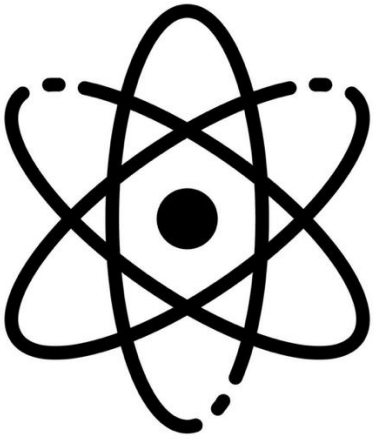
RADIO ACTIVITIES OF THE MUSEE CURIE

A game conceived by Claude Charvy.



To better understand the mysteries of atoms and radioactivity

musée**CURIE**

RADIO ACTIVITIES OF THE MUSEE CURIE

Presentation

What is an atom? What is it made of? What is radioactivity?

"***Radio-Activities of the Musée Curie***" feature 5 activities designed with the aim of discovering and explaining radioactivity in a fun and educational way.

Inspired by card and board games,"***Radio-Activities of the Musée Curie"*** help us understand that the name of the chemical elements is linked to the number of protons that make up the nuclei of atoms, that some atoms are radioactive, and that they can transform into other atoms by emitting alpha and/or beta rays (gamma radiation is not covered).

With these games you can explore these scientific notions in successive stages, and also discover the history of natural and artificial radioactivity: the elements discovered by Marie and Pierre Curie in 1898 (Polonium and Radium) and the radioactive family of Uranium-238 or Nitrogen-13, which were artificially produced by Frédéric and Irène Joliot-Curie in 1934.

You can have fun playing with the nuclei of atoms, protons, and neutrons!

Description

In this manual, you will find:

You will need the following materials to complete the activities:

- A periodic table
- A printed game kit

Each activity is independent and can be completed separately.

RADIO-ACTIVITY 1:

Match the number of protons to its chemical element

First, the presenter gives a presentation on atoms and nuclei. See the explanatory guide "Atoms, Nuclei and the Periodic Table" p 10-11.

Objective:

To make it clear that a chemical element is defined by the number of protons contained in its nucleus.

Materials:

- 1 periodic table
- Activity 1 Game Kit:
  - 12 cards with the Symbols and the names of the Chemical Elements
    - Level 1: H, He, B, C, N, O, F, Ca, Fe, Cu, Ag and Au
    - Level 2: Hg, Pb, Bi, Po, At, Rn, Fr, Ra, Ac, Th, Pa, U
  - 12 labels with the number of protons
    - Level 1: 1, 2, 5, 6, 7, 8, 9, 20, 26, 29, 47, 79
    - Level 2: 80, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92

Setup:

- The cards with the elements are shuffled and turned over (blank side up).
- The labels with the number of protons are laid out (number of protons on top).

How to play:

The game can be played alone or in teams of 2 players who take turns.

- Draw a card with a chemical element.
- Use the periodic table to find the label with the right number of protons.
- Place the label on top of the chemical element card.
- The game is over when all the cards/labels have been matched.

Variant:

- The player places all the element cards in front of them face up, and the labels are placed in a canvas bag
- Player randomly draws a label with a number of protons and matches the corresponding chemical element with it using the periodic table

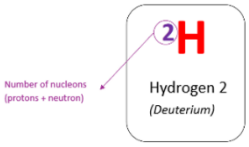
RADIO-ACTIVITY 2:

Find the name of a nuclei

First, the presenter gives a presentation on atoms and nuclei. See the explanatory guide "Atoms, Nuclei and the Periodic Table" p 10-11.

Objective: To understand how the atoms are named, then deduce the number of protons and neutrons contained in the nuclei.

Materials:



- 1 periodic table
- Activity 2 Game Kit:
  - 16 cards with the Symbols, the names of the chemical elements, and the number of nucleons
    - Level 1: ${}^{1}_{1}H$, ${}^{2}_{1}H$, ${}^{2}_{2}He.$, ${}^{11}_{5}B.$, ${}^{12}_{5}B.$, ${}^{11}_{6}C.$, ${}^{12}_{6}C.$, ${}^{13}_{6}C.$, ${}^{14}_{6}C.$, ${}^{12}_{7}Na$, ${}^{13}_{7}Na$, ${}^{14}_{7}Na$, ${}^{15}_{7}Na$, ${}^{14}_{8}0$
    - Level 2: ${}^{206}_{82}Pb$, ${}^{210}_{82}Pb$, ${}^{210}_{84}Po$, ${}^{214}_{84}Po$, ${}^{218}_{84}Po$, ${}^{226}_{88}Ra$, ${}^{222}_{86}Rn$, ${}^{232}_{90}Th$, ${}^{234}_{90}Th$, ${}^{234}_{92}U$, ${}^{235}_{92}U$, ${}^{238}_{92}U$
  - 18 Dominoes: "number of protons/number of neutrons"
    - Level 1: 1p/0n, 1p/1 n, 1p/2n, 2p/2n, 5p/6n, 5p/7n, 5p/8n, 6p/5n, 6p/6n, 6p/7n, 6p/8n, 7p/5 n, 7p/6n, 7p/7n, 7p/8n, 8p/5n, 7p/6n, 8p/7n
    - Level 2: 82p/124n, 82p/128n, 84p/126 n, 84p/130n, 84p/134n, 86p/136n, 88p/138n, 90p/142n, 90p/144n, 92p/142n, 92p/143n, 92p/146n

Setup:

- The cards with the elements are shuffled and turned over (blank side up).
- The dominoes are laid out (number of protons and neutrons facing up)

How to play:

The game can be played alone or in teams of 2 players who take turns.

