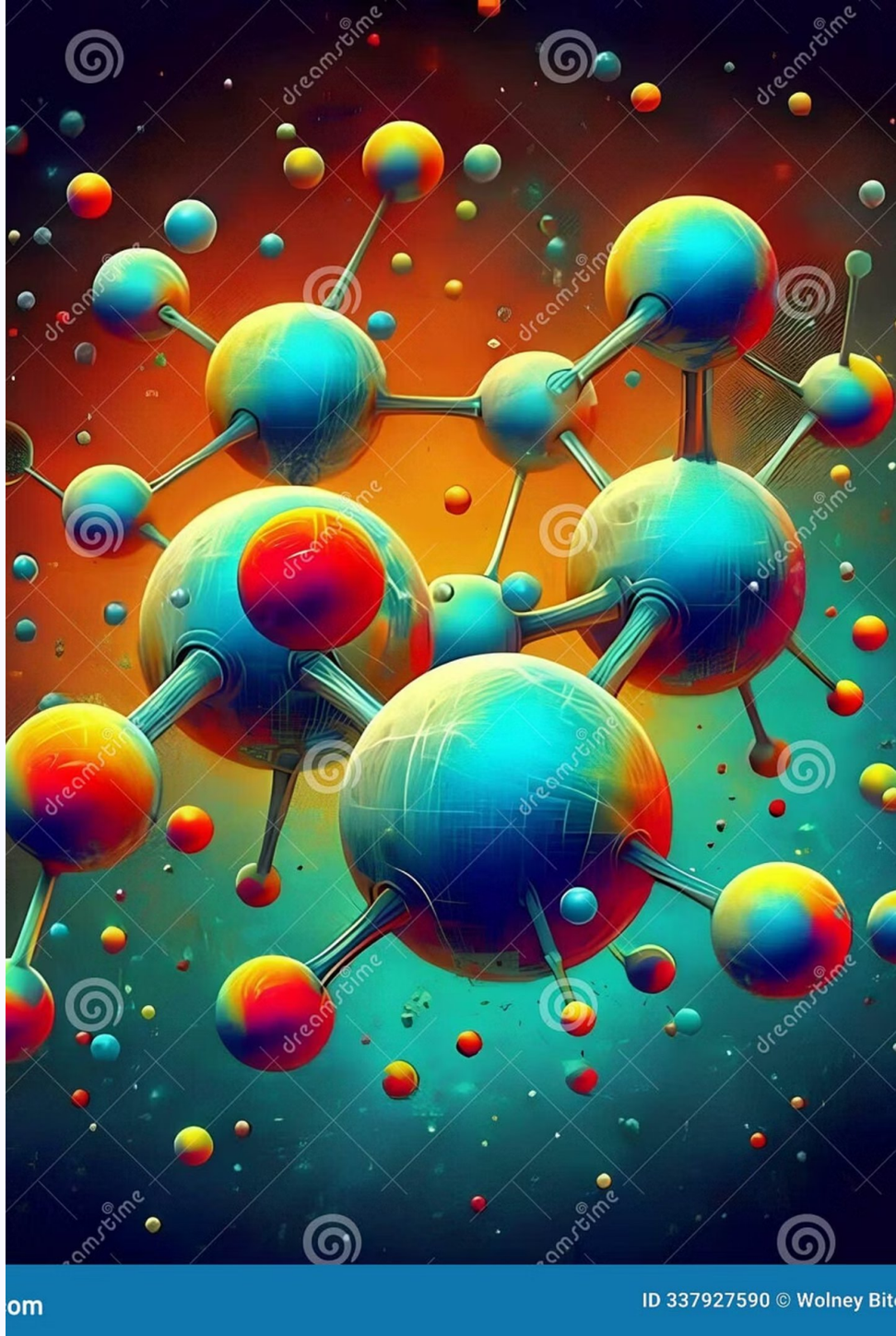
Chemistry O-Level

Atomic Structure

Join us on a journey into the fundamental world of atomic structure, elements, and the periodic table.



