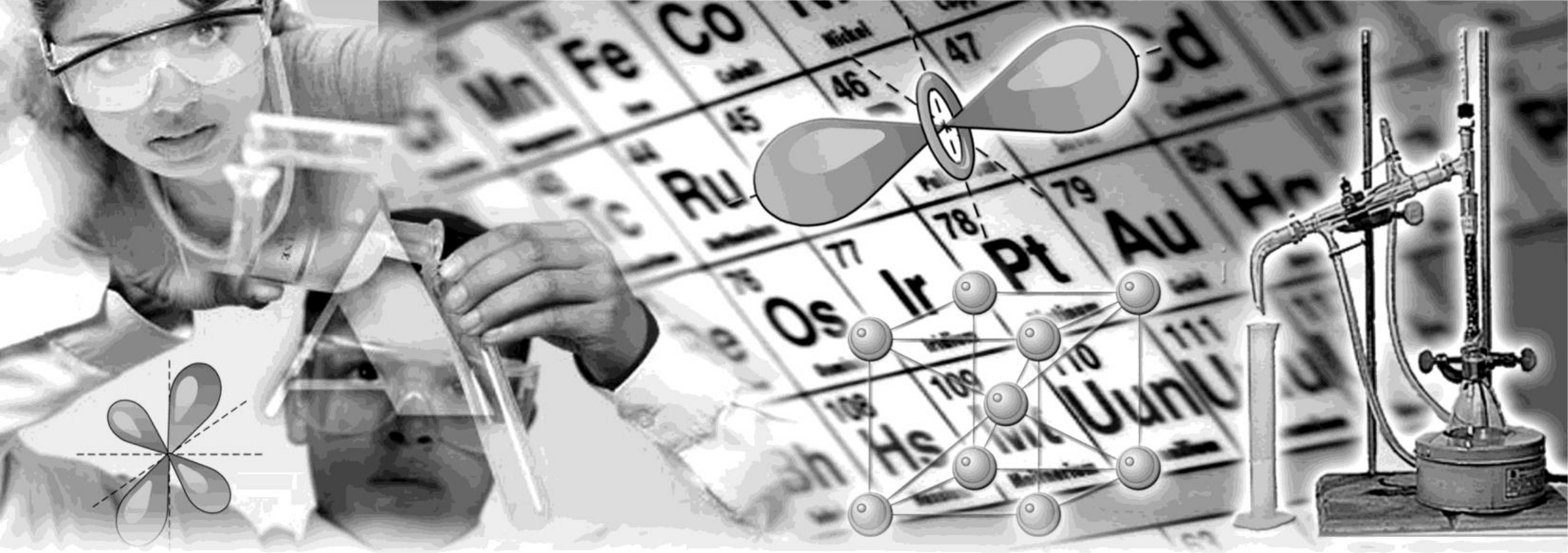

Chapter

7

Nuclear Chemistry

"The branch of chemistry which deals with the study of composition of atomic nucleus and the nuclear transformations is known as nuclear chemistry".

The common examples of nuclear processes are radioactivity, artificial transmutations, nuclear fission and nuclear fusion. The nuclear is also an important aspect of chemistry because the energies involved in some of these are million times greater than those in ordinary chemical reactions.

Radioactivity

"Radioactivity is a process in which nuclei of certain elements undergo spontaneous disintegration without excitation by any external means." and the elements whose atoms disintegrate and emit radiations are called radioactive elements.

Henry Becquerel (1891) observed the spontaneous emission of invisible, penetrating rays from *potassium uranyl sulphate* $K_2UO_2(SO_4)_2$, which influenced photographic plate in dark and were able to produce luminosity in substances like *ZnS*.

Later on, *M.M. Curie and her husband P. Curie* named this phenomenon of spontaneous emission of penetrating rays as, **Radioactivity**.

Curies also discovered a new radioactive element *Radium* from *pitchblende* (an ore of *U i.e.* U_3O_8) which is about 3 million times more radioactive than uranium. Now a days about 42 radioactive elements are known.

The radioactivity may be broadly classified into two types,

(1) If a substance emits radiations by itself, it is said to possess ***natural radioactivity***.

(2) If a substance starts emitting radiations on exposure to rays from some natural radioactive substance, the phenomenon is called ***induced*** or ***artificial radioactivity***.

Radioactivity can be detected and measured by a number of devices like ionisation chamber, Geiger Muller counter, proportional counter, flow counter, end window counter, scintillation counter, Wilson cloud chamber, electroscope, etc.

Nature and characteristics of radioactive emissions

The phenomenon of radioactivity arises because of the decay of unstable nuclei or certain element. The nature of the radiations emitted from a radioactive substance was investigated by *Rutherford* (1904) by applying electric and magnetic fields. When these radiation were subjected to electric or magnetic field, these were split into three types α, β and γ –rays.

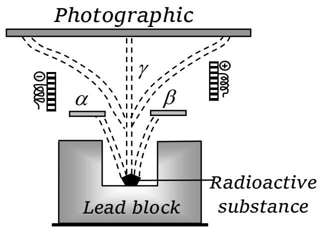

Fig. 7.1

Characteristics of radioactive rays

α-Ray	β-Ray	γ-Ray
Charge and mass : It carries +2 charge and 4 unit mass.	It carries -1 charge and no mass.	It has no charge and negligible mass.
Identity : Helium nuclei or helium ion ${}_2He^4$ or He^{2+}.	Electron ${}_{-1}e^0$	High energy raditons.
Action of magnetic field : Deflected towards the cathode.	Deflected to anode.	Not deflected.
Velocity : 1/10th to that of light.	Same as that of light.	Same as that of light.

Ionizing power : Very high nearly 100 times to that of β-rays.	Low nearly 100 times to that of γ-rays.	Very low.
Effect on ZnS plate : They cause luminescence.	Very little effect.	Very little effect.
Penetrating power : Low	100 times that of α-particles.	10 times that of β-particles.
Range : Very small.	More than α-particles.	More
Nature of product : Product obtained by the loss of 1 α-particle has atomic number less by 2 units and mass number less by 4 units.	Product obtained by the loss of 1 β-particle has atomic number more by 1 unit, without any change in mass number.	There is no change in the atomic number as well as in mass number.

Theory of radioactivity disintegration

Rutherford and *Soddy*, in 1903, postulated that radioactivity is a nuclear phenomenon and all the radioactive changes are taking place in the nucleus of the atom. They presented an interpretation of the radioactive processes and the origin of radiations in the form of a theory known as **theory of radioactive disintegration**. The main points of this theory are,

(1) The atomic nuclei of the radioactive elements are unstable and liable to disintegrate any moment.

(2) The disintegration is spontaneous, *i.e.*, constantly breaking. The rate of breaking is not affected by external factors like temperature, pressure, chemical combination etc.

(3) During disintegration, atoms of new elements called daughter elements having different physical and chemical properties than the parent elements come into existence.

(4) During disintegration, either alpha or beta particles are emitted from the nucleus.

The disintegration process may proceed in one of the following two ways,

(i) ***α-particle emission*** : When an α-particle $({}_2He^4)$ is emitted from the nucleus of an atom of the parent element, the nucleus of the new element, called daughter element possesses atomic mass or atomic mass number less by four units and nuclear charge or atomic number less by 2 units because α-particle has mass of 4 units and nuclear charge of two units.

$$\underset{\substack{\text{Atomic mass}: W \\ \text{Atomic number}: Z}}{\textbf{Parent element}} \xrightarrow{-\alpha} \underset{\substack{W-4 \\ Z-2}}{\textbf{Daughter element}}$$

(ii) ***β-particle emission*** *:* β-particle is merely an electron which has negligible mass. Whenever a beta particle is emitted from the nucleus of a radioactive atom, the nucleus of the new element formed possesses the same atomic mass but nuclear charge or atomic number is increased by 1 unit than the parent element. Beta particle emission is due to the result of decay of neutron into proton and electron. ${}_0n^1 \rightarrow {}_1p^1 + {}_{-1}e^0$

The electron produced escapes as a beta-particle-leaving proton in the nucleus.

$$\underset{\substack{\text{Atomic mass}: W \\ \text{Atomic number}: Z}}{\textbf{Parent element}} \xrightarrow{-\beta} \underset{\substack{W \\ Z+1}}{\textbf{Daughter element}}$$

(iii) ***γ-ray emission*** : γ-rays are emitted due to secondary effects. The excess of energy is released in the form of γ-rays. *Thus γ-rays arise from energy re-arrangements in the nucleus*. As γ-rays are short wavelength electromagnetic radiations with no charge and no mass, their emission from a radioactive element does not produce new element.

Special case : If in a radioactive transformation 1 alpha and 2 beta-particles are emitted, the resulting nucleus possesses the same atomic number but atomic mass is less by 4 units. A radioactive transformation of this type always produces an isotope of the parent element.

$${}_ZA^W \xrightarrow{-\alpha} {}_{Z-2}B^{W-4} \xrightarrow{-\beta} {}_{Z-1}C^{W-4} \xrightarrow{-\beta} {}_ZD^{W-4}$$

A and *D* are isotopes.

Group displacement law

Soddy, Fajans and Russell (1911-1913) observed that when an α-particle is lost, a new element with atomic number less by 2 and mass number less by 4 is formed. Similarly, when β-particle is lost, new element with atomic number greater by 1 is obtained. The element emitting then α or β-particle is called *parent element* and the new element formed is called *daughter element*. The above results have been summarized as,

(1) When an α-particle is emitted, the new element formed is displaced two positions to the **left** in the periodic table than that of the parent element (*because the atomic number decreases by 2*).

(2) When a β-particle is emitted, the new element formed is displaced one position to the **right** in the periodic table than that of the parent element (*because atomic number increased by 1*).

(3) When a positron is emitted, the daughter element occupies its position one group to the left of the parent element in periodic table.

Group displacement law should be applied with great care especially in the case of elements of lanthanide series (57 to 71), actinide series (89 to 103), VIII group (26 to 28; 44 to 46; 76 to 78), IA and IIA groups.

To determine the number of α- and β- particles emitted during the nuclear transformation. It can be done in following manner, ${}^a_cX \rightarrow {}^b_dY + x\,{}^4_2He + y\,{}_{-1}e^0$

$$a = b + 4x \;\; or \;\; x = \frac{a-b}{4} \qquad .....(i)$$

$c = d + 2x - y$ .....(ii)

where x = no. of α-emitted, y = no. of β-emitted substituting the value of x from eq. (i) in eq. (ii)

we get $c = d + \left(\frac{a-b}{4}\right)2 - y$; $y = d + \left[\frac{a-b}{2}\right] - c$

Radioactive disintegration series

The phenomenon of natural radioactivity continues till stable nuclei are formed. All the nuclei from the initial element to the final stable element constitute a series known as disintegration series. Further we know that mass numbers change only when α-particles are emitted (and not when β-particles are emitted) causing the change in mass of 4 units at each step. Hence the mass numbers of all elements in a series will fit into one of the formulae. $4n$, $4n+1$, $4n+2$ and $4n+3$, hence there can be only four disintegration series.

	4n	**4n + 1**	**4n + 2**	**4n + 3**
n	58	59	59	58
Parent element	$_{90}Th^{232}$	$_{94}Pu^{241}$	$_{92}U^{238}$	$_{92}U^{235}$
Half life (yrs)	1.39×10^{10}	10	4.5×10^{9}	7.07×10^{8}
Half life (yrs)	1.39×10^{10}	2.2×10^{6}	4.5×10^{9}	13.5
Name of series	Thorium (Natural)	Neptunium (Artificial)	Uranium (Natural)	Actinium (Natural)
End product	$_{82}Pb^{208}$	$_{83}Bi^{209}$	$_{82}Pb^{206}$	$_{82}Pb^{207}$
n	52	52	51	51
Number of lost particles	$\alpha = 6$, $\beta = 4$	$\alpha = 8$, $\beta = 5$	$\alpha = 8$, $\beta = 6$	$\alpha = 7$, $\beta = 4$

Nuclear structure and Nuclear forces

According to an earlier hypothesis, the nucleus is considered as being composed of two building blocks, proton's and neutron's, which are collectively called ***nucleons***. The *forces, which hold the nucleons together means stronger proton – proton, neutron – neutron and even proton – neutron attractive forces, exist in the nucleus. These attractive forces are called nuclear forces*. Nuclear forces operate only within small distance of about $1 \times 10^{-15} m$ or 1 fermi (1 fermi = $10^{-13} cm$) and drops rapidly to zero at a distance of $1 \times 10^{-13} cm$. These are referred to as short range forces. Nuclear forces are nearly 10^{21} times stronger than electrostatic forces.

Yukawa in 1935, put forward a postulate that neutrons and protons are held together by very rapid exchange of nuclear particles called *Pi-mesons (π-mesons have mass equal to 275 times of the mass of an electron and a charge equal to +1, 0 or –1. These are designated as π^+ π^0 and π^- respectively*). The nuclear force which is used in rapid exchange of *Pi*-mesons between nucleons are also called *exchange forces*.

The binding forces between unlike nucleons (*p* and *n*) are explained by the oscillation of a charged π-meson (π^+ or π^-)

(a) $p_1 + n_2 \rightleftharpoons n_1 + \pi^+ + n_2 \rightleftharpoons n_1 + p_2$

(b) $p_1 + n_2 \rightleftharpoons n_1 + \pi^- + p_2 \rightleftharpoons n_1 + p_2$

Binding forces between like nucleons (*p* - *p* or *n* - *n*) result from the exchange of neutral mesons (π^0) as represented below.

(a) $p_1 \rightleftharpoons p_2 + \pi^0$ or $p_1 + \pi^0 \rightleftharpoons p_2$

(b) $n_1 \rightleftharpoons n_2 + \pi^0$ or $n_1 + \pi^0 \rightleftharpoons n_2$

Nuclear stability

Nuclides can be grouped on the basis of nuclear stability, i.e. stable and unstable nucleus. The most acceptable theory about the atomic nuclear stability is based upon the fact that the observed atomic mass of all known isotopes (except hydrogen) is always less from the sum of the weights of protons and neutrons present in it. Electron (β- particle) from a radioactive nucleus may be regarded as derived from a neutron in the following way,

Neutron $\rightarrow$ Proton + Electron

Similarly, photons are produced from internal stresses within the nucleus.

The stability of nucleus may be discussed in terms of any one of the following,

(1) **Nuclear Binding Energy and Mass defect :** It is observed that atomic mass of all nuclei (except hydrogen) is different from the sum of masses of protons and neutrons. The difference is termed *mass defect*.

Mass defect = Total mass of nucleons – obs. atomic mass

The mass defect is converted into energy. This energy is called the *binding energy*. This is the energy required to break the nucleus into is constituents (*p* and *n*).

Binding energy = Mass defect $\times 931 MeV$

The stability of the nucleus is explained on the value of binding energy per nucleon and not on the basis of total binding energy . Binding energy per nucleon is maximum (8.7 *MeV*) in the case of iron (56). The value of binding energy per nucleon can be increased either by fusion of lighter nuclei or fission of heavier nuclei.

Value of binding energy predicts the relative stability of the different isotopes of an element. If the value of binding energy is negative, the product nucleus or nuclei will be less stable than the reactant nucleus. Thus the relative stability of the different isotopes of an element can be predicted by the values of binding energy for each successive addition of one neutron to the nucleus.

$$_2He^3 + {_0n^1} \longrightarrow {_2He^4} + 20.5MeV$$

$$_2He^4 + {_0n^1} \longrightarrow {_2He^5} - 0.8MeV$$

Therefore, $_2He^4$ is more stable than $_2He^3$ and $_2He^5$.

(2) **Packing fraction :** The difference of actual isotopic mass and the mass number in terms of packing fraction is defined as,

$$\text{Packing fraction} = \frac{\text{Actual isotopic mass} - \text{Mass number}}{\text{Mass number}} \times 10^4$$

The value of packing fraction depends upon the manner of packing of the nucleons with in the nucleus. Its value can be negative, positive or even zero. A negative packing fraction generally indicates stability of the nucleus.

In general, lower the packing fraction, greater is the binding energy per nucleon and hence greater is the stability. *The relatively low packing fraction of He, C and O implies their exceptional stability, packing fraction is least for Fe (negative) and highest for H (+78).*

(3) **Magic number :** Nucleus of atom, like extra-nuclear electrons, also has definite energy levels (shells).

Nuclei with 2, 8, 20, 28, 50, 82 or 126 protons or neutrons have been found to be particularly stable with a large number of isotopes. These numbers, commonly known as ***Magic numbers*** are defined as the number of nucleons required for completion of the energy levels of the nucleus. Nucleons are arranged in shells as two protons or two neutrons (with paired spins) just like electrons arranged in the extra-nuclear part. Thus the following nuclei $_2He^4, {_8O^{16}}, {_{20}Ca^{40}}$ and $_{82}Pb^{208}$ containing protons 2, 8, 20 and 82 respectively (all magic numbers) and neutrons 2, 8, 20 and 126 respectively (all magic numbers) are the most stable.

Magic numbers for protons : 2, 8, 20, 28, 50, 82,114

Magic numbers for neutrons : 2, 8, 20, 28, 50, 126, 184, 196

When both the number of protons and number of neutrons are magic numbers, the nucleus is very stable. That is why most of the radioactive disintegration series terminate into stable isotope of lead (magic number for proton = 82, magic number for neutron = 126). Nuclei with nucleons just above the magic numbers are less stable and hence these may emit some particles to attain magic numbers.

(4) **Neutron-proton ratio or causes of radioactivity** It has been found that the stability of nucleus depends upon the neutron to proton ratio (*n*/*p*). If we plot the number of neutrons against number of protons for nuclei of various elements, it has been observed that most of the stable (non-radioactive) nuclei lie in a belt shown by shaded region in figure this is called ***stability belt*** or ***stability zone***. The nuclei whose *n*/*p* ratio does not lie in the belt are unstable and undergo spontaneous radioactive disintegration.

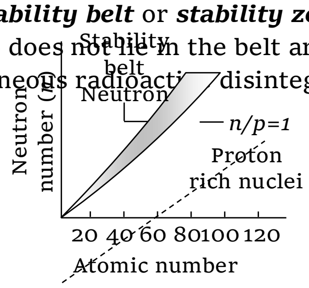

Fig. 7.2

It has been observed that,

(i) n/p ratio for stable nuclei lies quite close to unity for elements with low atomic numbers (20 or less) but it is more than one for nuclei having higher atomic numbers. Nuclei having n/p ratio either very high or low undergo nuclear transformation.

(ii) When n/p ratio is higher than required for stability, the nuclei have the tendency to emit $\beta -$rays *i.e.,* a neutron is converted into a proton.

(iii) When n/p ratio is lower than required for stability, the nuclei increase the ratio, either by emitting $\alpha -$particle or by emitting a position or by *K*-electron capture.

Rate of radioactive decay

"*According to the law of radioactive decay, the quantity of a radio-element which disappears in unit time* (*rate of disintegration*) *is directly proportional to the amount present*."

The law of radioactive decay may also be expressed mathematically.

Suppose N_0 be the number of atoms of the radioactive element present at the commencement of observation, $t = 0$ and after time *t*, the number of atoms remaining unchanged is N_t. The rate of disintegration $\left(-\frac{dN_t}{dt}\right)$ at any time *t* is directly proportional to *N*.

Then, $-\frac{dN_t}{dt} = \lambda N$

where λ is a radioactive constant or decay constant.

Various forms of equation for radioactive decay are,

$$N_t = N_0 e^{-\lambda t}\ ;\ \log N_0 - \log N_t = 0.4343\,\lambda t$$

$$\log \frac{N_0}{N_t} = \frac{\lambda t}{2.303}\ ;\ \ \lambda = \frac{2.303}{t}\log \frac{N_0}{N_t}$$

This equation is similar to that of first order reaction, hence we can say that radioactive disintegration are examples of first order reactions. However, unlike first order rate constant (K), the decay constant (λ) is independent of temperature.

Rate of decay of nuclide is **independent** of temperature, so its energy of activation is zero.

(1) **Half-life period ($T_{1/2}$ or $t_{1/2}$) :** The half-life period of a radioelement is defined, as the time required by a given amount of the element to decay to one-half of its initial value.

$$t_{1/2} = \frac{0.693}{\lambda}$$

Now since λ is a constant, we can conclude that half-life period of a particular radioelement is independent of the amount of the radioelement. In other words, whatever might be the amount of the radioactive element present at a time, it will always decompose to its half at the end of one half-life period.

Let the initial amount of a radioactive substance be N_0

Amount of radioactive substance left after n half-life periods

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

Total time $T = n \times t_{1/2}$ where n is a whole number.

(2) **Average-life period (T) :** Since total decay period of any element is infinity, it is meaningless to use the term total decay period (total life period) for radioelements. Thus the term **average life** is used.

$$\text{Average life } (T) = \frac{\text{Sum of lives of the nuclei}}{\text{Total number of nuclei}}$$

Average life (T) of an element is the inverse of its decay constant, *i.e.*, $T = \frac{1}{\lambda}$, Substituting the value of λ in the above equation,

$$T = \frac{t_{1/2}}{0.693} = 1.44\, t_{1/2}$$

Thus, **Average life (T)** $= 1.44 \times \text{Half life}(T_{1/2}) = \sqrt{2} \times t_{1/2}$

Thus, the average life period of a radioisotope is approximately under-root two times of its half life period.

(3) **Activity of population or specific activity :** It is the measure of radioactivity of a radioactive substance. It is defined as ' the number of radioactive nuclei, which decay per second per gram of radioactive isotope.' Mathematically, if 'm' is the mass of radioactive isotope, then

$$\text{Specific activity} = \frac{\text{Rate of decay}}{m} = \frac{\lambda N}{m} = \lambda \times \frac{\text{Avogadro number}}{\text{Atomic mass in } g}$$

where N is the number of radioactive nuclei which undergoes disintegration.

(4) **Radioactive equilibrium :** Suppose a radioactive element A disintegrates to form another radioactive element B which in turn disintegrates to still another element C.

$$A \longrightarrow B \longrightarrow C$$

B is said to be in radioactive equilibrium with A if its rate of formation from A is equal to its rate of decay into C.

It is important to note that the term equilibrium is used for reversible reactions but the radioactive reactions are irreversible, hence it is preferred to say that B is in a steady state rather than in equilibrium state.

At a steady state, $\frac{N_A}{N_B} = \frac{\lambda_B}{\lambda_A} = \frac{T_A}{T_B} = \frac{(t_{1/2})_A}{(t_{1/2})_B}$

Thus at a steady state (at radioactive equilibrium), the amounts (number of atoms) of the different radioelements present in the reaction series are inversely proportional to their radioactive constants or directly proportional to their half-life and also average life periods.

(5) **Units of radioactivity :** The standard unit in radioactivity is curie (c) which is defined as that amount of any radioactive material which gives 3.7×10^{10} disintegration's per second (dps), *i.e.*, 1c = Activity of 1g of $Ra^{226} = 3.7 \times 10^{10}\, dps$

The millicurie (mc) and microcurie (μc) are equal to 10^{-3} and 10^{-6} curies *i.e.* 3.7×10^7 and $3.7 \times 10^4\, dps$ respectively.

$$1c = 10^3 mc = 10^6 \mu c\ ;\ 1c = 3.7 \times 10^{10} dps$$

$$1mc = 3.7 \times 10^7 dps\ \ ;\ 1\mu c = 3.7 \times 10^4 dps$$

But now a day, the unit curie is replaced by rutherford (*rd*) which is defined as the amount of a radioactive substance which undergoes $10^6\,dps$. *i.e.*, $1\,rd = 10^6\,dps$. The ***millicurie*** and ***microcurie*** correspondingly rutherford units are ***millirutherford*** (*mrd*) and ***microrutherford*** (μrd) respectively.

$$1\,c = 3.7\times10^{10}\,dps = 37\times10^3\,rd$$

$$1\,mc = 3.7\times10^{7}\,dps = 37\,rd$$

$$1\,\mu c = 3.7\times10^{4}\,dps = 37\,mrd$$

However, in SI system the unit of radioactivity is ***Becquerel*** (*Bq*)

1 *Bq* = 1 disintegration per second = 1 *dps* = $1\mu rd$, $10^6\,Bq = 1\,rd$, $3.7\times10^{10}\,Bq = 1\,c$

(6) **The Geiger-Nuttal relationship :** It gives the relationship between decay constant of an α-radioactive substance and the range of the α-particle emitted.

$$\log\lambda = A + B\log R$$

Where *R* is the range or the distance which an α-particle travels from source before it ceases to have ionizing power. *A* is a constant which varies from one series to another and *B* is a constant for all series. It is obvious that the greater the value of λ the greater the range of the α-particle.

Artificial transmutation of elements

The conversion of one element into another by artificial means, *i.e.*, by means of bombarding with some fundamental particles, is known as artificial transmutation. The phenomenon was first applied on nitrogen whose nucleus was bombarded with α-particles to produce oxygen.

$$\underset{\text{Nitrogen isotope}}{_7N^{14}} + \underset{\text{Alpha particle}}{_2He^4} \rightarrow \underset{\text{Oxygen isotope}}{_8O^{17}} + \underset{\text{Proton}}{_1H^1}$$

The element, which is produced, shows radioactivity, the phenomenon is known as ***Induced radioactivity***. The fundamental particles which have been used in the bombardment of different elements are,

α-particle : $_2He^4$; Proton : $_1H^1$

Deutron : $_1H^2$ or $_1D^2$; Neutron : $_0n^1$

Since α-particles, protons and deutrons carry positive charge, they are repelled by the positively charged nucleus and hence these are not good projectiles. On the other hand, neutrons, which carry no charge at all, are the **best projectiles**. **Cyclotron** is the most commonly used instrument for accelerating these particles. The particles leave the instrument with a velocity of about 25,000 miles per *second*. A more recent accelerating instrument is called the **synchrotron** or **bevatron**. It is important to note that this instrument cannot accelerate the neutrons, being neutral.

When a target element is bombarded with neutrons, product depends upon the speed of neutrons. **Slow neutrons** penetrate the nucleus while a **high-speed neutron passes through the nucleus.**

$$_{92}U^{238} + \underset{\text{slow speed}}{_0n^1} \rightarrow {_{92}U^{239}};\ _{92}U^{238} + \underset{\text{high speed}}{_0n^1} \rightarrow {_{92}U^{237}} + 2\,{_0n^1}$$

Thus slow neutrons, also called **thermal neutrons** are more effective in producing nuclear reactions than high-speed neutrons.

Alchemy : The process of transforming one element into other is known as alchemy and the person involved in such experiments is called alchemist. Although, gold can be prepared from lead by alchemy, the gold obtained is radioactive and costs very high than natural gold.

(i) ***Transmutation by α-particles***

(a) **α, *n* type**

$_4Be^9(\alpha,n)_6C^{12}$ *i.e.* $_4Be^9 + {_2He^4} \rightarrow {_6C^{12}} + {_0n^1}$

$_{94}Pu^{239}(\alpha,n)_{96}Cm^{242}$ *i.e.*

$_{94}Pu^{239} + {_2He^4} \rightarrow {_{94}Cm^{242}} + {_0n^1}$

(b) **α, *p* type**

$_9F^{19}(\alpha,p)_{10}Ne^{22}$ *ie.* $_9F^{19} + {_2He^4} \rightarrow {_{10}Ne^{22}} + {_1H^1}$

$_7N^{14}\ (\alpha,p)\ _8O^{17}$ *i.e.*, $_7N^{14} + {_2He^4} \rightarrow {_8O^{17}} + {_1H^1}$

(c) **α, β type**

$_{26}Fe^{59}(\alpha,\beta)_{29}Cu^{63}$ *i.e.*, $_{26}Fe^{59} + {_2He^4} \rightarrow {_{29}Cu^{63}} + {_{-1}e^0}$

(ii) ***Transmutation by protons***

(a) ***p*, *n* type**

$_{15}P^{31}(p,n)_{16}S^{31}$ *i.e.*, $_{15}P^{31} + {_1H^1} \rightarrow {_{16}S^{31}} + {_0n^1}$

(b) ***p*, γ type**

$_6C^{12}(p,\gamma)_7N^{13}$ *i.e.*, $_6C^{12} + {_1H^1} \rightarrow N^{13} + \gamma$

(c) ***p*, *d* type**

$_4Be^9(p,d)_4Be^8$ *i.e.*, $_4Be^9 + {_1H^1} \rightarrow {_4Be^8} + {_1H^2}$

(d) ***p*, α type**

$_8O^{16}(p,\alpha)_7N^{31}$ *i.e.*, $_8O^{16} + {_1H^1} \rightarrow {_7N^{13}} + {_2He^4}$

(iii) ***Transmutation by neutrons***

(a) ***n*,*p* type**

$_{13}Al^{27}(n,p)_{12}Mg^{27}$ *i.e.*, $_{13}Al^{27} + {_0n^1} \rightarrow {_{12}Mg^{27}} + {_1H^1}$

(b) ***n*,α type**

$_8O^{16}(n,\alpha)_{12}Mg^{27}$ *i.e.*, $_8O^{16} + {_0n^1} \rightarrow {_6C^{13}} + {_2He^4}$

(c) ***n*, γ type**

$_{92}U^{238}(n,\lambda)_{92}U^{239}$ *i.e.*, $_{92}U^{238} + {_0n^1} \rightarrow {_{92}U^{238}} + \lambda$

(d) ***n*,β type**

$_8O^{18}(n,\beta)_9F^{19}$ *i.e.*, $_8O^{18} + {_0n^1} \rightarrow {_9F^{19}} + {_{-1}e^0}$

(iv) ***Transmutation by deutrons***

(a) **d,p type**

$_{3}Li^{6}(d,p)_{3}Li^{7}$ *i.e.*, $_{3}Li^{6}+{}_{1}H^{2}\rightarrow {}_{3}Li^{7}+{}_{1}H^{1}$

$_{32}As^{75}(d,p)_{32}As^{76}$ *i.e.*, $_{32}As^{75}+{}_{1}H^{2}\rightarrow {}_{32}As^{76}+{}_{1}H^{1}$

(v) ***Transmutation by γ-radiations***

(a) **γ, n type**

$_{4}Be^{9}(\lambda,n)_{4}Be^{8}$ *i.e.*, $_{4}Be^{9}+\gamma\rightarrow {}_{4}Be^{8}+{}_{0}n^{1}$

Synthetic elements : Elements with atomic number greater than 92 *i.e.* the elements beyond uranium in the periodic table are not found in nature like other elements. All these elements are prepared by artificial transmutation technique and are therefore known as *transuranic elements* or *synthetic elements*.