- Draw a card with a chemical element.
- Use the periodic table to find the domino with the right number of protons and neutrons.
  - E.g.: the C13 card will be matched with the domino: 6 protons/7 neutrons
- Place the domino on top of the chemical element card.
- The game is over when all the cards/dominoes have been matched.

Variant:

- The player places all the element cards in front of them face up, and the dominoes are placed in a canvas bag
- Player randomly draws a domino with a number of protons and neutrons and then matches the corresponding chemical element with it using the periodic table

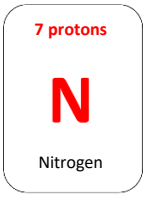
RADIO-ACTIVITY 3:

Beta radioactivity

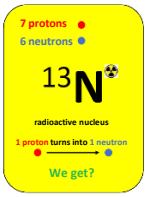
First, the presenter gives a presentation on radioactivity. See the explanatory guide "Radioactivity" p 12-13.

Objective: To understand radioactivity, isotopes, and the "transmutation of the elements". In this game we will limit ourselves to β radioactivity.

Materials:

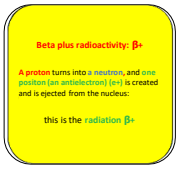


front



reverse

- 1 periodic table
- Board 1: " B, C, N, O, F" *(or a periodic table)*
- Board 2 of the game *(where we will arrange the cards during the game)*
- Two-color red/blue tokens
- Activity 3 Game Kit:
  - 24 nucleus cards:
    - Front: number of protons, symbol, and name of the corresponding chemical element.
    - Back: characteristic of the isotope (number of protons/neutrons) and its stability
  - 9 emitted radiation cards:
    - Beta Radioactivity +
    - Beta Radioactivity -
  - Two-color tokens:
    - Red side: represents the protons
    - Blue side: represents the neutrons



Setup:

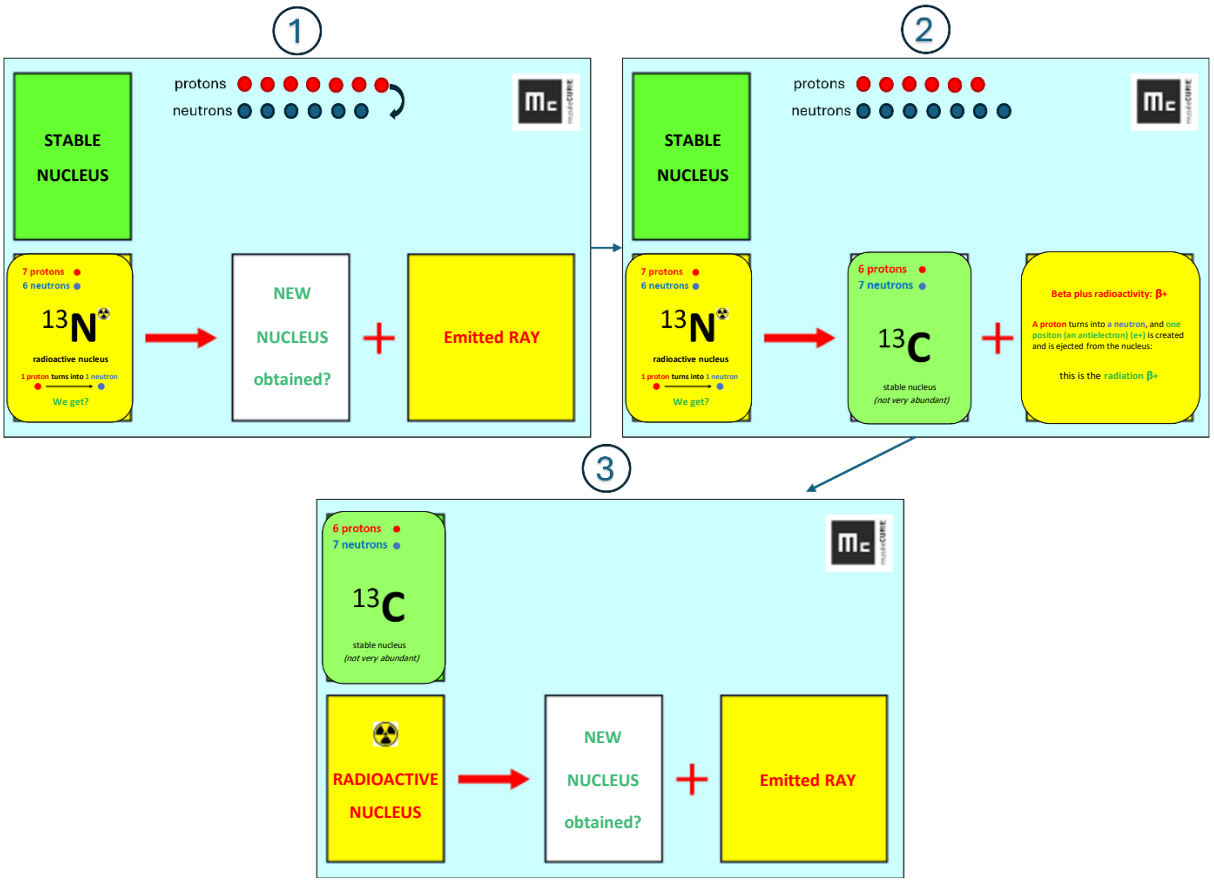
- On board 1 ("Family B, C, N, O, F") the cards by family are placed on each of the corresponding family squares (front of the cards on top)
  - The 4 Bore cards on the Bore square of board 1
  - The 6 Carbon cards on the Carbon square of board 1
  - The 6 Nitrogen cards on the Nitrogen square of board 1
  - The 6 Oxygen cards on the Oxygen square of board 1
  - The 2 Fluorine cards on the Fluorine square of board 1
- Put the two-color tokens in a small jar
- Arrange the emitted radiation cards next to each other

