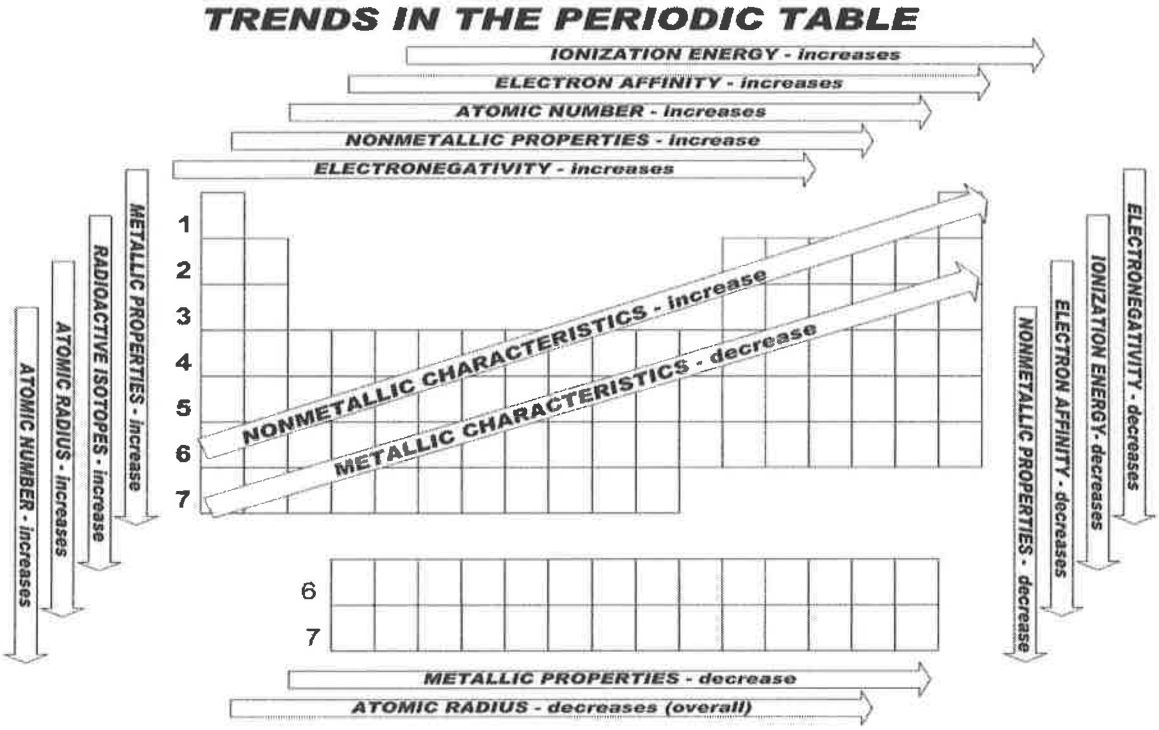
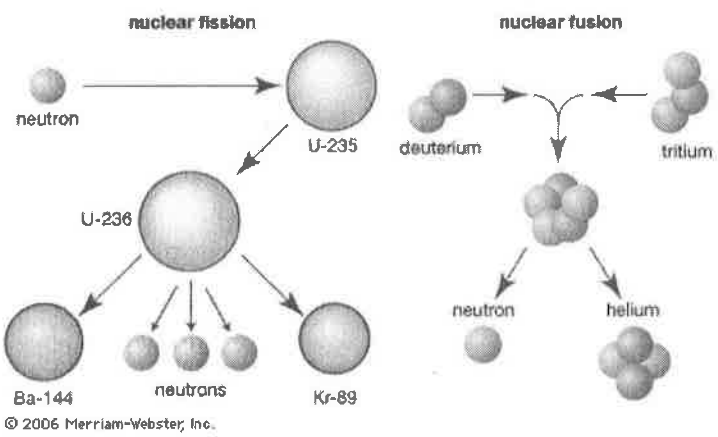
Chapter 5 (Periodic Table)



Chapter 21 Nuclear

Fission/Fusion/ Nuclear Equations)



Type	Description	Change?	Example
Alpha	Nucleus releases a He atom. He atom is known as an alpha particle	A Helium atom is released. Remaining nucleus weighs 4 less and has 2 less protons	${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$
Beta	Nucleus releases an electron and converts a neutron to a proton	Remaining atom has: •Same mass •One more proton, one less neutron	${}^{231}_{53}I \rightarrow {}^{231}_{54}Xe + {}^{0}_{-1}e$
Gamma	Nucleus goes from high energy state to a low energy state.	Nucleus remains same, but a gamma ray is released	${}^{238}_{92}U \rightarrow {}^{238}_{92}U + \gamma$
Positron	Nucleus releases a positively charged electron and converts a proton to a neutron	Remaining atom has: •Same mass •One more neutron, one less proton	${}^{11}_{6}C \rightarrow {}^{11}_{5}B + {}^{0}_{1}e$
Electron Capture	An electron from the electron cloud converts a proton into a neutron	Remaining atom has: •Same mass •One more neutron, one less proton	${}^{201}_{80}Hg + {}^{0}_{-1}e \rightarrow {}^{231}_{79}Au$

Name____________________________________

Period _______

CHAPTER 5 (PERIODIC TABLE and TRENDS)

Chapter 5 Periodic Table/Trends

Short form notation:

Electron configuration of ions: (isoelectronic)

What are the contributions of the following scientists?

1817 Johann Wolfgang Dobereiner:

1865 John Newlands

1869 Dmitri Mendeleev

1868 (but not published until 1872) Julius Lothar Meyer

How did Mendeleev organize his periodic table?

What was the periodic law (as described by Mendeleev)?

What is the modern period law?

Identification of groups (families), periods etc.... (SEE BLANK PERIODIC TABLE)

What is the definition of malleability? Ductility?

The colors of the symbols on the periodic table tell you states at room temperature.

Which elements are liquids at room temperature?

Periodic Trends:

As one move down a group of metals, they become more active. They are said to become more metallic.

As one moves up a group of nonmetals, they become more active. They are said to become more nonmetallic.

Ionization energy: Energy needed to remove the most loosely held electron from an outer energy level in the gas phase of an atom. The addition of ionization energy (I.E.) always results in the formation of a positive ion.

Kernel:

Valence electrons:

Shielding effect:

First IE, Second IE, Third IE etc:

Which I.E. will be the highest for Mg? First, second, or third

Where is the largest increase in I.E. for aluminum?

Write the trend regarding I.E. in the space below:

Atomic Radius

How is atomic radius calculated?

Trend :

Reason:

Ionic Radius

Trend for CATIONS:

Trend for ANIONS:

Trend within a group:

Electronegativity: Tendency for atoms of an element to attract electrons when they are chemically combined with atoms of another element.

TREND:

Measured in Pauling units.

Highest =

Lowest=

Electron affinity: The energy change, *generally a release*, that takes place when an electron is added to a neutral atom.

Trend for metals and noble gases:

Trend for nonmetals:

Name ______________________________ Date__________________

Isoelectronic Species

For each of the following ions:

Tell with which noble gas it is isoelectronic

Provide the name of the ion

Provide a complete electron configuration for each ion.

(The first one has been completed as an example.)

a. Br^- Br^- is isoelectronic with krypton.

Bromide [Ar] $4s^2\ 3d^{10}\ 4p^6$

b. Mg^{2+}

c. N^{3-}

d. Ba^{2+}

e. P^{3-}

f. Li^+

g. O^{2-}

h. K^+

i. Sr^{2+}

j. S^{2-}

Name ______________________ Date ____________ Class ____________

(5)

5–3 Practice Problems

1. Chlorine, selenium, and bromine are located near each other on the periodic table. Which of these elements is (a) the smallest atom? (b) the atom with the highest ionization energy?

2. Phosphorus, sulfur, and selenium are located near each other on the periodic table. Which of these elements is (a) the largest atom? (b) the atom with the highest ionization energy?

3. Scandium, yttrium, and lanthanum are located near each other in the periodic table. Which of these elements is (a) the largest atom? (b) the atom with the smallest ionization energy?

4. (a) Which of the following atoms is smallest: vanadium, chromium, or tungsten? (b) Which of these atoms has the highest ionization energy?

5. (a) Which of the following atoms is smallest: nitrogen, phosphorus, or arsenic? (b) Which of these atoms has the smallest ionization energy?

6. Which of the following is the largest: a potassium atom, a potassium ion with a charge of 1+, or a rubidium atom?

7. Which of the following is the largest: a chlorine atom, a chlorine ion with a charge of 1–, or a bromine atom?

8. Which of the following is the smallest: a lithium atom, a lithium ion with a charge of 1+, or a sodium atom?

9. Which of the following is the largest: a tellurium ion with a charge of 2–, an iodine ion with charge of 1–, or a xenon atom?

10. Aluminum, silicon, and phosphorus are located near each other in the periodic table. Which of these elements is (a) the largest atom? (b) the atom with the highest ionization energy?

Name ______________________ Date __________ Class __________

5–3 Review and Reinforcement

(7)

Periodic Trends

Use the periodic table and your knowledge of periodic trends to answer the following questions.

Which atom in each pair has the larger atomic radius?

_____ **1.** Li or K

_____ **2.** Ca or Ni

_____ **3.** Ga or B

_____ **4.** O or C

_____ **5.** Cl or Br

_____ **6.** Be or Ba

_____ **7.** Si or S

_____ **8.** Fe or Au

Which ion in each pair has the smaller atomic radius?

_____ **9.** K^+ or O^{2-}

_____ **10.** Ba^{2+} or I^-

_____ **11.** Al^{3+} or P^{3-}

_____ **12.** K^+ or Cs^+

_____ **13.** Fe^{2+} or Fe^{3+}

_____ **14.** F^- or S^{2-}

Which atom or ion in each pair has the larger ionization energy?

