CHAPTER 9

Modern Physics

SYNOPSIS

- Every atom is composed of three subatomic particles
  - (i) negatively charged electrons,
  - (ii) positively charged protons and
  - (iii) neutrons having no net electric charge.
- In a neutral atom, the number of protons is equal to the number of electrons.
- The mass of a subatomic particle is generally expressed in atomic mass unit (a.m.u) and one atomic mass unit is defined as $1/12^{th}$ mass of C-12 atom. 1 amu = $1.6605402 \times 10^{-27}$ kg
- The protons and neutrons are held together in the nucleus by nuclear force.
- The atomic number (z) is the number of protons in a nucleus.
- The mass number (A) refers to the total number of nucleons. That is number of neutrons and protons together.
- Electrons revolve around the nucleus in fixed circular orbits having well defined energy levels.
- When an electron moves from a higher energy level to a lower energy level, the difference in the energy levels is emitted as radiation. When it moves from a lower energy level to a higher energy level, the difference in energy is absorbed.
- Atoms of the same element having the same atomic number but, different mass number are known as isotopes.
- An electric discharge tube is a device that is used to study the flow of charges (current) through gases.
- The rays emitted from cathode are known as cathode rays which consists of electrons.
- Gases conduct electricity at sufficiently high potential differences and at low pressures. This is known as electric discharge.
- When high speed electrons are stopped by certain objects like metals, X–rays are produced.
- Charge on electron is equal to -1.6×10^{-19} C and its mass is equal to 9.11×10^{-31} kg.
- The charge to mass ratio of an electron (e/m ratio) is given as 1.76×10^{11} C kg^{-1}.
- X-rays are electromagnetic radiations, travel in a straight line with a velocity of light (3×10^8 ms^{-1}) in free space, their wavelength is very short of the order of 1 A°, they are not affected by electric and magnetic fields.
- Radioactivity is the phenomenon of disintegration and spontaneous emission of radiations by some unstable nuclei. Substances which give such spontaneous emission of radiations are known as radioactive substances.

- The radiations of radioactive substance consist of three distinct constituents alpha (α), beta (β) and gamma (γ) radiations.
- α (alpha) rays are same as ionized helium atoms, they are positively charged particles.
- β (Beta) rays are highly energized electrons, they are negatively charged particles.
- γ-(gamma) rays are high energy electromagnetic radiation, they are electrically neutral, they are undeflected when passing through electric or magnetic fields.
- When an α-particle is emitted from a radioactive nucleus, the atomic number (Z) decreases by 2 and the mass number (A) decreases by 4.
- Whenever a β-particle is emitted from a radioactive nucleus, the atomic number increases by 1 where as the mass number remains the same.
- There is no change in the atomic number (Z) or in the mass number (A) of the atom which undergoes γ decay, the emission of γ-ray results in a change in the energy state of the nucleus.
- The law of radioactive disintegration states that in any radioactive substance, the number of atoms disintegrating per second $-\left(\frac{\Delta N}{\Delta t}\right)$ is directly proportional to the number of atoms present.

  $\frac{\Delta N}{\Delta t} = -\lambda N$, where λ is decay constant.
- $N = N_0 e^{-\lambda t}$ where N_0 and N are the total number of atoms of a radioactive substance at instants when time is zero and 't' respectively and 'e' is an irrational number. λ is decay constant its value is $0.693/T$.
- The process of estimating the age by measuring the disintegration of C – 14 is known as 'carbon dating'.
- Background radiations are those radioactive radiations that everyone is exposed due to the presence of natural radioactive substance on the earth as well as the cosmic radiations and also the radioactive substances present in the body.
- The difference between the sum of the individual masses of constituents in a nucleus and the mass of the nucleus itself is called the 'mass defect'.
- Einstein's mass–energy equivalence is given as $E = (\Delta m) c^2$.

  Δm is the change in mass and c is the velocity of light in vacuum.

  Thus mass of 1 u = 931.5×10^6 eV.
- Nuclear fission is a process in which the heavy nucleus of a radioactive substance is split into lighter nuclei by the bombardment of a low energy neutron, the reaction being accompanied by the release of energy and two or three or more neutrons.
- A nuclear reaction combining nuclei of lighter atoms together to form heavier nuclei resulting in the release of tremendous amount of energy is called a nuclear fusion reaction.

