PHYSICS

BOOKS - GK PUBLICATIONS PHYSICS (HINGLISH)

NUCLEAR PHYSICS AND RADIOACTIVITY

Discusion Question

1. Is the mass excess of an alpha particle greater than or less than the particle's total binding energy?

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2. We have stimulated and spontaneous emission.Do we also have stimulated absorption and spontaneous absorption?

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3. Tritium is the $.^{3}H$ isotope of hydrogen. Its atomic mass is 3.016amu: the atomic mass of $.^{1}H$ is 1.0078 amu, and that for the neutron is 1.00867 amu. What do you predict about the stability of tritium? Repeat for $.^{2}H$, deuterium, which has an atomic mass of 2.0141 amu.

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4. If neutrons exert only attractive force, why don't we have a nucleus containing neutrons alone?

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5. Consider two pairs of neutrons. In each pair, the separation between the neutrons is the same. Can the force between the neutrone have different magnitudes for the two pairs?

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6. A molecule of hydrogen contains two protons and two electrons. The nuclear force between these two protons is always neglected while discussing the behaviour of a hydrogen molecule. Why?

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7. Is it easier to take out a nucleon (a) from carbon or from iron (b) from iron or from lead?

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8. Suppose we have 12 protons and 12 neutrons. We can assemble them to form either a $\hat{}\ 24Mg$ nucleus or two $\hat{}\ 12C$ nuclei. In which of the two cases more energy will be liberated?

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9. What is the difference between cathode rays and beta rays? When the two are travelling in space, can you make out which is the cathode ray and which is the beta ray?

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10. At t=0, a sample of radionuclide A has the same decay rate as a sample of radionuclide B has at t=30min. The disintegration constants are λ_A and λ_B, with $\lambda_A < \lambda_B$. Will the two samples ever have (simultaneously) the same decay rate?

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11. At t=0 we begin to observe two identical radioactive nuclei with a half life of 5 min. At t=1 min one of the nuclei decays. Does that event increase or decrease the chance of the second nucleus decaying in the next 4 min. or is there no effect on the second nucleus?

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12. If the nucleons of a nucleus are separated from each other, the total mass is increased. Where does this mass come from?

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13. The radionuclides $.^{209}At$ and $.^{209}Po$ emit alpha particles with energies of 5.65 and 4.88MeV. Respectively. Which nuclide has the longer half life?

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14. In beta decay, an electron (or a positron) is emitted by a nucleus. Does the remaining atom get oppositely charged?

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15. When a boron nucleus ($_5^{10}B$) is bombarded by a neutron, an α-particle is emitted. Which nucleus will be formed as a result?

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16. Does a nucleus lose mass when it suffers gamma decay?

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17. In a typical fission reaction, the nucleus is split into two middle-weight nuclei of unequal masses. Which of the two (heavier or lighter) has greater kinetic energy? Which one has greater linear momentum?

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18. Consider the fission reaction

$.^{235}U + n \rightarrow X + Y + 2n$

Rank the following possible nuclides for representation by X (orY), most likely first:

(a) $.^{152}Nd$, (b) $.^{140}I$, (c) $.^{128}In$, (d) $.^{115}Pd$, (e) $.^{105}Mo$

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19. If three helium nuclei combine to form a carbon nucleus, energy is liberated. Why can't helium nuclei combine on their own and minimise the energy?

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20. Estimate the atomic mass of $.^{64}_{30}Zn$ from the fact to be the binding energy per nucleon for it is about 8.7 MeV.

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21. Why do chemists consider different isotopes to be the same element even through their nuclei are not the same?

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22. Suppose that a $.^{238}U$ nucleus "swallows" a neutron and then decays not by fission but by beta decay, emitting an electron and a neutrino. Which nuclide remains after this decay:

(a) $.^{239}Pu$, (b) $.^{238}Np$, (c) $.^{239}Np$, or (d) $.^{238}Pa$?

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23. The neutron number is not conserved in a beta decay. Is this a violation of the conservation of nucleons? Explain.

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24. Which physical or chemical properties affect thedecay rate or half-life ofa radioactive isotope ?

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25. The energy produced in fission reactions is carried off askinetic energies ofthe products. How is this energy converted to heat in a nuclear reactor ?

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26. Why is it found experimentally difficult to detect neutrinos in nuclear β-decay?

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27. Why are heavy nuclei usually unstable?

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28. why do nearly all the naturally occuering isotope lie above the N=Z line in figure 4.1?

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29. If a nucleus has a half -life of 1 year, does this mean it will be completely decayed after 2 years ? Explain.

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30. What fraction of a radiactive sample has decayed after two half-lives have elapsed?

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31. Two samples of the same sradiactive nuclide are prepared. Sample A has twice the initial activity of sample B. How does the hfalf-life of A compare with the half-life of B? After each has passed through five half-lives, what is the ratio of their activities?

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32. Explain why the half-lives for radiactive nuclei are essentially independent of temperature.

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33. If a nucleus such as $.^{226}Ra$ that is initially at rest undergoes α- decay , then which of the following statemnets is true?

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34. Explain why many heavy nuclei undergo alpha decay but do not spontaneously emit neutrons or protons.

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35. If an alpha particle and an electron have the same kinetic energy. Which undergoes the greater deflection when passed through a magnetic field?

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36. If ilm is kept in a wooden box, alpha paritlces from a radiactive source outside the box cannot expose the film but beta particles can. Explain.

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37. Why would a fusion reactor produces less radiactive waste than a fission reactor?

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38. What factors make a fusion difficult to achieve?

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39. Discuss the advantage and disadvantages of fusion power from the point of safety. Pollution, and resources.

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40. Discuss three major problems associated with the development of a controlled fusion reactor.

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41. If two radioactive samples have the same activity measured in curies, will they necessarily create the same damage to a medium? Explain.

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42. Why aren't the masses of all nuclei exact integer multiples of the mass of a single nucleion?

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43. Compared to α- particles with the same energy. β particles can much more easily penetrate through matter why is this?

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44. Some decays that are not possible from a nucleus in its ground state are possible if the nucleus is in an excited state, Explain why.

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45. What are the propeties of a nucleus that is likely to undergo(a) alpha decay, (b) beta decay, and (c) gamma decay?

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46. Assertion : Rate of radioactivity cannot be increased or decreased by increasing or decreasing pressure or temperature.

Reason : Rate depends on the number of nuclei present in the radioactive sample.

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47. Why is radium still found in nature? Its half-life is 1600 years, and the estimated age of the universe is five billion years.

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48. Assertion: Isotopes of an element can be separated by using a mass spectrometer.

Reason: Separation of isotopes is possible because of difference in electron numbers of isotope.

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49. Can you suggest any reasons why natural radiactivity contains helium nuclei but neither hydrogen nor lithium nuclei?

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Concptual Mcqs

1. A radioactive element ${}_{90}X^{238}$ decay into ${}_{83}Y^{222}$. The number of $\beta -$ particles emitted are.

A. 4

B. 6

C. 2

D. 1

Answer: D

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2. Three speciments A,B,C of same radiactive element have activites, 1 curie 1 rutherford and 1 becquerel respectively. Which specimen has maximu mass:

A. A

B. B

C. C

D. All have equal mass

Answer: A

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3. Which of the following radiation has the least wavelength ?

A. $\gamma-$ rays

B. $\beta-$ rays

C. $\alpha-$ rays

D. X -rays

Answer: A

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4. A nucleus with $Z = 92$ emits the following in a sequence

$a, \beta^{-}, \beta^{-} a, a, a, a, a, \beta^{-}, \beta^{-}, a, \beta^{+}, \beta^{+}, a$

Then Z of the resulting nucleus is

A. 76

B. 78

C. 82

D. 74

Answer: B

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5. When aluminium is bombarded with fast neutrons, it changes into- sodium with emission of particle according to the equation

$._{13}^{27} Al + ._{0}^{1} n \rightarrow ._{11}^{24} Na + x$

What is the name of x?

A. Electron

B. Proton

C. Neutron

D. Alpha-particle

Answer: D

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6. The mean density of the nuclei is proportinal to:

A. Mass number

B. Atomic number

C. The number of nucleons

D. None of the above

Answer: D

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7. In the following nuclear reaction

$._{13}Al^{27} + ._{2}He^{4} \rightarrow ._{15}P^{30} + X$, X will be

A. $._{-1}^{0}e$

B. $._{1}^{1}H$

C. $._{2}^{4}He$

D. $._{0}^{1}n$

Answer: D

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8. Choose the WRONG statement. A thermonuclear fusion reactor is better than a fission reactor for the following reasons:

A. For the same mass of substances involved, a fusion reaction releases much more energy than a fission reaction

B. A fusion reaction can be much more easily controlled than a fission reaction

C. A fusion reaction produces almost no radioactive waste

D. The fuel required for fusion is radily available in abundance from sea-water.

Answer: B

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9. The chemical behaviour of a atom depends upon:

A. The number of electrons orbiting aroung its nucleus.

B. The number of protons in its nucleus

C. The number of neutrons in its nucleus

D. The number of nucleons in its nucleus

Answer: A

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10. The critical mass of a fissionable uranium -235 can be reduced by

A. Heating it

B. Cooling it

C. Adding impurities to it

D. Surrounding it with a shield that will reflect neutrons

Answer: D

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11. Cadmium and Broron rods are used in a nuclear reactor to

A. Slowing down fast neutrons

B. Speedingup slow neutrons

C. Absorbing neutrons

D. Regulating the power level of the reactor

Answer: D

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12. A $\beta -$ particle is emitted by a radioactive nucleus at the time of convertsion of a:

A. Neutron into a proton

B. Proton into a neutron

C. Nucleon into energy

D. Positron into energy

Answer: A

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13. Why does the fussion occur at high temeprature?

A. Atoms are inised at high temperature

B. Molecuels break up at high temperature

C. Nuclei break up at high temperature

D. Kinetic energy is high enough to overcome repulsion between nuclei

Answer: D

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14. Mass defect of an atom refers to

A. Inaccurate measurement of nucleons

B. Mass annihilated to produce energy to bind the nucleus

C. Packing fraction

D. Difference in number of neutrons and protons in the nucleus

Answer: B

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15. If M is the mass of a nucleus and A its atomic mass, then the packing fraction is:

A. $\frac{M-A}{M+A}$

B. $\frac{M-A}{M}$

C. $\frac{M-A}{A}$

D. $\frac{M+A}{M-A}$

Answer: C

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16. The fusion of hydrogen into helium is more likely to take place:

A. At high temperature and high pressure

B. At high temperature and low pressure

C. At low temperature and low pressure

D. At low temperature and high pressure

Answer: A

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17. The number of neutrons that are released on an average during the fission of U^{235} nucleus is

A. 1

B. 2

C. 2.5

D. 3

Answer: C

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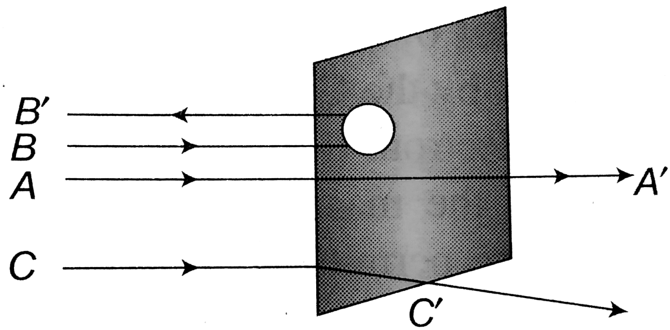
18. A beam of fast moving alpha particles were directed towards a thin film of gold. The parts A', B' and C' of the transmitted and refected beams correcponding ro the incident parts A, B and C of the beam, are shown in the adjoining diagram. The number of alpha particles in



A. B' will be minimum and in C' maximum

B. A' will be maximum and in B' minimum

C. A' will be minimum and in B' maximum

D. C' will be minimum and in B' maximum

Answer: B

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19. From the following equations pick out the possible nuclear fusion reaction:

A. $._6^{13}C + ._1^1H \rightarrow ._6^{14}C + 4.3$ MeV

B. $._6^{12}C + ._1^1H \rightarrow ._7^{13}C + 2$ MeV

C. $._7^{14}C + ._1^1H \rightarrow ._8^{16}O + 7.3$ MeV

D. $._{92}^{235}U + ._0^1n \rightarrow ._{54}^{140}Xe + ._{38}^{94}Sr + 2(._0^1n) + \gamma + 200$ MeV

Answer: B

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20. Radio carbon dating is done by estimating in the speciment:

A. The amount of ordinary carbon still present

B. The amount of radio carbon still present

C. The ratio of the amounts of $._{6}^{14}C$ to $._{6}^{12}C$ still present

D. None of the above

Answer: C

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21. Which of the following cannot be emitted by radioactive substances during their decay ?

