Nuclear chemistry

Introduction

Nuclear chemistry: → Is the study of reactions involving changes in atomic nuclei.

Application of nuclear chemistry

- ☒ used in manufacture of atomic bombs.
- ☒ hydrogen bombs.
- ☒ neutron bombs.

The nature of nuclear reactions

All nuclei contain two Kinds of particles

- Protons "+ve"
- Neutrons" ∓ "

Radioactivity :→ It's the emission of particles or electromagnetic radiation spontaneously from unstable nuclei.

Note that

- ✓ All element having an atomic number greater than 83 are radioactive.
- ✓ heavier elements are synthesized from lighter elements.

Nuclear transmutation:→ result from the bombardment of nuclei by neutrons , protons or other nuclei.

☒ **Example:** conversion of atmospheric $^{14}_{7}N$ to $^{14}_{6}C$ and $^{1}_{1}H$

The symbols for elementary particles are:

Proton $_{1}^{1}P$ or $_{1}^{1}H$ electron $_{-1}^{0}e$ or $_{-1}^{0}\beta$

Neutron $_{0}^{1}n$ positron $_{+1}^{0}e$ or $_{+1}^{0}\beta$

α particle $_{2}^{4}He$ or $_{2}^{4}\alpha$

Atomic number: → the number of proton.

Mass number: → the total number of neutrons and protons present.

What is the difference between $_{-1}^{0}e$ or $_{-1}^{0}\beta$?!

$_{-1}^{0}e$:→ represents an electron which comes from an atomic orbital.

$_{-1}^{0}\beta$:→ represents any other electron comes from a nucleus.

Positron: → has the same mass as the electron, but bears a +1 charge.

α particle :→ has two protons and two neutrons , so its atomic number is 2 and its mass number is 4.

In balancing any nuclear equation, we observe the following rules:

- ☒ The total number of protons plus neutrons in the products and in the reactants must be the same " mass number".
- ☒ The total number of nuclear charges in the products and in the reactants must be the same " atomic number".

Chemical Reactions	Nuclear Reactions
1. Atoms are rearranged by the breaking and forming of chemical bonds.	1. Elements (or isotopes of the same elements) are converted from one to another.
2. Only electrons in atomic or molecular orbitals are involved in the breaking and forming of bonds.	2. Protons, neutrons, electrons, and other elementary particles may be involved.
3. Reactions are accompanied by absorption or release of relatively small amounts of energy.	3. Reactions are accompanied by absorption or release of tremendous amounts of energy.
4. Rates of reaction are influenced by temperature, pressure, concentration, and catalysts.	4. Rates of reaction normally are not affected by temperature, pressure, and catalysts.

Example

Balance the following nuclear equations.

(a) $^{212}_{84}Po \rightarrow {}^{208}_{82}Po + X$

Mass number of X = 212 – 208 = 4

Atomic number of X = 84 - 82 = 2

$^{4}_{2}X$ Which means that it is an $^{4}_{2}\alpha$ ...

(b) $^{137}_{55}Cs \rightarrow {}^{137}_{56}Ba + X$

Mass number of X = 137 – 137 = 0

Atomic number of X = 55 - 56 = -1

$^{0}_{-1}X$ Which means that it is $\beta\ negative$ particle.

Choose:-

1) ……is the emission of particles or electromagnetic radiation spontaneously from unstable nuclei.

A) Radio activity
B) Nuclear chemistry
C) mass number
D) atomic number

2) All element having an atomic number greater than….. are radioactive.

A) 55
B) 73
C) 83
D) 84

3) …….is result from the bombardment of nuclei by neutrons, protons or other nuclei.

A) radioactivity
B) mass number
C) nuclear decay
D) nuclear transmutation

4) Number of protons denoted by……

A) atomic number
B) mass number
C) electronic configuration
D) none of them

5) The total number of neutrons and protons is called…….

A) atomic number
B) mass number
C) electronic configuration
D) none of them

6) The symbol e^{0}_{-1} is represent an electron which come from…...

A) atomic orbital
C) outer shell
B) Nucleus
D) none of them

7) The symbol B^{0}_{-1} is represented an electron which come from …..

A) atomic orbital
C) outer shell
B) Nucleus
D) none of them

8) ……. has the same mass as the electron but bears +1 charge.

A) α Particle
C) Positron
B) β Particle
D) γ Particle

9) α Particle has ……. proton and …… neutron.