Solved Examples

1. If $\frac{7}{8}^{th}$ of the initial mass of a radioactive substance decays in 15 days, then what is the half-life period of the radioactive substance?

Solution: Let the initial number of radioactive nuclei be N_0.

Then, after a half-life period, the number of nuclei present would be $N_0 \cdot \times \frac{1}{2}$.

After two half-lives, the number of nuclei present would be $\frac{1}{2} \times \left(N_0 \times \left(\frac{1}{2}\right)\right) . = N_0 \left(\frac{1}{2}\right)^2$

Similarly, after 'n' half-lives, the number of nuclei present would be $N = N_0 \left(\frac{1}{2}\right)^n$ $\quad \rightarrow (1)$

If 't' is the given time period and T is the half-life period of the radioactive substance,

then $n = \frac{t}{T}$ $\quad \rightarrow (2)$

Also, if 'mo' is the initial mass and 'm' the mass of undecayed nuclei of the substance,

then $\frac{N}{N_0} = \frac{m}{m_o}$ $\quad \rightarrow (3)$

$\therefore$ Equation (1) can be written as

$$m = m_0\left(\frac{1}{2}\right)^n \text{ or } m = m_0\left(\frac{1}{2}\right)^{\frac{t}{T}} \qquad \rightarrow (4)$$

In the given problem, undecayed mass

$$m = m_0 - \frac{7}{8}m_0 = \frac{1}{8}m_0 \text{ ; } t = 15 \text{ days, } T = ?$$

Substituting the values of 'm', 'm_0' and 't' in equation (4), we get

$$\frac{1}{8}m_0 = m_0\left(\frac{1}{2}\right)^{\frac{15}{T}} \Rightarrow \frac{1}{8} = \left(\frac{1}{2}\right)^{\frac{15}{T}} \Rightarrow \left(\frac{1}{2}\right)^3 = \left(\frac{1}{2}\right)^{\frac{15}{T}}$$

$$\Rightarrow \frac{15}{T} = 3 \Rightarrow T = \frac{15}{3} \text{ days} = 5 \text{ days}$$

2. Calculate of mass of helium nucleus. [Mass of proton is 1.0078 u and mass of neutron is 1.0087 u]

Solution: Consider a helium atom $_2He^4$.

It has 2 electrons, 2 protons and 2 neutrons.

The mass of a proton = 1.0078 u; The mass of a neutron = 1.0087 u.

$\therefore$ The total mass of the nucleus = 2 × 1.0078 + 2 × 1.0087 = 4.0330 u

3. What is the energy required to increase the mass of a system by one atomic mass unit?

Solution: $\Delta m = 1$ u

E = 1 × 931.5 MeV = 931.5 MeV

4. In a given radio-active sample, there are 10^{24} nuclei present. If its half life period is 20 years, how many nuclei will be present after 10 years? (Take $1/\sqrt{2} = 0.707$)

Solution: The number of nuclei (N) present after 'n' half lives is given by

$$N = N_0\left(\frac{1}{2}\right)^n \rightarrow (1) \text{ Where } n = \frac{t}{T}$$

In the question, we are given that $N_o = 10^{24}$; n = 10/20 = ½; N = ?

Substituting the above values in equation (1), we get

$$N = 10^{24}\left(\frac{1}{2}\right)^{\frac{1}{2}} = 10^{24} \times 0.707 = 7.07 \times 10^{23}$$

5. Calculate the binding energy per nucleon for Beryllium $_4Be^9$, its mass being 9.012 u. The masses of proton and neutron are 1.008 u and 1.009 u. (Take 1 u = 931.5 MeV)

Solution: First, let us find the mass defect. The Beryllium nucleus contains 4 protons and 5 neutrons.

Mass of 4 protons = 4 × 1.008 = 4.032 u; Mass of 5 neutrons = 5 × 1.009 u = 5.045 u

Total mass of protons (4) and neutrons (5) = 4.032 + 5.045 = 9.077 u

Mass defect = 9.077 – 9.012 = 0.065 u

The mass defect converted into equivalent energy gives binding energy.

