IIT-JEE / MEDICAL

PHYSICS

QUESTIONS

Atoms and Nuclei

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VERY SHORT ANSWER QUESTIONS

1. Which series of H-spectrum lines in the visible region?
2. Which series of H-spectrum has the shortest wavelength?
3. What is the shortest wavelength present in Paschen Series of H-spectrum?
4. Name the famous experiment which led to the discovery of atomic nucleus?
5. What is radius of nucleus?
6. Name the experiment which showed that atom is hollow.
7. A free neutron is unstable .What is its half-life?
8. Why is neutron so effective as the bombarding particle?
9. Which fundamental force is strongest?
10. State the energy equivalent to 1 amu in MeV.
11. Complete the equation

$$_{92}U^{235} + {}_{0}n^{1} = \ldots\ldots\ldots\ldots$$

12. Complete the equation

$$_{1}^{2}H + {}_{1}^{2}H = \ldots\ldots\ldots\ldots\ldots$$

13. Name the process in which two lighter nuclei combine to give a heavier one.
14. Name the process in which a heavier nucleus breaks into two lighter nuclei.
15. What is an α-particle?
16. What is an β-particle?
17. What do you mean by γ-radiation?
18. Why do heavy nuclei decay spontaneously?
19. How does a parent nucleus transform after an α-particle emission?
20. How does a parent nucleus transform after β-particle emission?
21. How does a parent nucleus transform after γ-photon emission?
22. Can a radioactive nucleus emit an α-particle and β-particle simultaneously?
23. Is radioactivity an atomic or a nucleus phenomenon?
24. Complete the following reaction

$$_{4}Be^{9} + {}_{2}He^{4} \rightarrow {}_{6}C^{12} + \ldots\ldots\ldots\ldots$$

25. Complete the following reaction

$$_{6}C^{12} + {}_{2}He^{4} \rightarrow {}_{8}O^{17} + \ldots\ldots\ldots\ldots$$

26. What is the reaction between mean life and half-life ? Which of the two is longer?
27. Two nuclei have mass number in the ratio 1 : 8 .What is the ratio of their nuclear radii?
28. Express 1 amu in Kilpgram.
29. In heavy nuclei what is neutron – proton ratio : less than 1 or greater than 1 or equal to 1?
30. What is the ratio of nuclear radii of $_{2}He^{4}$ and $^{12}_{6}C$ nuclei ?
31. What is the ratio of nuclear radii of $_{2}He^{4}$ and $^{12}_{6}C$?

32. What do you mean by mass defect?
33. What are the number of protons , neutrons and electrons in nucleus ${}_ZX^A$?
34. What is the source of steller energy?
35. What is the energy of thermal neutron at room tempracture?
36. What is the temperature at which nuclear fusion of protons is most likely to take place?
37. A radioactivity substance has N nuclei at time t. What will be the number disintegrated in 2 half lives?
38. Define impact parameter.
39. The energy of electron in nth orbit of H-atom is $E_n = -\frac{13.6}{n^2} eV$. What is the energy required for transition from ground state to first exited state.
40. What is the relation of kinetic energy K and potential energy U of an electron in nth state of H-atom.
41. Draw the graph showing the distribution of kinetic energy U of an electrons emitted during β-decay.

SHORT ANSWER QUESTIONS

1. Define half-life and mean life of a radioactive sample.
2. Why a γ-radiation may be emitted along with an α and β-particle?
3. A nucleus ${}_ZX^A$ undergoes an α-particle decay followed by a β-particle decay .What is the mass number and atomic number of the resulting nucleus?
4. Why an α-particle but not a proton is emitted by radioactive nuclei?
5. If both the number of protons and the number of neutrons are conserved in each nuclear reaction , then how is it said that un a nuclear reaction mass is being converted into energy?
6. Explain the term chain reaction. What is the role of moderator in a chain reaction?
7. Distinguish between nuclear fission and nuclear fusion?
8. Distinguish between nuclear fission and radioactive decay?
9. Define half- life of a substance and find an expression for it?
10. What is the critical nuclear chain reaction ? Explain the role of control rods in it.
11. What do you mean by impact parameter and angle of scattering in Rutherford's experiment? What is the relation between them?
12. Why is so much energy released in nuclear reactions but not in chemical reactions?
13. Write nuclear equations for
    (i) α-decay of ${}^{226}_{88}Ra$ (ii) β-decay of ${}^{32}_{15}P$?
14. What is the role of a neutrino in β-decay?
15. Define the terms defect and binding energy .Which nucleus has the maximum energy per nucleon?

16. A nucleus is represented by ${}_zX^A$ Write an expression for its binding energy per nucleon as a function of mass of proton m_p , mass of neutron m_n and mass of nucleus m_x.
17. Write two consequences of Rutherford's scattering experiment.
18. What is the Rutherford's atom model ? Name its two shortcomings.
19. State the assumptions of Bhor-atom model.
20. Name the series of H –emission spectrum.
21. Explain the origin of spectrum lines of Hydrogen using Bhor's theory.
22. Why is heavy water but not ordinary water is used as a moderator in a nuclear reactor?
23. Give a labelled diagram of a critical chain reaction using U-235 fuel and graphite as moderator .
24. Write two properties of α-rays.
25. Write two properties of β-rays.
26. Write two properties of γ-rays.
27. Compare the ionising and penetrating power of –α , -β and -γ radiations.
28. Write Rutherford-Soddy's law of radioactivity.
29. Why α-particles but not the protons as such the emitted by radioactive nuclei?
30. Explain why the spectrum of electrons emitted in beta decay is continuous?