CHAPTER 1

Atomic Structure: The Basics

What is an Atom?

The smallest particle of an element, atoms are spherical, with negatively charged electrons revolving around a central nucleus.

Neutrality

Atoms are neutral because the number of positive protons equals the number of negative electrons.

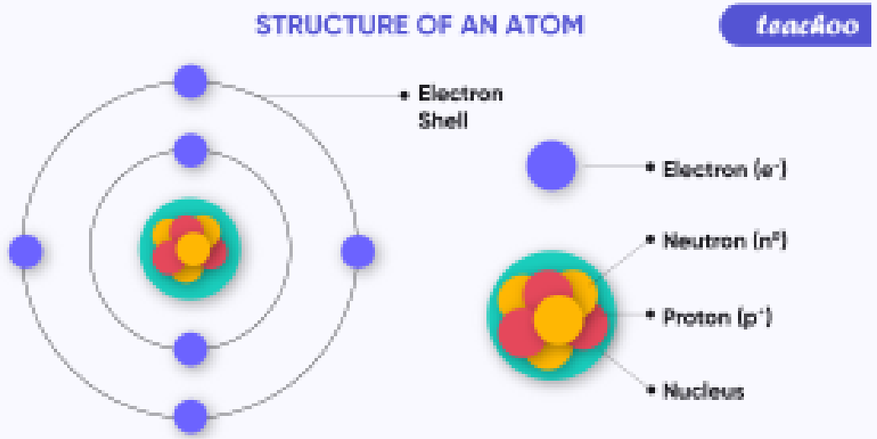
Nucleus

Contains positively charged protons (p+) and neutral neutrons (n0).

Valence Shell

The outermost shell, containing valence electrons that participate in chemical reactions.

Subatomic Particles



Particle	Mass (a.m.u.)	Charge
Proton (p+)	1	+1
Neutron (n0)	1	0
Electron (e-)	1/2000 (negligible)	-1

*a.m.u. = Atomic mass unit. The electron's mass is considered negligible compared to protons and neutrons.

Defining Elements

What is an Element?

A pure substance composed of similar atoms with the same atomic number and chemical behavior.

Atomic (Proton) Number

The number of protons (p+) inside the nucleus. It uniquely identifies an element. For a neutral atom, it also equals the number of electrons.

Mass (Nucleon) Number

The total number of protons and neutrons (p+ + n0) inside the nucleus.

Calculating Neutrons

Number of neutrons = Mass number - Atomic number. This helps distinguish isotopes.

Electronic Structure & Isotopes

Electronic Structure

Arrangement of electrons in an atom's shells, also known as electronic distribution or configuration.

- First shell: max 2 electrons
- Second shell: max 8 electrons
- Third shell: max 18 electrons (sometimes 8)
- Any other shell: max 32 electrons

The outermost shell should not contain more than 8 electrons (octet rule), except for the first shell.

Isotopes

Atoms of the same element with the same atomic number (protons) but different mass numbers (neutrons).

- Identical chemical properties (same valence electrons).
- Different physical properties (mass, density).
- Separated physically, not chemically.

Example: Chlorine-35 and Chlorine-37 contribute to chlorine's relative atomic mass of 35.5.

Periodic Table of the Elements

1																	18
1 H Hydrogen 1.01	2											13	14	15	16	17	2 He Helium 4.00
3 Li Lithium 6.94	4 Be Beryllium 9.01											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
11 Na Sodium 22.99	12 Mg Magnesium 24.31	3	4	5	6	7	8	9	10	11	12	13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.95
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.88	23 V Vanadium 50.94	24 Cr Chromium 51.99	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.63	33 As Arsenic 74.92	34 Se Selenium 78.97	35 Br Bromine 79.90	36 Kr Krypton 83.80
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.95	43 Tc Technetium 98.91	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.90	54 Xe Xenon 131.29
55 Cs Cesium 132.91	56 Ba Barium 137.33	57-71 Lanthanides	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.85	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.20	83 Bi Bismuth 208.98	84 Po Polonium [208.98]	85 At Astatine 209.98	86 Rn Radon 222.02
87 Fr Francium 223.02	88 Ra Radium 226.03	89-103 Actinides	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]

