

Chapter 25 Nuclear Chemistry Practice Problems Answer Key

Chapter 25 Nuclear Chemistry Practice Problems Answer Key Chapter 25 Nuclear Chemistry Practice Problems Answer Key This document provides detailed solutions to the practice problems presented in Chapter 25 of your textbook Its designed to help you reinforce your understanding of key concepts in nuclear chemistry Note This answer key is intended as a supplement to your textbook and class notes Its crucial to work through the problems yourself first before consulting these solutions Understanding the thought process and the steps involved in solving each problem is more important than simply memorizing the answers Organization The answer key is organized by section corresponding to the chapters structure Each problem is presented with 1 The original problem statement To refresh your memory 2 A detailed solution Explaining the steps involved and the reasoning behind each step 3 Key concepts Highlighting the key concepts from the chapter that are relevant to the problem Remember Nuclear chemistry is a fascinating and complex field Use this answer key as a tool to deepen your comprehension and build confidence in your problemsolving skills

Section 1 Nuclear Structure and Stability Problem 1 Problem Statement What is the difference between the strong nuclear force and the electrostatic force within the nucleus **Solution** The strong nuclear force is a shortrange attractive force that acts between nucleons protons and neutrons within the nucleus Its responsible for holding the nucleus together despite the electrostatic repulsion between protons The electrostatic force on the other hand is a longrange repulsive force that acts between charged particles In the nucleus it tries to push 2 the protons apart **Key Concepts** Strong Nuclear Force Attractive force that binds nucleons together overcoming electrostatic repulsion Electrostatic Force Repulsive force between like charges protons in the nucleus **Problem 2 Problem Statement** Explain the concept of nuclear binding energy and its relation to nuclear stability **Solution** Nuclear binding energy is the energy released when nucleons bind together to form a nucleus This energy is equivalent to the difference in mass between the individual nucleons and the nucleus itself mass defect as described by Einsteins famous equation $E=mc^2$ A higher binding energy per nucleon indicates a more stable nucleus **Key Concepts** Nuclear Binding Energy Energy released during the formation of a nucleus Mass Defect Difference in mass between individual nucleons and the nucleus Nuclear Stability Related to the binding energy per nucleon higher binding energy more stable nucleus

Section 2 Radioactive Decay Problem 3 Problem Statement Describe the different types of radioactive decay and their associated

changes in nuclear composition

Solution Alpha Decay Emission of an alpha particle He which contains two protons and two neutrons This results in a decrease of the atomic number by 2 and the mass number by 4

Beta Decay Emission of a beta particle e^- which is an electron This results in an increase of the atomic number by 1 while the mass number remains unchanged

Gamma Decay Emission of a gamma ray which is a highenergy photon This doesn't change the atomic number or mass number but simply releases excess energy from the nucleus

Positron Emission Emission of a positron e^+ which is the antiparticle of an electron This results in a decrease of the atomic number by 1 while the mass number remains unchanged

3 Electron Capture An inner shell electron is captured by the nucleus combining with a proton to form a neutron This results in a decrease of the atomic number by 1 while the mass number remains unchanged

Key Concepts Radioactive Decay Spontaneous process by which unstable nuclei emit particles or energy to become more stable

Alpha Particle He nucleus 2 protons and 2 neutrons

Beta Particle Electron e^-

Gamma Ray Highenergy photon

Positron Antiparticle of an electron e^+

Electron Capture Absorption of an inner shell electron by the nucleus

Problem 4 Problem Statement Write the nuclear equation for the alpha decay of Polonium-210

Solution $\text{Po} \rightarrow \text{Pb} + \text{He}$

Key Concepts Nuclear Equation A balanced equation that represents a nuclear reaction

Alpha Decay Emission of an alpha particle He

Atomic Number The number of protons in an atom subscript

Mass Number The total number of protons and neutrons in an atom superscript

Section 3 Nuclear Reactions and Fission Problem 5 Problem Statement Describe the basic principles behind nuclear fission and fusion

Solution Nuclear Fission The splitting of a heavy nucleus like Uranium-235 into two or more lighter nuclei accompanied by the release of a tremendous amount of energy This process is initiated by the absorption of a neutron and can be sustained in a chain reaction

Nuclear Fusion The joining of two light nuclei like deuterium and tritium to form a heavier nucleus releasing a large amount of energy This process requires extremely high temperatures and pressures to overcome the electrostatic repulsion between the nuclei

4 Key Concepts Nuclear Fission Splitting of a heavy nucleus

Nuclear Fusion Joining of light nuclei

Chain Reaction A self-sustaining series of nuclear fissions

Critical Mass The minimum amount of fissile material needed to sustain a chain reaction

Problem 6 Problem Statement What are the advantages and disadvantages of using nuclear power as an energy source

Solution Advantages High Energy Yield Nuclear power plants produce a large amount of energy from a relatively small amount of fuel

Low Greenhouse Gas Emissions Nuclear power plants do not emit carbon dioxide or other greenhouse gases during operation contributing to cleaner air and a reduced carbon footprint

Reliable Energy Source Nuclear power plants can operate continuously and reliably providing a consistent energy source

Disadvantages Nuclear Waste Nuclear power plants produce radioactive waste which requires careful storage and disposal

Risk of Accidents Accidents at nuclear power plants such as Chernobyl and Fukushima can have catastrophic consequences

Proliferation

Concerns The nuclear technology used for power generation can be misused to produce weapons Key Concepts Nuclear Power The use of nuclear reactions to generate electricity Radioactive Waste Byproducts of nuclear reactions that are radioactive Nuclear Accidents Events that can result in significant releases of radiation Nuclear Proliferation The spread of nuclear weapons technology Section 4 Applications of Nuclear Chemistry Problem 7 5 Problem Statement Describe three different applications of nuclear chemistry in various fields Solution 1 Medicine Radioactive isotopes like iodine-131 and technetium-99m are used in medical imaging to diagnose and treat diseases Carbon-14 dating is used to determine the age of ancient artifacts and fossils 2 Industry Radioactive isotopes are used in gauging thickness and density in industrial processes Cobalt-60 is used in radiation therapy for cancer treatment 3 Archaeology and Geology Carbon-14 dating is used to determine the age of fossils and ancient artifacts Uranium-238 dating is used to determine the age of rocks and minerals Key Concepts Radioactive Isotopes Atoms of an element with different numbers of neutrons Medical Imaging Use of radioactive isotopes to visualize internal organs and tissues Radiation Therapy Use of high-energy radiation to treat cancer Carbon-14 Dating A method used to determine the age of organic materials Uranium-238 Dating A method used to determine the age of rocks and minerals Remember These problems and solutions represent only a fraction of the topics covered in Chapter 25 It is crucial to thoroughly review the chapter content consult your textbook and ask questions in class to ensure a comprehensive understanding of nuclear chemistry

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