_____ **15.** Na or O

_____ **16.** Be or Ba

_____ **17.** Ar or F

_____ **18.** Cu or Ra

_____ **19.** I or Ne

_____ **20.** K or V

_____ **21.** Ca or Fr

_____ **22.** W or Se

NAME________________________________

CHEMISTRY
The Periodic Table

Examine the periodic table below and use the letters in the table to answer questions

													E			I	
														G	H		J
A	B					C			D				F				

1.Which element represents a nonmetal with a charge of –3?___ -2?___ -1?___

2 Which element's ourt electron configuration would be $2s^2 2p^2$?___

3. Which element's outer electron configuration would be 4s2 3d5?___

4. Which element's out electron configuration would be $3s^2$ 3p6?___

5. Star the space of the element whose electron configuration is $6s^2 4f^{14} 5d^7$? $5s^2 4d^{10} 5p^3$?

6. Which element of those above, is the most reactive metal?___

7. Which element has the largest radius?___ smallest ioniztion energy?____ highest electreon affinity?_____ Highest electronegativity?_____

8. Which element has the smallest radius? ___

9. Which elements(2) are in the "d" block of the table?

10 Which element is the most stable or least reactive?_____

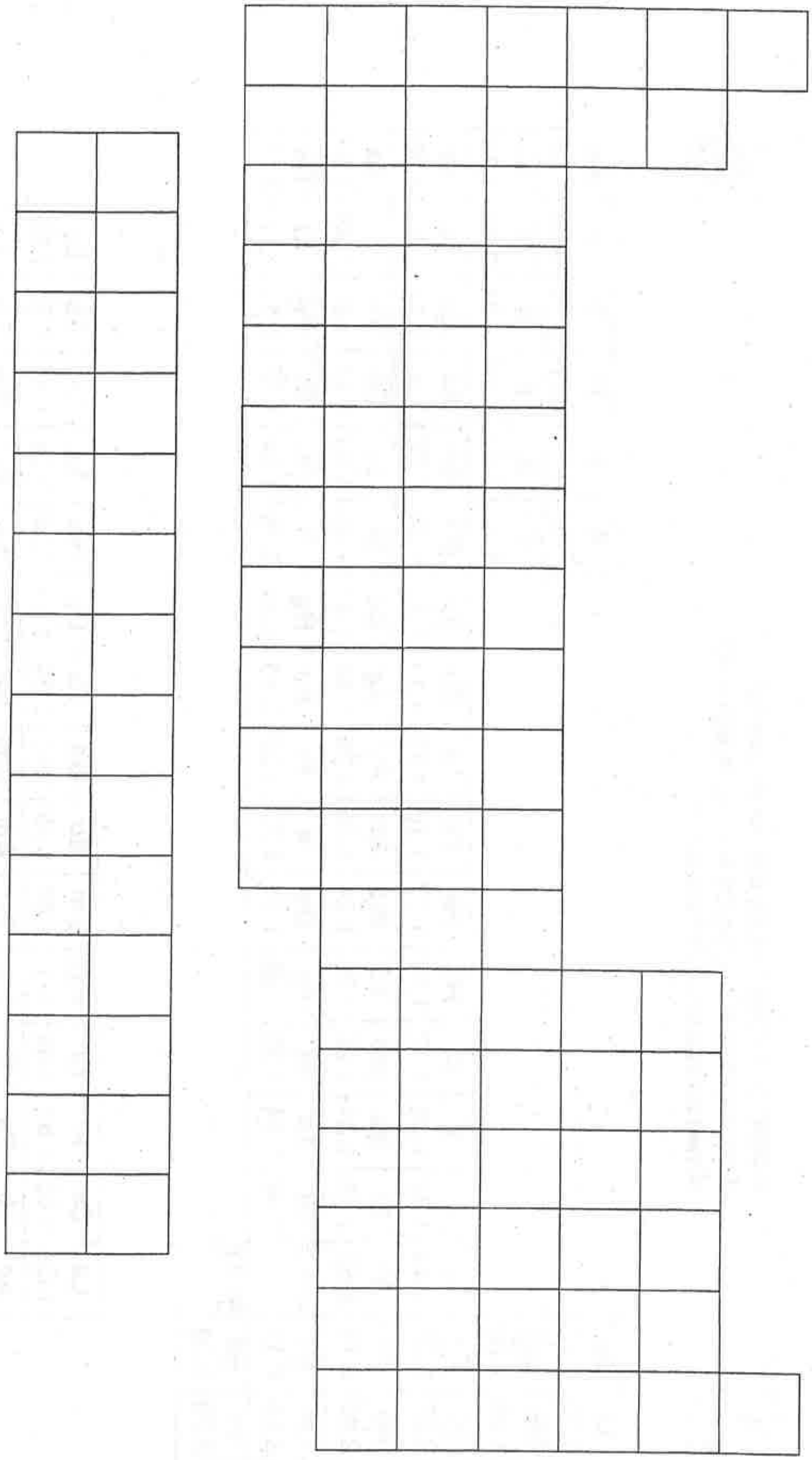
11. Which elements(2) are in the same family?

12. Which element(s) are halogens?_____ chalcogens?___ alkali metals_____, alkaline earth metals?___ noble gases?___ transition metals?___

13. Which element represents a metal with an ion of charge +1?___ +2?___ +3?____

14. Which elements form ions that have a larger radius than the neutral atom?_______

15. What block is missing from the above table? _____

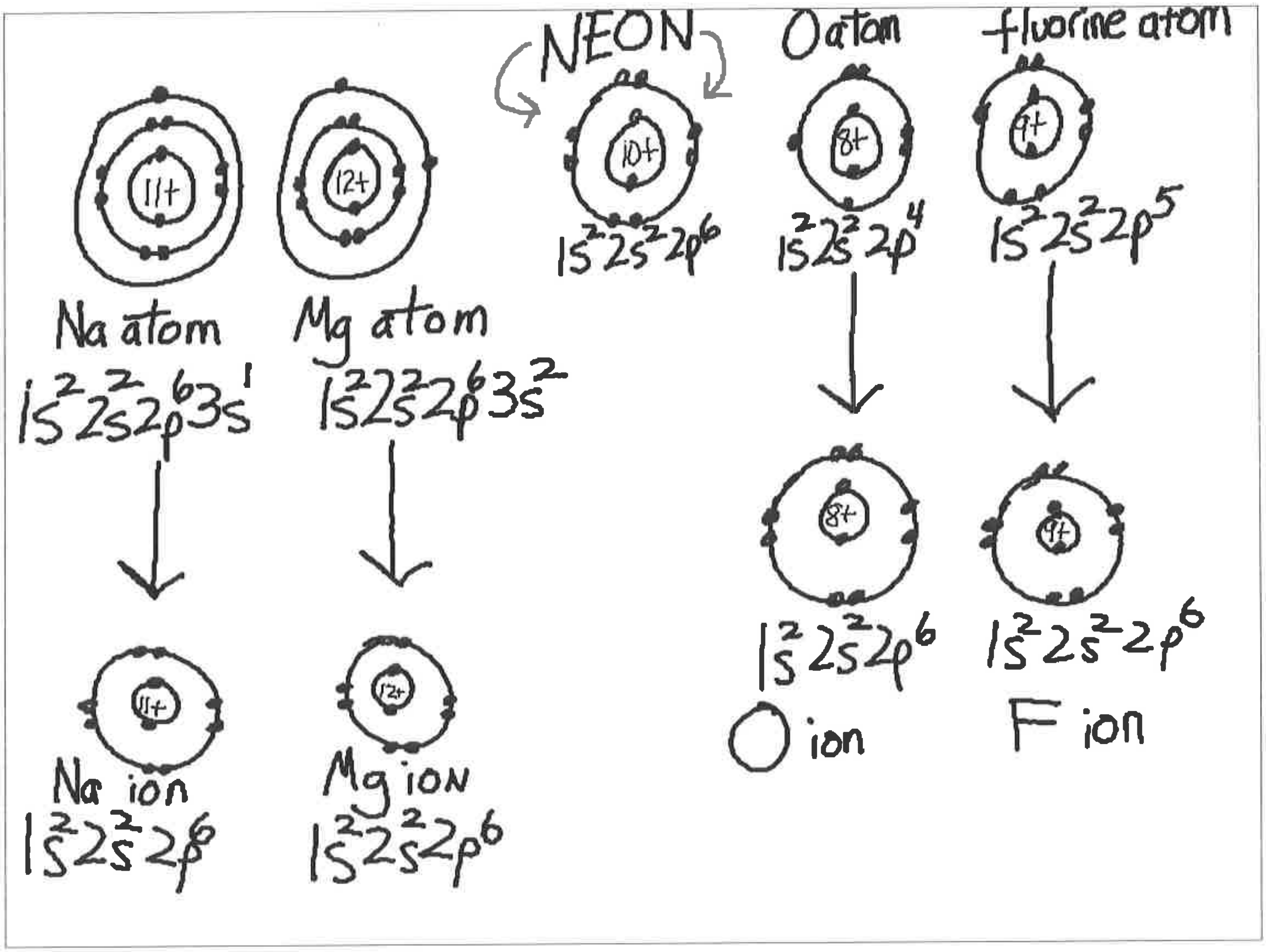


Radii of Atoms

A dash (–) indicates data are not available.
Atomic radius is measured in nanometers (nm).
(One nanometer = 10^{-9} meter)

H 0.37																	He 1.22
Li 1.52	Be 1.13											B 0.88	C 0.77	N 0.70	O 0.66	F 0.64	Ne 1.31
Na 1.86	Mg 1.60											Al 1.43	Si 1.17	P 1.10	S 1.04	Cl 0.99	Ar 1.74
K 2.27	Ca 1.97	Sc 1.44	Ti 1.32	V 1.22	Cr 1.17	Mn 1.17	Fe 1.17	Co 1.16	Ni 1.15	Cu 1.17	Zn 1.25	Ga 1.22	Ge 1.22	As 1.21	Se 1.17	Br 1.14	Kr 1.89
Rb 2.48	Sr 2.15	Y 1.62	Zr 1.45	Nb 1.34	Mo 1.29	Tc 1.29	Ru 1.24	Rh 1.25	Pd 1.28	Ag 1.44	Cd 1.41	In 1.63	Sn 1.40	Sb 1.41	Te 1.37	I 1.33	Xe 2.09
Cs 2.65	Ba 2.17	La-Lu	Hf 1.44	Ta 1.34	W 1.30	Re 1.28	Os 1.26	Ir 1.26	Pt 1.29	Au 1.44	Hg 1.44	Tl 1.70	Pb 1.54	Bi 1.52	Po 1.53	At (–)	Rn 2.14
Fr 2.70	Ra 2.20	Ac-Lr															

