One Two Academy | Atomic and Nuclear Physics

Maximum Marks : 25 **PHYSICS** **Time: 50 Minutes**

Choose the correct answer :- **3x1=3**

1. The charge of Cathode ray particle is
(a) positive (b) negative (c) neutral (d) not defined

2. The half-life period of a radioactive element A is same as the mean life time of another radioactive element B. Initially both have the same number of atoms. Then

(a) A and B have the same decay rate initially
(b) A and B decay at the same rate always
(c) B will decay at faster rate than A
(d) A will decay at faster rate than B.

3. If a heavier nucleus decays into lighter nuclei, it is called
(a) Nuclear fusion (b) Nuclear fission (c) Alpha decay (d) Beta decay

Answer the following :- **3x2=6**

4. Define curie.
5. What is meant by activity or decay rate? Give its unit.
6. Calculate the number of nuclei of carbon-14 undecayed after 22,920 years if the initial number of carbon-14 atoms is 10,000. The half-life of carbon-14 is 5730 years.

Answer any two of the following:- **2x3=6**

7. What is half-life of a radio active nucleus? Give the expression.
8. Write down the draw backs of Bohr atom model.
9. Compute the binding energy of the ${}_{2}^{4}He$ nucleus using the following data : Atomic mass of He = 4.00260 u and that of hydrogen atom = 1.00785 u.

Answer the following :- **2x5=10**

10. (a) Derive the energy expression for an electron in the hydrogen atom using Bohr atom model.

(OR)

(b) Obtain the law of radioactivity.

11. i). Define mass defect .
ii) Calculate the mass defect and the binding energy per nucleon of the ${}_{47}^{108}Ag$ nucleus. [atomic mass of Ag = 107.905949].

ALL THE BEST

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Answer key attached in next page!!!

This page is to prevent seeing answer key

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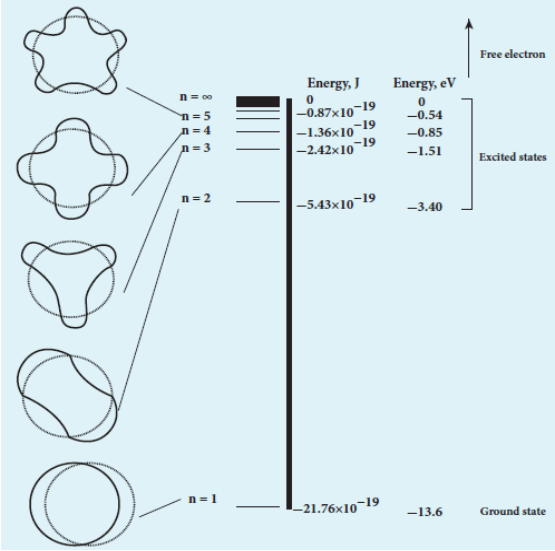
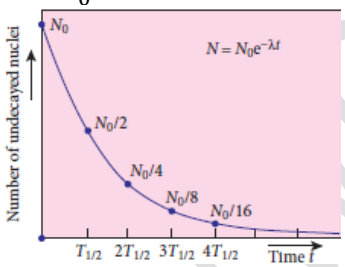
ANSWER KEY