LONG ANSWER QUESTIONS

1. What is radioactivity ? Which radiations are emitted in this process ? Give a simple expiations of α-decay , β-decay and γ-decay.
2. What is the source of energy in sun? Explain with the help of necessary equations ?
3. What is chain reaction? Describe construction and working of a nuclear reactor. What are its uses?
4. Draw a curve showing the variation in binding energy per nucleon with mass number .Explain the release of energy in the process of fission and fusion on the basis of this curve.
5. Discuss the general shape of the plot of the binding energy per nucleon verses the mass number of different nuclei. Hence explain why we must expect a release of nuclear energy during (i) nuclear fission (ii) nuclear fusion.
6. State the laws of radioactive decay . Prove the formula $N = N_0 e^{-\lambda t}$ .Hence find an expression for half –life in terms of decay constant λ.
7. Name the fundamental forces. What are the properties of nuclear forces? Write expression for nuclear radius and show that the density of nuclear matter is independent of mass number A.

NUMERICAL QUESTIONS

1. The ground state energy of hydrogen atom is -13.6 eV.
   (i) What is the potential energy of the electron in the third exited state.
   (ii) If the electron jumps from the third state to the ground state , calculate the wavelength of the photon emitted.

   [**Hint :** For third exited state n=4]

   [**Ans.** (i) $U_4=2E_4=-1.70$ eV (ii) 975 A^0]

2. Energy released per fission of U^{235} is 200 MeV. How much U^{235} is required per day in a nuclear reactor of capacity of 10 MW ? Assume efficiency of reactor to be 2%.
   [**Ans.** 43.5 g]

3. Calculate the binding energy per nucleon of $_{85}Ba^{209}$. Given m(Bi^{209})=208.980388 amu , m_n=1.008665 amu , m_p=1.007825 amu.
   [**Ans.** 7.848 MeV]

4. The fission of uranium by slow neutron is as given below

$$_{92}U^{235} + {}_0n^1 \rightarrow {}_{38}Mo^{98} + {}_{54}Xe^{136} + 2({}_0n^1) + Q$$

   If Mass of $_{92}U^{235}$ =235.0439 amu

   Mass of $({}_0n^1)$ =1.0087 amu

   Mass of $_{38}Mo^{98}$ =97.9054 amu

   Mass of $_{54}Xe^{136}$ =135.9072 amu

   Calculate the value of Q.
   [**Ans.** Q=210 MeV]

5. For hydrogen nuclei fuse together to form a helium nucleus with the emission of two positrons (β^+-particles). Calculate the energy released in the reaction.
   Given M($_1H^1$) =1.007825 u

   M($_2He^4$)=4.002603 u

   M(β^+)=0.000549 u

   [**Ans.** 25.71 MeV]

6. The binding energies per nucleon of deuteron ($_1H^2$) and helium ($_2He^4$) nuclei are 1.1 MeV and 7.0 MeV respectively .How much energy will released when two deuteron fuse to from a helium nucleus?
   [**Ans.** 23.6 MeV]
   [**Hint :** Released energy = 4 x 7.0-4x1.1=23.6 MeV]

7. Find the half- life period of a radioactivity material if its drops to $\frac{1}{32}$ of its initial value in 25 years.
   [**Ans.** 5 years]

8. The half-life of a radioactivity material is 2 days . How much of a sample of 50g would be left undecayed after 6 days?
   [**Ans.** 6.25 g]
9. The activity of a radioactive element is reduced to $\frac{1}{8}$ of its initial value in 30 days .Find (i) half-life of element and (ii) decay constant of element.
   [**Ans.** (i) 10 Years (ii) 0.0693 day^{-1}]
10. The decay constant for a radioactive nuclide is 1.386 day^{-1}. After how much time will a given sample of this radioactive nuclide get reduced to only 6.25% of its present number?
    [**Ans :** 2 days]
11. The half-life of a given radioactive nuclide is 138.6 days. What is the mean life of this nuclide ? After how much time will a given sample of this radioactive nuclide get reduced to only 12.5% of its initial value?
    [**Ans :** Mean life $\tau = \frac{T}{\log_e 2} = \frac{138.6}{0.693} = 200\ days, t = 415.8\ days$]
12. Tritium has a half-life of 12.5 years against β-decay . Calculate the fraction of pure tritium left undecayed after 25 years.
    [**Ans :** 0.25]
13. The half-life of radioactive substance is 1672 years. If the initial mass of the substance is 1 g; after how many years only 1 mg of it will be left behind?
    [**Ans :** 16670 years]
14. The half-life of $^{238}_{92}U$ against α-decay is 1.5 x 10^{17} s. What is the activity of sample of $^{238}_{92}U$ having 25 x 10^{20} s^{-1}.
    [**Ans :** 1.15 x 10^{4} s^{-1}]
15. A neutron is obserbed by a $^{6}_{3}Li$ neclus with the subsequent emission of an alpha particle.
    (i) Write the corresponding nuclear reaction.
    (ii) Calculate the energy released , in MeV , in this reaction.
    Given : mass of $^{6}_{3}Li$ =6.015126 u; mass (neutron)=1.008665 u ;
    Mass(alpha particle)=4.0026044 u and mass (triton)=3.0100000 u.
    Take 1 u=931 MeV/c^2.
    [Ans. (i) $^{6}_{3}Li + {}^{1}_{0}n \rightarrow {}^{4}_{2}He + {}^{3}_{1}He + Q$ (ii) 10.415 MeV **]**

Note : if any mistake on this, kindly inform on the mail id :

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Your Observation! Our Correction !!