Name: ______________________________ Period: _______ Date: ________________

KIPP NYC College Prep General Chemistry

**UNIT 14: Nuclear Chemistry**

**Lesson 3: How can we ACTUALLY change lead into gold?**

**By the end of today, you will have an answer to:**

***What is the difference between artificial and natural transmutation?***

## Do Now Refresh:

Zn-71 undergoes a beta decay. Write the balanced nuclear reaction below:

9 Given the balanced equation representing the reaction between methane and oxygen:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

According to this equation, what is the mole ratio of oxygen to methane?

(1) $\frac{1 \text{ gram } O_2}{2 \text{ grams } CH_4}$ (3) $\frac{2 \text{ grams } O_2}{1 \text{ gram } CH_4}$

(2) $\frac{1 \text{ mole } O_2}{2 \text{ moles } CH_4}$ (4) $\frac{2 \text{ moles } O_2}{1 \text{ mole } CH_4}$

23 For a reaction at equilibrium, which change can increase the rates of the forward and reverse reactions?

(1) a decrease in the concentration of the reactants
(2) a decrease in the surface area of the products
(3) an increase in the temperature of the system
(4) an increase in the activation energy of the forward reaction

Base your answers to questions 51 through 53 on the information below and on your knowledge of chemistry.

The balanced equation below represents the reaction of glucose, $C_6H_{12}O_6$, with oxygen at 298 K and 101.3 kPa.

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

51 Determine the mass of $CO_2$ produced when 9.0 grams of glucose completely reacts with 9.6 grams of oxygen to produce 5.4 grams of water. [1]

52 Compare the entropy of the reactants to the entropy of the products. [1]

53 Write the empirical formula for glucose. [1]

***New Vocab:*** Transmutation—______________________________________________

| Natural Transmutation | Artificial Transmutation |
|---|---|
| • Radioactive isotope = Unstable nucleus<br>• Spontaneously occur—happen on their own<br>• Alpha, beta, gamma, positron<br>• Examples:<br>$^{238}_{92}U \rightarrow ^{4}_{2}He + ^{234}_{90}Th$<br>$^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}e$<br>$^{226}_{88}Ra \rightarrow ^{4}_{2}He + ^{222}_{86}Rn$ | • Man-made transmutations<br>• High energy particles are fired at the reactant<br>• Two things are combined<br>○ The nucleus being bombarded<br>○ A high-energy particle<br>$^{27}_{13}Al + ^{4}_{2}He \rightarrow ^{30}_{15}P + ^{1}_{0}n$<br>$^{238}_{92}U + ^{1}_{0}n \rightarrow ^{239}_{94}Pu + 2\,^{0}_{-1}e$<br>$^{239}_{94}Pu + ^{1}_{0}n \rightarrow ^{147}_{56}Ba + ^{90}_{38}Sr + 3\,^{1}_{0}n$ |

## *Think and Write:*

- Note one similarity between natural and artificial transmutations:

_______________________________________________________________

_______________________________________________________________

- **Label the following reactions as either natural or artificial transmutation:**

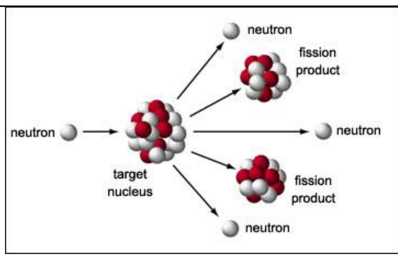
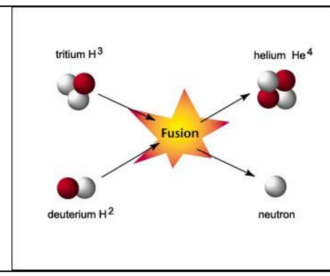
1. $^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}e$ ________________________________

2. $^{27}_{13}Al + ^{4}_{2}He \rightarrow ^{30}_{15}P + ^{1}_{0}n$ ________________________________

3. $^{238}_{92}U + ^{1}_{0}n \rightarrow ^{239}_{94}Pu + 2\,^{0}_{-1}e$ ________________________________