1 u = 931.5 Me V

$\therefore$ 0.065 u = 0.065 × 931.5 MeV = 60.5475 MeV

Binding energy per nucleon

$$= \frac{\text{Binding energy}}{\text{No. of nucleons}} = \frac{60.5475}{9} = 6.7275 \text{ MeV}$$

6. In a Coolidge tube, high speed electrons emitted from the cathode are accelerated through a potential difference of 20 kV. Find the minimum wavelength of the X-rays produced.

(Take Planck's constant, h = 6.6 × 10^{-34} J s)

Solution: When electrons are accelerated through a potential difference, the work done on them is equal to the change in their kinetic energy. When cathode rays are stopped, they lose kinetic energy which is then converted into X-rays.

Thus, Work done on cathode rays (W)

$$= V \times q = \frac{1}{2}mv^2. \qquad \rightarrow (1)$$

The energy and frequency of X-rays (any radiation) is related as E = hν. Where 'h' is Planck's constant.

$$\text{But } \nu = \frac{c}{\lambda}; \therefore E = h\nu = \frac{hc}{\lambda} \qquad \rightarrow (2)$$

Equating (1) and (2) and solving for λ.

$\frac{hc}{\lambda} = V \times q$; $\lambda = \frac{hc}{Vq}$. Substituting h = 6.6 × 10^{-34} J s, we have c = 3 × 10^8 ms^{-1}.

V = 20 × 10^3 V, q = 1.6 × 10^{-19} C

$$\lambda = \frac{6.6\times10^{-34}\times3\times10^8}{20\times10^3\times1.6\times10^{-19}} = 0.61875 \text{ A°}.$$

7. What is the mass defect and binding energy of $_{27}Co^{59}$ which has a nucleus of mass of 58.933 u? (m_p = 1.0078 u, m_n = 1.0087 u)

Solution: In $_{27}Co^{59}$ number of protons = 27.

Number of neutrons = 59 – 27 = 32.

∴ The total mass of the nucleus = 27 × 1.0078 u + 32 × 1.0087 u = 27. 2106 u + 32.2784 u = 59.489 u.

Given, The actual mass of the nucleus = 58.933 u.

∴ The mass defect = 59.489 u – 58.933 u = 0.556 u.

∴ The binding energy = Δm × 931.5 MeV = 0.556 u × 931.5 MeV = 517.914 MeV.

8. Assuming 200 MeV energy is released per fission of $_{92}U^{235}$, calculate the energy released when 1 kg of $_{92}U^{235}$ undergoes complete fission. What percentage of mass of $_{92}U^{235}$ gets converted into energy?

Solution: 235 g of $_{92}U^{235}$ contains Avogadro number (6.023×10^{23}) of atoms.

No. of atoms of $_{92}U^{235}$ in 1 kg of uranium =

$$1000 \times \frac{6.023 \times 10^{23}}{235} = 2.563 \times 10^{24}$$

Energy released = No. of atoms × energy released per fission.

$= 2.563 \times 10^{24} \times 200$ MeV $= 5.126 \times 10^{26}$ MeV

The mass that liberates the above energy can be calculated using $E = mc^2$ …(2)

where $E = 5.126 \times 10^{26} \times 1.6 \times 10^{-13}$ J $= 8.2 \times 10^{13}$ J

$c = 3 \times 10^8$ ms^{-1}

Substituting in (2), we get $m = \frac{E}{c^2} = \frac{8.2 \times 10^{13}}{9 \times 10^{16}} = 9.11 \times 10^{-4}$ kg

$$\% \text{ of mass} = \frac{9.11 \times 10^{-4}}{1} \times 100 = 0.0911\% = 0.1\%$$

approximately

9. Two protons and two neutrons combine to form a nucleus of $_2He^4$. Find the energy released during the process. What type of nuclear reaction is it? Take masses of proton, neutron and helium nucleus as 1.007 u, 1.009 u, 4.002 u respectively.

Solution: The nuclear reaction is $2\ _1p^1 + 2\ _0n^1 \rightarrow {}_2He^4$.

First, let us find mass defect and then energy.

