Chapter 31. Nuclear Chemistry

1. A nuclide of an alkaline earth metal undergoes radioactive decay by emission of the α-particles in succession. The group of the periodic table to which the resulting daughter element would belong is
(a) Gr. 13 (b) Gr. 17
(c) Gr. 14 (d) Gr. 16 *(2005)*

2. The radioactive isotope $^{60}_{27}\text{Co}$ which is used in the treatment of cancer can be made by (n, p) reaction. For this reaction the target nucleus is
(a) $^{59}_{28}\text{Ni}$ (b) $^{59}_{27}\text{Co}$
(c) $^{60}_{28}\text{Ni}$ (d) $^{60}_{27}\text{Co}$ *(2004)*

3. The radioisotope, tritium $\left(^{3}_{1}\text{H}\right)$ has a half-life of 12.3 years. If the initial amount of tritium is 32 mg, how many milligrams of it would remain after 49.2 years?
(a) 1 mg (b) 2 mg
(c) 4 mg (d) 8 mg *(2003)*

4. $^{235}_{92}\text{U}$, nucleus absorbs a neutron and disintegrate in $^{139}_{54}\text{Xe}$, $^{94}_{38}\text{Sr}$ and x so, what will be product x?
(a) 3-neutrons (b) 2-neutrons
(c) α-particle (d) β-particle
(2002)

5. A human body required 0.01 m activity of radioactive substance after 24 hours. Half life of radioactive substance is 6 hours. Then injection of maximum activity of radioactive substance that can be injected is
(a) 0.08 (b) 0.04
(c) 0.16 (d) 0.32 *(2001)*

6. If a $^{a}_{b}X$ species emits first a positron, then two α and two β particles and in the last, one α, is also emitted and gets converts to $^{c}_{d}Y$ species. So correct relation is
(a) $c = a - 12$, $d = b - 5$
(b) $c = a - 5$, $d = b - 1$
(c) $c = a - 6$, $d = b - 0$
(d) $c = a - 4$, $d = b - 2$ *(2001)*

7. A 300 gram radioactive sample at initial half life is 3 hours. After 18 hours remaining quantity
(a) 4.68 gram (b) 2.34 gram
(c) 3.34 gram (d) 9.37 gram
(2000)

8. Sulphur-35 (34.96903 a.m.u.) emits a β-particle but no γ-ray. The product is chlorine-35 (34.96885 a.m.u.). The maximum energy emitted by the β-particle is
(a) 0.16758 MeV
(b) 1.6758 MeV
(c) 16.758 MeV
(d) 0.016758 MeV
(1999)

9. In the following radioactive decay, $^{232}_{92}X \rightarrow {}^{220}_{89}Y$, how many α and β particles are ejected from X to form Y?
(a) 3α and 5β
(b) 5α and 3β
(c) 3α and 3β
(d) 5α and 5β *(1999)*

10. The half-life of $^{14}_{6}\text{C}$, if its l is 2.31×10^{-4}, is
(a) 3.5×10^{4} years
(b) 3×10^{3} years
(c) 2×10^{2} years
(d) 4×10^{3} years *(1999)*

11. Number of neutrons in a parent nucleus X, which gives $^{14}_{7}\text{N}$ nucleus after two successive β emissions, would be
(a) 7 (b) 6
(c) 9 (d) 8 *(1998)*

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* *Not included in the syllabus of AIPMT since 2006*

12. Carbon-14 dating method is based on the fact that
(a) ratio of carbon-14 and carbon-12 is constant
(b) carbon-14 is the same in all objects
(c) carbon-14 is highly insoluble
(d) all of these. *(1997)*

13. $^{235}_{92}U + n \rightarrow$ fission product + neutron + 3.20×10^{-11} J. The energy undergoes fission is
(a) 8.21×10^{7} J (b) 6.55×10^{6} J
(c) 12.75×10^{8} J (d) 18.60×10^{9} J
(1997)

14. After the emission of one a-particle followed by one β-particle from the atom of $^{238}_{92}X$, the number of neutrons in the atom will be
(a) 144 (b) 143
(c) 148 (d) 146
(1996)

15. Half-life for radioactive ^{14}C is 5760 years. In how many years 200 mg of ^{14}C will be reduced to 25 mg?
(a) 17280 years (b) 23040 years
(c) 5760 years (d) 11520 years
(1995)

16. In a radioactive decay, an emitted electron comes from
(a) outermost orbit of the atom
(b) orbit having principal quantum number one
(c) nucleus of the atom
(d) inner orbital of the atom. *(1994)*

17. If an isotope of hydrogen has two neutrons in its atom, its atomic number and atomic mass number will respectively be
(a) 2 and 1 (b) 3 and 1
(c) 1 and 1 (d) 1 and 3 *(1992)*

18. The age of most ancient geological formations is estimated by
(a) potassium - argon method
(b) carbon - 14 dating method
(c) radium - silicon method
(d) uranium - lead method. *(1989)*

19. Emission of an alpha particle leads to a
(a) decrease of 2 units in the charge of the atom
(b) increase of 2 units in the mass of the atom
(c) decrease of 2 units in the mass of the atom
(d) increase of 4 units in the mass of the atom.
(1989)

Answer Key

1. (c)	**2.** (c)	**3.** (b)	**4.** (a)	**5.** (c)	**6.** (a)	**7.** (a)	**8.** (a)	**9.** (c)	**10.** (b)
11. (c)	**12.** (a)	**13.** (a)	**14.** (b)	**15.** (a)	**16.** (c)	**17.** (d)	**18.** (d)	**19.** (a)	

EXPLANATIONS

1. (c) : Most stable product of radioactive disintegration is lead which belongs to group 14.