Nuclear fission and Nuclear fusion

(1) **Nuclear fission :** *The splitting of a heavier atom like that of uranium – 235 into a number of fragments of much smaller mass, by suitable bombardment with sub-atomic particles with liberation of huge amount of energy is called* ***Nuclear fission***. *Hahn* and *Startsman* discovered that when uranium-235 is bombarded with neutrons, it splits up into two relatively lighter elements.

$_{92}U^{235}+{}_{0}n^{1}\rightarrow {}_{56}Ba^{140}+{}_{36}Kr^{93}+3\,{}_{0}n^{1}+$ Huge amount of energy

Spallation reactions are similar to nuclear fission. However, they differ by the fact that they are brought by high energy bombarding particles or photons.

Elements capable of undergoing nuclear fission and their fission products. Among elements capable of undergoing nuclear fission, uranium is the most common. The natural uranium consists of three isotopes, namely $U^{234}(0.006\%)$, $U^{235}(0.7\%)$ and $U^{238}(99.3\%)$. Of the three isomers of uranium, nuclear fission of U^{235} and U^{238} are more important. Uranium-238 undergoes fission by fast moving neutrons while U^{235} undergoes fission by slow moving neutrons; of these two, U^{235} fission is of much significance. Other examples are Pu^{239} and U^{233}.

Uranium-238, the most abundant (99.3%) isotope of uranium, although itself does not undergo nuclear fission, is converted into plutonium-239.

$$_{92}U^{238}+{}_{0}n^{1}\rightarrow {}_{92}U^{239}\ ;\ {}_{92}U^{239}\rightarrow {}_{92}NP^{239}+{}_{-1}e^{0}$$

$$_{93}Np^{238}\rightarrow {}_{94}Pu^{239}+{}_{-1}e^{0}$$

Which when bombarded with neutrons, undergo fission to emit three neutrons per plutonium nucleus. Such material like *U*-238 which themselves are non-fissible but can be converted into fissible material (*Pu*-239) are known as **fertile materials**.

Nuclear chain reaction : With a small lump of U^{235}, most of the neutrons emitted during fission escape but if the amount of U^{235} exceeds a few kilograms (*critical mass*), neutrons emitted during fission are absorbed by adjacent nuclei causing further fission and so producing more neutrons. Now since each fission releases a considerable amount of energy, vast quantities of energy will be released during the chain reaction caused by U^{235} fission.

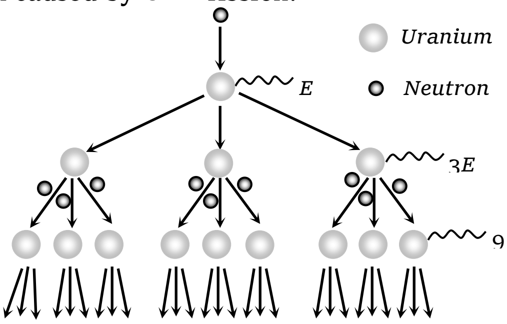

Fig. 7.3

Atomic bomb **:** An atomic bomb is based upon the process of that nuclear **fission** in which no secondary neutron escapes the lump of a fissile material for which the size of the fissile material should not be less than a minimum size called the critical size. There is accordingly a sudden release of a tremendous amount of energy, which represents an explosive force much greater than that of the most powerful TNT bomb. In the world war II in 1945 two atom bombs were used against the Japanese cities of Hiroshima and Nagasaki, the former contained *U*-235 and the latter contained *Pu*-239.

Atomic pile or Nuclear reactor **:** *It is a device to obtain the nuclear energy in a controlled way to be used for peaceful purposes*. The most common reactor consists of a large assembly of graphite (an allotropic form of carbon) blocks having rods of uranium metal (fuel). Many of the neutrons formed by the fission of nuclei of $_{92}U^{235}$ escape into the graphite, where they are very much slow down (from a speed of about 6000 or more *miles*/*sec* to a *mile*/*sec*) and now when these low speed neutrons come back into the uranium metal they are more likely to cause additional fissions. Such a substance like graphite, which slow down the neutrons without absorbing them is known as a **moderator**. Heavy water, D_2O is another important moderator where the nuclear reactor consists of rods of uranium metal suspended in a big tank of heavy water (swimming pool type reactor). Cadmium or boron are used as control rods for absorbing excess neutrons.

Plutonium from a nuclear reactor **:** For such purposes the fissile material used in nuclear reactors is the natural uranium which consists mainly (99.3%) of *U*-238. In a nuclear reactor some of the neutrons produced in *U*-235 (present in natural uranium) fission converts U-238 to a long-lived plutonium isotope, Pu-239 (another fissionable material). Plutonium is an important nuclear fuel. Such reactors in which neutrons produced from fission are partly used to carry out further fission and partly used to produce some other fissionable material are called **Breeder reactors**.

Nuclear reactors in India : India is equipped with the five nuclear reactors, namely

(i) Apsara (1952) (ii) Cirus (1960)

(iii) Zerlina (1961) (iv) Purnima (1972) and R-5

Purnima uses plutonium fuel while the others utilize uranium as fuel.

(2) **Nuclear fusion :** *"Oposite to nuclear fission, nuclear fusion is defined as a process in which lighter nuclei fuse together to form a heavier nuclei*. However, such processes can take place at reasonable rates only at very high temperatures of the order of several million degrees, which exist only in the interior of stars. Such processes are, therefore, called **Thermonuclear reactions** (temperature dependent reactions). Once a fusion reaction initiates, the energy released in the process is sufficient to maintain the temperature and to keep the process going on.

$$\underset{\text{Hydrogen}}{4\,{}_1H^1} \rightarrow \underset{\text{Helium}}{{}_2He^4} + \underset{\text{Positron}}{2\,{}_{+1}e^0} + \text{Energy}$$

This is not a simple reaction but involves a set of the thermonuclear reactions, which take place in stars including sun. In other words, *energy of sun is derived due to nuclear fission*.

Controlled nuclear fusion : Unlike the fission process, the fusion process could not be controlled. Since there are estimated to be some 10^{17} pounds of deuterium (${}_1H^2$) in the water of the earth, and since each pound is equivalent in energy to 2500 tonnes of coal, a controlled fusion reactor would provide a virtually inexhaustible supply of energy.

Hydrogen bomb : Hydrogen bomb is based on the *fusion of hydrogen nuclei into heavier ones by the thermonuclear reactions with release of enormous energy*.

As mentioned earlier the above nuclear reactions can take place only at very high temperatures. Therefore, it is necessary to have an external source of energy to provide the required high temperature. For this purpose, the atom bomb, (*i.e.*, *fission bomb*) is used as a *primer,* which by exploding provides the high temperature necessary for successful working of hydrogen bomb (*i.e.*, *fusion bomb*). In the preparation of a hydrogen bomb, a suitable quantity of deuterium or tritium or a mixture of both is enclosed in a space surrounding an ordinary atomic bomb. The first hydrogen bomb was exploded in November 1952 in Marshall Islands; in 1953 Russia exploded a powerful hydrogen bomb having power of 1 million tonnes of TNT

A hydrogen bomb is far more powerful than an atom bomb. Thus if it is possible to have sufficiently high temperatures required for nuclear fusion, the deuterium present in sea (as D_2O) is sufficient to provide all energy requirements of the world for millions of years. The first nuclear reactor was assembled by Fermi in 1942.

Difference between Nuclear fission and fusion

Nuclear fission	Nuclear fusion
The process occurs only in the nuclei of heavy elements.	The process occurs only in the nuclei of light elements.
The process involves the fission of the heavy nucleus to the lighter nuclei.	The process involves the fission of the lighter nuclei to heavy nucleus.
The process can take place at ordinary temperature.	The process takes place at higher temperature ($10^8\ {}^oC$).
The energy liberated during this process is high (200 MeV per fission)	The energy liberated during the process is comparatively low (3 to 24 MeV per fusion)
Percentage efficiency of the energy conversion is comparatively less.	Percentage efficiency of the energy conversion is high (four times to that of the fission process).
The process can be controlled for useful purposes.	The process cannot be controlled.

Application of radioactivity

Radioisotopes find numerous applications in a variety of areas such as medicine, agriculture, biology, chemistry, archeology, engineering and industry.

(1) **Age determination :** The age of earth has been determined by uranium dating technique as follows. Samples of uranium ores are found to contain Pb^{206} as a result of long series of α- and β-decays. Now if it is assumed that the ore sample contained no lead at the moment of its formation, and if none of the lead formed from U^{238} decay has been lost then the measurement of the Pb^{206}/U^{238} ratio will give the value of time t of the mineral.

$$\frac{\text{No. of atoms of } Pb^{206}}{\text{No. of atoms of } U^{238} \text{ left}} = e^{-\lambda t - 1}$$

where λ is the decay constant of uranium-238

Alternatively,

$$t = \frac{2.303}{\lambda}\log\frac{\text{Initial amount of } U^{238}}{\text{Amount of } U^{238} \text{ in the mineral present till date}}$$

Similarly, the less abundant isotope of uranium, U^{235} eventually decays to Pb^{207}; Th^{232} decays to Pb^{208} and thus the ratios of Pb^{207}/U^{235} and Pb^{208}/Th^{232} can be used to determine the age of rocks and minerals.

$_6C^{14}$ (half-life 5760 years) was used by ***Willard Libby*** (Nobel lauret) in determining the age of carbon-bearing materials (*e.g.* wood, animal fossils, etc.) Carbon-14 is produced by the bombardment of nitrogen atoms present in the upper atmosphere with neutrons (from cosmic rays).

$$_7N^{14} + _0n^1 \rightarrow _6C^{14} + _1H^1$$

Thus carbon-14 is oxidised to CO_2 and eventually ingested by plants and animals. The death of plants or animals puts an end to the intake of C^{14} from the atmosphere. After this the amount of C^{14} in the dead tissues starts decreasing due to its disintegration.

$$_6C^{14} \rightarrow _7N^{14} + _{-1}e^0$$

It has been observed that on an average, one gram of radioactive carbon emits about 12 β-particles per minute. Thus by knowing either the amount of *C*-14 or the number of β-particles emitted per minute per gram of carbon at the initial and final (present) stages, the age of carbon material can be determined by using the following formulae.

$$\lambda = \frac{2.303}{t}\log\frac{N_0}{N_t} \text{ or } t = \frac{2.303}{\lambda}\log\frac{N_0}{N_t}$$

where t = Age of the fossil, λ = Decay constant, N_0 = Initial radioactivity (in the fresh wood), N_t = Radioactivity in the fossil

The above formula can be modified as,

$$t = \frac{2.303}{\lambda}\log\frac{\text{Initial ratio of } C^{14}/C^{12} \text{ (in fresh wood)}}{C^{14}/C^{12} \text{ ratio in the old wood}}$$

Similarly, tritium $_1H^3$ has been used for dating purposes.

(2) **Radioactive tracers** (use of radio–isotopes) **:** A radioactive isotope can be easily identified by its radioactivity. The radioactivity can, therefore act as a tag or label that allows studying the behaviour of the element or compounding which contains this isotope. An isotope added for this purpose is known as isotopic tracer. The radioactive tracer is also known as an isotopic tracer. The radioactive tracer is also known as an indicator because it indicates the reaction. Radioisotopes of moderate half-life periods are used for tracer work. The activity of radioisotopes can be detected by means of electroscope, the electrometer or the Geiger-Muller counter. Tracers have been used in the following fields,

(i) ***To diagnose many diseases*** : For example, Arsenic – 74 tracer is used to detect the presence of tumours, Sodium – 24 tracer is used to detect the presence of blood clots and Iodine –131 tracer is used to study the activity of the thyroid gland. It should be noted that the radioactive isotopes used in medicine have very short half-life periods.

(ii) ***In agriculture*** : The use of radioactive phosphorus ^{32}P in fertilizers has revealed how phosphorus is absorbed by plants. This study has led to an improvement in the preparation of fertilizers. ^{14}C is used to study the kinetics of photo synthesis.

(iii) ***In industry*** : Radioisotopes are used in industry to detect the leakage in underground oil pipelines, gas pipelines and water pipes. Radioactive carbon has been used as a tracer in studying mechanisms involved in many reactions of industrial importance such as alkylation, polymerization, catalytic synthesis etc.

(iv) ***In analysis*** : Several analytical procedures can be used employing radioisotopes as tracers.

(a) A small amount of radioactive isotope is mixed with the inactive substance and the activity is studied before and after adsorption. Fall in activity gives the amount of substance adsorbed.

(b) The solubility of lead sulphate in water may be estimated by mixing a known amount of radioactive lead with ordinary lead.

(c) Ion exchange process of separation is readily followed by measuring activity of successive fractions eluted from the column.

(d) By labelling oxygen of the water, mechanism of ester hydrolysis has been studied.

(e) The efficiency of analytical procedures may be measured by adding a known amount of radio-isotopes to the sample before analysis begins. After the completion, the activity is again determined. The comparison of activity tells about the efficiency of separation.

(3) **Use of γ rays :** γ rays are used for disinfecting food grains and for preserving food stuffs. Onions, potatoes, fruits and fish etc., when irradiated with γ rays, can be preserved for long periods. High yielding disease resistant varieties of wheat, rice, groundnut, jute etc., can be developed by the application of nuclear radiations. The γ rays radiations are used in the treatment of cancer. The γ radiations emitted by cobalt –60 can burn cancerous cells. The γ radiations are used to sterilize medical instruments like syringes, blood transfusion sets. etc. These radiations make the rubber and plastics objects heat resistant.

Hazards of radiations

The increased pace of synthesis and use of radio isotopes has led to increased concern about the effect of radiations on matter, particularly in biological systems.

The accident of Chernobyl occurred in 1986 in USSR is no older when radioisotopes caused a hazard there. The nuclear radiations (alpha, beta, gamma as well as *X*-rays) possess energies far in excess of ordinary bond energies and ionisation energies. Consequently, these radiations are able to break up and ionise the molecules present in living organisms if they are exposed to such radiations. This disrupts the normal functions of living organisms. The damage caused by the radiations, however, depends upon the radiations received. The resultant radiation damage to living system can be classified as,

(1)**Somatic or pathological damage** : This affects the organism during its own life time. It is a permanent damage to living civilization produced in body. Larger dose of radiations cause immediate death whereas smaller doses can cause the development of many diseases such as paralysis, cancer, leukaemia, burns, fatigue, nausea, diarrhoea, gastrointestinal problems etc. some of these diseases are fatal. Many scientists presently believe that the effect of radiations is proportional to exposure, even down to low exposures. This means that any amount of radiation causes some finite risk to living civilization.

(2) **Genetic damage** : As the term implies, radiations may develop genetic effect. This type of damage is developed when radiations affect genes and chromosomes, the body's reproductive material. Genetic effects are more difficult to study than somatic ones because they may not become apparent for several generations.

Tips & Tricks

- The particle like mesons, positron, neutrino, *etc,* about 20 in number are created by stresses in nucleus but do not exist as component of nucleus.
- Highest degree of radioactivity is shown by radium.
- The nuclear forces are not governed by inverse square law.
- About 42 radioactive nuclides ($Z > 82$) occur in nature. Each of these gives stable end product of an isotope of lead.
- The half life is independent of physical or chemical state of a radioactive element.
- The average life of the natural radioactive element vary from $10^{-6}s$ 10^{10} years or more.
- It has been observed that fusion of 45 *mg* of hydrogen produce as much energy as obtained from one ton of coal.
- Beryllium has been found to be the best moderator as it occupies small space and have low absorption cross-section.
- The total life span of a radioactive element is infinite.
- The γ - radiation of total energy 1.02 *MeV*, emitted when a positron and an electron interact are known as annilation radiation.

Ordinary Thinking

Objective Questions

Nucleus (Stability and Reaction)

1. Nucleons are **[CPMT 1982]**

(a) Protons and electrons
(b) Protons and neutrons
(c) Electrons and neutrons
(d) Electrons, protons and neutrons

2. A deutron contains **[NCERT 1982; CPMT 1994]**

(a) A neutron and a positron
(b) A neutron and a proton
(c) A neutron and two protons
(d) A proton and two neutrons

3. The nucleus of radioactive element possesses

(a) Low binding energy (b) High binding energy
(c) Zero binding energy (d) High potential energy

4. On bombarding $_7N^{14}$ with α-particles, the nuclei of the product formed after the release of a proton will be **or** In nuclear reaction $_7N^{14} + {_2He^4} \rightarrow {_Z X^A} + {_1H^1}$, the term $_Z X^A$ represents **[NCERT 1979; MP PMT 1989; MNR 1995; MP PET 1996; BHU 1996]**

(a) $_8O^{17}$ (b) $_9F^{18}$
(c) $_9F^{17}$ (d) $_8O^{18}$

5. Nuclear energy is based on the conversion of

(a) Protons into neutrons
(b) Mass into energy
(c) Neutrons into protons
(d) Uranium into radium

6. Positron has nearly the same weight as that of **[NCERT 1975; JIPMER 1991; BHU 1995]**

(a) α-particle (b) Proton
(c) Neutron (d) Electron

7. In the reaction $_3Li^6 + (?) \rightarrow {_2He^4} + {_1H^3}$. The missing particle is **[CPMT 1983, 84]**

(a) Electron (b) Neutron
(c) Proton (d) Deutron

8. The $_6C^{14}$ in upper atmosphere is generated by the nuclear reaction **[MP PET 1993]**

(a) $_7N^{14} + {_1H^1} \longrightarrow {_6C^{14}} + {_{+1}e^0} + {_1H^1}$
(b) $_7N^{14} \longrightarrow {_6C^{14}} + {_{+1}e^0}$
(c) $_7N^{14} + {_0n^1} \longrightarrow {_6C^{14}} + {_1H^1}$
(d) $_7N^{14} + {_1H^3} + {_0n^1} \longrightarrow {_6C^{14}} + {_2He^4}$

9. Deuterons when bombarded on a nuclide produce $_{18}Ar^{38}$ and neutrons. The target is **[CPMT 1982, 87]**

(a) $_{17}Cl^{35}$ (b) $_{19}K^{27}$
(c) $_{17}Cl^{37}$ (d) $_{19}K^{39}$

10. Which can be used for carrying out nuclear reaction **[AFMC 2003]**

(a) Uranium – 238 (b) Neptunium – 239
(c) Thorium – 232 (d) Plutonium – 239

11. On comparing chemical reactivity of C^{12} and C^{14}, it is revealed that

(a) C^{12} is more reactive (b) C^{14} is more reactive
(c) Both are inactive (d) Both are equally active

12. The radionucleide $^{234}_{90}Th$ undergoes two successive β-decays followed by one α-decay. The atomic number and the mass number respectively of the resulting radionucleide are

(a) 92 and 234 (b) 94 and 230
(c) 90 and 230 (d) 92 and 230

13. Hydrogen and deuterium differ in **[CPMT 1980]**

(a) Reactivity with oxygen (b) Reactivity with chlorine
(c) Melting point (d) Reducing action

14. A nuclear reaction must be balanced in terms of

(a) Only energy (b) Only mass
(c) Mass and energy (d) None of these

15. In the following nuclear reaction, the other product is $_{52}Te^{130} + {_1H^2} \longrightarrow {_{53}I^{131}} + ?$ **[MP PET 1991]**

(a) Positron (b) Alpha particle
(c) One neutron (d) Proton

16. The reaction $_5B^8 \rightarrow {_4Be^8} + {_1e^0}$ is due to **[MP PMT 1991]**

(a) Loss of α-particles (b) Loss of β-particles
(c) Loss of positron (d) Electron loss

17. Positronium is the name given to an atom-like combination formed between **[NCERT 1980; JIPMER 1991]**

(a) A positron and a proton
(b) A positron and a neutron
(c) A positron and α-particle
(d) A positron and an electron

18. An electrically charged atom or a group of atoms is known as

(a) A meson (b) A proton
(c) An ion (d) A cyclotron

19. The charge on positron is equal to the charge on which one of the following **[NCERT 1977]**

(a) Proton (b) Electron

(c) α -particle (d) Neutron

20. In the nuclear reaction $_{12}Mg^{24} +_2 He^4 =_0 n^1 + ?$ The product nucleus is **[BHU 1987]**

(a) $_{13}Al^{27}$ (b) $_{14}Si^{27}$

(c) $_{13}Al^{28}$ (d) $_{12}Mg^{25}$

21. $_6C^{14}$ is formed from $_7N^{14}$ in the upper atmosphere by the action of the fundamental particle **[Orissa JEE 2002]**

(a) Positron (b) Neutron

(c) Electron (d) Proton

22. In the nuclear reaction

$_{92}U^{238} \to _{82}Pb^{206} + x\ _2He^4 + y\ _{-1}\beta^0$

the value of x and y are respectively .... **[Orissa JEE 2002]**

(a) 8, 6 (b) 6, 4

(c) 6, 8 (d) 8, 10

23. If an isotope of hydrogen has two neutrons in its atom, its atomic number and atomic mass number will respectively be **[CBSE 1992]**

(a) 2 and 1 (b) 3 and 1

(c) 1 and 1 (d) 1 and 3

24. Which one of the following nuclear transformation is (*n, p*) type **[AIIMS 1980, 83]**

(a) $_3Li^7 + _1H^1 \longrightarrow _4Be^7 + _0n^1$

(b) $_{33}As^{75} + _2He^4 \longrightarrow _{35}Br^{78} + _0n^1$

(c) $_{83}Bi^{209} + _1H^2 \longrightarrow _{84}Po^{210} + _0n^1$

(d) $_{21}Sc^{45} + _0n^1 \longrightarrow _{20}Ca^{45} + _1H^1$

25. What is X in the following nuclear reaction

$_7N^{14} + _1H^1 \longrightarrow _8O^{15} + X$ **[AIIMS 1983; MP PET 1997]**

(a) $_{+1}e^0$ (b) $_0n^1$

(c) γ (d) $_{-1}e^0$

26. In the reaction $_{93}Np^{239} \longrightarrow _{94}Pu^{239}$ + (?), the missing particle is **[MNR 1987]**

(a) Proton (b) Positron

(c) Electron (d) Neutron

27. According to the nuclear reaction $_4Be + _2He^4 \to _6C^{12} + _0n^1$, mass number of ($Be$) atom is **[AFMC 2002]**

(a) 4 (b) 9

(c) 7 (d) 6

28. Which of the following nuclides has the magic number of both protons and neutrons **[EAMCET 1989]**

(a) $_{50}Sn^{115}$ (b) $_{82}Pb^{206}$

(c) $_{82}Pb^{208}$ (d) $_{50}Sn^{118}$

29. In the carbon cycle, from which hot stars obtain their energy, the $_6C^{14}$ nucleus is

(a) Completely converted into energy

(b) Regenerated at the end of the cycle

(c) Combined with oxygen to form carbon monoxide

(d) Broken up into its constituents protons and neutrons

30. The atomic mass of lead is 208 and atomic number is 82. The atomic mass of bismuth is 209 and atomic number is 83. The ratio of *n/p* in the atom is **[EAMCET 1982]**

(a) Higher of lead (b) Higher of bismuth

(c) Same (d) None of these

31. Which of the following is an n, p reaction **[BHU 1995]**

(a) $_5C^{13} + _1H^1 \longrightarrow _6C^{14}$

(b) $_7N^{14} + _1H^1 \longrightarrow _8O^{15}$

(c) $_{13}Al^{27} + _0n^1 \longrightarrow _{12}Mg^{27} + _1H^1$

(d) $_{92}U^{235} + _0n^1 \longrightarrow _{54}Xe^{140} + _{38}Sr^{93} + 3\ _0n^1$

32. Which one of the following statements is *incorrect* **[MP PET 1997]**

(a) Mass defect is related with binding energy

(b) 'Meson' was discovered by Yukawa

(c) The size of the nucleus is of the order of $10^{-12} - 10^{-13}\,cm$

(d) Magnetic quantum number is a measure of 'orbital angular momentum' of the electron

33. In the sequence of following nuclear reactions $_{92}X^{238} \xrightarrow{-\alpha} Y \xrightarrow{-\beta} Z \xrightarrow{-\beta} L \xrightarrow{-n\alpha} _{84}M^{218}$

The value of n will be **[MP PMT 1999]**

(a) 3 (b) 4

(c) 5 (d) 6

34. The introduction of a neutron into the nuclear composition of an atom would lead to a change in **[MNR 19**

(a) The number of the electrons also

(b) The chemical nature of the atom

(c) Its atomic number

(d) Its atomic weight

35. The composition of tritium ($_1H^3$) is **[Manipal MEE 1995; DPMT 1982,96]**

(a) 1 electron, 1 proton, 1 neutron

(b) 1 electron, 2 protons, 1 neutron

(c) 1 electron, 1 proton, 2 neutrons

(d) 1 electron, 1 proton, 3 neutrons

36. Identify 'X' in $_{16}S^{32} + X \to _{15}P^{30} + _2He^4$

(a) $_1H^1$ (b) $_1D^2$

(c) $_0n^1$ (d) e^-

37. In terms of energy 1 a. m.u. is equal to **[MP PET/PMT 1998]**

(a) 100 J (b) 931.1 MeV

(c) 931.1 $kcal$ (d) 10^7 erg

38. Positron is **[AIIMS 1997]**

(a) Electron with $+ve$ charge

(b) A helium nucleus

(c) A nucleus with two protons

(d) A nucleus with one neutron and one proton

39. $X \xrightarrow{-\alpha} Y \xrightarrow{-\beta} Z \xrightarrow{-\beta} W$

In the above sequence of reaction, the elements which are isotopes of each other are

(a) X and W (b) Y and Z

(c) X and Z (d) None of these

40. Stable nuclides are those whose n/p ratio is **[MP PMT 1993]**

(a) $n/p = 1$ (b) $n/p = 2$

(c) $n/p > 1$ (d) $n/p < 1$

41. Neutrino has **[NCERT 1981]**

(a) Charge +1, mass 1 (b) Charge 0, mass 0

(c) Charge – 1, mass 1 (d) Charge 0 , mass 1

42. Which one of the following nuclear reaction is correct **[CPMT 1997]**

(a) ${}_6C^{13} + {}_1H^1 \rightarrow {}_7N^{13} + \beta^- + v^-$

(b) ${}_{11}Na^{23} + {}_1H^1 \rightarrow {}_{10}Ne^{20} + {}_2He^4$

(c) ${}_{13}Al^{23} + {}_0n^1 \rightarrow {}_{11}Na^{23} + e^0$

(d) None of these

43. Formation of nucleus from its nucleons is accompanied by **[NCERT 1975; RPET 2000]**

(a) Decrease in mass (b) Increase in mass

(c) No change of mass (d) None of them

44. A particle having the same charge and 200 times greater mass than that of electron is

(a) Positron (b) Proton

(c) Neutrino (d) Meson

45. The positron is **[AFMC 1997]**

(a) ${}_{-1}e^0$ (b) ${}_{+1}e^0$

(c) ${}_1H^1$ (d) ${}_0n^1$

46. Which of the following is the most stable atom **[AFMC 1997]**

(a) Bi (b) Al

(c) U (d) Pb

47. The positron is discovered by **[RPMT 1997]**

(a) Pauling (b) Anderson

(c) Yukawa (d) Segar

48. The nucleus of an atom is made up of X protons and Y neutrons. For the most stable and abundant nuclei **[NCERT 1980]**