The mass of 2p and 2n is (2 × 1.007 + 2 × 1.009)

= 2 × 2.016 = 4.032 u.

The mass of helium is = 4.002 u.

The mass defect = 4.032 – 4.002 = 0.030 u.

1 u liberates 931.5 MeV of energy. The energy equivalent to 0.030 u = 0.03 × 931.5 = 27.94 MeV.

The above nuclear reaction is called fusion as lighter nuclei combine together to form a single nuclei.

10. The binding energy of $_3Li^7$ and $_2He^4$ are 39.2 MeV and 28.24 MeV respectively. Which one of the two nuclei is more stable?

Solution: The nucleons present in $_3Li^7$ is 7.

The binding energy per nucleon for lithium is 39.2/7 = 5.6 MeV

The binding per nucleon for helium is 28.24/4 = 7.06 MeV

The binding energy per nucleon is the measure of stability of the nuclei. Therefore, helium is more stable than lithium.

11. A nuclear reactor generates 500 MW electrical energy using the fission of $_{92}U^{235}$. Find the mass of $_{92}U^{235}$ required to produce electricity for 30 days. (0.1% of the mass of $_{92}U^{235}$ gets converted into energy).

Solution: The electrical energy produced in one second is 500 MJ. The electrical energy generated in 30 days is $E = 500 \times 60 \times 60 \times 24 \times 30 \times 10^6 = 1.3 \times 10^{15}$ J. (approximately)

To generate above energy the mass required can be found using the formula $E = mc^2$

or $m = \frac{E}{c^2} = \frac{1.3 \times 10^{15}}{(3 \times 10^8)^2} = 0.144 \times 10^{-1}$ kg

$= 1.44 \times 10^{-2}$ kg.

Let M be the mass of uranium required to generate energy E.

Then 'm' is 0.1% of M.

i.e., $m = \frac{0.1}{100} \times M \Rightarrow M = 1000\ m$

$= 1000 \times 1.44 \times 10^{-2} = 14.4$ kg.

12. Find the energy released during the following nuclear reaction.

$$_1H^1 + {}_3Li^7 \longrightarrow {}_2He^4 + {}_2He^4$$

The mass of $_3Li^7$ is 7.0160 u, $_2He^4$ is 4.0026 u and proton is 1.0078 u.

Solution: The mass of the reactant nuclei = 7.0160 + 1.0078 = 8.0238 u

The mass of the product nuclei = 4.0026 + 4.0026 = 8.0052 u

Mass defect = Δm = 8.0238 – 8.0052 = 0.0186 u

Energy released = 0.0186 u × 931.5 MeV

= 17.326 MeV

PRACTICE EXERCISE 9 (A)

Directions for questions 1 to 35: Select the correct alternative from the given choices.

1. Carbon dating is used to
(1) assess the age of fossils.
(2) assess the amount of radioactivity.
(3) assess the rate of radioactivity.
(4) None of the above.

2. The specific charge is the highest for _______.
(1) α-rays (2) β-rays
(3) protons (4) neutrons

3. Which among the following statements is incorrect about visible light and X-rays?
(1) They have same velocity in vaccum or air.
(2) They are electromagnetic radiations.
(3) They have same wavelength in a given medium.
(4) They are not affected by electric field.

4. Which among the following has the lowest speed when travelling through a given medium?
(1) γ-rays
(2) α-rays
(3) β-rays
(4) Cathode rays

5. ${}_{z}P^{A} \rightarrow {}_{z-4}D^{A-16}$
In the above radioactive reaction, the number of α and β particles emitted are ______ and _____ respectively.
(1) 4, 4 (2) 6, 6
(3) 8, 8 (4) 4, 8

6. The mass number of an element in a radioactive series is 223. Which radioactive series is this?
(1) 4n + 2 (2) 4 n
(3) 4n + 1 (4) 4n + 3

7. If the half-life period of a radioactive substance is 0.693 years, what is its decay constant?
(1) 0.2 year^{-1} (2) 0.1 year^{-1}
(3) 0.5 year^{-1} (4) 1 year^{-1}

8. If the binding energy per nucleon for ${}_{3}Li^{7}$ is 5.6 MeV, determine the total binding energy of a lithium nucleus.
(1) 139.2 Mev (2) 39.2 Mev
(3) 15.8 Mev (4) 115.8 Mev