A. Protons

B. Neutrinos

C. Helium nellei

D. Electons

Answer: A

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22. The electron emitted in beta radiation originates from

A. Inner orbits of atoms

B. Free electrons existing in nuclei

C. Decay of neutron in a nucleus

D. Photn escaping from the nucleus

Answer: C

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23. In the following reaction the value of 'X' is.

$$._7 N^{14} + ._2 He^4 \rightarrow X + ._1 H^1.$$

A. Nitrogen of mass 16

B. Nitrogen of mass 17

C. Oxygen of mass 16

D. Oxygen of mass 17

Answer: D

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24. What is the respective number of α and β particles emitted in the following radioactive decay

$\cdot_{90} X^{200} \rightarrow \cdot_{80} Y^{168}$.

A. 8 and 6

B. 6 and 8

C. 8 and 8

D. 6 and 6

Answer: A

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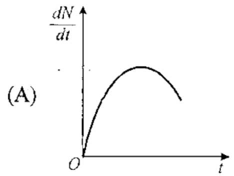
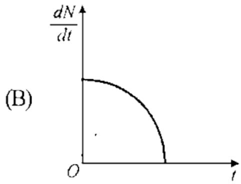
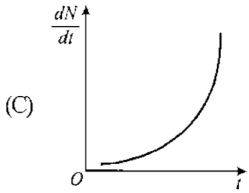
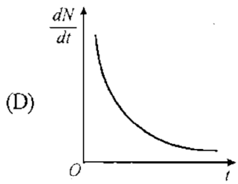
25. The radioactive nucleus of an element X decays to a stable nucleus of element Y.A graph of the rate of romation of Y against time would look like:

A. 

B. 

C. 

D. 

Answer: D

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26. The radioactive decay of uranium into thorium is represented by the equation:

$._{92}^{238} U \rightarrow ._{90}^{234} Th + x$

What is x ?

A. An electon

B. A proton

C. An alpha particle

D. A neutron

Answer: C

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27. At a result of radioactive decay a $._{92}^{238} U$ nucleus is changed to a $._{91}^{234} P$ nucleus. Which particles are emitted in the decay?

A. One proton and two neutrons

B. One $\alpha-$ particle and one $\beta-$ particle

C. Two $\beta-$ particles and one neutron

D. Two $\beta-$ partilces and one proton

Answer: B

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28. A free neutron decays into a proton, an electron and

A. A neutrino

B. An antineutrino

C. An $\alpha-$ particle

D. A photon

Answer: B

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29. A carbon nucleus emits a particles x and changes into nitrogen according to the equation:

$._{6}^{14}C \rightarrow ._{7}^{14}N + x$

What is x?

A. An electon

B. A proton

C. An alpha particle

D. A photon

Answer: A

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30. $._{92}^{239}U$ decays emitting a $\beta -$ particle producing neptunium nucleus. Which futher decays emitting a $\beta -$ particle and the daughter product is plutonium (Pu). The grand daughter product can be expressed as:

A. $._{90}{}^{239}Pu$

B. $._{90}^{241}Pu$

C. $._{92}^{239}Pu$

D. $._{94}^{241}Pu$

Answer: C

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31. The half-life of a radiactive substance depends upon:

A. Its temperature

B. The external pressure on it

C. The mass of the substance

D. The strength of the nuclear force between the nucleons of its atom

Answer: D

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32. The half-life period of a radio-active element X is same as the mean life time of another radio-active element Y. Initially they have the same number of atoms. Then:

A. X and Y have the same decay rate initially.

B. X and Y decay at the same rate always

C. Y will decay at a faster rate than X

D. X will decay at a faster rate than y

Answer: D

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33. In the given reaction

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

Radioactive radiations are emitted in the sequence.

A. α, β, γ

B. β, α, γ

C. γ, α, β

D. β, γ, α

Answer: B

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34. The nuclear reaction $._{48}^{107} Cd \rightarrow ._{47}^{107} Ag$ can occur with the:

A. Electron capture

B. Positron capture

C. Proton emission

D. $\alpha -$ particle emission

Answer: A

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35. Two radioactive elements X and Y have half-life periods of 50 min and 100 min , respectively. Initially, both of them contain equal number of atoms. Find the ratio of atoms left N_X / N_Y after 200 min .

A. 4

B. 2

C. $1/2$

D. $1/4$

Answer: D

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36. When a β^- particle is emitted from a nucleus, the neutrons-proton ratio:

A. Is decreased

B. Is increased

C. Remains the same

D. First (A) then (B)

Answer: A

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37. In the given reaction

$$\cdot_{z} X^{A} \rightarrow \cdot_{z+1} Y^{A} \rightarrow \cdot_{z-1} K^{A-4} \rightarrow \cdot_{z-1} K^{A-4}$$

Radioactive radiations are emitted in the sequence.

A. α, β, γ

B. β, α, γ

C. γ, α, β

D. α, γ, β

Answer: B

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38. Heavy water is used as moderator in a nuclear reactor. The function of the moderator is

A. To slow donw the neutrons to thermal energies

B. To absorb the neutrons and stop the chain reaction

C. To cool the reactor

D. To control the enrgy released in the reactor

Answer: A

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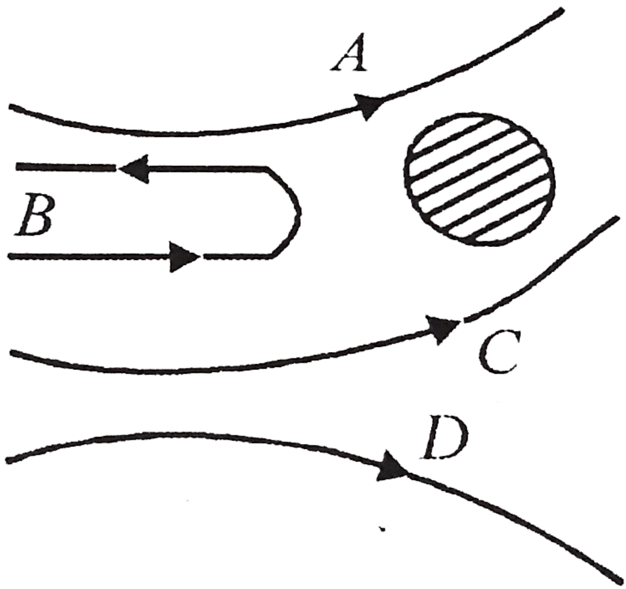
39. In the Rutherford experiment, α-particles are scattered from a nucleus as shown. Out of the four paths, which path is not possible?



A. 1

B. 2

C. 3

D. 4

Answer: C

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40. The decay constant λ of a radioactive sample:

A. Decreases with increase of external pressure and temperature

B. Increase with increase of external pressure and temperature

C. Decreases with increase of temperature and increase of pressure

D. Is independent of temperature and pressure.

Answer: D

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41. When high energy alpha particles $\left(._2^4 He\right)$ pass through nitrogen gas, an isotope of oxygen is formed with the emission of particles named x, the nuclar reaction is

$._7^{14} N + ._2^4 He \rightarrow ._8^{17} O + x$

What is the name of x?

A. Electron

B. Proton

C. Neutron

D. Positron

Answer: B

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42. When a boron nucleus ($_5^{10}B$) is bombarded by a neutron, an α-particle is emitted. Which nucleus will be formed as a result?

A. 11

B. 7

C. 6

D. 15

Answer: B

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43. Consider a particle , β particle and $\gamma - rays$, each having an energy of $0.5MeV$. In increase order of panetrating power , the radiation are .

A. α, β, γ

B. α, γ, β

C. β, γ, α

D. γ, β, α

Answer: A

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44. A radioactive nucleus emits a beta particle. The parent and daughter nuclei are:

A. Isotopes

B. Isobars

C. Isomers

D. Isotonex

Answer: B

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45. Fast neutrons can easily be slowed down by

A. The use of lead shielding

B. Passing them through water

C. Elastic collisions with heavy nuclei

D. Applying a strong electric field

Answer: B

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46. A nucleus ruptures into two nuclear parts, which have their velocity ratio equal to $2:1$. What will be the ratio of their nuclear size (nuclear radius)?

A. $3^{1/2}:1$

B. $1:3^{1/2}$

C. $2^{1/3}:1$

D. $1:2^{1/3}$

Answer: D

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47. For nuclei with $A > 100$, mark the INCORRECT statement:

A. The binding energy per nucleon decreases on the average as A increases

B. If the nucleus breaks into two roughly equal parts, energy is released

C. If two nuclei fuse to form a bigger nucelus energy is released

D. The nucleus with $Z > 83$ are generally unstable.

Answer: C

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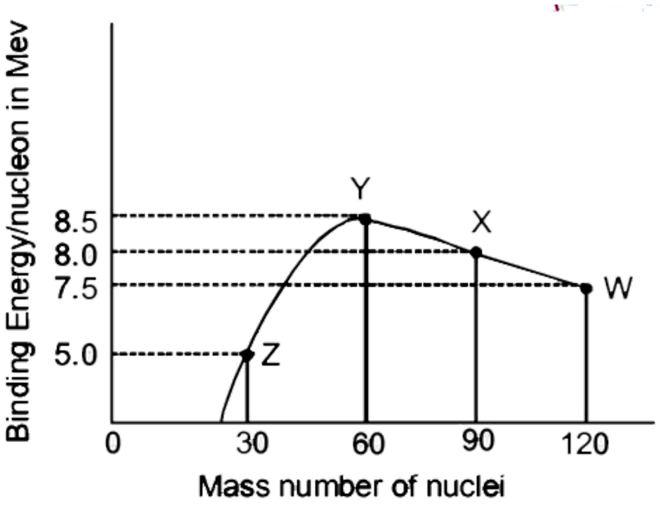
48. Binding energy per nucleons vs mass curve for nucleus is shown in the figure W, X, $Y$and Z are four nuclei indicated on the curve . The process that would release energy is



A. $Y \rightarrow 2Z$

B. $W \rightarrow X + Z$

C. $W \rightarrow 2Y$

D. $X \rightarrow Y + Z$

Answer: C

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Others

1. Find the binding energy of an α-particle from the following data.

Mass of helium nulceus $= 4.001235 amu$

Mass of proton $= 1.007277 amu$

Mass of neutron $= 1.00866 amu$

(take 1 amu=$931.4813 MeV$).

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2. A neutron breaks into a proton and electron. Calculate the energy produced in this reaction in MeV. Mass of an electron $= 9 \times 10^{-11}$ kg. mass of proton=1.6725xx10^{-27}kg, Mass of neutron=1.6747 $\times 10^{-27}$kg. speed of light =$3 \times 10^{8} m/\text{sec}$.

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3. The binding enrgy of $._{17}^{35} Cl$ nucleus is 298 MeV. Find the atomic mass. Given, mass of a proton $(m_P) = 1.007825$ amu, mass of a neutron $(m_n) = 1.008665$ amu.

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4. Find the density of $._{6}^{12}C$ nucleus. Take atomic mass of $._{6}^{12}C$ as $12.00amu$ Take $R_0 = 1.2 \times 10^{-15}m$.

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5. Calculte the binding energy per nucleon for $._{10}^{20}Ne, ._{26}^{56}Fe$ and $._{98}^{238}U$. Given that mass of neutron is $1.008665amu$, mass of proton is $1.007825amu$, mass of $._{10}^{20}Ne$ is $19.9924amu$, mass of $._{26}^{56}Fe$ is $55.93492amu$ and mass of $._{92}^{238}U$ is $238.050783amu$.

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6. Show that the nuclide $.^{8}Be$ has a positive binding energy but is unstable with respect to decay into two alpa particles, where masses of neutron, $.^{1}H$, and $.^{8}Be$ are 1.008665 u, $1.007825u$, and $8.005305u$, respectively.

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7. In a thermo-nuclear reaction $1.00 \times 10^{-3} kg$ hydrogen is converted into $0.993 \times 10^{-3} kg$ helium.

(a) Calculate the energy released m joule.

(b) If the efficiency of the generator be 5%, calculation the energy in kilowatt hours.

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8. Find the binding energy and the binding energy pernucleon of the nucleus of $._8^{16} O$. Given atomic mass of $._8^{16} O(m) = 15.994915$ amu, mass of proton $(m_p) = 1.007823$ amu, mass of a neutron $(m_n) = 1.008665$ amu and 1 amu =931.5 MeV.

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9. (a) Find an approximate expression for the mass of a nucleus of mass number A,

(b) Find an expression for the volume of this nucleus in terms of the mass number.

(c) Find a numerical value for its density.

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10. Calculate the binding energy of the deuteron, which consistss of a proton and a neutron, given that the atomic mass of the deuteron is 2.014102 amu,. Take mass of proton $(m_p) = 1.007825$ amu, mass of a neutron $(m_n) = 1.008665$ amu and 1amu=931.5 MeV

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11. Find the binding energy of the nucleus of lithium isotope $._3^7 Li\&$ hence find the binding energy per necleon in it. (Given $._3^7 LI$ atom=7.016005 amu $._1 H^1$ amu atom=1.007825 amu $\_(0)^1 \eta = 1.008665$

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12. Calculate the electric potential energy due to the electri repulsion between two nuclei of $\hat{\ } 12C$ when they touch each other at the surface.

