

## Chapter 4

### THE PERIODIC TABLE

#### Periodic Table

- Is an arrangement of the chemical elements, organized on the basis of their atomic numbers, electron configurations and recurring chemical properties.

#### Elements

- Are presented in order of increasing atomic number.
- The standard form of the table consists of a grid of elements, with rows called **periods** and columns called **groups**.

#### THE IMPORTANCE OF A PERIODIC TABLE

- Provides useful information that, directly or indirectly, affects everyone.
- Provides a useful framework for analyzing chemical behavior, and so the tables, in various forms, are widely used in chemistry and other sciences.

#### Standard form of Periodic Table

- Consists of a grid of elements laid out in 18 columns and 7 rows, with double row of elements below that.
- The table can also be deconstructed into four rectangular blocks: **the s- block** to the left, **the p- block** to the right, **the d- block** in the middle, and the **f- block** below that.

#### THE CATEGORIES IN THE PERIODIC TABLE

Groups 1 and 2 (Alkali metals and Alkaline earth metals): These are highly reactive metals that readily lose electrons to form **positive ions**. They are located on the left side of the periodic table.

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Examples:

Monatomic cations. (A **monatomic cation** is an ion that consists of only one atom and has a positive charge. This means it has lost one or more electrons, becoming positively charged compared to its neutral state.)

- Alkali metals:  $\text{Li}^+$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Rb}^+$ ,  $\text{Cs}^+$
- Alkaline earth metals:  $\text{Be}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Ba}^{2+}$
- Transition metals:  $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Cu}^+$ ,  $\text{Zn}^{2+}$
- Post-transition metals:  $\text{Al}^{3+}$ ,  $\text{Sn}^{2+}$ ,  $\text{Pb}^{2+}$

Polyatomic cations: (A **polyatomic cation**, also known as a molecular ion, is a group of atoms covalently bonded together that carries a net positive charge. This means the total number of protons in the molecule is greater than the total number of electrons.

- Ammonium ( $\text{NH}_4^+$ ): Formed by the addition of a proton ( $\text{H}^+$ ) to ammonia ( $\text{NH}_3$ )
- Hydronium ( $\text{H}_3\text{O}^+$ ): Formed by the addition of a proton to water ( $\text{H}_2\text{O}$ )
- Oxonium ( $\text{H}_3\text{O}^+$ ): Another name for hydronium

- Mercuronium (Hg<sub>2</sub><sup>+</sup>): Formed by the combination of two Hg atoms

Other examples:

- Sodium ions (Na<sup>+</sup>): Found in table salt (NaCl) and important for nerve function
- Potassium ions (K<sup>+</sup>): Important for muscle function
- Calcium ions (Ca<sup>2+</sup>): Important for bone health and muscle contraction
- Hydrogen ions (H<sup>+</sup>): Found in acids and important for many chemical reactions
- Magnesium ions (Mg<sup>2+</sup>): Important for enzyme function

Groups 3-12 (Transition metals): These metals are characterized by their ability to form multiple oxidation states. They are located in the center of the periodic table.

Groups 13-15 (Post-transition metals): These elements have properties that are intermediate between metals and nonmetals. They are located on the right side of the periodic table.

Group 16 (Chalcogens): These elements are nonmetals that typically form oxides and sulfides.

Group 17 (Halogens): These are highly reactive nonmetals that readily gain electrons to form negative ions.

Group 18 (Noble gases): These are nonreactive gases that have stable electron configurations

Periodic table of the elements

																		18						
period	group 1*																	2						
	1																	He						
	2																	Ne						
	3																	Ar						
	4																	Kr						
	5																	Xe						
	6																	Rn						
7																	Og							

Alkali metals	Halogens
Alkaline-earth metals	Noble gases
Transition metals	Rare-earth elements (21, 39, 57–71) and lanthanoid elements (57–71 only)
Other metals	Actinoid elements
Other nonmetals	

1	2											13	14	15	16	17	18
H												B	C	N	O	F	He
3	4											5	6	7	8	9	10
Li	Be											Al	Si	P	S	Cl	Ne
11	12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
87	88	89	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og

lanthanoid series 6	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
actinoid series 7	90	91	92	93	94	95	96	97	98	99	100	101	102	103
	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

\*Numbering system adopted by the International Union of Pure and Applied Chemistry (IUPAC). © Encyclopædia Britannica, Inc.

