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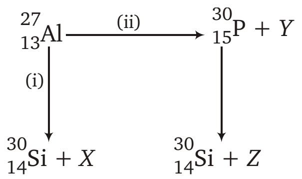
Nuclear Chemistry

Objective Questions I (Only one correct option)

1. Bombardment of aluminium by -particle leads to its artificial disintegration in two ways, (i) and (ii) as shown. Products X, Y and Z respectively, are **(2011)**



(a) proton, neutron, positron (b) neutron, positron, proton
(c) proton, positron, neutron (d) positron, proton, neutron

2. A positron is emitted from $^{23}_{11}$Na. The ratio of the atomic mass and atomic number of the resulting nuclide is **(2007, 3M)**
(a) 22/10 (b) 22/11 (c) 23/10 (d) 23/12

3. ^{23}Na is the more stable isotope of Na. Find out the process by which $^{24}_{11}$Na can undergo radioactive decay. **(2003, 1M)**
(a) -emission (b) -emission
(c) -emission (d) K-electron capture

4. The number of neutrons accompanying the formation of $^{139}_{54}$Xe and $^{94}_{38}$Sr from the absorption of a slow neutron by $^{235}_{92}$U, followed by nuclear fission is **(1999, 2M)**
(a) 0 (b) 2 (c) 1 (d) 3

5. $^{27}_{13}$Al is a stable isotope. $^{29}_{13}$Al is expected to decay by
(a) -emission (b) -emission **(1996, 1M)**
(c) positron emission (d) proton emission

6. The radiation from a naturally occurring radioactive substance, as seen after deflection by a magnet in one direction, are **(1984, 1M)**
(a) definitely alpha rays (b) definitely beta rays
(c) both alpha and beta rays (d) either alpha rays or beta rays

7. An isotope of Ge^{76}_{32} is **(1984, 1M)**
(a) Ge^{77}_{32} (b) As^{77}_{33} (c) Se^{77}_{34} (d) Se^{78}_{34}

8. If uranium (mass number 238 and atomic number 92) emits an -particle, the product has mass number and atomic number **(1981, 1 M)**
(a) 236 and 92 (b) 234 and 90
(c) 238 and 90 (d) 236 and 90

Objective Questions II
(One or more than one correct option)

9. A plot of the number of neutrons (n) against the number of protons (p) of stable nuclei exhibits upward deviation from linearity for atomic number, $Z > 20$. For an unstable nucleus having n/p ratio less than 1, the possible mode(s) of decay is (are) **(2016 Adv.)**
(a) - decay (- emission) (b) orbital or K-electron capture
(c) neutron emission (d) -decay (positron emission)

10. In the nuclear transmutation, $^{9}_{4}$Be X $^{8}_{4}$Be Y
X and Y are **(2013 Adv.)**
(a) (, n) (b) (p, D) (c) (n, D) (d) (, p)

11. Decrease in atomic number is observed during **(1998, 2M)**
(a) alpha emission (b) beta emission
(c) positron emission (d) electron capture

12. The nuclear reactions accompanied with emission of neutron(s) are **(1988, 1 M)**
(a) $^{27}_{13}$Al + $^{4}_{2}$He $^{30}_{15}$P (b) $^{12}_{6}$C + $^{1}_{1}$H $^{13}_{7}$N
(c) $^{30}_{15}$P $^{30}_{14}$Si + $^{0}_{1}e$ (d) $^{241}_{96}$Cm + $^{4}_{2}$He $^{244}_{97}$Bk + $^{0}_{1}e$

Assertion and Reason

Read the following questions and answer as per the direction given below:

(a) Statement I is true; Statement II is true; Statement II is the correct explanation of Statement I
(b) Statement I is true; Statement II is true; Statement II is not the correct explanation of Statement I
(c) Statement I is true; Statement II is false
(d) Statement I is false; Statement II is true

13. **Statement I** The plot of atomic number (y-axis) *versus* number of neutrons (x-axis) for stable nuclei shows a curvature towards x-axis from the line of 45° slope as the atomic number is increased.

Statement II Proton-proton electrostatic repulsions begin to overcome attractive forces involving protons and neutrons and neutrons in heavier nuclides. **(2008)**

14. **Statement I** Nuclide $^{30}_{13}$Al is less stable than $^{40}_{20}$Ca.