How to play:

The game can be played alone or in teams of 2 players who take turns.

We recommend playing with all the cards of the same family so as to fully understand beta radioactivity. The discovery of artificial radioactivity can be mentioned (N13).

- Draw a card from one of these families and place it on board 2 following the instructions on the card:
    - If the nucleus is stable (green card back) place the card on the "Stable Nucleus" square
        - The game is over, draw another card
    - If the nucleus is radioactive, place your card on the "Radioactive Nucleus" square
        - Continue playing the game
- If the nucleus is radioactive:
    - Follow the instructions to find the new nucleus obtained during the transmutation
        - To understand the transmutation, use colored tokens: one line with the blue tokens (neutrons) and another with the red tokens (protons)
    - Find the corresponding card among the isotopes and place it in the "New nucleus obtained" square
    - Find the emitted ray card:
        - Beta ray plus (β+): When 1 proton turns into 1 neutron, it emits a positron (antielectron: (e+)) and a neutrino (ν)
        - Beta radius less (β-): When 1 neutron turns into 1 proton, it emits an electron (e-) and an anti-neutrino ($\bar{\nu}$)



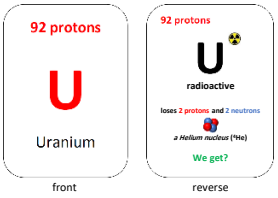
RADIO-ACTIVITY 4:

Alpha radioactivity

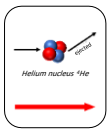
First, the presenter gives a presentation on radioactivity. See the explanatory guide "Radioactivity" p 12-13.

Objective: To understand radioactivity, isotopes, and the "transmutation of the elements". In this game we will limit ourselves to alpha radioactivity.

Materials:



- 1 periodic table
- Activity 4 Game Kit:
  - 11 nucleus cards (82 to 92 protons):
    - Front: number of protons, symbol, and name of the corresponding chemical element.
    - Back: cards contain information relating exclusively to alpha decays
  - 9 emitted radiation: cards alpha radioactivity



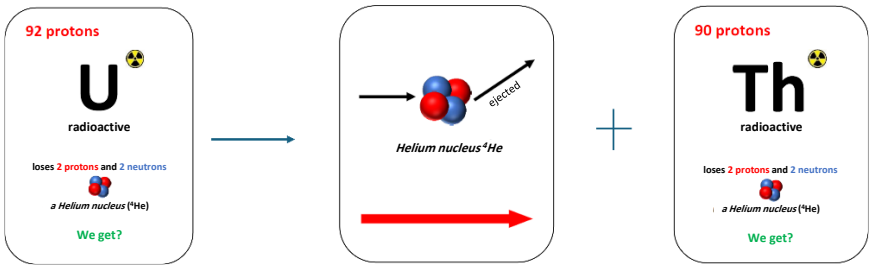
Setup:

- Lay out the 11 cards face down, arranging them in ascending order (number of protons from 82 to 92).

How to play:

The game can be played alone or in teams of 2 players who take turns. At the end of the game, the presenter can talk about radioactive families.

- Flip over the Uranium card with the 92 protons
- Follow the instructions provided on the back of the card
  - Take an emitted radiation card and place it next to the turned-over card
  - Find the new element obtained as a result of the alpha decay
- The game is over when the player comes across a card that reads: **stable**



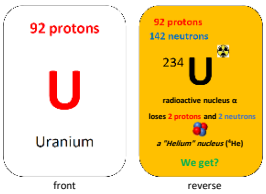
RADIO-ACTIVITY 5:

The radioactive family of Uranium (238)

First, the presenter gives a presentation on radioactivity. See the explanatory guide "Radioactivity" p 12-13.