9. X and Y are two radioactive isobars. Then the daughter nuclei formed after the emission of a β particle from each of them are _______.
(1) isosters (2) isotones
(3) isobars (4) isotopes

10. A physics student, named Raman, is studying nuclear reactions. He found that ${}_{92}U^{238}$ nucleus changes to ${}_{91}Pa^{234}$ nucleus due to radioactive disintegration. Then the number of α and β particles are emitted are _____ and ______ respectively?
(1) 1, 1 (2) 2, 2
(3) 1, 2 (4) 2, 1

11. Suresh found that a certain radioactive substance of 10 g reduces to 5 g in 3 hours. From this, he calculated the amount of time required by this radioactive substance to reduce from 80 g to 10 g. The time is _______ hours.
(1) 7 (2) 6
(3) 3 (4) 9

12. The half-life period of C^{14} is 5670 years. If 56 g of C^{14} was present initially, how many atoms of C^{14} is left after 22680 years?
(1) 1.5×10^{23} (2) 2.9×10^{27}
(3) 1.5×10^{27} (4) 2.9×10^{23}

13. How much energy is released when the mass of ${}_{8}O^{16}$ nucleus is completely converted into energy? The binding energy per nucleon of ${}_{8}O^{16}$ is 7.97 MeV and $m_p = 1.0078$ u and $m_n = 1.0087$ u.
(1) 14899.438 MeV (2) 148.99 MeV
(3) 4489.73 MeV (4) 448.973 MeV

14. Find x in the following nuclear reactions.
${}_{12}Mg^{24} + {}_{2}He^{4} \rightarrow {}_{14}Si^{x} + {}_{0}n^{1}$
(1) 17 (2) 27
(3) 37 (4) 24

15. The process of increasing the percentage of fissionable U-235 in naturally occurring uranium is called ________.
(1) controlled fission.
(2) artificial transmutation.
(3) chemical process.
(4) enrichment.

16. The nuclear reaction that takes place in a nuclear reactor is ______.

(1) controlled fission reaction
(2) uncontrolled fission reaction
(3) nuclear fusion reaction
(4) None of the above.

17. What are the different isotopes formed when protons combine to form a $_2He^4$ nucleus?

(1) $_1H^1$, $_2He^3$ (2) $_2He^3$, $_2He^3$
(3) $_1H^1$, $_1He^1$ (4) $_2H^3$, $_1H^2$

18. An α particle is emitted from a heavy radioactive nucleus. If the magnitude of the momenta of the α particle and the daughter nucleus are P_α and P_D which among the following is the correct relation between them?

(1) $P_\alpha = -P_D$ (2) $P_\alpha > P_D$
(3) $P_\alpha < P_D$ (4) $P_\alpha = P_D$

19. Mass of $_{92}U^{235}$ required to produce electrical energy in a nuclear reactor for 30 days is 23.5 kg. If 40% of the energy released by the fission is converted into electrical energy, determine the power of the nuclear reactor. (Assume that 200 MeV energy is released per fission of $_{92}U^{235}$)

(1) 390 MW (2) 297 W
(3) 297 MW (4) 297MW

20. In the radioactive decay, a $_ZX^A$ nucleus changes to $_{Z-1}Y^{A-4}$ nucleus. How many α and β particles are emitted?

(1) 1α, 4β (2) 1α, 1β
(3) 3α, 4β (4) 2α, 7β

21. Write down the sequence of radiations emitted in the following radioactive processes.

$$_{Z+2}X^A \rightarrow {}_ZY^{A-4} \rightarrow {}_{Z+1}Y^{A-4} \rightarrow {}_{Z-1}K^{A-8}$$

(1) γ – β – α (2) γ – α – β
(3) β – γ – α (4) α – β – γ

22. An α-particle is emitted from a stationary $_{92}U^{238}$ nucleus with a velocity of 2.34×10^4 ms^{-1}. Find the recoil velocity of the daughter nucleus.

(1) –300 ms^{-1} (2) –200 ms^{-1}
(3) –100 ms^{-1} (4) –400 ms^{-1}

23. An α particle is emitted from a heavy radioactive nucleus. Compare the kinetic energies of the α particle KE_α and the daughter nucleus KE_D.