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13. Find the binding energy of $._{20}^{56} Fe$. Atomic mass of $.^{56} Fe$ is 55.934939 amu. Mass of a proton is 1.007825 amu and that of neutron=1.008665 amu.

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14. The half life of radon is 3.8 days . After how many days will only one twentieth of radon sample be left over ?

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15. One gram of a radiactive material having a half-life period of 2 years is kept in store for a duration of 4 years. Calculate how much of the material ramins unchanged.

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16. 1 gm of radiactive substance takes 30sec to lose 1 centigram. Find its half life period.

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17. 1g of a radioactive substance disintegrates at the rate of 3.7×10^{10} disintegrations per second. The atomic massof the substance is 226. Calculate its mean life.

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18. There is a stream of neutrons with kinetic energy of 0.0327 eV. If half life of neutrons is 700s, what fraction of neutrons will decay before they travel a distance of 10m? Take mass of neutron =$1.675 \times 10^{-27} kg$.

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19. A experiment is done to determine that half life of a radiactive substance that emits one beta particle of each decays process Measurements show that an average of 8.4 beta particles are emitted each second by 2.5 milligram of the substance. The atomic weight of the substance is 230. Find the half life of the substance.

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20. In an experiment on two radioactive isotopes of an element (which do not decay into each other), their number of atoms ratio at a given instant was found to be 3. The rapidly decaying isotope has large mass and an activity of $1.0 \mu Ci$ initially. The half-lives of the two isotopes are known to be 12 hours and 16 hours. what would be the activity of each isotope and their number of atoms ration after two days?

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21. A small quantity of solution containing Na^{24} radio nuclide $(half - l \quad \text{if} \quad e = 15h)$ of activity $1.0 microcurie$ is injected into the blood of a person. A sample of the blood of volume $1cm^3$ taken after $5h$ shows an activity of 296 disintegrations per minute. Determine the total volume of the blood in the body of the person. Assume that the radioactive solution mixes uniformly in the blood of person.

(1 curie $= 3.7 \times 10^{10}$ disintegrations per second)

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22. In an ore containing Uranium, the ratio of U^{238} to Pb^{206} nuceli is 3. Calculate the age of the ore, assuming that alll the lead present in the ore is the final stable, product of U^{238}. Take the half-like of U^{238} to be 4.5×10^9 years. In $(4/3) = 0.288$.

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23. A bone suspected to have originated during the period of Ashoka the Great, was found in Bihar. Accelrator techniques gave its $\frac{.^{14}C}{.^{12}C}$ ratio as 1.1×10^{-12} is the bone old enough to have belonged to that period? (Take initial ratio of $.^{14}C$ with $.^{12}C = 1.2 \times 10^{-12}$ and half-life of $.^{14}C = 5730$ years).

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24. The half life of radium is 1500 years. After how many years will one gram of pure radium

(i) reduce to 1 centigram?

(ii) lose one milligram?

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25. The disintegration rate of a certain radioactive sample at any instant is 4750 disintegrations per minute. Five minutes later the rate becomes 2700 per minute. Calculate

(a) decay constant and (b) half-life of the sample

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26. Calculate the activity of one gm sample of $._{38}^{90}Sr$ whose half life period is 28.8 years.

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27. The half life of a cobalt radio-isotope is 5.3 years. Wht strength will a milli-curie soure of the isotope have after a period of one year.

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28. A sample contains $10^{-2} kg$ each of two substances A and B with half lives 4 sec and 8 sec respectively. Their atomic weights are in the ratio $1:2$. Find the amounts of A and B after an interval of 16 seconds.

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29. At a given instant there are 25% undecayed radioactive nuclei in a sample. After $10s$ the number of undecayed nuclei reduces to 12.5%. Calculate

(a) mean life of the nuclei,

(b) the time in which the number of undecayed nuclei will further reduce to6.25% of the reduced number.

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30. 1 gram of cesium-137 $\left(._{55}^{137} Cs\right)$ decays by β-emission with a half-life of 30 years. What is (a) the resulting isotope ? (b) the number of atoms left after 5 years? (c) if initial activity of sample is 1mCi then what is the activity of cesium after 5 years?

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31. The normal activity of a living matter containing carbon is found to be 15 decays per minute per gram of carbon. An archaeological specimen gives 6 decays per minute per gram of carbon. If the half -life of carbon is 5730 years, estimate the approximate age of the specimen.

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32. A radioactive isotope X has a half life of 3 seconds. At t=0, a given sample of this isotope contains 8000 atom. Calculate (i) its decay constant (ii) average life (iii) the time t_1, when 1000 atoms of the isotope X remain in the sample (iv) number of decay/sec in the sample at $t = t_1$ sec.

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33. A F^{32} radio nuclide with half-life $T = 14.3$ days is produced in a reactor at a constant rate $q = 2 \times 10^9$ nuclei per second. How soon after the beginning of production of that radio nuclide will its activity be equal to $R = 10^9$ disintegration per second?

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34. The mean lives of a radioactive substance are 1620 years and 405 years for α emission and β emission respectively. Find out the time during which three fourth of a sample will decay if it is decaying both by α-emission and β-emission simultaneously. $(\log_e 4 = 1.386)$.

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35. Lead $.^{206} Pb$ is found in a certain uranium ore due to disintegration of uranium. What is the age of uranium ore if its now contains 0.8gm of

$.^{206}Pb$ for each gram of $.^{238}U$ given the half life of uranium $= 4.5 \times 10^9$ years.

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36. Find the half-life of uranium, given that $3.32 \times 10^7 g$ radium is found per gram of uranium in old minerals. The atomic weights of uranium and radium are 238 and 226 and half-life of radium is 1600 years (Avogadro number is $6.023 \times 10^{23} / g - \text{atom}$).

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37. A sample of uranium is a mixture of three isotopes $._{92}U^{234}$, $._{92}U^{235}$ and $._{92}U^{238}$ present in the ratio 0.006%, 0.71% and 99.284% respectively. The half lives of then isotopes are 2.5×10^5 years, 7.1×10^8 years and 4.5×10^9 years respectively. The contribution to activity (in $\%$) of each isotope in the sample respectively

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38. A radionuclide with half life T is produced in a reactor at a constnat rate p nuclei per second. During each decay, energy E_0 is released. If production of radionuclide is started at t=0, calculate

(a) rate of release of energy as a function of time

(b) total energy released upto time t

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39. Nuclei of radioactive element A are being produced at a constant rate. α. The element has a decay constant λ. At time $t=0$, there areN_0 nuclei of the element.

(a) Calculate the number N of nuclei of A at time t.

(b) IF $\alpha=2N_0\lambda$, calculate the number of nuclei of A after one half-life time of A and also the limiting value of N at $t\rightarrow\infty$.

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40. On disintegration of one atom of $.^{235}U$, the amount of energy obtained is $200MeV$. The power obtained in a reactor is 1000 kilo watt. How many atoms are disintegrated per second in the reactor? What is the decay in mass per hour?

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41. A reactor is developing nuclear energy at a rate of 32,000 kilowatts. How many of $.^{235}U$ undergo fission per second ? How many $.^{235}U$ would be used up in 1000 hour op operation? Assume an average energy of 200MeV released per fission. Take Avogadro's number as $6 \times 10^{23}$and $1MeV = 1.6 \times 10^{-13}J$.

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42. The fission type of warhead of some guided missiles is estimated to be equivalent to 30000 tons of TNT. If $3.5 \times 10^{8}J$ of energy is released by one tone of expolining TNT, how many fissions occur in the explosions of warhead? An energy of $200MeV$ is released by fission of one atom of $.^{235}U$.

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43. Calculate the energy released by fission from $2g$ of $.^{235}._{92}U$ in kWh. Given that the energy released per fission is $200MeV$.

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44. In neutron-induced fission of $._{92}^{235}U$ (235.044amu) two stable end products usually formed are $._{42}^{98}Mo$ (97.905amu) and $._{54}^{136}Xe$ usually formed (135.917 amu. Assuming that these isotopes have come from the original fisiion process, find (i) what elementary particles are released (ii) mass defect of the reaction (iii) the equivalent energy released.

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45. IN a nuclear reactor, fission is produced in 1 g of $.^{235}U$ $(235.0349amu)$. In assuming that $._{53}^{92}Kr(91.8673amu)$ and $._{36}^{141}Ba(140.9139amu)$ are produced in all reactions and no energy is lost, calculate the total energy produced in killowatt. Given: $1amu = 931MeV$.

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46. A deuterium reaction that occurs in an experimental fusion reactor is in two stage:

(a) Two deuterium $\left(._1^2D\right)$ nuclei fuse together to form a tritium nucleus, with a proton as a by product written as $D(D, p)T$.

(b) A tritium nucleus fuses with another deuterium nucleus to form a helium $._2^4He$ nucleus with neutron as a by - product, written as T (D,n) $._2^4He$.

Compute (a) the energy released in each of the two stages, (b) the energy released in the combined reaction per deutrium. (c) What percentage of the mass energy of the initial deuterium is released. Given,

$._{1}^{2} D = 2.014102 amu$

$._{1}^{3} T = 3.016049$

$._{2}^{4} He = 4.002603 amu$.

$._{1}^{1} H = 1.007825 amu$

$._{0}^{1} n = 1.00665 amu$

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47. In the process of nuclear fission of $1g$ uranium, the mass lost is $0.92mg$. The efficiency of power house run by the fission reactor is 10% .To obtain 400 megawatt power from the power house, how much uranium will be required per hour? $\left(c = 3 \times 10^{8} ms^{-1}\right)$.

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48. The energy received from the sum by earth and its surrounding atmosphere is 2 $\text{cals}/cm^{2}/\text{min}$ on a surface normal to the rays of sun.

(a) What is the total energy received in joules by earth and its atmosphere.

(b) What is the total energy radiated in J/m by sun to the universe? Distance of sun to earth is $.149 \times 10^{8}$ km.

(c) At what rate in mega-grams per minute must hydrogen be consumed in the fusion reaction to provide the sun with the energy it radiate?

Take mass of hydrogen atom-1.008145amu.

Take mass of He atom=4.003874 amu.

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49. A nuclear reactor generates power at 50% efficiency by fission of $._{92}^{235}U$ into two equal fragments of $._{46}^{116}U$ into two equal fragments of $._{46}^{116}Pd$ with the emission of two gamma rays of 5.2 MeV each and three neutrons. The average binding energies per particle of $._{92}^{235}U$ and $._{46}^{116}Pd$ are 7.2 MeV and 8.2MeV respectiveley. Calculate the energy released in one fission event. Also-estimate the amount to $.^{235}U$ consumed per hour to produce 1600 megawatt power.

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50. In the fission of $._{94}^{239}Pu$ by a thermal neutron, two fission fragments of equal masses and sizes are produced and four neutron are emitted. Find the force between the two fission fragments at the moment they are produced.

Given : $R_0 = 1.1$ fermi.

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51. A nuclear reactor using $.^{235}U$ generates $250MW$ of electric power. The efficiency of the reactor (i.e., efficiency of conversion of thermal energy into electrical energy) is 25%. What is the amount of $.^{235}U$ used in the reactor per year? The thermal energy released per fission of $.^{235}U$ is $200MeV$.

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52. The deuterium-tritium fusion reaction (called the D-T reaction) is most likely to be the basic fusion reaction in a future thermonuclear fusion reactor is

$.^{2}_{1} H + .^{3}_{1} H \rightarrow .^{4}_{2} He + .^{1}_{0} n + Q$

(a) Calculate the amount energy released in the reaction, given $m(.^{2}_{1} H) = 0.014102$ amu. $m\left(- (1)^{3} H\right) = 3.016090$ amu, $m\left(.^{1_n}_{0}\right. = 1.008665$ amu and $m(.^{4}_{2} He) = 4.002603$ amu.

(b) Find the kinetic energy needed to overcome coulumb repulsion. Assume the radius of both deterium and tritium to he approximately $1.5 \times 10^{-15} m$.

(c) To what temperature must the gases be heated to initiate the fusion reaction? Take Boltzmann constant $k = 1.38 \times 10^{-23} JK^{-1}$.

