Chapter 23 Homework Pages 995 – 999: Set 1- 5, 6, 18, 20; Set 2 – 23, 25, 29, 34; Set 3 – 37, 43, 50, 81.

VIII. Nuclear Chemistry

A. Nuclear reactions involve changes in the number of _____ in the nucleus whereas chemical reactions involve changes in the number of electrons only.

B. Radiation - Radioactivity first observed by Henri _____ in 1896

1. can be defined as _____ or _____ that come from one place and travel through things to get to another place.
   EX. light, heat, alpha particle, beta particle, gamma rays, cosmic rays
2. _____ particle, α, is a _____ nucleus $^{4}_{2}He$ 2 protons and 2 neutrons
   _____ particle, β, is a high speed _____ $^{0}_{-1}e$ 0 protons, 0 neutrons
   _____ rays, γ, are high energy rays
   cosmic radiation, high energy charged particles

alpha particle	penetrating power 1	stopped by _____
beta particle	pentrating power 10	stopped by _____
gamma rays	penetrating power 100	stopped by _____; passes straight through _____ _____

3. Classification
   a. _____ radiation - produces ions, free radicals, from atoms and molecules - x-rays, gamma rays, cosmic rays
   b. _____ radiation - lower energy - light, radio
   c. damage to organism that receives radiation directly is _____ damage - burns, rashes, cataracts, cancer
   d. damage to reproductive organs is called _____ damage - birth defects
4. We are being bombarded at this moment by atomic nuclei, sub atomic particles, high energy rays, all kinds of stuff. This type of radiation is called _____ _____
5. Measuring radiation
   a. SI unit is the _____
   b. more common is the _____, Ci. 1 Ci = # of disintegrations per second per gram radium. This doesn't correspond to the level of damage done. 1 Ci of α is harmless, but 1 Ci of γ is devastating.
   c. _____ (roentgen equivalent for man) - named for Wilhelm _____, discovered X- rays. Used to measure exposure to humans. Rem includes both amount of _____ transferred by radiation and the _____ of the body to that type of radiation. 150 rem causes some tissue damage whether its α, γ. 1000 + rem is fatal; <1000 rem is eventually fatal. 100 mrem / year = avg. dose

d. detection - _____ counter (pg. 991 for diagram) - positive wire in a negative cylinder filled with argon. α,β,γ easily ionize Ar, ions are attacted to either wire or cylinder which creates an electrical pulse.

e. _____ Doses - use a _____ that measures total amount of radiation a person receives. Badge most people wear contains _____ film. Film is _____ every so often and amount of _____ is translated to the amount of _____ exposure.

6. Source - _____ nuclei - stability range is a ration of _____ or _____ of protons to neutrons. The larger the element the more likely it is to be unstable. Unstable nuclei _____ and _____ radiation in different ways

a. _____ emission - an alpha particle,α, is emitted

$^{230}_{90}Th \Longrightarrow {}^{4}_{2}He + $ _____

(mass numbers and atomic numbers must be _____ on both side of reaction)

Th is the _____ nuclide; He is _____ particle; Ra is the _____ nuclide.

b. _____ emission - emission of a beta negative particle,β^-, which is an electron from the nucleus. $^{234}_{91}Pa \Longrightarrow {}^{0}_{-1}e +$ _____ The decay of the neutron provides a _____ to the _____.

A beta _____, β^+, could also be emitted.

$^{251}_{98}Cf \Longrightarrow {}^{0}_{+1}e +$ _____

c. _____ capture - an _____ is captured from the K - shell

$^{234}_{92}U + {}^{0}_{-1}e \Longrightarrow$ _____

d. Some elements decay naturally in a decay series, until a stable nuclide is reached. Uranium - 238 decays in 14 steps to Lead - 206. The steps are :

α,β,β,α,α,α,α,α,β,α,β,β,α,β or α,β,β,α,α,α,α,α,β,β,α,β,β,α. (Try this)

e. Some nuclear reactions are induced by bombardment with other particles. $^{14}_{7}N + {}^{4}_{2}He \Longrightarrow$ _____ + $^{1}_{1}H$ this is called _____

$^{98}_{42}Mo + {}^{1}_{0}n \Longrightarrow$ _____ + $^{0}_{-1}e$

Neutrons are very effective since a zero charge can approach the nucleus easier and disrupt stability.