## RUSSIAN CHEMIST DMITRI MENDELEEV (1869 published)

- First scientist to make a periodic table similar to the one used today.
- Arranged the elements by atomic mass, corresponding to relative molar mass.

## CHARACTERISTICS AND DESCRIPTION OF THE METALS

### 1. Copper

- Is a reddish metal with a face- centered cubic crystalline structure. It reflects red and orange light and absorbs other frequencies in the visible spectrum, due to its band structure. It is malleable, ductile, and an extremely good conductor of both heat and electricity. Copper has chemical low reactivity.



### 2. Cobalt

- Is a hard ferromagnetic, silver- white, hard, lustrous, brittle element. It is stable in air and unaffected by water, but is slowly attacked by dilute acids.



### 3. Chromium

- Is a lustrous, brittle, hard metal. Its color is silver-gray and it can be highly polished. Chromium is unstable in oxygen, it immediately produces a thin layer that is impermeable to oxygen and protects the metal below.



### 4. Cesium

- Is silvery gold, soft, and ductile. It is the most electropositive and most alkaline element. Cesium , gallium, and mercury are the only three metals that are liquid at or room temperature. It reacts explosively with cold water, and reacts with ice at temperatures above – 116° C. it reacts with the halogens to form a fluoride, chloride, bromide, and iodide.



### 5. Calcium

- Ions solved in water form deposits in pipes and boilers and when the water is hard, that is, when it contains too much calcium or magnesium.



## 6. Cadmium

- Is a lustrous, silver- white, ductile, very malleable metal. Its surface has a bluish tinge and the metal is soft enough to be cut with a knife, but it tarnish in air.it is soluble in acids but not in alkalis. It is similar in many respects to zinc but it forms more complex compounds.



## 7. Bohrium

- Is a artificial produced radioactive element. It is probably silvery or metallic gray. Bohrium does not have any known application little is known about it.



## 8. Bismuth

- White, crystalline, brittle metal with a pinkish tinge. Is the most diamagnetic of all metals, and the thermal conductivity is lower than any metal except mercury. It has a high electrical resistance. Bismuth is stable to oxygen and water but dissolves in concentrated nitric air.



## 9. Beryllium

- Is a toxic bivalent element, steel gray , strong, light-weight, primarily used as hardening agent in alloys. It has one of the highest melting points of the light metals. It has excellent thermal conductivity, is nonmagnetic, it resist attack by concentrated nitric acid and at standard temperature and pressures beryllium resist oxidation when expose to air.



#### 10. Barium

- Is a silvery-white metal that can be found in the environment, where it exists naturally. It occurs combined with other chemicals, such as sulfur, carbon or oxygen. It is very light and its density is half that of iron. Barium oxidizes in air, reacts vigorously with water to form the hydroxide, liberating hydrogen. It reacts with almost all the non- metals, forming often poisoning compounds.



#### 11. Aluminum

- Is a soft and lightweight metal. It has a dull silvery appearance, because of a thin layer of oxidation that forms quickly when it is exposed to air. Aluminum is nontoxic, nonmagnetic and non- sparking.



#### 12. Actinium

- Is a silvery radioactive metallic element. Actinium glows in the dark due to its intense radioactivity with a blue light. It is about 150 tons times as radioactive as radium, making it valuable as a neutron source.



#### 13. Darmstadtium

- Is a synthetic element in the periodic table which quickly decays. It does not have known application and little is known about it.





#### 14. Dubnium

- Has the atomic weight of nine known isotopes range from 255 to 263; the longest – lived isotope, dubnium 268 has a half- life of 32 hours. It does not have any application and little is known about it.



#### 15. Francium

- Is extremely rare. It is the least electronegative of all the known elements. No use has been found for what little francium can be produced.