(a) X and Y are both even (b) X and Y are both odd

(c) X is even and Y is odd (d) X is odd and Y is even

49. Atom A possesses higher values of packing fraction than atom B. The relative stabilities of A and B are

(a) A is more stable than B

(b) B is more stable than A

(c) A and B both are equally stable

(d) Stability does not depend on packing fraction **[JIPMER 1997]**

50. How many neutrons are present in the nucleus of Ra **[CPMT 1980]**

(a) 88 (b) 226

(c) 140 (d) 138

51. In a nuclear explosion, the energy is released in the form of **[CPMT 1994]**

(a) Kinetic energy (b) Electrical energy

(c) Potential energy (d) None of these

52. In equation ${}_{11}Na^{23} + {}_1H^1 \rightarrow {}_{12}Mg^{23} + x$, x represents **[MP PMT 1990; MP PET 1999]**

(a) Neutron (b) Deutron

(c) α -particle (d) Positron

53. Which of the following atomic mass of uranium is the most radioactive **[AFMC 1997]**

(a) 238 (b) 235

(c) 226 (d) 248

54. Which of the following particle is emitted in the reaction ${}_{13}Al^{27} + {}_2He^4 \rightarrow {}_{14}P^{30} + ...$ **[DCE 1999]**

(a) ${}_0n^1$ (b) ${}_{-1}e^0$

(c) ${}_1H^1$ (d) ${}_1H^2$

55. Which of the following sub-atomic particles is not present in an atom **[JIPMER 1999]**

(a) Neutron (b) Proton

(c) Electron (d) Positron

56. Electromagnetic radiation with maximum wave length is **[DCE 2000; UPSEAT 2000]**

(a) Ultraviolet ray (b) Radiowave

(c) X-ray (d) Infrared

57. Neutrons are obtained by **[JIPMER 1999]**

(a) Bombardment of Ra with β-particles

(b) Bombardment of Be with α-particles

(c) Radioactive disintegration of uranium

(d) None of these

58. In the reaction, $Po \xrightarrow{-\alpha} Pb \xrightarrow{-\beta} Bi,$ if *Bi*, belongs to group 15, to which *Po* belongs **[DCE 2000]**

(a) 14 (b) 15
(c) 13 (d) 16

59. In the nuclear reaction $^{9}_{4}Be(p,\alpha)X,$ the *X* is **[MP PMT 2000]**

(a) $^{4}_{2}He$ (b) $^{6}_{3}Li$
(c) $^{7}_{3}Li$ (d) $^{8}_{4}Be$

60. Which of the following does not contain number of neutrons equal to that of $^{40}_{18}Ar$ **[MP PMT 2000]**

(a) $^{41}_{19}K$ (b) $^{43}_{21}Sc$
(c) $^{40}_{21}Sc$ (d) $^{42}_{20}Ca$

61. Nuclear reactivity of *Na* and Na^+ is same because both have **[Pb. PMT 2000]**

(a) Same electron and proton
(b) Same proton and same neutron
(c) Different electron and proton
(d) Different proton and neutron

62. Which of the following is the heaviest metal **[MH CET 2001]**

(a) *Hg* (b) *Pb*
(c) *Ra* (d) *U*

63. In the following reaction, *x* will be $_{29}Cu^{64} \rightarrow _{28}Ni^{64} + x$

(a) A proton (b) An electron
(c) A neutron (d) A positron

64. Which one out of the following statements is not correct for ortho and para hydrogen **[Orissa JEE 2002]**

(a) They have different boiling point
(b) Ortho form is more stable than para form
(c) They differ in the spin of their protons
(d) The ratio of ortho to para hydrogen increases with increase in temperature and finally pure ortho form is obtained

65. For the nuclear reaction, $^{24}_{12}Mg + _1D^2 \rightarrow \alpha + ?$, the missing nucleide is **[Kurukshetra CEE 2002]**

(a) $^{22}_{11}Na$ (b) $^{23}_{11}Na$
(c) $^{23}_{12}Mg$ (d) $^{26}_{12}Mg$

66. $_ZX^M + _2He^4 \rightarrow _{15}P^{30} + _0n^1$. Then **[KCET 2002]**

(a) $Z = 12, M = 27$ (b) $Z = 13, M = 27$
(c) $Z = 12, M = 17$ (d) $Z = 13, M = 28$

67. An element $_{96}X^{227}$ emits 4α and 5β particles to form new element *Y*. Then atomic number and mass number of *Y* are **[MH CET 2002]**

(a) 93; 211 (b) 211; 93
(c) 212; 88 (d) 88; 211

68. Meson was discovered **[MH CET 2004]**

(a) Yukawa (b) Austin
(c) Moseley (d) Einstein

Radioactivity and α, β and γ- rays

1. Which of the following does not contain material particles **[BHU 2002]**

(a) Alpha rays (b) Beta rays
(c) Gamma rays (d) Canal rays

2. Radioactive substances emit γ-rays, which are **[Orissa JEE 2002]**

(a) + *ve* charged particle (b) – *ve* charged particle
(c) Massive particle (d) Packet of energy

3. Which statement is incorrect **[CPMT 1982]**

(a) α -rays have more penetrating power than β -rays
(b) α -rays have less penetrating power than γ -rays
(c) β -rays have less penetrating power than γ -rays
(d) β -rays have more penetrating power than α -rays

4. The velocity of α -rays is approximately **[CPMT 1982]**

(a) Equal to that of the velocity of light
(b) 1/10 of the velocity of light
(c) 10 times more than the velocity of light
(d) Uncomparable to the velocity of light

5. The radiations having high penetrating power and not affected by electrical and magnetic field are **[Kerala CET**

(a) Alpha rays (b) Beta rays
(c) Gamma rays (d) Neutrons

6. Alpha particles are ...... times heavier (approximately) than neutrons **[CPMT 1971]**

(a) 2 (b) 4
(c) 3 (d) $2\frac{1}{2}$

7. Uranium $_{92}U^{235}$ on bombardment with slow neutrons produces **[CPMT 1982]**

(a) Deutrons (b) Fusion reaction
(c) Fission reaction (d) Endothermic reaction

8. α-particles can be detected using **[AIIMS 2005]**

(a) Thin aluminum sheet (b) Barium sulphate
(c) Zinc sulphide screen (d) Gold foil

9. Alpha rays consist of a stream of **[BHU 1979]**

(a) H^+ (b) He^{+2}
(c) Only electrons (d) Only neutrons

10. Which is the correct statement **[CPMT 1971]**

(a) Isotopes are always radioactive
(b) β -rays are always negatively charged particles
(c) α -rays are always negatively charged particles

(d) γ -rays can be deflected in magnetic field

11. The α -particle is identical with **[CPMT 1972, 82, 86; BHU 1984; MP PMT 1990, 91, 93; MP PET 1999]**
(a) Helium nucleus
(b) Hydrogen nucleus
(c) Electron
(d) Proton

12. If by mistake some radioactive substance gets inside the human body, then from the point of view of radiation damage, the most harmful will be the one which emits **[DPMT 1986]**
(a) γ -rays (b) Neutrons
(c) β -particles (d) α -particles

13. Radioactivity was discovered by **[CPMT 1983, 88; DPMT 1982; AMU 1983; MADT Bihar 1982]**
(a) Henry Becquerel (b) Rutherford
(c) J. J. Thomson (d) Madam Curie

14. Which of the following is radioactive element **[CPMT 1988]**
(a) Sulphur (b) Polonium
(c) Tellurium (d) Selenium

15. Penetrating power of α-particle is **[MP PMT 2002]**
(a) More than γ-rays (b) More than β-rays
(c) Less than β-rays (d) None of these

16. β-particle is emitted in radioactivity by **[AIEEE 2002; MP PMT 2004]**
(a) Conversion of proton to neutron
(b) Form outermost orbit
(c) Conversion of neutron to proton
(d) β-particle is not emitted

17. α -rays have **[CPMT 1973, 78; NCERT 1977]**
(a) Positive charge
(b) Negative charge
(c) No charge
(d) Sometimes positive charge and sometimes negative charge

18. X-rays are produced due to **[JIPMER 2002]**
(a) Bombarding of electrons on solids
(b) Bombarding of α-particle on solids
(c) Bombarding of γ-rays on solids
(d) Bombarding of neutron on solids

19. Choose the element which is not radioactive **[CPMT 1988]**
(a) *Cm* (b) *No*
(c) *Mo* (d) *Md*

20. A magnet will cause the greatest deflection of **[MP PMT 1991]**
(a) γ -rays (b) β -rays
(c) α -rays (d) Neutrons

21. Of the following radiations, the one most easily stopped by air is **[MP PMT 1991]**
(a) α -rays (b) β -rays
(c) γ -rays (d) X-rays

22. Uranium ultimately decays into a stable isotope of **[MP PET 1995]**
(a) Radium (b) Carbon
(c) Lead (d) Neptunium

23. Which leaves no track on Wilson cloud chamber **[AFMC 1988]**
(a) Electrons (b) Protons
(c) α -particles (d) Neutrons

24. Which has the least penetrating power **[CPMT 1994]**
(a) β -rays (b) α -rays
(c) γ -rays (d) X -rays

25. There exists on γ -rays **[MP PMT 1996; Pb. PMT 2004; EAMCET 2004]**
(a) Positive charge
(b) Negative charge
(c) No charge
(d) Sometimes positive charge, sometimes negative charge

26. Which is not emitted by radioactive substance **[AIIMS 1997]**
(a) α -rays (b) β -rays
(c) Positron (d) Proton

27. The radiations from a naturally occurring radio element, as seen after deflection in a magnetic field in one direction, are **[IIT 1984; MP PMT 1986; MP PET/PMT 1988 JIPMER 1999]**
(a) Definitely α-rays (b) Definitely β-rays
(c) Both α and β-rays (d) Either α or β-rays

28. The $_{88}Ra^{226}$ is **[AIIMS 2001]**
(a) *n*-mesons (b) *u*-mesons
(c) Radioactive (d) Non-radioactive

29. During β-decay **[UPSEAT 2001]**
(a) An atomic electron is ejected
(b) An electron which is already present with in the nucleus is ejected
(c) A neutron in the nucleus decays emitting an electron
(d) A part of binding of the nucleus is converted into an electron

30. The element californium belongs to the family of **[UPSEAT 2002]**
(a) Actinide series (b) Alkali metal family
(c) Alkaline earth family (d) Lantanide series

31. Which of the following is not deflected by magnetic field **[MP PMT 2001]**

(a) Deuteron (b) Positron
(c) Proton (d) Photon

32. Which of the following can be used to convert $^{14}_{7}N$ into $^{17}_{8}O$ **[MP PMT 2001]**
(a) Deuteron (b) Proton
(c) α-particle (d) Neutron

33. The amount of energy, which is required to separate the nucleons from a nucleus. The energy is called **[UPSEAT 2001]**
(a) Binding energy (b) Lattice energy
(c) Kinetic energy (d) None of these

34. What happens when α-particle is emitted **[CBSE PMT 1989; JIPMER 2002]**
(a) Mass number decreases by 12 unit, atomic number decreases by 4 unit
(b) Mass number decreases by 4 unit, atomic number decreases by 2 unit
(c) Only mass number decreases
(d) Only atomic number decreases

35. The charge on gamma rays is **[Pb. PMT 2004; EAMCET 2004]**
(a) Zero (b) +1
(c) –1 (d) +2

36. A nuclear reaction is accompanied by loss of mass equivalent to $0.01864\ amu$. Energy liberated is **[DCE 2002]**
(a) $931\ MeV$ (b) $186.6\ MeV$
(c) $17.36\ MeV$ (d) $460\ MeV$

37. Nuclear theory of the atom was put forward by **[KCET 2004]**
(a) Rutherford (b) Aston
(c) Neils Bohr (d) J.J. Thomson

38. Decrease in atomic number is observed during **[IIT 1998]**
(a) Alpha emission (b) Beta emission
(c) Positron emission (d) Electron capture

39. Calculate mass defect in the following reaction
$_1H^2 +_1 H^3 \rightarrow_1 He^4 +_0 n^1$
(Given : mass $H^2 = 2.014, H^3 = 3.016, He = 4.004$, $n = 1.008\ amu$) **[Kerala CET 2005]**
(a) 0.018 amu (b) 0.18 amu
(c) 0.0018 amu (d) 1.8 amu
(e) 18 amu

Causes of radioactivity and Group displacement law

1. $_{95}Am^{241}$ and $_{90}Th^{234}$ belong respectively to **[MP PMT 1999]**
(a) $4n$ and $4n+1$ radioactive disintegration series
(b) $4n+1$ and $4n+2$ radioactive disintegration series
(c) $4n+1$ and $4n+3$ radioactive disintegration series
(d) $4n+1$ and $4n$ radioactive disintegration series

2. Group displacement law states that the emission of α or β particles results in the daughter element occupying a position, in the periodic table, either to the left or right of that of the parent element. Which one of the following alternatives gives the correct position of the daughter element

	On emission of α particles	On emission of β particles
(a)	2 groups to the right	1 group to the right
(b)	2 groups to the right	1 group to the left
(c)	2 groups to the left	1 group to the left
(d)	2 groups to the left	1 group to the right

3. The nuclides (A nuclide is the general name for any nuclear species) $_6C^{12}, _{26}Fe^{56}$ and $_{92}U^{238}$ have 12, 56 and 238 nucleons respectively in the nuclei. The total number of nucleons in a nucleus is equal to **[NCERT 1975]**
(a) The total number of neutrons in the nucleus
(b) The total number of neutrons in the atom
(c) The total number of protons in the nucleus
(d) The total number of protons and neutrons in the nucleus

4. Radioactivity is due to **[DPMT 1983, 89; AIIMS 1988]**
(a) Stable electronic configuration
(b) Unstable electronic configuration
(c) Stable nucleus
(d) Unstable nucleus

5. Radioactive disintegration differs from a chemical change in being **[MNR 1991]**
(a) An exothermic change
(b) A spontaneous process
(c) A nuclear process
(d) A unimolecular first order reaction

6. $^{238}_{92}U$ emits 8 α-particles and 6 β-particles. The neutron/proton ratio in the product nucleus is **[AIIMS 2005]**
(a) 60/41 (b) 61/40
(c) 62/41 (d) 61/42

7. The element with atomic number 84 and mass number 218 change to other element with atomic number 84 and mass number 214. The number of α and β-particles emitted are respectively **[CPMT 1989]**
(a) 1, 3 (b) 1, 4
(c) 1, 2 (d) 1, 5

8. A radium $_{88}Ra^{224}$ isotope, on emission of an α-particle gives rise to a new element whose mass number and atomic number will be

[CPMT 1980; EAMCET 1985; MP PMT 1993]

(a) 220 and 86 (b) 225 and 87
(c) 228 and 88 (d) 224 and 86

9. $_{89}Ac^{231}$ gives $_{82}Pb^{207}$ after emission of some α and β-particles. The number of such α and β-particles are respectively **[MP PMT 1993; UPSEAT 2001]**

(a) 5, 6 (b) 6, 5
(c) 7, 5 (d) 5, 7

10. The number of α and β- particles emitted in the nuclear reaction $_{90}Th^{228} \rightarrow _{83}Bi^{212}$ are respectively

[MNR 1992; MP PMT 1993; AFMC 1998, 2001; MH CET 1999; UPSEAT 2000, 01; AMU 2001; CPMT 2002]

(a) 4, 1 (b) 3, 7
(c) 8, 1 (d) 4, 7

11. The number of neutrons in the parent nucleus which gives N^{14} on β-emission and the parent nucleus is

[EAMCET 1985; MNR 1992; Kurukshetra CEE 1998; UPSEAT 2000, 01]

(a) $8, C^{14}$ (b) $6, C^{12}$
(c) $4, C^{13}$ (d) None of these

12. After the emission of α-particle from the atom $_{92}X^{238}$, the number of neutrons in the atom will be

[MNR 1993; UPSEAT 1999, 2001, 02]

(a) 138 (b) 140
(c) 144 (d) 150

13. When a radioactive element emits an electron the daughter element formed will have **[EAMCET 1988; MP PET 1994]**

(a) Mass number one unit less
(b) Atomic number one unit less
(c) Mass number one unit more
(d) Atomic number one unit more

14. If the amount of radioactive substance is increased three times, the number of atoms disintegrated per unit time would **[MP PMT 1994]**

(a) Be double (b) Be triple
(c) Remain one third (d) Not change

15. β-particles are emitted from the atom

(a) Due to disintegration of neutron
(b) Due to disintegration of proton
(c) Due to removal of electron from K shell
(d) Due to removal of electron from outermost orbit

16. $Nd(Z = 60)$ is a member of group -3 in periodic table. An isotope of it is β-active. The daughter nuclei will be a member of

(a) Group -3 (b) Group - 4
(c) Group -1 (d) Group - 2

17. Number of neutrons in a parent nucleus X, which gives $_7N^{14}$ nucleus after two successive β emissions would be

[CBSE PMT 1998; MP PMT 2003]

(a) 9 (b) 8
(c) 7 (d) 6

18. The disintegration of an isotope of sodium. $_{11}Na^{24} \rightarrow _{12}Mg^{24} + _{-1}e^0$ shown is due to

[AMU (Engg.) 2000]

(a) The emission of β-radiation
(b) The formation of a stable nuclide
(c) The fall in the neutron : proton ratio
(d) None of these

19. After losing a number of α and β-particles. $_{92}U^{238}$ is changed to $_{82}Pb^{206}$. The total number of α-particles lost in this process is **[UPSEAT 1999, 2000]**

(a) 10 (b) 5
(c) 8 (d) 32

20. Which element is the end product of each natural radioactive series **[MP PMT 1996; MP PET/PMT 1998]**

(a) Sn (b) Bi
(c) Pb (d) C

21. $^{27}_{13}Al$ is a stable isotope. $^{29}_{13}Al$ is expected to disintegrate by

[IIT 1996; UPSEAT 2001]

(a) α-emission (b) β-emission
(c) Positron emission (d) Proton emission

22. An isotope $_YA^X$ undergoes a series of m alpha and n beta disintegration to form a stable isotope $_{Y-10}B^{X-32}$. The values of m and n are respectively **[MP PET**

(a) 6 and 8 (b) 8 and 10
(c) 5 and 8 (d) 8 and 6

23. During a β-decay the mass of the atomic nucleus

[MP PET 1996]

(a) Decreases by one unit (b) Increases by one unit
(c) Decreases by two units (d) Remains unaffected

24. Which one of the following notations shows the product incorrectly **[MP PET/PMT 1998]**

(a) $^{242}_{96}Cm(\alpha, 2n)^{243}_{97}Bk$ (b) $^{10}_{5}B(\alpha, n)^{13}_{7}N$
(c) $^{14}_{7}N(n, p)^{14}_{6}C$ (d) $^{28}_{14}Si(d, n)^{29}_{15}P$

25. An atom has mass number 232 and atomic number 90. How many α-particles should it emit after emission of two β-particles, so that the new element's atom has mass number 212 and atomic number 82

(a) 4 (b) 5

(c) 6 (d) 3

26. After the emission of one α-particle followed by one $\beta-$particle from the atom of $_{92}X^{238}$, the number of neutrons in the atom will be **[CBSE PMT 1995]**

(a) 142 (b) 146

(c) 144 (d) 143

27. A nuclide of an alkaline earth metal undergoes radioactive decay by emission of the $\alpha-$particles in succession. The group of the periodic table to which the resulting daughter element would belong is **[CBSE PMT 2005]**

(a) $Gr.14$ (b) $Gr.16$

(c) $Gr.4$ (d) $Gr.6$

28. Which one of the following is not correct **[MP PMT 1997]**

(a) $_3Li^7 + {_1H^1} \rightarrow {_4Be^7} + {_0n^1}$

(b) $_{21}Sc^{45} + {_0n^1} \rightarrow {_{20}Ca^{45}} + {_0n^1}$

(c) $_{33}As^{75} + {_2He^4} \rightarrow {_{35}Br^{78}} + {_0n^1}$

(d) $_{83}Bi^{209} + {_1H^2} \rightarrow {_{84}Po^{210}} + {_0n^1}$

29. The end product of $(4n+2)$ radioactive disintegration series is

[MP PET 1997; Pb. PMT 1998; BHU 2000]

(a) $_{82}Pb^{208}$ (b) $_{82}Pb^{206}$

(c) $_{82}Pb^{207}$ (d) $_{83}Bi^{210}$

30. The element $_{90}Th^{232}$ belongs to thorium series. Which of the following will act as the end product of the series

[BHU 2005]

(a) $_{82}Pb^{208}$ (b) $_{82}Bi^{209}$

(c) $_{82}Pb^{206}$ (d) $_{82}Pb^{207}$

31. On bombarding $_8O^{16}$ with deutrons, the nuclei of the product formed will be **[NCERT 1978]**

(a) $_9F^{18}$ (b) $_9F^{17}$

(c) $_8O^{17}$ (d) $_7N^{14}$

32. An element with atomic number 84 and mass number 218 loses one α-particle and two β-particles in three successive stages, the resulting element will have

[NCERT 1979; CPMT 1990]

(a) At. no. 84 and mass number 214

(b) At. no. 82 and mass number 214

(c) At. no. 84 and mass number 218

(d) At. no. 82 and mass number 218

33. Group displacement law was given by **[DPMT 1984]**

(a) Becquerel (b) Rutherford

(c) Soddy and Fajan (d) Madam Curie

34. How many alpha particles are emitted in the nuclear transformation $_{84}Po^{215} \longrightarrow {_{82}Pb^{211}}$ **[CPMT 1993]**

(a) 0 (b) 1

(c) 2 (d) 3

35. If uranium (mass no. 238 and atomic no. 92) emits α-particle, the product has mass number and atomic number

[CPMT 1984, 90, 93, 94; MNR 1991; IIT 1981]

(a) 234, 90 (b) 236, 92

(c) 238, 90 (d) 236, 90

36. Initial mass of a radioactive element is 40 g. How many grams of it would be left after 24 years, if its half-life period is 8 years **[MP PMT 1985]**

(a) 2 (b) 5

(c) 10 (d) 20

37. What is the symbol for the nucleus remaining after $_{20}Ca^{42}$ undergoes β-emission **[MNR 1987; UPSEAT 20**

(a) $_{21}Ca^{42}$ (b) $_{20}Sc^{42}$

(c) $_{21}Sc^{42}$ (d) $_{21}Sc^{41}$

38. When a radioactive nucleus emits an α-particle, the mass of the atom **[NCERT 1973, 82]**

(a) Increases and its at. number decreases

(b) Decreases and its at. number decreases

(c) Decreases and its at. number increases

(d) Remains same and its at. number decreases

39. A photon of hard gamma radiation knocks a proton out of $^{24}_{12}Mg$ nucleus to form **[AIEEE 2005]**

(a) The isotope of parent nucleus

(b) The isobar of parent nucleus

(c) The nuclide $^{23}_{11}Na$

(d) The isobar of $^{23}_{11}Na$

40. $_{84}Pb^{210} \longrightarrow {_{82}Pb^{206}} + {_2He^4}$. From the above equation, deduce the position of polonium in the periodic table (lead belongs to group IV A) **[AIIMS 1980]**

(a) II A (b) IV B

(c) VI B (d) VI A

41. Whenever the parent nucleus emits a β-particle, the daughter element is shifted in the periodic table **[NCERT 1**

(a) One place to the right

(b) One place to the left

(c) Two places to the right

(d) Two places to the left

42. In the nuclear reaction $_{92}U^{238} \rightarrow {_{82}Pb^{206}}$, the number of alpha and beta particles decayed are

[DPMT 1983; MNR 1985; Roorkee Qualifying 1998]

(a) $4\alpha, 3\beta$ (b) $8\alpha, 6\beta$

(c) $6\alpha, 4\beta$ (d) $7\alpha, 5\beta$

43. Atomic number after a β-emission from a nucleus having atomic number 40, will be **[BHU 1981]**

(a) 36 (b) 39
(c) 41 (d) 44

44. A certain nuclide has a half-life period of 30 minutes. If a sample containing 600 atoms is allowed to decay for 90 minutes, how many atoms will remain **[NCERT 1978]**

(a) 200 atoms (b) 450 atoms
(c) 75 atoms (d) 500 atoms

45. The reaction which disintegrates neutron is or neutron is emitted (which completes first)
[IIT 1988; MP PMT 1991; KCET 2005]

(a) ${}_{96}Am^{240} + {}_{2}He^{4} \rightarrow {}_{97}Bk^{244} + {}_{+1}e^{0}$

(b) ${}_{15}P^{30} \rightarrow {}_{14}Si^{30} + {}_{1}e^{0}$

(c) ${}_{6}C^{12} + {}_{1}H^{1} \rightarrow {}_{7}N^{13}$

(d) ${}_{13}Al^{27} + {}_{2}He^{4} \rightarrow {}_{15}P^{30}$

46. If ${}_{92}U^{236}$ nucleus emits one α-particle, the remaining nucleus will have
[MP PMT 1976, 80; BHU 1985; CPMT 1980]

(a) 119 neutrons and 119 protons
(b) 142 neutrons and 90 protons
(c) 144 neutrons and 92 protons
(d) 146 neutrons and 90 protons

47. α-rays have high ionization power because they possess
[CPMT 1982]

(a) Lesser kinetic energy
(b) Higher kinetic energy
(c) Lesser penetrating power
(d) Higher penetrating power

48. When radium atom which is placed in II group, loses an α- particle, a new element is formed which should be placed in group **[CPMT 1979, 80, 94; NCERT 1979, 82]**

(a) Second (b) First
(c) Fourth (d) Zero

49. Starting from radium, the radioactive disintegration process terminates when the following is obtained **[CPMT 1979]**

(a) Lead (b) Radon
(c) Radium A (d) Radium B

50. The appreciable radioactivity of uranium minerals is mainly due to **[NCERT 1980]**

(a) An uranium isotope of mass number 235
(b) A thorium isotope of mass number 232
(c) Actinium
(d) Radium

51. After losing a number of α and β-particles, ${}_{92}U^{238}$ changed to ${}_{82}Pb^{206}$. The total number of particles lost in this process is **[MNR 1985]**

(a) 14 (b) 5
(c) 8 (d) 32

52. When an radioactive element emits an alpha particle, the daughter element is placed in the periodic table
[MP PET 1991; MADT Bihar 1981]

(a) Two positions to the left of the parent element
(b) Two positions to the right of the parent element
(c) One position to the right of the parent element
(d) In the same position as the parent element

53. If the quantity of a radioactive element is doubled, then its rate of disintegration per unit time will be
[NCERT 1972, 92; MP PET 1989]

(a) Unchanged
(b) Reduced to half
(c) Increased by $\sqrt{2}$ times
(d) Doubled

54. The number of α and β-particles emitted during the transformation of ${}_{90}Th^{232}$ to ${}_{82}P^{208}$ are respectively
[MNR 1978; NCERT 1984;CPMT 1989; RPET 1999; MP PMT 2001; KCET 2003]

(a) 4, 2 (b) 2, 2
(c) 8, 6 (d) 6, 4

55. The atomic number of a radioactive element increases by one unit in **[EAMCET 1997]**

(a) Alpha emission (b) Beta emission
(c) Gamma emission (d) Electron capture

56. The end product of $(4n+1)$ radioactive disintegration series is **[MP PMT 1999]**

(a) ${}_{83}Bi^{209}$ (b) ${}_{84}Po^{210}$
(c) ${}_{82}Pb^{208}$ (d) ${}_{82}Pb^{207}$

57. When a β-particle emits from the atom of an element, then
[MP PET 1990]

(a) Atomic number increases by two units
(b) Atomic number increases by three units
(c) Atomic number decreases by one unit
(d) Atomic number increases by one unit

58. The number of β-particles emitted in radioactive change ${}_{92}U^{238} \rightarrow {}_{82}Pb^{206} + {}_{2}He^{4}$ is **[KCET 2000]**

(a) 2 (b) 4
(c) 6 (d) 10

59. If half-life of a certain radioactive nucleus is $1000\ s$, the disintegration constant is **[MP PET 2001]**

(a) $6.93 \times 10^{2}\ s^{-1}$ (b) $6.93 \times 10^{-4}\ s$
(c) $6.93 \times 10^{-4}\ s^{-1}$ (d) $6.93 \times 10^{3}\ s$

60. Radioactivity of naptunium stops when it is converted to
[JIPMER 2001]

(a) Bi (b) Rn
(c) Th (d) Pb

61. The highest binding energy per nucleon will be for **[AIIMS 2001]**
(a) Fe (b) H_2
(c) O_2 (d) U

62. In the Thorium series, $_{90}Th^{232}$ loses total of 6 α-particles and 4 β-particles in ten stages. The final isotope produced in the series is **[MP PET 2001]**
(a) $_{82}Pb^{209}$ (b) $_{83}Bi^{209}$
(c) $_{82}Pb^{208}$ (d) $_{82}Pb^{206}$