Statement II Nuclides having odd number of protons and neutrons are generally unstable. **(1998)**

Fill in the Blanks

15. (a) ${}^{235}_{92}U \quad {}_0n^1 \qquad {}^{137}_{52}A \quad {}^{97}_{40}B$ ......

(b) ${}^{82}_{34}Se \qquad 2 \ {}_1e^0$ ...... **(2005, 1M 2 = 2M)**

16. A radioactive nucleus decays by emitting one alpha and two beta particles, the daughter nucleus is.... of the parent. **(1989, 1M)**

17. The number of neutrons in the parent nucleus which gives N^{14} on beta emission is .... **(1985, 1M)**

18. Elements of the same mass number but different atomic number are known as .... **(1983, 1M)**

19. An element ${}_ZM^A$ undergoes an -emission followed by two successive -emissions. The element formed is ...... **(1982, 1M)**

Integer Answer Type Questions

20. The periodic table consists of 18 groups. An isotope of copper, on bombardment with protons, undergoes a nuclear reaction yielding element X as shown below. To which group, element X belongs in the periodic table? **(2012)**

$$ {}^{63}_{29}Cu + {}^1_1H \qquad 6{}^1_0n + {}^4_2 \quad + 2{}^1_1H + X $$

21. The number of neutrons emitted when ${}^{235}_{92}U$ undergoes controlled nuclear fission to ${}^{142}_{54}Xe$ and ${}^{90}_{38}Sr$ is **(2010)**

Subjective Questions

22. The total number of and particles emitted in the nuclear reaction ${}_{92}U^{238} \qquad {}_{82}Pb^{214}$ is ..... . **(2009)**

23. ${}_{92}X^{234} \quad \frac{7}{6} \quad Y$. Find out atomic number, mass number of Y and identify it. **(2004)**

24. ${}_{92}U^{238}$ is radioactive and it emits and particles to form ${}_{82}Pb^{206}$. Calculate the number of and particles emitted in this conversion.

An ore of ${}_{92}U^{238}$ is found to contain ${}_{92}U^{238}$ and ${}_{82}Pb^{206}$ in the weight ratio of 1 : 0.1. The half-life period of ${}_{92}U^{238}$ is $4.5 \quad 10^9$ yr. Calculate the age of the ore. **(2000)**

25. Write a balanced equation for the reaction of N^{14} with -particle.

26. ${}_{90}Th^{234}$ disintegrates to give ${}_{82}Pb^{206}$ as the final product. How many alpha and beta particles are emitted during this process? **(1986, 2M)**

Answers

1. (a)	**2.** (c)	**3.** (a)	**4.** (b)	**16.** isotope	**17.** eight	**18.** isobars	**19.** ${}_ZM^{A \quad 4}$
5. (b)	**6.** (c)	**7.** (a)	**8.** (b)	**20.** (8)	**21.** 3	**22.** (8)	**23.** ${}_{84}PO^{206}$
9. (b, d)	**10.** (a, b)	**11.** (a, c, d)	**12.** (a, d)	**24.** ($7.12 \quad 10^8$yr)		**26.** (13)	
13. (a)	**14.** (b)	**15.** $2\ {}_0n^1$, ${}_{36}Kr^{82}$					

Hints & Solutions

1. (i) ${}^{27}_{13}Al + {}^4_2He \qquad {}^{30}_{14}Si + {}^1_1X$

X is proton ${}^1_1H$.

(ii) ${}^{27}_{13}Al + {}^4_2He\,(\ ) \qquad {}^{30}_{15}P + {}^1_0Y$

Y is neutron, ${}^1_0n$.

$$ {}^{30}_{15}P \qquad {}^{30}_{14}Si + {}^0_1Z $$

Z is positron, ${}^{0}_{+1}e$.

2. The required nuclear reaction is

$$ {}_{11}Na^{23} \qquad {}_1e^0 \quad {}_{10}Na^{23} $$

3. In stable isotope of Na, there are 11 protons and 12 neutrons. In the given radioactive isotope of sodium (Na^{24}), there are 13 neutrons, one neutron more than that required for stability. A neutron rich isotope always decay by -emission as

$$ {}_0n^1 \qquad {}_1{}^0 \quad {}_1H^1 $$

4. The balanced nuclear reaction is

$$ 2{}_0n^1 \quad {}_{92}U^{235} \qquad {}_{54}Xe^{139} + {}_{38}Sr^{94} $$

5. ${}_{13}Al^{29}$ is neutron rich isotope, will decay by -emission converting some of its neutron into proton as

$$ {}_0n^1 \qquad {}_1{}^0 \quad {}_1H^1 $$

6. Both -rays and - rays are deflected by magnetic field.

7. Isotopes have same atomic number (Z) but different mass number (A). Therefore, ${}_{32}Ge^{76}$ and ${}_{32}Ge^{77}$ are isotopes.

