

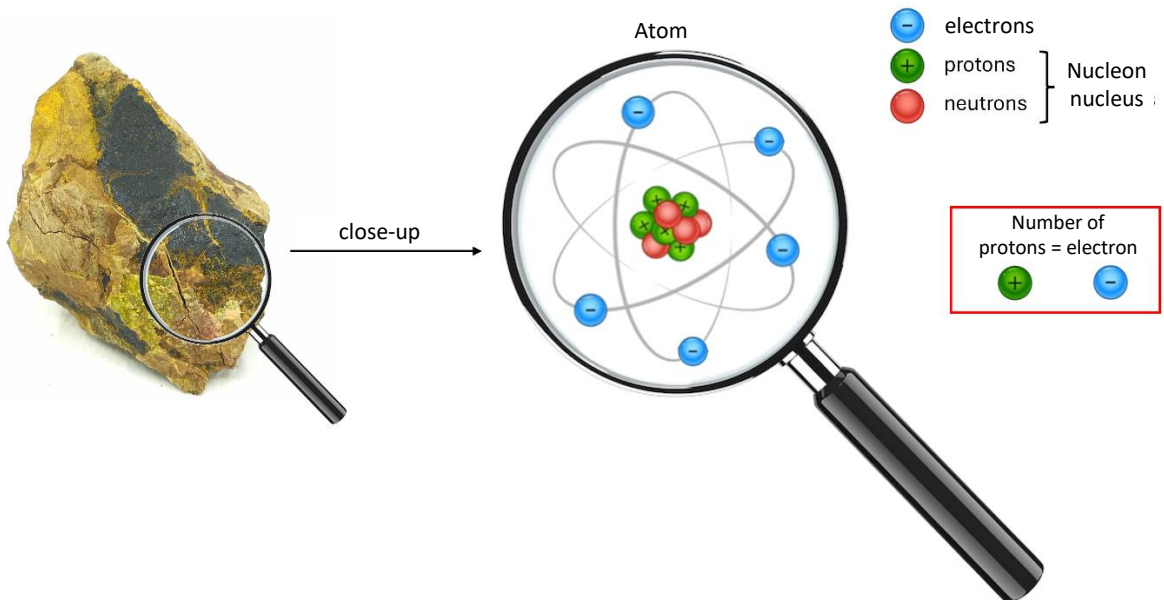
Printing boards and sheets



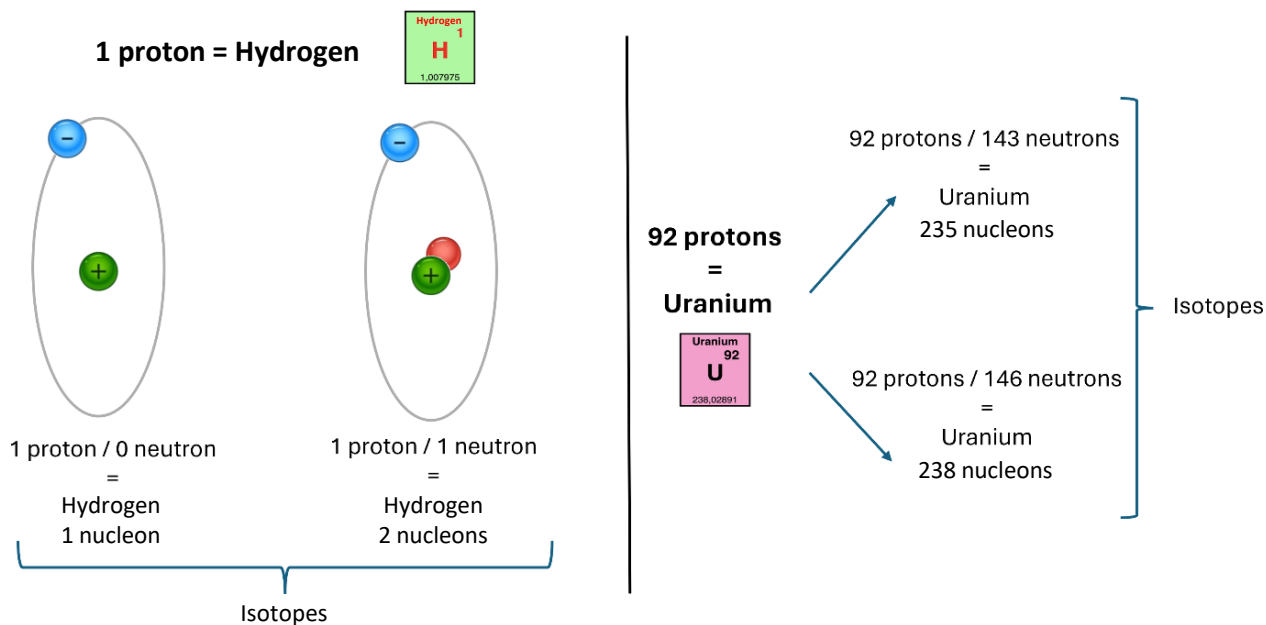
musée **CURIE**

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

Periodic table of chemical elements

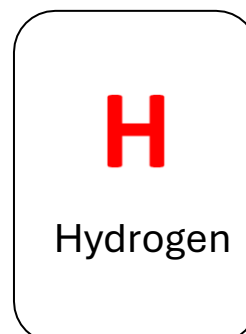
Name of the element (gas, liquid or solid at 0°C and 101.3 kPa)
 Atomic number
 Chemical symbol
 Relative atomic mass [or that of the most stable isotope]
 Source: CIAAW "Atomic Weights 2013" + Rev. 2015)