63. All the nuclei from the initial element to the final element constitute a series which is called **[Kerala (Med.) 2002]**
(a) g-series (b) b-series
(c) b-g series (d) Disintegration series

64. The number of neutrons in the parent nucleus which gives N^{14} on $\beta-$emission is **[Pb.CET 2004]**
(a) 7 (b) 14
(c) 6 (d) 8

65. The nuclear binding energy for Ar (39.962384 amu) is: (given mass of proton and neutron are 1.007825 amu and 1.008665 amu respectively) **[Pb.CET 2002]**
(a) 343.81 MeV (b) 0.369096 MeV
(c) 931 MeV (d) None of these

66. The number $\alpha-$and $\beta-$ particles emitted respectively during the transformation of $^{232}_{90}Th$ to $^{208}_{82}Pb$ is **[Kerala PMT 2004]**
(a) 3, 6 (b) 6, 3
(c) 4, 6 (d) 6, 4
(e) 6, 8

67. Consider the following nuclear reactions,
$^{238}_{92}M \rightarrow ^{x}_{y}N + 2\,^{4}_{2}He$
$^{x}_{y}N \rightarrow ^{A}_{B}L + 2\beta^{+}$
The number of neutrons in the element L is **[AIEEE 2004]**
(a) 140 (b) 144
(c) 142 (d) 146

68. The number of $\alpha-$and $\beta-$particles emitted when a radioactive element $_{90}E^{232}$ changes into $_{86}G^{220}$ will be **[MP PET 2004]**
(a) 5 and 4 (b) 2 and 3
(c) 3 and 2 (d) 4 and 1

69. The disintegration constant of radium with half-life 1600 years is **[MHCET 2004]**
(a) $2.12\times10^{-4} year^{-1}$ (b) $4.33\times10^{-4} year^{-1}$
(c) $3.26\times10^{-3} year^{-1}$ (d) $4.33\times10^{-12} year^{-1}$

70. The number of α and $\beta-$particles emitted in the nuclear reaction $_{92}U^{238} \rightarrow _{90}Th^{234} \rightarrow _{91}Pa^{234}$ are respectively **[Pb.CET 2001]**
(a) 1 and 1 (b) 1 and 2
(c) 2 and 1 (d) 2 and 2

71. In which radiation mass number and atomic number will not change **[JEE Orissa 2004]**
(a) α (b) β
(c) γ (d) α and 2β

72. Disintegration constant for a radioactive substance is 0.58 hr^{-1}. Its half-life period **[BHU 2004]**
(a) 8.2 hr (b) 5.2 hr
(c) 1.2 hr (d) 2.4 hr

73. A radioactive nucleus will not emit **[DPMT 2005]**
(a) Alpha and beta rays simultaneously
(b) Beta and gamma rays simultaneously
(c) Gamma and alpha rays
(d) Gamma rays only

74. $^{180}_{72}X \xrightarrow{2\alpha} \xrightarrow{\beta} \xrightarrow{\gamma} ^{A}_{Z}X'$. Z and A are **[DPMT 2005]**
(a) 69, 172 (b) 172, 69
(c) 180, 70 (d) 182, 68

75. Loss of a beta particle is equivalent to **[J & K 2005]**
(a) Increase of one neutron only
(b) Decrease of one neutron only
(c) Both (a) and (b)
(d) None of these

Rate of decay and Half-life

1. The half-life period of a radioactive substance is 8 years. After 16 years, the mass of the substance will reduce from starting $16.0g$ to **[MP PMT 1999]**
(a) $8.0g$ (b) $6.0g$
(c) $4.0g$ (d) $2.0g$

2. The atomic mass of an element is 12.00710 amu. If there are 6 neutrons in the nucleus of the atom of the element, the binding energy per nucleon of the nucleus will be **[MP PMT 1999]**
(a) 7.64 MeV (b) 76.4 MeV
(c) 764 MeV (d) 0.764 MeV
(e^{-} =0.00055 amu, p =1.00814 amu, n =1.00893 amu)

3. Half-life period of a metal is 20 days. What fraction of metal does remain after 80 days **[BHU 1996]**
(a) 1 (b) 1/16
(c) 1/4 (d) 1/8

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

5. Which of the following does not take place by α - decay **[MP PMT 1996]**
(a) $_{92}U^{238} \longrightarrow _{90}Th^{234}$ (b) $_{90}Th^{232} \longrightarrow _{88}Ra^{228}$
(c) $_{88}Ra^{226} \longrightarrow _{86}Rn^{222}$ (d) $_{83}Bi^{213} \longrightarrow _{84}Po^{213}$

6. $1.0\,g$ of a radioactive isotope was found to reduce to $125\,mg$ after 24 hours. The half-life of the isotope is **[MP PET 1996]**
(a) 8 hours (b) 24 hours
(c) 6 hours (d) 4 hours

7. A radioactive element decays at such a rate that after 15 minutes only 1/10 of the original amount is left. How many more minutes will be needed when only 1/100 of the original amount will be left
(a) 1.5 minutes (b) 15.0 mintues
(c) 16.5 minutes (d) 30 minutes

8. The radioactive decay of $_{35}X^{88}$ by a beta emission produces an unstable nucleus which spontaneously emits a neutron. The final product is **[MNR 1995; CBSE 2001]**
(a) $_{37}X^{88}$ (b) $_{35}Y^{89}$
(c) $_{34}Z^{88}$ (d) $_{36}W^{87}$

9. What is the half-life of a radioactive substance if 75% of a given amount of the substance disintegrates in 30 minutes
(a) 7.5 minutes (b) 25 minutes
(c) 20 minutes (d) 15 minutes

10. In radioactive decay which one of the following moves the fastest **[MP PET/PMT 1998]**
(a) α -particle (b) β -particle
(c) γ -rays (d) Positron

11. The half-life of a radionuclide is 69.3 minutes. What is its average life (in minutes)
(a) 100 (b) 10^{-2}
(c) $(69.3)^{-1}$ (d) 0.693×69.3

12. $10\,gm$ of a radioactive substance is reduced to $1.25\,gm$ after 15 days. Its $1\,kg$ mass will reduce (in how many days) to $500\,gm$ in
(a) 500 days (b) 125 days
(c) 25 days (d) 5 days

13. A radioactive isotope having a half-life of 3 days was received after 12 days. It was found that there were 3 *gm* of the isotope in the container. The initial weight of the isotope when packed was **[NCERT 1980; CPMT 1999; KCET 2000; Pb.CET 2001]**
(a) 12 *gm* (b) 24 *gm*
(c) 36 *gm* (d) 48 *gm*

14. C^{14} is radioactive. The activity and the disintegration product are
(a) β -active, $_7N^{14}$ (b) α - active, $_7Be^{10}$
(c) Positron active, $_5B^{14}$ (d) γ - active, C^{14}

15. Radioactivity of a radioactive element remains $\frac{1}{10}$ of the original radioactivity after 2.303 seconds. The half-life period is
(a) 2.303 (b) 0.2303
(c) 0.693 (d) 0.0693

16. A radioactive substance has $t_{1/2}$ 60 minutes. After 3 *hrs*, what percentage of radioactive substance will remain **[BHU 1995]**
(a) 50% (b) 75%
(c) 25% (d) 12.5%

17. A freshly prepared radioactive source of half-life 2 hours emits radiations of intensity which is 64 times the permissible safe level. The minimum time after which it would be possible to work safely with this source is **[IIT 1988]**
(a) 6 hours (b) 12 hours
(c) 24 hours (d) 128 hours

18. During a negative β -decay **[MNR 1990; IIT 1985]**
(a) An atomic electron is ejected
(b) An electron which is already present within the nucleus is ejected
(c) A neutron in the nucleus decays emitting an electron
(d) A part of the binding energy of the nucleus is converted into an electron

19. The decay constant of a radioactive sample is 'λ'. The half-life and mean life of the sample are respectively **[MNR 1990; IIT 1989]**
(a) $\frac{1}{\lambda}, \frac{\ln 2}{\lambda}$ (b) $\frac{\ln 2}{\lambda}, \frac{1}{\lambda}$
(c) $\lambda \ln 2, \frac{1}{\lambda}$ (d) $\frac{\lambda}{\ln 2}, \frac{1}{\lambda}$

20. The half-life of a radio isotope is 20 hours. After 60 hours, how much amount will be left behind **[MP PMT 1991]**
(a) 1/8 (b) 1/4
(c) 1/3 (d) 1/2

21. Half-life period of a zero order reaction is **[AMU (Engg.) 1999]**
(a) Inversely proportional to the concentration

(b) Independent of the concentration
(c) Directly proportional to the initial concentration
(d) Directly proportional to the final concentration

22. If 12 *g* of sample is taken, and 6 *g* of a sample decays in 1 *hr*. The amount of sample showing decay in next hour is **[AMU (Engg.) 1999]**
(a) 3 *g* (b) 1 *g*
(c) 2 *g* (d) 6 *g*

23. What will be half-life period of a nucleus if at the end of 4.2 *days*, $N = 0.798\, N_0$ **[MP PET 2000]**
(a) 15 *days* (b) 10 *days*
(c) 12.83 *days* (d) 20 *days*

24. If 2.0 *g* of a radioactive substance has half-life of 7 *days*. The half-life of 1 *g* sample is **[MP PET 2000]**
(a) 7 *days* (b) 14 *days*
(c) 28 *days* (d) 35 *days*

25. The half-life of $^{90}_{38}Sr$ is 20 *years*. If its sample having initial activity of 8000 *dis/min* is taken, what would be its activity after 80 *years*
(a) 500 *dis/min* (b) 800 *dis/min*
(c) 1000 *dis/min* (d) 1600 *dis/min*

26. $_{11}Na^{24}$ half-life is 15 hours. On heating it will
(a) Reduce (b) Remain unchanged
(c) Depend on temperature (d) Become double

27. In a radioactive decay, an emitted electron comes from **[CBSE 1994; Pb. PET 1999]**
(a) Nucleus of the atom
(b) Inner orbital of the atom
(c) Outermost orbit of the atom
(d) Orbit having principal quantum number one

28. What is the value of decay constant of a compound having half-life time $T_{1/2} = 2.95$ days **[AFMC 1997]**
(a) $2.7 \times 10^{-5} s^{-1}$ (b) $2.7 \times 10^{6} s^{-1}$
(c) $2.7 \times 10^{-6} s^{-1}$ (d) $3 \times 10^{5} s^{-1}$

29. What kind of radioactive decay does not lead to the formation of a daughter nucleus that is an isobar of the parent nucleus
(a) α-rays (b) β-rays
(c) Positron (d) Electron capture

30. The half-life of $_6C^{14}$ if its K or λ is 2.31×10^{-4} is **[BHU 1999]**
(a) $2 \times 10^2 yrs$ (b) $3 \times 10^3 yrs$
(c) $3.5 \times 10^4 yrs$ (d) $4 \times 10^3 yrs$

31. A radioactive isotope has a half-life of 10 days. If today 125 *mg* is left over, what was its original weight 40 days earlier **[KCET 2005]**
(a) 2*g* (b) 600 *mg*
(c) 1 *g* (d) 1.5 *g*

32. The binding energy of $_8O^{16}$ is 127 *MeV*. Its binding energy per neutron is
(a) 0.794 *MeV* (b) 1.5875 *MeV*
(c) 7.94 *MeV* (d) 15.875 *MeV*

33. If the half-life period of a first order reaction is 138.6 *minutes*, then the value of decay constant for the reaction will be **[MH CET 1999]**
(a) 5 $minute^{-1}$ (b) 0.5 $minute^{-1}$
(c) 0.05 $minute^{-1}$ (d) 0.005 $minute^{-1}$

34. Half-life of 10 *gm* of radioactive substance is 10 days. The half-life of 20 *gm* is
(a) 10 days (b) 20 days
(c) 25 days (d) Infinite

35. 8 *gm* of the radioactive isotope, cesium-137 were collected on February 1 and kept in a sealed tube. On July 1, it was found that only 0.25 *gm* of it remained. So the half-life period of the isotope is **[KCET 19**
(a) 37.5 days (b) 30 days
(c) 25 days (d) 50 days **[MP PMT 2000]**

36. The half-life of radium (226) is 1620 years. The time taken to convert 10 grams of radium to 1.25 grams is **[MP PET 1994; UPSEAT 2001]**
(a) 810 years (b) 1620 years
(c) 3240 years (d) 4860 years

37. Half-life of a radioactive substance is 120 days. After 480 days, 4 gm will be reduced to **[EAMCET 1993]**
(a) 2 (b) 1
(c) 0.5 (d) 0.25

38. The half-life of Co^{60} is 7 years. If one *gm* of it decays, the amount of the substance remaining after 28 years is **[EAMCET 1992]**
(a) 0.25 *gm* (b) 0.125 *gm*
(c) 0.0625 *gm* (d) 0.50 *gm*

39. A radioactive isotope decays at such a rate that after 96 minutes only $\frac{1}{8}th$ of the original amount remains. The half-life of this nuclide in minutes is **[KCET 1** **[JIPMER 1999]**
(a) 12 (b) 24
(c) 32 (d) 48

40. $C-14$ has a half-life of 5760 years. 100 *mg* of a sample containing $C-14$ is reduced to 25 *mg* in **[Bihar CEE 1992; AMU 2002; MHCET 1999]**
(a) 11520 years (b) 2880 years
(c) 1440 years (d) 17280 years

41. Half-life of a radioactive element is 100 yrs. The time in which it disintegrates to 50% of its mass, will be **[MP PMT 1995]**

(a) 50 yrs (b) 200 yrs
(c) 100 yrs (d) 25 yrs

42. The average life period of a radioactive element is the reciprocal of its **[MP PET 1995]**
(a) Half-life period
(b) Disintegration constant
(c) Number of atoms present at any time
(d) Number of neutrons

43. The half-life period of a radioactive element is 30 minutes. One sixteenth of the original quantity of the element will remain unchanged after **[CPMT 1983; MP PMT 1994]**
(a) 60 minutes (b) 120 minutes
(c) 70 minutes (d) 75 minutes

44. For a radioactive substance with half-life period 500 years, the time for complete decay of 100 milligram of it would be
[MADT Bihar 1984]
(a) 1000 years (b) 100×500 years
(c) 500 years (d) Infinite time

45. A substance of which one gram is taken, after half-life time what fraction of it is left ? **[MADT Bihar 1983]**
(a) $\frac{1}{4}$ (b) $\frac{1}{8}$
(c) $\frac{1}{2}$ (d) $\frac{1}{32}$

46. The half-life of the radio element $_{83}Bi^{210}$ is 5 days. Starting with 20 g of this isotope, the amount remaining after 15 days is
(a) 10 g (b) 5 g
(c) 2.5 g (d) 6.66 g

47. In radioactive decay of X into Y below, $_ZY^m$ is
$_6X^{14} \xrightarrow{-3\beta} {_ZY^m}$
(a) $_6Y^{15}$ (b) $_7Y^{17}$
(c) $_9Y^{14}$ (d) $_8Y^{14}$

48. 75% of the first order reaction was completed in 32 minutes. When was 50% of the reaction completed
[MNR 1983; MP PET 1997; EAMCET 1998]
(a) 24 minutes (b) 16 minutes
(c) 8 minutes (d) 4 minutes

49. If $2.0g$ of a radioactive isotope has a half-life of 20 hr, the half-life of $0.5g$ of the same substance is
[MP PMT 1990; MNR 1992]
(a) 20 *hr* (b) 80 *hr*
(c) 5 *hr* (d) 10 *hr*

50. Radioactive lead $_{82}Pb^{201}$ has a half-life of 8 hours. Starting from one milligram of this isotope, how much will remain after 24 hours **[MP PMT 1990]**
(a) $1/2\,mg$ (b) $1/3\,mg$
(c) $1/8\,mg$ (d) $1/4\,mg$

51. The half-life of $_{92}U^{238}$ is 4.5×10^9 years. After how many years, the amount of $_{92}U^{238}$ will be reduced to half of its present amount **[CPMT 1990; MP PET 1999]**
(a) 9.0×10^9 years (b) 13.5×10^9 years
(c) 4.5×10^9 years (d) $4.5 \times 10^{4.5}$ years

52. Radium has atomic weight 226 and a half-life of 1600 years. The number of disintegrations produced per second from $1gm$ are **[BHU 1990]**
(a) 4.8×10^{10} (b) 9.2×10^6
(c) 3.7×10^{10} (d) Zero

53. The half-life of a radioactive element is 6 months. The time taken to reduce its original concentration to its 1/16 value is
[MP PET 1991]
(a) 1 year (b) 16 years
(c) 2 years (d) 8 years

54. In the case of a radio isotope the value of $T_{1/2}$ and λ are identical in magnitude. The value is **[KCET 2002]**
(a) 0.693 (b) $(0.693)^{1/2}$
(c) 1/0.693 (d) $(0.693)^2$

55. A radioactive element has half-life of one day. After three days, the amount of the element left will be
[MNR 1985; UPSEAT 2000, 01; MH CET 2002]
(a) 1/2 of the original amount
(b) 1/4 of the original amount **[BHU 1987]**
(c) 1/8 of the original amount
(d) 1/16 of the original amount

56. The radioactivity due to C^{14} isotope (half-life 6000 years) of a sample of wood from an ancient tomb was found to be nearly half that of fresh wood, the tomb is therefore about
[NCERT 1980, 81; MP PET 1989]
(a) 3000 years old (b) 6000 years old
(c) 9000 years old (d) 1200 years old

57. The decay of a radioactive element follows first order kinetics, as a result
(a) Half-life period = constant $/k$, where k is the decay constant
(b) Rate of decay is independent of temperature
(c) Rate can be changed by changing chemical conditions
(d) The element will be completely transformed into a new element after expiry of two half-life period

58. Half-life of a radioactive substance which disintegrates by 75 % in 60 *minutes*, will be **[MP PMT 2002]**
(a) 120 *min* (b) 30 *min*
(c) 45 *min* (d) 20 *min*

59. 87.5% decomposition of a radioactive substance complete in 3 *hours*. What is the half-life of that substance **[MP PMT 2003]**

(a) 2 *hours* (b) 3 *hours*
(c) 90 *minutes* (d) 1 *hours*

60. Tritium undergoes radioactive decay giving **[CPMT 1976; NCERT 1978]**

(a) α -particles (b) β -particles
(c) Neutrons (d) None of these

61. Given that a radioactive species decays according to exponential law $N = N_0 e^{-\lambda t}$. The half-life of the species is **[Kerala (Med.) 2003]**

(a) λ (b) No
(c) $\lambda/\ln 2$ (d) $\ln 2/\lambda$

62. Half-life of a radioactive disintegration ($A \rightarrow$ B) having rate constant $231 \sec^{-1}$ is **[CPMT 1988]**

(a) 3.0×10^{-2} *sec* (b) 3.0×10^{-3} *sec*
(c) 3.3×10^{-2} *sec* (d) 3.3×10^{-3} *sec*

63. The amount of $_{53}I^{128}$ $t_{1/2} = 25$ minutes) left after 50 minutes will be **[AIIMS 1982; DPMT 1982, 83]**

(a) One – half (b) One – third
(c) One – fourth (d) Nothing

64. If 3/4 quantity of a radioactive element disintegrates in two hours, its half-life would be **[MP PMT 1989; CPMT 1984]**

(a) 1 hour (b) 45 minutes
(c) 30 minutes (d) 15 minutes

65. Radioactive decay is a **[MP PMT 1989, 97]**

(a) Second order reaction (b)First order reation
(c) Zero order reaction (d) Third order reaction

66. The half-life of a radioactive element depends upon **[EAMCET 1980]**

(a) The amount of the element
(b) The temperature
(c) The pressure
(d) None of these

67. The activity of radio isotope changes with**[MNR 1986]**

(a) Temperature (b) Pressure
(c) Chemical environment (d) None of these

68. A certain nuclide has a half-life of 25 minutes. If one starts with 100 *g* of it, how much of it will remain at the end of 100 minutes

(a) 1.0 *g* (b) 4.0 *g*
(c) 6.25 *g* (d) 12.50 *g*

69. If U^{235} is bombarded with neutrons, atom will split into **[CPMT 1981]**

(a) *Sr* + *Pb* (b) *Cs* + *Rb*
(c) *Kr* + *Cd* (d) *Ba* + *Kr*

70. If 8.0 of a radioactive isotope has a half-life of 10 *hrs*. The half-life of 2.0 *g* of the same substance is **[UPSEAT 2**

(a) 2.5 *hrs*. (b) 5 *hrs*.
(c) 10 *hrs*. (d) 40 *hrs*.

71. If the disintegration constant is 6.93×10^{-6}, then half-life of $_6C^{14}$ will be **[KCET 2001]**

(a) 10^2 *yrs* (b) 10^3 *yrs*
(c) 10^4 *yrs* (d) 10^5 *yrs*

72. The decay constant of Ra^{226} is $1.37 \times 10^{-11} \sec^{-1}$. A sample of Ra^{226} having an activity of 1.5 millicurie will contain ...... atoms

(a) 4.1×10^{18} (b) 3.7×10^{17}
(c) 2.05×10^{15} (d) 4.7×10^{10}

73. Amount of $_{53}I^{128} (t_{1/2} = 25 \text{ min})$ left after 75 minutes is **[DCE 2002]**

(a) 1/6 (b) 1/4
(c) 1/8 (d) 1/9

74. The half-life of a radioisotope is four hours. If the initial mass of the isotope was 200 *g*, the mass remaining after 24 hours undecayed is

(a) 3.125 *g* (b) 2.084 *g*
(c) 1.042 *g* (d) 4.167 *g*

75. An artificial radioactive isotope gave $^{14}_{7}N$ after two successive $\beta -$particle emissions. The number of neutrons in the parent nucleus must be

(a) 9 (b) 14
(c) 5 (d) 7

76. If the half-life of an isotope *X* is 10 years, its decay constant is **[DCE 2004]**

(a) $6.932\ yr^{-1}$ (b) $0.6932\ yr^{-1}$
(c) $0.06932\ yr^{-1}$ (d) $0.006932\ yr^{-1}$

77. A radioactive isotope decays at such a rate that after 192 minutes only 1/16 of the original amount remains. The half-life of the radioactive isotope is **[Kerala CET 2004]**

(a) 32 min (b) 48 min
(c) 12 min (d) 24 min

78. In the given reaction,
$_{92}U^{235} \xrightarrow{-\alpha} (A) \xrightarrow{-\beta} (B) \xrightarrow{-\beta} (C)$ isotope are
[DPMT 1982] **[Pb. CET 2000]**

(a) *A* and *C* (b) $_{92}U^{235}$ and *C*
(c) *A* and *B* (d) *A*, *B* and *C*

79. Rate constant for a reaction is λ. Average life is representative by **[Orissa JEE 2004]**

(a) $1/\lambda$ (b) $\text{In}2/\lambda$

(c) $\frac{\lambda}{\sqrt{2}}$ (d) $\frac{0.693}{\lambda}$

80. For a reaction, the rate constant is $2.34\ sec^{-1}$. The half-life period for the reaction is

(a) 0.30 *sec* (b) 0.60 *sec*
(c) 3.3 *sec* (d) Data is insufficient

81. $T_{1/2}$ of C^{14} isotope is 5770 years. time after which 72% of isotope left is **[Orissa JEE 2005]**

(a) 2740 years (b) 274 years
(c) 2780 years (d) 278 years

82. A radioactive substance takes 20 min to decay 25%. How much time will be taken to decay 75% **[Orissa JEE 2005]**

(a) 96.4 *min* (b) 68 *min*
(c) 964 *min* (d) 680 *min*

83. A radioactive sample is emitting 64 times radiations than non hazardous limit. if its half life is 2 hours, after what time it becomes non-hazardous **[DPMT 2005]**

(a) 16 *hr* (b) 12 *hr*
(c) 8 *hr* (d) 4 *hr*

84. If 8.0 *g* of a radioactive substance has a half-life of 10 *hrs*., the half life of 2.0 *g* of the same substance is **[J & K 2005]**

(a) 2.6 *hr* (b) 5 *hr*
(c) 10 *hr* (d) 40 *hr*

Artificial transmutation

1. The age of most ancient geological formation is estimated by

[NCERT 1981; MP PET/PMT 1988; CBSE 1989; MP PET 1997; MP PMT 2002]

(a) Potassium – Argon method
(b) Carbon – 14 dating method
(c) Radium – Silicon method
(d) Uranium – Lead method

2. The equation $_3Li^6 +_1 H^2 \longrightarrow 2_2He^4 +$ energy represents

(a) Synthesis of helium (b) Transmutation of element
(c) Fusion reaction (d) Nuclear fission

3. The phenomenon of radioactivity arises from the **[Kerala (Med.) 2002]**

(a) Binary fission
(b) Nuclear fusion
(c) Stable nuclei
(d) Decay of unstable nuclei

4. The first artificial disintegration of an atomic nucleus was achieved by **[Kerala (Engg.) 2002]**

(a) Geiger (b) Wilson
(c) Madame curie (d) Rutherford
(e) Soddy

5. Artificial elements have been prepared by bombardment reactions in high energy accelerators. What is the mass number of the element *X* produced in the following nuclear reaction $^{249}_{95}Cf +^{15}_{7}N \rightarrow_{105} X + 4^1_0n$ **[AMU (Engg.) 2002]**

(a) 261 (b) 264
(c) 260 (d) 257

6. Radioactive carbon dating was discovered by **[MP PET 2001]**

(a) W.F. Libby (b) G.N. Lewis
(c) J. Willard Gibbs (d) W. Nernst

7. The nuclear reaction $^{63}_{29}Cu +^4_2He \rightarrow^{37}_{17}Cl + 14^1_1H + 16^1_0n$ is referred to as **[MP PET 2002]**

(a) Spallation reaction (b) Fusion reaction
(c) Fission reaction (d) Chain reaction

8. The carbon dating is based on **[MP PMT 2001]**

(a) $^{15}_{6}C$ (b) $^{14}_{6}C$
(c) $^{13}_{6}C$ (d) $^{11}_{6}C$

9. A possible material for use in the nuclear reactors as a fuel is **[DPMT 1986]**

(a) Thorium (b) Zirconium
(c) Beryllium (d) Plutonium

10. Heavy water freezes at **[UPSEAT 2001]**

(a) $0°C$ (b) $3.8°C$
(c) $38°C$ (d) $-0.38°C$

11. To determine the masses of the isotopes of an element which of the following techniques is useful **[NCERT 1978; MNR 1979]**

(a) The acceleration of charged atoms by an electric field and their subsequent deflection by a variable magnetic field
(b) The spectroscopic examination of the light emitted by vaporised elements subjected to electric discharge
(c) The photographing of the diffraction patterns which arise when X-rays are passed through crystals
(d) The bombardment of metal foil with alpha particles

12. The radioisotope, tritium (^3_1H) 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* **[CBSE 2003]**

(a) 8 *mg* (b) 1 *mg*
(c) 2 *mg* (d) 4 *mg*

13. Neutron is used as a **[CPMT 1988]**

(a) Reducing agent (b) Moderator
(c) Tracer (d) In biological programme

14. Hydrogen bomb is based on the phenomenon of **[EAMCET 1980; CPMT 1984, 96; MP PMT 1993, 95, 2002; RPET 1999]**

(a) Nuclear fission (b) Nuclear fusion
(c) Nuclear explosion (d) Disintegration

15. In the nuclear reactors the speed of the neutrons is slowed down by **[CPMT 1983, 84]**

(a) Heavy water (b) Ordinary water
(c) Zinc rods (d) Molten caustic soda

16. By which law, energy produced in nuclear reaction is given **[MP PET 2000]**

(a) Graham's law (b) Charle's law
(c) Gas Lussac's Law (d) Einstein's law

17. If two light nuclei are fused together in nuclear reaction the average energy per nucleon **[Pb. PMT 2001]**

(a) Increases (b) Cannot be determined
(c) Remains same (d) Decreases

18. A wood piece is 11460 *years* old. What is the fraction of ^{14}C activity left in the piece? (Half-life period of ^{14}C is 5730 *years*) **[MP PMT 2000]**

(a) 0.12 (b) 0.25
(c) 0.50 (d) 0.75

19. When nuclear energy is intended to be harnessed for generation of electricity, potentially destructive neutron released in a nuclear reactor are absorbed by **[MH CET 2001]**

(a) Long rods of *Cd* (b) Heavy water
(c) Cubical blocks of steel (d) Both (a) and (c)

20. The proper rays for radiocarbon dating are **[MP PET 2002]**

(a) *UV*-rays (b) *IR*-rays
(c) Cosmic rays (d) *X*-rays

21. $_1H^2 + _1H^2 \rightarrow _2He^3 + _0n^1$. Above nuclear reaction is called **[UPSEAT 2001]**