Q NO	ANSWERS	MARKS
1.	(B) negative	**1**
2.	(C) B will decay at faster rate than A	**1**
3.	(B) Nuclear fission	**1**
4.	one curie was defined as number of decays per second in 1 g of radium and it is equal to 3.7 $\times 10^{10}$ decays/s.	**2**
5.	Activity (or) Decay rate is the number of nuclei decayed per second and it is denoted as $R = \left\|\frac{dN}{dt}\right\|$ .It is always positive.	**2**
6.	$n = \frac{t}{T_{\frac{1}{2}}} = 4$ $N = \left(\frac{1}{2}\right)^n N_0 = 625$	**2**
7.	We can define the half-life $T_{1/2}$ as the time required for the number of atoms initially present to reduce to one half of the initial amount. The half-life is the important characteristic of every radioactive sample. Some radioactive nuclei are known to have half-life as long as 10^{14} years and some nuclei have very shorter half-life time (10^{-14}s). We can express the half life in terms of the decay constat. At t = $T_{1/2}$, the number of undecayed nuclei N = N_0 / 2. $\Longrightarrow \frac{N_0}{2} = N_0 e^{-\lambda T_{1/2}}$ $e^{\lambda T_{1/2}} = 2$ $T_{\frac{1}{2}} = \ln\frac{2}{\lambda} = \frac{0.6931}{\lambda}$	**3**
8.	The following are the drawbacks of Bohr atom model (a) Bohr atom model is valid only for hydrogen atom or hydrogen like-atoms but not for complex atoms. (b) When the spectral lines are closely examined, individual lines of hydrogen spectrum are accompanied by a number of faint lines. This is called **fine structure**. This cannot be explained by Bohr atom model. (c) Bohr atom model fails to explain the intensity variations in the spectral lines. (d) The distribution of electrons in various levels cannot be completely explained by Bohr atom model.	**3**

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9.	$BE = \left[Z_{m_H} + N_{m_n} - M_A\right]c^2$ $\Delta m = 0.03043\ u \quad \Rightarrow \quad BE = 28.33\ MeV$	**3**
10. a	$U_n = \frac{\frac{1}{4\varepsilon_0^2} Z^2 me^2}{h^2 n^2}$ $K.E_n = \frac{1}{2}mv_n^2 = \frac{\frac{me^4}{8\varepsilon_0^2 h^2} Z^2}{n^2}$ $E_n = U_n + KE_n = -\frac{me^4}{8\varepsilon_0^2 h^2}\frac{Z^2}{n^2}$ For hydrogen atom, Z=1 $E_n = -\frac{me^4}{8\varepsilon_0^2 h^2}\frac{1}{n^2}$ = -13.6 1/n^2 joule For the first orbit (ground state), the total energy of electron is E_1= – 13.6 *eV*. For the second orbit (first excited state), the total energy of electron is E_2= –3.4 *eV*. For the third orbit (second excited state), the total energy of electron is E_3= –1.51 *eV* and so on. the energy of the first excited state is greater than that of the ground state, second excited state is greater than that of the first excited state and so on. Thus, the orbit which is closest to the nucleus (*r*1) has lowest energy (minimum energy what it is compared with other orbits). So, it is often called ground state energy (lowest energy state). The ground state energy of hydrogen (–13.6 *eV*) is used as a unit of energy called Rydberg (1 Rydberg = –13.6 *eV*). The negative value of this energy is because of the way the zero of the potential energy is defined. When the electron is taken away to an infinite distance (very far distance) from nucleus, both the potential energy and kinetic energy terms vanish and hence the total energy also vanishes. The energy level diagram along with the shape of the orbits for increasing values of *n* are shown in Figure 9.20. It shows that the energies of the excited states come closer and closer together when the principal quantum number *n* takes higher values.	**5**

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10. b	At any instant *t*, the number of decays per unit time, called rate of decay $\left(\frac{dN}{dt}\right)$ is proportional to the number of nuclei (N) at the same instant. $-\frac{dN}{N} \propto N \quad => \quad \frac{dN}{dt} = -\lambda N$ $\int_{N_0}^{N} \frac{dN}{N} = -\lambda \int_0^t dt$ $N = N_0 e^{-\lambda t}$  $R = R_0 e^{-\lambda t}$ $R = \lambda N$	**5**
11	i) if M, m_p, and m_n are mass of the nucleus (${}_A^Z X$), the mass of a proton and the mass of a neutron respectively, then the mass defect is given by $\mathbf{\Delta}\mathrm{m} = \left(\mathrm{Z}_{\mathrm{m_p}} + N_{m_n}\right) - M$ ii) $\mathbf{\Delta}\mathrm{m} = \left(\mathrm{Z}_{\mathrm{m_p}} + N_{m_n}\right) - M = 0.990391\ u$ $BE = \left[Z_{m_H} + N_{m_n} - M_A\right]c^2 = 8.5MeV$	**5**

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