(1) $KE_\alpha > KE_D$ (2) $KE_\alpha = KE_D$
(3) $KE_D > KE_\alpha$ (4) $KE_\alpha = 4KE_D$

24. Complete the following reactions.

$$_{13}Al^{27} + \_\_\_\_\_\_ \rightarrow {}_{15}P^{30} + {}_0n^1$$

(1) α (2) β
(3) γ (4) ^1_1H

25. Find the binding energy per nucleon for lithium nucleus $_3Li^7$. Take mass of $_3Li^7$ = 7 u, mass of proton = 1.007825 u and mass of neutron = 1.008665 u. Take 1 u = 931.5 MeV.

(1) 3.7 MeV (2) 4.9 MeV
(3) 1.7 MeV (4) 7.736 MeV

26. The conditions for the discharge of electricity in a discharge tube are ______.

(1) high temperature and high potential
(2) low pressure and high potential
(3) low pressure and high temperature
(4) low potential and high pressure

27. The lamp whose working is based on a discharge tube is ______.

(1) fluorescent lamp
(2) incandescent lamp
(3) CFL
(4) Both (1) and (3)

28. A light paddle wheel placed in the path of ______ will rotate.

(1) cathode rays
(2) α-rays
(3) β-rays
(4) All the above

29. A modified discharge tube is used as ______.

(1) cathode ray oscilloscope
(2) fluorescent tube
(3) X-ray tube
(4) All the above

30. The emission of 'weak X-rays' from uranium salts discovered by Becquerel could ______.

(1) ionize gases
(2) affect photographic plates
(3) penetrate through matter
(4) All the above

31. X-rays are produced by impinging ______ on a target.

(1) α particles
(2) protons
(3) electrons
(4) X-rays

32. _____ are useful in studying the crystal structures.

(1) All electromagnetic radiations
(2) Light rays
(3) X-rays
(4) γ-rays

33. The total electric charge on a certain number of electrons is found to be 96368 C. What is the mass of these electrons?

(1) 0.5 kg (2) 50 g
(3) 0.55 mg (4) 5 mg

34. In plants and animals, the ratio of C^{14} to C^{12} is ________.

(1) $10^{-12} : 1$
(2) $1 : 10^{-12}$
(3) $1 : 10^{-10}$
(4) $10^{-10} : 1$

35. Find x in the following nuclear reactions

${}_2He^4 + {}_{13}AI^{27} \longrightarrow {}_xP^{30} + {}_0n^1$.

(1) 14 (2) 13
(3) 15 (4) 11

PRACTICE EXERCISE 9 (B)

Directions for questions 1 to 35: Select the correct alternative from the given choices.

1. The common product formed in the artificial transmutation by a proton is ________.

(1) helium (2) hydrogen
(3) photon (4) newtron

2. Even when no radioactive substances are present near a Geiger counter always shows a reading. This is due to the presence of ________ radiations.

(1) cosmic (2) background
(3) light (4) radio

3. The radioactive isotope used in the treatment of cancer is a good source of ________ radiations.

(1) β (2) α
(3) γ (4) IR

4. A radioactive isotope of radium placed in the second group in the periodic table emits one α-particle and one β-particle. The new element formed is in the ______ group.

(1) first (2) second
(3) third (4) fourth

5. Which of the following radiations has the highest penetrating power?

(1) α (2) β
(3) γ (4) X-rays

6. The property of cathode rays used in a monitor of a computer is ______.

(1) high velocity
(2) high ionization power
(3) to cause fluorescence by phosphorus
(4) rectilinear propagation

7. Higher value of decay constant indicates ______.

(1) faster decay
(2) high half-life period
(3) slower decay
(4) Both (1) and (2)

8. Using $E = mc^2$, find out the energy released, when 2 u of mass is destroyed completely.

Take 1 u = 1.66×10^{-27} kg.

(1) 4.65 MeV (2) 3627 MeV
(3) 91.5 MeV (4) 1865 MeV

9. A radioactive substance was reduced to 1/4 of the total amount in 8 days. Determine the further time taken by this radioactive substance to get reduced to $1/8^{th}$ of the remaining amount.

