neutrons don't exist as fractions, yet for sodium, the difference between the atomic mass and the atomic number is 11.989770. Why do you think the atomic mass is NOT a whole number in the periodic table, and how can you calculate the number of neutrons in an element from these decimal atomic weights? (We'll learn how these weights are determined shortly.)

KEEP GOING!

4. What do the colors in the periodic table tell you about the elements?

5. Which type of element is most abundant: metals, nonmetals, or semimetals (metalloids)?

6. What are characteristics that you associate with metals? (Just write down what you know from life experience.)

7. As well as colors, there are other classifications for the elements in the periodic table. What are they?

YOU'RE NOT DONE YET... THERE IS MORE CHEMISTRY FUN TO COME...

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Part 2. Ions

Model: Ions of several elements, P = protons, N = neutrons, e^- = electrons

The diagrams below show atoms and ions formed by several elements.

Cations

| Atom | Configuration | Corresponding Ion | Configuration |
|------|--------------------|-------------------|--------------------|
| Na | 11P, 12N, 11 e^- | Na ⁺ | 11P, 12N, 10 e^- |
| K | 19P, 20N, 19 e^- | K ⁺ | 19P, 20N, 18 e^- |
| Ca | 20P, 20N, 20 e^- | Ca ⁺² | 20P, 20N, 18 e^- |
| Mg | 12P, 12N, 12 e^- | Mg ⁺² | 12P, 12N, 10 e^- |
| Al | 13P, 14N, 13 e^- | Al ⁺³ | 13P, 14N, 10 e^- |
| Fe | 26P, 30N, 26 e^- | Fe ⁺² | 26P, 30N, 24 e^- |
| | | Fe ⁺³ | 26P, 30N, 23 e^- |
| Cr | 24P, 28N, 24 e^- | Cr ⁺³ | 24P, 28N, 21 e^- |
| | | Cr ⁺⁶ | 24P, 28N, 18 e^- |
| Mn | 25P, 30N, 25 e^- | Mn ⁺² | 25P, 30N, 23 e^- |
| | | Mn ⁺⁴ | 25P, 30N, 21 e^- |
| | | Mn ⁺⁷ | 25P, 30N, 18 e^- |

Anions

| Atom | Configuration | Corresponding Ion | Configuration |
|------|--------------------|-------------------|--------------------|
| F | 9P, 10N, 9 e^- | F ⁻ | 9P, 10N, 10 e^- |
| O | 8P, 8N, 8 e^- | O ⁻² | 8P, 8N, 10 e^- |
| N | 7P, 7N, 7 e^- | N ⁻³ | 7P, 7N, 10 e^- |
| Cl | 17P, 18N, 17 e^- | Cl ⁻ | 17P, 18N, 18 e^- |
| S | 16P, 16N, 16 e^- | S ⁻² | 16P, 16N, 18 e^- |
| P | 15P, 16N, 15 e^- | P ⁻³ | 15P, 16N, 18 e^- |

DON'T GIVE UP YET...

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Key questions:

1. What is the difference between the sodium atom and the sodium ion? The magnesium atom and the magnesium ion? The oxygen atom and the oxygen ion?

2. How is the charge on the ion determined? Where is the charge written with the elemental symbols?

3. What type of charge do metal atoms have in their ionic form? What are these ions called?

4. What type of charge do nonmetals have in their ionic form? What are these ions called?

YOU'RE ALMOST THERE...

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5. What would you predict the charge of Cs will be in its ionic form? What would you predict for the charge on Ba as an ion? What about In? Devise a rule summarizing your predictions.

6. What would you predict the charge of I will be in its ionic form? What would you predict for the charge on Se as an ion? Devise a rule summarizing your predictions (this is harder than for the metals).

7. What do you notice about the ions formed by Fe? Cr? Mn? Where are they located in the periodic table? How can you predict what charges ion in this section will form?

ONE MORE PAGE TO GO!!

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8. Complete the following table:

| Symbol | Protons | Neutrons | Electrons |
|-------------------------------|---------|----------|-----------|
| ${}_{37}^{86}\text{Rb}^{+1}$ | | | |
| ${}_{56}^{137}\text{Ba}^{+2}$ | | | |
| ${}_{34}^{79}\text{Se}^{-2}$ | | | |
| | 53 | | 54 |
| | 15 | | 18 |
| | 15 | | 15 |
| ${}_{27}^{59}\text{Co}^{+2}$ | | | |
| ${}_{47}^{108}\text{Ag}^{+1}$ | | | |
| | 38 | | 36 |

THE END!

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