#### 16. Gallium

- Is solid at normal room temperatures, but as well as mercury, cesium, and rubidium it becomes liquid when heated slightly. It is stable in air and water; but it reacts with and dissolves in acids and alkali.



#### 17. Gold

- Is metallic, with a yellow color when in a mass, but when finely divided it may be black, ruby, or purple. It is the most malleable and ductile metal and is a soft metal and is usually alloyed to give it more strength it is a good conductor of heat and electricity, and is unaffected by air and most reagents.



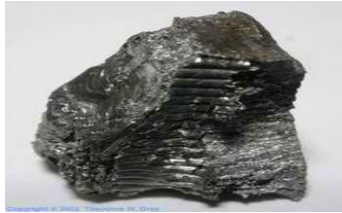
#### 18. Hafnium

- Is a lustrous, silvery, ductile metal. It resists corrosion due to formation of a tough, impenetrable oxide film on its surface.



### 19. Hassium

- Is a synthetic chemical element, expected to have chemical properties similar to those of Osmium and a silvery white or metallic gray color. Hassium does not have any known application and little is known about it.



### 20. Indium

- Is a soft, ductile, malleable, lustrous metallic metal. Its color is silvery white and it has a face- centered tetragonal structure. Indium is stable in air and in water but dissolves in acids.



### 21. Iridium

- Is a hard, brittle, lustrous, dense, transition metal of the platinum family.



### 22. Iron

- Is a lustrous, ductile, malleable, silver- gray metal. Iron rusts in a damp air, but not in dry air. It dissolves readily in dilute acids. Iron is chemically active and forms two major series of chemical compounds, the bivalent iron (II), or ferrous, compounds and the trivalent iron (III), or ferric, compounds.



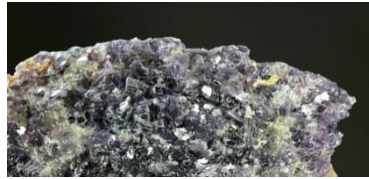
### 23. Lead

- Is a bluish- white lustrous metal. It is soft, highly malleable, ductile, and a relatively poor conductor of electricity. It is very resistant to corrosion but tarnishes upon exposure to air. Lead is a major constituent of the lead-acid battery used extensively in car batteries.



#### 24. Lithium

- Is the first of the alkali in the periodic table. It's the lightest solid metal, it's soft, silvery-white, with a low melting point and reactive. It reacts easily with oxygen to form monoxide and peroxide. It reacts easily with hydrogen at almost  $500^{\circ}\text{C}$  (  $930^{\circ}\text{F}$  ) to form lithium hydride.



#### 25. Magnesium

- Is silvery white and very light. It is known for a long time as the lighter structural metal in the industry, due to its low weight and to its capability of forming mechanically resistant alloys. Magnesium is very chemically active, it takes the place of hydrogen in boiling water and a great number of metals can be produced by thermic reduction of its salts and oxidized forms with magnesium.



#### 26. Manganese

- Is a pinkish- gray, chemically active element. It is a hard metal and is very brittle. It is hard to melt, but easily oxidized. It is reactive when pure, and as a powder it will burn in oxygen, it reacts with water and dissolves in dilute acids.



#### 27. Meitnerium

- Is an artificially produced radioactive element. It does not have any known application and little is known about it.



#### 28. Mercury

- Is the only common metal which is liquid at ordinary temperatures. It is sometimes called quicksilver. It is a heavy, silvery- white liquid metal. It is rather poor conductor of heat if compared with other metals but it is fair conductor of electricity.





### 29. Molybdenum

- Is a silvery white, very hard transition metal, but is softer and more ductile than tungsten. It was often confused with graphite and lead ore. It has a high elastic modulus, and only tungsten and tantalum, of the more readily available metals, have higher melting points. It is attacked slowly by acids.



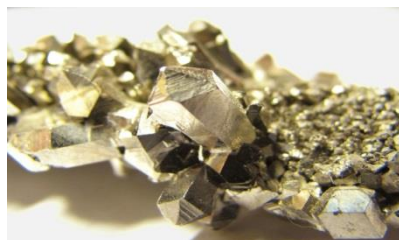
### 30. Nickel

- Is silvery-white, hard, malleable, and ductile metal. It is of the iron group and it takes on high polish. It is fairly good conductor of heat and electricity. Nickel dissolves slowly in dilute acids but, like iron, becomes passive when treated with nitric acid.