4. $^{87}_{37}Rb \rightarrow ^{0}_{-1}e + ^{87}_{38}Sr$ ________________________________

**Two awesome examples of artificial transmutation**

| ***FISSION*** | ***FUSION*** |
|---|---|
| **Describe:** | **Describe:** |
|  |  |
| ***FISSION and FUSION**: The Music Video* Notes: | |



*****In both cases the *exact* masses of the products are slightly less than the reactants. The missing mass has turned into ENERGY!!!** **$E = mc^2$**

- **Label the following as either examples of fission or fusion**

1. $^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$ ________________________________

2. $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{142}_{56}Ba + ^{91}_{36}Kr + 3\,^{1}_{0}n$ ________________________________

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**CW 14.3: Artificial and Natural Transmutation; fission and fusion** **10 points**

Nuclear fission has been used to produce electricity. However, nuclear fusion for electricity production is still under development. The notations of some nuclides used in nuclear reactions are shown in the table below.

**Some Nuclides Used in Nuclear Reactions**

| Reaction | Nuclides |
|---|---|
| nuclear fission | ${}^{233}_{92}U$, ${}^{235}_{92}U$ |
| nuclear fusion | ${}^{1}_{1}H$, ${}^{3}_{1}H$ |

1. Compare the atomic masses of nuclides used in fusion to the atomic masses of nuclides used in fission.

__________________________________________________________________________

__________________________________________________________________________

2. Complete the table below that compares the total number of protons and the total number of neutrons for the hydrogen nuclides used for fusion.

| Nuclide | Total Number of Protons | Total Number of Neutrons |
|---|---|---|
| ${}^{1}_{1}H$ | | |
| ${}^{3}_{1}H$ | | |

3. Complete the nuclear equation below for the fission of U-235 by writing the notation of the missing product.

$${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{142}_{56}Ba + {}^{91}_{36}Kr + 3 \_\_\_\_\_\_ + \text{energy}$$

4. State one potential benefit of using nuclear fusion instead of the current use of nuclear fission to produce electricity.

__________________________________________________________________________

***Real-World examples of fission and fusion:***

1. Summarize each scenario in 1-2 sentences.
2. Determine if the reaction depicts fission or fusion.
3. Write out the nuclear reaction associated with the scenario (the answers are posted at the bottom of the page—but not in the correct order)

| **Nuclear Power Plant:** | **Summary:** |
|---|---|
| Uranium-235 is used as the fuel for the nuclear power reaction as it is naturally radioactive, and is therefore unstable enough to be broken down into smaller parts.<br>In a nuclear power plant, a neutron is shot at the uranium atom causing it to split into Ba-142, Kr-91 and 3 neutrons. The neutrons then cause other U-235 atoms to split. A tremendous amount of energy is released.<br>This energy becomes heat energy as the particles slow down, and it is this heat energy, which is used to produce electricity. | **Circle 1: FISSION OR FUSION**<br><br>**Nuclear Reaction:** |

