Nuclear Chemistry Worksheet

Using your knowledge of nuclear chemistry, write the equations for the following processes:

1) The alpha decay of radon-198

2) The beta decay of uranium -237

3) Positron emission from silicon-26

4) Sodium-22 undergoes electron capture

5) What is the difference between nuclear fusion and nuclear fission?

6) What is a “mass defect” and why is it important?

7) Name three uses for nuclear reactions.

Chemistry I 2005

Worksheet 3-3
Half-life

Name__________________________

Period______

Glencoe Chemistry pp. 817-826

Show your work for all calculation problems.

1. Define half-life.

2. How is the half-life of a radioisotope similar to a sporting tournament in which the losing team is eliminated?

3. The half-life of radium-226 is 1600 years. How many grams of a 0.25g sample will remain after 4800 years?

4. Sodium-24 has a half-life of 15 hours. How much sodium-24 will remain in an 18.0g sample after 60 hours?

5. After 42 days a 2.0 g sample of phosphorus-32 contains only 0.25g of isotope. What is the half-life of phosphorus-32?

6. The half-life of radon-222 is 3.823 days. What was the original mass if 0.050g remains after 7.646 days?

7. The half-life of thorium-227 is 18.72 days. How many days are required for 75% of a given amount to decay?

8. The half-life of protactinium-234 is 6.75 hours. What percentage of a given sample will remain after 27 hours?

9. A rock once contained 1.0mg of uranium-238, but now contains only 0.25mg. Given that the half-life for uranium-238 is 4.5×10^9 years, how old is the rock?

10. The half-life of tritium (^3H) is 12.3 years. If 48.0mg of tritium is released from a nuclear power plant during the course of a mishap, what mass of the nuclide will remain after 49.2 years?

Name ______________________ Date __________ Class __________

REVIEW

6 SECTION 6.2

Nuclear Fission and Fusion

1. **Match** the terms on the left with the correct definition on the right.

   a. critical mass
   b. strong nuclear force
   c. fusion reaction

   A. attractive force that acts between nucleons at very short distances
   B. joining of two lighter nuclei to form a heavier nuclei
   C. the minimum mass of a fissionable isotope in which a nuclear chain reaction can occur

2. **Describe** how a fission reaction is started.

____

____

____

3. **Describe** a characteristic of a fissionable substance that is essential for a chain-reaction to sustain itself.

____

____

____

4. **Explain** why the energy associated with even a small mass is immense. (**Hint:** Consider the way *c* appears in the mass-energy equation.)

____

____

____

____

5. **Determine** whether the following statements are true or false.

   __________ a. The strong nuclear force that causes protons and neutrons in the nucleus to attract each other is not quite as strong as the electric repulsion between protons.

   __________ b. The attraction caused by the strong nuclear force occurs over a very short distance.

   __________ c. Protons in a nucleus both repel and attract each other, while neutrons only attract.

   __________ d. In stable nuclei, the attractions between the particles are stronger than the repulsions.

   __________ e. A nucleus with more than 83 protons is unstable and undergoes radioactive decay.

25. When a uranium nucleus breaks up into fragments, which type of nuclear reaction occurs? (1) fusion (2) fission (3) replacement (4) redox

26. Which pair of nuclei can undergo a fusion reaction? (1) potassium-40 and cadmium-113 (2) zinc-64 and calcium-44 (3) uranium-238 and lead-208 (4) hydrogen-2 and hydrogen-3

27. What process is represented by the following reaction?

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}He + \text{energy}$$

(1) fission (2) fusion (3) artificial transmutation (4) alpha decay

28. During a fission reaction, which type of particle is captured by a nucleus? (1) deuteron (2) electron (3) neutron (4) proton

29. What is the primary result of a fission reaction? (1) conversion of mass to energy (2) conversion of energy to mass (3) binding together of two heavy nuclei (3) binding together of two light nuclei