La 1.69	Ce 1.65	Pr 1.65	Nd 1.64	Pm (–)	Sm 1.66	Eu 1.85	Gd 1.61	Tb 1.59	Dy 1.59	Ho 1.58	Er 1.57	Tm 1.56	Yb 1.70	Lu 1.56
Ac 2.00	Th (–)	Pa (–)	U (–)	Np (–)	Pu (–)	Am (–)	Cm (–)	Bk (–)	Cf (–)	Es (–)	Fm (–)	Md (–)	No (–)	Lr (–)


NEON
11+
12+
10+
8+
9+
1s2 2s2 2p6
O atom
1s2 2s2 2p4
fluorine atom
1s2 2s2 2p5
Na atom
1s2 2s2 2p6 3s1
Mg atom
1s2 2s2 2p6 3s2
8+
9+
1s2 2s2 2p6
O ion
1s2 2s2 2p6
F ion
11+
12+
Na ion
1s2 2s2 2p6
Mg ion
1s2 2s2 2p6

Name ______________________ Date ____________ Class ____________

CHAPTER 5 REVIEW

The Periodic Law

SECTION 1

SHORT ANSWER **Answer the following questions in the space provided.**

1. ______ In the modern periodic table, elements are ordered

(a) according to decreasing atomic mass.
(b) according to Mendeleev's original design.
(c) according to increasing atomic number.
(d) based on when they were discovered.

2. ______ Mendeleev noticed that certain similarities in the chemical properties of elements appeared at regular intervals when the elements were arranged in order of increasing

(a) density. (c) atomic number.
(b) reactivity. (d) atomic mass.

3. ______ The modern periodic law states that

(a) no two electrons with the same spin can be found in the same place in an atom.
(b) the physical and chemical properties of an element are functions of its atomic number.
(c) electrons exhibit properties of both particles and waves.
(d) the chemical properties of elements can be grouped according to periodicity, but physical properties cannot.

4. ______ The discovery of the noble gases changed Mendeleev's periodic table by adding a new

(a) period. (c) group.
(b) series. (d) level.

5. ______ The most distinctive property of the noble gases is that they are

(a) metallic. (c) metalloid.
(b) radioactive. (d) largely unreactive.

6. ______ Lithium, the first element in Group 1, has an atomic number of 3. The second element in this group has an atomic number of

(a) 4. (c) 11.
(b) 10. (d) 18.

7. An isotope of fluorine has a mass number of 19 and an atomic number of 9.

______ **a.** How many protons are in this atom?

______ **b.** How many neutrons are in this atom?

______ **c.** What is the nuclear symbol of this fluorine atom, including its mass number and atomic number?

SECTION 1 continued

8. Samarium, Sm, is a member of the lanthanide series.

______________ **a.** Identify the element just below samarium in the periodic table.

______________ **b.** By how many units do the atomic numbers of these two elements differ?

9. A certain isotope contains 53 protons, 78 neutrons, and 54 electrons.

______________ **a.** What is its atomic number?

______________ **b.** What is the mass number of this atom?

______________ **c.** What is the name of this element?

______________ **d.** Identify two other elements that are in the same group as this element.

10. In a modern periodic table, every element is a member of both a horizontal row and a vertical column. Which one is the group, and which one is the period?

____

____

11. Explain the distinction between atomic mass and atomic number of an element.

____

____

____

____

12. In the periodic table, the atomic number of I is greater than that of Te, but its atomic mass is less. This phenomenon also occurs with other neighboring elements in the periodic table. Name two of these pairs of elements. Refer to the periodic table if necessary.

____

____

____

____

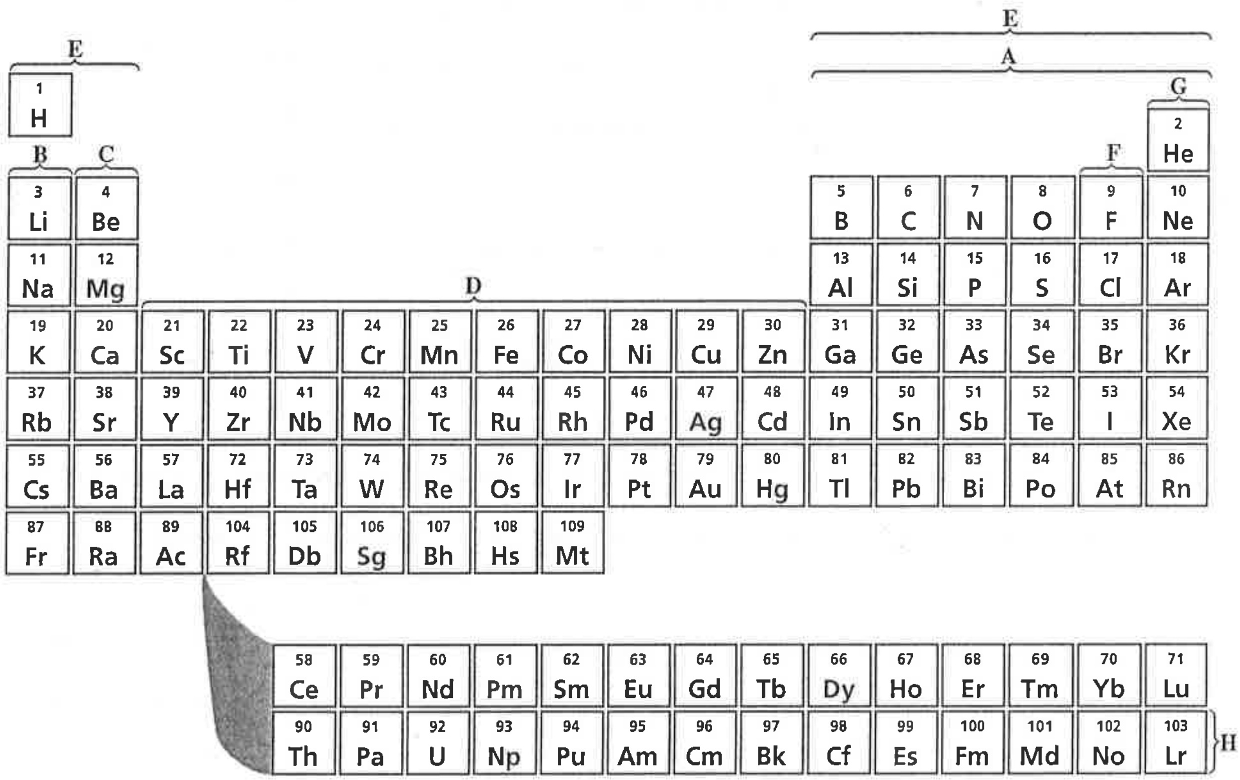
Name ________________________ Date ______________ Class ______________

CHAPTER 5 REVIEW

The Periodic Law

SECTION 2

SHORT ANSWER Use this periodic table to answer the following questions in the space provided.



1. Identify the element and write the noble-gas notation for each of the following:

a. the Group 14 element in Period 4

____

b. the only metal in Group 15

____

c. the transition metal with the smallest atomic mass

____

d. the alkaline-earth metal with the largest atomic number

____

Name ______________________ Date ______________ Class ______________

SECTION 2 continued

2. On the periodic table given, several areas are labeled with letters A–H.

______________ **a.** Which block does A represent, *s*, *p*, *d*, or *f*?

b. Identify the remaining labeled areas of the table, choosing from the following terms: *main-group elements, transition elements, lanthanides, actinides, alkali metals, alkaline-earth metals, halogens, noble gases.*

______________________ **B**

______________________ **C**

______________________ **D**

______________________ **E**

______________________ **F**

______________________ **G**

______________________ **H**

3. Give the symbol, period, group, and block for the following:

a. sulfur

____

____

b. nickel

____

____

c. $[Kr]5s^1$

____

____

d. $[Ar]3d^5 4s^1$

____

____

4. There are 18 columns in the periodic table; each has a group number. Give the group numbers that make up each of the following blocks:

______ **a.** *s* block

______ **b.** *p* block

______ **c.** *d* block

Name ______________________ Date ____________ Class ____________

CHAPTER 5 REVIEW

The Periodic Law

SECTION 3

SHORT ANSWER **Answer the following questions in the space provided.**

1. ______ When an electron is added to a neutral atom, energy is

(a) always absorbed.
(b) always released.
(c) either absorbed or released.
(d) neither absorbed nor released.

2. ______ The energy required to remove an electron from a neutral atom is the atom's

(a) electron affinity.
(b) electron energy.
(c) electronegativity.
(d) neither absorbed nor released.

3. From left to right across a period on the periodic table,

________________ **a.** electron affinity values tend to become more (negative or positive).

________________ **b.** ionization energy values tend to (increase or decrease).

________________ **c.** atomic radii tend to become (larger or smaller).

4. ______ **a.** Name the halogen with the least-negative electron affinity.

______ **b.** Name the alkali metal with the highest ionization energy.

______ **c.** Name the element in Period 3 with the smallest atomic radius.

______ **d.** Name the Group 14 element with the largest electronegativity.

5. Write the electron configuration of the following:

a. Na

____

b. Na^+

____

c. O

____

d. O^{2-}

____

e. Co^{2+}

____

SECTION 3 continued

6. **a.** Compare the radius of a positive ion to the radius of its neutral atom.

____

____

b. Compare the radius of a negative ion to the radius of its neutral atom.

____

____

7. **a.** Give the approximate positions and blocks where metals and nonmetals are found in the periodic table.

____

____

____

b. Of metals and nonmetals, which tend to form positive ions? Which tend to form negative ions?

____

____

8. **Table 3** on page 155 of the text lists successive ionization energies for several elements.

