Chapter 2: Atoms, Ions, and the Periodic Table

August 29, 2022

Chemistry Department, Cypress College

Lecture Weekly Agenda

- Cover Ch 1 - pg $1 - 55$
- Go over Ch 2 - pg $56 - 88$
- In-class Ch $1+2$ worksheet
- First class quiz released Fri, Sept 2nd at 11am

Correction to Lecture 3

- Water is a pure substance

Outline

Review: Scientific Method and Atoms

Periodic Table - Grouped Elements

Review: Scientific Method

1. Gather observations
2. Ask a question. Propose a hypothesis which is a supposed explanation of a given phenomenon
3. Design and perform your experiment
4. If results support the hypothesis, then propose a theory, which explains the observation. If not, then revise the hypothesis.

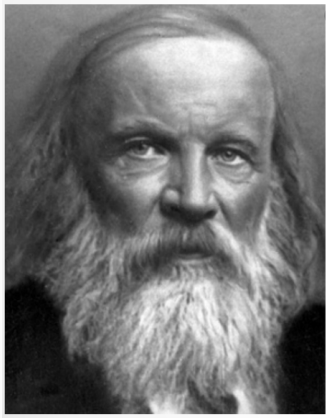
What are atoms made of?

	Mass (g)	Atomic Units (Amu)	Charge (C)
Neutron	1.675×10^{-24}	1	0
Proton	1.675×10^{-24}	1	1.6022×10^{-19}
Electron	9.1094×10^{-28}	$1/1840$	-1.6022×10^{-19}

- 1 amu $= 1.6606 \times 10^{-24}$ g
- Protons and neutrons are located in the nucleus
- Electrons revolve around the nucleus (difference between core electrons and valence electrons)