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|--|--|--|--|--|---|--|---|---|--|--|--|---|---|--|---|---|--------|--|--|--|--|--|--|--|--|--|------------|--|--|--|--|--|--|--|----------|----------------|-------------|-----------|-------------------|-------------|------------|------------------|----------|-------------|----------------|------------|-------------------------|-----------|--|--|--|--|--|
| Hydrogen 1 H 1.00794 | | | | | | | | | | | | | | | | | Helium 2 He 4.002602 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lithium 3 Li 6.939 | Beryllium 4 Be 9.0121831 | | | | | | | | | | | Boron 5 B 10.811 | Carbon 6 C 12.0106 | Nitrogen 7 N 14.006432 | Oxygen 8 O 15.9994 | Fluorine 9 F 18.9984032 | Neon 10 Ne 20.1797 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sodium 11 Na 22.98976928 | Magnesium 12 Mg 24.305 | | | | | | | | | | | Aluminium 13 Al 26.9815385 | Silicon 14 Si 28.085 | Phosphorus 15 P 30.97376200 | Sulfur 16 S 32.067 | Chlorine 17 Cl 35.453 | Argon 18 Ar 39.948 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Potassium 19 K 39.0983 | Calcium 20 Ca 40.078 | Scandium 21 Sc 44.955908 | Titanium 22 Ti 47.867 | Vanadium 23 V 50.9415 | Chromium 24 Cr 51.9961 | Manganese 25 Mn 54.938044 | Iron 26 Fe 55.845 | Cobalt 27 Co 58.933194 | Nickel 28 Ni 58.6934 | Copper 29 Cu 63.546 | Zinc 30 Zn 65.38 | Gallium 31 Ga 69.723 | Germanium 32 Ge 72.630 | Arsenic 33 As 74.921595 | Selenium 34 Se 78.971 | Bromine 35 Br 79.904 | Krypton 36 Kr 83.798 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rubidium 37 Rb 85.4678 | Strontium 38 Sr 87.62 | Yttrium 39 Y 88.90584 | Zirconium 40 Zr 91.224 | Niobium 41 Nb 92.90637 | Molybdenum 42 Mo 95.95 | Technetium 43 Tc [98] | Ruthenium 44 Ru 101.07 | Rhodium 45 Rh 102.90550 | Palladium 46 Pd 106.42 | Silver 47 Ag 107.8682 | Cadmium 48 Cd 112.414 | Indium 49 In 114.818 | Tin 50 Sn 118.710 | Antimony 51 Sb 121.760 | Tellurium 52 Te 127.60 | Iode 53 I 126.90447 | Xenon 54 Xe 131.293 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cesium 55 Cs 132.905452 | Barium 56 Ba 137.327 | Lanthanides 57-71 | Hafnium 72 Hf 178.49 | Tantalum 73 Ta 180.94788 | Tungsten 74 W 183.84 | Rhenium 75 Re 186.207 | Osmium 76 Os 190.23 | Iridium 77 Ir 192.217 | Platinum 78 Pt 195.084 | Gold 79 Au 196.966569 | Mercury 80 Hg 200.592 | Thallium 81 Tl 204.3835 | Lead 82 Pb 207.2 | Bismuth 83 Bi 208.98040 | Polonium 84 Po [209] | Astatine 85 At [210] | Radon 86 Rn [222] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Francium 87 Fr [223] | Radium 88 Ra [226] | Actinides 89-103 | Rutherfordium 104 Rf [261] | Dubnium 105 Db [268] | Seaborgium 106 Sg [269] | Bohrium 107 Bh [270] | Hassium 108 Hs [277] | Mtnerium 109 Mt [276] | Darmstadtium 110 Ds [281] | Roentgenium 111 Rg [282] | Copernicium 112 Cn [285] | Nihonium 113 Nh [286] | Flerovium 114 Fl [289] | Moscovium 115 Mc [290] | Livermorium 116 Lv [293] | Tennesine 117 Ts [294] | Oganesson 118 Og [294] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | Lanthanum 57 La 138.90547 | Cerium 58 Ce 140.116 | Praseodymium 59 Pr 140.90766 | Neodymium 60 Nd 144.242 | Promethium 61 Pm [145] | Samarium 62 Sm 150.36 | Europium 63 Eu 151.964 | Gadolinium 64 Gd 157.25 | Terbium 65 Tb 158.92535 | Dysprosium 66 Dy 162.500 | Holmium 67 Ho 164.93033 | Erbium 68 Er 167.259 | Thulium 69 Tm 168.93422 | Ytterbium 70 Yb 173.045 | Lutetium 71 Lu 174.9668 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | Actinium 89 Ac [227] | Thorium 90 Th 232.0377 | Protactinium 91 Pa 231.03688 | Uranium 92 U 238.02891 | Neptunium 93 Np [237] | Plutonium 94 Pu [244] | Americium 95 Am [243] | Curium 96 Cm [247] | Berkelium 97 Bk [247] | Californium 98 Cf [251] | Einsteinium 99 Es [252] | Fermium 100 Fm [257] | Mendelevium 101 Md [258] | Nobelium 102 No [259] | Lawrencium 103 Lr [260] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr> <td colspan="10">Metals</td> <td colspan="8">Non-metals</td> </tr> <tr> <td>Alkaline</td> <td>Alkaline earth</td> <td>Lanthanides</td> <td>Actinides</td> <td>Transition metals</td> <td>Poor metals</td> <td>Metalloids</td> <td>Other non-metals</td> <td>Halogens</td> <td>Noble gases</td> <td>Not classified</td> <td>Primordial</td> <td>Decay of other elements</td> <td>Synthetic</td> <td colspan="5"></td> </tr> </table> | | | | | | | | | | | | | | | | | | Metals | | | | | | | | | | Non-metals | | | | | | | | Alkaline | Alkaline earth | Lanthanides | Actinides | Transition metals | Poor metals | Metalloids | Other non-metals | Halogens | Noble gases | Not classified | Primordial | Decay of other elements | Synthetic | | | | | |
| Metals | | | | | | | | | | Non-metals | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Alkaline | Alkaline earth | Lanthanides | Actinides | Transition metals | Poor metals | Metalloids | Other non-metals | Halogens | Noble gases | Not classified | Primordial | Decay of other elements | Synthetic | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