(a) Nuclear fission
(b) Nuclear fusion
(c) Artificial transmutation
(d) Spontaneous disintegration

22. Which of the following is used as a moderator in a nuclear reactor **[AIIMS 2001]**

(a) D_2O (b) N_2O
(c) H_2O (d) $NaOH$

23. The fuel of atomic pile is **[NCERT 1973; AFMC 1989]**

(a) Thorium (b) Sodium
(c) Uranium (d) Petroleum

24. Atom bomb is based on the principle of **[CPMT 1982; BHU 1985]**

(a) Nuclear fusion
(b) Nuclear fission
(c) Radioactivity
(d) Fusion and fission both

25. Who observed that when the nucleus of uranium atom was bombarded with fast moving neutrons, it becomes so very unstable that it is immediately broken into two nuclei of nearly equal mass besides other fragments

(a) J.J. Thomson (b) Chadwick
(c) Einstein (d) Hahn and Strassmann

26. When a radioactive substance is subjected to vacuum, the rate of disintegration per second **[DPMT 1985; NCERT 1972]**

(a) Increases considerably
(b) Increases only if the products are gaseous
(c) Is not affected
(d) Suffers a slight decrease

27. A radio isotope will not emit **[KCET 2002]**

(a) Gamma and alpha rays simultaneously
(b) Gamma rays only
(c) Alpha and beta rays simultaneously
(d) Beta and gamma rays simultaneously

28. What is the packing fraction of $^{56}_{26}Fe$

(Isotopic mass = 55.92066)

(a) -14.167 (b) 173.90
(c) -14.187 (d) -73.90

29. The energy released in an atom bomb explosion is mainly due to **[BVP 2003]**

(a) Release of neutrons
(b) Release of electrons
(c) Greater mass of products than initial material
(d) Lesser mass of products than initial material

30. C^{14} is **[KCET 2002]**

(a) A natural radioactive isotope
(b) A natural non-radioactive isotope
(c) An artificial radioactive isotope
(d) An artificial non-radioactive isotope

31. A radioactive isotope has a half-life of 10 *years*. What percentage of the original amount of it remain after 20 *years* **[KCET 2001]**

(a) 0 (b) 12.5
(c) 8 (d) 25

32. In a chain reaction, uranium atom gets fissioned forming two different materials. The total weight of these put together is **[EAMCET 1986]**

(a) More than the weight of parent uranium atom
(b) Less than the weight of parent uranium atom
(c) More or less depends upon experimental conditions
(d) Neither more nor less

33. A substance used as a moderator in nuclear reactors is **[MP PET 1995]**

(a) Cadmium (b) Uranium-235
(c) Lead (d) Heavy water

34. Equation $_{17}Cl^{37} + {}_{1}H^{2} \rightarrow {}_{18}Ar^{38} + {}_{0}n^{1}$ is **[MP PMT 1989]**

(a) Nuclear fission
(b) Nuclear fusion
(c) Transformation of chlorine
(d) Synthesis of argon

35. $1.0\,gm$ radioactive sodium on decay becomes $0.25\,gm$ in 16 hours. How much time $48\,gm$ of same radioactive sodium will need to become $3.0\,gm$

(a) 48 hours (b) 32 hours
(c) 20 hours (d) 16 hours

36. Large energy released in an atomic bomb explosion is mainly due to **[CPMT 1972, 73, 81, 90]**

(a) Products having a lesser mass than initial substance
(b) Conversion of heavier to lighter atoms
(c) Release of neutrons
(d) Release of electrons

37. The reaction $_{1}H^{2} + {}_{1}H^{3} \rightarrow {}_{2}He^{4} + {}_{0}n^{1} + \text{energy}$ represents **[MP PMT 1990; CPMT 1990; KCET 1992]**

(a) Nuclear fission
(b) Nuclear fusion
(c) Artificial disintegration
(d) Transmutation of element

38. Carbon-14 dating method is based on the fact that **[CBSE 1997]**

(a) Carbon-14 fraction is the same in all objects
(b) Carbon-14 is highly insoluble
(c) Ratio of carbon-14 and carbon-12 is constant
(d) All of these

39. Half-life period of a radioactive element is 10.6 *yrs*. How much time will it take in its 99% decomposition **[RPET 1999]**

(a) 7046 *yrs* (b) 7.046 *yrs*
(c) 704.6 *yrs* (d) 70.4 *yrs*

40. Deuterium resembles hydrogen in chemical properties but reacts **[JIPMER 2001]**

(a) More vigorously than hydrogen
(b) Faster than hydrogen
(c) Slower than hydrogen
(d) Just as hydrogen

41. Which of the following is heavy water **[AFMC 1997]**

(a) H_2O_{18} (b) H_2O_{16}
(c) H_2O_3 (d) D_2O

42. D_2O is used in **[CPMT 1997]**

(a) Industry (b) Nuclear reactor
(c) Medicine (d) Insecticide

43. India conducted an underground nuclear test at **[KCET 1998]**

(a) Tarapur (b) Narora
(c) Pokhran (d) Pushkar

44. Energy required to separate neutron and proton from the nucleus is called **[RPMT 1999]**

(a) Bond energy (b) Nuclear energy
(c) Chemical energy (d) Radiation energy

45. Liquid sodium finds use in nuclear reactors. Its function is

(a) To collect the reaction products
(b) To act as a heat exchanger or coolant
(c) To absorb the neutrons in order to control the chain reaction
(d) To act as a moderator which slows down the neutrons

46. Which is least effective for artificial transmutation **[DPMT 2000]**

(a) Deuterons (b) Neutrons
(c) α-particles (d) Protons

47. A piece of wood was found to have C^{14}/C^{12} ratio 0.7 *times* that in a living plant. The time period when the plant died is (Half-life of $C^{14} = 5760\ yrs$) **[Pb. PMT**

(a) 2770 *yrs* (b) 2966 *yrs*
(c) 2980 *yrs* (d) 3070 *yrs*

48. When a slow neutron goes sufficiently close to a U^{235} nucleus, then the process which takes place is **[AFMC 2000]**

(a) Fusion of U^{235} (b) Fission of U^{235}
(c) Fusion of neutron (d) First (a) then (b)

49. $_{13}Al^{28}$ when radiated by suitable projectile gives $_{15}P^{31}$ and neutron. The projectile used is **[MP PMT/PET 1988; CPMT 1985, 82]**

(a) Proton (b) Neutron
(c) Alpha particle (d) Deuteron

50. Which of the following statements about radioactivity of an element is incorrect

(a) It is a nuclear property
(b) It does not involve any rearrangement of electrons
(c) Its rate is affected by change in temperature and/or pressure
(d) It remains unaffected by the presence of other element or elements chemically combined with it

51. Radioactive iodine is being used to diagnose the disease of **[MP PET 1996]**

(a) Bones (b) Kidneys
(c) Blood cancer (d) Thyroid

52. $C-14$ is used in carbon dating of dead objects because **[DPMT 1996]**

(a) Its half-life is 10^3 years
(b) Its half-life is 10^4 years
(c) It is found in nature abundantly and in definite ratio
(d) It is found in dead animals abundantly

53. A radioactive element resembling iodine in properties is **[Kurukeshetra CEE 1998]**

(a) Astatine (b) Lead
(c) Radium (d) Thorium

54. For artificial transmutation of nuclei, the most effective one is **[MP PMT 1996]**

(a) Proton (b) Deuteron
(c) Helium nuclei (d) Neutron

55. Which of the following cannot be accelerated **[KCET 2005]**

(a) α -particle (b) β -particle
(c) Protons (d) Neutrons

56. For the fission reaction

$_{92}U^{235} + {_0}n^1 \rightarrow {_{56}}Ba^{140} + {_y}E^x + 2\,{_0}n^1$

The value of x and y will be

(a) $x = 93$ and $y = 34$ (b) $x = 92$ and $y = 35$
(c) $x = 89$ and $y = 44$ (d) $x = 94$ and $y = 36$

57. Heavy water is used as **[Bihar MEE 1996; UPSEAT 1999, 2000, 02]**

(a) Control rods (b) Moderator
(c) Fuel (d) Coolant
(e) None of these

58. Unit for radioactive constant is **[MP PET 1990]**

(a) $Time^{-1}$ (b) *Time*
(c) $Mole - time^{-1}$ (d) $Time - mole^{-1}$

59. Which of the following is used in dating archeological findings **or** In a method of absolute dating of fossils a radioactive element is used. It is **[CPMT 1983, 85; NCERT 1978; BHU 1981; MP PMT 1993; AFMC 1997]**

(a) $_{92}U^{235}$ (b) $_6C^{14}$
(c) $_6C^{12}$ (d) $_{20}Ca^{40}$

60. A radioactive isotope has a half-life of 20 days. If 100 *gm* of the substance is taken, the weight of the isotope remaining after 40 days is

(a) 25 gm (b) 2.5 gm
(c) 60 gm (d) 40 gm

61. In a fission reaction the nucleus of an element **[NCERT 1977]**

(a) Loses only some elementary nuclear particles from another nucleus
(b) Captures some elementary nuclear particles from another nucleus
(c) Breaks up into several smaller nuclei
(d) Breaks up into two smaller nuclei with the loss of same elementary nuclear particles

62. The huge amount of energy which is released during atomic fission is due to **[CPMT 1990]**

(a) Loss of mass (b) Loss of electrons
(c) Loss of protons (d) Loss of α -particles

63. The measure of binding energy of a nucleus is the **[CPMT 1982; Kurukshetra CEE 1998]**

(a) Mass defect (b) Energy of protons
(c) Energy of neutrons (d) Total energy of nucleons

64. The first controlled artificial disintegration of an atomic nucleus was achieved by **[BHU 1987]**

(a) Geiger (b) Wilson
(c) Cockcroft (d) Rutherford

65. Artificial radioactivity was first discovered by **[CPMT 1972; BHU 1984; KCET 1999]**

(a) Seaberg (b) Rutherford
(c) Einstein (d) Irene Curie & Juliot

66. The half-life period of a radioactive element is 140 days. After 560 days, one gram of the element will reduce to **[CPMT 1989; IIT 1986; EAMCET 1992; MP PET 1997; UPSEAT 1999]**

(a) $1/2\,g$ (b) $1/4\,g$
(c) $1/8\,g$ (d) $1/16\,g$

67. A device used for the measurement of radioactivity is **[BHU 1979]**

(a) Mass spectrometer (b) Cyclotron
(c) Nuclear reactor (d) G.M. counter

68. In a nuclear reactor, chain reaction is controlled by introducing **[EAMCET 1984]**

(a) Iron rod (b) Cadmium rod
(c) Graphite rod (d) Platinum rod

69. In atomic reactors, graphite is used as a **[NCERT 1980; MP PET 1989]**

(a) Lubricant
(b) Moderator to slow down neutrons
(c) Fuel
(d) Liner of the reactor

70. The modern basis of atomic weight is **[NCERT 1979]** **[MP PET 1989; CPMT 1993]**

(a) Isotope $H^1 = 1.000$ (b) Oxygen = 16.000
(c) Isotope $O^{16} = 16.000$ (d) Isotope $C^{12} = 12.000$

71. Which radioactive carbon has been helpful in understanding the mechanism of photosynthesis in plants

(a) ${}_6C^{14}$ (b) ${}_6C^{13}$

(c) ${}_6C^{12}$ (d) ${}_6C^{15}$

72. Artificial transmutation was discovered by **[Pb.CET 2003]**

(a) Pauli (b) Rutherford

(c) Soddy (d) Curie

73. Which of the following is an example of nuclear fusion

[MP PMT 1989; DCE 2004]

(a) ${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4 + \text{energy}$

(b) ${}_{92}U^{235} + {}_on^1 \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + {}_{30}n^1 + \text{energy}$

(c) ${}_{13}Al^{27} + {}_1H^1 \rightarrow {}_{12}Mg^{24} + {}_2He^4$

(d) None of these

74. The radioactivity isotope ${}^{60}_{27}Co$ which is used in the treatment of cancer can be made by (n, p) reaction. For this reaction the target nucleus is **[CBSE PMT 2004]**

(a) ${}^{60}_{28}Ni$ (b) ${}^{60}_{27}Co$

(c) ${}^{59}_{28}Ni$ (d) ${}^{59}_{27}Co$

75. Fusion bomb involves **[AFMC 2004]**

(a) Combination of lighter nuclei into bigger nucleus

(b) Destruction of heavy nucleus into smaller nuclei

(c) Combustion of oxygen

(d) Explosion of TNT

76. The element used for dating the ancient remains is

[AFMC 2004]

(a) *Ni* (b) *C*-14

(c) *C*-12 (d) *Rd*

77. If radium and chlorine combine to from radium chloride the compound is **[Kerala PMT 2004]**

(a) No longer radioactive

(b) Twice as radioactive as radium

(c) Half as radioactive as radium

(d) As radioactive as radium

(e) Thrice as radioactive as radium

78. Which of the following is an example of nuclear fission

[Pb. CET 2002]

(a) ${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4 + \gamma$

(b) $A + B \rightarrow C + \text{energy}$

(c) ${}_{92}U^{235} + {}_0n^1 \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + \text{energy}$

(d) ${}_{13}Al^{27} + {}_2He^4 \rightarrow {}_{15}P^{30} + {}_0n^1$

79. The C^{14} to C^{12} ratio in a wooden article is 13% that of the fresh wood. Calculate the age of the wooden article. Given that the half-life of C^{14} is 5770 years **[Pb.CET 2004]**

(a) 16989 *years* (b) 16858 *years*

(c) 15675 *years* (d) 17700 *years*

80. Hydrogen bomb is based on the principle of **[AIEEE 2005]**

(a) Nuclear fission (b) Natural radioactivity

(c) Nuclear fusion (d) Artificial radioactivity

81. Match List –I and List-II and choose right one by using code given in list **[Kerala CET 2005]**

List – I	List –II
Nuclear reactor Component	Used substance
1. Moderator	(A) Uranium
2. Control rods	(B) Graphite
3. Fuel rods	(C) Boron
4. Coolent	(D) Lead
	(E) Sodium

Code :

	1	2	3	4
(a)	B	A	C	E
(b)	B	C	A	E
(c)	C	B	A	E
(d)	C	D	A	B
(e)	D	C	B	A

Isotopes-Isotones and Nuclear isomers

1. Substances which have identical chemical properties but differ in atomic weights are called

[EAMCET 1980, 83; DPMT 1985; MNR 1982]

(a) Isothermals (b) Isotopes

(c) Isentropus (d) Elementary particles

2. Tritium is an isotope of **[DPMT 1985]**

(a) Hydrogen (b) Titanium

(c) Tantalum (d) Tellurium

3. O – 18 isotope of oxygen will have **[CPMT 1972, 79]**

(a) 18 protons

(b) 9 protons and 9 neutrons

(c) 8 neutrons and 10 protons

(d) 10 neutrons and 8 protons

4. Which of the following is an isobaric pair **[CPMT 1987, 93]**

(a) ${}_6C^{13}, {}_7N^{13}$ (b) ${}_6C^{13}, {}_7N^{14}$

(c) ${}_7N^{14}, {}_8O^{15}$ (d) ${}_7N^{13}, {}_8O^{15}$

5. Isotopes are atoms having the same

[EAMCET 1978, 79; MP PMT 1980; CPMT 1973;

BHU 2001; AFMC 2003]

(a) Atomic mass (b) Mass number

(c) Atomic number (d) Number of neutrons

6. Successive emission of an α-particle and two β-particles by an atom of an element results in the formation of its

[MP PMT/PET 1988; BHU 1979]

(a) Isobar (b) Isomorph

(c) Isotope (d) Isomer

7. In treatment of **cancer,** which of the following isotope is used **[DPMT 1985; BHU 1995; KCET 1999; AMU 1999; Pb.CET 2001; MP PET 2002; Kurukshetra CET 2002]**

(a) ${}_{53}I^{131}$ (b) ${}_{15}P^{32}$

(c) ${}_{27}Co^{60}$ (d) ${}_{1}H^{2}$

8. Elements having different nuclear charge but the same mass number are called **[NCERT 1974; MP PMT 1991; CBSE PMT 1991; CPMT 1989; EAMCET 1992]**

(a) Isotopes (b) Isobars

(c) Isomers (d) Isotones

9. Which isotope on bombardment with α-particles will give ${}_{8}O^{17}$ and ${}_{1}H^{1}$ **[NCERT 1983]**

(a) ${}_{8}O^{16}$ (b) ${}_{7}N^{14}$

(c) ${}_{7}N^{15}$ (d) ${}_{6}C^{14}$

10. Emission of β-particle by an atom of an element results in the formation of its **[BHU 1979; DPMT 1985; KCET 1993]**

(a) Isotope (b) Isomer

(c) Isomorph (d) Isobar

11. Radioactive isotopes that have an excessive neutron/proton ratio generally exhibit

(a) e^- emission (b) ${}_{2}He^{4}$ emission

(c) e^+ emission (d) K-electron capture

12. Atomic weights of carbon, nitrogen and oxygen are 12, 14 and 16 respectively. An atom of atomic weight 14 and nuclear charge + 6 is an isotope of

(a) Oxygen (b) Carbon

(c) Nitrogen (d) None of these

13. Isotopes of an element have **[MNR 1985]**

(a) Similar chemical properties but different physical properties

(b) Similar chemical and physical properties

(c) Similar physical properties but different chemical properties

(d) Different chemical and physical properties

14. Whose number is common in isotopes **[AIIMS 1988]**

(a) Proton (b) Neutron

(c) Proton and neutron (d) Nucleon

15. In the following radioactive transformation $R\xrightarrow{\alpha}X\xrightarrow{\beta}Y\xrightarrow{\beta}Z$; the nuclei R and Z are

[BHU 1987]

(a) Isotopes (b) Isobars

(c) Isomers (d) Isotones

16. Which one of the following pairs represents isobars

[CPMT 1988]

(a) ${}_{2}^{3}He$ and ${}_{2}^{4}He$

(b) ${}_{12}^{24}Mg$ and ${}_{12}^{25}Mg$

(c) ${}_{19}^{40}K$ and ${}_{20}^{40}Ca$

(d) ${}_{19}^{39}K$ and ${}_{19}^{40}K$

17. Nuclei of isotopes differ in **[CPMT 1986, 90; MP PMT 1987]**

(a) The number of protons

(b) The number of neutrons

(c) The number of protons and neutrons both

(d) None of these

18. An isotope of 'parent' is produced, when its nucleus loses

[CPMT 1987; MP PET 1991]

(a) One α-particle

(b) One β-particle

(c) One α and two β-particles

(d) One β and two α- particles

19. Which of the following isotopes is likely to be most stable

[EAMCET 1982]

(a) ${}_{30}Zn^{71}$ (b) ${}_{30}Zn^{66}$

(c) ${}_{30}Zn^{64}$ (d) None of these

20. Which of the following statement is false

[Manipal MEE 1995]

(a) In chlorine gas, the ratio of Cl^{35} and Cl^{37} is 1 : 3

(b) The hydrogen bomb is based on the principle of nuclear fusion

(c) The atom bomb is based on the principle of nuclear fission

(d) The penetrating power of a proton is less than that of an electron

21. Isotones are elements having

[Bihar MEE 1996; Bihar CEE 1995]

(a) Same mass number but different neutrons

(b) Same atomic number but different neutrons

(c) Same atomic number, mass number and neutrons

(d) Different atomic and mass number but same neutrons

22. Isobaric atoms may contain

(a) Same number of p^+ and different number of n^0

(b) Same number of n^0 and different number of p^+

(c) Same number of both p^+ and n^0

(d) Different numbers of both p^+ and n^0

23. $_{20}X^{40}$ and $_{21}X^{40}$ are **[CPMT 1996]**

(a) Isobars (b) Isotopes

(c) Isotones (d) Isostereomers

24. Which property is different for neutral atoms of the two isotopes of the same element **[JIPMER 2001]**

(a) Number of protons (b) Atomic number

(c) Number of neutrons (d) None of these

25. Which of the following species is isotonic with $_{37}Rb^{86}$ **[BHU 2001]**

(a) $_{36}Kr^{84}$ (b) $_{37}Rb^{85}$

(c) $_{38}Sr^{87}$ (d) $_{39}Y^{89}$

26. The maximum sum of the number of neutrons and protons in an isotope of hydrogen is **[Pb. PMT 2001]**

(a) 4 (b) 5

(c) 6 (d) 3

27. Difference in $_{17}Cl^{35}$ and $_{17}Cl^{37}$ is of **[AFMC 2000]**

(a) Atomic number (b) Number of protons

(c) Number of neutrons (d) Number of electrons

28. Which of the following is an isotonic pair **[AMU (Engg.) 2000]**

(a) $^{40}_{19}K, ^{40}_{20}Ca$ (b) $^{39}_{19}K, ^{40}_{20}Ca$

(c) $^{33}_{18}Ar, ^{40}_{18}Ar$ (d) $^{40}_{18}Ar, ^{40}_{20}Ca$

29. $_6C^{11}$ and $_5B^{11}$ are referred as **[NCERT 1978]**

(a) Nuclear isomers (b) Isobars

(c) Isotopes (d) Fission products

30. The atomic number of bromine is 35 and its atomic weight is 79. Two isotopes of bromine are present in equal amounts. Which of the following statements represents the correct number of neutrons **[NCERT 1983]**

	First isotope	Second isotope
(a)	34	36
(b)	44	46
(c)	45	47
(d)	79	81

31. Isotopes are those which contain **[RPMT 1997]**

(a) Same number of neutrons

(b) Same physical properties

(c) Same chemical properties

(d) Different atomic mass

32. An element 'A' emits an α-particle and forms 'B'.'A' and 'B' are **[DPMT 1990]**

(a) Isotopes (b) Isobars

(c) Isotones (d) Isodiasphere

33. Which of the following properties are different for neutral atoms of isotopes of the same element **[EAMCET 1987; NCERT 1971; CPMT 1976; MP PET 1994]**

(a) Mass

(b) Atomic number

(c) General chemical reactions

(d) Number of electrons

34. The isotope $_{92}U^{235}$ decays in a number of steps to an isotope of lead $_{82}Pb^{207}$. The groups of particles emitted in this process will be

(a) $4\alpha, 7\beta$ (b) $6\alpha, 4\beta$

(c) $7\alpha, 4\beta$ (d) $10\alpha, 8\beta$

35. Addition of two neutrons in an atom A would **[AMU 1984]**

(a) Change the chemical nature of A

(b) Produce an isobar of A

(c) Produce an isotope of A

(d) Produce another element

36. Atomic weight of the isotope of hydrogen which contains 2 neutrons is the nucleus would be **[CPMT 1980]**

(a) 2 (b) 3

(c) 1 (d) 4

37. If a radioactive isotope with atomic number A and mass number M emits an α-particle, the atomic number and mass number of that new isotope will become **[NCERT 1980]**

(a) A – 2, M – 4 (b) A – 2, M

(c) A, M – 2 (d) A – 4, M – 2

38. Which character is different of the two isotopes of an element **[NCERT 1971; EAMCET 1980, 92; CPMT 1992]**

(a) Atomic mass (b) Atomic number

(c) Number of electrons (d) Number of protons

39. The symbol of an isotope is $_{32}X^{65}$, this reveals that **[MP PET 1991]**

(a) Its atomic number is 32 and atomic weight is 65

(b) Its atomic number is 65

(c) It has 65 electrons

(d) It has 32 neutrons

40. Two atoms have the same atomic mass but different atomic numbers. Such atoms are called as **[NCERT 1971, 76; IIT 1983]**

(a) Isotopes (b) Isobars

(c) Isomer (d) Isoelectronic

41. $_{18}Ar^{40}, _{20}Ca^{40}$ and $_{19}K^{40}$ are **[MNR 1983; DPMT 1991; EAMCET 1992; RPMT 1997; Pb.CET 2000]**

(a) Isomers (b) Isotopes

(c) Isobars (d) Isotones

42. Atoms in hydrogen gas have preponderance of

[CPMT 1972]

(a) $_1H^1$ atoms

(b) Deuteron atoms

(c) Tritium atoms

(d) All the three (a), (b) and (c) are in equal proportion

43. Positron emission results from the transformation of one nuclear proton into neutron. The isotope thus produced possesses **[MP PMT 1990]**

(a) Same mass number (b) Higher nuclear charge

(c) Intense radioactivity (d) No radioactivity

44. An isotope of oxygen has mass number 18. Other isotopes of oxygen will have the same

[MP PMT 1985; MADT Bihar 1981]

(a) Mass number (b) Atomic weight

(c) Number of neutrons (d) Number of protons

45. Two nuclei which are not identical but have the same number of nucleons represent

(a) Isotopes (b) Isobars

(c) Isotones (d) None of the three

46. The β-decay of $_{11}Na^{24}$ produces an isotope of

[NCERT 1978]

(a) *Mg* (b) *Na*

(c) *Al* (d) *Ne*

47. Isotopes differ in **[NCERT 1973]**

(a) Number of protons (b) Valency

(c) Chemical reactivity (d) Number of neutrons

48. The isobars are atoms with the same number of

[DPMT 1982; CPMT 1994]

(a) Protons (b) Neutrons

(c) Protons and neutrons (d) Nucleons

49. Radioactive isotope of hydrogen is

[MP PMT 2001; MPPET 2003]

(a) Tritium (b) Deuterium

(c) Para hydrogen (d) Ortho hydrogen

50. Isotopes of same elements have the same number of

[BHU 1984; DPMT 1983; CPMT 1972, 78; AFMC 2000, 01]

(a) Protons (b) Neutrons

(c) Deutrons (d) None

51. In chlorine gas, ratio of Cl^{35} and Cl^{37} is

[BHU 1984; CPMT 1977, 80]

(a) 1 : 3 (b) 3 : 1

(c) 1 : 1 (d) 1 : 4

52. An ordinary oxygen contains **[NCERT 1977]**

(a) Only $O-16$ isotopes

(b) Only $O-17$ isotopes

(c) A mixture of $O-16$ and $O-18$ isotopes

(d) A mixture of O – 16, $O-17$ and $O-18$ isotopes

53. Isotopes were discovered by **[AMU 1983; AFMC 1995]**

(a) Aston (b) Soddy

(c) Thomson (d) Millikan

54. Which of the following are iso-electronic **[CBSE 2002]**

(a) CO_2 and NO (b) SO_2 and CO_2

(c) CN and CO (d) NO_2 and CO_2

55. Which of the following are pairs of isotopes

[Bihar CEE 1982]

(a) $^2_1H^+$ and ^3_1H (b) ^3_1H and $^4_2H^-$

(c) ^3_2He and ^4_2He (d) $^{12}_6C$ and $^{14}_7N^+$

56. Which among the following isotope is not found in natural uranium **[Orissa JEE 2002]**

(a) $_{92}U^{234}$ (b) $_{92}U^{235}$

(c) $_{92}U^{238}$ (d) $_{92}U^{239}$

57. An isotone of $^{76}_{32}Ge$ is (one or more are correct)

[IIT 1984; MADT Bihar 1995; MP PMT 1995]

(a) $^{77}_{32}Ge$ (b) $^{77}_{33}As$

(c) $^{77}_{34}Se$ (d) $^{78}_{34}Se$

Critical Thinking

Objective Questions

1. $^{23}_{11}Na$ is the more stable isotope of *Na*. Find out the process by which $^{24}_{11}Na$ can undergo radioactive decay

[IIT Screening 2003]

(a) β^- emission (b) α emission

(c) β^+ emission (d) *K* electron capture

2. Oxygen contains 90% of O^{16} and 10% of O^{18}. Its atomic mass is **[KCET 1998]**

(a) 17.4 (b) 16.2

(c) 16.5 (d) 17

3. The missing particle in the reaction, $^{235}_{92}U + ^1_0n \rightarrow {}_{56}Ba^{146} + ... + 3^1_0n$ is

(a) $^{87}_{32}Ge$ (b) $^{89}_{35}Br$

(c) $^{87}_{36}Kr$ (d) $^{86}_{35}Br$

4. Sulphur-35 (34.96903 *amu*) emits a $\beta-$particle but no $\gamma-$rays, the product is chlorine-35 (34.96885 *amu*). The maximum energy emitted by the $\beta-$particle is

[DPMT 2004]

(a) 0.016767 *MeV* (b) 1.6758 *MeV*

(c) 0.16758 *MeV* (d) 16.758 *MeV*

5. A radioactive substance has a constant activity of 2000 disintegration/minute. The material is separated into two fractions, one of which has an initial activity of 1000 disintegrations per second while the other fraction decays with $t_{1/2}$ = 24 *hours*. The total activity in both samples after 48 *hours* of separation is **[JIPMER 2000]**

