Name: ________________________

Period: ____ Subject: AP Chem

Date: ________________________

Snow Day Problems

1. Be able to describe what the following mean: Hund's rule, Pauli exclusion principle, Aufbau principle.

Aufbau principle says you fill the electron energy shells from the bottom up – i.e. you fill the lowest energy levels first, then work up to each next highest energy level. The Pauli exclusion principle states that no two electrons can have all 4 quantum numbers exactly the same. Hund's rule states that when filling orbitals, you must first put one electron in each orbital of a subshell before putting a second electron (with opposite spin) in the same orbital.

2. Using a periodic table, be able to list the entire aufbau sequence.

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^6\ 7s^2\ 5f^{14}\ 6d^{10}\ 7p^6$

3. What are the 4 quantum numbers (both name and symbol). What does each represent?

n	principal quantum number	energy level/size of shell
ℓ	angular momentum quantum number	subshell, shape of orbital
m_ℓ	magnetic quantum number	orientation of orbital
m_s	spin quantum number	magnetic spin

4. Give the name and symbols for each of the types of nuclear decay we've discussed. (Don't worry about a symbol for fission.)

${}^{4}_{2}\mathrm{He}$ α particle

${}^{0}_{-1}e$ β particle

${}^{0}_{1}e$ positron

${}^{0}_{0}\gamma$ gamma radiation

Fission is splitting of a nucleus into two new nuclei, electron capture doesn't emit a particle but captures an electron on the reactant side of the equation.

The following problems are all from Chpt. 18 in the textbook.

9. Write balance equations for each of the processes described below:

a. Chromium-51, which targets the spleen and is used as a tracer in studies of red blood cells, decays by electron capture.

b. Iodine-131, used to treat hyperactive thyroid glands, decays by producing a β particle.

a. $^{51}_{24}\text{Cr} + {}^{0}_{-1}e \rightarrow {}^{51}_{23}\text{V}$

b. $^{131}_{53}\text{I} \rightarrow {}^{131}_{54}\text{Xe} + {}^{0}_{-1}e$

11. Write an equation describing the radioactive decay of each of the following nuclides. (The particle produced is shown in parentheses, except for electron capture, where an electron is a reactant.)

a. ^{68}Ga (electron capture)

b. ^{62}Cu (positron)

c. ^{212}Fr (α)

d. ^{129}Sb (β)

a. $^{68}_{31}\text{Ga} + {}^{0}_{-1}e \rightarrow {}^{68}_{30}\text{Zn}$

b. $^{62}_{29}\text{Cu} \rightarrow {}^{62}_{28}\text{Ni} + {}^{0}_{1}e$

c. $^{212}_{87}\text{Fr} \rightarrow {}^{208}_{85}\text{At} + {}^{4}_{2}\text{He}$

d. $^{129}_{51}\text{Sb} \rightarrow {}^{129}_{52}\text{Te} + {}^{0}_{-1}e$

14. One type of commercial smoke detector contains a minute amount of radioactive americium-241 (^{241}Am), which decays by α-particle production. The α particles ionize molecules in the air, allowing it to conduct an electric current. When smoke particles enter, the conductivity of the air is changed and the alarm buzzes.

a. Write the equation for the decay of ^{241}Am by α-particle production.

b. The complete decay of ^{241}Am involves successively α, α, β, α, α, β, α, α, α, β, α, and β production. What is the final stable nucleus produced in this decay series?

a. $^{241}_{95}\text{Am} \rightarrow {}^{237}_{93}\text{Np} + {}^{4}_{2}\text{He}$

b. $^{209}_{83}\text{Bi}$

17. In 1994 it was proposed that element 106 be named seaborgium, Sg, in honor of Glenn T. Seaborg, discoverer of the transuranium elements.

a. ^{263}Sg was produced by the bombardment of ^{249}Cf with a beam of ^{18}O nuclei. Complete and balance an equation for the reaction.

b. ^{263}Sg decays by α emission. What is the other product resulting from the α decay of ^{263}Sg?

a. $^{249}_{98}\text{Cf} + {}^{18}_{8}\text{O} \rightarrow {}^{263}_{106}\text{Sg} + 4\,{}^{1}_{0}n$

b. $^{259}_{104}\text{Rf}$

31. The sun radiates 3.9 x 10^{23} J of energy into space every second. What is the rate at which mass is lost from the sun?