| | |
|---|---|
| The heat is moved through a transfer medium, such as water, and is used to turn water into steam. This steam turns a turbine, which is connected to a generator. As the turbine turns the generator it creates electricity, which is then transferred to the consumers. | |
| **Atomic Bomb:**<br>The first atomic bombs dropped to kill humans exploded in 1945 over the Japanese cities of Hiroshima and Nagasaki. Roughly 70,000 people died instantly at Hiroshima and another 70,000 died within four months of the explosion due to radioactive particles in the area.<br>In an atomic bomb, a radioactive isotope such as U-235 is compressed together and then bombarded with 1 neutron. This causes the isotope to split into smaller isotopes—for example: Cs-140 and Rb-92 and two more neutrons. These neutrons then hit other atoms of Pu-239 causing a chain reaction.<br>The amount of energy released from the earliest atomic bombs was equivalent to 20,000 tons of TNT. Today's atomic bombs produce thousands of times this amount of energy. | **Summary:**<br><br>**Circle 1: FISSION OR FUSION**<br><br>**Nuclear Reaction:** |
| **Hydrogen Bomb:**<br>Hydrogen bombs are the most powerful and deadly weapon ever invented by humanit. They can produce explosions equivalent of 10,000,000 tons of TNT.<br>Hydrogen bombs take an explosion of an atomic bomb to provide the energy to detonate. In this reaction, H-2 and H-3 fuse together to form He-4 and an extra neutron. In this process an immense amount of energy is released.<br>The blast of a hydrogen bomb could potentially destroy everything within 100 square miles and cause damage within 400 square miles. | **Summary:**<br><br>**Circle 1: FISSION OR FUSION**<br><br>**Nuclear Reaction:** |
| **The Sun:**<br>The sun is a typical average star. It is large enough to fit 1.3 million Earths. It provides the energy for most things on Earth to live.<br>The sun works by generating a nuclear reaction. At the core, the sun is 15,000,000 degrees C. There is so much heat and pressure inside the sun due to its intense gravity that atoms are formed from smaller atoms smashing together.<br>One reaction inside the sun is as follows: Two protons combine to form Hydrogen-2 and a positron. Much energy is also produced.<br>Ultimately these reactions inside the sun and other stars are responsible for forming all of the atoms in our Universe. | **Summary:**<br><br>**Circle 1: FISSION OR FUSION**<br><br>**Nuclear Reaction:** |

Answers (out of order):

${}^{1}_{1}p^{+} + {}^{1}_{1}p \rightarrow {}^{2}_{1}H + {}^{0}_{+1}\beta$ ${}^{2}_{1}H^{+} + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$ ${}^{235}_{92}U^{+} + {}^{1}_{0}n \rightarrow {}^{91}_{36}Kr + {}^{142}_{56}Ba + 3\,{}^{1}_{0}n$ ${}^{235}_{92}U^{+} + {}^{1}_{0}n \rightarrow {}^{140}_{55}Cs + {}^{92}_{37}Rb + 4\,{}^{1}_{0}n$

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**HW 14.3: Artificial and Natural Transmutation; fission and fusion** **10 points**

1. What is the name of the process in which the nucleus of an atom of one element is changed into a different element?
   (1) decomposition
   (2) transmutation
   (3) substitution
   (4) reduction

2. Which nuclear equation represents a natural transmutation?

(1) ${}^{9}_{4}\text{Be} + {}^{1}_{1}\text{H} \rightarrow {}^{6}_{3}\text{Li} + {}^{4}_{2}\text{He}$

(2) ${}^{27}_{13}\text{Al} + {}^{4}_{2}\text{He} \rightarrow {}^{30}_{15}\text{P} + {}^{1}_{0}\text{n}$

(3) ${}^{14}_{7}\text{N} + {}^{4}_{2}\text{He} \rightarrow {}^{17}_{8}\text{O} + {}^{1}_{1}\text{H}$

(4) ${}^{235}_{92}\text{U} \rightarrow {}^{231}_{90}\text{Th} + {}^{4}_{2}\text{He}$

3. The change that is undergone by an atom of an element made radioactive by bombardment with high-energy protons is called

   (1) natural transmutation
   (2) artificial transmutation

4. Given the nuclear equation:

$${}^{1}_{1}\text{H} + X \rightarrow {}^{6}_{3}\text{Li} + {}^{4}_{2}\text{He}$$

The particle represented by X is:

(1) ${}^{9}_{4}\text{Li}$ (3) ${}^{10}_{5}\text{Be}$

(2) ${}^{9}_{4}\text{Be}$ (4) ${}^{10}_{6}\text{C}$

5. Which equation is an example of artificial transmutation?

(1) ${}^{9}_{4}\text{Be} + {}^{4}_{2}\text{He} \rightarrow {}^{12}_{6}\text{C} + {}^{1}_{0}\text{n}$

(2) $\text{U} + 3\ \text{F}_2 \rightarrow \text{UF}_6$

(3) $\text{Mg(OH)}_2 + 2\ \text{HCl} \rightarrow 2\ \text{H}_2\text{O} + \text{MgCl}_2$