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53. Calcualte the excitation energy of the compound nuclei produced when

$n + .^{235} U \rightarrow .^{236} U *$
$n + .^{238} U \rightarrow .^{239} U *$

Given:

$M(.^{235} U) = 235.0439\text{amu}, \quad M(n) = 1.0087\text{amu},$
$M(.^{238} U) 238.0508\text{amu}, \quad M(.^{236} U) = 236.0456\text{amu}, .$
$M(.^{239} U) = 239.0543\text{amu}$

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54. Calculate the ground state Q value of the induced fission raction in the equation

$n + ._{92}^{235} U \rightarrow ._{92}^{236} U * \rightarrow ._{40}^{99} Zr + ._{52}^{134} Te + 2n$

If the neutron is thermal. A thermal neutorn is in thermal equilibrium with its envitronmnet, it has an avergae kinetic energy given by $(3/2)kT$.

Given :

$m(n) = 1.0087amu, M(.^{235} U) = 235.0439)amu,$

$M(.^{99} Zr) = 98.916amu, M(.^{134} Te) = 133.9115amu.$

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55. Show that $._{92}^{230} U$ does not decay by emitting a neutron or proton.

Given:

$M(._{92}^{230} U) = 230.033927amu, M(._{92}^{230} U) = 229.033496amu,$

$M(._{92}^{229} Pa) = 229.032089amu, M(n) = 1.008665amu$

$m(p) = 1.007825amu.$

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56. Compute the minimum kinetic energy of proton incident on $.^{13}C$ nuclei at rest in the laboratory the will produce the endothermic reaction $\hat{}\ (13)C(p, n)^{13}N$. Given masses are

$M(.^{13}C) = 13.003355$ amu,

$M(.^{1}H) = 1.007825$ amu

$m(n) = 1.008665$ amu,

$M(.^{13}N) = 13.005738$ amu

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57. The nuclear reaction $n + ._{5}^{10}B \rightarrow ._{3}^{7}Li + ._{2}^{4}He$ is observed to occur even when very slow-moving neutrons $(M_{n} = 1.0087 amu)$ strike a boron atom at rest. For a particular reaction in which $K_{n} = 0$, the helium $(M_{He} = 4.0026 amu)$ is observed to have a speed of $9.30 \times 10^{6} ms^{-1}$. Determine (a) the kinetic energy of the lithium $(M_{Li} = 7.0160 amu)$ and (b) the Q value of the reaction.

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58. Find the amount of energy produced in joules due to fission of 1 gram of uranium assuming that 0.1 percent of mass is transformed into energy.

Take 1amu=$1.66 \times 10^{-27} kg = 931.5 MeV$

Mass of uranium =235amu.

Avogadro number =6.02×10^{23}

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59. What is the power output of a $._{92}U^{235}$ reactor if it is takes 30 days to use up $2kg$ of fuel, and if each fission gives $185 MeV$ of usable energy ?.

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60. Assuming that 200MeV of energy is released per fission of uranium atom, find the number of fission per second required to release one kilowatt power.

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61. It is proposed to use the nuclear fusion reaction,

$._1^2 H +_1^2 H \rightarrow_2^4 He$

in a nuclear reactor $200 MW$ rating. If the energy from the above reaction is used with a 25 per cent efficiency in the reactor, how many grams of deuterium fuel will be needed per day?(The masses of $._1^2 H$ and $._2^4 He$ are 2.0141 atomic mass units and 4.0026 atomic mass units respectively.)

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62. A fusion reaction of the type given below

$._1^2 D + ._1^2 D \rightarrow ._1^3 T + ._1^1 p + \Delta E$

is most promissing for the production of power. Here D and T stand for deuterium and tritium, respectively. Calculate the mass of deuterium required per day for a power output of $10^9 W$. Assume the efficiency of the process to be 50%.

Given : $m\left(._1^2 D\right) = 2.01458 amu, \quad m\left(._1^3 T\right) = 3.01605 amu$

$m\left(._1^1 p\right) = 1.00728 amu$ and $1 amu = 930 MeV$.

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63. The binding energies per nucleon for deuteron ($._1 H^2$) and helium ($._2 He^4$) are $1.1 MeV$ and $7.0 MeV$ respectively. The energy released when two deutrons fuse to form a helium nucleus ($._2 He^4$) is........

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64. Find the amount of energy released when 1 atom of Uranium $._{92} U^{235} (235.0439 \text{amu})$ undergoes fission by slow neturon (1.0087amu) and is splitted into Krypton $._{36} Kr^{92} (91.8973 \text{amu})$ and Barium $._{56} Br^{141} (140.9139 \text{amu})$ assuming no energy is lost. Hence find the enrgy in kWh, when $1 g$ of it undergoes fission.

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65. Find the Q value of the reaction $P+.^7 Li \rightarrow .^4 He+.^4 He$. Determine whether the reaction is exothermic or endothermic. The atomic masses of $.^1 H, .^4 He$ and $.^7 Li$ are $1.007825u, 4.002603u$, and $7.016004u$, respectively.

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66. How many alpha and beta particles are emitted when uranium $._{92}^{238} U$ decays to lead $._{82}^{206} Pb$?

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67. The nucleus $.^{23} Ne$ deacays by β-emission into the nucleus $.^{23} Na$. Write down the β-decay equation and determine the maximum kinetic energy of the electrons emitted. Given, $\left(m\left(._{11}^{23} Ne\right)=22.994466 amu\right.$ and $m\left(._{11}^{23} Na=22.989770 amu\right.$. Ignore the mass of antineuttino $(\bar{v})$.

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68. A radioavtive source in the form of a metal sphere of daimeter 10^{-3} m emits β-particles at a constant rate of 6.25×10^{10} particles per second. If the source is electrically insulated, how long will it take for its potential to rise by $1.0V$, assuming that 80% of the emitted β-particles escape the socurce?

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69. A nucleus X, initially at rest , undergoes alpha dacay according to the equation ,

$_(92)^A X \rightarrow_Z^{228} Y + \alpha$

(a) Find the value of A and Z in the above process.

(b) The alpha particle produced in the above process is found to move in a circular track of radius $0.11m$ in a uniform magnetic field of 3 Tesla find the energy (in MeV) released during the process and the binding energy of the parent nucleus X

Given that : $m(Y) = 228.03u, m\left(_(0)^1 n\right) = 1.0029u.$

$m\left(_(2)^4 He\right) = 4.003u, m\left(_(1)^1 H\right) = 1.008u$

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70. Polonium $\left(._{84}^{210}Po\right)$ emits $._{2}^{4}He$ particles and is converted into lead ($._{82}^{206}Pb$). This reaction is used for producing electric power in a space mission. Po^{210} has half-life of 138.6 days. Assuming an efficiency of 10% for the thermoelectric machine, how much $.^{210}Po$ is required to produce $1.2\times10^{7}J$ of electric energy per day at the end of $693 days$. Also find the initial activity of the material.

Given : Masses of nuclei

$.^{210}Po = 209.98264$ amu, $.^{206}Pb = 205.97440$ amu, $._{2}^{4}He = 4.00260$ amu,

$1 amu = 931 MeV/c^{2}$ and Avogadro's number $= 6\times10^{23}/mol$

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71. Find whether $\alpha -$ deacy or any of the $\beta -$ decay are allowed for $._{89}^{226}Ac$.

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72. Show that $\left(._{26}^{55} Fe\right)$ may electron capture, but not β^{+} decay.

Masses given are $M\left(._{26}^{55} Fe\right)=54.938298 amu$,

$M\left(._{25}^{55} Mn\right)=54.938050 amu, m(e)=0.000549 amu$.

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73. A sample of $.^{18} F$ is used internally as a medical diagnostic tool to look for the effects of the positron decay $\left(T_{1/2}=110 \text{ min }\right)$. How long does it take for 99% of the $.^{18} F$ to decay?

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74. A radioactive source, in the form of a metallic sphere of radius $10^{-2} m$ emits $\beta-$ particles at the rate of 5×10^{10} particles per second. The source is electrically insulated. How long will it take for its potential to be raised by $2V$, assuming that 40% of the emitted $\beta-$ particles escape the source.

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75. The nucleus of $._{90}^{230} Th$ is unstable against $\alpha -$ decay with a half-life of 7.6×10^3 years. Write down the equation of the decay and estimate the kinetic energy of the emitted $\alpha -$ particle from the following data: $m\left(._{90}^{230} Th\right)$=230.033131 amu, $m\left(._{88}^{226} Ra\right)$=226.025406 amu and $m\left(._{2}^{4} He\right)$ =4.002603 amu.

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76. $._{235}^{239} Pu ._{94}$ is undergoing $\alpha - decay$ according to the equation $._{94}^{235} Pu \rightarrow \left(._{97}^{235} U\right) + ._{2}^{4} He$. The energy released in the process is mostly kinetic energy of the α-particle. However, a part of the energy is released as γ rays. What is the speed of the emiited α-particle if the γ rays radiated out have energy of $0.90 MeV$? Given: Mass of $._{94}^{239} Pu = 239.05122u$, mass of $\left(._{97}^{235} U\right) = 235.04299u$ and mass of $._{1}^{4} He = 4.002602u(1u = 931 MeV)$.

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77. Calculate the maximum kinetic energy of the beta particle emitted in the following decay scheme:

$N^{12} \rightarrow C^{12} + e^{+} + v$

$C^{12} \rightarrow C^{12} + \gamma(4.43 MeV)$.

The atomic mass of N^{12} is $12.018612u$.

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78. The $\alpha -$ decay of $.^{210}Po$ nuclei (in the ground state) is accompanied by emission of two groups of $\alpha -$ particles with kinetic energies 5.30 $\&$ 4.50 MeV. Following the emission of these particles the daughter nuclei are found in the ground $\&$ excited states. find the energy of gamma-quanta emtted by the excited nuclei.

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79. Proton with kinetic energy $T = 1.0 MeV$ strinking a lithium target induces a nuclear reaction $._1^1 P + ._3^7 Li \rightarrow 2._2^4 He$. Find the kinetic energy of each $\alpha -$ particle and the angle of their divergence provided their motion directions are symmetrical with respect to that of incoming protons.

$[m_p = 1.00783 \text{amu}, m_{Li} = 7.01601 \text{amu}, m_{He} = 4.00260 \text{amu}]$

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80. Th^{228}emits an alpha particle to reduce to Ra^{224}.Calculate the kinetic energy of the alpha particle emitted in the following decay:

$Th^{228} \rightarrow Ra^* + \alpha$

$\left(Ra^{224}\right)^* \rightarrow Ra^{224} + \gamma(217 keV)$

Atomic mass of Th^{228} is $228.028726u$,that of $Ra^{224}$is $224.020196u$ and that of He_2^4 is $4.00260u$.

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81. When thermal neutrons (energy=0.04eV) are used to induce the reaction,

$._5^{10}B + ._0^1 \rightarrow ._3^7Li + ._2^4He. \; Alpha$-particles are emitted with an energy of 1.83 MeV. Given the masses of boron neutron $\&.^4He$ as 10.01167,1.00894 $\&$ 4.00386 amu respectively. What is the mass of $._3^7Li$?

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82. Two identical samples (same material and same amout) P and Q of a radioactive substance having mean life T are observed to have activities A_P and A_Q respectively at the time of observation. If P is older than Q, then the difference in their age is

A. $Tln\left(\frac{A_p}{A_Q}\right)$

B. $Tln\left(\frac{A_Q}{A_P}\right)$

C. $\frac{I}{T}ln\left(\frac{A_P}{A_Q}\right)$

D. $T\left(\frac{A_P}{A_Q}\right)$

Answer: B

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83. The life-life of Bi^{210} is 5 days. What time is taken by $(7/8)^t h$ part of the sample of decay ?

A. 3.4 days

B. 10 days

C. 15 days

D. 20 days

Answer: C

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84. A radioactive sample has half-life of 5 years. Probability of decay in 10 years will be.

A. 50%

B. 75%

C. 60%

D. 100%

Answer: B

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85. $A \xrightarrow{\lambda_1} B \xrightarrow{\lambda_2} C$

t=0 N_0 0 0

$tN_1 N_2 N_3$ In the above radioactive decay C is stable nucleus. Then:

A. rate of decay of A will first increase and then decrease

B. Number of nuclei of B will first increase and then decrease

C. if $\lambda_2 > \lambda_1$ then activity of B will always be higher than activity of A

D. If $\lambda_1 > \ > \lambda_2$ then number of nucleus of C will always be less than number of nucleus of B.

Answer: B

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86. The half-life of a radioactive substance is 10 days. This means that

A. The substance completely disintegrates in 20 days

B. The substace completely disintegrates in 40 days

C. $1/8$ part of the mass of the substance will be left intact at the end of 40 days

D. $7/8$ part of the mass of the substance disintegrates in 30 days

Answer: D

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87. 90% of the active nuclei present in a radioactive sample are found to remain undecyayed after 1 day. The precentage of undecayed nuclei left after two days will be

A. $85\ \%$

B. $81\ \%$

C. $80\ \%$

D. $79\ \%$

Answer: B

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88. Atomic weight of boron is 10.81 and it has two isotopes $._5\ B^{10}$ and $._5\ B^{11}$. Then ratio of $._5\ B^{10}$ in nature would be.