(1) 18 days (2) 12 days
(3) 24 days (4) 6 days

10. Complete the reaction: ${}_{86}Rn^{220} \longrightarrow {}_{84}Po^{216} +$ ______

(1) β (2) γ
(3) α (4) H_1^1

11. A multi-speciality medical lab bought a radioactive isotope which has a half-life of 3 hours. When it is brought to lab, Dinakar, a research scholar found that it contained 1.024×10^{23} atoms. With this information he found out how many atoms was left after 30 hours. Find the number of atoms that were left undisintegrated.

(1) 10^{30} (2) 10^{20}
(3) 10^{10} (4) 10^{5}

12. 15/16th of a radioactive substance disintegrates in 12 days. How much more time will it take for the remaining amount of radioactive substance to reduce to 1/32 of the reduced amount? What is the half-life period of the radioactive substance?

(1) 40 days, 3 days (2) 30 days, 3 days
(3) 15 days, 3 days (4) 5 days, 2 days

13. The binding energy per nucleon for deuterium and helium is 1.1 MeV and 7 MeV respectively. Find how much energy is released by the fusion of 1g of deuterium.

(1) 5.68×10^{11} J (2) 1.72×10^{7} J
(3) 9.68×10^{5} J (4) 5.68×10^{3} J

14. Katen was studying about nuclear physics. There, he collected values of binding energies of ${}_1H^2$, ${}_2He^4$ ${}_{26}Fe^{56}$ and ${}_{92}U^{235}$ and they are 2.22 MeV, 28.3 MeV, 492 MeV and 1786 MeV respectively. Then, he got a doubt that stability of the nucleus depends on its binding energy which among the above four is the most stable nucleus?

(1) He_2^4 (2) U_{92}^{235}
(3) ${}_1H^2$ (4) ${}_{26}Fe^{56}$

15. Write down the sequence of radiations emitted in the following radioactive processes.

${}_{Z+1}X^A \rightarrow {}_{Z-1}Y^{A-4} \rightarrow {}_{Z-1}Y^{A-4} \rightarrow {}_{Z}K^{A-4}$

(1) $\alpha - \gamma - \beta$ (2) $\alpha - \beta - \gamma$
(3) $\gamma - \beta - \alpha$ (4) $\beta - \gamma - \mu$

16. Find x in the following nuclear reactions.

${}_7N^{14} + {}_2He^4 \rightarrow {}_xO^{17} + {}_1H^1$

(1) 6 (2) 8
(3) 9 (4) 7

17. Find x in the following nuclear reactions.

${}_{92}U^{236} \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{x} + 3\,{}_0n^1 + Q$

(1) 93 (2) 94
(3) 92 (4) 90

18. Which of the following are used as a nuclear fuel?

(1) ${}_{82}Pb^{208}$ (2) ${}_{92}U^{235}$
(3) ${}_{92}U^{238}$ (4) Both (2) and (3)

19. How many grams of U^{235} is required to produce 8×10^{11} J of energy, if 200 MeV of energy is released when one U^{235} atom undergoes fission?

(1) 39.54 g (2) 9.754 g
(3) 19.51 g (4) 49.754 g

20. Determine the energy released during the fusion of ${}_1H^1$ to form a ${}_2He^4$ nucleus, if the total mass of the products is 4.001506 u, mass of proton is 1.0078u and mass of neutron is 1.0087u.

(1) 27.67 MeV (2) 27.67 J
(3) 127.67 J (4) 127.67 MeV

21. Sikar read that when ${}_{92}U^{235}$ undergoes fission, approximately 0.1% of its original mass changes into energy. With this information, calculate the amount of energy released when 1 kg of ${}_{92}U^{235}$ undergoes fission.

(1) 9×10^{13} J (2) 119×10^{13} J
(3) 99×10^{13} J (4) 177×10^{13} J

22. Write down the sequence of radiations emitted in the following radioactive processes.

${}_ZX^A \rightarrow {}_ZP^A \rightarrow {}_{Z-2}Y^{A-4} \rightarrow {}_{Z-1}Y^{A-4}$

(1) $\alpha - \gamma - \beta$ (2) $\beta - \gamma - \alpha$
(3) $\gamma - \alpha - \beta$ (4) $\alpha - \beta - \gamma$

23. How many nuclei of ${}_{92}U^{235}$ should undergo fission per second, to produce a power of 10 MW, if 200 MeV of energy is released per fission of ${}_{92}U^{235}$?