57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium 144.91	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.06	71 Lu Lutetium 174.97
89 Ac Actinium 227.03	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium 237.05	94 Pu Plutonium 244.06	95 Am Americium 243.06	96 Cm Curium 247.07	97 Bk Berkelium 247.07	98 Cf Californium 251.08	99 Es Einsteinium [254]	100 Fm Fermium 257.10	101 Md Mendelevium 258.10	102 No Nobelium 259.10	103 Lr Lawrencium [262]

Alkali Metal | Alkaline Earth | Transition Metal | Basic Metal | Metalloid | Nonmetal | Halogen | Noble Gas | Lanthanide | Actinide

Metals vs. Non-Metals

Metals

- Incomplete outer shell (less than 4 electrons).
- Tend to lose electrons, forming positive ions.
- Located below the zigzag line on the periodic table.
- Combine with non-metals by electron transfer.
- Examples: Alkali metals (Group I), Earth alkali metals (Group II).

Non-Metals

- Incomplete outer shell (4 or more electrons).
- Tend to gain electrons, forming negative ions.
- Located above the zigzag line on the periodic table.
- Combine with metals by gaining electrons.
- Combine with other non-metals by sharing electrons.
- Examples: Halogens (Group VII).

Noble Gases & Exceptions

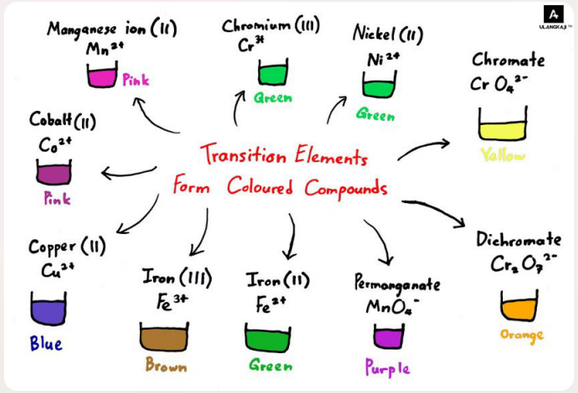
Noble (Inert) Gases

- Found in Group 0 (VIII).
- Complete outer valence shell (8 electrons, except Helium with 2).
- No chemical reactivity; cannot lose, gain, or share electrons.
- Used in light bulbs (longer lifespan) and weather balloons (Helium).

Key Reminders

All elements are solids or gases at room temperature, except **Mercury (liquid metal)** and **Bromine (liquid non-metal)**.

- Period number = Number of filled electron shells. Group number = Number of outermost electrons (except Helium).
- Carbon and Silicon (Group IV) do not form ions as they cannot lose or gain more than 3 electrons.



Properties of Transition Metals

Physical Properties

- Higher density and strength.
- Higher melting points (e.g., used in light bulbs).

Chemical Properties

- Compounds are often colored, especially when hydrated.
- Form ions with multiple oxidation states (e.g., Fe+2 & Fe+3).
- Can act as catalysts, accelerating reaction rates without changing chemically.

Calculating Relative Atomic Mass

The relative atomic mass (Ar) is the average mass of naturally occurring atoms of an element relative to Carbon-12. It's not always a whole number due to isotopes.

$$Relativeatomicmass(R.A.M) = \quad (r1xAr1) + \quad (r2xAr2) + \quad .../Sumofratios(or$$

Example: Copper (Cu)

Copper has two isotopes: 63Cu (69% abundance) and 65Cu (31% abundance).

Calculation: (69 x 63) + (31 x 65) / (69 + 31) = 63.62 a.m.u.

Isotopes of the same element have identical chemical properties but slightly different physical properties due to mass differences.