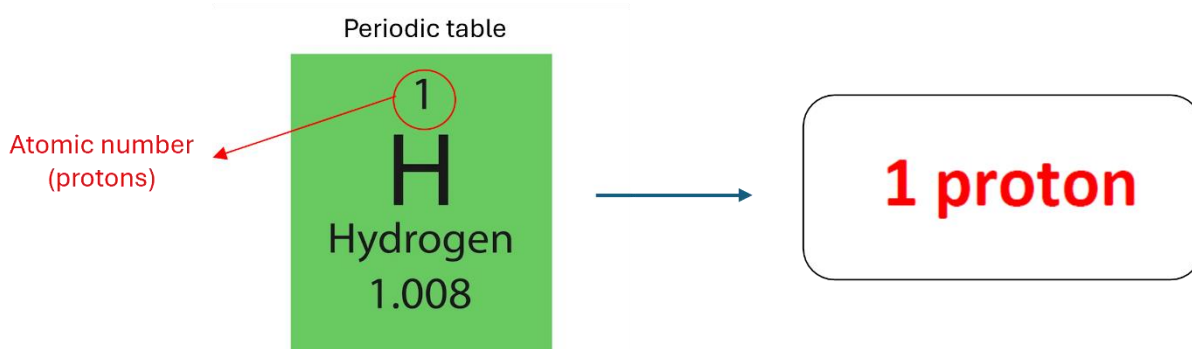
D'ARIES MICHA B/WIKIMEDIA COMMONS

Game rules - Activity 1

1 Draw a core card

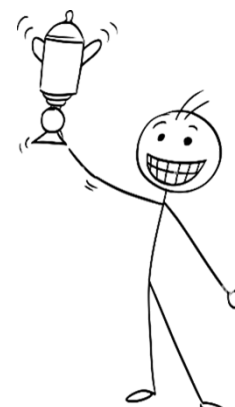


2 Find the label with the right number of protons (with help from the periodic table)



The diagram illustrates the process of identifying the number of protons. On the left, a green square represents a periodic table entry for Hydrogen. At the top, it says 'Periodic table'. Inside the square, the number '1' is circled in red. A red arrow points from this circled '1' to the text 'Atomic number (protons)'. Below the '1' is the symbol 'H', followed by the word 'Hydrogen' and the atomic weight '1.008'. A blue arrow points from the right side of the green square to a white rounded rectangular box on the right. Inside this box, the text '1 proton' is written in a large, bold, red font.

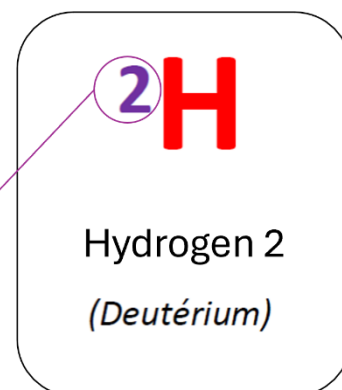
The one who finds the
most of pairs won!



Game rules - Activity 2

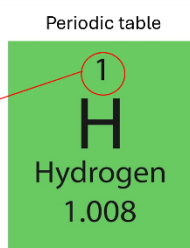
1 Draw a core card

Number of nucleons
(protons + neutrons)

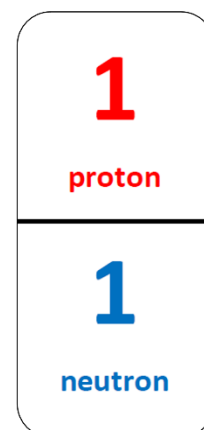


2 Find the domino carrying the right number of protons and neutrons (with the help of the periodic table)

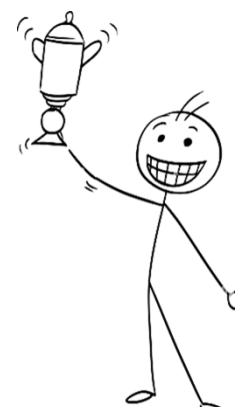
Atomic number
(protons)



$$\begin{array}{c} \text{Neutrons} \\ = \\ \text{Nucleons (2)} - \text{Protons (1)} \end{array}$$



The one who finds the most of pairs won!



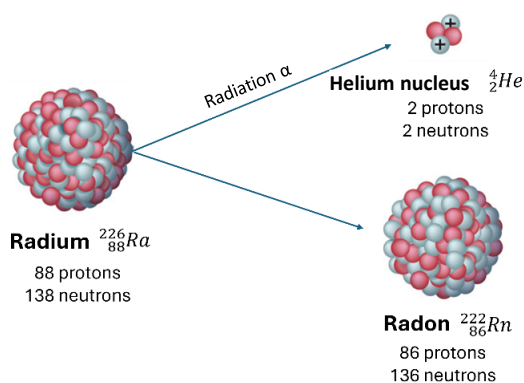
Radioactivity

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 .