A) 1 - 2
C) 2 - 2
B) 2 - 3
D) 3 - 4

10) $^{26}_{12}Mg + {}^{1}_{1}P \rightarrow {}^{4}_{2}\alpha + X$

identify X in that case.

A) $^{23}_{11}X$
C) $^{25}_{11}X$
B) $^{27}_{15}X$
D) $^{27}_{12}X$

11) $^{59}_{27}Co + {}^{2}_{1}H \rightarrow {}^{60}_{27}Co + X$

identify X in that case.

A) $^{1}_{0}X$

B) $^{1}_{1}X$

C) $^{0}_{1}X$

D) $^{1}_{2}X$

12) $^{20}_{8}O \rightarrow {}^{20}_{9}F + X$

identify X in that case.

A) $^{1}_{0}X$

B) $^{0}_{1}X$

C) $^{0}_{-1}X$

D) $^{1}_{1}X$

13) Alpha particles are identical to……..

A) protons

B) helium atoms

C) hydrogen atoms

D) helium nuclei

14) Beta particles are identical to…….

A) electrons

B) helium nuclei

C) hydrogen atoms

D) helium atoms

15) How many neutrons and protons (nucleons) does an atom with the symbol S^{33}_{16} have?

A) 33

B) 16

C) 49

D) none of them

16) A radioactive isotope decays to give an alpha particle and Pb-208. What was the original element?

A) Se
B) Bi
C) Po
D) Hg

17) As a result of beta decay, the product nucleus is……..

A) one atomic number lower than the original element.
B) two atomic numbers higher than the original element.
C) one atomic number higher than the original element.
D) two atomic numbers lower than the original element.

18) When atoms of beryllium-9 are bombarded with alpha particles, neutrons are produced ,What new isotope is also formed?

$$^{4}_{2}He + ^{9}_{4}Be \rightarrow ^{1}_{0}n + \_\_\_\_$$

A) $^{12}_{6}C$
B) $^{5}_{3}Li$
C) $^{8}_{3}Li$
D) $^{10}_{5}B$

19) When atoms of aluminum-27 are bombarded with alpha particles, a neutron and an element are produced , The particular isotope formed is.....

$$^{4}_{2}He + ^{27}_{13}Al \rightarrow ^{1}_{0}n + \_\_\_\_\_$$

A) $^{31}_{14}Si$

B) $^{30}_{14}Si$

C) $^{31}_{16}Si$

D) $^{30}_{15}P$

20) What is the missing symbol in this plutonium fission reaction?

$$^{239}_{94}Pu + ^{1}_{0}n \rightarrow \_\_\_\_\_ + ^{91}_{38}Sr + 3^{1}_{0}n$$

A) $^{148}_{56}Ba$

B) $^{143}_{54}Xe$

C) $^{91}_{38}Sr$

D) $^{146}_{56}Ba$

21) Predict the other product of the following nuclear transmutation.

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

A) $^{6}_{2}He$

B) $^{2}_{1}H$

C) $^{3}_{1}H$

D) $^{0}_{+1}\beta$

22) Radium-226 decays by alpha emission ,What is its decay product ?

A) $^{228}_{87}Fr$

B) $^{222}_{86}Rn$

C) $^{230}_{90}Th$

D) $^{226}_{89}Ac$

23) Sulfur-35 decays by beta emission. The decay product is…..

A) $^{35}_{15}P$
C) $^{31}_{30}Si$
B) $^{34}_{17}Cl$
D) $^{35}_{17}Cl$

24) In the $^{232}_{90}Th$ decay series there are six radioisotopes that decay by alpha emission, including Th-232 itself, and four radioisotopes that decay by beta emission. The final product of this series is a stable isotope. The symbol for this product is

A) $^{204}_{74}W$
C) $^{204}_{82}Pb$
B) $^{208}_{74}W$
D) $^{208}_{82}Pb$

25) In the uranium-238 decay series there are eight radioactive isotopes starting with $^{238}_{92}U$ that decay by alpha emission, and six radioactive isotopes that decay by beta emission. The final product of this series is a stable isotope, The symbol for this product is…….

A) $^{206}_{82}Pb$
C) $^{222}_{86}Rn$
B) $^{206}_{70}Yb$
D) $^{208}_{82}Pb$

26) The only stable isotope of iodine is iodine-127,Predict the mode of decay of $^{130}_{53}I$.

A) alpha emission
C) positron emission
B) beta emission
D) electron Capture