Chemistry Name: _____

Section _____ CHAPTER 24 LEARNING GUIDE Date: _____

Nuclear Chemistry

Stability of isotopes

Related to the ratio of protons and neutrons in the nucleus

Stable light elements ($Z \leq 20$) have a $p^+:n^0$ ratio of 1 to 1

Stable heavy elements ($Z > 75$) have a $p^+:n^0$ ratio of 1 to 1.5

Related to the size of the nucleus

There are no known stable isotopes with Z > 83 or long > 92

Related to the number of p^+ and n^0 being even or odd

Summary of E (even) and O (odd) primordial isotopes

$p^+:n^0$	E:E	E:O	O:E	O:O	Total
Stable	148	53	48	5	254
Long-lived	22	4	5	4	35
All Primordial	170	57	53	9	289

Types of radioactive decay and nuclear particles (See Table O)

Name	Notation	Symbol
alpha particle	${}^{4}_{2}He$ or ${}^{4}_{2}\alpha$	α
beta particle	${}^{0}_{-1}e$ or ${}^{0}_{-1}\beta$	β^-
gamma radiation	${}^{0}_{0}\gamma$	γ
neutron	${}^{1}_{0}n$	n
proton	${}^{1}_{1}H$ or ${}^{1}_{1}p$	p
positron	${}^{0}_{+1}e$ or ${}^{0}_{+1}\beta$	β^+

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Penetrating power

Name	Penetrating Power	Mass	Speed	Charge
alpha particle	very slight	high	low	+2
beta particle	slightly higher	low	higher	–1
gamma radiation	very high	very low	light	0

Transmutation Reactions

Alpha decay: ${}^{210}_{84}\mathrm{Po} \rightarrow {}^{206}_{82}\mathrm{Pb} + {}^{4}_{2}\mathrm{He}$

Beta decay: ${}^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + {}^{0}_{-1}\mathrm{e}$

Positron emission: ${}^{23}_{12}\mathrm{Mg} \rightarrow {}^{23}_{11}\mathrm{Na} + {}^{0}_{+1}\mathrm{e}$

Electron capture: ${}^{81}_{37}\mathrm{Rb} + {}^{0}_{-1}e \rightarrow {}^{81}_{36}\mathrm{Kr} + v_e$ where v_e is an x – ray photon

Gamma emission: ${}^{60}_{27}\mathrm{Co} \rightarrow {}^{60}_{28}\mathrm{Ni} + {}^{0}_{-1}\mathrm{e} + {}^{0}_{0}\gamma + {}^{0}_{0}\gamma$ where $\gamma_1 = 1.17$ MeV and $\gamma_2 = 1.33$ MeV

Use Table N

${}^{85}_{36}\mathrm{Kr} \rightarrow {}^{85}_{37}\mathrm{Rb} + {}^{0}_{-1}\mathrm{e}$

${}^{232}_{90}\mathrm{Th} \rightarrow {}^{228}_{88}\mathrm{Ra} + {}^{4}_{2}\mathrm{He}$

Rates of decay – all radioactive decay is first order

Half-life: the time required for ½ the mass of a radioisotope to decay

How much of a 5.00 g sample of ${}^{131}\mathrm{I}$ would remain after 40.105 days? 0.156 g

How old is a wood sample containing 12.5% as much ${}^{14}\mathrm{C}$ as modern wood? 17 100 yrs

Radioactive series: occurs when the product of nuclear decay creates another radioisotope.

Isotopes that begin a series are called parent material while the products are called the

daughter material

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Uses for radioisotopes

Medical

Iodine–131: used to diagnose and treat thyroid disorders

Cobalt–60: used as a gamma ray source for radiation therapy for certain cancers

Industrial gauging

Krypton–85: β^- used to measure the thickness of plastic film

Tagging or tracing chemical or biological processes

Oxygen–18: used to tag or trace oxygen atoms to determine their source

Dating

Carbon–14: used to find the age or date once living materials (like wood)