Objective: To discover the radioactive family of Uranium-238 (U238) and to understand how radium (226), radon (222), and polonium nuclei (218, 214 and 210) are formed thanks to successive beta or alpha decays.

Materials:



- 1 periodic table
- Board 2 of the game *(where we will arrange the cards)*
- Activity 5 Game Kit:
  - 36 nuclei cards
    - 7 lead nuclei (Pb 206; 207; 208; 210; 211; 212; 214)
    - 4 cards with 83 protons = 4 Bismuth nuclei (Bi 209; 210; 212; 214)
    - 4 cards with 84 protons = 4 Polonium nuclei (Po 210; 214; 216; 218)
    - 1 card with 85 protons = 1 Astatine nuclei (At 210)
    - 4 cards with 86 protons = 4 Radon nuclei (Rn 218; 219; 220; 222)
    - 1 card with 87 protons = 1 Francium nucleus (Fr 223)
    - 4 cards with 88 protons = 4 Radium nuclei (Ra 223; 224; 226; 228)
    - 2 cards with 89 protons = 2 Actinium nuclei (Ac 227; 228)
    - 4 cards with 90 protons = 4 Thorium nuclei (Th 230; 231; 232; 234)
    - 2 cards with 91 protons = 2 Protactinium nuclei (Pa 231; 234)
    - 3 cards with 92 protons = 3 Uranium nuclei (U 234); 235; 238)
  - Emitted radiation cards
    - Beta plus (β+) radioactivity (a card with yellow background on the back)
    - Beta minus (β-) radioactivity (a card with yellow background on the back)
    - Alpha (α) radioactivity (a card with orange background on the back)

Setup:

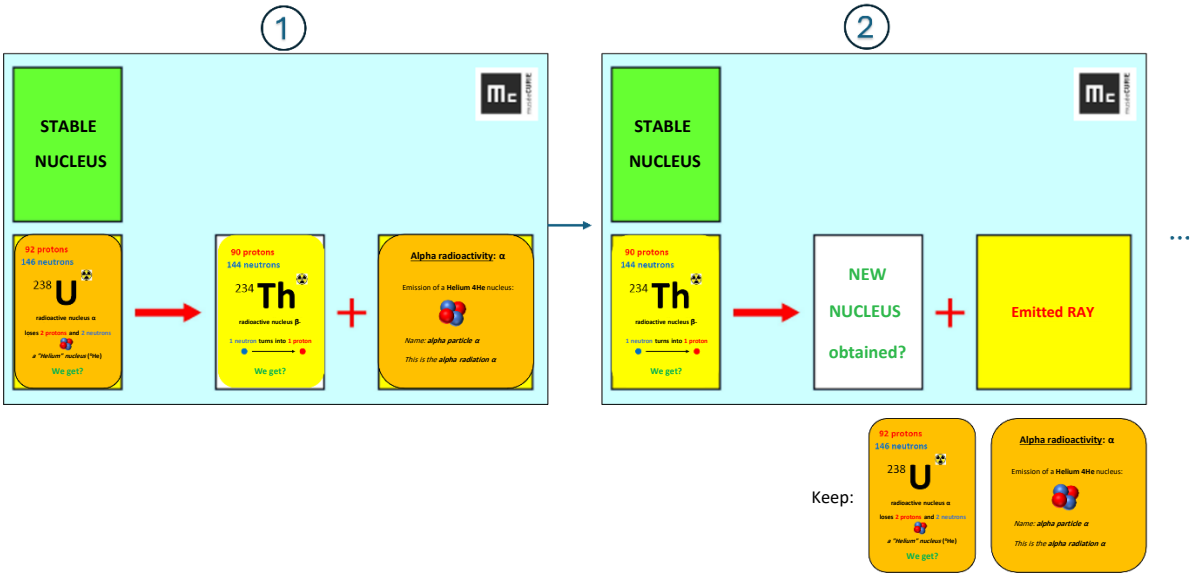
- Group the cards by chemical element, front side

How to play:

The game can be played alone or in teams of 2 players who take turns. At the end of the game, the presenter can talk about the radioactive families in detail. See the explanatory guide "The radioactive family of uranium" p 14-15.

- Turn over the Uranium card with 92 protons and place it on Board 2 on the "Radioactive nucleus" square
- Follow the instructions provided on the back of the card
  - Find the new element obtained in one of the chemical element piles (check the number of protons and neutrons on the back) and put it on Board 2
  - Match the emitted ray