A. $19:81$

B. $10:11$

C. $15:16$

D. $81:19$

Answer: A

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89. Half-lives of two radioactive substances A and B are respectively 20 minutes and 40 minutes. Initially, he sample of A and B have equal number of nuclei. After 80 minutes the ratio of the remaining number of A and B nuclei is :

A. $1:16$

B. $4:1$

C. $1:4$

D. $1:1$

Answer: C

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90. A 100ml solution having activity 50 dps is kept in a beaker It is now constantly diluted by adding water at a constant rate of $10ml/\sec$ and $2ml/\sec$ of solution is constantly being taken out. Find the activity of 10 ml solution which is taken out, assuming half life to be effectively very large :

A. $10\left[1-\left(\frac{2}{7}\right)^{1/4}\right]$

B. $10\left[1-(5/7)^{1/2}\right]$

C. $50\left[1-\left(\frac{5}{7}\right)^{1/4}\right]$

D. $50\left[1-\left(\frac{2}{7}\right)^{1/2}\right]$

Answer: C

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91. A radioactive source has a half life of 3 hours. A freshly prepared sample of the same emits radiation 16 times the permissible safe value.

The minimum time after which it would be possible to work safely with the source is :

A. 6 hours

B. 12 hours

C. 18 hours

D. 24 hours

Answer: B

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92. The half life period of a sample is 100 second. If we take 40 gram of the radioactive sample, then after 400 second how much substance will be left undecayed ?

A. 10 gram

B. 5 gram

C. 2.5 gram

D. 1.25 gram

Answer: C

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93. The kinetic energy of a 300 K thermal neutron is:

A. 300 eV

B. 300 eV

C. 0.026 eV

D. 0.026 MeV

Answer: C

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94. A sample has two isotopes A and B having masses $50g$ and $30g$, respectively. A is radioactive and B is stable. A decays to A' by emitting α-particles. The half-life of A is $2h$. Find the mass of the sample after $4h$ and number of α-particles emitted.

A. 43 gm

B. 58 gm

C. 61gm

D. 79 gm

Answer: D

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95. In previous question find the approximate number of alpha particles emitted.

A. 1.2×10^{23}

B. 1.5×10^{23}

C. 2.3×10^{23}

D. 3.4×10^{23}

Answer: B

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96. In a fission reaction $._{92}^{236} U \rightarrow ^{117} X + ^{117} Y + n + n$, the binding energy per nucleon of X and Y is $8.5 MeV$ whereas of $.^{236} U$ is $7.6 MeV$. The total energy liberated will be about.

A. 176.2 MeV

B. 183.7 MeV

C. 195.4 MeV

D. 208.6 MeV

Answer: C

Watch Video Solution

97. The count rate from $100cm^3$ of a radioactive liquid is c. Some of this liquid is now discarded. The count rate of the remaining liquid is found to be $c/10$ after three half-lives. The volume of the remaining liquid, in cm^3, is

A. 20

B. 40

C. 60

D. 80

Answer: D

Watch Video Solution

98. A sample of radioactive material decays simultaneouly by two processes A and B with half-lives $\frac{1}{2}$ and $\frac{1}{4}h$, respectively. For the first half hour it decays with the process A, next one hour with the proecess B, and for further half an hour with both A and B. If, origianlly, there were N_0 nuceli, find the number of nuclei after 2 h of such decay.

A. $\frac{N_0}{(2)^8}$

B. $\frac{N_0}{(2)_4}$

C. $\frac{N_0}{(2)^6}$

D. $\frac{N_0}{(2)^5}$

Answer: A

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99. The binding energy of deuteron $._1^2 H$ is $1.112 MeV$ per nucleon and an $\alpha -$ particle $._2^4 He$ has a binding energy of $7.047 MeV$ per nucleon. Then in the fusion reaction $._1^2 H + ._1^2 h \rightarrow ._2^4 He + Q$, the energy Q released is.

A. 1 MeV

B. 11.9 MeV

C. 23.8 MeV

D. 931 MeV

Answer: C

Watch Video Solution

100. A radioactive substance is being consumed at a constant of $1s^{-1}$. After what time will the number of radioactive nuclei becoem 100. Initially, there were 200 nuceli present.

A. 1 sec

B. $\frac{1}{ln(2)}$ sec

C. In (2) sec

D. 2 sec

Answer: C

Watch Video Solution

101. The rest energy of an electron is.

A. 1 eV

B. 0.51 MeV

C. 931 MeV

D. None of these

Answer: B

Watch Video Solution

102. $A \xrightarrow{\lambda} B \xrightarrow{2\lambda} C$

$T = 0, N_0, 0,$

$T N_1 N_2 N_3$

The ratio of $N_1 \text{ to } N_2$ is maximum I s

A. at no time this is possible

B. 2

C. $1/2$

D. $\frac{ln2}{2}$

Answer: B

Watch Video Solution

103. After two hours $1/6$ th of the initial amount of a certain radioactive isotope remains undecayed. The half life of the isotope is :

A. 17.3 min

B. 34.7 min

C. 46.4 min

D. 1 hour

Answer: C

Watch Video Solution

104. The half life of $.^{218} Pa$ is 3 minutes. What mass of a 16 g sample of $.^{218} Pa$ will remain after 15 minutes ?

A. 3.2 g

B. 2.0 g

C. 1.6 g

D. 0.5 g

Answer: D

Watch Video Solution

105. N atoms of a radioactive element emit n alpha particles per second. The half-life of tge element is.

A. $\frac{n}{N}$ sec

B. 1.44 $\frac{n}{N}$ sec

C. 0.69 $\frac{n}{N}$ sec

D. 0.69 $\frac{N}{n}$ sec

Answer: D

Watch Video Solution

106. Consider a nuclear decay process $A \rightarrow B \rightarrow C(stab \leq)$

At a certain time, the activity of nuclei A is 'x' and the nett rate of increase of number of nuclei B is 'y' The activity of nuclei B at this instant is :

A. y

B. $x - y$

C. $y - x$

D. x

Answer: B

Watch Video Solution

107. Activity of radioactive element decreased to one third of original activity R_0 in 9 years. After further 9 years, its activity will be

A. $A_0/3$

B. $A_0/6$

C. $A_0/9$

D. $A_0/18$

Answer: C

Watch Video Solution

108. The radioactivity of a sample is R_1 at a time T_1 and R_2 at time T_2. If the half-life of the specimen is T, the number of atoms that have disintegrated in the time $(T_2 - T_1)$ is proporational to

A. $Xt_1 - Yt_2$

B. $X - Y$

C. $(X - Y)/\tau$

D. $(X - Y)\tau$

Answer: D

Watch Video Solution

109. A radioactive nucleus can decay be either emitting an α particle or by emitting a β particle. Probability of α decay is 75% while that of β decay is 25% the decayconstatnt of α decay is λ_1 and that of β decay is λ_2 is $\frac{\lambda_1}{\lambda_2}$

A. 3

B. $\frac{1}{3}$

C. 1

D. cannot be said

Answer: A

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110. Part of uranium decay series is shown

$$\cdot_{92} U^{234} \rightarrow \cdot_{90} Th^{234} \rightarrow \cdot_{91} Pa^{234} \rightarrow \cdot_{90} Th^{230} \rightarrow \cdot_{88} Ra^{226}$$

How many parts of isotopes are there in the above series

A. 1

B. 2

C. 3

D. 0

Answer: B

Watch Video Solution

111. A radioactive element A with a half-value period of 2 hours decays giving a stable element Y. After a time t the ratio of X and Y atoms is $1:7$ then t is :

A. 6 hours

B. 8 hours

C. 10 hours

D. 12 hours

Answer: A

Watch Video Solution

112. The energy released by the fission of one uranium atom is 200 MeV. The number of fissions per second required to produce 3.2 MW of power is :

A. 10^7

B. 10^{10}

C. 10^{15}

D. 10^{17}

Answer: D

Watch Video Solution

113. Nuclei X decay into nuclei Y by emitting α-aprticles. Energies of α-particle are found to be only $1MeV$ & $1.4MeV$. Disregarding the recoil of nuclei Y. The energy of γ photon emitted will be

A. 0.8 MeV

B. 1.4 MeV

C. 1 MeV

D. 0.4 MeV

Answer: D

Watch Video Solution

114. An element X decays , first by positron emission and then two α-particles are emitted in successive radiactive decay. If the product nucleus has a mass number 229 and atomic number 89, the mass number and atomic number of element X are.

A. 237,93

B. 237,94

C. 221,84

D. 237,92

Answer: B

Watch Video Solution

115. The decay constant of a radioactive substance is 1 per month. The percentage of radioactive substance left undecayed after two months will be

A. 25%

B. 50%

C. 66%

D. 87%

Answer: D

Watch Video Solution

116. The rate of disintegration of a radioactive substance falls from 800 $decay/\min$ to 100 $decay/\min$ in 6 hourse. The half life of the radioactive substance is :

A. $6/7$

B. 2 hrs

C. 3 hrs

D. 1 hr

Answer: B

Watch Video Solution

117. The activity of a radioactive sample decreases to one tenth of the original activity A_0 in a period of one year further After further 9 years, its activity will be :

A. $\frac{A_0}{100}$

B. $\frac{A_0}{90}$

C. $\frac{A_0}{10^{10}}$

D. None of these

Answer: C

Watch Video Solution

118. Half life of a radioactive elemets is 12.5 hour and its quantity is 256 gm. After how much time is quantity will remain 1 gm ?

A. 50 hrs

B. 100 hrs

C. 150 hrs

D. 200 hrs

Answer: B

Watch Video Solution

119. An unknown stable nuclide after absorbing a neutron emits an electron, and the new nuclide splits spontaneously into two alpha particles. The unknown nuclide is :

A. $._4 Be^9$

B. $._3 Li^7$

C. $._2 He^4$

D. $._5 B^{10}$

Answer: B

Watch Video Solution

120. A radioactive material is made at the constant rate of 10^4 nuclei per second and the material is getting decayed with decay constant 0.0123 $month^{-1}$ Activity of material after a very long time (if initially there was no radioactive material) is:

A. $\frac{10^4}{0.0123}$ dps

B. 1.6×10^8 dps

C. 10^4 dps

D. None of these

Answer: C

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Watch Video Solution

121. The half life of a certain radio isotope is 10 minutes. The number of radioactive nuclei at a given instant of time is 10^8 Then the number of radioactive nuclei left 5 minutes later would be:

A. $\frac{10^8}{2}$

B. 10^4

C. $\sqrt{2} \times 10^7$

D. $\frac{10^8}{\sqrt{2}}$

Answer: D

Watch Video Solution

122. A uranium nucleus (atomic number 92, mass number 231) emits an α-particle and the resultant nucleus emits a β-particles. What are the atomic and mass numbers of the final nucleus? .

A. 90240

B. 90236

C. 91234

D. 92232

Answer: C

Watch Video Solution

123. A radioactive nuclide is produced at the constant rate of n per second (say, by bombarding a target with neutrons). The expected number N of nuclei in existence t s after the number is N_0 is given by

A. $N = N_0 e^{-\lambda t}$

B. $N = \frac{n}{\lambda} + N_0 e^{-\lambda t}$

C. $N = \frac{n}{\lambda} + \left(N_0 - \frac{n}{\lambda}\right) e^{-\lambda t}$

D. $N = \frac{n}{\lambda} + \left(N_0 + \frac{n}{\lambda}\right) e^{-\lambda t}$

Answer: C

Watch Video Solution

124. The equation

$4H^{+} \rightarrow_{2}^{4} He^{2+} + 2e \overline{+} 26 MeV represents$

A. β - decay

B. ϕ -decay

C. Fusion

D. Fission

Answer: C

Watch Video Solution

125. At time $t = 0 N_1$ nuclei of decay constant $\lambda_1 \& N_2$ nuclei of decay constant λ_2 are mixed. The decay rate of the mixture at time 't' is:

A. $N_1 N_2 e^{-(\lambda_1 + \lambda_2)t}$

B. $\left(\frac{N_1}{N_2}\right) e^{-(\lambda_1 - \lambda_2)t}$

C. $\left(N_1 \lambda_1 e^{-(\lambda_1 t)} + N_2 \lambda_2 e^{-\lambda_2 t}\right)$

D. $N_1 \lambda_1 N_2 \lambda_2 e^{-(\lambda_1 + \lambda_2)t}$

Answer: C

Watch Video Solution

126. The number of α and β- emitted during the radioactive decay chain starting from $._{226}^{88} Ra$ and ending at $._{206}^{82} Pb$ is

A. $3\alpha \& 6\beta^-$

B. $4\alpha \& 5\beta^-$

C. $5\alpha \& 4\beta^-$

D. $6\alpha \& 6\beta^-$

Answer: C

Watch Video Solution

127. Two identical nuclei A and B of the same radioactive element undergo β^- decay. A emits a β^- particle and changes to A'. B emits a β^- particle and then a γ-photon immediately afterwards, and changes to B.