$E = mc^2$
$m = E/c^2 = 3.9\times10^{23}/9.00\times10^{16} = 4.33\times10^{6}$ kg/sec

33. Many transuranium elements, such as plutonium-232, have very short half-lives. (For ^{232}Pu, the half-life is 36 minutes.) However, some, like protactinium-231 (half-life = 3.34 x 10^4 years), have relatively long half-lives. Use the masses given below to calculate the change in energy when one mol of ^{232}Pu nuclei and one mol of ^{231}Pa nuclei are each formed from their respective number of protons and neutrons.

Atom or Particle	Atomic Mass
neutron	1.67493 x 10^{-24} g
proton	1.67262 x 10^{-24} g
electron	9.10939 x 10^{-28} g
Plutonium-232	3.85285 x 10^{-22} g
Protactinium-231	3.83616 x 10^{-22} g

(Since the masses of ^{232}Pu and ^{231}Pa are atomic masses, they each include the mass of the electrons present. The mass of the nucleus will be the atomic mass minus the mass of the electrons.)

$\Delta E_{Pu} = (m_{Pu\ nucleus} - m_{n+p})c^2$ (units = J, kg, m/s)
$m_{Pu\ nucleus} = 3.85285\times10^{-22}$ g - $94*9.10939\times10^{-28}$ g
$m_{n+p} = 94*1.67262\times10^{-24}$ g + $138*1.67493\times10^{-24}$ g (change to kg for next step)
$\Delta E_{Pu} = (3.16724827\times10^{-27})(3.00\times10^{8})^2 = 2.850523439\times10^{-10}$ J (per atom)
$2.850523439\times10^{-10} * 6.022\times10^{23} = 1.716585215\times10^{14}$ J = 1.717×10^{14} J (per mol)

$\Delta E_{Pa} = (m_{Pa\ nucleus} - m_{n+p})c^2$
$m_{Pa\ nucleus} = 3.83616\times10^{-22}$ g - $91*9.10939\times10^{-28}$ g
$m_{n+p} = 91*1.67262\times10^{-24}$ g + $140*1.67493\times10^{-24}$ g
$\Delta E_{Pu} = (3.16551545\times10^{-27})(3.00\times10^{8})^2 = 2.848963904\times10^{-10}$ J (per atom)
$2.848963904\times10^{-10} * 6.022\times10^{23} = 1.715646063\times10^{14}$ J = 1.716×10^{14} J (per mol)

41. Photosynthesis in plants can be represented by the following overall reaction:

$$6CO_2(g) + 6H_2O(l) \implies C_6H_{12}O_6(s) + 6O_2(g)$$

Algae grown in water containing some ^{18}O (in $H_2{}^{18}O$) evolve oxygen gas with the same isotopic composition as the oxygen in the water. When algae growing in water containing only ^{16}O were furnished carbon dioxide containing ^{18}O, no ^{18}O was found to be evolved from oxygen gas produced. What conclusions about photosynthesis can be drawn from these experiments?

The first experiment shows that the oxygen the plant gives off as a product of photosynthesis has the same isotope ratio as the oxygen found in the water in the reactants. The second experiment shows that *none* of the oxygen from the carbon dioxide in the reactants was given off as oxygen in the products. The data shows that the oxygen given off from plants is derived from the oxygen the plant gets from the water and not from the oxygen in the carbon dioxide the plant takes in.

43. Which do you think would be the greater health hazard: the release of a radioactive nuclide of Sr or a radioactive nuclide of Xe into the environment? Assume the amount of radioactivity is the same in each case. Explain your answer on the basis of the chemical properties of Sr and Xe. Why are chemical properties of a radioactive substance important in assessing its potential health hazards?

With the radioactivity given as the same for each case, then exposure becomes the main concern. Strontium is in the same family as calcium and could be assimilated into the body in a similar manner as calcium (bones, muscles, teeth, etc.). Xenon, being a noble gas, is highly nonreactive. So, while there might be some short term exposure to whatever radioactive xenon might be in the air, it wouldn't react with the body or be incorporated into the body in the same way the strontium would.