Part A: Introduction

Atom Tiny piece of matter, made of protons, neutrons, and electrons.
Element A substance made of atoms that are all the same type.
Period Table of Elements A systematic table listing all discovered elements.

A.1
Gold, silver, and carbon are all examples of ____________________________. They are listed on the ____. If you had a golden ring and an amazing machine, you could break it down into tiny pieces called ________________________.

Atomic Number The number of protons in a nucleus of an atom. All nuclei of a particular atom have *the same* number of protons.
Mass number The number of protons + the number of neutrons All nuclei DO NOT have the same number of neutrons and DO NOT have the same mass number.
Isotope All atoms of one element have the *same number* of protons, but they do not have the same mass. Different *isotopes* of one element are the different atoms of one element.

While in chemical reactions, different isotopes don't really matter, in nuclear reactions, different isotopes are the most important thing.

When you add the number of protons and the number of neutrons, you get the ____________________ of an atom.

The number of protons in an atom is called the ________________.

 Name ______________________

When we write down a particular isotope, we write the NAME OF THE ELEMENT followed by the MASS number. Note that the mass number of the isotope in question may not be the atomic mass of that element.

Isotope	**Atomic Symbol**	**Number of Protons**	**Number of Neutrons**
Uranium-238			
Radium-226			
Lead-206			
Hydrogen-3			
Sodium-22			
Argon-39			
Radon-222			
Carbon-12			
Carbon-13			
Carbon-14			

Carbon-12, Carbon-13, and Carbon-14 are all different _____________________________ of carbon.

Part B: Representing a Nucleus

This is how we represent the nucleus of Carbon-14. When we draw it this way, we call it a **nuclide**.

$$^{14}_{6}\mathrm{C}$$

Atomic Symbol Tells which element the nucleus is. In the above example, it is C, representing the element carbon
Atomic Number (Charge) The number of protons in a nucleus, also tells which element the nucleus is. In the above example, it is 6, representing 6 protons.
Mass Number Number of protons + number of neutrons. In the above example, it is 14, representing a mass of 14 atomic mass units.
Isotope One *version* of the nucleus of a particular element. All nuclei of one element have the same number of protons, but different isotopes have different mass numbers. For example, $^{12}_{6}\mathrm{C}$, $^{13}_{6}\mathrm{C}$, $^{14}_{6}\mathrm{C}$ Are three isotopes of carbon.

Nuclide Notation: Start by drawing the atomic symbol On the lower left put the atomic number. On the upper left put the mass number.

For each nuclide, use the periodic table of elements to fill in the missing information:

B.1. $^{23}_{??}\mathrm{Na}$

B.2. $^{16}_{??}\mathrm{O}$

B.3. $^{1}_{1}??$

B.4. $^{124}_{52}??$

B.5. $^{40}_{??}\mathrm{Ar}$

Nuclear Physics Name ______________________

How many *neutrons* and *protons* does each nucleus have?

Nucleus	Element	Number of Protons	Number of Neutrons
$^{14}_{7}N$			
$^{1}_{1}H$			
$^{222}_{86}Rn$			
$^{238}_{92}U$			
$^{14}_{6}C$			

For each isotope, draw the *nuclide notation*.

Isotope	**Nuclide Notation**
Lithium-7	
Iron-56	
Magnesium-24	
Gold-197	
Antimony-123	

Part C: Radioactive Decay

When a nucleus decays, we draw the arrow with an arrow, like this:

$$^{14}_{6}\mathrm{C} \rightarrow {}^{10}_{4}\mathrm{Be} + {}^{4}_{2}\mathrm{He}$$

Conservation of Mass: The mass numbers of the reactants and products must add up. In the example above: 14 = 10 + 4
Conservation of Charge: The atomic numbers (which represent charge) of the reactants and products must add up. In the example above: 6 = 4 + 2

Using the **conservation of mass** and **conservation of charge**, find the missing nuclide:

C.1 $^{238}_{92}\mathrm{U} \rightarrow {}^{??}_{??}?? + {}^{4}_{2}\mathrm{He}$

C.2 $^{222}_{88}\mathrm{Ra} \rightarrow {}^{??}_{??}?? + {}^{4}_{2}\mathrm{He}$

C.3 $^{208}_{84}\mathrm{Po} \rightarrow {}^{??}_{??}?? + {}^{4}_{2}\mathrm{He}$

Part D: Radioactive Decay

Alpha Particle (α) A Helium-4 Nucleus Represented by ${}^{4}_{2}He$
Beta Particle (β) An electron Represented by ${}^{0}_{-1}e$
Gamma Ray (γ) A very high energy photon, or electromagnetic wave Represented by γ, the Greek letter gamma.

For **D.1 – D.7** write whether this describes an alpha particle, a beta particle, or a gamma ray.