C. Half- life and Geological dating

1. By knowing the _____ of an element we can determine the age of a substance containing that element.
2. The half - life, (_____) of a substance is the time it takes for _____ the nuclei in a radioactive sample to _____.
3. Carbon - 14 has a half life of _____ years. $^{14}_{6}C \Longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e$ (Carbon - 14 is produced when cosmic rays bombard nitrogen - 14.) Ex. If we had 100 carbon - 14 atoms, after 5730 years there would only be _____; after another 5730 there would only be _____and so on.
4. Carbon - 14 is used for dating since almost every living organism contains carbon. This method is only reliable for things that are _____ years

old or younger. The β^- emission is too _____ to be measured reliably after that.

5. How does this work ? Since radioactivity is measurted in # of disintegrations that occur per min per gram. A living plant gives off 15.3 ± 0.1 disint/min/gram. So by measuring the # of disint/min/g being given off something no longer living we can determine the age of the material. Ex. How old is a piece of wood that is emitting 1.9 ± 0.1 disint/min/g of β^- particles ?

_____

_____

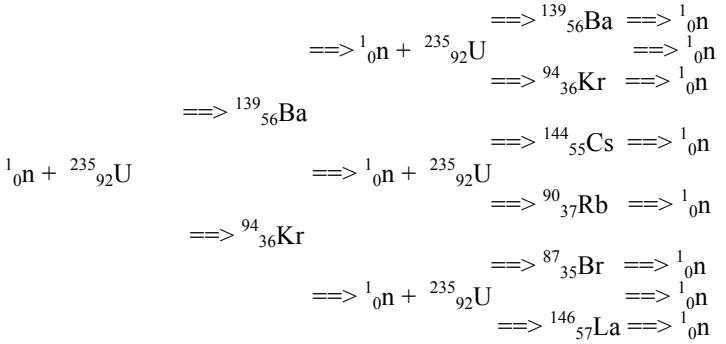
_____

_____

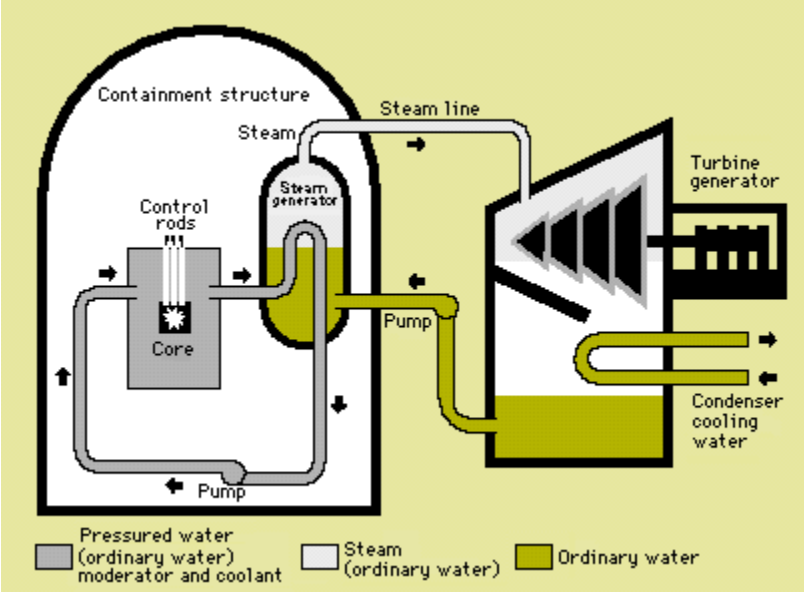
D. Uses of Nuclear Chemistry
   1. Development of synthetic elements. This process is called _____. The elements are called _____.
      a. Most were made at Lawrence Radiation Lab at the University of California, Berkley. The team was led by Glen _____ and Albert _____.
      b. The first synthetic element was _____ in Italy in 1937.
      c. Production of transuranium elements
      d. Massive amounts of energy are needed to accelerate particles fast enough so the will combine in a nuclear reaction.
      e. Accomplished with particle accelerators. _____ uses alternating currents in the "Dee" rods. _____ uses electromagnets. Both use the push pull effect to _____ particles. Synchrotrons are very large (6.3 km circ.) Linear accelerators are also used.
   2. Radioactive Isotopes as Tracers
      a. Used to trace functions in the _____, _____ _____, _____, _____ _____.
      b. In the body ; Iodine - 131 is used to trace proper functions of the thyroid, lungs and kidneys. Technetium - 99 is used for the brain, lungs, liver, spleen and bones. Cobalt - 58 is used to trace the bodies ability to absorb B_{12} . Also some are used to kill cancerous cells by being injected into tumor and decay very quickly to give pulse of radiation. $^{192}_{77}Ir$ in metal seed of Pt so Ir can't escape and keeps α, β^- contained. $^{60}_{27}Co$ used as an external treatment. Chemo attacks fast growing cells like stomach lining and hair thus hair loss and nausea. Radon has a $T_{1/2}$ of minutes. The gas itself is not harmful, but when breathed into lungs it decays before being exhaled. Limit is 4 picocuries/L air.
      c. Instruments used to diagnose are PET (positron emission tomography) and the SPECT (single photon emission computed tomography).
      d. $^{32}_{15}P$ is used to study uptake of nutrients by plant cells.
      e. $^{140}_{56}BaSO_4$ is used to follow movement of silt in rivers.
   3. Nuclear Energy