A. A' and B' have the same atomic number and mass number

B. A' and B' have the same atomic number nut different mass numbers

C. A' and B' have different atomic numbers but the same mass number

D. A' and B' are isotopes.

Answer: A

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128. In nuclear fission 0.1% mass is converted into energy How much electrical energy can be generated by the fission of 1 kg of fuel ?

A. 1 kWh

B. 10^7 kWh

C. 2.5 kWh

D. 2.5×10^7 kWh

Answer: D

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129. If the binding energy per nucleon in $._3 Li^7$ and $._2 He^4$ nuclei are respectively 5.60 MeV and 7.06 MeV, then the energy of proton in the reaction $._3 Li^7 + p \rightarrow 2._2 He^4$ is

A. 19.60 MeV

B. 12.26 MeV

C. 8.46 MeV

D. 17.28Mev

Answer: D

Watch Video Solution

130. In which of the following processes, the number of protons in the nuleus increase ?

A. $\alpha - decay$

B. $\beta^{-} - decay$

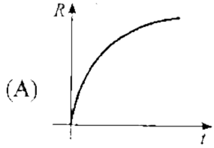
C. $bata^{+} - decay$

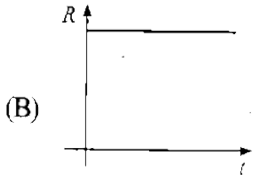
D. k-capture

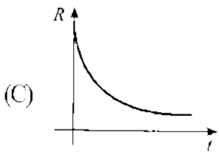
Answer: B

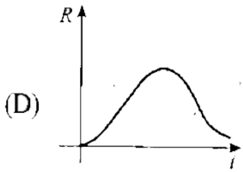
Watch Video Solution

131. A radioactiev nuleus X deays to a stable nuleus Y. Then, time graph of rate of formation of Y against time t will be:

A. 

B. 

C. 

D. 

Answer: C

Watch Video Solution

132. Suppose the speed of light were half of the present value, the amount of energy released in the atomic bomb explosion will be decreased by a fraction:

A. $\frac{1}{4}$

B. $\frac{1}{2}$

C. $\frac{3}{4}$

D. $\frac{3}{8}$

Answer: C

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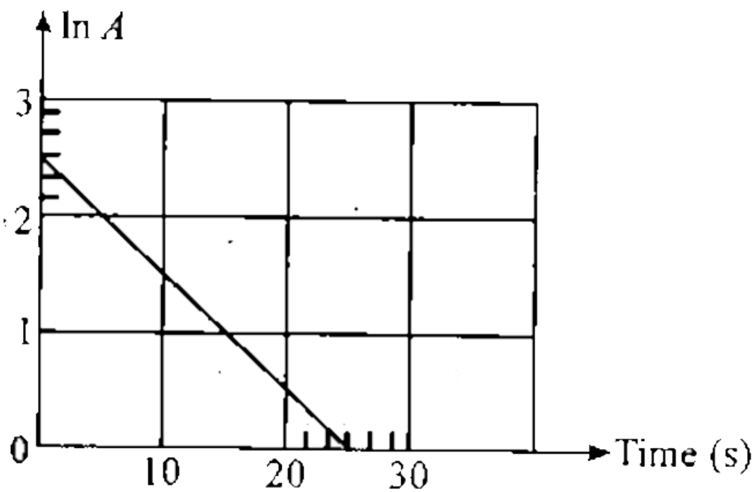
133. The graph shows how the count-rate A of a radioactive source varies with time t. A and t are related as: (assume in (12)=2.5)



A. $A = 2.5e^{-10t}$

B. $A = 12e^{10t}$

C. $A = 2.5e^{-(0.1t)}$

D. $A = 12e^{-(0.1t)}$

Answer: D

Watch Video Solution

134. The ratio of molecular mass of two radioactive substances is $3/2$ and the ratio of their decay cosntatnt is $4/3$. Then. The ratio of their initial activity per mole will be

A. 2

B. $\frac{8}{9}$

C. $\frac{4}{3}$

D. $\frac{9}{8}$

Answer: C

Watch Video Solution

135. The count rate of a Geiger Muller counter for the radiation of a radioactive material of half-life 30 min decreases to $5s^{-1}$ after $2h$. The initial count rate was

A. 80 $\sec ond^{-1}$

B. 625 $\sec ond^{-1}$

C. 20 $\sec ond^{-1}$

D. 25 $\sec ond^{-1}$

Answer: A

Watch Video Solution

136. A radioactive nuclide can decay simultaneously by two different processes which have decay constants λ_1 and λ_2. The effective decay constant of the nuclides is λ.

A. $\lambda = \sqrt{\lambda_1 \lambda_2}$

B. $\frac{1}{\lambda} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$

C. $\lambda = \frac{1}{2}(\lambda_1 + \lambda_2)$

D. $\lambda = \lambda_1 + \lambda_2)$

Answer: D

Watch Video Solution

137. An alpha particle of energy $5MeV$ is scattered through 180° by a found uramiam nucleus . The distance of closest approach is of the order of

A. $1A$

B. $10^{-10} cm$

C. 10^{-12}cm

D. 10^{-15} cm

Answer: C

Watch Video Solution

138. Half lives of two isotopes X and Y of a material are known to be 2×10^9 years and 4×10^9 years respectively if a planet was formed with equal number of these isotopes, then the current age of planet, given that currently the material has 20% of X and 80% of Y by number, will be:

A. 2×10^9 years

B. 4×10^9 years

C. 6×10^9 years

D. 8×10^9 years

Answer: D

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139. A nucleus ruptures into two nuclear parts, which have their velocity ratio equal to $2:1$. What will be the ratio of their nuclear size (nuclear radius)?

A. $2^{1/3}:1$

B. $1:2^{2/3}$

C. $3^{1/2}:1$

D. $1:3^{1/2}$

Answer: B

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140. In which of the following case the total number of decays will be maximum in a time interval of t=0 to t=4 hr. The first term represents the number of nuclei at time t=0 and the second represents the half life of the radionuclide:

A. $N_0, 4hr$

B. $2N_0, 3hr$

C. $3N_0, 2hr$

D. $4N_0, 1hr$

Answer: D

Watch Video Solution

141. There are two radioactive substance A and B. Decay consant of B is two times that of A. Initially, both have equal number of nuceli. After n half-lives of A,rates of disintegaration of both are equal. The value of n is

.

A. 1

B. 2

C. 4

D. All of these

Answer: A

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142. An atom of mass number 15 and atomic number 7 captures an $\alpha -$ particle and then emits a proton. The mass number and atomic number of the resulting product will respectively be.

A. 14 and 2 respectively

B. 16 and 4 respectively

C. 17 and 6 respectively

D. 18 and 8 respectively

Answer: D

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143. A radioactive element$X$ converts into another stable elemnet Y. Half-life of X is $2h$. Initally, only X is present. After time t, the ratio of atoms of X and Y is found to be $1:4$ Then t in hours is .

A. 2

B. 4

C. between 4 and 6

D. 6

Answer: C

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144. Two radioactive materials X_1 and X_2 have decay constants 5λ and λ respectively. If initially they have the same number of nuclei, then the ratio of the number of muclei of X_1 to that of X_2 will be $\frac{1}{e}$ after a time

A. $\frac{1}{10\lambda}$

B. $\frac{1}{11\lambda}$

C. $\frac{11}{10\lambda}$

D. $\frac{1}{9\lambda}$

Answer: D

Watch Video Solution

145. A radioactive material decays by simulataneous emission of two particle from the with respective half - lives 1620 and 810 year . The time , in year , after which one - fourth of the material remains is

A. 1080

B. 2430

C. 3240

D. 4860

Answer: A

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146. A star initially has 10^{40} deuterons. It produces energy via the process $_{(1)}H^2 +_1 H^2 + \rightarrow_1 H^3 + p$. and $_{(1)}H^2 +_1 H^3 + \rightarrow_2 He^4 + n$ .If the average power radiated by the state is $10^{16} W$, the deuteron supply of the star is exhausted in a time of the order of .

The masses of the nuclei are as follows:

$M(H^2) = 2.014 a\mu,$

$M(p) = 1.007 a\mu, M(n) = 1.008 a\mu, M(He^4) = 4.001 a\mu.$

A. 10^6 s

B. 10^8 s

C. 10^{12} s

D. 10^{16} s

Answer: C

Watch Video Solution

147. Masses of two isobars $._{29}Cu^{64}$ and $._{30}Zn^{64}$ are $63.9298u$ and $63.9292u$, respectively. It can be concluded from these data that .

A. Both the isobars are stable

B. $.^{64}Zn$ is radioactive, decaying to $.^{64}Cu$ through β -decay

C. $.^{64}Cu$ is radioactive, decaying to $.^{64}Zn$ through y- decay

D. $.^{64}Cu$ is radioactive, decaying to $.^{64}Cu$ is radioactive, decaying to $._{64}Zn$ through β - decay

Answer: D

Watch Video Solution

148. A radioactive substance X decys into another radioactive substance Y. Initially, only X was present . λ_x and λ_y are the disintegration constant of X and Y. N_y will be maximum when.

A. $\frac{N_y}{N_x - N_y} = \frac{\lambda_y}{\lambda_x - \lambda_y}$

B. $\frac{N_y}{N_x - N_y} = \frac{\lambda_x}{\lambda_x - \lambda_y}$

C. $\lambda_y N_y = \lambda_x N_x$

D. $\lambda_y N_x = \lambda_x N_y$

Answer: C

Watch Video Solution

149. A particle of mass M at rest dacays into two particle of masses m_1 and $m_2$having non zero velocity . The ratio of the de Broglie wavelength . The ratio of the de Broglie wavelength of the particle $\lambda,_1 / \lambda_2$ is

A. m_1 / m_2

B. m_2 / m_1

C. 1.0

D. $\sqrt{m_2 / m_1}$

Answer: C

Watch Video Solution

150. A radioacitve nucleus is being produced at a constant rate α per second. Its decay constant is λ. If N_0 are the number of nuclei at time $t = 0$, then maximum number of nuceli possible are .

A. $\frac{\alpha}{\lambda}$

B. $N_0 + \frac{\alpha}{\lambda}$

C. N_0

D. $\frac{\lambda}{\alpha} + N_0$

Answer: A

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151. A radioactive isotope X with a half-life of 1.37×109 years decays to Y which is stable. A sample of rock from the moon was found to contain both the elements X and Y which were in the ratio of $1:7$. The age of the rock is.

A. 1.96×10^{8} years

B. 3.85×10^{9} years

C. 4.11×10^{9} years

D. 9.59×10^{9} years

Answer: C

Watch Video Solution

152. N_1 atoms of a radioactive element emit N_2 beta partilces per second. The decay cosntant of the element is (in s^{-1})

A. $\frac{N_1}{N_2}$

B. $\frac{N_2}{N_1}$

C. N_1 in (2)

D. N_2 in (2)

Answer: B

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153. The sun radiates energy in all directions. The average radiations received on the earth surface from the sun is $1.4 \text{kilowatt} / m^2$. The average earth-sun distance is 1.5×10^{11} meters. The mass lost by the sun per day is.

A. 4.4×10^9 kg

B. 7.6×10^{14} kg

C. 3.8×10^{12} kg

D. 3.8×10^{14} kg

Answer: D

Watch Video Solution

154. What is the power output of a $._{92}U^{235}$ reactor if it is takes 30 days to use up $2kg$ of fuel, and if each fission gives $185MeV$ of usable energy ?.

A. 5.585 MW

B. 58.5 KW

C. .585MW

D. None of these

Answer: A

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155. A radioactive material of half-life T was kept in a nuclear reactor at two different instants. The quantity kept second time was twice of the kept first time. If now their present activities are A_1 and A_2 respectively, then their age difference equals

A. $\frac{T}{\ln 2}\left|ln\frac{2A_1}{A_2}\right|$

B. $T\left|ln\frac{A_1}{A_2}\right|$

C. $\frac{T}{\ln 2}\left|ln\frac{A_2}{2A_1}\right|$

D. $T\ln\left|\frac{A_2}{2A_1}\right|$

Answer: C

Watch Video Solution

156. The half life of a radioactive material is 12.7 hr. What fraction of the original active material would become inactive in 63.5 hr.

A. $1/32$

B. $1/23$

C. $31/32$

D. $23/32$

Answer: C

Watch Video Solution

157. In the nuclear fusion reaction

$_(1)^2H +_1^3 H \rightarrow_2^4 He + n$

given that the repulsive potential energy between the two nuclei is $-7.7 \times 10^{-14} J$, the temperature at which the gases must be heated the reaction is nearly

[Boltzmann's constant $k = 1.38 \times 10^{-23} J/K]$

A. 10^7 K

B. 10^5 K

C. 10^3 K

D. 10^9 K

Answer: D

Watch Video Solution

158. The activity of a sample of radioactive material A_1 at time t_1 and A_2 at time $t_2(t_2 > t_1)$. Its mean life is T.