D.1 γ

D.2 α

D.3 β

D.4 ${}^{0}_{-1}e$

D.5 ${}^{4}_{2}He$

D.6 Helium-4

D.7 Electron

Alpha Decay In alpha decay, a nucleus gives off an alpha particle (Helium-4).
Beta Decay In beta decay, a nucleus gives off a beta particle (electron).

Draw an alpha decay for each nuclide.

For full credit, you must write the entire reaction in the box. The entire reaction includes the initial nuclide, the products, and an arrow between them.
Do not write only the products.
Do not draw an arrow through the shaded space. Write the entire reaction in the proper box.

	Nuclide		Decay Reaction
D.8	$^{256}_{103}Lr$		
D.9	$^{231}_{91}Pa$		
D.10	$^{225}_{89}Ac$		
D.11	$^{211}_{87}Fr$		
D.12	$^{185}_{79}Au$		

Draw a beta decay of each nuclide

	Nuclide		Decay Reaction
D.13	$^{6}_{2}He$		
D.14	$^{24}_{11}Na$		
D.15	$^{201}_{79}Au$		
D.16	$^{52}_{26}Fe$		
D.17	$^{42}_{19}K$		

Answers

A.1

Gold, silver, and carbon are all examples of elements. They are listed on the periodic table of elements. If you had a golden ring and an amazing machine, you could break it down into tiny pieces called atoms.

Isotope	**Atomic Symbol**	**Number of Protons**	**Number of Neutrons**
Uranium-238	U	92	146
Radium-226	Ra	88	138
Lead-206	Pb	82	124
Hydrogen-3	H	1	2
Sodium-22	Na	11	11
Argon-39	Ar	18	21
Radon-222	Rn	86	136
Carbon-12	C	6	6
Carbon-13	C	6	7
Carbon-14	C	6	8

Carbon-12, Carbon-13, and Carbon-14 are all different isotopes of carbon.

B.1. ${}^{23}_{11}\mathrm{Na}$

B.2. ${}^{16}_{8}\mathrm{O}$

B.3. ${}^{1}_{1}\mathrm{H}$

B.4. ${}^{124}_{52}\mathrm{Te}$

B.5. ${}^{40}_{18}\mathrm{Ar}$

Nucleus	Element	Number of Protons	Number of Neutrons

$^{14}_{7}N$	Nitrogen	7	7
$^{1}_{1}H$	Hydrogen	1	0
$^{222}_{86}Rn$	Radon	86	136
$^{238}_{92}U$	Uranium	92	146
$^{14}_{6}C$	Carbon	6	8

C.1 $^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$

C.2 $^{222}_{88}Ra \rightarrow {}^{218}_{86}Rn + {}^{4}_{2}He$

C.3 $^{208}_{84}Po \rightarrow {}^{204}_{82}Pb + {}^{4}_{2}He$

D.1 gamma ray

D.2 alpha particle

D.3 beta particle

D.4 beta particle

D.5 alpha particle

D.6 alpha particle

D.7 beta particle

Draw an alpha decay for each nuclide.

	Nuclide		Decay Reaction
D.8	$^{256}_{103}Lr$		$^{256}_{103}Lr \rightarrow {}^{252}_{101}Md + {}^{4}_{2}He$
D.9	$^{231}_{91}Pa$		$^{231}_{91}Pa \rightarrow {}^{227}_{89}Ac + {}^{4}_{2}He$
D.10	$^{225}_{89}Ac$		$^{225}_{89}Ac \rightarrow {}^{221}_{87}Fr + {}^{4}_{2}He$

D.11	${}^{211}_{87}\text{Fr}$		${}^{211}_{87}\text{Fr} \rightarrow {}^{207}_{85}\text{At} + {}^{4}_{2}\text{He}$
D.12	${}^{185}_{79}\text{Au}$		${}^{185}_{79}\text{Au} \rightarrow {}^{181}_{77}\text{Ir} + {}^{4}_{2}\text{He}$

Draw a beta decay of each nuclide

	Nuclide		Decay Reaction
D.13	${}^{6}_{2}\text{He}$		${}^{6}_{2}\text{He} \rightarrow {}^{6}_{3}\text{Li} + {}^{0}_{-1}\text{e}$
D.14	${}^{24}_{11}\text{Na}$		${}^{24}_{11}\text{Na} \rightarrow {}^{24}_{12}\text{Mg} + {}^{0}_{-1}\text{e}$
D.15	${}^{201}_{79}\text{Au}$		${}^{201}_{79}\text{Au} \rightarrow {}^{201}_{80}\text{Hg} + {}^{0}_{-1}\text{e}$
D.16	${}^{52}_{26}\text{Fe}$		${}^{52}_{26}\text{Fe} \rightarrow {}^{52}_{27}\text{Co} + {}^{0}_{-1}\text{e}$
D.17	${}^{42}_{19}\text{K}$		${}^{42}_{19}\text{K} \rightarrow {}^{42}_{20}\text{Ca} + {}^{0}_{-1}\text{e}$