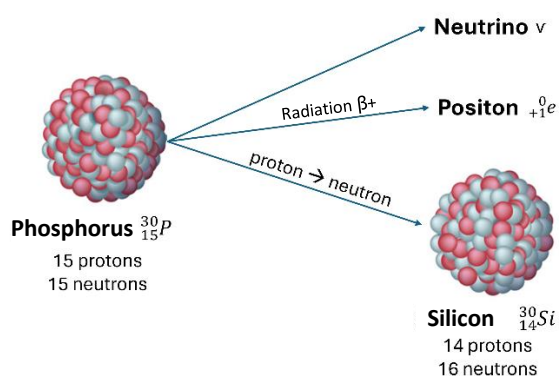
Radioactivity α

Ejection of a helium nucleus



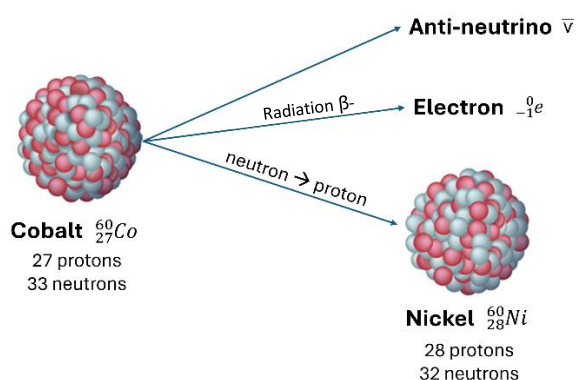
Radioactivity β^+

Transformation of 1 proton into 1 neutron



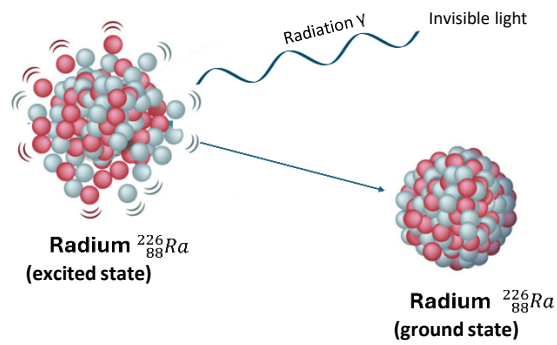
Radioactivity β^-

Transformation of 1 neutron into 1 proton

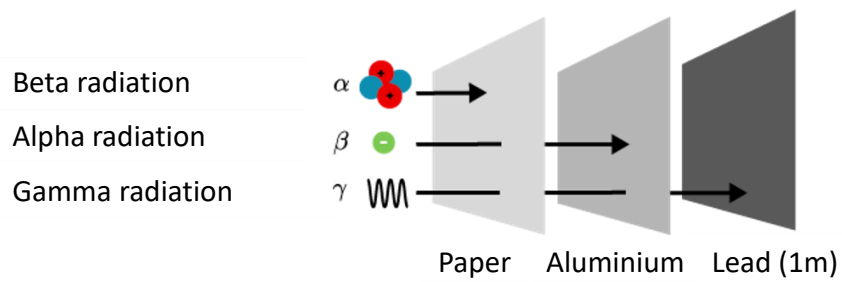


Radioactivity γ

De-excitation by electro-magnetic rays

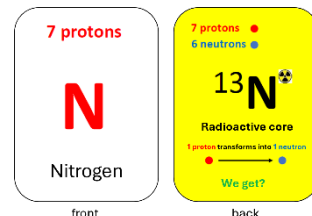


Depending on the type of rays, different types of protection are required:

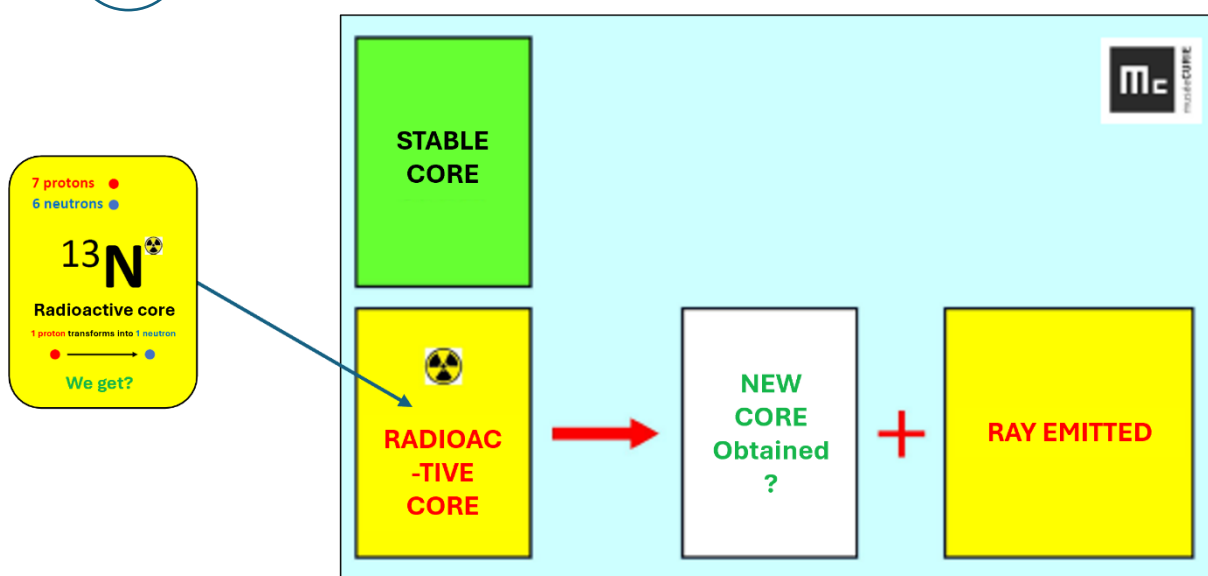


Game rules - Activity 3

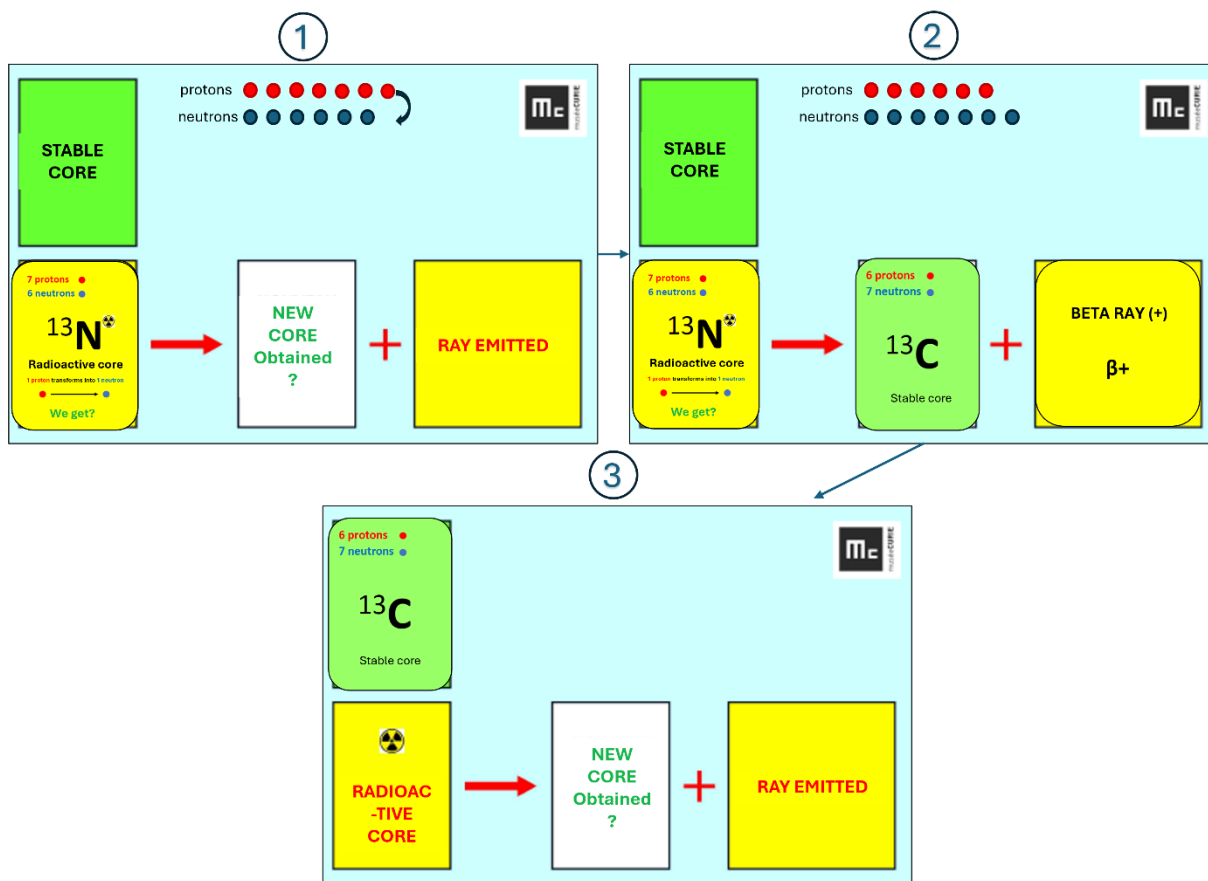
1 Draw a card from one of the families



2 Place the card back side on the board



3 Follow the instructions to obtain the new core and the radiation emitted (help yourself with the colored tokens) and continue until you obtain a stable core



4 Draw a card again...

The one who ends a family
the fastest wins!

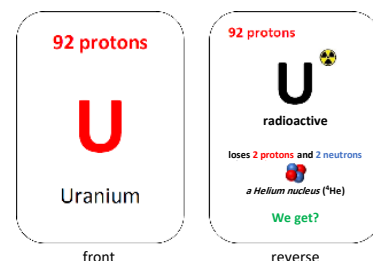


At the end of the game, all the rays emitted are those that you would have received if you manipulated these radioactive atoms!

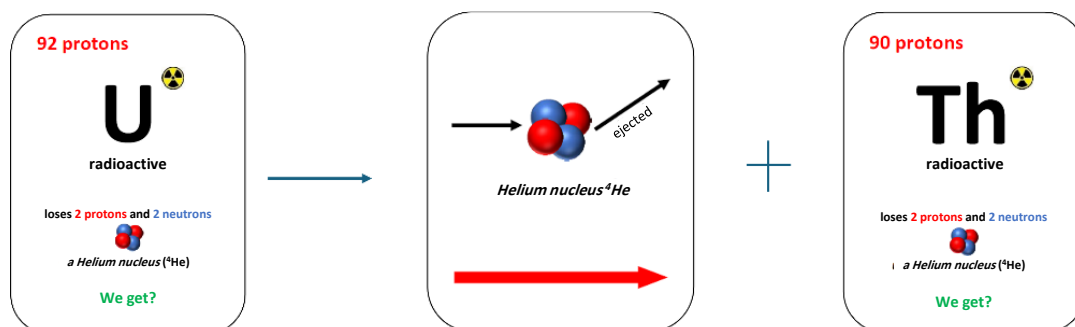


Game rules - Activity 4

- 1** Flip the Uranium card with the 92 protons

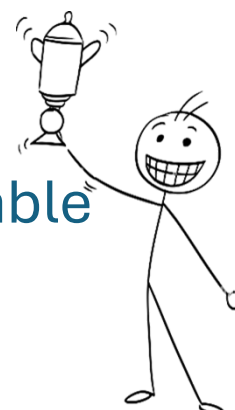


- 2** Follow the directions to obtain the new core and the radiation emitted



- 3** Continue until you obtain a stable atom

The one who falls on an atom stable
the fastest wins!