Outline

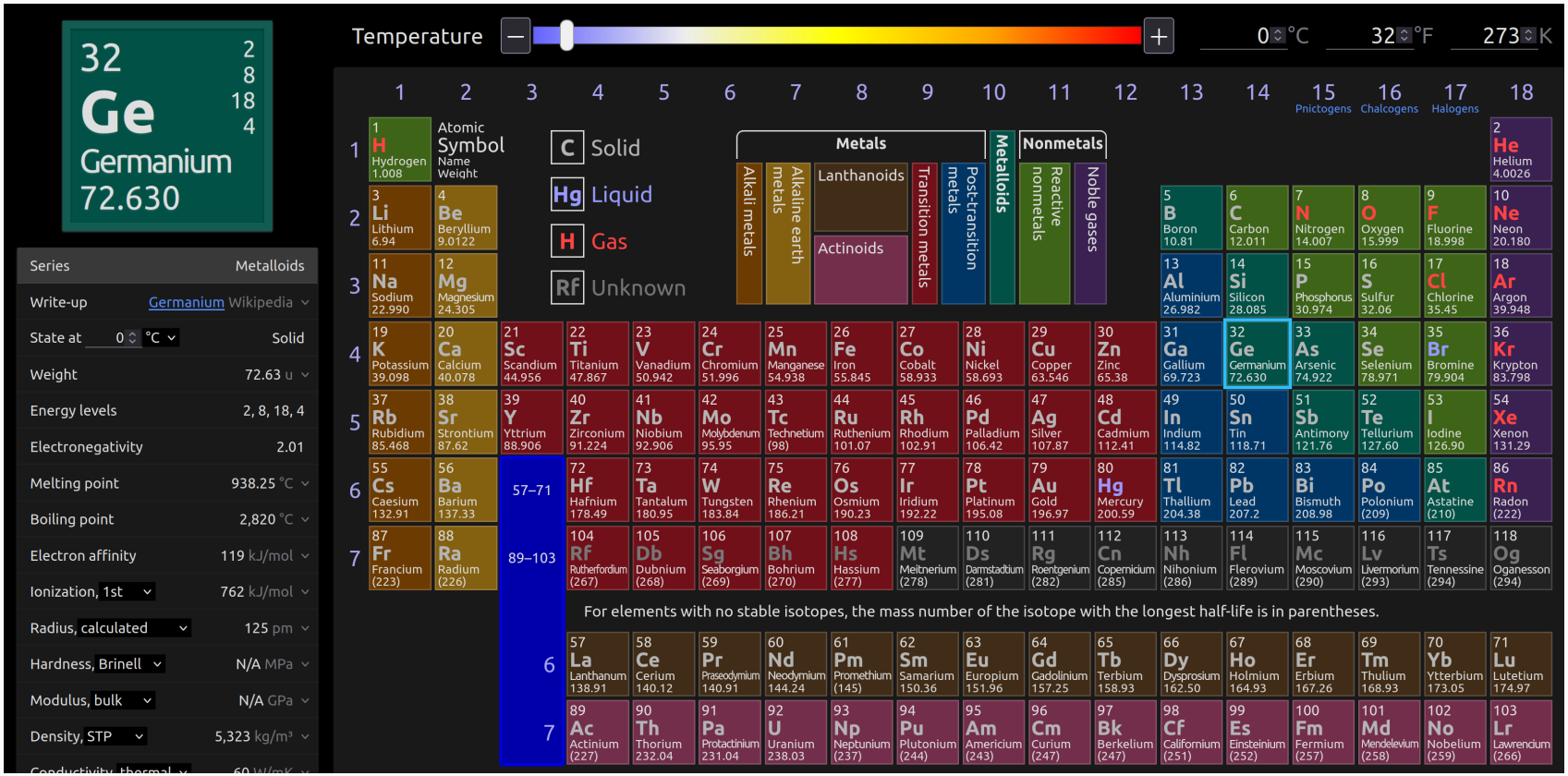
Earliest Periodic Table



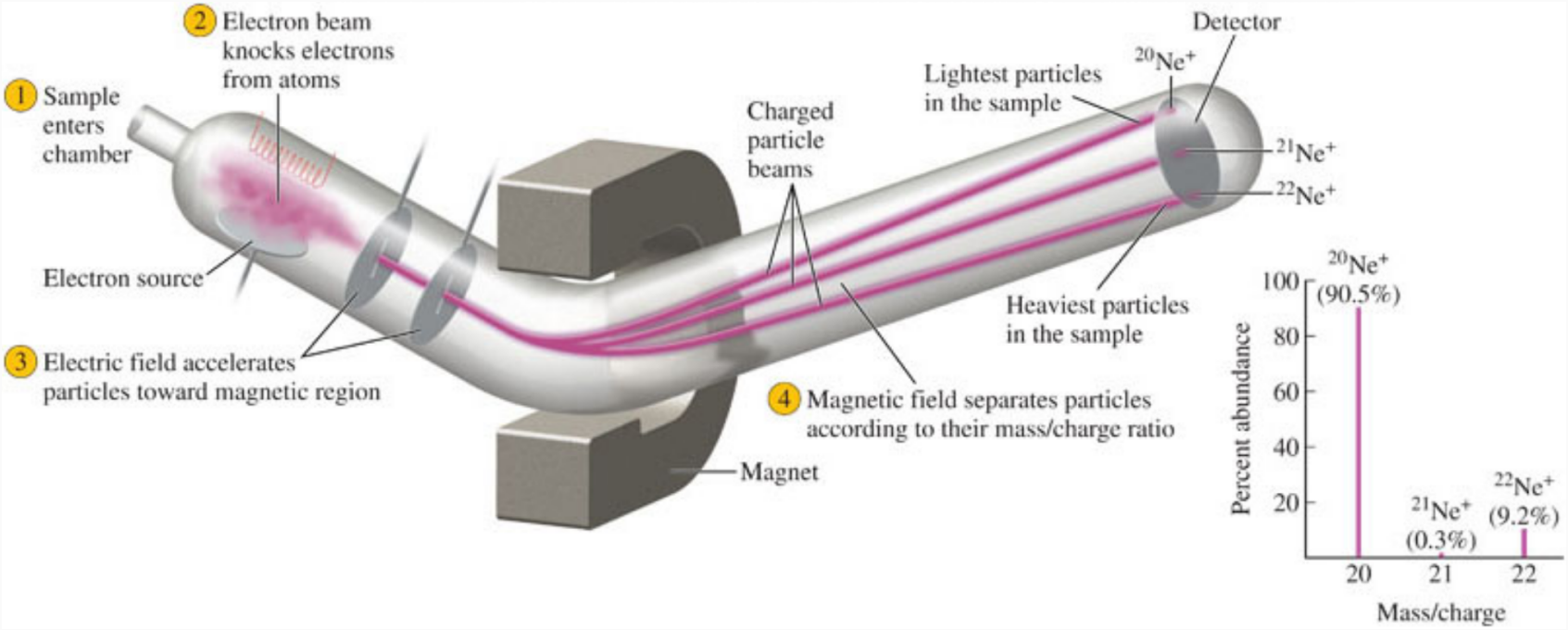
			Ti = 50	Zr = 90	? = 180	
			V = 51	Nb = 94	Ta = 182	
			Cr = 52	Mo = 96	W = 186	
			Mn = 55	Rh = 104,4	Pt = 197,4	
			Fe = 56	Ru = 104,4	Ir = 198	
			Ni = Co = 59	Pd = 106,6	Os = 199	
H = 1			Cu = 63,4	Ag = 108	Hg = 200	
	Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112		
	B = 11	Al = 27,4	? = 68	Ur = 116	Au = 197?	
	C = 12	Si = 28	? = 70	Sn = 118		
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?	
	O = 16	S = 32	Se = 79,4	Te = 128?		
	F = 19	Cl = 35,5	Br = 80	J = 127		
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Ti = 204	
		Ca = 40	Sr = 87,6	Ba = 137	Pb = 207	
		? = 45	Ce = 92			
		?Er = 56	La = 94			
		?Yt = 60	Di = 95			
		?In = 75,6	Th = 118?			