(4) $\text{Ca} + 2\ \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{H}_2$

6. A change that is undergone by an atom of an element made radioactive by bombardment with high-energy protons is called:

(1) natural transmutation
(2) artificial transmutation
(3) natural decay
(4) radioactive decay

7. Which balanced equation represents nuclear fusion?

(1) ${}^{1}_{0}\text{n} + {}^{235}_{92}\text{U} \rightarrow {}^{142}_{56}\text{Ba} + {}^{91}_{36}\text{Kr} + 3{}^{1}_{0}\text{n}$

(2) ${}^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He}$

(3) ${}^{6}_{3}\text{Li} + {}^{1}_{0}\text{n} \rightarrow {}^{3}_{1}\text{H} + {}^{4}_{2}\text{He}$

(4) ${}^{2}_{1}\text{H} + {}^{3}_{1}\text{H} \rightarrow {}^{4}_{2}\text{He} + {}^{1}_{0}\text{n}$

8. The energy released from a nuclear reaction results primarily from the

(1) breaking of bonds between atoms
(2) formation of bonds between atoms
(3) conversion of mass into energy
(4) conversion of energy into mass

9. Describe one similarity and one difference between artificial and natural transmutation:

10. Describe one similarity and one difference between fusion and fission reactions:

Please classify each equation as artificial transmutation or natural transmutation:

11. $^{6}_{3}Li + ^{1}_{0}n \rightarrow ^{3}_{1}H + ^{4}_{2}He$ ______________________________

12. $^{227}_{92}U \rightarrow ^{223}_{90}Th + ^{4}_{2}He$ ______________________________

Please classify each equation as fusion or fission:

13. $^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$ ______________________________

14. $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{142}_{56}Ba + ^{91}_{36}Kr + 3^{1}_{0}n$ ______________________________

15. Label the following, fission or fusion:

| | **Fission or Fusion?** |
|---|---|
| $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{1}H + ^{1}_{1}p$ | |
| $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3\ ^{1}_{0}n$ | |
| $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{138}_{54}Xe + ^{95}_{38}Sr + 3\ ^{1}_{0}n$ | |
| $^{3}_{2}He + ^{3}_{2}He \rightarrow ^{4}_{2}He + 2^{1}_{1}H$ | |

16. Which equation represents a fusion reaction?

1. $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}He$
2. $^{14}_{6}C \rightarrow ^{0}_{-1}e + ^{17}_{7}N$
3. $^{238}_{92}U + ^{4}_{2}He \rightarrow ^{241}_{94}Pu + ^{1}_{0}n$
4. $^{1}_{0}n + ^{27}_{13}Al \rightarrow ^{24}_{11}Na + ^{4}_{2}He$

17. Which equation is an example of artificial transmutation? (hint: which answer is DIFFERENT?)

1. $^{238}_{92}U \rightarrow ^{4}_{2}He + ^{234}_{90}Th$
2. $^{27}_{13}AL + ^{4}_{2}He \rightarrow ^{30}_{15}P + ^{1}_{0}n$
3. $^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}e$
4. $^{226}_{88}Ra \rightarrow ^{4}_{2}He + ^{222}_{86}Ra$

Given the nuclear equation: $^{1}_{1}H + X \rightarrow ^{6}_{3}Li + ^{4}_{2}He$

18. The particle represented by $X$ is

1. $^{9}_{4}Li$
2. $^{9}_{4}Be$
3. $^{10}_{5}Be$
4. $^{10}_{6}C$

19. Which balanced equation represents nuclear fusion?

1. $^{1}_{0}n + ^{235}_{92}U \rightarrow ^{142}_{56}Ba + ^{91}_{36}Kr + 3^{1}_{0}n$
2. $^{226}_{88}Ra \rightarrow ^{222}_{86}Rn + ^{4}_{2}He$
3. $^{6}_{3}Li + ^{1}_{0}n \rightarrow ^{3}_{1}H + ^{4}_{2}He$
4. $^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$