______ **a.** Identify the electron that is removed in the first ionization energy of Mg.

______ **b.** Identify the electron that is removed in the second ionization energy of Mg.

______ **c.** Identify the electron that is removed in the third ionization energy of Mg.

d. Explain why the second ionization energy is higher than the first, the third is higher than the second, and so on.

____

____

____

____

9. Explain the role of valence electrons in the formation of chemical compounds.

____

____

____

____

Name ______________________ Date ______________ Class ______________

CHAPTER 5 REVIEW

The Periodic Law

MIXED REVIEW

SHORT ANSWER Answer the following questions in the space provided.

1. Consider the neutral atom with 53 protons and 74 neutrons to answer the following questions.

______________ **a.** What is its atomic number?

______________ **b.** What is its mass number?

______________ **c.** Is the element's position in a modern periodic table determined by its atomic number or by its atomic mass?

2. Consider an element whose outermost electron configuration is $3d^{10}4s^24p^x$.

______________ **a.** To which period does the element belong?

______________ **b.** If it is a halogen, what is the value of *x*?

______________ **c.** The group number will equal $(10 + 2 + x)$. True or False?

3. ______________ **a.** In which block are metalloids found, *s*, *p*, *d*, or *f*?

______________ **b.** In which block are the hardest, densest metals found, *s*, *p*, or *d*?

4. ______________ **a.** Name the most chemically active halogen.

______________ **b.** Write its electron configuration.

______________ **c.** Write the configuration of the most stable ion this element makes.

5. Refer only to the periodic table at the top of the review of Section 2 to answer the following questions on periodic trends.

______________ **a.** Which has the larger radius, Al or In?

______________ **b.** Which has the larger radius, Se or Ca?

______________ **c.** Which has a larger radius, Ca or Ca^{2+}?

______________ **d.** Which class has greater ionization energies, metals or nonmetals?

______________ **e.** Which has the greater ionization energy, As or Cl?

______________ **f.** An element with a large negative electron affinity is most likely to form a (positive ion, negative ion, or neutral atom)?

____________ **g.** In general, which has a stronger electron attraction, a large atom or a small atom?

____________ **h.** Which has greater electronegativity, O or Se?

____________ **i.** In the covalent bond between Se and O, to which atom is the electron pair more closely drawn?

____________ **j.** How many valence electrons are there in a neutral atom of Se?

6. ____________ Identify all of the following ions that do not have noble-gas stability.
K^+ S^{2-} Ca^+ I^- Al^{3+} Zn^{2+}

7. Use only the periodic table in the review of Section 2 to give the noble-gas notation of the following:

____________ **a.** Br

____________ **b.** Br^-

____________ **c.** the element in Group 13, Period 5

____________ **d.** the lanthanide with the smallest atomic number

8. Use electron configuration and position in the periodic table to describe the chemical properties of calcium and oxygen.

____

____

____

____

____

____

9. Copper's electron configuration might be predicted to be $3d^94s^2$. But in fact, its configuration is $3d^{10}4s^1$. The two elements below copper in Group 11 behave similarly. (Confirm this in the periodic table in **Figure 6** on pages 140–141 of the text.)

____________ **a.** Which configuration for copper is apparently more stable?

____________ **b.** Is the *d* sublevel completed in the atoms of these three elements?

____________ **c.** Every element in Period 4 has four levels of electrons established. True or False?

CHAPTER 21 (Fission/Fusion and Nuclear Equations)

The Lifecycle of our Sun Nuclear

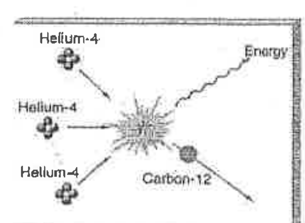
The lifecycle of a star is based entirely on its mass and the law of Gravity. Since gravity works to force all mass toward a center, its is concluded that within a mass of a star, the center of mass is the center of the star, and the place where that mass is condensed to the smallest possible space.

The simplest rule is that where gravitational pressure is greatest , the packing of material is the most dense, and the temperature will be the greatest. A star with a large mass will have a greater gravitational force affecting its mass, generating greater internal pressures and thus higher temperatures. Higher temperatures means greater kinetic energy of the molecules and increased collision frequency, resulting in a greater release of energy. A star with small mass will have less gravitational force operating on it, resulting in lower internal pressures and lower temperatures. The low mass star will have interior particles at lower energy levels, reducing collision frequency and yielding a lower release of energy. **To put it more simply, high mass stars burn hot and energetically, and low mass stars burn cool and less energetically.** It may seem that high mass stars ought to live longer owing to their greater amount of material, but it is the low mass stars that live longest because they burn what little material they have more slowly.

Our Sun is an average star, and of spectral class G2V. No one on Earth can life long enough to watch the entire lifecycle of our Sun, so we turn to the stars in space to see those of similar mass and at different stages of their lifecycle to make a theoretical picture of what our Sun's life may have been like and will be.

FROM GAS CLOUD TO PROTOSTAR

Our Sun, like all other stars in the Universe begins its life as a cloud of dust and gas. The exact materials in the dust and gas will vary depending on the galaxy type, the location of the cloud within the galaxy, the source of the cloud. Typically, these clouds of material are immense, spanning light years, but are also very sparse, with densities of less than several hundred atoms per cubic centimeter. In the case of our Sun, the cloud of dust and gas must have come from a much older star which blew up and scattered its remains outward. Somehow, that cloud, or at least a portion of it, was affected in such a way that the material began to collapse inwardly. With the collapse now under the relentless force of gravity, the dust particles and gaseous elements began to move toward the center of mass and on their journey encountered other particles. The physical bouncing of these particles into each other generated frictional heat. This heat is like rubbing your hands together. While this form of heat is invisible to the naked eye, it is visible to an Infrared Camera or telescope. The heat may only be several hundreds Kelvins, but the widespread scattering of the particles results in a reduction of energy per unit area. The kinetic energy of the particles will be increasing, but they are simply too spread out to be visible. However, the very broad spreading of these particles means an infrared glow over a large area. This glowing cloud of collapsing material is called a "Protostar" . This is how our Sun began it life so very long ago.



As the dust and gas matter collapsed further and further toward the center of mass, the collisions became more frequent and the energy release was greater. However, with the reduction in size of the cloud, the energy output was reduced too. Eventually, the material in the center of the cloud mass was squeezed so

;trongly by gravity that pressures exceeded billions of atmospheres and temperatures soared up to 7 million K. This is the critical temperature, for at this temperature, Hydrogen nuclei can collide with such speed that they 'use. The result of this Hydrogen fusion is the release of Gamma radiation and the star is now generating light of ts own. Astronomers define the moment of Hydrogen fusion ignition as the moment a star is born. The interior ;ore temperature is 7 million K. Hydrogen is being fused into Helium and huge amounts of energy are being ·eleased.

Gravity is NOT resting. This force never stops, and if left to its own would crush the Sun into nothing. However, he fusion of Hydrogen into Helium is the same as the events of a hydrogen bomb. The sheer energy of the fusion s making every effort to literally blow up the Sun. The ever-present crushing force of gravity is trying to collapse he Sun into the smallest possible ball. The two forces reach a point where balance is achieved ... a term called Hydrostatic Equilibrium. Inward gravitation pressure is balanced by outward fusion pressure in all directions and he Sun is shaped nice as nice round ball of glowing gas.

THE SUN BECOMES A RED GIANT

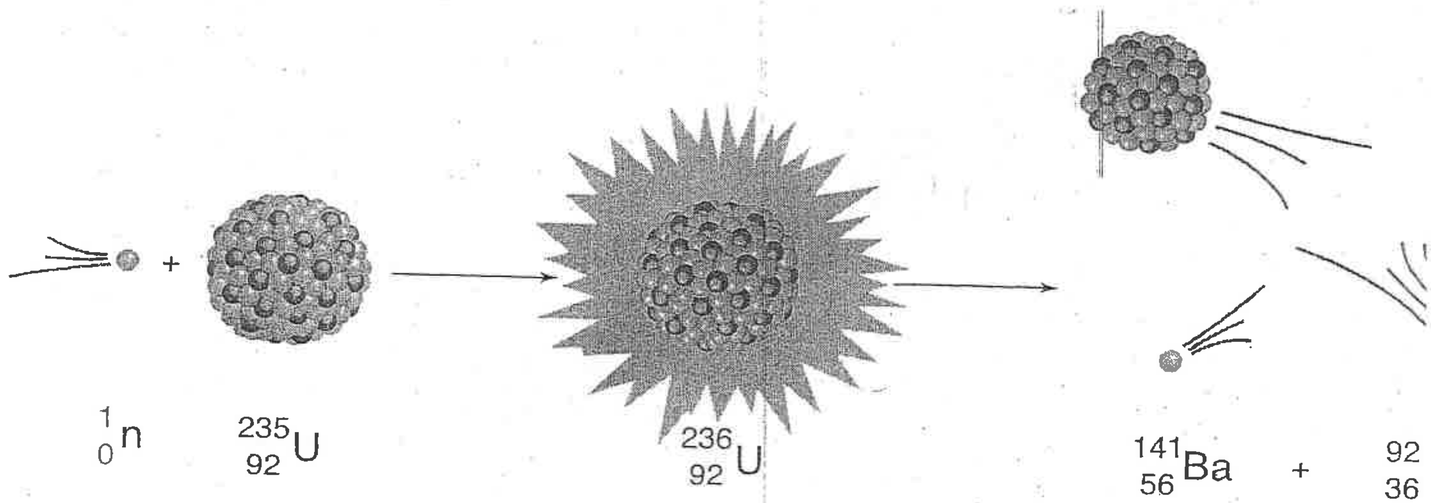
The rate of this fusion is 700 million tons of Hydrogen into 695 million tons of Helium per second ... for 10 billion years. Eventually, the entire core of our Sun will be fused Helium. Sure, the majority of the Sun's volume s Hydrogen gas, but only in the core is the pressure and temperature sufficient to fuse that Hydrogen into Helium. When all of the core is Helium, there is no longer any Hydrogen fuel for further nuclear fusion. With no more outward fusion pressure, the core begins to shrink under the patiently waiting force of gravity. However, as the core shrinks, the pressure increases and so too does temperature. At a core temperature of 100 million K, the Helium in the core suddenly ignites a sets of fusion reactions that make Carbon. A great deal more gamma radiation is generated from this fusion than simple Hydrogen fusion, and the outward pressure is very great. In fact, the heat of the interior is so great, that a layer of Hydrogen gas around the Helium-fusing core begins to fuse nto Helium, generating even more outward pressure. The gas of the Sun is blown outward, and the Sun grows arger and larger. Gravity eventually balances this expansion, but only after the Sun has enlarged to an object perhaps with a diameter someplace between Venus and Mars. Earth may very well be swallowed up. The Sun still has the same amount of material, but is spread over a much larger surface area, resulting in a more cool "surface." This makes the spectral class of the Sun in the "M" range owing to the cooler Red color. The Sun has become a 'Red Giant."