(a) 2000 (b) 1250
(c) 1000 (d) 1500

6. How many alpha particles are emitted per second by 1 microgram of radium

(a) 3.62×10^4 / sec (b) 0.362×10^4 / sec
(c) 362×10^4 / sec (d) 36.2×10^4 / sec

7. If 1 microgram of radium has disintegrated for 500 years, how many alpha particles will be emitted per second

(a) 2.92×10^4 / sec (b) 292×10^4 / sec
(c) 0.292×10^4 / sec (d) 29.2×10^4 / sec

8. A radioactive nucleide *X* decays at the rate of 1.00×10^5 disintegration $s^{-1}g^{-1}$. Radium decays at the rate of 3.70×10^{10} disintegration $s^{-1}g^{-1}$. The activity of *X* in millicuries g^{-1} $(m\,ci\,g^{-1})$ is

(a) 0.027 (b) 0.270×10^{-5}
(c) 0.00270 (d) 0.000270

9. If $_{92}U^{235}$ nucleus absorbs a neutron and disintegrates in $_{54}Xe^{139}$, $_{38}Sr^{94}$ and *X*, then what will be the product *X* **[CBSE 2002]**

(a) α-particle (b) β-particle
(c) 2-neutrons (d) 3-neutrons

10. The half-life of a radioactive isotope is 3 *hours*. Value of its disintegration constant is **[BHU 2002]**

(a) 0.231 *per hr* (b) 2.31 *per hr*
(c) 0.2079 *per hr* (d) 2.079 *per hr*

11. The activity of carbon-14 in a piece of an ancient wood is only 12.5%. If the half-life period of carbon-14 is 5760 years, the age of the piece of wood will be $(\log 2 = 0.3010)$ **[MP PMT 1999]**

(a) 17.281×10^2 years (b) 172.81×10^2 years
(c) 1.7281×10^2 years (d) 1728.1×10^2 years

12. The radium and uranium atoms in a sample of uranium mineral are in the ratio of $1 : 2.8 \times 10^6$. If half-life period of radium is 1620 years, the half-life period of uranium will be **[MP PMT 1999]**

(a) 45.3×10^9 years (b) 45.3×10^{10} years
(c) 4.53×10^9 years (d) 4.53×10^{10} years

13. Half-life of radium is 1580 *yrs*. Its average life will be **[AIIMS 1999; AFMC 1999; CPMT 1999]**

(a) $2.5 \times 10^3 yrs$ (b) $1.832 \times 10^3 yrs$
(c) $2.275 \times 10^3 yrs$ (d) $8.825 \times 10^2 yrs$

14. 8 *gms* of a radioactive substance is reduced to $0.5g$ after 1 *hour*. The $t_{1/2}$ of the radioactive substance is **[DCE 2000]**

(a) 15 *min* (b) 30 *min*
(c) 45 *min* (d) 10 *min*

15. A first order nuclear reaction is half completed in 45 *minutes*. How long does it need 99.9% of the reaction to be completed **[KCET 2001]**

(a) 5 *hours* (b) 7.5 *hours*
(c) 10 *hours* (d) 20 *hours*

16. Number of α-particles emitted per second by a radioactive element falls to 1/32 of its original value in 50 *days*. The half-life-period of this elements is **[AMU 2001]**

(a) 5 *days* (b) 15 *days*
(c) 10 *days* (d) 20 *days*

17. What is the half-life of a radioactive substance if 87.5% of any given amount of the substance disintegrates in 40 minutes **[MP PET 2001]** **[Kerala CET 1996]**

(a) 160 *min* (b) 10 *min*
(c) 20 *min* (d) 13 *min* 20 *sec*

18. A radioactive isotope has a $t_{1/2}$ of 10 days. If today 125 *gm* of it is left, what was its weight 40 days earlier **[EAMCET 1991]**

(a) $600\,gm$ (b) $1000\,gm$
(c) $1250\,gm$ (d) $2000\,gm$

19. The half-life of $_6C^{14}$, if its decay constant is 6.31×10^{-4} is **[CBSE PMT 2001]**

(a) 1098 *yrs* (b) 109.8 *yrs*
(c) 10.98 *yrs* (d) 1.098 *yrs*

20. A radioactive sample has a half-life of 1500 years.A sealed tube containing $1gm$ of the sample will contain after 3000 years **[MNR 1994; UPSEAT 2001, 02]**

(a) $1gm$ of the sample
(b) $0.5gm$ of the sample
(c) $0.25gm$ of the sample
(d) $0.00gm$ of the sample

21. The half-life of a radioactive isotope is three hours. If the initial mass of the isotope were 256 *g*, the mass of it remaining undecayed after 18 *hours* would be **[AIEEE 2003]**

(a) 4.0 *g* (b) 8.0 *g*

(c) 12.0 *g* (d) 16.0 *g*

22. $\frac{15}{16}th$ of a radioactive sample decays in 40 *days* half-life of the sample is **[DCE 2001]**

(a) 100 *days* (b) 10 *days*

(c) 1 *day* (d) $\log_e 2$ *days*

23. A radioactive element with half-life 6.5 *hrs* has 48×10^{19} atoms. Number of atoms left after 26 *hrs* **[BHU 2003]**

(a) 24×10^{19} (b) 12×10^{19}

(c) 3×10^{19} (d) 6×10^{19}

24. The half-life of 1 *gm* of radioactive sample is 9 *hours*. The radioactive decay obeys first order kinetics. The time required for the original sample to reduce to 0.2 *gm* is **[AMU (Engg.) 2002]**

(a) 15.6 *hours* (b) 156 *hours*

(c) 20.9 *hours* (d) 2.09 *hours*

25. The half-life period of a radioactive substance is 140 *days*. After how much time 15 *g* will decay from 16 *g* sample of it **[AFMC 2002]**

(a) 140 *days* (b) 560 *days*

(c) 280 *days* (d) 420 *days*

26. Percentage of a radioactive element decayed after 20 *sec* when half-life is 4 *sec* **[BHU 2003]**

(a) 92.25 (b) 96.87

(c) 50 (d) 75

27. Consider an α-particle just in contact with a $_{92}U^{238}$ nucleus. Calculate the coulombic repulsion energy (*i.e.* the height of the coulombic barrier between U_{238} and alpha particle) assuming that the distance between them is equal to the sum of their radii **[UPSEAT 2001]**

(a) $23.8517 \times 10^4 eV$

(b) $26.147738 \times 10^4 eV$

(c) $25.3522 \times 10^4 eV$

(d) $20.2254 \times 10^4 eV$

28. The half-life period of Pb^{210} is 22 *years*. If 2 *gm* of Pb^{210} is taken, then after 11 *years* how much of Pb^{210} will be left **[KCET 2001]**

(a) 1.414 *gm* (b) 2.428 *gm*

(c) 3.442 *gm* (d) 4.456 *gm*

29. A wood specimen from an archeological centre shows a $^{14}_{6}C$ activity of 5.0 *counts/min/gm* of carbon. What is the age of the specimen ($t_{1/2}$ for $^{14}_{6}C$ is 5000 *years*) and a freshly cut wood gives 15 *counts/min/gm* of carbon **[AMU (Engg.) 2002]**

(a) 5.78×10^4 *years* (b) 9.85×10^4 *years*

(c) 7.85×10^3 *years* (d) 0.85×10^4 *years*

30. $_{92}U^{235} + n \rightarrow$ fission product+neutron $+ 3.20 \times 10^{-11} J$. The energy released when 1*g* of $_{92}U^{235}$ undergoes fission is **[CBSE PMT 1997]**

(a) $12.75 \times 10^8 kJ$ (b) $18.60 \times 10^9 kJ$

(c) $8.21 \times 10^7 kJ$ (d) $6.55 \times 10^6 kJ$

31. The triad of nuclei that is isotonic is **[IIT 1988; DCE 2000;MP PMT 2004]**

(a) $_6C^{14}, _7N^{15}, _9F^{17}$

(b) $_6C^{12}, _7N^{14}, _9F^{19}$

(c) $_6C^{14}, _7N^{14}, _9F^{17}$

(d) $_6C^{14}, _7N^{14}, _9F^{19}$

32. The relative abundance of two isotopes of atomic weight 85 and 87 is 75% and 25% respectively. The average atomic weight of element is **[DCE 2003]**

(a) 75.5 (b) 85.5

(c) 40.0 (d) 86.0

Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) If the assertion and reason both are false.
(e) If assertion is false but reason is true.

1. Assertion : Mass number of an atom is equal to total number of nucleons present in the nucleus.

Reason : Mass number defines the identity of an atom.

2. Assertion : $_1H^1, _1H^2$ and $_1H^3$ are isotopes of hydrogen.

Reason : Nuclides of the same element of different mass numbers are called isotopes of that element.

3. Assertion : The activity of 1 *g* pure uranium-235 will be greater than the same amount present as U_3O_8.

Reason : In the combined state, the activity of the radioactive element decreases.

4. Assertion : Nuclear forces are called short range forces.

Reason : Nuclear forces operate over very small distance *i.e.,* $10^{-15} m$ or 1 fermi.

5. Assertion : An example of *K*-capture is $^{133}_{56}Ba + e^- \rightarrow ^{133}_{55}Cs + X -$ ray.

Reason : The atomic number decreases by one unit as result of *K*-capture.

6. Assertion : Radioactive heavy nuclei decay by a series of $\alpha -$ and / or $\beta -$ emission, to form a stable isotope of lead.

Reason : Radioactivity is a physical phenomenon.

7. Assertion : Actinium series is so called because it starts with an isotope of actinium.

Reason : Actinium is formed in the nature as such and is not formed from the disintegration of any other radioisotope.

8. Assertion : For maximum stability *N*/*P* ratio must be equal to 1.

Reason : Loss of $\alpha -$ and $\beta -$ particles has no role in *N*/*P* ratio.

9. Assertion : The neutrons are better initiators of nuclear reactions, than the protons, deutrons or α- particles of the same energy.

Reason : Neutrons are uncharged particles and hence, they are not repelled by positively charged nucleus.

10. Assertion : Breeder reactor produces fissile $_{94}Pu^{239}$ from non-fissile uranium.

Reason : A breeder reactor is one that produces more fissionable nuclei that it consumes.

11. Assertion : The activation energies for fusion reactions are very low.

Reason : They require very low temperature to overcome electrostatic repulsion between the nuclei.

12. Assertion : The archeological studies are based on the radioactive decay of carbon-14 isotope.

Reason : The ration of *C*-14 to *C*-12 in the animals and plants is same as that in the atmosphere.

13. Assertion : Photochemical smog is produce by nitrogen oxides.

Reason : Vehicular pollution is a major sources of nitrogen oxides.

14. Assertion : A nuclear binding energy per nucleon is in the order $^{9}_{4}Be > ^{7}_{3}Li > ^{4}_{2}He$.

Reason : Binding energy per nuclear increases linearly with difference in number of neutrons and protons.

15. Assertion : Nuclear fission is always accompanied by release of energy.

Reason : Nuclear fission is a chain process.

[AIIMS 1994]

16. Assertion : Protones are more effective than neutrons of equal energy in causing artificial disintegration of atoms.

Reason : Neutrons are neutral they penetrate the nucleus. **[AIIMS 1998]**

17. Assertion : A beam of electrons deflects more than a beam of α-particles in an electric field.

Reason : Electrons possess negative charge while α-particles possess positive charge.

[AIIMS 2002]

18. Assertion : $^{22}_{11}Na$ emits a position giving $^{22}_{12}Mg$.

Reason : In β^+ emission neutron is transformed into proton. **[AIIMS 1994]**

Answers

Nucleus (Stability and Reaction)

1	b	2	b	3	a	4	a	5	b
6	d	7	b	8	c	9	c	10	d
11	b	12	c	13	c	14	c	15	c
16	c	17	d	18	c	19	a	20	b
21	b	22	a	23	b	24	d	25	c
26	c	27	b	28	c	29	b	30	a
31	c	32	d	33	b	34	d	35	c
36	b	37	b	38	a	39	a	40	a
41	b	42	b	43	a	44	d	45	b
46	d	47	b	48	a	49	b	50	d
51	d	52	a	53	b	54	c	55	d
56	b	57	b	58	d	59	b	60	c
61	b	62	d	63	d	64	d	65	a
66	b	67	a	68	a				

Radioactivity and α, β and γ- rays

1	c	2	d	3	a	4	b	5	c
6	b	7	c	8	c	9	b	10	b
11	a	12	a	13	a	14	b	15	c
16	c	17	a	18	a	19	c	20	b
21	a	22	c	23	d	24	b	25	c
26	d	27	d	28	c	29	c	30	a
31	d	32	c	33	a	34	b	35	a
36	c	37	a	38	acd	39	a		

Causes of radioactivity and Group displacement law

1	b	2	d	3	d	4	d	5	c
6	c	7	c	8	a	9	b	10	a
11	a	12	c	13	d	14	b	15	a
16	a	17	a	18	a,b,c	19	c	20	c
21	b	22	d	23	d	24	a	25	b
26	d	27	b	28	b	29	b	30	a
31	a	32	a	33	c	34	b	35	a
36	b	37	c	38	b	39	c	40	d
41	a	42	b	43	c	44	c	45	d
46	b	47	b	48	d	49	a	50	d
51	a	52	a	53	d	54	d	55	b
56	a	57	d	58	c	59	c	60	a
61	a	62	c	63	d	64	d	65	a
66	d	67	b	68	c	69	b	70	a
71	c	72	c	73	d	74	a	75	b

Rate of decay and Half-life

1	c	2	a	3	b	4	a	5	d
6	a	7	d	8	d	9	d	10	c
11	a	12	d	13	d	14	a	15	c
16	d	17	b	18	c	19	b	20	a
21	b	22	a	23	c	24	a	25	a
26	b	27	a	28	c	29	a	30	b
31	a	32	c	33	d	34	a	35	b
36	d	37	d	38	c	39	c	40	a
41	c	42	b	43	b	44	d	45	c
46	c	47	c	48	b	49	a	50	c
51	c	52	c	53	c	54	b	55	c
56	b	57	a	58	b	59	d	60	b
61	d	62	b	63	c	64	a	65	b
66	d	67	d	68	c	69	d	70	c
71	d	72	a	73	c	74	a	75	a
76	c	77	b	78	b	79	a	80	a
81	a	82	a	83	b	84	c		

Artificial transmutation

1	b	2	c	3	d	4	d	5	c
6	a	7	a	8	b	9	d	10	b
11	a	12	c	13	c	14	b	15	a
16	d	17	d	18	b	19	a	20	c
21	b	22	a	23	c	24	b	25	d
26	c	27	b	28	a	29	d	30	a
31	d	32	b	33	d	34	c	35	b
36	a	37	b	38	c	39	d	40	c
41	d	42	b	43	c	44	b	45	b
46	c	47	b	48	b	49	c	50	c
51	d	52	c	53	a	54	d	55	d
56	d	57	b,d	58	a	59	b	60	a
61	d	62	a	63	a	64	d	65	d
66	d	67	d	68	b	69	b	70	d
71	a	72	b	73	a	74	a	75	a
76	b	77	d	78	c	79	a	80	c
81	b								

Isotopes-Isotones and Nuclear isomers

1	b	2	a	3	d	4	a	5	c
6	c	7	c	8	b	9	b	10	d
11	a	12	b	13	a	14	a	15	a

16	c	17	b	18	c	19	c	20	a
21	d	22	d	23	a	24	c	25	c
26	d	27	c	28	b	29	b	30	b
31	cd	32	d	33	a	34	c	35	c
36	b	37	a	38	a	39	a	40	b
41	c	42	a	43	a	44	d	45	b
46	a	47	d	48	d	49	a	50	a
51	b	52	d	53	b	54	c	55	ac
56	d	57	bd						

Critical Thinking Questions

1	a	2	b	3	c	4	a	5	a
6	a	7	a	8	b	9	d	10	a
11	b	12	c	13	c	14	a	15	b
16	c	17	d	18	d	19	a	20	c
21	a	22	b	23	c	24	c	25	b
26	b	27	b	28	a	29	c	30	c
31	a	32	b						

Assertion & Reason

1	c	2	a	3	d	4	a	5	b
6	c	7	d	8	c	9	a	10	a
11	d	12	a	13	b	14	d	15	b
16	e	17	b	18	d				

Answers and Solutions

Nucleus (Stability and Reaction)

1. (b) Protons + Neutrons = Nucleons

2. (b) A deutron $({}_1H^2)$ contains a neutron and a proton

3. (a) Low binding energy causes radioactivity.

4. (a) ${}_7N^{14} + {}_2He^4 \rightarrow {}_8O^{17} + {}_1H^1$

5. (b) Follow Einstein mass-energy relation.

6. (d) Mass (weight) of positron and electron is $9.11 \times 10^{-31} kg$.

7. (b) ${}_3Li^6 + {}_0n^1 \rightarrow {}_2He^4 + {}_1H^3$

8. (c) ${}_7N^{14} + {}_0n^1 \rightarrow {}_6C^{14} + {}_1H^1$

9. (c) ${}_{17}Cl^{37} + {}_1H^2 \rightarrow {}_{18}Ar^{38} + {}_0n^1$

10. (d) Because of its high unstability.

12. (c) ${}_{90}Th^{234} \xrightarrow{-\beta} {}_{91}X^{234} \xrightarrow{-\beta} {}_{92}Y^{234} \xrightarrow{-\alpha} {}_{90}Z^{230}$.

13. (c) Isotopes of an element have similar chemical properties but different physical properties.

14. (c) A nuclear reaction must be balanced in terms of mass and energy.

15. (c) ${}_{52}Te^{130} + {}_1H^2 \rightarrow {}_{53}I^{131} + {}_0n^1$

16. (c) The emission of positron takes place.

18. (c) An ion is electrically charged atom or a group of atoms.

19. (a) Charge on positron and proton is about $+1.602 \times 10^{-19}\,C$.

20. (b) ${}_{12}Mg^{24} + {}_2He^4 \rightarrow {}_0n^1 + {}_{14}Si^{27}$

21. (b) The radioactive isotope ${}_6C^{14}$ is produced in the atmosphere by the action of cosmic ray neutrons on ${}_7N^{14}$

${}_7N^{14} + {}_0n^1 \rightarrow {}_6C^{14} + {}_1H^1$

23. (b) Tritium is the isotope.

24. (d) ${}_{21}Sc^{45}(n, p)\,{}_{20}Ca^{45}$ according to Beath's notation

25. (c) ${}_7N^{14} + {}_1H^1 \rightarrow {}_8O^{15} + \gamma$

26. (c) ${}_{93}Np^{239} \rightarrow {}_{94}Pu^{239} + {}_{-1}e^o$

27. (b) Equate atomic no. and mass no.

28. (c) Magic no. are 2, 8, 20, 28, 50 and 82 protons in nucleus or 2, 8, 20, 28, 50, 82, 126 neutrons in nucleus. These numbers imparts stability to nucleus.

30. (a) $\frac{n}{p}$ of ${}_{82}Pb^{208} = \frac{126}{82} = 1.53$

$\frac{n}{p}$ of ${}_{83}Bi^{209} = \frac{126}{83} = 1.51$

31. (c) According to Beath's notation ${}_{13}Al^{27}(n, p)\,{}_{12}Mg^{27}$.

32. (d) Azimuthal quantum no. is related to angular momentum.

33. (b) The value of $n = \frac{238 - 218}{4} = \frac{20}{4} = 5 - 1 = 4$

34. (d) Mass number increases by one unit.

36. (b) Equal atomic number and mass number.

37. (b) 1 *amu* = 931.478 *MeV*.

38. (a) Positron is anti-particle of electron.

39. (a) Isotopes are formed by the emission of one α - and two β -particles respectively.

40. (a) The $\frac{n}{p}$ ratio of stable nucleoide is $\frac{n}{p} = 1$.

41. (b) Neutrino have no mass and no charge and thus known as ghost particles.

42. (b) Equate mass number and atomic number on both sides.

43. (a) Due to mass decay.

44. (d) Mesons (μ) have 200-300 times mass of electron and + *ve*, 0 or – *ve* charges.

45. (b) ${}_{+1}e^o$ is positron.

46. (d) *Pb* is the most stable atom.

47. (b) Anderson discovered positron in 1932.

48. (a) Even-Even are most stable

Odd- Odd are most unstable

49. (b) The atom which have lower value of packing fraction is stable.

50. (d) Number of neutrons in ${}_{88}Ra^{226} = 226 - 88 = 138$.

51. (d) Nuclear reactions involves exchange of nuclear energy.

52. (a) ${}_{11}Na^{23} + {}_1H^1 \rightarrow {}_{12}Mg^{23} + {}_0n^1$

53. (b) ${}_{92}U^{235}$ is radioactive because it is most unstable.

54. (c) Equate atomic no. and mass no.

57. (b) ${}_4Be^9 + {}_2He^4 \rightarrow {}_6C^{12} + {}_0n^1$

58. (d) According to group displacement law.

59. (b) ${}^9_4Be + \underset{(p)}{{}_1H^1} \rightarrow {}^6_3Li + \underset{(\alpha - particle)}{{}_2He^4}$

60. (c) ${}^{40}_{18}Ar$ having 40 – 18 = 22 neutrons

While ${}^{40}_{21}Sc$ having 40 – 21 = 19 neutrons.

61. (b) Nuclear reactivity depends upon the number of protons and neutrons.

63. (d) ${}_{29}Cu^{64} \rightarrow {}_{28}Ni^{64} + {}_{+1}e^0$

65. (a) ${}^{24}_{12}Mg + {}_1D^2 \rightarrow {}_2He^4 + {}^{22}_{11}Na$

66. (b) Equate atomic no. and mass no.

67. (a) ${}_{96}X^{227} \rightarrow Y + 4\alpha + 5\beta$

On equating mass number

227 = *y* + 4 × 4 + 0, $y = 211$

On equating atomic number

96 = *y* + 2 × 4 – 5, *y* = 93.

68. (a) Meson was discovered by Yukawa

Radioactivity and α, β and γ- rays

1. (c) γ – rays does not contain material particles.

2. (d) γ -rays are neutral energy packet.

3. (a) The order of penetrating power is : $\alpha < \beta < \gamma$-rays. It is due to lower mass and high speed.

4. (b) α-rays travel with a velocity which is $\frac{1}{10}$ *th* to $\frac{1}{20}$ *th* of that of light.

5. (c) γ-rays have maximum penetrating power.

6. (b) α-particles are 4 time heavier than neutrons.

7. (c) ${}_{92}U^{235} + {}_0n^1 \rightarrow {}_{56}Ba^{145} + {}_{36}Kr^{88} + 3{}^1_0n$

8. (c) Rutherford first of all used zinc sulphide (ZnS) as phosphor in the detection of α-particles.

9. (b) α-rays consist of a stream of He^{2+}.

10. (b) α-rays are positively charged, β-rays are negatively charged, γ-rays carry no charge and thus not deflected in field.

11. (a) α-particle is identical with $_2He^4$ helium nucleus.

12. (a) γ-rays have maximum penetrating power.

13. (a) Henry Becquerel noticed the emission of penetrating rays from potassium uranyl sulphate and Madam Curie named it as radioactivity.

15. (c) Penetrating powers $\alpha-\text{rays} < \beta-\text{rays} < \gamma-\text{rays}$

17. (a) α-rays are positively charged, β-rays are negatively charged, γ-rays carry no charge.

20. (b) Deflection in β-rays is large.

21. (a) Penetrating power of α-rays are less than β, γ and X-rays.

22. (c) Lead is a stable isotope.

23. (d) Neutrons carry no charge.

24. (b) α-rays has least penetrating power.

25. (c) γ-rays carry no charge.

26. (d) Proton is not emitted by radioactive substances.

27. (d) Due to it's nature.

28. (c) $_{88}Ra^{226}$ is radioactive because $\frac{n}{p}$ ratio for it is 1.56 which is greater than 1.5.

30. (a) Cf – 98 belongs to actinid series.

31. (d) Photons are not carry any charge.

32. (c) $_7N^{14} + _2He^4(\alpha-\text{particle}) \rightarrow _8O^{17} + _1H^1$

33. (a) Definition of binding energy.

34. (b) α – particle is $_2He^4$.

35. (a) Gamma ray doesn't deviate from electromagnetic field, the main reason of it is that there is no charge on gamma rays.

36. (c) Energy liberated = loss of mass $\times 931$

$= 0.01864 \times 931 = 17.36\, MeV$

38. (acd) Beta emission causes increase in atomic number by one unit.

39. (a) Mass loss = mass of reactant – mass of product.

$= (2.014 + 3.016) - (4.004 + 1.008)$

$= 5.030 - 5.012 = 0.018\, amu$

Causes of Radioactivity and Group Displacement Law

1. (b) In $_{95}Am^{241}$ the mass no. division by four gives a residue of 1.

In $_{90}Th^{234}$ the mass no. division by four gives a residue of 2.

2. (d) On emission of α-particles daughter element shift 2 group to the left. On emission of β-particles daughter element shift 1 group to the right.

3. (d) Protons + Neutrons = Nucleons

4. (d) Radioactivity is characteristic property of unstable nucleus.

5. (c) Chemical change is extra nuclear phenomenon.

6. (c) $_{92}U^{238} \xrightarrow[-6\beta]{-8\alpha} _{82}X^{206}$

Number of protons = 82; Number of neutrons = 124

Neutron/proton ratio in the product nucleus $= \frac{124}{82} = \frac{62}{41}$

7. (c) $_{84}X^{218} \rightarrow _{84}Y^{214} + x\, _{+2}\alpha^4 + y\, _{-1}\beta^0$

no. of α-particle = $\frac{218-214}{4} = \frac{4}{4} = 1$

no. of β-particle = $84 - 84 + 2 \times 1 = 2$.

8. (a) When an α-particle is emitted by any nucleus than atomic weight decreases by four units and atomic number decreases by two units

$_{88}Ra^{224} \xrightarrow{-\alpha} _{86}X^{220}$

9. (b) Number of α-particles = $\frac{231-207}{4} = 6$

Number of β-particles $= 89 - 82 - 2 \times 6 = 5$.

10. (a) $_{90}Th^{228} \rightarrow _{83}Bi^{212}$

No. of α-particles = $\frac{228-212}{4} = \frac{16}{4} = 4$

No. of β-particles = $90 - 83 - 2 \times 4 = 1$.

11. (a) $_6C^{14} \rightarrow _7N^{14} + _{+1}e^0$

No. of neutrons in $C^{14} = 14 - 6 = 8$.

12. (c) $_{92}X^{238} \xrightarrow{-\alpha} _{90}Y^{234}$

Number of neutrons = $234 - 90 = 144$.

13. (d) $_ZA^m \rightarrow _{Z+1}B^m + _{-1}e^0$

14. (b) $r = \lambda . N$

15. (a) $_on^1 \rightarrow _{+1}P^1 + _{-1}e^0$ (β-particle comes out)

16. (a) Element 57 to 71 are placed in III group.

17. (a) $_5X^{14} \xrightarrow{-2\beta} _7N^{14}$ than no. of neutrons in $_5X^{14} = 14 - 5 = 9$.

18. (a,b,c) An emission of β-particle means that atomic number increases by 1 but mass number remains unaffected and neutron- proton ratio decreases.

19. (c) Suppose the no. of α-particles emitted = x and the no. of β-particles emitted = y, then

$_{92}U^{238} \rightarrow _{82}Pb^{206} + x\, _{+2}\alpha^4 + y\, _{-1}\beta^0$

Equating the mass number on both sides, we get

$238 = 206 + 4x + 0y$ or $4x = 32$ or $x = \frac{32}{4} = 8$

Hence 8 α-particles will be emitted.

20. (c) *Pb* is the end product of each natural radioactive series.

21. (b) The $\frac{n}{p}$ ratio of ${}_{13}Al^{29}$ places it above the belt of stability and thus it emits β-particles.

22. (d) ${}_{Y}A^{X} \rightarrow {}_{Y-10}B^{X-32} + m\,{}_{2}He^{4} + n\,{}_{+1}e^{0}$

Value of $m = \frac{X-(X)-32}{4} = 8$

Value of $n = Y - Y - 10 - 2 \times 8 = 6$.

23. (d) During β-decay atomic mass is unaffected while atomic no. increases by one unit.

24. (a) Equate atomic number and mass no.

25. (b) ${}_{90}X^{232} \xrightarrow{-2\beta} {}_{92}Y^{232} \rightarrow {}_{82}Z^{212} + x\,{}_{2}He^{4}$

No. of α-particles $= \frac{232-212}{4} = \frac{20}{4} = 5$.

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

no. of neutrons = 234 – 91 = 143.

27. (b) $\underset{\text{Gr.2}}{{}_{Z}A^{M}} \xrightarrow{-\alpha} \underset{\text{Gr.18}}{{}_{Z-2}B^{M-4}} \xrightarrow{-\alpha} \underset{\text{Gr.16}}{{}_{Z-4}C^{M-8}}$.

28. (b) Equate atomic no. and mass no.

29. (b) The mass no. on division by four gives a residue of 2.