- Dmitrij Mendeleev Arranged base on atomic mass
- Grouped known elements into rows and columns

Modern Period Table



Mass Spectroscopy: Determining the Atomic Mass



- Ionizes the atom and electric field accelerates atoms
- Time of flight - heavier atoms will travel slower than lighter ones
- Weighter average of atomic masses

Relative Atomic Mass Formula

$$\text{Relative Atomic Mass} = (I_1 \times A_1) + (I_2 \times A_2) + \ldots \qquad (1)$$

where I is the mass of the isotope, and A is the relative abundance between 0 and 1

Calculating the Relative Atomic Masses

Magnesium is composed of three isotopes. Calculate the relative atomic mass of magnesium and compare to the periodic table.

Isotope	Mass (amu)	Natural Abundance (%)
^{24}Mg	23.985	78.99
^{25}Mg	24.986	10.00
^{26}Mg	25.983	11.01

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$$23.985\text{amu} \times 0.7899 = 18.95\text{amu}$$

$$24,986\text{amu} \times 0.1000 = 2.499\text{amu}$$

$$25.983\text{amu} \times 0.1101 = 2.861\text{amu}$$

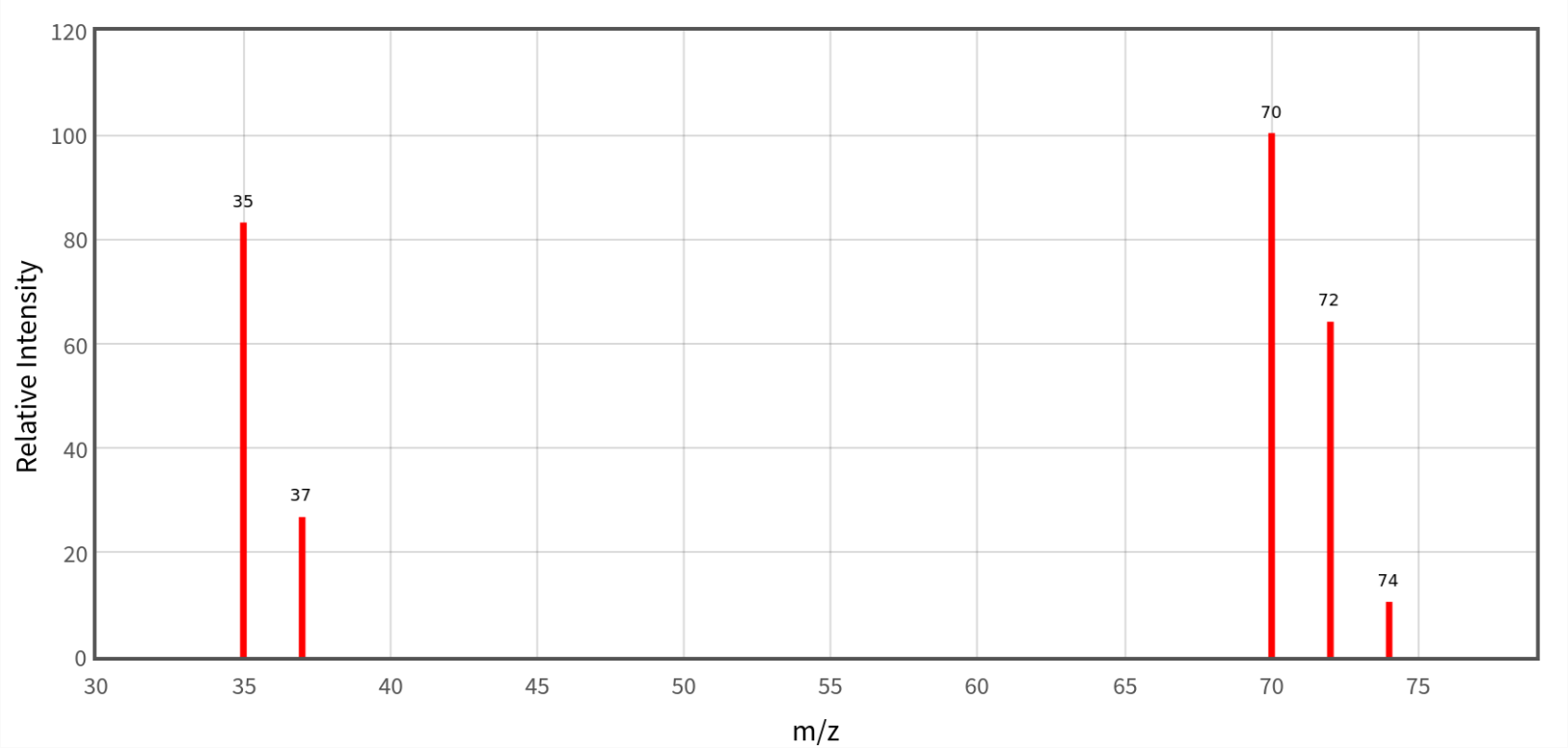
$$24.31\text{amu}$$

Practice: Calculate the Atomic Mass

Boron has two naturally occuring isotopes. Determine the atomic mass of boron.

Isotope	Natural Abundance (%)
^{10}B	19.9
^{11}B	80.1

Practice: Calculate the Atomic Mass



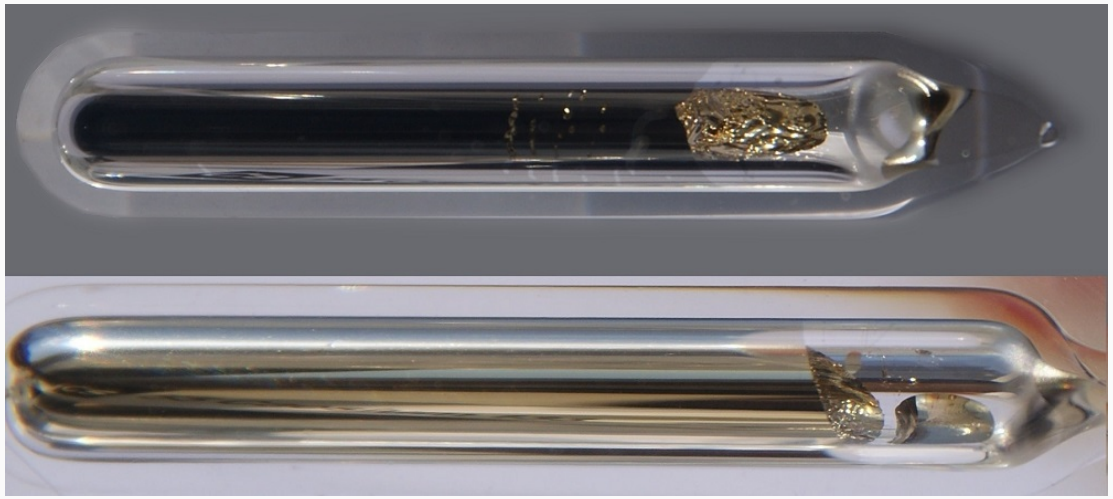
Determine atomic mass of Cl given the mass spectrum. Hint: Cl naturally exists as a diatomic e.g. Cl_2.

