ANSWER KEY.

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Nuclear Stability and Nuclear Energy

Chemistry | ANSWER KEY

Use a periodic table. Show your work. Use the word bank and sentence frames where they are given.

1. Match each description with a word from the word bank. Each word is used once.

Word bank: alpha decay, beta decay, gamma decay, fission, fusion

(a) Two small nuclei join into one larger nucleus. (b) A helium-4 nucleus leaves the nucleus.

(c) A large nucleus splits into two smaller nuclei. (d) High-energy light leaves the nucleus.

(e) A neutron turns into a proton, and a fast electron leaves the nucleus.

(a) **fusion** (b) **alpha decay** (c) **fission** (d) **gamma decay** (e) **beta decay**

2. Complete the table. The first row is done for you.

Particle	Symbol	Mass number	Charge
alpha particle	$^{4}_{2}\mathrm{He}$	4	2+
beta particle	$\mathbf{^{0}_{-1}e}$	**0**	**1−**
gamma ray	$\mathbf{^{0}_{0}\gamma}$	**0**	**0**
neutron	$\mathbf{^{1}_{0}n}$	**1**	**0**

See the completed table. A beta particle is an electron, so its mass number is 0 and its charge is 1−.

3. Is each nucleus likely to be stable or radioactive? Explain using the numbers of protons and neutrons.

(a) oxygen-16 (8 protons, 8 neutrons) (b) carbon-14 (6 protons, 8 neutrons) (c) uranium-238 (92 protons, 146 neutrons)

Sentence frame: _____ *is* _____ *because* _____.

(a) **Stable:** a small nucleus with equal protons and neutrons (8 and 8). (b) **Radioactive:** 8 neutrons for 6 protons is too many neutrons for a small nucleus.

(c) **Radioactive:** every element after atomic number 83 has only unstable isotopes, and uranium is 92.

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4. Complete each nuclear equation. Name the new element or the missing particle.

(a) $^{210}_{84}\text{Po} \rightarrow {}^{206}_{82}\text{Pb} + ?$ *First step: 210 = 206 + ?, and 84 = 82 + ?*

(b) $^{60}_{27}\text{Co} \rightarrow ? + {}^{0}_{-1}\text{e}$ (c) $^{238}_{92}\text{U} \rightarrow ? + {}^{4}_{2}\text{He}$ (d) $^{131}_{53}\text{I} \rightarrow {}^{131}_{54}\text{Xe} + ?$

(a) mass 210 − 206 = 4, atomic 84 − 82 = 2: $^{4}_{2}$**He, an alpha particle**.

(b) mass 60 − 0 = 60, atomic 27 − (−1) = 28: $^{60}_{28}$**Ni, nickel-60**.

(c) mass 238 − 4 = 234, atomic 92 − 2 = 90: $^{234}_{90}$**Th, thorium-234**.

(d) mass 131 − 131 = 0, atomic 53 − 54 = −1: $^{0}_{-1}$**e, a beta particle**.

5. Identify each decay as alpha, beta, or gamma. An asterisk (*) means the nucleus has extra energy.

(a) $^{222}_{86}\text{Rn} \rightarrow {}^{218}_{84}\text{Po} + {}^{4}_{2}\text{He}$ (b) $^{3}_{1}\text{H} \rightarrow {}^{3}_{2}\text{He} + {}^{0}_{-1}\text{e}$ (c) $^{60}_{28}\text{Ni}^{*} \rightarrow {}^{60}_{28}\text{Ni} + {}^{0}_{0}\gamma$

(a) **alpha**: mass number down 4, atomic number down 2. (b) **beta**: same mass number, atomic number up 1.

(c) **gamma**: only energy leaves, so both numbers stay the same.

6. Classify each reaction as fission or fusion. Then check that it is balanced.

(a) $^{1}_{0}\text{n} + {}^{235}_{92}\text{U} \rightarrow {}^{139}_{56}\text{Ba} + {}^{94}_{36}\text{Kr} + 3\ {}^{1}_{0}\text{n}$ (b) $^{1}_{1}\text{H} + {}^{2}_{1}\text{H} \rightarrow {}^{3}_{2}\text{He}$

(a) **Fission**: a large nucleus splits. Mass: 1 + 235 = 236 and 139 + 94 + 3 = 236. Atomic: 0 + 92 = 92 and 56 + 36 + 0 = 92.

(b) **Fusion**: two small nuclei join. Mass: 1 + 2 = 3. Atomic: 1 + 1 = 2. Both sides match.

7. In a model chain reaction, each fission releases neutrons, and each neutron causes one new fission. Step 1 has 1 fission.

(a) If each fission releases 2 neutrons, how many fissions happen in step 5? (b) If each releases 3 neutrons, how many in step 5?

(c) Control rods in a power plant absorb some neutrons. Explain why this keeps the reaction steady.

(a) 1, 2, 4, 8, **16 fissions**. (b) 1, 3, 9, 27, **81 fissions**.

(c) If the rods absorb the extra neutrons, each fission causes only **about one new fission**, so the number of fissions and the energy released stay about the same each step instead of growing.

8. Splitting one uranium-235 nucleus releases about 200,000,000 eV of energy. Burning one carbon atom releases about 4 eV.

(a) About how many times more energy does one fission release?

(b) A student says a nuclear power plant burns uranium the way a coal plant burns coal. Explain why the student is wrong.

Sentence frame: *The student is wrong because burning is a _____ change, but fission is a _____ change that _____.*

(a) 200,000,000 ÷ 4 = **50,000,000 times** (about 50 million).

(b) Burning is a **chemical change**: atoms only rearrange their electrons. Fission is a **nuclear change**: the uranium nucleus splits into new elements, and it releases millions of times more energy per atom.

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