THE SUN BECOMES A WHITE DWARF After an estimated billion years or so, the rapid fusion of Helium nto Carbon ceases because all of the core of the Red Giant Sun is now Carbon. Sure, there are other lighter elements in the core, but the majority is Carbon. With no more nuclear fuel for fusion, patient gravity again takes over and squeezes the core in a smaller and smaller ball. Pressure and temperature rise, but never enough to achieve 600 million K, at which Carbon can ignite into heavier element fusion. The core cannot reignite nuclear fusion, and the outward pressure is lost. Eventually, the Red Giant Sun will lose its outer envelope, leaving behind a tiny ball of tightly squeezed Carbon. The Sun has become a "White Dwarf." Our Sun will be very, very small, and yet very hot, with an expanding shell of released gas flying out away from it. The expanding shell of gas and nner White Dwarf comprise a "Planetary Nebula."

All of humanity is long gone in the death throes of our future Sun. Don't worry about this. The Sun is expected o live for a long time yet (another 5 billion years) before disaster sets in. BLACK DWARF AND FINAL DEATH Finally, the White Dwarf cools over a long period until it is nothing but a black stellar corpse, called a Black Dwarf." Carbon is squeezed under great pressure and heated to a high temperature, it changes its form nto something VERY hard and crystalline ... Diamond. The White Dwarf is literally a form **of a giant diamond**

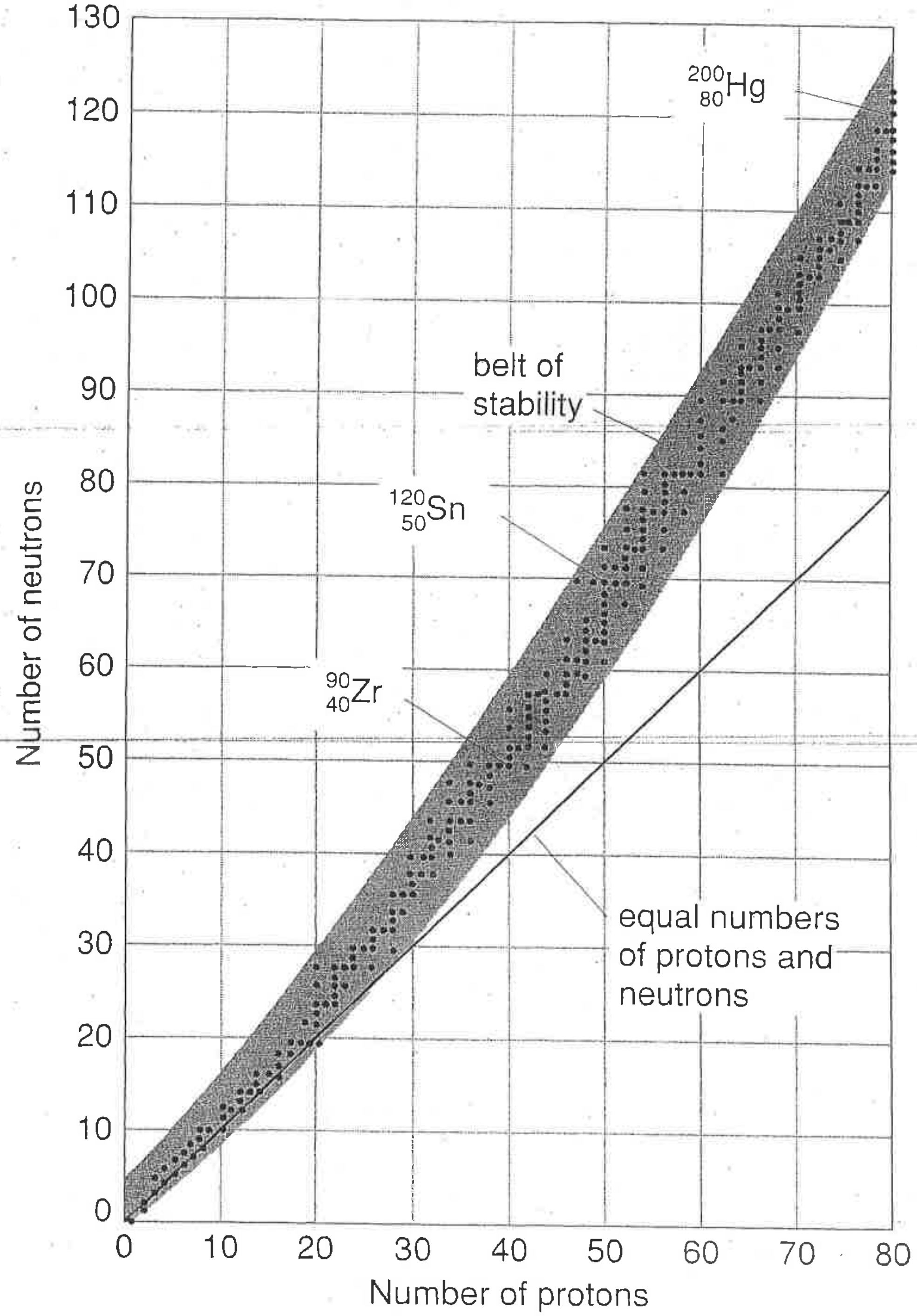
24 Transparency Master

Fission of a Uranium Nucleus

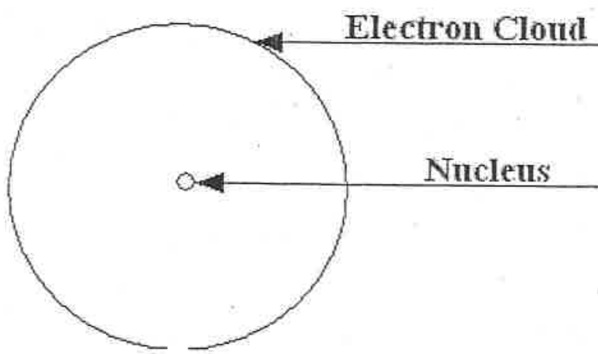


3 Transparency Master

Composition of Stable Nuclei



Atomic Structure



- Contains the electrons
- Makes up most of the volume of the atom
- Negatively charged (electrons are negative)
- Electrons are small and essentially have no mass, so the electron cloud is mostly empty space

- Contains the protons and neutrons
- Positively charged (positive protons, neutral neutrons)
- Small
- Contains all of the mass of the atom
- *Extremely* dense

	Where Found	*Charge*	*Mass Number*
Proton	Nucleus	+1	1
Neutron	Nucleus	0	1
Electron	Electron Cloud	-1	0

Definitions

- Atom: the smallest particle of an element that retains the properties of that element
- Atomic number: the number of protons in the nucleus of an atom
- Mass number: the total number of protons and neutrons in the nucleus of an atom
- Isotopes: Atoms of the same element that differ in mass number (differing numbers of neutrons)

Basic Electrostatics:

Opposite charges attract and identical charges repel

- Electrons and protons attract each other
- Protons repel other protons
- Electrons repel other electrons
- Neutrons are neutral and should neither repel nor attract any particles

Nuclear Forces:

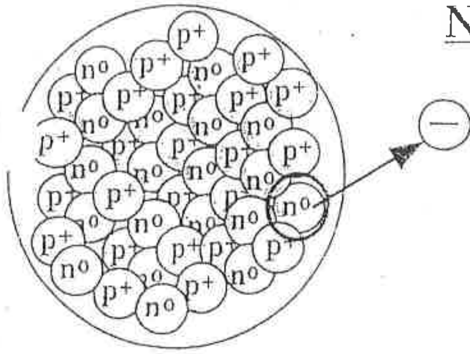
Powerful short range forces in the nucleus that hold the nuclear particles (protons and neutrons) together. These forces overcome the electrostatic repulsion of protons.

Nuclear Decay Organizer

Students know the three most common forms of radioactive decay (alpha, beta, and gamma) and know how the nucleus changes in each type of decay.
Students know alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrations.
Students know some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions.

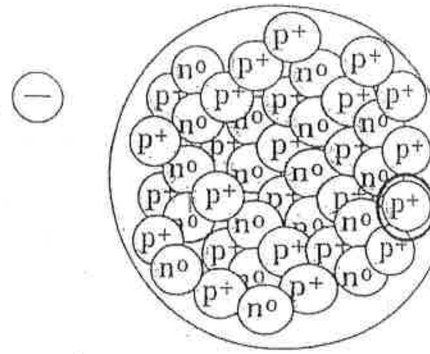
	Alpha Particle Emission	Beta Particle Emission	Gamma Ray Emission
Symbol	${}^{4}_{2}He^{2+}$ or ${}^{4}_{2}\alpha^{2+}$	${}^{0}_{-1}e$ or ${}^{0}_{-1}\beta$	${}^{0}_{0}\gamma$
Mass	Heavy	Light	No Mass
How it changes the nucleus	• Decreases the mass number by 4 • Decreases the atomic number by 2	• Converts a neutron into a proton • Increases atomic number by 1	No change to the nucleus
Penetration	Low	Medium	High
Protection provided by...	Skin	Paper, clothing	Lead
Danger	Low	Medium	High

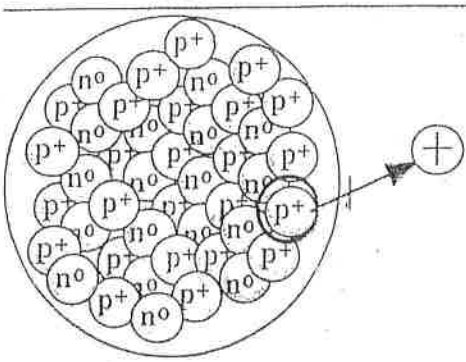
Nuclear Decay Reactions



Beta decay (β-) - a beta particle, the same as an electron, is emitted by a neutron. The neutron, by losing a negative charge, becomes a proton. The atom changes into a different element with an atomic number 1 more than the parent atom.