30. Compared to an ordinary chemical reaction, a fission reaction will (1) release smaller amounts of energy (2) release larger amounts of energy (3) absorb small amounts of energy (4) absorb larger amounts of energy

31. Which type of reaction produces energy and intensely radioactive waste products? (1) fusion of tritium and deuterium (2) fission of uranium (3) burning of heating oil (4) burning of wood

32. Which process occurs in a controlled fusion reaction?
(1) Light nuclei collide to produce heavier nuclei.
(2) Heavy nuclei collide to produce lighter nuclei.
(3) Neutron bombardment splits light nuclei.
(4) Neutron bombardment splits heavy nuclei.

33. Consider this reaction.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{138}_{56}Ba + ^{95}_{36}Kr + 3^{1}_{0}n + \text{energy}$$

This equation can best be described as (1) fission (2) fusion (3) natural decay (4) endothermic

Half-Life

Radioactive substances decay at a constant rate that is not dependent on factors such as temperature, pressure or concentration. It is also a random event. That is, it is impossible to predict when a given unstable nucleus will decay. However, the number of unstable nuclei that will decay in a given time in a sample of the element can be predicted. The time it takes for half of the atoms in a given sample of an element to decay is called the **half-life** of the element. Each isotope has its own half-life. The shorter the half-life of an isotope, the less stable it is. Table N in *Reference Tables for Physical Setting/Chemistry* lists various isotopes together with their half-lives and the mode by which they decay. Figure 12-6 shows the decay of carbon-14.

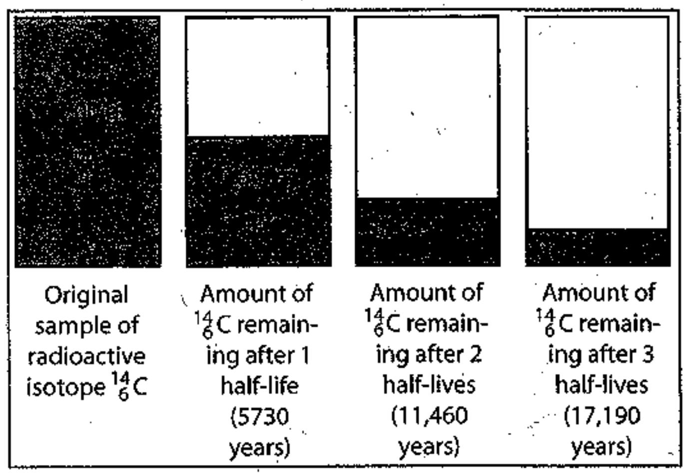

Figure 12-6. The half-life of C-14

If radioactive substance X has a half-life of 5 s, each five seconds will result in the amount of X present at the beginning of the time being reduced by half. If 20 g of X begins to decay, after 5 s only 10 g will remain. Five seconds later, only 5 g of the original 20 g will remain. ($1/2 \times 1/2 = 1/4$). The fraction remaining after a given number of half-lives is calculated using the relationship

$$\text{fraction remaining} = (1/2)^n$$

where n is equal to the number of half-lives. The number of half-lives is calculated by dividing the total time that the substance has decayed by the half-life of the isotope.

SAMPLE PROBLEM

Most chromium atoms are stable, but Cr-51 is an unstable isotope with a half-life of 28 days.
(a) What fraction of a sample of Cr-51 will remain after 168 days?
(b) If a sample of Cr-51 has an original mass of 52.0 g, what mass will remain after 168 days?

Nuclear Chemistry Worksheet – Solutions

Using your knowledge of nuclear chemistry, write the equations for the following processes:

1) The alpha decay of radon-198

$$^{198}_{86}Rn \rightarrow ^{4}_{2}He + ^{194}_{84}Po$$

2) The beta decay of uranium-237

$$^{237}_{92}U \rightarrow ^{0}_{-1}e + ^{237}_{93}Np$$

3) Positron emission from silicon-26

$$^{26}_{14}Si \rightarrow ^{26}_{13}Al + ^{0}_{+1}e$$

4) Sodium-22 undergoes electron capture

$$^{22}_{11}Na + ^{0}_{-1}e \rightarrow ^{22}_{10}Ne$$

5) What is the difference between nuclear fusion and nuclear fission?