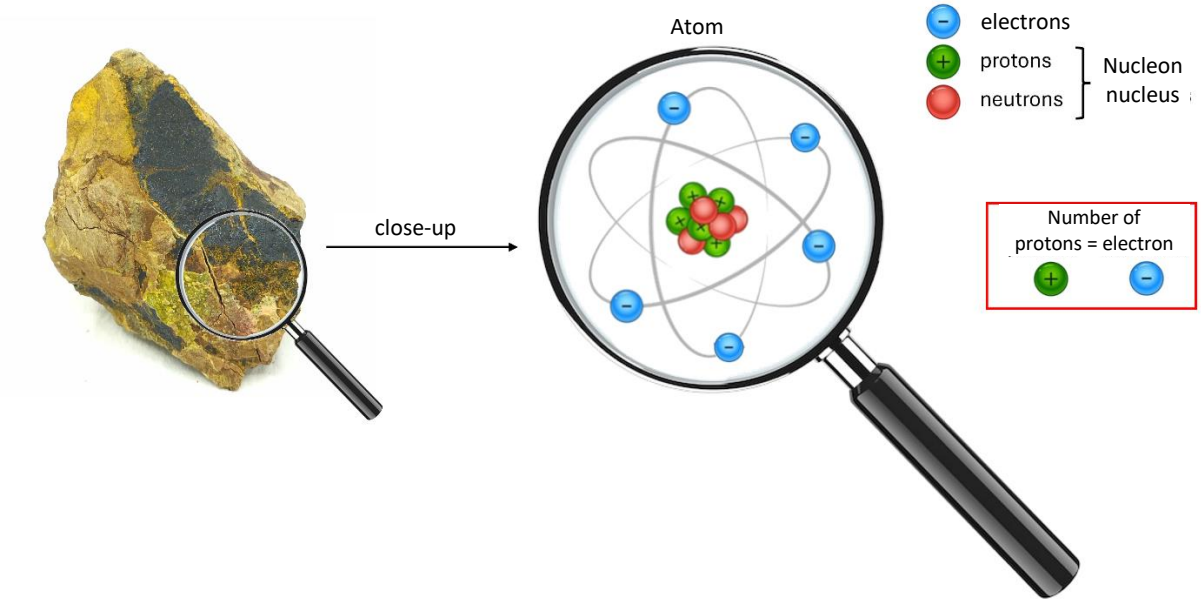
- Place on Board 2 in the corresponding square the new nucleus card, as well as the card with the ray emitted during this decay
- Then remove from the board:
    - The original Uranium nuclei (238) card and keep it in front of you
    - The emitted ray card and keep it
- Move the card with the newly obtained nuclei to the left on the board square
    - On the "Stable Nucleus" square if the nucleus obtained is stable
    - On the "Radioactive Nucleus" square if the nucleus obtained is radioactive
        - In this case, continue playing the game
- The game is over when the player gets a new nucleus that is stable (Pb206)



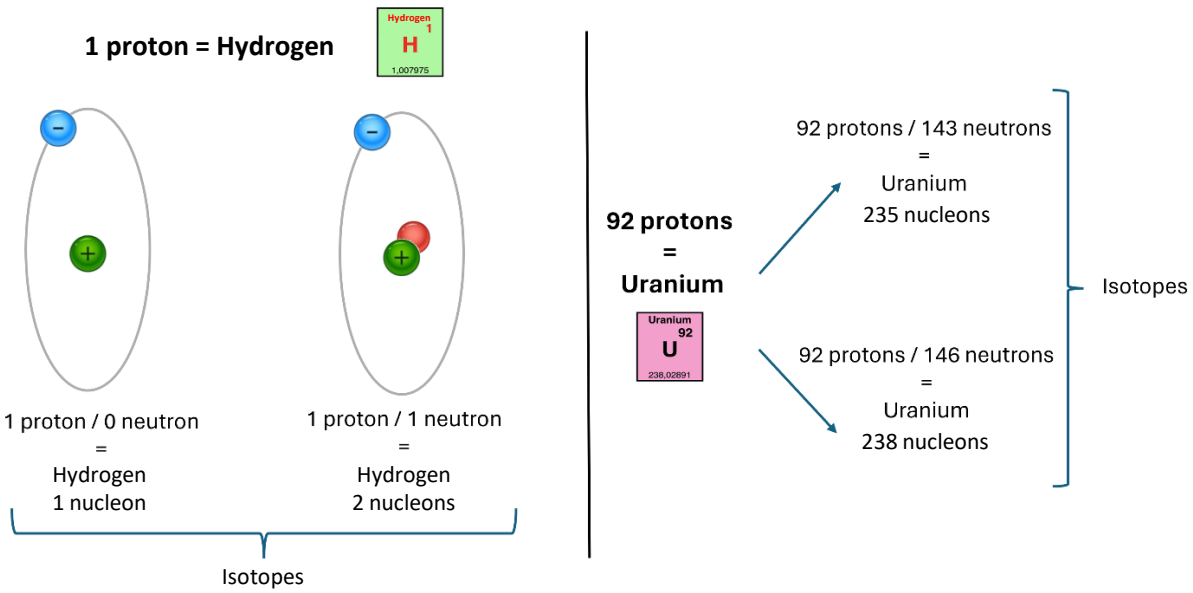
EXPLANATORY GUIDES

Atoms, Nuclei and the Periodic Table

Everything is made up of atoms! They are tiny - for example, a human hair is a million atoms thick.