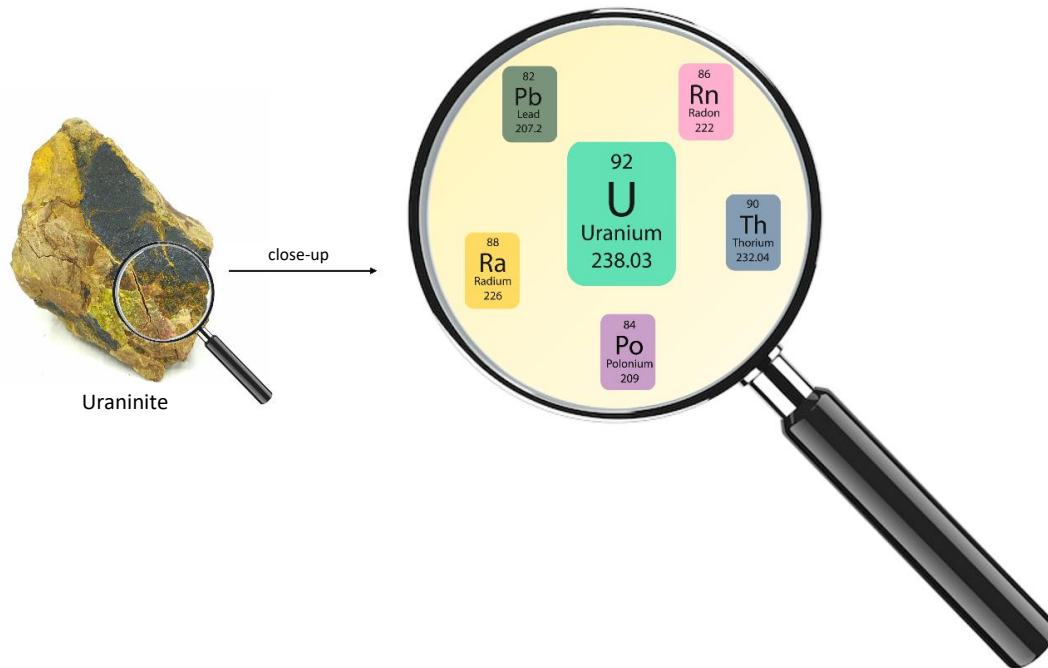


At the end of the game, all the rays emitted are those that you would have received if you manipulated these radioactive atoms!



