Thème : Constitution et transformations de la matière	P9 : Transformations nucléaires

Activity 1 : Nuclear fission and fusion

Activity Goals :

-identify the physical, chemical, or nuclear nature of a transformation

-link Energy and matter

Doc 0 : useful info

→ *vocabulary*

Token	To spur	Unsung	To overshadow	To grab	Nucleus	Energy release	To occur	Physical quantity	reactant
gage, symbole	inciter, pousser	méconnu	**éclipser**	saisir	noyau	dégagement /libération d'énergie	avoir lieu	grandeur physique (masse, charge, énergie…)	réactif

→*nuclei ,particles and their symbols*

Nucleus/particle	Baryum	Deuterium	Helium	Hydrogen	Krypton	Neutron	Tritium	Uranium
Symbol	$^{140}_{56}Ba$	$^{2}_{1}H$	$^{4}_{2}$He	$^{1}_{1}H$	$^{93}_{36}Kr$	$^{1}_{0}n$	$^{3}_{1}H$	$^{235}_{92}U$

Part one : Lise Meitner and the discovery of fission

Doc1 : The Matilda effect

http://www.openculture.com/2018/08/the-matilda-effect.html

(extract)

I the history of science, like most every history we learn, comes to us as a procession of great, almost exclusively white, men, unbroken but for the occasional token woman—well-deserving of her honors but seemingly anomalous nonetheless. "If you believe the history books," notes the Timeline series The Matilda Effect, "science is a guy thing. Discoveries are made by men, which spur further innovation by men, followed by acclaim and prizes for men. But too often, there is an unsung woman genius who deserves just as much credit" and who has been overshadowed by male colleagues who grabbed the glory.

In 1993, Cornell University historian of science Margaret Rossiter dubbed the denial of recognition to women scientists "the Matilda effect," for suffragist and abolitionist Matilda Joslyn Gage, whose 1893 essay "Woman as an Inventor" protested the common assertion that "woman… possesses no inventive or mechanical genius." Gage wrote that "even the United States census" failed "to enumerate her among the inventors of the country." Such assertions, Gage proceeded to demonstrate, "are carelessly or ignorantly made… although woman's scientific education has been grossly neglected, yet some of the most important inventions of the world are due to her."

Over 100 years later, Rossiter's tenacious work in unearthing the contributions of U.S. women scientists inspired the History of Science Society to name a prestigious prize after her. The Timeline series profiles of the few of the women whom it describes as prime examples of the Matilda effect, including Dr. Lise Meitner, the Austrian-born physicist and pioneer of nuclear technology who escaped the Nazis and became known in her time as "the Jewish Mother of the Bomb," though she had nothing to do with the atomic bomb. Instead, "Meitner led the research that ultimately discovered nuclear fission." But Meitner would become "little more than a footnote in the history of Nazi scientists and the birth of the Atomic age."

Instead, Meitner's colleague Otto Hahn received the accolades, a Nobel Prize in Chemistry and "renown as the discoverer of nuclear fission. Meitner, who directed Hahn's most significant experiments and calculated the energy release resulting from fission, received a few essentialist headlines followed by decades of obscurity." Likewise, the name of Alice Augusta Ball has been "all but scrubbed from the history of medicine," though it was Ball, an African American chemist from Seattle, Washington, who pioneered what became known as the Dean Method, a revolutionary treatment for leprosy.

Doc 2 : nuclear fission

https://www.classzone.com/books/earth_science/terc/content/visualizations/es0702/es0702page01.cfm?chapter_no=visualization

Part two : Nuclear fusion in the Sun

Doc 3 : Nuclear fusion (animation)

https://www.youtube.com/watch?v=1n8OPDRsupw

Doc 4 : how does fusion power the Sun?

https://www.youtube.com/watch?v=W1ZQ4JBv3-Y

Questions

1. Explain in your own words the difference between a nuclear reaction and a chemical reaction.
   A nuclear reaction occurs within the atom's nucleus, it modifies the atom itself, whereas a chemical reaction modifies the arrangement of the atoms.
2. Which conservation laws should a nuclear reaction respect?
   Two physical quantities are conserved : the number of protons and neutrons has to be the same on both sides of the equation.

Part 1 : nuclear fission

3. Explain nuclear fission (cause, results).
   Nuclear fission occurs when a neutron hits a heavy nucleus. This nucleus becomes unstable, it splits into 2 lighter nuclei. As a result, neutrons and a great amount of energy are released.
4. Explain why a neutron is used to achieve fission (and not a proton or an electron for instance).
   A charged particle cannot be used to achieve fission :
   -in case of a positive particle, it would be repelled by the nucleus (two positive charges repel each other).
   -in case of a negative particle , it would be attracted by the nucleus (a positive and a negative particle attract each other) .
5. Using conservation laws, write the equation of the fission of the ^{235}U nucleus.
   Two physical quantities are conserved : the number of protons and neutrons has to be the same on both sides of the equation.
   According to document #2, a ^{235}U nucleus gets hit by a neutron and becomes ^{236}U , which is unstable .
   This ^{236}U splits into 2 lighter nuclei, and releases 3 neutrons :

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{236}_{92}U \rightarrow {}^{140}_{56}Ba + {}^{93}_{36}Kr + 3\,{}^{1}_{0}n$$

6. A)Who discovered nuclear fission? Lise Meitner is the physicist who discovered nuclear fission : she calculated the energy released by fission and led the main experiments.
   B) Who got credited for this discovery? Otto Hahn got credited for the discovery, he received the Nobel prize in Chemistry.
   C) Define the Matilda effect. The Matilda effect was theorized in 1993 by Margaret Rossiter (historian of science). It was named after Matilda Joslyn Gage, who wrote an essay about the non-recognition of women's work in science . In the 1800's , women in science were rare. They gave a big contribution to scientific discoveries, but men got credit for the discoveries.
7. Give a real-life example of nuclear fission. Nuclear fission occurs in nuclear powerplants.

Part 2 : nuclear fusion

8. What is the difference between deuterium and tritium? What are these two nuclei called?
   Deuterium and tritium nuclei have the same number of protons, but a different number of neutrons. These nuclei are called isotopes.
9. Explain nuclear fusion (cause , results). Two light atoms hit each other and become one heavier nucleus.
10. Using conservation laws, write the equation of the fusion of deuterium and tritium.
    Two physical quantities are conserved : the number of protons and neutrons has to be the same on both sides of the equation.
    According to document #3, Deuterium and tritium nuclei hit each other and as a result, a Helium nucleus is created and a neutron is released

$$^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$$

11. Why does nuclear fusion occur in the Sun? According to document #4 , fusion is very difficult to achieve under "normal" temperature and pressure conditions, since protons repel each other. Fusion occurs in the Sun because of the special conditions there (temperature and pressure) . The gravitational force overcomes repulsion, which leads to fusion reactions in the Sun.
12. Which physical quantity is converted into Energy during fusion?
    During fusion, the number of protons and neutrons is conserved.
    But in the process, a bit of mass is lost (mass of the products < mass of the reactants) and this mass is converted into energy, according to Einstein's famous equation E= m. c^2.