Conceptual Question

Naturally occurring gallium (ga) is made of two isotopes Ga-69 and Ga-71. Which of the following statements is true? Hint: Look at the periodic table.

1. Gallium's relative atomic mass is 70.00 amu
2. Both isotopes have the same mass: 69.72 amu
3. The isotopes are present in the same percentages
4. Ga-71 is present in the largest percent abundance
5. Ga-69 is present in the largest percent abundance

Alkali Metal



- Lower densities than other metals
- Extremely soft metals
- Highly reactive e.g. forming H_2 when in contact with water
- Prefer to lose an electron

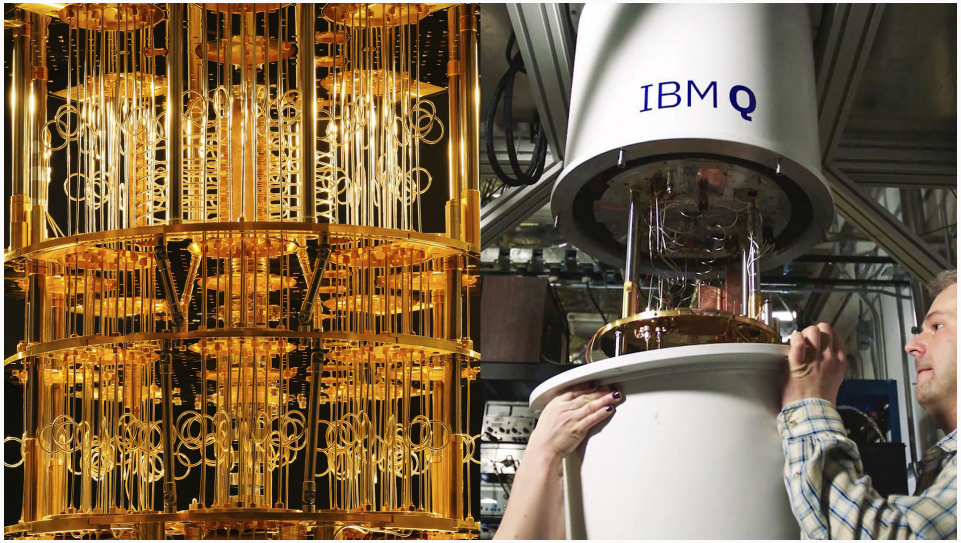
Alkaline Earth Metal

- Fairly reactive metals
- Can form solutions with a pH greater than 7 (more basic or alkaline)
- Calcium and magnesium important for life
- Prefer to lose 2 electrons

Transition Metals

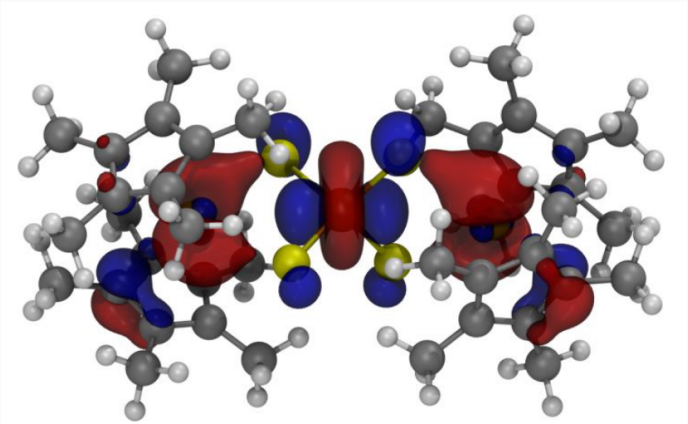
- Easily malleable and great conductors of heat and electricity
- High melting points except mercury (liquid at Room temperature)
- High densities
- Oxidation states (ability to gain/lose electrons) can vary between 1+ to 6+