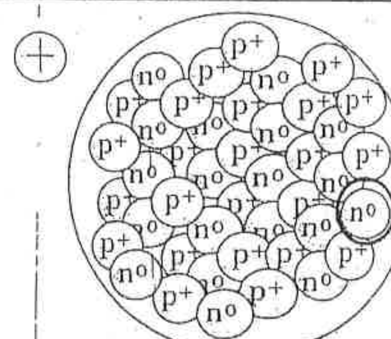
A beta particle ⊖

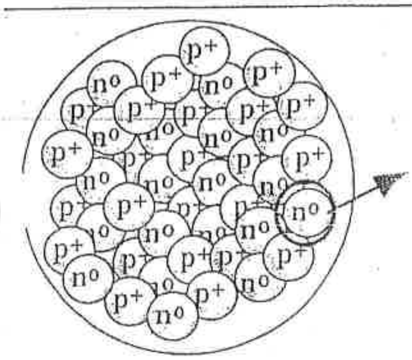




Positron decay (β+) - a positron particle, the same as an anti-electron, is emitted by a proton. The proton, by losing a positive charge, becomes a neutron. The atom changes into a different element with an atomic number 1 less than the parent atom.

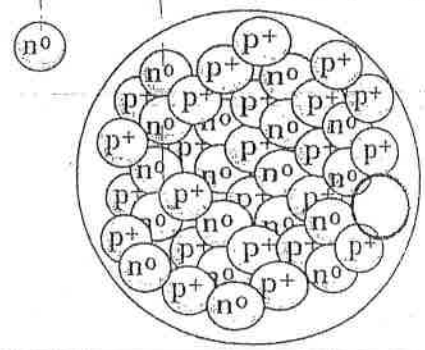
A positron particle ⊕

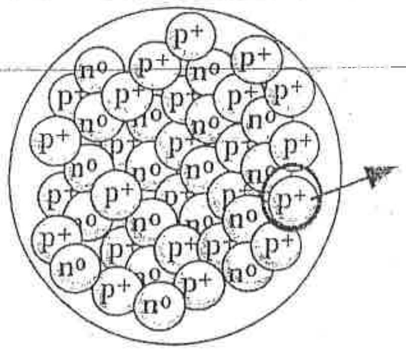




Neutron decay (n^o) - a neutron leaves the nucleus. The atom becomes a different isotope of the same element with a mass number 1 less than the parent atom.

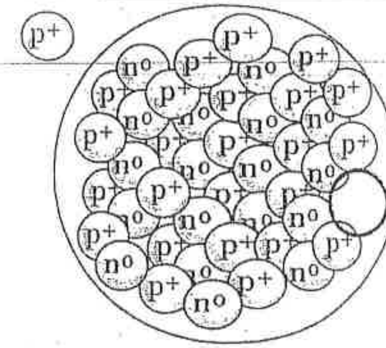
A neutron (n^o)

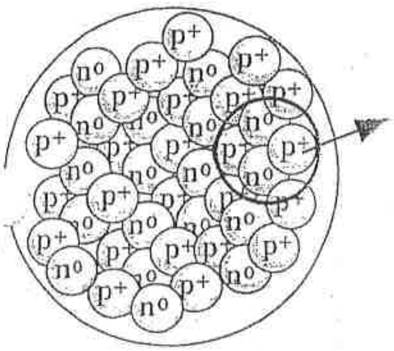




Proton decay (p^+) - a proton leaves the nucleus. The atom changes into a different element with both an atomic number and a mass number 1 less than the parent atom.

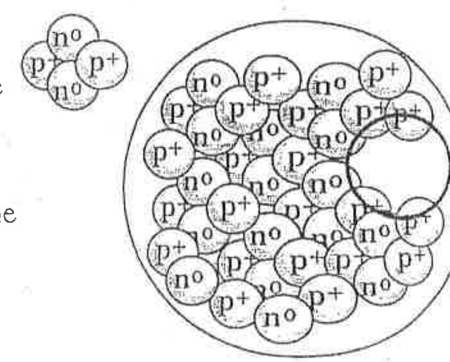
A proton (p^+)





Alpha decay (α) - an alpha particle leaves the nucleus. The atom changes into a different element with both an atomic number 2 less and the mass number 4 less than the parent atom.

An alpha particle



Name ______________________ Date ____________ Class ____________

3–4 Practice Problems

1. Write a nuclear equation for the alpha decay of $^{231}_{91}Pa$.

6. Write a nuclear equation for the alpha decay of $^{146}_{62}Sm$.

2. Write a nuclear equation for the beta decay of $^{223}_{87}Fr$.

7. Write a nuclear equation for the beta decay of $^{198}_{85}At$.

3. Write a nuclear equation for the alpha decay of $^{149}_{62}Sm$.

8. Write a nuclear equation for the alpha decay of $^{150}_{64}Gd$.

4. Write a nuclear equation for the beta decay of $^{165}_{61}Pm$.

9. Write a nuclear equation for the beta decay of $^{152}_{54}Xe$.

5. Write a nuclear equation for the alpha decay of $^{249}_{101}Md$.

10. Write a nuclear equation for the beta decay of $^{120}_{55}Cs$.

Name ______________________________ Date_______________

Balancing Nuclear equations (Homework)

Balance the following nuclear equations. Write the mass number, atomic number and the element symbol for the "?".

a. $^{236}_{88}Ra \rightarrow ^{222}_{86}Rn + ?$ ____________

b. $^{42}_{19}K \rightarrow ^{0}_{-1}e + ?$ ____________

c. $^{239}_{92}U \rightarrow ? + ^{235}_{90}Th$ ____________

d. $^{14}_{6}C \rightarrow ^{14}_{7}N + ?$ ____________

e. $^{218}_{84}Po \rightarrow ? + ^{4}_{2}He$ ____________

f. $^{241}_{95}Am \rightarrow ^{237}_{93}Np + ?$ ____________

g. $^{137}_{55}Cs \rightarrow ^{137}_{56}Ba + ?$ ____________

h. $^{13}_{6}C + ^{1}_{1}H \rightarrow ? + ^{0}_{0}\gamma$ ____________

HALF-LIFE WORKSHEET Name ______________________

Use Reference Table on side to assist you in answering the following questions.

Equations:

½ lifes:
As-81 = 33 seconds
Au-198 = 2.69 days
C-14 = 5730 years

1 How long does it take a 100.00g sample of As-81 to decay to 6.25g?

2. How long does it take a 180g sample of Au-198 to decay to 1/8 its original mass?

3. What percent of a sample of As-81 remains un-decayed after 66 seconds?

4. What is the half-life of a radioactive isotope if a 500.0g sample decays to 62.5g in 24.3 hours?

5. How old is a bone if it presently contains 0.3125g of C-14, but it was estimated to have originally contained 80.000g of C-14?

Name ______________________ Date ____________ Class ____________

24–1 Practice Problems

1. The half-life of cesium-137 is 30.2 years. If the initial mass of a sample of cesium-137 is 1.00 kg, how much will remain after 151 years?

2. Given that the half-life of carbon-14 is 5730 years, consider a sample of fossilized wood that, when alive, would have contained 24 g of carbon-14. It now contains 1.5 g of carbon-14. How old is the sample?

3. A 64-g sample of germanium-66 is left undisturbed for 12.5 hours. At the end of that period, only 2.0 g remain. What is the half-life of this material?

4. With a half-life of 28.8 years, how long will it take for 1 g of strontium-90 to decay to 125 mg?

5. Cobalt-60 has a half-life of 5.3 years. If a pellet that has been in storage for 26.5 years contains 14.5 g of cobalt-60, how much of this radioisotope was present when the pellet was put into storage?

6. A 1.000-kg block of phosphorus-32, which has a half-life of 14.3 days, is stored for 100.1 days. At the end of this period, how much phosphorus-32 remains?

7. A sample of air from a basement is collected to test for the presence of radon-222, which has a half-life of 3.8 days. However, delays prevent the sample from being tested until 7.6 days have passed. Measurements indicate the presence of 6.5 μg of radon-222. How much radon-222 was present in the sample when it was initially collected?

8. A 0.500 *M* solution of iodine-131, which has a half-life of 8.0 days, is prepared. After 40. days, how much iodine will remain in 1.0 L of solution? Express the result in moles.

9. The half-life of sodium-25 is 1.0 minute. Starting with 1 kg of this isotope, how much will remain after half an hour?

10. What is the half-life of polonium-214 if, after 820. seconds, a 1.0-g sample decays to 31.25 mg?

UNIT 16 – NUCLEAR CHEMISTRY

HALF-LIFE PROBLEMS WORKSHEET

1.) What is the half-life of a 100.0 g sample of nitrogen-16 that decays to 12.5 grams in 21.6 seconds?

2.) All isotopes of technetium are radioactive, but they have widely varying half-lives. If an 800.0 gram sample of technetium-99 decays to 100.0 g of technetium-99 in 639,000 years, what is its half-life?

3.) A 208 g sample of sodium-24 decays to 13.0 g of sodium-24 within 60.0 hours. What is the half-life of this radioactive isotope?

4.) If the half-life of iodine-131 is 8.10 days, how long will it take a 50.00 g sample to decay to 6.25 g?

5.) The half-life of hafnium-156 is 0.025 seconds. How long will it take a 560 g sample to decay to one-fourth of its original mass?

6.) Chromium-48 has a short half-life of 21.6 hours. How long will it take 360.00 g of chromium-48 to decay to 11.25 g?