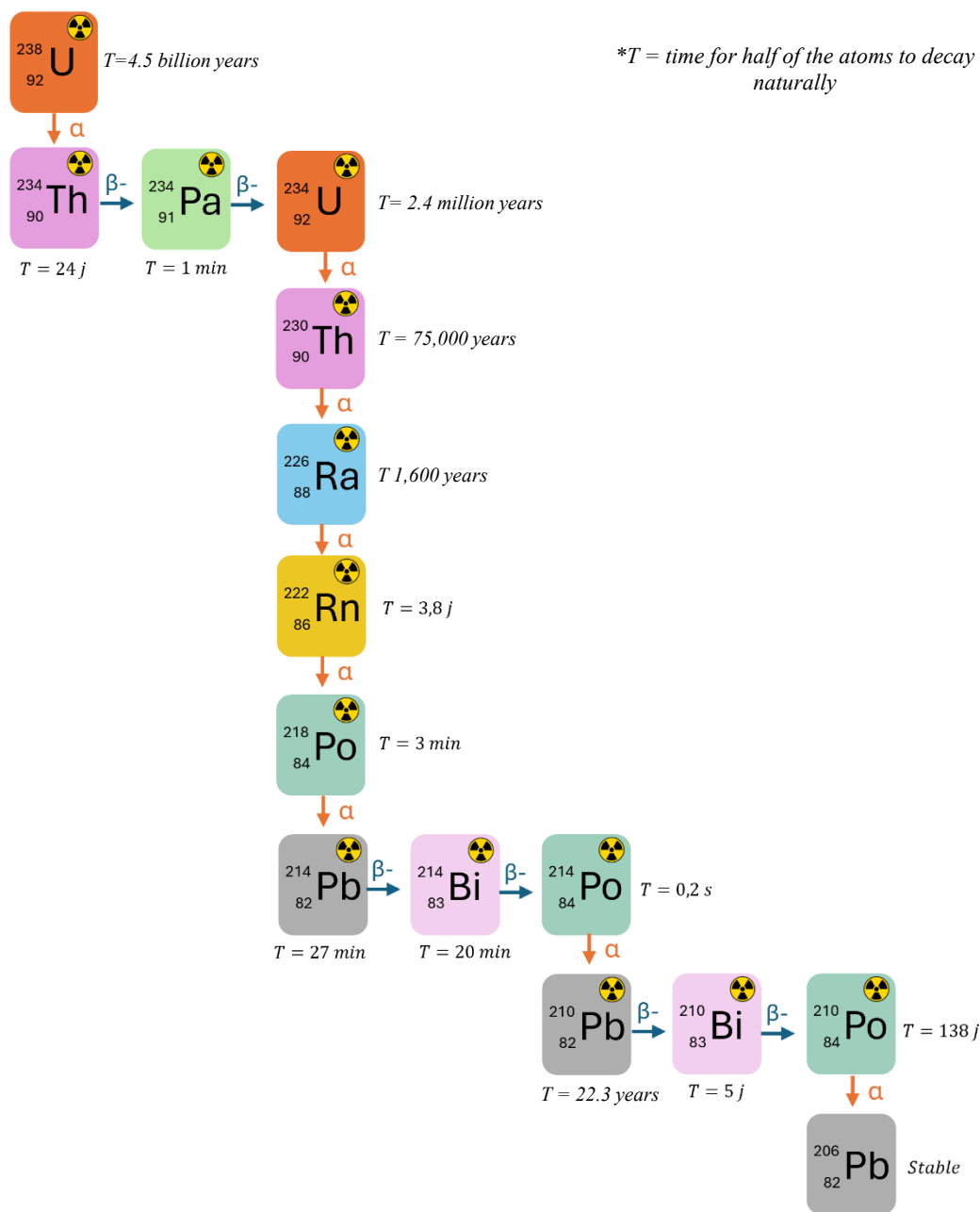
The Radioactive Family of Uranium

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.



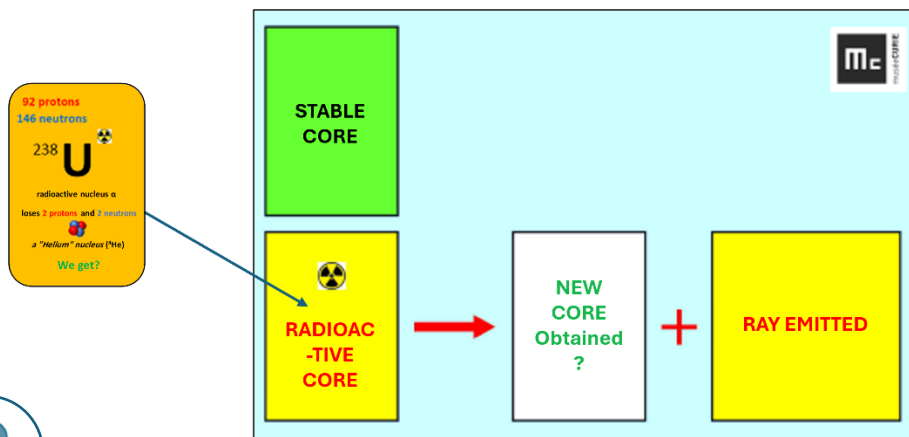
In fact, uranium decays into a radioactive atom, which in its turn decays into a radioactive atom until it forms a stable atom - this is called the radioactive family of uranium. Radium and polonium are part of this family, which is why they are found in uranium ores.

The more radioactive the atoms, the faster they decay.

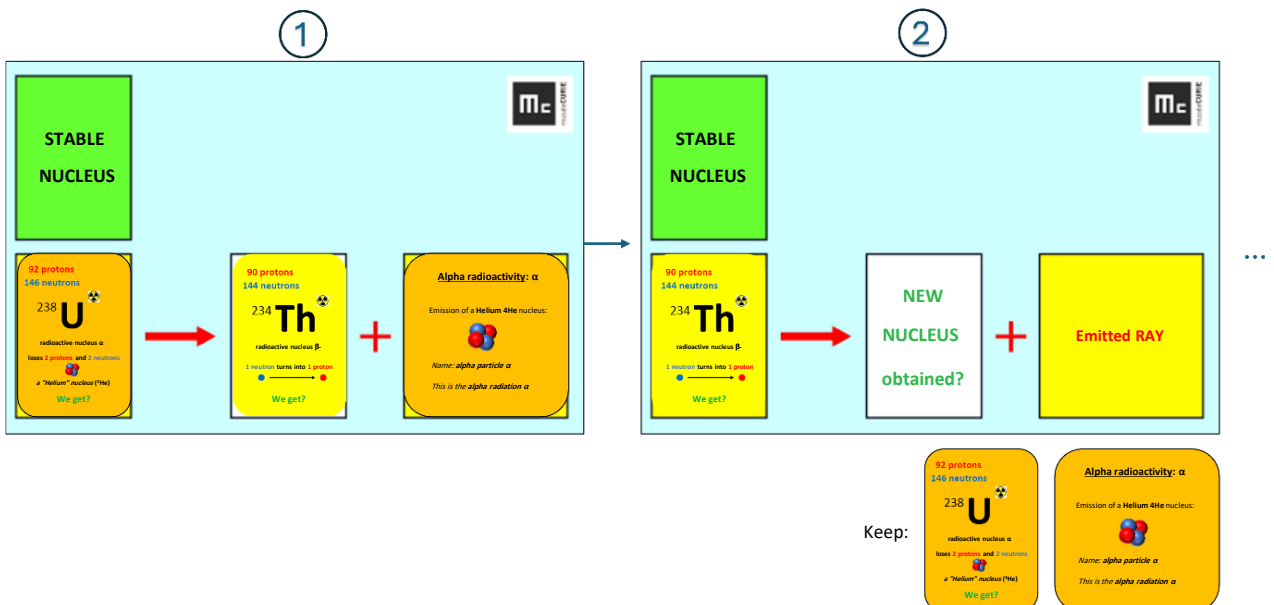


Game rules - Activity 5

- 1 Take the card corresponding to the uranium 238 nucleus and put it on the board

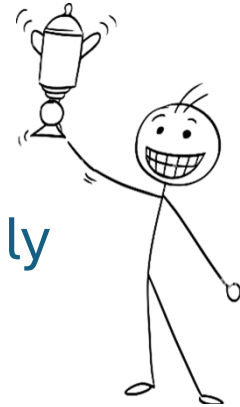


- 2 Follow the disintegration and place the card of the atom obtained and that of the ray emitted in their corresponding box



3 Continue until you obtain a stable atom

Check that you have
well found the whole family
radioactive uranium!



