

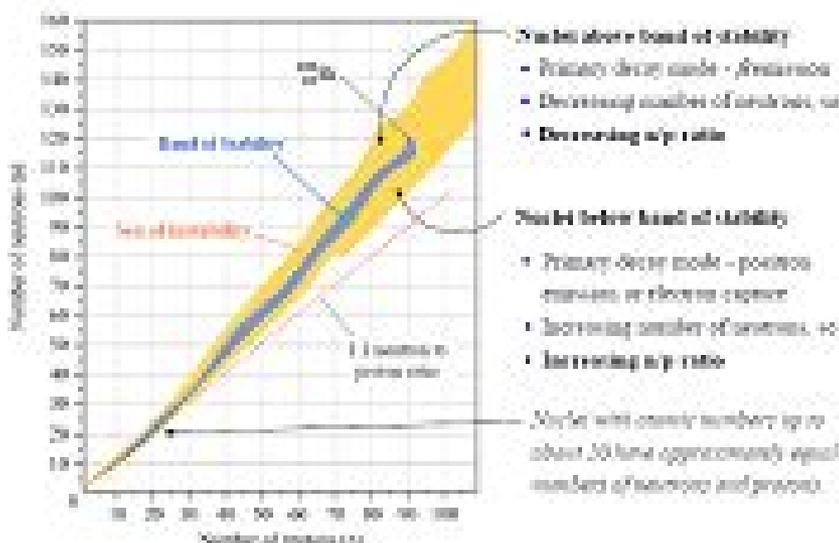
Nuclear Stability

We can establish a pattern of reactions between protons and neutrons in nuclear reactions



The question is why. For example, some nuclei undergo an alpha decay and not a beta decay. This has to do with the neutrons to proton ratio (n/p) in the nuclei. When the nuclei of all 1000 known isotopes are plotted based on their number of protons and neutrons, a band/belt of stability is obtained (blue region). The nuclei in this region are stable. The isotopes that fall outside of this region (are off-balance) are radioactive and decay spontaneously. Example 11 is the last element on the band of stability, so all nuclei with 84 or more protons are radioactive. The type of radioactivity depends on the n/p

- The nuclei above the band of stability tend to decrease the n/p ratio.
- The nuclei below the band of stability tend to increase the n/p ratio.



Nuclei with the magic numbers of 2, 8, 20, 28, 50, or 82 protons or 2, 8, 20, 28, 50, 82, or 126 neutrons, and in general, with even numbers of protons, neutrons are more stable.

Rates of Radioactive Decay

Radioactive decay obeys first-order kinetics laws. And although the half-life of radioactive elements may vary enormously (10^2 second to billions of years), it is independent of the quantity of the element. This advantage is used in **radiocarbon dating** which is used for **estimating the ages of fossils and artifacts**. The technique is based on the rate of ${}^{14}\text{C}$ decay which spreads from the atmosphere to living organisms.



The half-life of carbon 14 decay is averaged by emission of a β^- particle is 5715 years.



The ${}^{14}\text{C} : {}^{12}\text{C}$ ratio is constant in living organisms. However, when a living organism dies, the ${}^{14}\text{C} : {}^{12}\text{C}$ ratio begins to decrease, and so does the decay rate of ${}^{14}\text{C}$. The relationship of the quantity or rates of decay is given by the first-order rate law:

$$\ln \left(\frac{N}{N_0} \right) = -kt \quad \ln \left(\frac{\text{rate}_t}{\text{rate}_0} \right) = -kt$$

Example: A sample of wood from an Egyptian mummy case gives a count of 9.4 counts/g this is the current decay rate (assumed exponentially). How old is the wood if its initial decay rate is 15.3 counts/g?

Solution: We are going to use the integrated rate law of first-order reactions. The rates are given, so we need to determine the rate constant of the decay.

The half-life of first-order reactions is $t_{1/2} = 0.693/k$. Therefore, $k = 1.209 \times 10^{-4} \text{ y}^{-1}$.

$$k = \frac{0.693}{t_{1/2}} = \frac{0.693}{5715 \text{ y}} = 1.209 \times 10^{-4} \text{ y}^{-1}$$

$$\ln \left(\frac{9.4}{15.3} \right) = (1.209 \times 10^{-4})t \implies t = \frac{\ln \left(\frac{9.4}{15.3} \right)}{(1.209 \times 10^{-4})} = \boxed{4,829 \text{ years}}$$

Energy Changes in Nuclear Reactions

The energies associated with nuclear reactions are extremely large. For example, the energy change in the reaction is $-4.1 \times 10^{12} \text{ J/mol}$



For comparison, the energy change for combustion of 1 mol CH_4 is 890 kJ/mol.

Unit 17 Nuclear Chemistry Study Guide Answers

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Draw Lewis structures for each of the following. 1. NO₃. 1-. 2. CH₄. Skill Practice 26 Skill Practice 26. Name: Date: Hour: _____. 1. What does it mean to say that a bond is polar? One of the atoms ... Skill Practice 16 - Atomic Size Skill Practice 16. Atomic Size. Practice. Name: KEY. Date: Hour: 1. What force of attraction does the second energy level of a phosphorus atom "feel" from the ... Skill Practice 13 Obtain permission for classroom use at www.ChemistryInquiry.com. Skill Practice 13. Name: Date: Hour: _____. 1 ... Sample Guided Inquiry Chemistry Lessons Please evaluate all of the materials for the unit. You will find ChemQuests, Skill Practice assignments, review sheets, video explanations, and labs. To ... Skill Practice 9 Skill Practice 9. Practice Problems. Name: Average Atomic Mass. Date: Period: _____. A certain element exists as ... Skill Practice 14 (ANSWER KEY) Skill Practice 14 (ANSWER KEY). Lewis Practice. Name: Date: Hour: _____. How many valence electrons does each of ... Skill Practice 30-33 answers.doc View Homework Help - Skill Practice 30-33 answers.doc from CHEM 202 at Simon Fraser University. Skill Practice 30 Name: _ Date: _ Hour: _ 1.