7.) Potassium-42 has a half-life of 12.4 hours. How much of an 848 g sample of potassium-42 will be left after 62.0 hours?

8.) Carbon-14 has a half-life of 5730 years. How much of a 144 g sample of carbon-14 will remain after 1.719×10^4 years?

9.) If the half-life of uranium-235 is 7.04×10^8 years and 12.5 g of uranium-235 remain after 2.82×10^9 years, how much of the radioactive isotope was in the original sample?

WKS
Nuclear Reactions & Decay Series

Name ____________________
Date ____________
Period ____________

Nuclear Equations

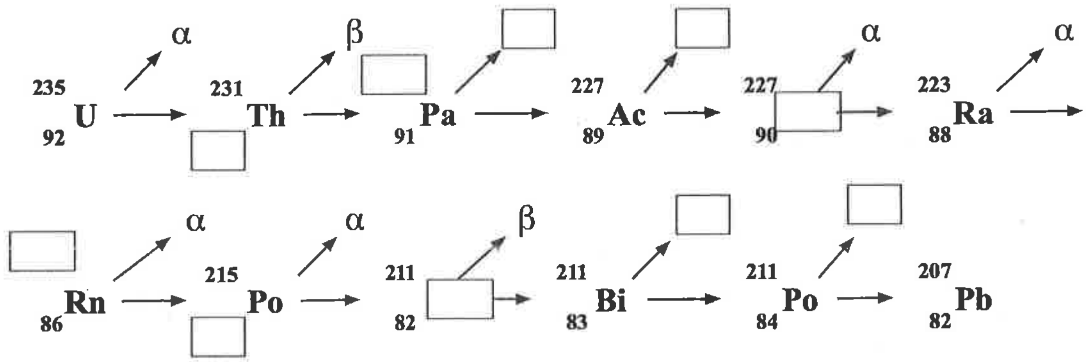
Fill in the blanks to complete the following equations. Use a periodic table to identify elements by atomic number.

Radioactive Decay (Spontaneous Transmutation)

1. $^{214}_{84}Po \rightarrow ^{210}_{82}Pb +$ ______
2. $^{222}_{86}Rn \rightarrow$ ______ $+ ^{4}_{2}He$
3. $^{214}_{82}Pb \rightarrow ^{214}_{83}Bi +$ ______
4. $^{239}_{93}Np \rightarrow$ ______ $+ ^{0}_{-1}\beta$
5. $^{37}_{19}K \rightarrow$ ______ $+ ^{0}_{+1}\beta$
6. Write the equation for the alpha decay of radon-198
7. Write the equation for the beta decay of uranium-237
8. Write the equation for the positron emission from silicon-26
9. Write the equation for the electron capture of sodium-22
10. Write the α-decay equation in which Tl-208 is the product (identify the starting isotope)
11. Write the β-decay equation in which Cu-63 is the product (identify the starting isotope)
12. Write the β^+-emission equation in which Ar-37 is the product (identify the starting isotope)
13. Write the electron-capture equation in which Mg-26 is the product (identify the starting isotope)
14. Write the equation and determine the particle emitted in the conversion of Na-24 to Mg-24:
15. Write the equation and determine the particle emitted in the conversion of Th-228 to Ra-224:

16. Write *two* decay process equations (one emission, one capture) that could account for the conversion of V-49 to Ti-49 and identify the particle emitted or captured.

17. Complete the following radioactive decay series:



18. What kind of nucleus does every radioactive decay series end with?

Induced Transmutation

19. $^{206}_{82}Pb + ^{4}_{2}He \rightarrow$ ______

20. $^{1}_{1}H + ^{3}_{1}H \rightarrow$ ______

21. $^{238}_{92}U + ^{4}_{2}He \rightarrow$ ______ $+ ^{1}_{0}n$

22. $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{139}_{56}Ba + 3^{1}_{0}n +$ ______

23. Write the equation for the proton ($^{1}_{1}p$) bombardment of Be-9 that forms an α-particle, and identify the other product:

24. Write the equation for the α-particle bombardment of Al-27 that forms P-30 and identify the other product:

25. Write the equation and identify the bombardment particle that converts Al-27 to Na-24 and an α-particle:

26. Write the equation for the Am-241 bombardment with Be-9, which results in 3 neutrons [be careful: use $3(^{1}_{0}n)$] and identify the other nucleus formed:

For more practice, go to http://dbhs.wvusd.k12.ca.us/ChemTeamIndex.html and click on the Radioactivity link.

Name______________________________ Per _____

Nuclear Decay Using a periodic table, fill in the blanks to complete the following nuclear equations. Then, identify which type(s) of decay particles were produced. ***Standard:*** Students know the three most common forms of radioactive decay (alpha, beta, and gamma) and know how the nucleus changes in each type of decay.	Alpha	Beta	Gamma
${}^{42}_{19}K \rightarrow {}^{0}_{-1}e + $ ______________			
Describe the change that took place above.			
${}^{235}_{92}U \rightarrow$ ____________ $+ {}^{231}_{90}Th$			
Describe the change that took place above.			
${}^{241}_{95}Am \rightarrow {}^{239}_{93}Np +$ ____________			
Describe the change that took place above.			
${}^{14}_{6}C \rightarrow$ ____________ $+ {}^{14}_{7}N$			
Describe the change that took place above.			
${}^{239}_{94}Pu \rightarrow {}^{4}_{2}He +$ __________			
Describe the change that took place above.			
______ $+ {}^{1}_{0}n \rightarrow {}^{142}_{56}Ba + {}^{91}_{36}Kr + 3\,{}^{1}_{0}n + {}^{0}_{0}\gamma$			
Describe the change that took place above.			
${}^{137}_{55}Cs \rightarrow {}^{137}_{56}Ba +$ ____________			
Describe the change that took place above.			
${}^{13}_{6}C + {}^{1}_{1}H \rightarrow$ __________ $+ {}^{0}_{0}\gamma$			
Describe the change that took place above.			

Table N
Selected Radioisotopes

Nuclide	Half-Life	Decay Mode	Nuclide Name
^{198}Au	2.69 d	β^-	gold-198
^{14}C	5730 y	β^-	carbon-14
^{37}Ca	175 ms	β^+	calcium-37
^{60}Co	5.26 y	β^-	cobalt-60
^{137}Cs	30.23 y	β^-	cesium-137
^{53}Fe	8.51 min	β^+	iron-53
^{220}Fr	27.5 s	α	francium-220
^{3}H	12.26 y	β^-	hydrogen-3
^{131}I	8.07 d	β^-	iodine-131
^{37}K	1.23 s	β^+	potassium-37
^{42}K	12.4 h	β^-	potassium-42
^{85}Kr	10.76 y	β^-	krypton-85
^{16}N	7.2 s	β^-	nitrogen-16
^{19}Ne	17.2 s	β^+	neon-19
^{32}P	14.3 d	β^-	phosphorus-32
^{239}Pu	2.44×10^4 y	α	plutonium-239
^{226}Ra	1600 y	α	radium-226
^{222}Rn	3.82 d	α	radon-222
^{90}Sr	28.1 y	β^-	strontium-90
^{99}Tc	2.13×10^5 y	β^-	technetium-99
^{232}Th	1.4×10^{10} y	α	thorium-232
^{233}U	1.62×10^5 y	α	uranium-233
^{235}U	7.1×10^8 y	α	uranium-235
^{238}U	4.51×10^9 y	α	uranium-238

ms = milliseconds; s = seconds; min = minutes;
h = hours; d = days; y = years

16

Why Do We Need Radioactive Materials?

If you brewed this morning's coffee in a coffeemaker…drove to work on radial prescription drug…or flew on an airplane, radioactive materials made your day a little more healthful, safe and convenient.

Radioactive materials cross our paths many times in a typical day—although few of us realize it. Unnoticed, they quietly benefit us in ways we never think about.

Here's just a sampling of radioactive materials…and the many ways they improve our lives.

Americium-241	Used in many smoke detectors for homes and businesses…to measure levels of toxic lead in dried paint samples…to ensure uniform thickness in rolling processes like steel and paper production…and to help determine where oil wells should be drilled.
Cadmium-109	Used to analyze metal alloys for checking stock, sorting scrap.
Calcium-47	Important aid to biomedical researchers studying the cell function and bone formation of mammals.
Californium-252	Used to inspect airline luggage for hidden explosives…to gauge the moisture content of soil in the road construction and building industries…and to measure the moisture of materials stored in silos.
Carbon-14	Helps in research to ensure that potential new drugs are metabolized without forming harmful by-products.
Cesium-137	Used to treat cancers…to measure correct patient dosages of radioactive pharmaceuticals…to measure and control the liquid flow in oil pipelines…to tell researchers whether oil wells are plugged by sand…and to ensure the right fill level for packages of food, drugs and other products. (The products in these packages do not become radioactive.)
Chromium-51	Used in research in red blood cell survival studies.
Cobalt-57	Used in nuclear medicine to help physicians interpret diagnostic scans of patients' organs, and to diagnose pernicious anemia.
Cobalt-60	Used to sterilize surgical instruments…to improve the safety and reliability of industrial fuel oil burners...and to preserve poultry, fruits and spices.
Copper-67	When injected with monoclonal antibodies into a cancer patient, helps the antibodies bind to and destroy the tumor.

Name ______________________ Date ______________ Class ____________

CHAPTER 21 REVIEW

Nuclear Chemistry

SECTION 1

SHORT ANSWER **Answer the following questions in the space provided.**

1. ______ Based on the information about the three elementary particles on page 683 of the text, which has the greatest mass?

(a) the proton
(b) the neutron
(c) the electron
(d) They all have the same mass.

2. ______ The force that keeps nucleons together is

(a) a strong nuclear force.
(b) a weak nuclear force.
(c) an electromagnetic force.
(d) a gravitational force.

3. ______ The stability of a nucleus is most affected by the

(a) number of neutrons.
(b) number of protons.
(c) number of electrons.
(d) ratio of neutrons to protons.