Actinides and Lanthanides

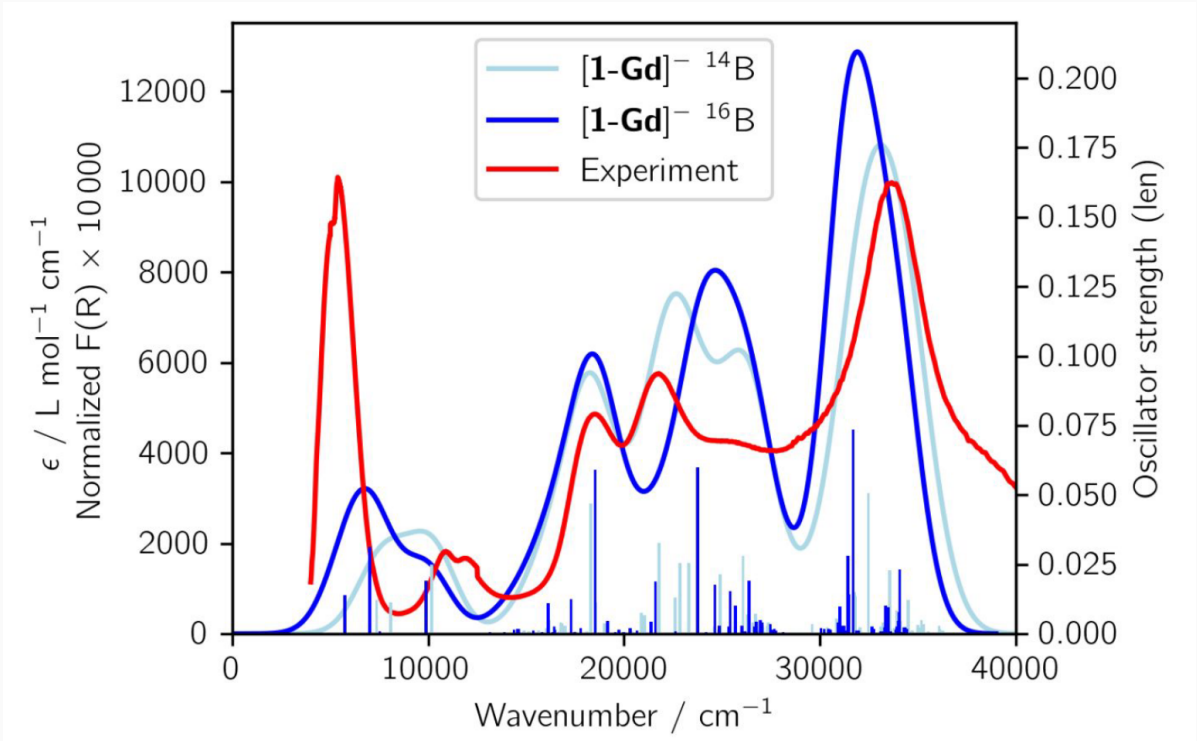


- Radioactive due to instability
- Silvery/silvery-white luster in metallic form
- Potential application to quantum computers and nuclear power
- Oxidation states can range from 2+ to 7+