8. The nuclear reaction is

$$ {}_{92}U^{238} \qquad {}_2He^4(\ ) \quad {}_{90}Th^{234} $$

9. For the elements with atomic number (Z) larger than 20,

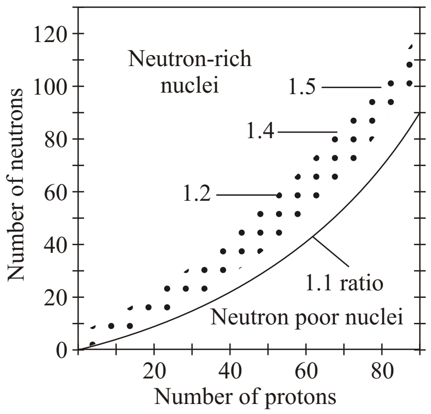
Neutrons (n) > Protons (p); Thus, $n/p \quad 1$
Thus, there is upward deviation from linearity.
If $n < p$, Thus $n/p \quad 1$, then

(a) By - decay, ${}^1_0n \qquad {}^1_1p \quad {}^0_1e$ neutron changes to proton. Thus, (n/p) ratio further decreases below 1.
Thus, this decay is not allowed.

(b) By orbital or K- electron capture, ${}^1_1p \quad {}^0_1e \qquad {}^1_0n$
proton changes to neutron, hence, (n/p) ratio increases. Thus stability increases. Thus correct.

(c) Neutron emission further decreases n/p ratio.

(d) By -emission, ${}^1_1p \qquad {}^1_0n \quad {}^0_1e$
proton changes to neutron.
Hence, n/p ratio increases. Thus correct.



Plot of the number of neutrons against the number of protons in stable nuclei (shown by dots).

10. **PLAN** ${}^{9}_{4}\text{Be}$ ${}^{b}_{a}X$ ${}^{8}_{4}\text{Be}$ ${}^{d}_{c}Y$

Atomic number same

$$4 \quad a \quad 4 \quad c$$
$$9 \quad b \quad 8 \quad d$$

If X $\begin{smallmatrix}0\\0\end{smallmatrix}$ $\qquad a \quad 0$, $b \quad 0$

Y ${}^{1}_{0}n$ $\qquad c \quad 0$, $d \quad 1$

If X ${}^{1}_{1}p$ $\qquad a \quad 1$, $b \quad 1$

Y ${}^{2}_{1}\text{D}$ $\qquad c \quad 1$, $d \quad 2$

$${}^{9}_{4}\text{Be} \quad \begin{smallmatrix}0\\0\end{smallmatrix} \qquad {}^{8}_{4}\text{Be} \quad {}^{1}_{0}n$$
$${}^{9}_{4}\text{Be} \quad {}^{1}_{1}p \qquad {}^{8}_{4}\text{Be} \quad {}^{2}_{1}\text{D}$$

11. In the following nuclear reactions, there occur decrease in atomic number (Z)

$${}_{Z}X^{A} \qquad {}_{2}\text{He}^{4} \quad {}_{Z\ \ 2}Y^{A\ \ 4}, \quad \text{- emission}$$
$${}_{Z}X^{A} \qquad {}_{1}e^{0} \quad {}_{Z\ \ 1}Y^{A}, \text{ positron emission}$$
$${}_{Z}X^{A} \qquad {}_{1}e^{0} \qquad {}_{Z\ \ 1}Y^{A}, \text{ electron capture}$$

In beta emission, increase in atomic number is observed.

$${}_{Z}X^{A} \qquad {}_{1}e^{0} \quad {}_{Z\ \ 1}Y^{A}, \quad \text{-emission}$$

12. If sum of mass number of product nuclides is less than the sum of parent nuclides, then neutron emission will occur. In both (a) and (d), sum of mass number of product nuclides is one unit less than the sum of parent nuclides, neutron emission will balance the mass number.