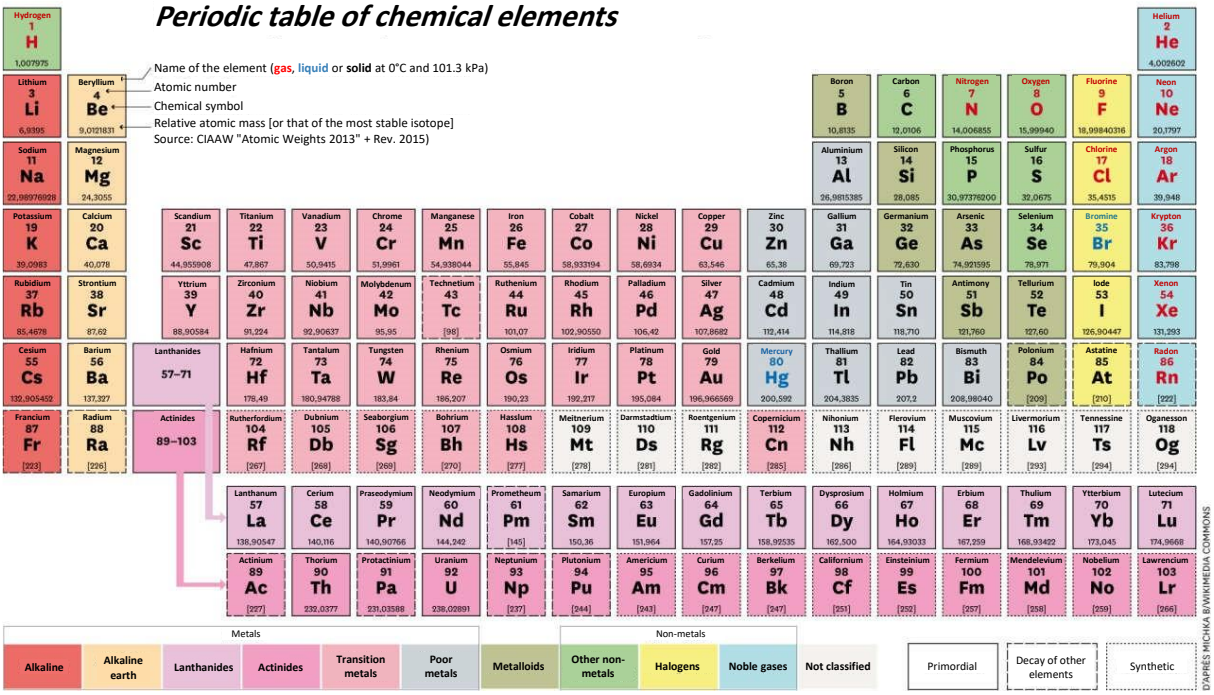


The number of protons = the atom's identity card



The Periodic Table

- Rows (= period): ascending order of the number of protons (atomic number)
- Columns (= group): similar properties of atoms



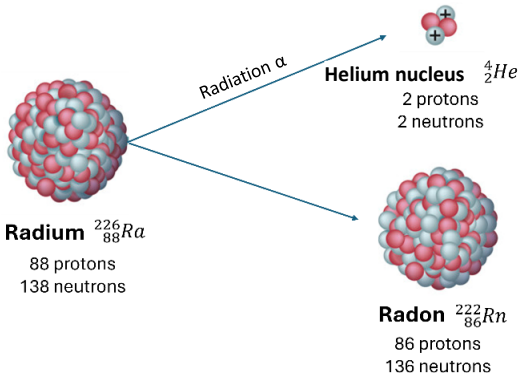
Radioactivity

When atoms contain too many nucleons, or when there is too great an imbalance between the number of protons and neutrons, the force that holds the nucleus together is no longer sufficient. The atoms then tend to reorganize themselves to become stable - this is referred to as radioactivity.

When this happens, the nuclei decay and emit particles and energy in the form of radiation. 3 types of radiation can occur: alpha α, beta β, and gamma γ.