a. Nuclear reactions involve amounts of energy about _____ greater than the energy derived form chemical reactions.
b. In nuclear reactions it seems as if some matter is _____. This matter has been transformed into energy as Einstein predicted with his _____ equation. "Matter and energy are two different interchangeable forms of a single more fundamental quantity."
c. ____ = energy in joules (1J = 1kg m^2 / s^2)
____ = mass in kg
____ = speed of light (3.00 x 10^8 m / s)
Thus the quantity of Energy released from a small amount of matter can be determined.
d. Example - $^{226}_{88}Ra$ ==> $^{222}_{86}Rn$ + $^{4}_{2}He$ let's use I mole of Ra
Molar mass of Radium - 226 = 225.9771g
Molar mass of Radon - 88 = 221.9703g
Molar mass of Helium - 4 = 4.0015g
Difference in mass is the mass defect. The amount of energy equal to this mass is the binding energy (energy needed to break up nucleus, often measured in J / particle). This reaction releases 4.77 x 10^{11} J. This is enough energy to melt all the steel beams and girders in a 30 story building !

4. _____
a. _____ of atoms into smaller _____ by bombardment with low energy neutrons.
b. Occurs through a _____ _____ rxn called a chain rxn.
c. The uranium - 235 absorbs a neutron and becomes unstable and breaks into 2 smaller nuclei plus more neutrons. The neutrons produced are absorbed by more uranium and the chain rxn contiunues.



d. Minimum amount of matter needed to sustain a chain reaction is called the _____ mass . 4.5 g of $^{235}_{92}U$ satisfies 1 persons energy need for 1 year whereas, 15 tons of coal will accomplish same task.
e. Nuclear Power plant (See Diagram page 983) fuel is _____ and _____. European are called _____ Reactors because they make their own fuel.



f. Problems - Nuclear waste - what do we do with it ?

_____

_____

_____

_____

5. _____

a. More powerful than fission. It's when small _____ join to form larger _____. This is the energy in the _____.

b. $^{2}_{1}H + {}^{3}_{1}H \Longrightarrow {}^{4}_{2}He + {}^{1}_{0}n + 1.7 \times 10^{9}$ KJ / mole
deuterium + tritium must be in _____ phase so the electrons don't get in the way and they are moving _____ enough.

c. To accomplish this 40 million K are needed. A _____ _____ creates plasma and uses a magnetic field to hold the plasma in a doughnut shaped chamber called a magnetic bottle. Lasers can also be used to create high enough temperatures.

d. In one day the energy reaching the earth from the sun equals all the energy ever used by humans on this planet.

e. Reasons to explore fusion - _____

_____

_____

_____

6. _____

a. Theoretical particle with a fractional charge of either 1/3 or 2/3

b.

_____	+2/3
_____	-1/3
_____	+2/3
_____	-1/3
_____ (truth)	+2/3
_____ (beauty)	-1/3

c. Most matter is made of ups and downs

proton		neutron	
_____	+2/3	_____	+2/3
_____	+2/3	_____	-1/3
_____	-1/3	_____	-1/3

d. Electrons are made of _____

f. _____ - _____, electrons and positrons , when they meet they completely annihilate each other and are turned completely into energy.