4. ______ If an atom should form from its constituent particles,

(a) matter is lost and energy is taken in.
(b) matter is lost and energy is released.
(c) matter is gained and energy is taken in.
(d) matter is gained and energy is released.

5. ______ For atoms of a given mass number, those with greater mass defects, have

(a) smaller binding energies per nucleon.
(b) greater binding energies per nucleon.
(c) the same binding energies per nucleon as those with smaller mass defects.
(d) variable binding energies per nucleon.

6. Based on **Figure 1** on page 684 of the text, which isotope of He, helium-3 or helium-4,

____________________ **a.** has the smaller binding energy per nucleon?

____________________ **b.** is more stable to nuclear changes?

7. The number of neutrons in an atom of magnesium-25 is _____.

8. Nuclides of the same element have the same ____________________.

SECTION 1 continued

9. Atom X has 50 nucleons and a binding energy of 4.2×10^{-11} J. Atom Z has 80 nucleons and a binding energy of 8.4×10^{-11} J.

______________ **a.** The mass defect of Z is twice that of X. True or False?

______________ **b.** Which atom has the greater binding energy per nucleon?

______________ **c.** Which atom is likely to be more stable to nuclear transmutations?

10. Identify the missing term in each of the following nuclear equations. Write the element's symbol, its atomic number, and its mass number.

______________ **a.** ${}^{14}_{6}C \rightarrow {}^{0}_{-1}e +$ ____

______________ **b.** ${}^{63}_{29}Cu + {}^{1}_{1}H \rightarrow$ ____ $+ {}^{4}_{2}He$

11. Write the equation that shows the equivalency of mass and energy.

____

12. Consider the two nuclides ${}^{56}_{26}Fe$ and ${}^{14}_{6}C$.

a. Determine the number of protons in each nucleus.

____

b. Determine the number of neutrons in each nucleus.

____

c. Determine whether the ${}^{56}_{26}Fe$ nuclide is likely to be stable or unstable, based on its position in the band of stability shown in **Figure 2** on page 685 of the text.

____

PROBLEM Write the answer on the line to the left. Show all your work in the space provided.

13. ______________ Neon-20 is a stable isotope of neon. Its actual mass has been found to be 19.992 44 amu. Determine the mass defect in this nuclide.

Name ______________________ Date ____________ Class ____________

CHAPTER 21 REVIEW

Nuclear Chemistry

SECTION 2

SHORT ANSWER **Answer the following questions in the space provided.**

1. ______ The nuclear equation $^{210}_{84}Po \rightarrow {}^{206}_{82}Pb + {}^{4}_{2}He$ is an example of an equation that represents

(a) alpha emission.
(b) beta emission.
(c) positron emission.
(d) electron capture.

2. ______ When $^{a}_{b}Z$ undergoes electron capture to form a new element X, which of the following best represents the product formed?

(a) $^{a-1}_{b}X$
(b) $^{a+1}_{b}X$
(c) $^{a}_{b+1}X$
(d) $^{a}_{b-1}X$

3. ______ Which of the following best represents the fraction of a radioactive sample that remains after four half-lives have occurred?

(a) $\left(\frac{1}{2}\right)^4$ **(c)** $\left(\frac{1}{4}\right)$

(b) $\left(\frac{1}{2}\right) \times 4$ **(d)** $\left(\frac{1}{4}\right)^2 \times 4$

4. Match the nuclear symbol on the right to the name of the corresponding particle on the left.

______ beta particle **(a)** $^{1}_{1}p$

______ proton **(b)** $^{4}_{2}He$

______ positron **(c)** $^{0}_{-1}\beta$

______ alpha particle **(d)** $^{0}_{+1}\beta$

5. Label each of the following statements as True or False. Consider the U-238 decay series on page 692 of the text. For the series of decays from U-234 to Po-218, each nuclide

______________ **a.** shares the same atomic number

______________ **b.** differs in mass number from others by multiples of 4

______________ **c.** has a unique atomic number

______________ **d.** differs in atomic number from others by multiples of 4

Name ______________________ Date ______________ Class ______________

SECTION 2 continued

6. ______________ Identify the missing term in the following nuclear equation. Write the element's symbol, its atomic number, and its mass number.

$$\underline{\ ?\ } \rightarrow {}^{231}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$$

7. Lead-210 undergoes beta emission. Write the nuclear equation showing this transmutation.

____

8. Einsteinium is a transuranium element. Einsteinium-247 can be prepared by bombarding uranium-238 with nitrogen-14 nuclei, releasing several neutrons, as shown by the following equation:

$${}^{238}_{92}\mathrm{U} + {}^{14}_{7}\mathrm{N} \rightarrow {}^{247}_{99}\mathrm{Es} + x\,{}^{1}_{0}n$$

What must be the value of x in the above equation? Explain your reasoning.

____

____

____

PROBLEMS **Write the answer on the line to the left. Show all your work in the space provided.**

9. ______________ Phosphorus-32 has a half-life of 14.3 days. How many days will it take for a sample of phosphorus-32 to decay to one-eighth its original amount?

10. ______________ Iodine-131 has a half-life of 8.0 days. How many grams of an original 160 mg sample will remain after 40 days?

11. ______________ Carbon-14 has a half-life of 5715 years. It is used to determine the age of ancient objects. If a sample today contains 0.060 mg of carbon-14, how much carbon-14 must have been present in the sample 11 430 years ago?

Name ______________________ Date ______________ Class ______________

CHAPTER 21 REVIEW

Nuclear Chemistry

SECTION 3

SHORT ANSWER **Answer the following questions in the space provided.**

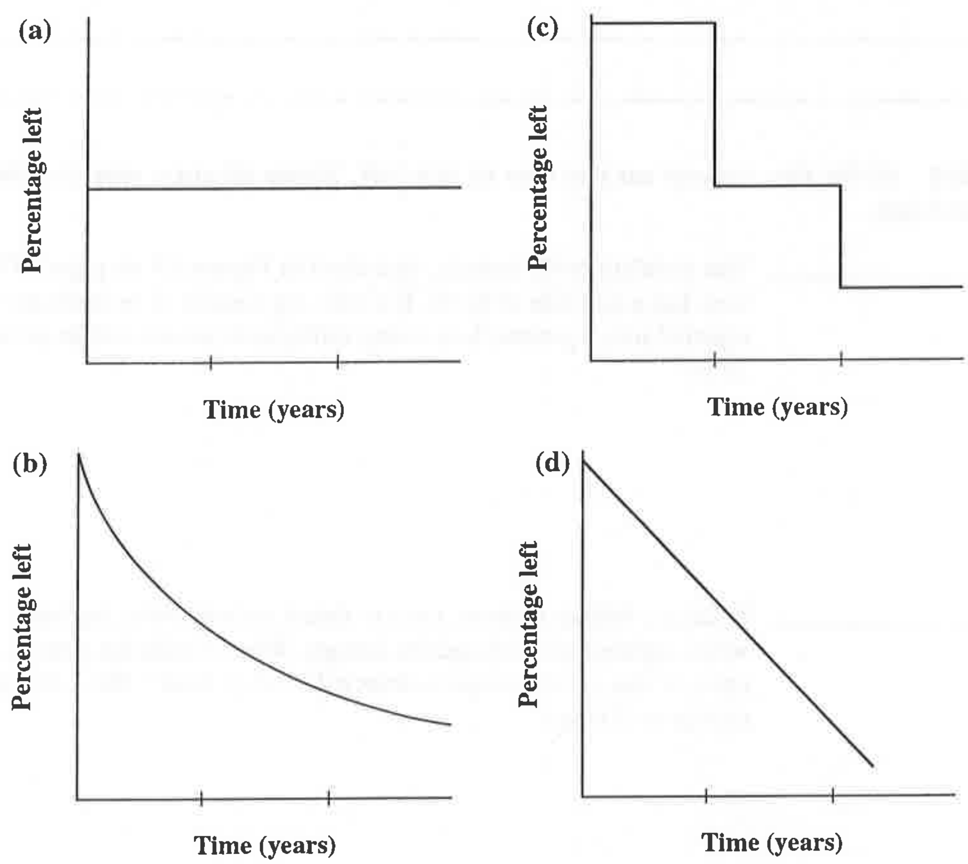
1. ______ The radioisotope cobalt-60 is used for all of the following applications *except*

(a) killing food-spoiling bacteria.
(b) preserving food.
(c) treating heart disease.
(d) treating certain kinds of cancers.

2. ______ All of the following contribute to background radiation exposure *except*

(a) radon in homes and buildings.
(b) cosmic rays passing through the atmosphere.
(c) consumption of irradiated foods.
(d) minerals in Earth's crust.

3. ______ Which one of the graphs shown below best illustrates the decay of a sample of carbon-14? Assume each division on the time axis represents 5715 years.



Name ______________________ Date ______________ Class ______________

SECTION 3 continued

4. Match the item on the left with its description on the right.

______	Geiger-Müller counter	**(a)**	device that uses film to measure the approximate radiation exposure of people working with radiation
______	scintillation counter	**(b)**	instrument that converts scintillating light to an electric signal for detecting radiation
______	film badge	**(c)**	meter that detects radiation by counting electric pulses carried by gas ionized by radiation
______	radioactive tracers	**(d)**	radioactive atoms that are incorporated into substances so that movement of the substances can be followed by detectors

5. Which type of radiation is easiest to shield? Why?

____

____

6. One technique for dating ancient rocks involves uranium-235, which has a half-life of 710 million years. Rocks originally rich in uranium-235 will contain small amounts of its decay series, including the nonradioactive lead-206. Explain the relationship between a sample's relative age and the ratio of lead-206 to uranium-235 in the sample.

____

____

PROBLEMS **Write the answer on the line to the left. Show all your work in the space provided.**

7. ______________ The technetium-99 isotope, described in **Figure 13** on page 697 of the text, has a half-life of 6.0 h. If a 100. mg sample of technetium-99 were injected into a patient, how many milligrams would still be present after 24 h?

8. ______________ A Geiger-Müller counter, used to detect radioactivity, registers 14 units when exposed to a radioactive isotope. What would the counter read, in units, if that same isotope is detected 60 days later? The half-life of the isotope is 30 days.