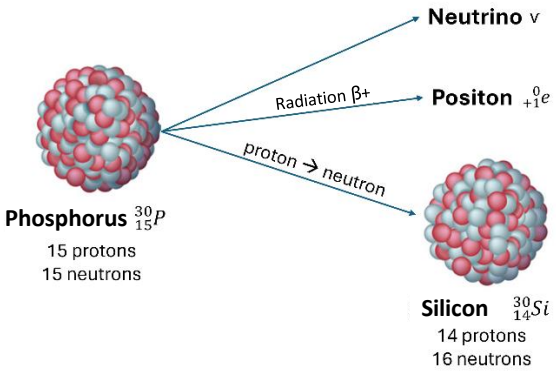
Radioactivity α

Ejection of a helium nucleus



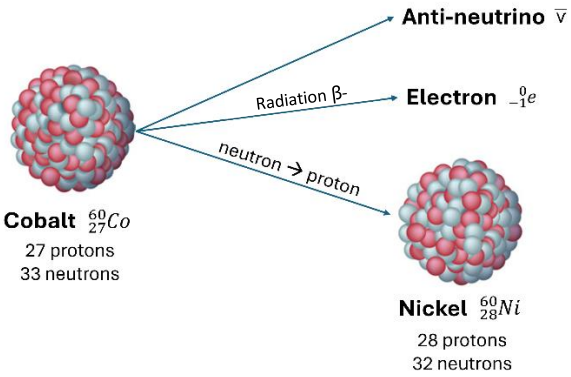
Radioactivity β+

Transformation of 1 proton into 1 neutron



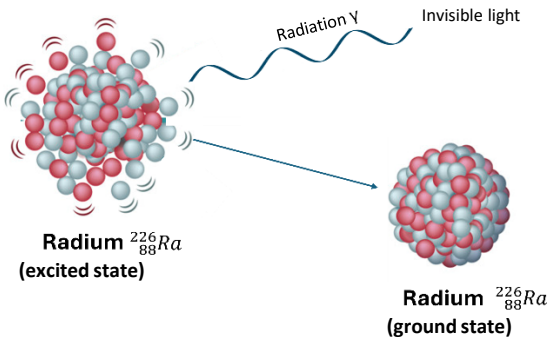
Radioactivity β-

Transformation of 1 neutron into 1 proton

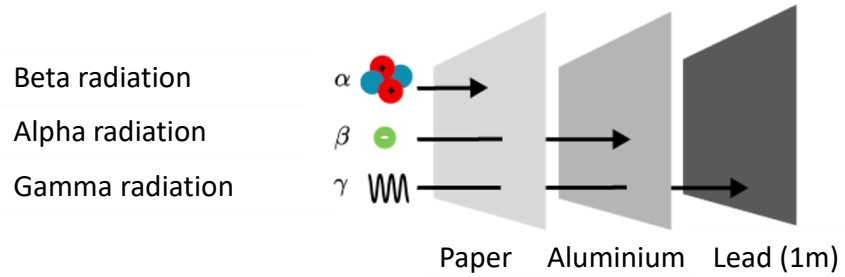


Radioactivity γ

De-excitation by electro-magnetic rays

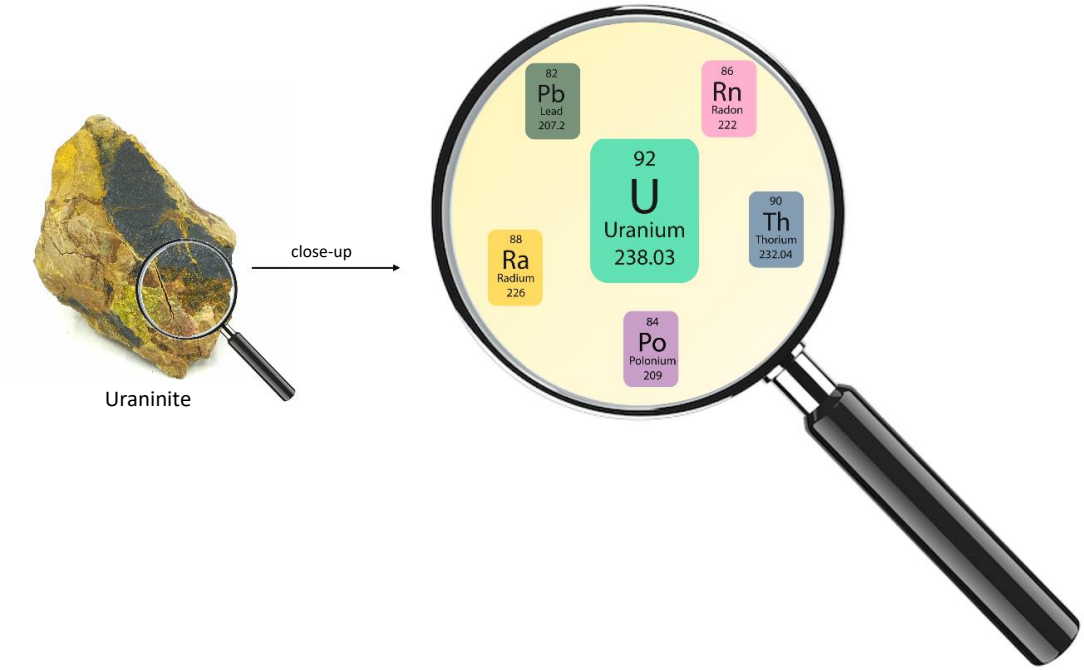


Depending on the type of rays, different types of protection are required:



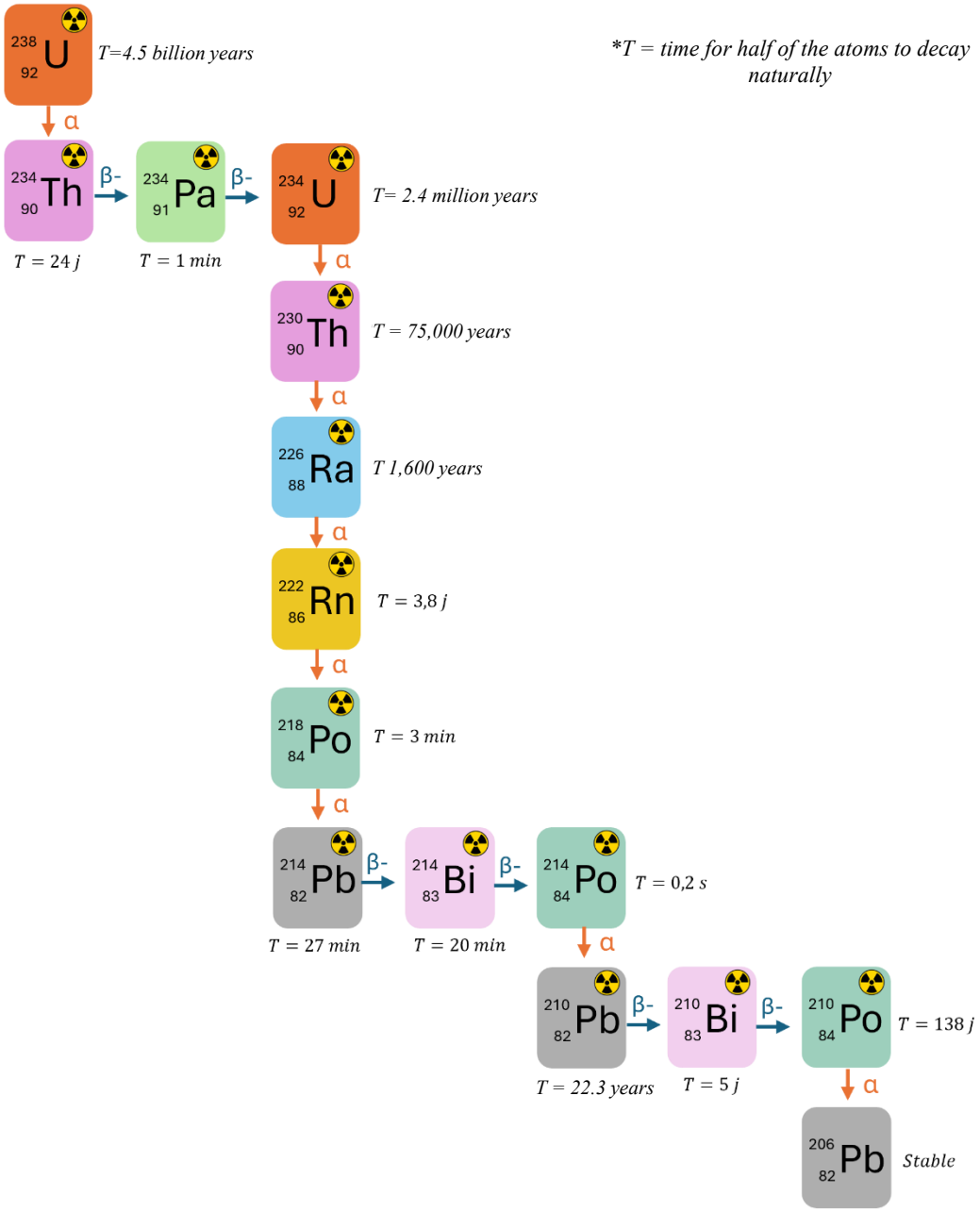
The Radioactive Family of Uranium

In uranium ores, such as pitchblende, there are many other highly radioactive atoms, such as radium and polonium, discovered in 1898 by Marie and Pierre Curie.



In fact, uranium decays into a radioactive atom, which in its turn decays into a radioactive atom until it forms a stable atom - this is called the radioactive family of uranium. Radium and polonium are part of this family, which is why they are found in uranium ores.

The more radioactive the atoms, the faster they decay.



*T = time for half of the atoms to decay naturally

Impression of the game

For the printing of these cards and other elements, here is a summary of the specifications:

1. **Types of Materials:**
    - **Activity Cards:** Cardstock similar to playing cards.
    - **Boards and Sheets:** Laminated sheets.
2. **Double-sided Printing:**
    - The cards for Activities 1 and 2, as well as some solo cards from Activity 4, will not initially be printed double-sided.
    - To make these cards easier to identify, we've added a colored back design.
3. **Back Design Colors:**
    - Activity 1 - Easy Version: Light blue, RGB (R: 180, G: 243, B: 254).
    - Activity 1 - Difficult Version: Dark blue, RGB (R: 75, G: 71, B: 239).
    - Activity 2 - Easy Version: Pink, RGB (R: 250, G: 172, B: 244).
    - Activity 2 - Difficult Version: Purple, RGB (R: 177, G: 14, B: 190).
    - Activity 4 - Solo Card 7x10: White, RGB (R: 255, G: 255, B: 255).
4. **Final Formats and Quantities:**
    - Game Set: 51 A4 sheets printed double-sided.
    - Boards: 3 A3 boards printed single-sided.
    - Table: 1 A4 table printed single-sided.
    - Sheets: 8 A4 sheets printed double-sided.

These specifications will ensure a clear and organized printing of the game components.