30. (a)

Series	Name of the series	Parent element	End stable element
$4n$	Thorium series	Th-232	*Pb*–208
$4n + 1$	Neptunium series	Pu-241	*Bi*–209
$4n + 2$	Uranium series	U-238	*Pb*–206
$4n + 3$	Actinium series	U-235	*Pb*–207

31. (a) ${}_{8}O^{16} + {}_{1}H^{2} \rightarrow {}_{9}F^{18}$

32. (a) ${}_{84}A^{218} \rightarrow {}_{84}B^{214} + {}_{2}He^{4} + 2\,{}_{-1}e^{0}$.

33. (c) It is also called Soddy and Fajan rule.

34. (b) ${}_{84}Po^{215} \rightarrow {}_{82}Pb^{211} + {}_{2}He^{4}$

35. (a) ${}_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4}$

36. (b) $N = \frac{N_o}{2^n}$ and $n = \frac{24}{8} = 3$

$N = \frac{40}{2^3} = \frac{40}{8} = 5$

37. (c) ${}_{20}Ca^{42} \rightarrow {}_{21}Sc^{42} + {}_{-1}e^{0}$

38. (b) ${}_{A}X^{M} \xrightarrow{-\alpha} {}_{A-2}Y^{M-4}$

39. (c) ${}^{24}_{12}Mg + \gamma \longrightarrow {}^{23}_{11}Na + {}^{1}_{1}H$.

40. (d) An element formed by losing one α-particle occupies two position left to parent element, *Pb* in IVA, thus *Po* should be in VIA.

41. (a) According to group displacement law.

42. (b) Number of α-particles $= \frac{238-206}{4} = 8$

Number of β-particles $= 92 - 82 - 2 \times 8 = 6$.

43. (c) ${}_{40}X \rightarrow {}_{41}Y + {}_{-1}e^{0}$ (β-emission)

44. (c) $n = \frac{90}{30} = 3 \Rightarrow N = \frac{600}{2^3} = 75$ atoms.

45. (d) Equate mass no. and atomic no.

46. (b) ${}_{92}U^{236} \rightarrow {}_{90}X^{232} + {}_{2}He^{4}$

${}_{90}X^{232}$ have 90 protons and 142 neutrons.

47. (b) α-rays have high I.P. due to high kinetic energy.

48. (d) Going two positions back from 2nd group gives zero group.

49. (a) *Ra* belongs to $(4n+2)$ series. End product will also belong to the same series.

50. (d) *Ra* contaminated with uranium mineral shows appreciable radioactivity.

51. (a) ${}_{92}U^{238} \rightarrow {}_{82}Pb^{206} + x\,{}_{+2}\alpha^{4} + y\,{}_{-1}\beta^{0}$

no. of α-particles $= \frac{238-206}{4} = 8$

no. of β-particles $= 92 - 82 - 2 \times 8 = 6$

Total no. of particles $= 8 + 6 = 14$.

52. (a) According to Group displacement law.

53. (d) Rate = λ × number of atoms.

54. (d) ${}_{90}Th^{232} \rightarrow {}_{82}Pb^{208} + x\,{}_{2}He^{4} + y\,{}_{-1}\beta^{0}$

Equating mass no.

$232 = 208 + 4x + 0y$ or $4x = 24$ or $x = 6$

Equating atomic no.

$90 = 82 + 2x - y$ or $90 = 82 + 2 \times 6 - y$ or $y = 4$

Hence 6α and 4β particles will be emitted.

55. (b) ${}_{Z}A^{m} \rightarrow {}_{Z+1}B^{m} + {}_{-1}e^{0}$

56. (a) The mass no. division by four gives a residue of 1

57. (d) ${}_{A}X^{m} \xrightarrow{-\beta} {}_{A+1}Y^{m}$

58. (c) Suppose the no. of α-particles emitted $= x$ and the no. of β-particles emitted $= y$. Then

${}_{92}U^{238} \rightarrow {}_{82}Pb^{206} + x\,{}^{4}_{+2}\alpha + y\,{}^{0}_{-1}\beta$

equating the mass number on both sides, we get

$238 = 206 + 4x + 0y$ or $4x = 32$, $x = 8$

equating the atomic number on both sides, we get

$92 = 82 + 2x - y$

$92 = 82 + 2 \times 8 - y$

$y = 6$

Hence 8 α and 6β are emitted.

59. (c) $k=\frac{0.693}{t_{1/2}}=\frac{0.693}{1000\,s}=0.000693=6.93\times10^{-4}\,s^{-1}$

60. (a) *Bi* is a stable end product of Neptunium series.

62. (c) *Pb* – 208 is the stable end product of thorium series.

63. (d) Definition of disintegration series.

64. (d) ${}_6X^{14}\xrightarrow{\beta}{}_{6+1}N^{14}$

in ${}_6X^{14}$ no. of neutrons 14 – 6 = 8.

65. (a) ${}_{18}Ar^{40}$

Total no of protons = 18

Total no of neutrons = 22

Mass defect $=[m\times p+m\times n]-39.962384$

$=[1.007825\times18+1.008665\times22]-39.962384$

$=[18.14085+22.19063]-39.962384=0.369$

Binding energy = mass defect × 931

$=0.369\times931=343.62\,MeV$

66. (d) ${}_{90}Th^{232}\longrightarrow{}_{82}Pb^{208}$

No. of α - particle $\Rightarrow\frac{232-208}{4}=6$

No. of β - particle $\Rightarrow82-[90-6\times2]=4$

67. (b) ${}_{92}M^{238}\longrightarrow{}_yN^x+2\,{}_2He^4$

${}_yN^x\longrightarrow{}_BL^A+2\beta^+$

${}_yN^x={}_{(92-2\times2)}N^{(238-4\times2)}={}_{88}N^{230}$

${}_{88}N^{230}\xrightarrow{2\beta^+}{}_{(88-2)}L^{(230)}={}_{86}L^{230}$

Total no of neutrons in ${}_{90}L^{330}$

$230-86=144$

68. (c) ${}_{90}E^{232}\longrightarrow{}_{86}G^{220}$

No. of α particle $=\frac{232-220}{4}=3$

No. of β particle $=86-[90-2\times3]=2$

69. (b) $K=\frac{0.693}{t_{1/2}}=\frac{0.693}{1600}$

$=4.33\times10^{-4}\,year^{-1}$

70. (a) ${}_{92}U^{238}\longrightarrow{}_{90}Th^{234}\longrightarrow{}_{91}Pa^{234}$

No. of α particle $=\frac{238-234}{4}=\frac{4}{4}=1$

No. of β particle $=91-90=1$

72. (c) $K=\frac{0.693}{t_{1/2}}$

$t_{1/2}=\frac{0.693}{K}=\frac{0.693}{0.58}\Rightarrow1.2\,hrs$

73. (d) A radioisotope first emits α or β particles, then it becomes unstable and emits γ -rays.

74. (a) ${}^{180}_{72}X\xrightarrow{2\alpha}{}^{172}_{68}P\xrightarrow{\beta}{}^{172}_{69}Q\xrightarrow{\gamma}{}^{172}_{69}X$.

75. (b) Loss of beta particle is equivalent to decrease of one neutron only.

$n\rightarrow p+e^-+\bar{v}$.

Rate of decay and Half-life

1. (c) $n=\frac{16}{8}=2,\ N=\frac{N_o}{2^n}=\frac{16.0}{2^2}=\frac{16.0}{4}=4.0\,gm.$

2. (a) Mass of 6 neutrons = 6.05358 *amu*, Mass of 6 protons = 6.04884 *amu*, Mass of *n* + Mass of *p* =12.10242 *amu*

Mass defect = 12.10242 – 12.00710 = 0.09532

Binding energy = 0.09532 × 931 = 88.74292 *MeV*.

Binding energy per neucleon = 88.74292/12 =7.39 *MeV*

3. (b) $T=t_{1/2}\times n,\ \therefore\ n=\frac{80}{20}=4$

Amount left $=\frac{1}{2^n}=\frac{1}{2^4}=\frac{1}{16}$.

4. (a) ${}_{92}X^{232}\rightarrow{}_{89}Y^{220}+x\,{}_2He^4+y\,{}_{-1}e^o$

no. of α -particles = $\frac{232-220}{4}=3$

no. of β -particles = 89 –[92 – 2 × 3] = 3.

5. (d) It is occurs by β -decay.

6. (a) $N=\left[\frac{1}{2}\right]^n\times N_o$ = 125 *mg* = $\left(\frac{1}{2}\right)^n\times1000\,mg$

$\left(\frac{1}{2}\right)^n=\frac{125}{1000}=\frac{1}{8}$

$\left(\frac{1}{2}\right)^n=\left(\frac{1}{2}\right)^3,n=3,$ so number, of $t_{1/2}=3$

Total time = 24 hours, Half-life time $=\frac{24}{3}=8\,\text{hours}$.

8. (d) ${}_{35}X^{88}\xrightarrow{-\beta}{}_{36}W^{88}\rightarrow{}_{36}W^{87}+{}_on^1$

9. (d) 75% of the substance disintegrates in two half lives.

2 half lives = 30 min $\therefore t_{1/2}=15\,\text{min}$.

10. (c) γ -rays are electromagnetic waves.

11. (a) Average life

$(\tau)=1.44\ t_{1/2}=1.44\times69.3=99.7\approx100$ minutes.

12. (d) $N=\left[\frac{1}{2}\right]^n\times N_o$

$1.25=\left[\frac{1}{2}\right]^n\times10$

$\left[\frac{1}{2}\right]^n=\frac{1.25}{10}=\frac{1}{8}=\left[\frac{1}{2}\right]^3,n=3$

Half-life time = $\frac{15}{3} = 5$ days.

13. (d) $n = \frac{12}{3} = 4$

$\therefore\ N_o = N \times 2^n = 3 \times 2^4 = 48g$.

14. (a) ${}_6C^{14} \rightarrow {}_7N^{14} + {}_{-1}e^o$, β-active.

15. (c) $2.303 = \frac{2.303}{0.693} \times t_{1/2} \log 10$

$\because\ N = \frac{N_o}{10}\ \therefore \frac{N_o}{N} = 10$.

16. (d) Amount left $= \frac{N_o}{2^3} = \frac{100}{8} = 12.5\%$

17. (b) $N = \frac{N_o}{64} = \frac{N_o}{2^6}\quad \therefore n = 6$

Thus total time $= 2 \times 6 = 12hr$.

18. (c) β-decay occurs by the nuclear change $n \rightarrow p + {}_{-1}e^0$.

19. (b) $t_{1/2} = \frac{\log_e 2}{\lambda}$, Average life $= \frac{1}{\lambda}$

20. (a) $N = \frac{N_o}{2^n}, n = \frac{60}{20} = 3; N_o = 1g,$ then $N = \frac{1}{2^3} = \frac{1}{8}$.

21. (b) $t_{1/2}$ of zero order reaction is independent of the concentration.

22. (a) Half-life is 1 *hr* and thus in each half-life, half of the sample decays.

23. (c) $t = \frac{2.303 \times t_{1/2}}{0.693} \log \frac{N_o}{N}, N = 0.798\, N_o$

24. (a) Half-life is independent of initial amount.

25. (a) 80 years = 4 half lives

Activity after n half lives $= \frac{1}{2^n} \times a$.

26. (b) $t_{1/2}$ is independent of all external factors and is constant for a given species.

27. (a) In nucleus electrons formed by the following decay. ${}_0n^1 \rightarrow {}_{+1}P^1 + {}_{-1}e^0$

28. (c) $t_{1/2} = 2.95\ days$

= 2.95 × 24 × 60 × 60*s* = 254880

$\lambda = \frac{0.693}{t_{1/2}} = \frac{0.693}{254880} = 2.7 \times 10^{-6} s^{-1}$

29. (a) When a radioactive element emits an α-particle, the atomic no. of the resulting nuclide decreases by two units and atomic mass decreases by 4 units.

30. (b) $t_{1/2} = \frac{0.693}{k} = \frac{0.693}{2.31 \times 10^{-4}} = 0.3 \times 10^4 yrs$

$= 3.0 \times 10^3 yrs.$

31. (a) $N = N_0 \left(\frac{1}{2}\right)^n$. $n = \frac{40}{10} = 4$

$\frac{125}{1000} = N_0 \left(\frac{1}{2}\right)^4, N_0 = \frac{125}{1000} \times 2 \times 2 \times 2 \times 2 = 2g$

32. (c) Binding energy per nucleon = $\frac{127}{16} = 7.94\, MeV$.

33. (d) $k = \frac{0.693}{t_{1/2}} = \frac{0.693}{138.6\, min} = 0.005\, min^{-1}$

34. (a) Half-life period is independent of initial amount.

35. (b) t = Feb 1 to July 1 = $28 + 31 + 30 + 31 + 30 = 150$ days

$\lambda = \frac{2.303}{150} \log \frac{8}{0.25} = \frac{2.303}{150} \log 2^5 = \frac{0.693}{30} \text{day}^{-1}$

$t_{1/2} = \frac{0.693}{0.693/30} = 30$ days .

36. (d) $t = \frac{2.303 \times t_{1/2}}{0.693} \log \frac{N_o}{N}$

37. (d) $n = \frac{480}{120} = 4,\ N = \frac{N_o}{2^n}, N = \frac{4}{2^4} = \frac{4}{16}$ = 0.25 *gm*.

38. (c) $n = \frac{28}{7} = 4, N = \frac{N_o}{2^n}, N = \frac{1}{2^4} = \frac{1}{16} = 0.0625$ *gm*.

39. (c) $\lambda = \frac{2.303}{t} \log \frac{[N_o]}{[N]} = \frac{2.303}{96} \log \frac{1}{1/8}$

$= \frac{2.303}{98} \times 0.9 = 0.0216$

$\therefore\ t_{1/2} = \frac{0.693}{\lambda} = \frac{0.693}{0.0216} = 32.0$ min .

40. (a) $25 = \left[\frac{1}{2}\right]^n \times 100, \left[\frac{1}{2}\right]^n = \frac{25}{100} = \frac{1}{4} = \left[\frac{1}{2}\right]^2$

n = 2, No. of half lives = 2

so time required = $2 \times 5760 = 11520$ *yr*.

41. (c) $t_{1/2} = 100$ *years*.

42. (b) Average life $(\tau) = \frac{1}{\lambda}$.

43. (b) $\frac{1}{16} = \frac{1}{2^n}$ or $\frac{1}{2^4} = \frac{1}{2^n}$ or $n = 4$

$\therefore$ Required time $= 4 \times t_{1/2} = 120 min$.

44. (d) The time required for complete decay (I order) is always infinite.

45. (c) After half-life time the half of the substance will be decayed.

46. (c) $n = \frac{15}{5} = 3, N = \frac{N_o}{2^n} = \frac{20}{2^3} = \frac{20}{8} = 2.5gm.$

47. (c) ${}_6X^{14} \xrightarrow{-3\beta} {}_9Y^{14}$

48. (b) $N = \frac{25}{100} N_o$ (at $t = 32$ *minutes*)

Thus $t = \frac{2.303}{0.693} \times t_{1/2} \log \frac{N_o}{N}$

49. (a) Half-life period is a characteristic of radioactive isotope which is independent of initial concentration.

50. (c) $n = \frac{24}{8} = 3,\ N = \frac{N_o}{2^n} = \frac{1}{2^3} = \frac{1}{8} mg$.

51. (c) Because $t_{1/2} = 4.5 \times 10^9$ years, so after 4.5×10^9 years the amount of $_{92}U^{238}$ will be half decayed.

52. (c) $r = \frac{0.693}{t_{1/2}} \times N_o$

$= \frac{0.693}{1600 \times 365 \times 24 \times 60 \times 60} \times \frac{6.023 \times 10^{23}}{226}$

$= 3.7 \times 10^{10} dps$.

53. (c) $t = \frac{2.303 \times t_{1/2}}{0.693} \log \frac{N_o}{N}; N = \frac{1}{16}$

54. (b) $t_{1/2} = \frac{0.693}{k \text{ or } \lambda}$

55. (c) $n = \frac{3}{1} = 3; N = \frac{N_o}{2^3} = \frac{1}{8}$

56. (b) $N = N_0 \times \left(\frac{1}{2}\right)^n$

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

$t = n \times t_{1/2} = 1 \times 6000 = 6000$ yrs.

57. (a) For Ist order $t_{1/2} = 0.693\ K^{-1}$.

58. (b) 75% of the substance disintegrates in two half lives 2 half lives = 60 min. $\therefore t_{1/2} = 30$ min .

59. (d) $\frac{0.693}{t_{1/2}} = \frac{2.303}{180} \times \log \frac{100}{12.5}$

$t_{1/2} = \frac{0.693 \times 180}{2.303 \times 3 \times 0.3010} = 60 min = 1 hr.$

60. (b) Tritium $(_1H^3 \rightarrow {}_2He^3 + {}_{-1}e^0)$ is a β-emitter.

61. (d) $t_{1/2} = \ln 2/\lambda$

62. (b) $t_{1/2} = \frac{0.693}{\lambda} = \frac{0.693}{231 \sec^{-1}} = 3.0 \times 10^{-3}$ sec.

63. (c) The amount of $_{53}I^{128}$ left after 50 minutes will be

= 25 minutes $= \frac{100}{25} = \frac{1}{4}$.

64. (a) $N = \frac{25}{100} N_o (\text{at } t = 2\,hr)$

Thus $t = \frac{2.303}{0.693} \times t_{1/2} \log \frac{N_o}{N}$

65. (b) Radioactive decay is a first order reaction.

66. (d) $t_{1/2}$ is independent of all external factors.

67. (d) Rate of decay of radioactive species is independent of all external factors.

68. (c) $n = \frac{100}{25} = 4, N = \frac{N_o}{2^n} = \frac{100}{2^4} = \frac{100}{16} = 6.25 gm$.

69. (d) $_{92}U^{235} + {}_0n^1 \rightarrow {}_{56}Ba^{145} + {}_{36}Kr^{88} + 3{}_0^1n$

70. (c) Half-life is independent of initial amount.

71. (d) $t_{1/2} = \frac{0.693}{k} = \frac{0.693}{6.93 \times 10^{-6}} = 0.1 \times 10^6 = 10^5 yrs$.

72. (a) 1 milli curie $= 3.7 \times 10^7 dps$

1.5 milli curie $= 5.55 \times 10^7 dps$

$\frac{5.55 \times 10^7}{N_o} = \lambda = 1.37 \times 10^{-11}$

73. (c) $\frac{N}{N_o} = \left(\frac{1}{2}\right)^{\frac{T}{t_{1/2}}}$; $\frac{N}{N_o} = \left(\frac{1}{2}\right)^{\frac{75}{25}}$; $\frac{N}{N_o} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$

74. (a) $\frac{N}{N_o} = \left(\frac{1}{2}\right)^{\frac{T}{t_{1/2}}}$; $\frac{N}{200} = \left(\frac{1}{2}\right)^{\frac{24}{4}}$; $\frac{N}{200} = \left(\frac{1}{2}\right)^6$

$N = \frac{200}{64} = 3.125\ g$

75. (a) $_xX^y \xrightarrow{2\beta} {}_7N^{14}$

$_{x=7-2}X^{y=14} = {}_5X^{14}$

Total no. of neutrons =14 - 5 = 9

76. (c) $K = \frac{0.693}{t_{1/2}}$; $K = \frac{0.693}{10} = 0.0693\ yr^{-1}$

77. (b) $\frac{N}{N_o} = \left(\frac{1}{2}\right)^{\frac{T}{t_{1/2}}}$; $\left(\frac{1}{16}\right) = \left(\frac{1}{2}\right)^{\frac{192}{t_{1/2}}}$; $\left(\frac{1}{2}\right)^4 = \left(\frac{1}{2}\right)^{\frac{192}{t_{1/2}}}$

$t_{1/2} = 48$ min

78. (b) $_{92}U^{235} \xrightarrow{-\alpha} (A) \xrightarrow{-\beta} (B) \xrightarrow{-\beta} (C)$

(i) $_{92-2}A^{235-4} = {}_{90}A^{231}$

(ii) $_{90}A^{231} \xrightarrow{-\beta} {}_{(90+1)}B^{(231)} = {}_{91}B^{231}$

(iii) $_{91}B^{231} \xrightarrow{-\beta} {}_{(91+1)}C^{231} = {}_{92}C^{231}$

Isotopes are $_{92}U^{235}$ and C

80. (a) $t_{1/2} = \frac{0.693}{K} = \frac{0.693}{2.34} = 0.296$ sec

81. (a) $K = \frac{0.693}{T_{1/2}} = \frac{0.693}{5770}$

$\therefore\ t = \frac{2.303}{K} \log \frac{100}{72} = \frac{2.303 \times 5770}{0.693} \log \frac{100}{72}$

$= 19175.05 \times (\log 100 - \log 72)$

$19175.05 \times 0.143 = 2742.03$ years.

82. (a) For 25% decay

$K = \frac{2.303}{20} \log \frac{100}{75} = \frac{2.303}{20} \times 0.1249 = 0..1438$

For 75% decay,

$t = \frac{2.303}{0.01438} \log \frac{100}{25} = 96.4$ minute.

83. (b) $N = N_0 \left(\frac{1}{2}\right)^n \Rightarrow \frac{N}{N_0} = \left(\frac{1}{2}\right)^n$

or $\frac{1}{64} = \left(\frac{1}{2}\right)^n \Rightarrow \left(\frac{1}{2}\right)^6 = \left(\frac{1}{2}\right)^n \Rightarrow n = 6$

$T = t_{1/2} \times n = 2 \times 6 = 12$ hours.

After 12 hours, sample became non-hazardous.

84. (c) Half-life of same substance remains same.

Artificial transmutation

1. (b) $C-14$ dating method is used in estimate the age of most ancient geological formation.

2. (c) Joining up of two lighter nuclei is fusion.

5. (c) Equate atomic no. and mass no.

6. (a) For studies on carbon dating, W. F. Libby was awarded a Nobel prize.

7. (a) Spallation reactions are similar to fission reactions. They brought about by high energy bombarding particles or photons.

9. (d) Uranium or Plutonium are atomic fuel.

11. (a) It is the required technique.

12. (c) $N_t = N_o\left(\frac{1}{2}\right)^n = 32\times\left(\frac{1}{2}\right)^{49.2/12.3} = 32\times\left(\frac{1}{2}\right)^4 = 2$.

14. (b) In hydrogen bomb, the following reaction is occur,

$${}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + {}_0^1n + \text{energy} \ .$$

15. (a) Heavy water is D_2O.

16. (d) Einstein's law is $E = mc^2$.

17. (d)

18. (b) 11460 years = 2 half lives

Activity left = 25% = 0.25.

19. (a) The control rods used in nuclear reactor are made up of *Cd* – 113 or *B* -10. They can absorb neutrons.

20. (c) The radioactive isotope ${}_6C^{14}$ is produced in the atmosphere by the action of cosmic ray neutrons on ${}_7N^{14}$

22. (a) Heavy water (D_2O) is used as a moderator in a nuclear reactor. It slows down the speed of neutrons. It also acts as a coolant.

23. (c) Uranium or Plutonium are atomic fuel.

24. (b) atom bomb is based on the principal of nuclear fission.

25. (d) Hahn and Strassmann discovered the phenomenon of nuclear fission in 1939.

26. (c) Rate of disintegration is not affected by environmental conditions.

27. (b) It is believed that when an α or β-particle is emitted, the nucleus becomes excited *i.e.* has higher energy and emits the excess energy in the from of radiation which form γ-rays.

28. (a) Packing fraction $= \frac{\text{Isotopic mass} - \text{Massnumber}}{\text{Massnumber}}\times 10^4$

30. (a) C^{14} is a natural radioactive isotope of C^{12}.

31. (d) $t_{1/2} = 10 yrs, t = 20 yrs.$

$$\therefore n = \frac{t}{t_{1/2}} = \frac{20}{10} = 2$$

$$N = \frac{N_o}{2^2} = \frac{1}{4}N_o = \frac{1}{4}\times 100\,\%\text{ of } N_o = 25 \ .$$

32. (b) Due to evolution of nuclear energy as a result of mass decay.

33. (d) Heavy water (D_2O) is used as a moderator in nuclear reactor.

34. (c) It is a transformation of chlorine.

35. (b) 48 *gm* of radioactive sodium will need 32 hours to become 3.0 *gm*.

36. (a) Mass decay occurs.

37. (b) In hydrogen bomb, the following reaction is occur,

$${}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + {}_0^1n + \text{energy} \ .$$

38. (c) A reason for the *C*-14 dating technique.

39. (d) $t = \frac{2.303}{k}\log\frac{a}{0.99a}, (a-x) = \frac{99}{100} = 0.99a$

But $k = \frac{0.693}{t_{1/2}} = \frac{0.693}{10.6} = 0.0653$ *year*$^{-1}$

$$t = \frac{2.303}{0.0653}\log\frac{1}{0.99} = 70.4 yrs.$$

41. (d) D_2O is heavy water.

42. (b) D_2O is used as moderator in nuclear reactor.

45. (b) Liquid sodium use in nuclear reactors as heat exchanger or coolant.

46. (c) Due to heavy mass α-particles can not easily pass through solid matter so they are less effective for artificial transmutation.

47. (b) Given $N_o = 1, N_t = 0.70$ and $t_{1/2} = 5760$ *yrs*.

$$k = \frac{0.693}{t_{1/2}} = \frac{0.693}{5760} \ .$$

We also know, $k = \frac{2.303}{t}\log\frac{N_0}{N_t}.\frac{0.693}{5760}$

or $t = \frac{2.303\times 5760\times 0.155}{0.693} = 2966 yrs.$

48. (b) The splitting of a heavier atom like that of *U*-235 into a number of fragments of much smaller mass by suitable bombardment with sub-atomic particles with liberation of huge amount of energy is called nuclear fission.

49. (c) ${}_{13}Al^{28} + {}_2He^4 \rightarrow {}_{15}P^{31} + {}_0n^1$

50. (c) Rate of radioactivity is independent of all external factors.

51. (d) I^{131} is used for goitre therapy, *i.e.* iodine deficiency.

52. (c) *C*-14 is found in nature abundantly and in definite ratio.

53. (a) Astatine (At) is resembles in properties with iodine.

56. (d) Equate mass number and atomic number.

57. (b,d) D_2O is used as moderator in nuclear reactor.

58. (a) The rate of disintegration is expressed in terms of the number of disintegrations per second.

59. (b) ${}_6C^{14}$ is used in dating archeological findings.

60. (a) $n=\frac{40}{20}=2$

$\therefore$ Amount left $\frac{N_0}{2^n}=\frac{100}{2^2}=25\,gm$

61. (d) The definition of nuclear fission.

62. (a) The huge amount of energy released during atomic fission is due to loss of mass.

63. (a) Mass defect is the measure of binding energy of a nucleus.

65. (d) Irene curie and Juliot studied the artificial radioactivity.

66. (d) $N=\frac{N_o}{2^n}$ and $n=\frac{560}{140}=4$; $N=\frac{1}{2^4}=\frac{1}{16}\,gm.$

67. (d) G.M counter is used to determine rate of decay.

68. (b) *Cd* and boron rods are control rods used in reactors.

69. (b) Graphite is used as moderator to slow down the speed of neutrons in atomic reactors.

70. (d) Isotope C^{12} is the modern basis of atomic weight.

71. (a) ${}_6C^{14}$ is used to determine the mechanism of photosynthesis.

74. (a) ${}_{28}Ni^{60}+{}_0n^1 \longrightarrow {}_{28}Ni^{61} \longrightarrow {}_{27}Co^{60}+{}_1p^1$

76. (b) ${}_6C^{14}$ used for dating process.

79. (a) $\frac{N}{N_o}=\left(\frac{1}{2}\right)^{\frac{T}{t_{1/2}}} \Rightarrow \frac{13}{100}=\left(\frac{1}{2}\right)^{\frac{T}{5770}}$

Taking log $\Rightarrow \log\frac{13}{100}=\frac{T}{5770}\log 1/2 \Rightarrow 16989\ yrs$

Isotopes-Isotones and Nuclear isomers

1. (b) The definition of Isotopes.

2. (a) Isotopes of hydrogen is ${}_1H^1, {}_1H^2, {}_1H^3$ known as protium, deuterium and tritium respectively.

3. (d) ${}_8O^{18}$ isotope of oxygen have 10 neutrons and 8 protons.

4. (a) Atoms of different elements having different atomic no. but same mass no. are called isobars.

5. (c) Isotopes have same atomic number but different mass number.

6. (c) ${}_ZA^m \rightarrow {}_ZB^{m-4}+{}_2He^4+2{}_{-1}e^0$

7. (c) Co^{60} is used in radiotherapy of cancer.

8. (b) Atoms of different elements having different atomic no. but same mass no. are called isobars.

9. (b) ${}_7N^{14}+{}_2He^4 \rightarrow {}_8O^{17}+{}_1H^1$

10. (d) ${}_1H^3 \rightarrow {}_2He^3+{}_{-1}e^0$

${}_1H^3$ and ${}_2He^3$ are isobars (same mass no.)

