1

Element 92 - U

3 isotopes: ^{238}U (99.3%) ^{235}U (0.7%) ^{234}U (trace)

2×10^{-5} % by weight in earth's crust

U_3O_8 (pitchblend)

^{235}U used in weapons; ^{234}U and ^{235}U are used in nuclear power plants

"Nothing in life is to be feared. It is only to be understood."

--Marie Curie

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Discovery of Radioactivity

1. X-rays (W. Roentgen)
2. Bequerel- studying phosphorescent (glow in the dark) rocks. Saw that something was emitted from rock which exposed film. Deduced it was a + charged particle now known as α particle (He^{2+} ion).
3. Rutherford. Deduced there were 3 types of particles emitted from radioactive source.
4. Madame Curie. Went on to find new radioactive elements.

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Properties of the Three Particles

Particle	Identity	Distance Traveled	Penetrating Power
α	$^{4}_{2}He^{2+}$ helium ion	few mm	paper
ß	$^{0}_{-1}e$ electron	few cm	0.5 cm of lead
γ	$^{0}_{0}\gamma$ photon	until it hits something	10 cm of lead

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Nuclear Reaction Defined

Nuclear Reaction- natural change of an isotope of one element into an isotope of a different element.

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Differences Between Chemical and Nuclear Reactions

1. Not balanced in the traditional sense. In other words, we don't have the same elements on both sides of the equation.

Balance *nucleons* instead

nucleons- protons and neutrons

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One Nuclear Reaction (α emission)

$^{226}_{88}Ra$

Parent Nucleus

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One Nuclear Reaction (α emission)

$$^{226}_{88}Ra \longrightarrow {}^{222}_{86}Rn + {}^{4}_{2}He^{2+}$$

Parent Nucleus — Daughter Nucleus

You are not expected to know what type of decay an element undergoes.

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Differences Between Chemical and Nuclear Reactions Continued

2. Reactions involve nucleus instead of electrons.
3. A huge amount of energy is involved in a nuclear reaction, small amount in chemical reaction.
4. Temperature and pressure have no effect on nuclear, but do influence chemical reactions.

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Sample Test Question

What product is formed by alpha emission from uranium-235?

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Second Kind of Nuclear Reaction (ß-emission)

$$^{3}_{1}H \longrightarrow {}^{3}_{2}He + {}^{0}_{-1}e$$

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Other Kinds of Nuclear Reactions are Known, Including Positron Emission

Positron- positively charged electron

$$^{30}_{15}P \longrightarrow {}^{30}_{14}Si + {}^{0}_{+1}e$$

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Decay Series

Decay Series- The decay of a heavy radioactive element proceeds through a series of defined intermediates. The same pathway is always followed.

^{206}Pb is a common decay product

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Why are Some Elements Stable and Others are Radioactive?

Z- the atomic number.

All elements with Z>82 are radioactive

A second factor is the ratio of Neutrons (N) to Protons (Z). *Generally*, stable isotopes will be N=Z.

Put another way, 2Z=mass for stable isotopes.

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Half-life

Half-life- the amount of time it takes for 1/2 the mass of a radioactive element to decay.

- ^{238}U - 4.51 billion years
- ^{14}C - 5730 years
- ^{3}H - 12.3 years
- ^{35}S - 90 days

can be less than a second

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How is Radioactivity Expressed?

Becquerel (Bq)- one disintegration per second (dps).

Curie (Ci)- 1 Ci is 3.7×10^{10} dps or
1 μCi is 37,000 dps

Rem = roentgen equivalent to man

Example Problem
The EPA requires action if 4.0 pCi of radiation are found in 1.0 L of air. How many dps is this amount?

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What is Your Exposure to Radiation?

80-85% is from natural sources
- Radon- geology is important
- "Internal"
- Cosmic- location is important
- Terrestrial

15-20% from manmade sources
- X-rays and other medical uses

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What is Your Exposure to Radiation?

It is important to note that exposure is cumulative.

Exposure is measured in mRem (Rem = roentgen equivalent to man).

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What Happens Once You're Exposed to Radiation?

Chemical Bonds can be (and often are) broken

Somatic effects- affect only the cell exposed

Genetic effects- passed on to offspring

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Natural and Artificial Nuclear Reactions

$$^{1}_{0}n + {}^{14}_{7}N \longrightarrow {}^{14}_{6}C + {}^{1}_{1}H$$

$$^{4}_{2}He + {}^{14}_{7}N \longrightarrow [{}^{18}_{9}F] \longrightarrow {}^{17}_{8}O + {}^{1}_{1}H$$

Compound Nucleus

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Many Other Elements have been Made

- Most are so unstable their properties can't be determined.
- Accelerators are used (cyclotron).

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Transuranium Elements

Transuranium Elements- elements with Z > 92

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How is Radiation Used?

1. Basic Research
2. Time-Dating of Samples

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Sample Test Question

1. How old is a fossil that only contains 6.25% of the original carbon-14? The carbon-14 half-life is 5,730 years.

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How is Radiation Used?

1. Basic Research
2. Time-Dating of Samples
3. Medical Use
4. Irradiating Food
5. Materials testing

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Problem Set 3 - Due October 4th

On the course web page

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Chemical Bonds can be (and often are) Broken When You're Exposed to Radiation

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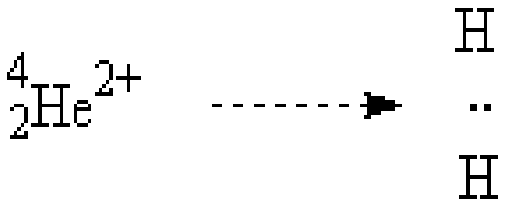
Chemical Bonds can be (and often are) Broken When You're Exposed to Radiation



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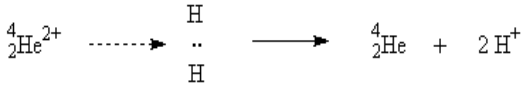
Chemical Bonds can be (and often are) Broken When You're Exposed to Radiation



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Chemical Bonds can be (and often are) Broken When You're Exposed to Radiation