At the end of the game, all the rays emitted are those that you would have received if you manipulated just one of these uranium atoms!





| PERIOD | GROUP 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|--------|--------------------------------|---------------------------------|--------------------------------|-------------------------------------|--------------------------------|----------------------------------|---------------------------------|---------------------------------|----------------------------------|------------------------------------|-----------------------------------|-----------------------------------|---------------------------------|---------------------------------|---------------------------------|-----------------------------------|----------------------------------|---------------------------------|
| 1 | H Hydrogen 1.008 | | | | | | | | | | | | | | | | | He Helium 4.003 |
| 2 | Li Lithium 6.94 | Be Beryllium 9.012 | | | | | | | | | | | B Boron 10.81 | C Carbon 12.01 | N Nitrogen 14.01 | O Oxygen 16.00 | F Fluorine 19.00 | Ne Neon 20.18 |
| 3 | Na Sodium 22.99 | Mg Magnesium 24.31 | | | | | | | | | | | Al Aluminum 26.98 | Si Silicon 28.09 | P Phosphorus 30.97 | S Sulfur 32.06 | Cl Chlorine 35.45 | Ar Argon 39.95 |
| 4 | K Potassium 39.10 | Ca Calcium 40.08 | Sc Scandium 44.96 | Ti Titanium 47.88 | V Vanadium 50.94 | Cr Chromium 52.00 | Mn Manganese 54.94 | Fe Iron 55.85 | Co Cobalt 58.93 | Ni Nickel 58.69 | Cu Copper 63.55 | Zn Zinc 65.39 | Ga Gallium 69.72 | Ge Germanium 72.64 | As Arsenic 74.92 | Se Selenium 78.96 | Br Bromine 79.90 | Kr Krypton 83.79 |
| 5 | Rb Rubidium 85.47 | Sr Strontium 87.62 | Y Yttrium 88.91 | Zr Zirconium 91.22 | Nb Niobium 92.91 | Mo Molybdenum 95.96 | Tc Technetium (98) | Ru Ruthenium 101.1 | Rh Rhodium 102.9 | Pd Palladium 106.4 | Ag Silver 107.9 | Cd Cadmium 112.4 | In Indium 114.8 | Sn Tin 118.7 | Sb Antimony 121.8 | Te Tellurium 127.6 | I Iodine 126.9 | Xe Xenon 131.3 |
| 6 | Cs Cesium 132.9 | Ba Barium 137.3 | 57-71 Lanthanides | Hf Hafnium 178.5 | Ta Tantalum 180.9 | W Tungsten 183.9 | Re Rhenium 186.2 | Os Osmium 190.2 | Ir Iridium 192.2 | Pt Platinum 195.1 | Au Gold 197.0 | Hg Mercury 200.5 | Tl Thallium 204.38 | Pb Lead 207.2 | Bi Bismuth 209.0 | Po Polonium (209) | At Astatine (210) | Rn Radon (222) |
| 7 | Fr Francium (223) | Ra Radium (226) | 89-103 Actinides | Rf Rutherfordium (261) | Db Dubnium (261) | Sg Seaborgium (263) | Bh Bohrium (264) | Hs Hassium (277) | Mt Meitnerium (266) | Ds Darmstadtium (281) | Rg Roentgenium (281) | Cn Copernicium (285) | Nh Nihonium (284) | Fl Flerovium (289) | Mc Moscovium (288) | Lv Livermorium (293) | Ts Tennessine (294) | Og Oganesson (294) |

- Alkali Metals
- Alkaline Earth Metals
- Transition Metals
- Other Metals
- Metalloids
- Non-metals
- Halogens
- Noble Gases
- Lanthanides
- Actinides

78 — Atomic Number
Pt — Symbol
 Platinum — Name
 195.1 — Average Atomic Mass

| | | | | | | | | | | | | | | |
|---------------------------------|-------------------------------|------------------------------------|---------------------------------|----------------------------------|---------------------------------|---------------------------------|----------------------------------|---------------------------------|-----------------------------------|-----------------------------------|-------------------------------|-----------------------------------|---------------------------------|----------------------------------|
| 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 |
| La Lanthanum 138.9 | Ce Cerium 140.1 | Pr Praseodymium 140.9 | Nd Neodymium 144.2 | Pm Promethium (145) | Sm Samarium 150.4 | Eu Europium 152.0 | Gd Gadolinium 157.2 | Tb Terbium 158.9 | Dy Dysprosium 162.5 | Ho Holmium 164.9 | Er Erbium 167.3 | Tm Thulium 168.9 | Yb Ytterbium 173.0 | Lu Lutetium 175.0 |
| 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 |
| Ac Actinium (227) | Th Thorium 232.0 | Pa Protactinium 231.0 | U Uranium 238.0 | Np Neptunium (237) | Pu Plutonium (244) | Am Americium (243) | Cm Curium (247) | Bk Berkelium (247) | Cf Californium (251) | Es Einsteinium (252) | Fm Fermium (257) | Md Mendelevium (258) | No Nobelium (259) | Lr Lawrencium (262) |

5 protons

B

Boron

6 protons

C

Carbon

7 protons

N

Nitrogen

8 protons

O

Oxygen

9 protons

F

Fluorine

**STABLE
CORE**


**RADIOAC-
TIVE
CORE**



**NEW
CORE
obtained ?**



**RAYS
EMITTED**