13. After atomic number 20, proton-proton repulsion increases immensely, more neutrons are required to shield this electrostatic repulsion, curve of stability incline towards neutron axis.

14. Upto atomic number of 20, stable nuclei possess neutron to proton ratio (n/p) 1.

$$\frac{n}{p}\,({}_{13}\text{Al}^{30}) \quad \frac{17}{13} \quad 1.3 > 1, \text{ unstable, } \text{-emitters.}$$
$$\frac{n}{p}\,({}_{20}\text{Ca}^{40}) \quad \frac{20}{20} \quad 1, \text{ stable.}$$

Also, nuclei with both neutrons and protons odd are usually unstable but it does not explain the assertion appropriately.

15. (a) ${}_{92}\text{U}^{235} \quad {}_{0}n^{1} \qquad {}_{52}A^{137} \quad {}_{40}B^{97} \quad 2\,{}_{0}n^{1}$

(b) ${}_{34}\text{Se}^{82} \qquad 2\ \ {}_{1}e^{0} \quad {}_{36}\text{Kr}^{82}$

16. Isotope : ${}_{Z}X^{A} \qquad {}_{2}\text{He}^{4} \quad 2\ \ {}_{1}e^{0} \quad {}_{Z}Y^{A\ \ 4}$

17. 8 : ${}_{6}\text{C}^{14} \qquad {}_{7}\text{N}^{14} \qquad {}_{1}e^{0}$

18. Isobars have same mass number but different atomic number.

19. ${}_{Z}M^{A\ \ 4} : {}_{Z}M^{A} \qquad {}_{2}\text{He}^{4} \quad 2\ \ {}_{1}e^{0} \quad {}_{Z}M^{A\ \ 4}$

20. Balancing the given nuclear reaction in terms of atomic number (charge) and mass number:

$${}_{29}\text{Cu}^{63} \quad {}_{1}\text{H}^{1} \qquad 6_{0}n^{1} \quad {}_{2}\text{He}^{4}(\ \ ) \quad 2_{1}\text{H}^{1} \quad {}_{26}X^{52}$$

The atomic number 26 corresponds to transition metal Fe which belongs to 8th group of modern periodic table.

21. ${}_{92}\text{U}^{235} \qquad {}_{54}\text{Xe}^{142} \quad {}_{38}\text{Sr}^{90} \quad 3_{0}n^{1}$

22. ${}_{92}\text{U}^{238} \qquad {}_{82}\text{Pb}^{214} \quad 6\,{}_{2}\text{He}^{4} \quad 2\ \ {}_{1}e^{0}$

Number of ( ) 6 2 8

23. ${}_{92}X^{234} \qquad 7\,{}_{2}\text{He}^{4} \quad 6\ \ {}_{1}e^{0} \quad {}_{84}Y^{206}$

Y is ${}_{84}\text{Po}^{206}$.

24. ${}_{92}\text{U}^{238} \qquad {}_{82}\text{Pb}^{206} + 8\,{}_{2}\text{He}^{4} + 6\ \ {}_{1}e^{0}$

Present : $N_0 \quad N \qquad N$

Given, $\dfrac{w(\text{U})}{w(\text{Pb})} \quad \dfrac{1}{0.1} \quad 10$

$$\frac{N\,(\text{U})}{N\,(\text{Pb})} \quad \frac{10}{238} \quad \frac{206}{1} \quad \frac{N_0 \quad N}{N}$$
$$\frac{N}{N_0 \quad N} \quad \frac{238}{2060} \qquad \frac{N_0}{N_0 \quad N} \quad 1 \quad \frac{238}{2060} \quad \frac{2298}{2060}$$

Now, applying first order rate law

$$\frac{\ln 2}{t_{1/2}} \quad t \quad \ln \frac{N_0}{N_0 \quad N} \qquad t \quad \frac{(t_{1/2})}{\log 2} \log \frac{N_0}{N_0 \quad N}$$
$$\frac{4.5 \quad 10^{9}}{0.3} \log \frac{2298}{2060} \quad 7.12 \quad 10^{8} \text{ yr}$$

25. ${}_{7}\text{N}^{14} \quad {}_{2}\text{He}^{4} \qquad {}_{9}\text{F}^{18}$

26. ${}_{90}\text{Th}^{234} \qquad {}_{82}\text{Pb}^{206} \quad 7\,{}_{2}\text{He}^{4} \quad 6\ \ {}_{1}e^{0}$