A. $A_1t_1 - A_2t_2$

B. $\frac{A_1 - A_2}{\tau}$

C. $(A_1 - A_2)(t_2 - t_1)$

D. $(A_1 - A_2)\tau$

Answer: D

Watch Video Solution

159. Nuclei of radioactive element A are produced at rate t^2 (where t is time) at any time t. The element A has decay constant λ. Let N be the number of nuclei of element A at any time t. At time $t = t_0$, dN/dt is minimum. The number of nuclei of element A at time $t = t_0$ is

A. $\dfrac{2t_0 - \lambda t_0^2}{\lambda^2}$

B. $\dfrac{t_0 - \lambda t_0^2}{\lambda^2}$

C. $\dfrac{2t_0 - \lambda t_0^2}{\lambda}$

D. $\dfrac{t_0 - \lambda t_0^2}{\lambda}$

Answer: A

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160. Suppose a radioactive substance disintegrates completely in 10 days. Each day it disintegrates at a constant rate which is twice the rate of the previous day. The percentage of the material left to be disintegrated after passing of 9 days is :

A. 10

B. 20

C. 25

D. 50

Answer: D

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161. When a nucleus with atomic number Z and mass number A undergoes a radioactive decay process,

(i) Both Z and A will decrease, if the process is α decay

(ii) Z will decrease but A will not change, if the process is $\beta^{+} -$ decay

(iii) Z will increase but A will not change, if the process is $\beta -$ decay

(iv) Z and a will remain uncharged, if the prices is γ decay

A. Both Z and A will decrease, if the process is α decay

B. Z Will decrease but A will not change, if the process is β^{-} decay

C. Z Will decrease but A will not change, if the process is β^+ decay

D. Z and A will remain unchanged, if the process is γ decay

Answer: All

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162. When the nucleus o fan eletrically neutral atom undergoes a radioactive decay process , it will remain after he decay if the process is

A. An α decay

B. A β^- decay

C. A γ decay

D. A K-capture process

Answer: C,D

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163. Which of the following assertions are correct?

(i) A neutron can decay to a proton only inside a nucleus

(ii) A proton can change to a neutron only inside a nucleus

(iii) An isolated neutron can change into a proton

(iv) An isolated proton can change into a neutron

A. A neutron can decay to a proton only inside a nucleus

B. A proton can change to a neutron only inside a nucleus

C. An isolated neutron can change into a proton

D. An isolated proton can change into a neutron

Answer: B, C

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164. Disintegration constant of a radioactive material is λ:

A. Its half lif eequal to $\dfrac{\log_e 2}{\lambda}$

B. Its mean life equal to $\frac{1}{\lambda}$

C. At time equal to mean life, 63% of the initial radioactive material is left undecayed

D. After 3-half lives, $\frac{1}{3}$ rd of the initial radioactive material is left undecayed.

Answer: A, B

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165. A nucleus undergoes a series of decay according to the scheme $A \xrightarrow{\alpha} B \xrightarrow{\beta} C \xrightarrow{\alpha} D \xrightarrow{\gamma} E$

Atomic number and mass number of E are 69 and 172

A. Atomic number of A is 72

B. Mass number of B is 176

C. Atomic number of D is 69

D. Atomic number of C is 69

Answer: B, C

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166. The half life of a radioactive substance is T_0. At $t = 0$,the number of active nuclei are N_0. Select the correct alternative.

A. The number of nuclei decayed in time internal $0 - t$ is $N_0 e^{-\lambda t}$

B. The number of nuclei decays in time interval $0 - t$ is $N_0\left(1 - e^{-\lambda t}\right)$

C. The probability that a radioactive nuclei does not decay in interval $0 - t$ is $e^{-\lambda t}$

D. The probability that a radioactive nuclei does not decay in interval $1 - e^{-\lambda t}$

Answer: B, C

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167. Two identical nuclei A and B of the same radioactive element undergo β^- decay. A emits a β^- particle and changes to A'. B emits a β^- particle and then a γ-photon immediately afterwards, and changes to B.

A. A' and B' may have the same atomic number and mass number

B. A' and B' may have the same atomic number but different mass numbers

C. A' and B'may have different atomic numbers but the same mass number

D. A' and B' may are isotopes

Answer: A

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168. A and B are isotopes. B and C are isobars. All three are radioactive. Which one of the following is true.

A. A ,B and C must belong to the same element

B. A, B and C may belong to the same element

C. It is possible that A will change to B through a radioactive decay process

D. It is possible that B will change to C through a radioactive decay process

Answer: D

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169. A nuclide A undergoes α-decay and another nuclides B undergoes β-decay

A. All the α-particles emitted by A will have almost the same speed

B. The α-particles emitted by A may have widely different speeds

C. Al lthe β-particles emitted by B will have almost the same speed

D. The β-particles emitted by B will have different speeds

Answer: A, D

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170. Which of the following is/are correct for nuclear reactor? a)A typical fission is represented by ${}_{92}{}^{235}U = {}_{0}{}^{1}n \rightarrow {}_{54}{}^{140}Ba + {}_{36}{}^{93}Kr +$ Energy b)Heavy water (D_2O) is used as moderator in preference to orduinary water (H_2O) because hydrogen may capture neutrons, while D would not do that c)Cadmium rods increse the reactor power when they go in and decrease when they go outwards d)Slower neutrons are more effective in causing fission than faster neutrons in the case of ${}_{235}U$

A. A typical fission represented by

$\cdot_{92} U^{235} + \cdot_{0} n^{1} \rightarrow \cdot_{56} Ba^{143} + \cdot_{36} Kr^{93} +$ Energy

B. Heavy water is used as moderator in preference to ordinary water

C. Cadmium rods increase the reactor power when they go in, decrease when they go outward

D. Slower neutrons are more effective in causing fission than faster neutrons in case of U^{235}

Answer: A, B, D

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171. The decay constant of a radioactive substance is 0.173 $(\text{years})^{-1}$. Therefore:

A. Nearly 63% of the radioactive substance will decay in $(1/0.173)$ year

B. Half life of the radio active substance is $(1/0.173)$ years.

C. One-fourth of the radioactive substance will be left after nearly 8 years

D. All the above statement are true

Answer: A, C

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172. Which of the following statement (s) is (are) correct ?

A. The rest mass of a stable nucleus is less than the sum of the rest masses of its separated nucleons.

B. The rest mass of a stable nucleus is greater than the sum of the rest masses of its seprated nucleons.

C. In nuclear fission, energy is released by fusing two nuclei of medium mass (approximately 100 u)

D. In nuclear fission, energy is released by fragmentation of very heavy nucleus.

Answer: A, D

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173. A radioactive sample has initial concentration N_0 of nuclei. Then,

A. The number of undecayed nuclei present in the sample decays exponentially with time

B. The activity (R) of the sample at any instant is directly proportional to the number of undecayed nuclei present in the sample at that time

C. The number of decayed nuclei grows linearly with time

D. The number of decayed nuclei grows exponentially with time

Answer: A, B, D

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174. For the graph shown in figure -4.17, which of the following statement is/are possible?

A. y-axis shows number of nuclei of a radioactive element which is produced at a constant rate

B. y-axis represents number of nuclei decayed in a radio nuclide

C. y-axis represents activity of a radio nuclide

D. none of these

Answer: A, B

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175. $._{92}U^{235}$ is α (alpha) active. Then in a large quantity of the element:

A. the probability of nucleus distintegrating during one second is lower in the first half life and hreater in the fifth half life

B. the probability of a nucleus disintegrating during one second remains constant for all time

C. quite an appreciable quantity of U^{235} will remain, even after the average life

D. the energy of the emitted $'\alpha'$ particle is less than the disintegration energy of the U^{235} nucleus

Answer: B, C, D

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176. Let m_p be the mass of a poton , M_1 the mass of a $\_(10)^{20}Ne$ nucleus and M_2 the mass of a $\_(20)^{40}Ca$ nucleus . Then

A. $M_2 = 2M_1$

B. $M_2 > 2M_1$

C. $M_2 < 2M_1$

D. $M_1 < 10(m_n + m_p)$

Answer: C, D

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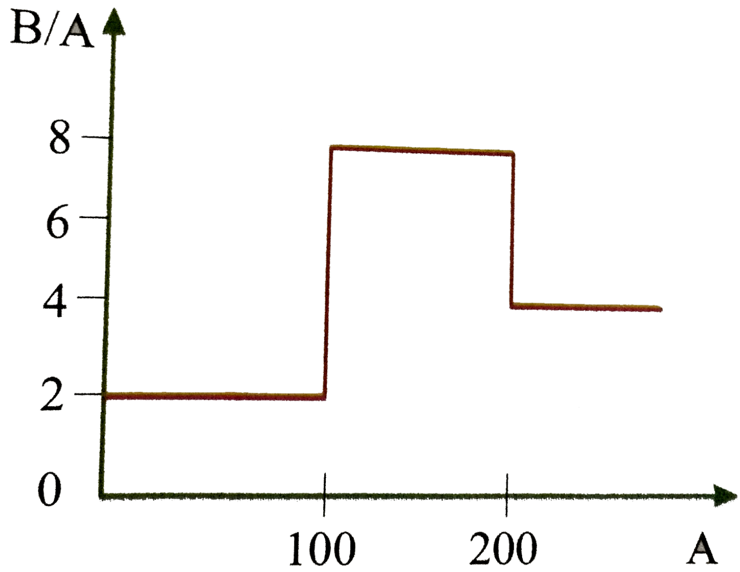
177. Assume that the nuclear binding energy per uncleon (B/A) versus mass number (A) is as shwon in Fig. Use this plot to choose the correct choice (s) given below:



A. Fusion of two nuclei with mass numbers lying in the range of $1 < A < 50$ will release energy

B. Fusion of two nuclei with mass numbers lying in the range of $51 < A < 100$ will release energy

C. Fission of a nucleus lying in the mass range of $100 < A < 200$ will release energy when broken into two equal fragments

D. Fission of a nucleus lying in the mass range of $200 < 4 < 260$ will release energy when broken intotwo equal fragments

Answer: B, D

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178. During radioactive decay:

A. atomic mass number cannot increases

B. atomic number may increase

C. atomic number may decrease

D. atomic number may remain unchanged

Answer: ALL

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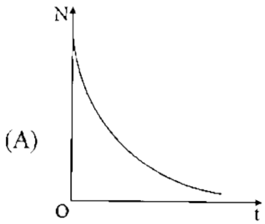
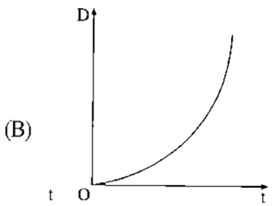
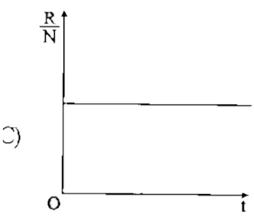
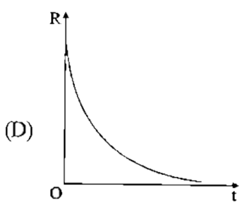
179. A large population of radioactive nucleus starts disintegrating at $t = 0$.At time t, if N= number of parent nuclei present, D= the number of daughter nuclei present and R= rate at which the daughter nuclei are produced , then the correct representation will be:

A. 

B. 

C. 

D. 

Answer: A, C, D

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180. After 200 days the activity of a radioactive sample reduces to 8000 dps. After another 100 days the activity reduces to $\frac{8000}{\sqrt{2}}$ dps. It can be said that:

A. Initial activity of the sample was $8000\sqrt{2}$ dps

B. Initial activity of the sample was 16000 dps

C. Half life of the sample is 200 days

D. After yet another 100 days the activity will reduce to 4000 dps

Answer: B, C, D

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181. The decay constant of a radioactive substance is 0.173 $(\text{years})^{-1}$.

Therefore:

A. Nearly 63% of the radioactive substance will decay in $(1/0.173)$ year

B. Half life of the radio active substance is $(1/0.173)$ years.

C. One-fourth of the radioactive substance will be left after nearly 8 years

D. All the above statement are true

Answer: A, C

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182. In the α-decay process occuring in different types of nuclei at rest

(i) the $K.E.$ of the daughter nucleus is always greater than the $K.E.$ of the α-particle

(ii) the $K.E.$ of the daughter nucleus is always less than the $K.E.$ of the α-particle

(iii) the magnitudes of the linear momenta of the α-particle and the daughter nucleus are always equal

(iv) the daughter nucleus is always in a stable state

A. The kinetic energy of the daughter nucleus is always greater than the kinetic energy of the α-particle

B. The kinetic energy of the daughter nucleus is always less than the kinetic energy of the α-particle

C. The magnitudes of the linear momenta of the α-particle and the daughter nucleus are always equal

D. The daughter nucleus is always in a stable state

Answer: B, C

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183. At $t=0$,a sample of radionuclide A has the same decay rate as a sample of radionuclide B has at $t=60$ min. The disintegration constants of A and B are λ_A and λ_B respectively, with $\lambda_A < \lambda_B$.