11. (a) The isotopes having an excessive n/p ratio exhibit e^--emission.

12. (b) ${}_6C^{14}$ is an isotope of carbon $({}_6C^{12})$.

14. (a) Isotopes differ in number of neutrons but have same number of protons.

15. (a) ${}_ZA^m \rightarrow {}_ZB^{m-4}+{}_2He^4+2{}_{-1}e^o$

16. (c) Atoms of different elements having different atomic no. but same mass no. are called isobars.

17. (b) Isotopes differ in number of neutrons but have same number of protons.

18. (c) ${}_ZA^m \rightarrow {}_ZB^{m-4}+{}_2He^4+2{}_{-1}e^o$

19. (c) $\frac{n}{p}$ is minimum for this isotope.

20. (a) In chlorine gas ratio of Cl^{35} and Cl^{37} is 3 : 1.

21. (d) Isotones have the same number of neutrons but different number of nucleons $(n+p)$. *e.g.*, ${}^{39}_{18}Ar, {}^{40}_{19}K$.

22. (d) Isobars have different no. of protons and neutrons.

23. (a) Atoms of different elements having different atomic no. but same mass no. are called isobars.

24. (c) Isotopes differ in mass no. and hence in the number of neutrons.

25. (c) Isotones are the species which have same number of neutrons and different number of nucleons ($p + n$).

26. (d) In ${}^3_1H$ their are 1 proton and 2 neutrons.

27. (c) Isotopes differ in mass number, and hence in the number of neutrons.

28. (b) In isotones have same number of neutrons.

29. (b) Atoms of different elements having different atomic no. but same mass no. are called isobars.

30. (b) Two isotopes of bromine are ${}_{35}Br^{79}, {}_{35}Br^{81}$

No. of neutrons in ${}_{35}Br^{79}$ $= 79-35=44$

No. of neutrons in ${}_{35}Br^{81}$ $= 81-35=46$.

31. (c,d) Isotopes have same atomic number but different mass number and same chemical properties.

33. (a) Isotopes have same atomic number but different mass number.

34. (c) ${}_{92}U^{235} \rightarrow {}_{82}Pb^{207} + x\ {}_2He^4 + y\ {}_{-1}\beta^0$

no. of α-particles = $\frac{235-207}{4} = \frac{28}{4} = 7\alpha$

no. of β-particles = $92 - 82 - 2\times 7 = 4\beta$.

35. (c) ${}_zA^m + 2\ {}_on^1 \rightarrow {}_zA^{m+2}$, an isotope of A.

36. (b) Atoms of different elements having different atomic no. but same mass no. are called isobars.

37. (a) ${}_AX^M \xrightarrow{-\alpha} {}_{A-2}Y^{M-4}$

38. (a) Isotopes have same atomic number but different mass number.

39. (a) In isotope ${}_{32}X^{65}$, 32 is atomic number and 65 is atomic weight.

40. (b) Atoms of different elements having different atomic no. but same mass no. are called isobars.

41. (c) Atoms of different elements having different atomic no. but same mass no. are called isobars.

43. (a) Mass no. will remain same as proton is replaced by neutron.

44. (d) Isotopes differ in number of neutrons but have same number of protons.

45. (b) Atoms of different elements having different atomic no. but same mass no. are called isobars.

46. (a) ${}_{11}Na^{24} \rightarrow {}_{12}Mg^{24} + {}_{-1}e^0$ (β-particle comes out).

47. (d) Isotopes differ in number of neutrons but have same number of protons.

48. (d) Atoms of different elements having different atomic no. but same mass no. are called isobars.

49. (a) ${}_1H^3 \rightarrow {}_2He^3 + {}_{-1}e^o$

50. (a) Isotopes of same elements have the same number of protons but different number of neutrons.

51. (b) 35.5 = $\frac{x\times 37 + (100-x)35}{100} \Rightarrow 35.5 = \frac{3500-2x}{100}$

$2x = 50 \Rightarrow x = 25 \Rightarrow$ Ratio 75 : 25 = 3 : 1

52. (d) An ordinary oxygen contains a mixture of O-16 (99.8%), O-17(0.037%), O-18(0.204%) isotopes.

54. (c) They are isosters *i.e,* Number of atoms = same

Number of e^- = same ;Physical properties = same

55. (ac) Isotopes have same atomic number but different mass number.

57. (bd) Both have 34 neutrons; Isotones have same number of neutrons.

Critical Thinking Questions

1. (a) ${}^{23}_{11}Na \rightarrow \frac{n}{p}$ ratio $= 12/11$

${}^{24}_{11}Na \rightarrow \frac{n}{p}$ ratio $= 23/11$

so decrease in $\frac{n}{p}$ ratio gives out β-particle

$n \rightarrow p + e(\beta^-)$.

2. (b) Oxygen have 90% O^{16} and 10% O^{18}

Atomic mass = $\left[\frac{90}{100}\times 16 + \frac{10}{100}\times 18\right]$

$= \frac{1440+180}{100} = \frac{1620}{100} = 16.2$.

3. (c) It is a neutron induced fission reaction.

4. (a) Mass defect = mass of sulphur – mass of chlorine

$= 34.96903 - 34.96885 = 0.00018\ g$

Binding energy =mass defect $\times$ 931

$= 0.00018 \times 931$

$= 0.1675\ MeV$

5. (a) The problem refers that rate is constant.

6. (a) $1C$ = Activity of $1g$ of $Ra^{226} = 3.7\times 10^{10} dps$

Activity of $1\mu g$ of $Ra^{226} = 3.7\times 10^4 dps$

So, the no. of α-particles are emitted per second by $1\mu g$ of Ra is $3.7\times 10^4 dps \approx 3.62\times 10^4$ / sec

7. (a) 2.92×10^4 α-particles will be emitted per second.

8. (b) $\frac{dx_1}{dt} = \lambda N_1,\ 1\times 10^5 = \lambda N_1$

$\frac{dx_2}{dt} = \lambda N_2, 3.7\times 10^{10} = \lambda N_2$

$\frac{N_1}{N_2} = \frac{1\times 10^5}{3.7\times 10^{10}} = \frac{1\times 10^{-5}}{3.7} = 0.27\times 10^{-5}$.

9. (d) ${}_{92}U^{235} + {}_on^1 \rightarrow {}_{54}X_e^{139} + {}_{38}Sr^{94} + 3{}_on^1$

10. (a) $k = \frac{0.693}{t_{1/2}} = \frac{0.693}{3hr.} = 0.231$ *per hrs.*

11. (b) $t_{1/2}$ of C–14 = 5760 year, $\lambda = \frac{0.693}{5760}$,

Now $t = \frac{2.303}{\lambda}\log\frac{{}^{14}C\text{ original}}{{}^{14}C\text{ after time } t}$

$= \frac{2.303\times 5760}{0.693}\log\frac{100}{12.5} = \frac{2.303\times 5760\times 0.9030}{0.693}$

= 17281= 172.81 × 10^2 *years.*

12. (c) According to radioactive equilibrium

$\lambda_A N_A = \lambda_B N_B$

or $\frac{0.693\times N_A}{t_{1/2}(A)} = \frac{0.693\times N_B}{t_{1/2}(B)}\left[\lambda = \frac{0.693}{t_{1/2}}\right]$

Where $t_{1/2}(A)$ and $t_{1/2}(B)$ are half periods of A and B respectively

$\therefore \frac{N_A}{t_{1/2}(A)} = \frac{N_B}{t_{1/2}(B)}$ or $\frac{N_A}{N_B} = \frac{t_{1/2}(A)}{t_{1/2}(B)}$

$\therefore$ At equilibrium A and B are present in the ratio of their half lives $\frac{1}{2.8\times10^6} = \frac{1620}{\text{Half life of uranium}}$

$\therefore$ Half-life of uranium

$= 2.8\times10^6 \times 1620 = 4.53\times10^9$ *years*.

13. (c) Average life period $= 1.44\times t_{1/2}$

$1.44\times1580 = 2275.2 = 2.275\times10^3\, yrs.$

14. (a) $N_o = 8gms$, N = 0.5g and t = 1 $hr.$ = 60 $min.$

find $t_{1/2}$ by $t = \frac{2.303\times t_{1/2}}{0.693}\log\frac{N_o}{N}$.

15. (b) $k = \frac{0.693}{0.75\text{hr}} = \frac{2.303}{\text{t}}\log\frac{a}{a-0.999a}$

$= \frac{2.303}{t}\log 10^3 = 7.5\, hrs$.

16. (c) T = 50 days, $t_{1/2}$ = ?, $N_o = 1, N = \frac{1}{32}$,

$N = N_o\times\left(\frac{1}{2}\right)^n$ or $\frac{1}{32} = 1\times\left(\frac{1}{2}\right)^n$,

or $\left(\frac{1}{2}\right)^5 = \left(\frac{1}{2}\right)^n$ or n = 5

$T = t_{1/2}\times2$, or $t_{1/2} = \frac{50}{5} = 10$ *days*.

17. (d) $K = \frac{2.303}{40}\log\frac{a}{a-0.875a} = \frac{2.303}{40}\log 8$

$= 0.05199\ \text{min}^{-1}$ $t_{1/2}$ = 0.693/0.05199

= 13.33 *min.* = 13 *min* 20 *sec.*

18. (d) $t_{1/2} = 10$ days, $N = 125$

Calculate as, $t = \frac{2.303\times t_{1/2}}{0.693}\log\frac{N_o}{125}$.

19. (a) $t_{1/2} = \frac{0.693}{k} = \frac{0.693}{6.31\times10^{-4}} = 0.1098\times10^4 = 1098\, yrs$.

20. (c) $T = t_{1/2}\times n$, $\therefore 3000 = 1500\times\text{n}$ $\therefore n = 2$

$\therefore$ Amount left $= \frac{1}{2^2} = \frac{1}{4} = 0.25g$.

21. (a) $N_t = N_o\left(\frac{1}{2}\right)^n$, $N_t = 256\left(\frac{1}{2}\right)^{18/3} = 256\left(\frac{1}{2}\right)^6 = 4$.

22. (b) Quantity of radioactive element decayed $= \frac{15}{16}$

Quantity left $= 1-\frac{15}{16} = \frac{1}{16}$

$\frac{1}{16} = 1\times\left(\frac{1}{2}\right)^n$ or $\left(\frac{1}{2}\right)^4 = \left(\frac{1}{2}\right)^n$

one half-life $= \frac{40}{4} = 10$ *days*.

23. (c) $N_t = N_o\left(\frac{1}{2}\right)^n = 48\times10^{19}\left(\frac{1}{2}\right)^{26/6.5}$

$= 48\times10^{19}\left(\frac{1}{2}\right)^4 = 3\times10^{19}$.

24. (c) $\frac{0.693}{9} = \frac{2.303}{t}\log\frac{1}{1-0.2}$

25. (b) $\frac{0.693}{140} = \frac{2.303}{t}\log\frac{16}{16-15} = 560$ days

26. (b) $n = \frac{20}{4} = 5, \frac{N_t}{N_o} = \left(\frac{1}{2}\right)^5 = \frac{1}{32}$, $\therefore$ decayed

$= \left(1-\frac{1}{32}\right)\times100 = \frac{31}{32}\times100 = 96.87$.

27. (b) $r_{\text{nucleus}} = 1.3\times10^{-13}\times(A)^{1/3}$, where A is mass number

$r_{U^{238}} = 1.3\times10^{-13}\times(238)^{1/3} = 8.06\times10^{-13}\, cm.$

$r_{He^4} = 1.3\times10^{-13}\times(4)^{1/3} = 2.06\times10^{-13}\, cm.$

$\therefore$ Total distance in between uranium and α nuclei

= 8.06$\times 10^{-13}$ + 2.06 $\times 10^{-13}$ = 10.12 $\times 10^{-13}$ *cm*

Now repulsion energy =

$\frac{Q_1Q_2}{r} = \frac{92\times4.8\times10^{-10}\times2\times4.8\times10^{-10}}{10.12\times10^{-13}}\, erg$

$= 418.9\times10^{-7}\, erg = 418.9\times10^{-7}\times6.242\times10^{11}\, eV$

$= 26.147738\times10^4\, eV$.

28. (a) $N_t = N_o\left(\frac{1}{2}\right)^2$ [$\therefore t_{1/2}$ = 22 years, T = 11 years, N_o =2, N_t =?]

$T = t_{1/2}\times n$, 11= 2 × n or $n = \frac{11}{22} = \frac{1}{2}$

$\therefore N_t = 2gm\times\left(\frac{1}{2}\right)^{1/2} = 1.414\, gm$.

29. (c) $t = \frac{2.303}{0.693}\times5000\times\log\frac{15}{5}$

$= \frac{2.303}{0.693}\times5000\times\log 3 = 7927 = 7.92\times10^3\, yrs.$

30. (c) 1g U-235 $= \frac{6.023\times10^{23}}{235}$ *atoms*

$\therefore$ energy released $= 3.2\times10^{-11}\times\frac{6.023\times10^{23}}{235}\, J = 8.21\times10^{10}\, J$

$= 8.2\times10^7\, kJ$.

31. (a) Isotones have same number of neutrons.

32. (b) Average atomic weight of element

$$=\frac{85\times 3+87\times 1}{3+1}=85.5$$

Assertion & Reason

1. (c) Atomic number defines identity of an atom because each atom has a definite number of protons in its nucleus.

3. (d) The activity of $1g$ of pure $U-235$ and that in U_3O_8 is same. Activity does not depend upon the state of combination.

5. (b) In some nuclides, the nucleus may capture an electron from the K-shell and the vacancy created is filled by electrons from higher levels giving rise to characteristic X-rays. This process is known as K-electron capture or simply K-capture.

6. (c) Radioactivity of an element is independent of its physical state its chemical environment or temperature, suggesting that it is a property of nucleus i.e., nuclear phenomenon.

7. (d) At onetime, it was believed that actinium series starts with $Ac-227$ but now it is well known that it starts with $U-235$ and $Ac-227$ is one of the main products.

9. (a) ${}_{92}U^{238}+{}_0n^1\longrightarrow {}_{92}U^{239}\xrightarrow{-\beta}{}_{93}Np^{239}\xrightarrow{-\beta}{}_{94}Pu^{239}$

In breeder reactors, the neutrons produced from fission of $U-235$ are partly used to carry on the fission of $U-235$ and partly used to produce some other fissionable material.

10. (a) The activation energies for fusion reactions are very high. They require very high temperature $(>10^6)$ to over come electrostatic repulsion between the nuclei.

12. (c) Loss of α or β-particle is to change N/P ratio so that it lies with in the stability belt. Loss of α-particle increases N/P ratio while loss of β-particle decreases N/P ratio.

13. (b) It is correct that photochemical smog is produced by nitrogen oxide and it is also fact that vehicular pollution is a major source of nitrogen oxide but it is not correct explanation.

14. (d) Binding energy per nucleon of ${}_3Li^7$ (5.38 MeV) is lesser than ${}_2He^4$ (7.08 MeV) as helium is found to be more stable than Li. As the atomic mass number increases, the binding energy per nucleon decreases. As the atomic number and the atomic mass number increase, the repulsive electrostatic forces with in the nucleus increase due to the greater number of protons in the heavy elements. To over come this increased repulsion, the proportion of neutrons in the nucleus must increase to maintain stability. This increase in the neutron to proton ratio only partially compensates for the growing proton – proton repulsive force in the heavier, naturally occurring elements.

Because the repulsive forces are increasing less energy must be supplied, on the average, to remove a nucleon from the nucleus. The BE/A has decreased. The BE/A of a nucleus is an indication of its degree of stability. Generally, the more stable nuclides have higher BE/A than the less stable ones. The increase in BE/A as the atomic mass number decreases from 260 to 60 is the primary reason for the energy liberation in the fission process. The increase in the BE/A as the atomic mass number increases from 1 to 60 is the reason for the energy liberation in the fusion process, which is the opposite reaction of fission.

15. (b) It is correct that during nuclear fission energy is always released and it is also true that nuclear fission is a chain prouss.

16. (e) Neutrons are more effective than protons of equal energy in causing artificial disintegration of atoms. neutrons are neutral they penetrate the nucleus and do not exert any repulsive force like positive charged protons.

17. (b) It is true that abeam of electrons deflects more than a beam of α-particles in am electric field. It is also true that electrons have –ve while α-particles have +ve charge. Here both are true but reason is not a correct explanation.

18. (d) ${}_{11}Na^{22}\longrightarrow {}_{12}Mg^{22}+{}_{-1}\beta^0$.

Thus this change involves a β-particle emission and not a positron. Also, proton emission convert proton into neutron as : ${}_1P^1\longrightarrow {}_0n^1+{}_{+1}\beta^0$

Nuclear Chemistry

SET Self Evaluation Test - 7

1. When $_3Li^7$ are bombarded with protons, γ-rays are produced. The nuclide formed is **[CPMT 1987]**
   (a) $_3Li^8$ (b) $_4Be^8$
   (c) $_3B^9$ (d) $_4Be^9$

2. Nuclides **[BVP 2003]**
   (a) Have specific atomic numbers
   (b) Have same number of protons
   (c) Have specific atomic number and mass numbers
   (d) Are isotopes

3. In the following nuclear reactions
   $_7N^{14} +_2 He^4 \rightarrow_8 O^{17} + X_1$ and $_{13}Al^{27} +_1 D^2 \rightarrow_{14} Si^{28} + X_2$
   X_1 and X_2 are respectively
   (a) $_1H^1$ and $_0n^1$ (b) $_0n^1$ and $_1H^1$
   (c) $_2He^4$ and $_0n^1$ (d) $_0n^1$ and $_2He^4$

4. Gamma rays are
   [NCERT 1978; MNR 1990; UPSEAT 1999, 2000]
   (a) High energy electromagnetic waves
   (b) High energy electrons
   (c) High energy protons
   (d) Low energy electrons

5. Which particle can be used to change $_{13}Al^{27}$ into $_{15}P^{30}$
   [MP PMT 2003]
   (a) Neutron (b) α-particle
   (c) Proton (d) Deuteron

6. Which of the following does not characterise X-rays
   [UPSEAT 2001]
   (a) The radiation can ionise gases
   (b) It causes ZnS to fluorescence
   (c) Deflected by electric and magnetic field
   (d) Have wavelengths shorter than ultraviolet rays

7. During emission of β-particle **[Bihar MEE 1996]**
   (a) One electron increases
   (b) One electron decreases
   (c) One proton increases
   (d) No change
   (e) None of these

8. Emission is caused by the transformation of one neutron into a proton. This results in the formation of a new element having
   (a) Same nuclear charge
   (b) Very lower nuclear charge
   (c) Nuclear charge higher by one unit
   (d) Nuclear charge lower by one unit

9. The end product of $4n$ series is **[MNR 1983]**
   (a) $_{82}Pb^{208}$ (b) $_{82}Pb^{207}$
   (c) $_{82}Pb^{209}$ (d) $_{83}Bi^{204}$
   [MP PMT 1999]

10. $_{92}U^{235}$ belongs to group III B of periodic table. If it loses one α-particle, the new element will belong to group
    [MNR 1984; CPMT 2001]
    (a) I B (b) I A
    (c) III B (d) V B

11. Radioactive disintegration differs from a chemical change in being **[UPSEAT 2000, 01, 02]**
    (a) An exothermic change
    (b) A spontaneous process
    (c) A nuclear process
    (d) A unimolecular first order reaction

12. Half-life is the time in which 50% of radioactive element disintegrates. Carbon-14 disintegrates 50% in 5770 years. Find the half-life of carbon-14**[DPMT 1**
    (a) 5770 years
    (b) 11540 years
    (c) $\sqrt{5770}$ years
    (d) None of the above

13. The half-life of ^{14}C is about **[MP PET 1996]**
    (a) 12.3 years
    (b) 5730 years
    (c) 4.5×10^9 years

(d) 2.52×10^5 years

14. Half-life for radioactive C^{14} is 5760 years. In how many years $200\,mg$ of C^{14} sample will be reduced to $25\,mg$

[CBSE PMT 1995]

(a) 11520 years (b) 23040 years

(c) 5760 years (d) 17280 years

15. The decay constant of a radioactive element is $3\times10^{-6}\,\text{min}^{-1}$. Its half-life is

[MP PET 1993; Pb. CET 2002]

(a) 2.31×10^5 min

(b) 2.31×10^6 min

(c) 2.31×10^{-6} min

(d) 2.31×10^{-7} min

16. A radioactive sample decays to half of its initial concentration in 6.93 *minutes*.It further decays half in next 6.93 *minutes*. The rate constant for the reaction is

[RPET 2000]

(a) 0.10 min^{-1} (b) 0.01 min^{-1}

(c) 1.0 min^{-1} (d) 0.001 min^{-1}

17. The half-life of an isotope is 10 *hrs*. How much will be left behind after 4 *hrs* in $1gm$ sample**[BHU 1997]**

(a) 45.6×10^{23} atoms

(b) 4.56×10^{23} atoms

(c) 4.56×10^{21} atoms

(d) 45.6×10^{21} atoms

18. The half-life period $t_{1/2}$ of a radioactive element is N years. The period of its complete decay is**[KCET 1998]**

(a) N^2 years (b) $2N$ years

(c) $\frac{1}{2}N^2$ years (d) Infinity

19. A radioactive element has a half-life of 20 minutes. How much time should elaspe before the element is reduced to $\frac{1}{8}th$ of the original mass**[EAMCET 1990]**

(a) 40 minutes

(b) 60 minutes

(c) 80 minutes

(d) 160 minutes

20. The half-life period of a radioactive material is 15 minutes. What % of radioactivity of that material will remain after 45 minutes

(a) 10 % (b) 12.5%

(c) 15% (d) 17.5%

21. ^{226}Ra disintegrates at such a rate that after 3160 *years* only one-fourth of its original amount remains. The half-life of ^{226}Ra will be

(a) 790 *years* (b) 3160 *years*

(c) 1580 *years* (d) 6230 *years*

22. The ratio of the amount of two elements *X* and *Y* at radioactive equilibrium is $1:2\times10^{-6}$. If the half-life period of element *Y* is 4.9×10^{-4} days, then the half-life period of element X will be

(a) 4.8×10^{-3} days (b) 245 days

(c) 122.5 days (d) None of these

23. If half-life of a substance is 5 *yrs*, then the total amount of substance left after 15 *years*, when initial amount is 64 *grams* is **[AIEEE 2002]**

(a) 16 *grams* (b) 2 *grams*

(c) 32 *grams* (d) 8 *grams*

24. An element has half-life 1600 *years*. The mass left after 6400 *years* will be **[AFMC 2003]**

(a) 1/16 (b) 1/12

(c) 1/4 (d) 1/32

25. Wooden artitact and freshly cut tree are 7.6 and $15.2\,\text{min}^{-1}g^{-1}$ of carbon ($t_{1/2}=5760$ years) respectively. The age of the artitact is **[AIIMS 1980]**

(a) 5760 years

(b) $5760\times\frac{15.2}{7.6}$ years

(c) $5760\times\frac{7.6}{15.2}$ years

(d) $5760\times(15.2-7.6)$ years

26. An element has two main isotopes of mass numbers 85 and 87. In nature they occur in the ratio of 75% and 25% respectively. The atomic weight of the element will be approximately

(a) 86.0 (b) 86.5

(c) 85.5 (d) 85.75

27. A sample of rock from moon contains equal number of atoms of uranium and lead ($t_{1/2}$ for $U=4.5\times10^9$ years). The age of the rock would be**[MNR 198**

(a) 9.0×10^9 years

(b) 4.5×10^9 years

(c) 13.5×10^9 years

(d) 2.25×10^9 years

28. The value of one microcurie = ... disintegrations / second

[EAMCET 1982]

(a) 3.7×10^5 (b) 3.7×10^7

(c) 3.7×10^4 (d) 3.7×10^{10}

29. The sum of the number of neutrons and proton in the radio isotope of hydrogen is **[IIT 1986]**

(a) 6 (b) 5

(c) 4 (d) 3

Answers and Solutions

(SET -7)

1. (b) ${}_3Li^7 + {}_1H^1 \rightarrow {}_4Be^8 + \gamma$

2. (d) The isotopes of an element is represented by writing the symbol of the element and representing the atomic number and mass number as subscript and superscript respectively are called nuclides.

3. (a) Equate atomic no. and mass no.

4. (a) γ-rays are designated by $h\nu$.

5. (b) ${}_{13}Al^{27} + {}_2He^4 \rightarrow {}_{15}P^{30} + {}_on^1$

6. (c) *x*-rays do not carry any charge and hence are not deflected by electric and magnetic fields.

7. (c) During β-particle emission one proton increases.

8. (c) ${}_on^1 \rightarrow {}_{+1}p^1 + {}_{-1}e^o$ (β-particle comes out).

9. (a) The end product of 4n series is ${}_{82}Pb^{208}$.

10. (c) Elements 89 to 103 are placed in III group.

11. (c) Chemical reaction is not nuclear reaction, but radioactivity is nuclear distingration.

12. (a) $t_{1/2} = 5770$ *years.*

13. (b) $t_{1/2}$ of C^{14} = 5730 *years.*

14. (d) $25 = \left[\frac{1}{2}\right]^n \times 200, \left[\frac{1}{2}\right]^n = \frac{25}{200} = \frac{1}{8} = \left[\frac{1}{2}\right]^3$

n = 3, Number of half lives = 3

so time required = 3 × 5760 = 17280 *yrs*.

15. (a) $t_{1/2} = \frac{0.693}{\lambda} = \frac{0.693}{3\times10^{-6}min^{-1}} = 2.31\times10^5 min.$

16. (a) $k = \frac{0.693}{t_{1/2}} = \frac{0.693}{6.93} = 0.10 \text{ min}^{-1}$

17. (b) 4.56×10^{23} atoms will be left behind after 4 *hrs* in 1 *gm*. sample.

18. (d) The $t_{1/2}$ of a radioactive element = *N years*

∴ The period of its complete decay is infinity.

19. (b) $t_{1/2} = 20$ minute, $N = \frac{1}{9}N_o$

Use, $t = \frac{2.303}{0.693}\times t_{1/2}\log\frac{N_o}{N}$.

20. (b) $N = \frac{N_o}{2^n}$ and $n = \frac{45}{15} = 3$

Also use $N_o = 100$ than $N = \frac{100}{2^3} = 12.5\%$.

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21. (c) For an element to disintegrate

$N = N_o\left(\frac{1}{2}\right)^n$ .....(i), $t = n \times t_{1/2}$ .....(ii)

For Ra^{226} $\frac{N}{N_o} = \frac{1}{4}$, from *eq*. (i)

$\frac{1}{4} = \left(\frac{1}{2}\right)^n$ or $\left(\frac{1}{2}\right)^n$ or $\left(\frac{1}{2}\right)^2 = \left(\frac{1}{2}\right)^n, n = 2$; from *eq*. (ii)

$T_{1/2} = \frac{t}{n} = \frac{3160}{2} = 1580$ yrs.

22. (b) $\frac{N_X}{N_Y} = \frac{t_{1/2}(X)}{t_{1/2}(Y)}, t_{1/2}(X) = \frac{4.9\times10^{-4}}{2\times10^{-6}} = 245$ days.

23. (d) $t_{1/2} = 5\,yrs.$, t = 15 *yrs*

$\therefore n = \frac{t}{t_{1/2}} = \frac{15}{5} = 3$

Now $N = \frac{N_o}{2^n} = \frac{N_o}{2^3} = \frac{1}{8}N_o = \frac{1}{8}\times 64 = 8$ *grams.*

24. (a) $T_{1/2} = 1600\,yrs.$, $N_o = 1$, $N = ?$, $T = 6400\,yrs.$

$T = t_{1/2}\times n, or\ n = \frac{6400}{1600} = 4$

$N = N_o\times\left(\frac{1}{2}\right)^n$, $N = 1\times\left(\frac{1}{2}\right)^4$, $N = \frac{1}{16}$.

25. (a) $r_o = 15.2$ and $r = 7.6$, $\therefore t = \frac{2.303}{\lambda} \log \frac{r_o}{r}$.

26. (c) Isotopes have 75% and 25% respectively.

$\therefore$ Atomic mass = $\left[\frac{75}{100} \times 85 + \frac{25}{100} \times 87\right]$

= $\frac{6375 + 2175}{100} = 85.5$.

27. (b) $N = \frac{N_0}{2^n}$, use $t = \frac{2.303 \times t_{1/2}}{0.693} \log \frac{N_o}{N}$

28. (c) 1 Ci = $3.7 \times 10^{10}\, dps$ or $3.7 \times 10^{10}\, Bq$.

1mCi = $3.7 \times 10^{4}\, dps$.

29. (d) Tritium $({}_1H^3)$ consist of 1 proton and 2 neutrons.