Materials for Quantum Computing: Lanthanide Complexes

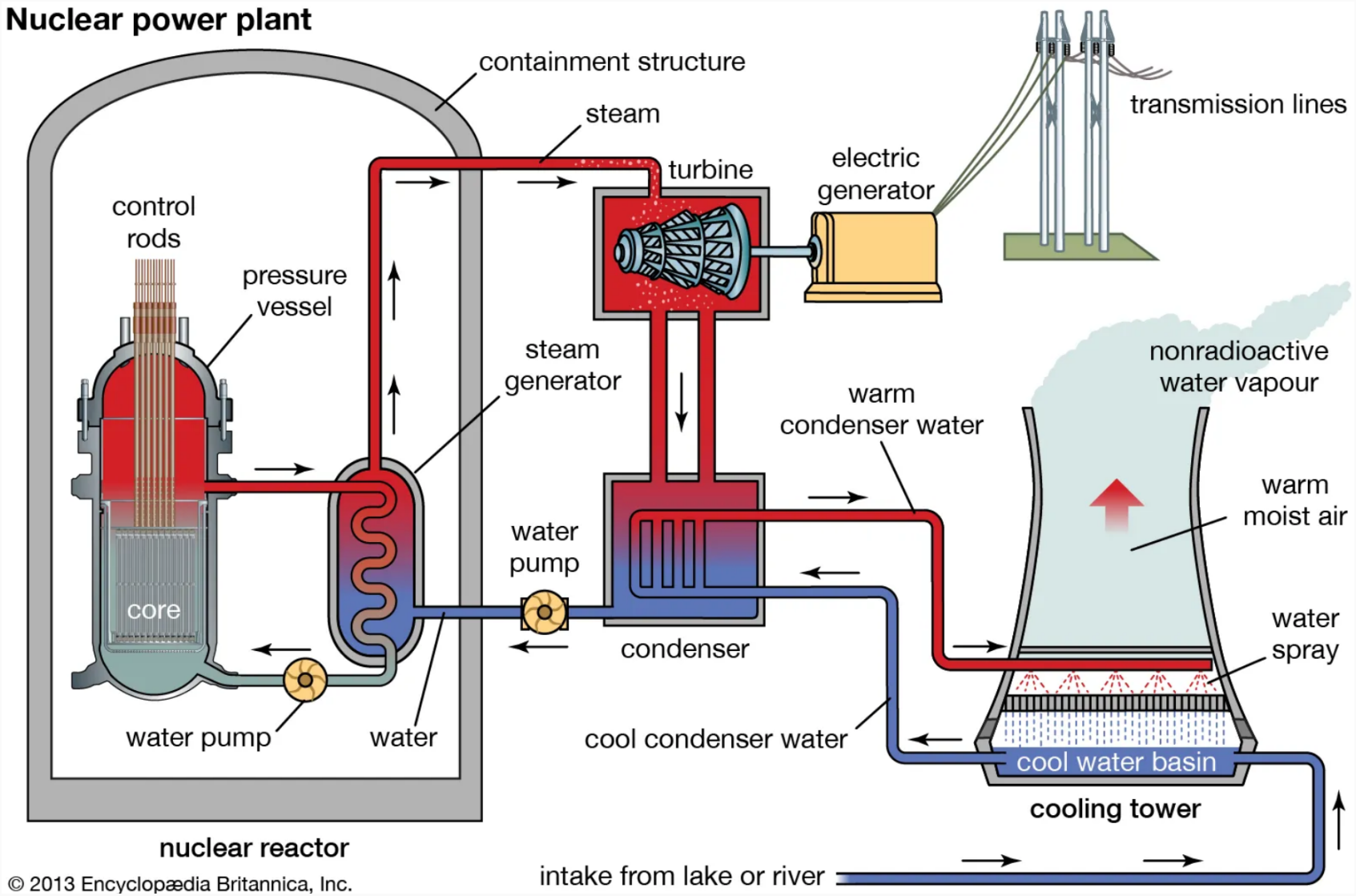


$[\mathbf{1\text{-}Gd}]^{-1}$ HOMO



- Understanding the electronic structure
- Hysteresis - electronic spin memory
- Lanthanide MoS_4 research article