Uranium–238: used to date rocks to determine the age of the earth

Power

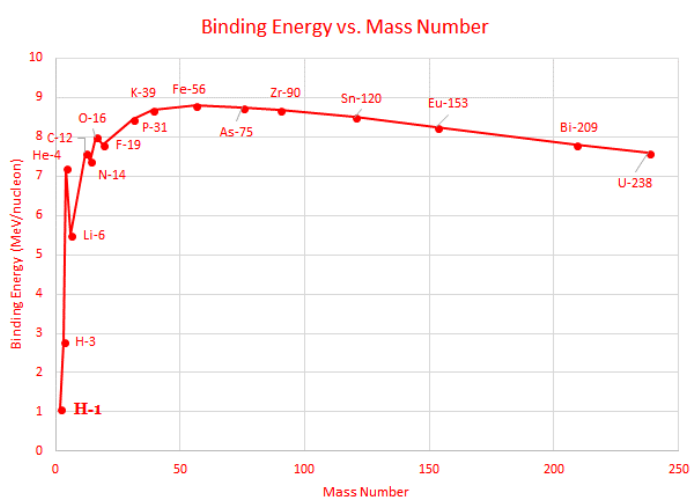
Nuclear reactions can generate thousands times more energy than coal, gas, or oil

Fission: splitting heavy nuclei to form lighter isotopes

Fusion: combining nuclei to form heavier atoms

Binding energy: the energy released when protons and neutrons are combined to form a nucleus

Make a graph showing the binding energy per nucleon in an atom's nucleus



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Binding energy comes from converting matter to energy as shown by Einstein's famous equation:

$\Delta E = \Delta mc^2$

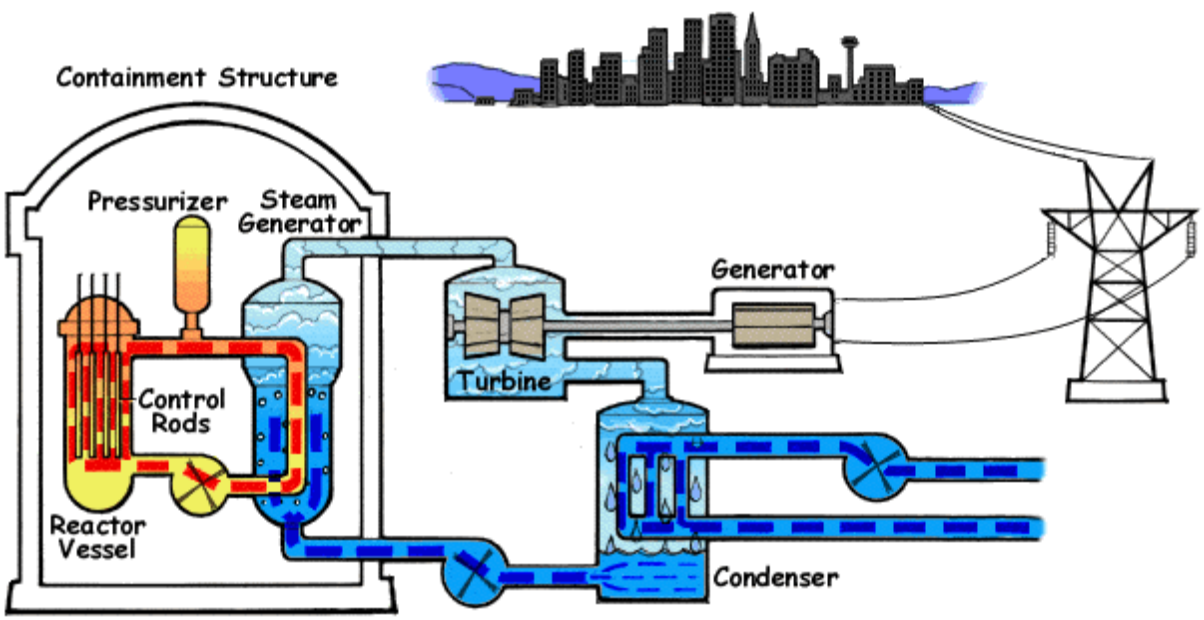
Nuclear reactors

Nuclear reactors in use today use fission to drive a steam turbine

Finish the nuclear reaction: $^{235}_{92}U + ^{1}_{0}n \rightarrow 3\ ^{1}_{0}n + ^{92}_{36}Kr + ^{141}_{56}Ba$

The amount of radioisotope required to sustain a chain reaction is the critical mass

Sketch a nuclear reactor in the space below



From: http://en.wikipedia.org/wiki/File:PressurizedWaterReactor.gif

The greatest risks in using radioactive fuels are biological exposure ,

long term storage and disposal and nuclear accidents

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