(1) 3.12500 (2) 3.125×10^{7}
(3) 3.125×10^{17} (4) 3.125×10^{27}

24. How many α and β particles are emitted when ${}_{92}U^{238}$ disintegrates to form lead ${}_{82}Pb^{206}$?

(1) 4 α, 2 β (2) 3 α, 16 β
(3) 8 α, 6 β (4) 8α, 26 β

25. If 20% of a radioactive substance decays in 5 days, then find the approximate percentage of initial amount left after 20 days.

(1) 41% (2) 82%
(3) 39% (4) 59%

26. Complete the following reactions.

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

(1) ${}_7N^{14}$ (2) ${}_7N^{14}$
(3) ${}_6C^{12}$ (4) ${}_6C^{14}$

27. Complete the following reactions.

${}_3Li^7 + {}_1H^1 \rightarrow 2$ ______

(1) ${}_1H^2$ (2) He_2^3
(3) He_2^4 (4) He_1^3

28. The high temperature required to initiate the nuclear fusion reaction is to overcome ______.

(1) electric force (2) electrostatic force
(3) gravitational force (4) magnetic force

29. The fluorescence of the glass (discharge) tube at very low pressure is characteristic of ________.

(1) the phosphors in the material of the glass
(2) the gas used in the tube
(3) the cathode
(4) All the above

30. Cathode ray particles have a mass of ________ times that of hydrogen nucleus.

(1) 1 (2) $\frac{1}{10}$
(3) 1840 (4) $\frac{1}{1840}$

31. When cathode rays moving horizontally pass through an electric field directed vertically downward, the rays would deflect ________.

(1) downward (2) upward
(3) backward (4) None of the above

32. The target used in a Coolidge tube for the production of X-rays is made up of ________.

(1) manganese (2) molybdenum
(3) uranium (4) radium

33. The radiations from uranium discovered by Becquerel are ________.

(1) γ-rays
(2) X-rays
(3) cathode rays
(4) canal rays

34. When a charged particle of charge x C moves through a potential difference of y V the gain in kinetic energy is equal to xy J.

An electron and an alpha particle have their masses in the ratio of 1:7200 and charges in the ratio of 1:2. If they start moving from rest through the same electrical potential difference then the ratio of their velocities is ________.

(1) 1 : 60 (2) 60 : 1
(3) 1 : 20 (4) 20 : 1

35. The study of radiations involving X- rays were carried out by ________.

(1) Henri Becquerel
(2) William Roentgen
(3) Marie and Pierre Curie
(4) All the above

ANSWER KEYS

PRACTICE EXERCISE 9 (A)

1. 1	**2.** 2	**3.** 3	**4.** 2	**5.** 1	**6.** 4	**7.** 4	**8.** 2	**9.** 3	**10.** 1
11. 4	**12.** 1	**13.** 1	**14.** 2	**15.** 4	**16.** 1	**17.** 1	**18.** 1	**19.** 3	**20.** 2
21. 3	**22.** 4	**23.** 1	**24.** 1	**25.** 4	**26.** 2	**27.** 4	**28.** 4	**29.** 4	**30.** 4
31. 3	**32.** 3	**33.** 3	**34.** 1	**35.** 3					

PRACTICE EXERCISE 9 (B)

1. 1	**2.** 2	**3.** 3	**4.** 1	**5.** 3	**6.** 3	**7.** 1	**8.** 4	**9.** 2	**10.** 3
11. 2	**12.** 3	**13.** 1	**14.** 4	**15.** 1	**16.** 2	**17.** 3	**18.** 4	**19.** 2	**20.** 1
21. 1	**22.** 3	**23.** 3	**24.** 3	**25.** 1	**26.** 4	**27.** 3	**28.** 2	**29.** 1	**30.** 4
31. 2	**32.** 2	**33.** 1	**34.** 2	**35.** 4					