In nuclear fusion, small nuclei are combined to form a larger nucleus – this process releases a very large amount of energy, and is the main source of energy in the sun. In nuclear fission, large nuclei break apart to form smaller ones, releasing a large amount of energy. Fission is used in nuclear power plants to generate energy.

6) What is a "mass defect" and why is it important?

"Mass defect" refers to the difference between the mass of the nucleons (protons + neutrons) in a nucleus when weighed separately and the mass of the nucleus when it's put together. This difference is important because this missing mass is converted to energy using $E=mc^2$ that's used to hold the nucleus together.

7) Name three uses for nuclear reactions.

- **Nuclear weapons**
- **Medicine**
- **Nuclear power generation**

Nuclear Chemistry Vocabulary:

1) **Radiation** = a general term for any type of energy that emanates or radiates outward in all directions
2) **Electromagnetic radiation (ER)** = radiation moving at the speed of light, ranging from high-energy gamma rays to low energy radio waves; includes visible light
3) **Electromagnetic spectrum** = all the forms of electromagnetic radiation
4) **Ionizing radiation** = radiation with sufficient energy to ionize atoms or molecules (higher energy ER); damages DNA
5) **Non-ionizing radiation** = radiation with insufficient energy to ionize atoms or molecules (lower energy ER)
6) **Marie Curie** = studied radioactivity and completed much of the pioneering work on nuclear changes. Won two Nobel Prizes (the first for discovering radioactivity; the second for discovering the radioactive elements radium and polonium)
7) **Nuclear reactions** = involve changes in particles in an atom's nucleus and thus cause a change in the atom itself
8) **Isotope** = atoms of the same element having different numbers of neutrons and, therefore, a different mass number and atomic mass
9) **Hyphen notation** = (example) U-238
10) **Nuclear notation** = (example)
11) **Transmutation** =change in the identity of a nucleus because of a change in the number of its protons
12) **Radioactive isotope** = an isotope with an unstable nucleus that undergoes radioactive decay
13) **Radioactive decay** = the spontaneous break-down of a nucleus into a slightly lighter nucleus, accompanied by the emission of nuclear radiation
14) **Nuclear radiation** = particles or ER emitted from a nucleus during radioactive decay
15) **Alpha particle** (α)= helium nucleus (+2); 2 protons and 2 neutrons bound together emitted from a radioactive nucleus $^{4}_{2}He$
16) **Beta particle** (β)= electron(−) ejected at a high speed when a neutron changes into a proton and an electron $^{0}_{-1}\beta$
17) **Gamma ray** (γ) = form of high-energy ER (0); often emitted during and simultaneous to, α or β radioactive decay. $^{0}_{0}\gamma$
18) **Half-life** = time needed for decay of one-half the atoms in a *sample* of radioactive material
19) **Nuclear bombardment** = nucleus is bombarded with alpha particles, protons, neutrons or other particles
20) **Nuclear fission** =process in which a heavy nucleus splits to form medium-weight nuclei; Ex: TMI
21) **Chain reaction** = in fission reactions, neutrons are emitted; these neutrons can split more nuclei and a chain reaction can occur
22) **Critical mass** = mass of fissionable material needed to sustain a nuclear chain reaction
23) **Nuclear fusion** = the process in which light weight nuclei combine to form a heavier, more stable nucleus; Ex: the sun
24) **Nuclear fission** = the process in which a very heavy nucleus splits to form medium-weight nuclei; Ex: TMI (nuclear power plant)
25) **Mass defect** = the missing mass of a nuclear reaction that is converted into energy.