### 31. Niobium

- Is a rare, soft, malleable, ductile, gray-white metal. It has a body-centered cubic crystalline structure and in its physical and chemical properties it resembles tantalum. It must be placed in a protective atmosphere when processed at even moderate temperatures because it tends to react with oxygen, carbon, the halogens, nitrogen, and sulfur.



### 32. Osmium

- Is lustrous, silvery metal, one of the so-called platinum groups of metals. It is the densest metal known, although only by the narrowest margins. It is not affected by water and acids, but dissolves with molten alkalis. Its powder reacts slowly with the oxygen of the air and gives off detectable amounts of osmium tetroxide vapor.



### 33. Palladium

- Is a lustrous silver-white metal. It has face-centered cubic crystalline structure, at ordinary temperatures it is strongly resistant to corrosion in air and to the action of acids. It is attacked by hot acids, and it dissolves in aqua regia. It forms many compounds and several complex salts. It has a great ability to absorb hydrogen (up to 900 times its own volume)



### 34. Platinum

- Is a lustrous silvery-white, malleable, ductile metal and a member of group 10 of the periodic table of the elements. It has the third highest density, behind osmium and iridium. Platinum is unaffected by air and water, but will dissolve in hot aqua regia, in hot concentrated phosphoric and sulfuric acids, and in molten alkali.



### 35. Potassium

- Is a soft, silvery-white metal, member of the alkali group of the periodic chart. Potassium is silvery when first cut but it oxidizes rapidly in air and tarnishes within minutes, so it is generally stored under oil or grease. It is light enough to float in water with which it reacts instantly to release hydrogen, which burns with a lilac flame.



### 36. Radium

- Is silvery, lustrous, soft, and intensely radioactive. It readily oxidizes on exposure to air, turning from almost pure white to black. Radium is luminescent, corrodes in water to form radium hydroxide.



### 37. Rhenium

- Is a silvery metal but rarely seen as such on account of its high melting point, which is the third highest after carbon and tungsten. It is very hard, it resists corrosion but slowly tarnishes in moist air.



### 38. Rhodium

- Is lustrous and silvery white. It has a higher melting point, and lower density than platinum. It has a high reflectance and is hard and durable. Rhodium it is unaffected by air and water up to 600 C. it is insoluble in most acids, including aqua regia, but is dissolved in hot concentrated sulfuric acid and it is attacked by molten alkalis.



### 39. Rubidium

- Is a soft, silvery- white metallic element of the alkali metals group. it is one of the most electropositive and alkali elements. It can be liquid at ambient temperature, but only on a hot day given that its melting point is about 40°C. it ignites spontaneously in air and reacts violently with water and even with ice at – 100 C, setting fire to the liberated hydrogen. Rubidium salts are used in glasses and ceramics and in fireworks to give them a purple color.



### 40. Ruthenium

- Is a hard, white metal. It does not tarnish at room temperatures, but oxidizes in air about 800°C. it dissolved in molten alkalis.



#### 41. Rutherfordium

- Is a highly radioactive chemical element. It does not have any application and little is known about it.



#### 42. Scandium

- Is a soft, silvery transition element which occurs in rare minerals from Scandinavia. It develops a slightly yellowish or pinkish cast when exposed to air. It tarnishes in air and burns easily, once it has been ignited. It reacts with water to form hydrogen gas and will dissolve in many acids.



#### 43. Seaborgium

- Is an artificially produced radioactive chemical element, its appearance is unknown, and it probably has a silvery white or metallic gray color, it does not have any known application and little is known about it.



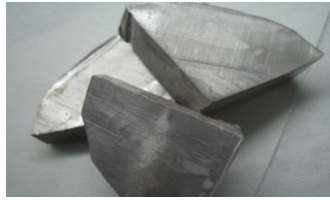
#### 44. Silver

- Is nearly white, lustrous, soft, very ductile, and malleable. It is an excellent conductor of heat and electricity. It is not chemically active metal, but it is attacked by nitric acid and by hot concentrated sulfuric acid. It has the highest electrical conductivity of all metals, but its greater cost has prevented it from being widely used for electrical purposes.