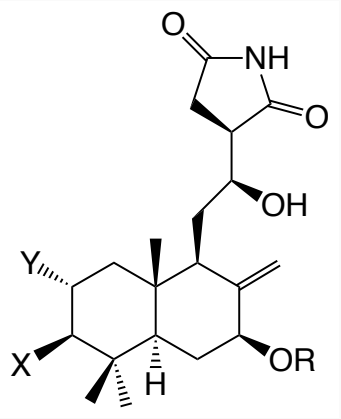
Nuclear Power Plants



Halogens

- Fairly toxic and form acids when combined with hydrogen
- Readily react with metals to form salts e.g. NaCl
- Important for drug development due to their "sticky" nature
- Prefers to gain an electron

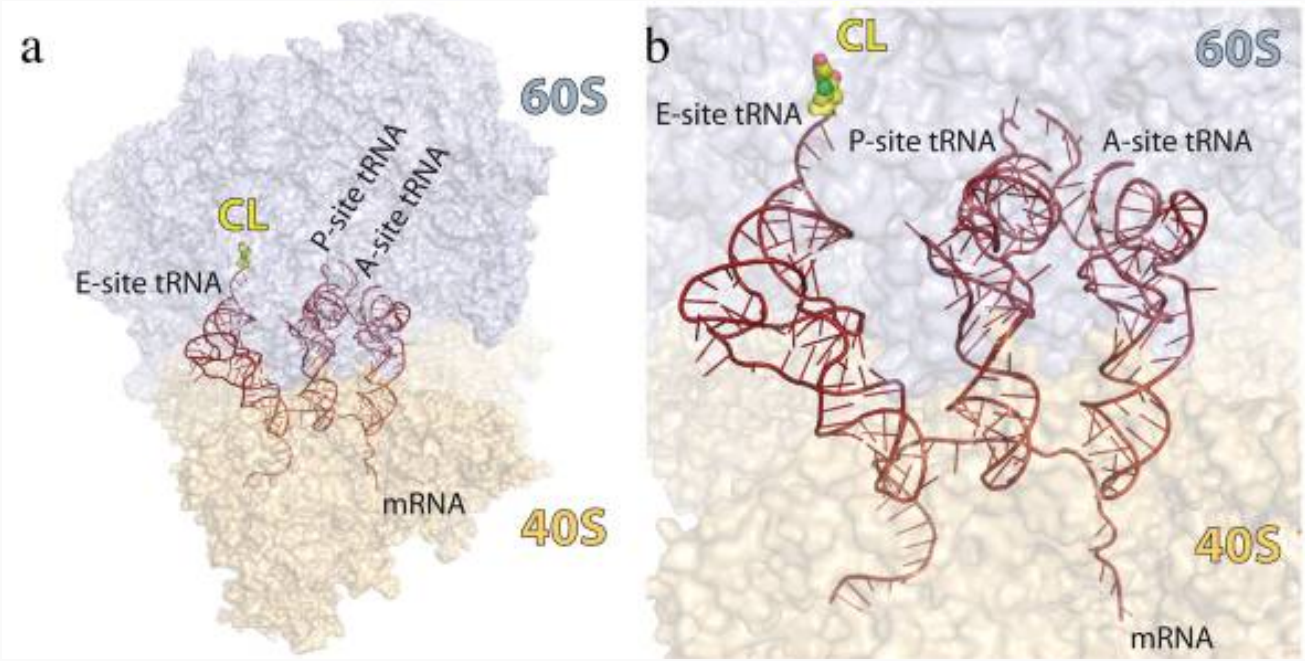
Cancer Therapeutics



Compound	X	Y	R
Chlorolissoclimide (CL)	H	Cl	H
Dichlorolissoclimide (DCL)	Cl	Cl	H

- Chlorolissoclimide is a potent cancer drug that is naturally found in sea squirts
- Understanding the structure–activity relationships e.g. interactions between drug and ribosome

My Research Project: Chlorolissoclimide



- Chlorolissoclimide research article

Noble Gases

- Colorless, odorless, tasteless, and non-flammable under standard conditions
- Extremely non-reactive and most stable elements
- Do not like to gain or lose electrons

Practice: Periodic Table

Group the elements into the following groups

- Br
- K
- Mg
- Al
- Mn
- Ar
- U

Practice

What is the charge of the ions for each of the following elements?

- Al
- P
- Br
- S