2. (c) : ${}^{60}_{28}\text{Ni} + {}^{1}_{0}n \rightarrow {}^{60}_{27}\text{Co} + {}^{1}_{1}p$

3. (b) : $T = t_{1/2} \times n$; $n = \frac{49.2}{12.3} = 4$

$N = N_0(1/2)^n = 32(1/2)^4 = 32\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2} = 2$ mg

4. (a) : ${}^{235}_{92}\text{U} + {}^{1}_{0}n \rightarrow {}^{139}_{54}\text{Xe} + {}^{94}_{38}\text{Sr} + 3{}^{1}_{0}n$

Product x is 3 neutron.

5. (c) : At the end of 24 hrs. activity = 0.01 M
Half life = 6 hrs.
In 24 hrs. there are 24/6 = 4 half life.

Activity of substance after n half-life = $\frac{(A)}{2^n}$

$\Rightarrow \frac{(A)}{2^4} = 0.01$. $\therefore$ $(A) = 0.16$

6. (a) :

$${}^{a}_{b}X \xrightarrow{-{}^{0}_{+1}\beta} {}^{a}_{b-1}X \xrightarrow{-2{}^{4}_{2}\text{He}} {}^{a-8}_{b-5}X \xrightarrow{-2{}^{0}_{-1}\beta}$$

$${}^{a-8}_{b-3}X \xrightarrow{-{}^{4}_{2}\text{He}} {}^{a-12}_{b-5}X \equiv {}^{c}_{d}X$$

$\therefore$ $c = a - 12$ and $d = b - 5$

7. (a) : no. of half life's gone $= \frac{18}{3} = 6$, $N_0 = 300$ g.

$$N_t = N_0 \times \left(\frac{1}{2}\right)^n$$

$$= 300\times\left(\frac{1}{2}\right)^6 = 300\times\frac{1}{64} = 4\cdot68 \text{ g}$$

8. (a) : Mass defect = 34.96903 – 34.96885
= 0.00018 amu
Energy emitted = 0.00018 × 931 MeV
= 0.16758 MeV

9. (c) : ${}^{232}_{92}X \rightarrow {}^{220}_{89}Y \rightarrow m{}^{4}_{2}\alpha + n{}^{0}_{-1}\beta$

$\Rightarrow 232 = 220 + 4m \Rightarrow m = 3;\ 92 = 89 + 2m - n$

$\Rightarrow n = 89 + 6 - 92 = 3$

Hence 3α and 3β particles are ejected.

10. (b) : $t_{1/2} = \frac{0.693}{\lambda} = \frac{0.693}{2.31\times10^{-4}} = \frac{6.93}{2.31}\times10^3$
$= 3 \times 10^3$ yr.

11. (c) : ${}^{b}_{a}X \rightarrow {}_{7}\text{N}^{14} + 2{}_{-1}\text{b}^{0} \Rightarrow b = 14$ and
$a = 7 + 2(-1) = 5 \Rightarrow {}^{14}_{5}X$

Number of neutrons = 14 – 5 = 9

12. (a) : With the passage of time, calculated amount of carbon-14 degrades. This fact is the basis of C-14 dating method.

13. (a) : 1 atom of ${}^{235}_{92}\text{U}$ on fission gives energy
$= 3.2 \times 10^{-11}$ J

6.023×10^{23} atom (1 mole) on fission gives energy
$= 3.2 \times 10^{-11} \times 6.023 \times 10^{23}$ J $= 3.2 \times 6.023 \times 10^{12}$ J

235 g of ${}^{235}_{92}\text{U}$ on fission gives energy

$$= \frac{6.023}{235}\times3.2\times10^{12} = 8.2\times10^7 \text{ kJ}$$

14. (b) : ${}^{238}_{92}X \xrightarrow{-\alpha} {}^{234}_{90}Y \xrightarrow{-\beta} {}^{234}_{91}Z$

Therefore, number of neutrons in ${}^{234}_{91}Z$
$= 234 - 91 = 143$.

15. (a) : Quantity left after 5760 years $\frac{200}{2} = 100$ mg
Similarly quantity left after another 5760 years (*i.e.* 11520 years) $= \frac{100}{2} = 50$ mg and the quantity left after another 5760 years (*i.e.* 17280 years) $= \frac{50}{2} = 25$ mg

Thus time taken by 200 mg of ${}^{14}\text{C}$ to reduce to 25 mg
= (5760 + 5760 + 5760)years = 17280 years

16. (c): Since radioactivity is a nuclear phenomenon, therefore electron comes from nucleus of the atom. During this process a neutron breaks down into a proton and an electron.

$$n \rightarrow p + {}^{0}_{-1}e$$

17. (d) : Hydrogen has 3 isotopes ${}^{1}_{1}\text{H}, {}^{2}_{1}\text{H}, {}^{3}_{1}\text{H}$

Here $Z = 1, A = 3$ viz. Tritium $({}^{3}_{1}\text{H})$

So, it has 1p and 2n.

18. (d) : The age of minerals and rocks is estimated by U-Pb method which is also known as helium dating.

Remember : C-14 dating method is used to predict the age of fossils or dead animals or a fallen tree.

19. (a) : Emission of a-particle $({}^{4}_{2}\text{He})$ leads to decrease of 2 units of charge

Example : ${}^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He}$