#### 45. Sodium

- Reacts quickly with water, and also with snow and ice, to produce sodium hydroxide and hydrogen. It doesn't react with nitrogen, not even at very high temperatures, but it can react with ammonia to form sodium amide. It hardly reacts with carbon, but it does react with halogens. It also reacts with various metallic halides to form the metal and sodium chloride. It doesn't react with paraffinic hydrocarbons, but it forms addition compounds with naphthalene and other aromatic polycyclic compounds and with aryl alkenes.



#### 46. Strontium

- Is a soft, silver- yellow, alkaline-earth metal. It has three allotropic crystalline forms and in its physical and chemical properties. It is similar to calcium and barium. It reacts vigorously with water and quickly tarnishes in air, so it must be stored out of contact with air and water.



#### 47. Tantalum

- Is a shiny, silvery metal which is soft when is pure. It is almost immune to chemical attack to temperatures below 150 C. it is virtually resistant to corrosion due to an oxide film on its surface. It finds use in four areas: high- temperature applications, such as aircraft engines; electrical devices, such as capacitors; surgical implants and handling corrosive chemicals.it is rarely as an alloying agent because it tends to make metals brittle.



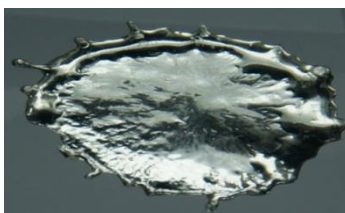
#### 48. Technetium

- Is a silvery- gray metal that tarnishes slowly in moist air. It dissolves in nitric acid, aqua regia, and conc. Sulfuric acid, but is not soluble in hydrochloric acid of any strength.



#### 49. Tin

- Is a soft, pliable, silvery- white metal. It is not easily oxidized and resist corrosion because it is protected by an oxide film. It resists corrosion from distilled sea and soft tap water, and can be attacked by strong acids, alkalis and acid salts.



#### 50. Titanium



- Is a transition metal light with a white- silvery – metallic color. It is strong, lustrous, and corrosion- resistant. Pure titanium is not soluble in water but is soluble in concentrated acids. Titanium alloys are characterized by very high tensile strength even at high temperatures, light weight, high corrosion resistance, and ability to withstand extreme temperatures.



#### 51. Tungsten

- Is a lustrous and silvery white metal. The bulk metal resists attack by oxygen, acids and alkalis. It has the highest melting point of any metal.



#### 52. Ununbium

- Does not have known application and little is known about it.

#### 53. Ununhexium

- Is the temporary name of an unconfirmed chemical element in the periodic table that has temporary symbol Uuh and has the atomic number 116.

#### 54. Ununquadium

- Is expected to have properties similar to those of lead and tin. Ununquadium can be synthesized by bombarding plutonium 244 targets with calcium 48 heavy beams. Ununquadium does not have known application and little is known about it.

#### 55. Vanadium

- Is a rare, soft, ductile gray- white found combined in certain minerals and used mainly to produce certain alloys. Vanadium resists corrosion due to a protective film of oxide on the surface.



#### 56. Yttrium

- Is a highly crystalline iron-gray, rare-earth metal. It is fairly stable in air, because it is protected by the formation of a stable oxide film on its surface, but oxidizes readily when heated. It reacts with water decomposing it to release hydrogen gas, and it reacts with mineral acids,



#### 57. Zinc

- Is a lustrous bluish- white metal. It is found in group IIB of the periodic table. It is brittle and crystalline at ordinary temperatures, but it becomes ductile and malleable when heated between  $110^{\circ}\text{C}$ .



#### 58. Zirconium

- Is a very strong, malleable, ductile, lustrous silver- gray metal. Its chemical and physical properties are similar to those of titanium. It is extremely resistant to heat and corrosion. It is lighter than steel and its hardness is similar to copper.