A. The half life of radionuclide A is greater than that of B.

B. At $t=60$ min, number of atoms in sample of meterial A is greater than that of smaple B.

C. The two samples will never have the same decay rate simultaneously.

D. After some time, the two samples will have the same decay rate simultaneously for an instant.

Answer: A, C

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184. When charcoal is prepared from a living tree, it shows a disintergration rate of 15.3 disintergrations of C^{14} per gram per minute. A sample form an ancient piece of charcoal shows C^{14}activity to be 12.3 disintergrations per gram per minute. How old is this sample ? Half-life of C^{14} is 5730 y.

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185. The half-life of Ra^{226} is 1602 y.Calculate the activity of 0.1g of $RaCl_2$ in which all the radium is in the form of Ra^{226}.Taken atomic weight of Ra to be the 226 g mol^{-1} and that of C1 to be $35.5 gmol^{-1}$.

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186. A vessel of vloume $125 cm^3$ contains tritium $\left(H^3, t_{1/2} = 12.3y\right)$ at 500 kPa and 300 k. Calculate the activity of the gas.

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187. A piece of ancient wood shows an activity of 3.9 disintergration per sec. per gram of $.^{14}C$. Calculate the age of the wood. $T_{1/2}$ of $.^{14}C = 5570$ years. Activity of fresh $.^{14}C = 15.6$ disinteration per second per gram.

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188. Consider the beta decay

$\hat{} 198Au \rightarrow^{198} Hg* + B\eta^{-1} + \vec{v}.$

where $\hat{} 198Hg^{*}$ represents a mercury nucleus in an excited state at energy $1.088MeV$ above the ground state. What can be the maximum kinetic energy of the electron emitted? The atomic mass of $\hat{} 198Au$ is $197.968233u$ and that of $\hat{} 198Hg$ is $197.966760u$.

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189. What is the age of an ancient wooden piece if it is known that the specific activity of C^{14} nuclide in it amouts to $3/5$ of that in fresh trees?

Given: the half of C nuclide is $5570 years$ and $\log_e(5/3) = 0.5$.

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190. A sample of Uranium is a mixture of two isotopes $._{92}^{234}U$ and $._{92}^{238}U$ present in the ratio 10% and 90% by weight. The half lives of these isotopes are 2.5×10^5 years and 4.5×10^5 years respectively. Calculate the contribution to activity in percentage of each isotope in this sample.

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191. In the uranium ore, the ratio of U^{238} nuclei to Pb^{206} nuclei is 2.8. If it is assumed that all the lead Pb^{206} to be a final decay product of the uranuium series, the age of the ore is $[T_{1/2}$ for U^{238} is 4.5×10^9 years]

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192. 4×10^{23} tritium atoms are contained in a vessel. The half-life of decay of trituim nuclei is 12.3 y. Find (a) the activity of the sample ,(b) the number of decays in the next 10 hours (c) the number of decays in the next 6.15 y.

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193. (a) The half life period of radium is 1590 yrs. After how many years will one gram of the pure element,

(i)be reduced to one centigram, (ii) lose one centigram. (b) The half life of radon is 3.8 days. After how many days will only one twentieth of radon sample be left over?

(c) 1 gm of radioactive substance takes 50 sec. to lose 1 centigram. Find its half life period?

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194. Suppose a nucleus initally at rest undergoes α decay according to equation

$._{92}^{225} X \rightarrow Y + \alpha$

At $t = 0$, the emitted α-particles enter a region of space where a uniform magnetic field $\overrightarrow{B} = B_0 \hat{i}$ and elecrtic field $\overrightarrow{E} = E_0 \hat{i}$ exist. The α-particles enters in the region with velocity $\overrightarrow{V} = v_0 \hat{j}$ from $x = 0$. At time $t = \sqrt{3} \times 10^6 \frac{m_0}{q_0 E_0} s$, the particle was observed to have speed twice the initial velocity v_0. Then, find (a) the velocity v_0 of the α-particles,

(b) the initial velocity v_0 of the α-particle, (c) the binding energy per nucleon of the α-particle.

$[\text{Given that} m(Y) = 221.03u, m(\alpha) = 4.003u, m(n) = 1.09u, m(P) = 1.0$

.

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195. Some amount of a radioactice substance (half-life =10 days) is spread inside a room and consequently the level of radiation become 50 times the permissible level for normal occupancy of the room. After how many days will the room be safe for occupation?.

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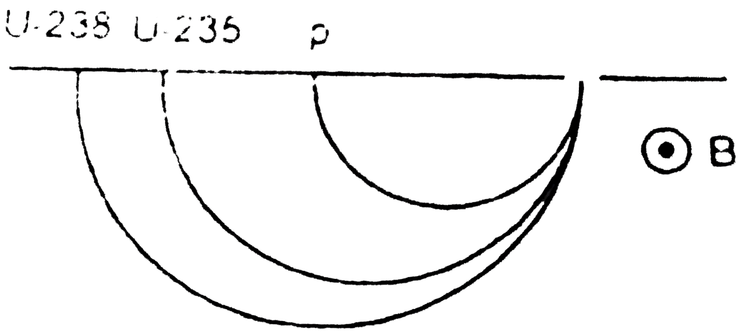
196. Protons and singly ionized atoms of U^{235} & U^{238} are passed in turn (which means one after the other and not at the same time) through a velocity selector and then enter a uniform magnetic field. The protons describe semicircles of radius $10mm$. The separation between the ions of U^{235} and U^{238} after describing semicircle is given by



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197. Polonium $\left({}_{84}^{210}Po\right)$ emits ${}_{2}^{4}He$ particles and is converted into lead (${}_{82}^{206}Pb$). This reaction is used for producing electric power in a space mission. Po^{210} has half-life of 138.6 days. Assuming an efficiency of 10 % for the thermoelectric machine, how much ${}^{210}Po$ is required to produce $1.2 \times 10^{7} J$ of electric energy per day at the end of $693 days$. Also find the initial activity of the material.

Given : Masses of nuclei

${}^{210}Po = 209.98264$ amu, ${}^{206}Pb = 205.97440$ amu, ${}_{2}^{4}He = 4.00260$ amu,

$1 amu = 931 MeV / c^{2}$ and Avogadro's number $= 6 \times 10^{23} / mol$

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198. The specific activity of a preparation consisting of radioactive Co^{58} and non-radioactive Co^{59} is equal to 2.2×10^{12} disintegration per sec gram. The half-life of Co^{58} is 71.3 days. The ratio of the mass of radioactive cobalt in that preparation to the total mass of the preparation in percentage is

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199. A solution contains a mixture of two isotopes A ($half-l \text{ if } e=10days$) and B ($half-l \text{ if } e=5days$). Total activity of the mixture is 10^{10} disintegration per second at time $t=0$. The activity reduces to 20% in $20days$. Find (a) the initial activities of A and B, (b) the ratio of initial number of their nuclei.

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200. Find the quantity of polonium $._{80}^{210}Po$ whose activity is 3.7×10^{10} dps. Find also the number of atoms of polonium disintegrated during its mean life. (Half life of polonium is 138 days)

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201. The nuclei inbolbed in the nuclear reaction $A_1+A_2\to A_3+A_4$ have the binding energies E_1, E_2, E_3, and E_4. Find the energy of this reaction.

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202. Complete the following nuclear reactions:

(a) $._{7}^{14}N + ._{2}^{4}He \rightarrow ._{8}^{17}O + \_\_\_\_.$

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

(c) $._{4}^{9}Be + ._{2}^{4}He \rightarrow ._{6}^{12}C + \_\_\_\_.$

(d) $._{1}^{3}H + ._{1}^{2}H \rightarrow_{2}^{4} He + \_\_\_\_.$

(e) $._{4}^{9}Be(p, \alpha) \_\_\_\_.$

(f) $._{20}^{43}Ca(\alpha, \_\_\_\_\_).{}_{21}^{46}Sc$

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203. On an average, a neutron loses half of its energy per collision with a quesi-free proton. To reduce a $2MeV$ neutron to a thermal neutron having energy $0.04eV$, the number of collisions requaired is nearly .

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204. A radio nuclide with half life $T = 14.3$ daysis produced in a reactor at a constant rate $q = 10^9$ nuclei persecond. How soon after the beginning of production of that radio nuclide will, its activity be equal to $A = 10^8$ disintegrations per second. Plot a rough graph of its activity with time.

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205. (a) Calculate the energy released if $.^{238}U$ emits an α particle. (b) Calculate the energy to be supplied to $.^{238}U$ if two protons and two neutrons are to be emitted one by one. The atomic masses are :

$.^{238}U = 238.0508$ amu $.^{234}Th = 234.04363$ amu $._2^4He = 4.0026$ amu

$._0^1 = 1.008665$ amu $._1^1p = 1.007276$ amu

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206. The radius of a nucleus ofa mass number A is given by $R = R_0 A^{1/3}$, where $R_0 = 1.3 \times 10^{-15} m$. Calculate the electrostatic potential energy between two equal nuclei produced in the fission of $._{92}^{238} U$ at the moment of their fission

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207. Consider the case of bombardment of U^{235} nucleus with a thermal neutron. The fission products are Mo^{95} & La^{139} and two neutrons. Calculate the energy released by one U^{235} nucleus. (Rest masses of the nuclides are $U^{235} = 235.0439u, ._0^1 n = 1.0087u, Mo^{95} = 94.9058u, La^{139} .9061u)$.

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208. A radio nuclide with disintegration constant λ is produced in a reactor at a constant rate α nuclei per second. During each decay energy E_0 is released. 20% of this energy is utilized in increasing the temperature of water. Find the increase in temperature of m mass of water in time t. Specific heat of water is s. Assume that there is no loss of energy through water surface.

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209. The isotope of U^{238} and U^{235} occur in nature in the ratio $140:1$. Assuming that at the time of earth's formation, they were present in equal ratio, make an estimate of the age of earth. The half lives of U^{238} and U^{235} are 4.5×10^9 years and 7.13×10^8 years respectively. Given $\log_{10} 140 = 2.1461$ and $\log_{10} 2 = 0.3010$.

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210. Consider a nuclear power plant to be put up to deliver $4 \times 10^3 MW$ power.

(a) what will be the ratio of consumption of $.^{235} U$ to operate this plant for 1 year ?

(b) Typically 3% of the $.^{235} U$ mass is converted into $.^{90}_{38} Sr$, which is a beta emitter, with half life 29 yrs. What is the beta activity in the Sr produced in curies, just after the end of 1 yr. Assume 200 MeV is the average yield per fission of $.^{235}U$.

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211. An isotopic species of lithium hydride LiH is a potential fuel in a reactor on the basis of reaction $._3^6Li + ._1^2H \rightarrow 2._2^4He$. Find the possible power production in kW assciated with the consumption of 1g of $.^6Li^2H$ per day, if the efficiency of the process is 100%.

$[M(._3^6Li) = 6.01702amu, M(._1^2H) = 2.01474amu, M(._2^4He) = 4.00388a$

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212. In a uranium reactor whose thermal power is $P = 100MW$, if the average number of neutrons liberated in each nuclear spitting is 2.5. Each splitting is assumed to release an energy $E = 200MeV$. The number of neutrons generated per unit time is-

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213. The half-life of Au^{198} is 2.7 days.(a) Find the activity of a sample containing $1.00 \mu g$ of Au^{198}.(b) What will be the activity after 7 days ? Take the atomic weight of Au^{198} to be $198 g mol^{-1}$.

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214. In a nuclear reactor $.^{235} U$ undergoes fission liberating $200 MeV$ of energy. The reactor has a 10% efficiency and produces $1000 MW$ power. If the reactor is to function for $10 yr$, find the total mass of uranium required.

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215. The $._{92}^{235} U$ absorbs a slow neutron (thermal neutron) & undergoes a fission represented by

(i) The energy release E per fission.

(ii) The energy release when 1g of $._{92}^{236}U$ undergoes complete fission.

Given : $._{92}^{235}U = 235.1175amu$ (atom), $._{56}^{141}Ba = 140.9577amu$ (atom), $._{36}^{92}Kr = 91.9264amu$(atom), $._{0}^{1}n = 1.00898amu$.

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216. The kinetic energy of α- particles emiited in the decay of $._{88}Ra^{226}$ into $._{86}Rn^{222}$ is measured to be $4.78MeV$. What is the total disintegration energy or the $'Q'$-value of this process ?

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217. A town has a population of 1 million. The average electric power needed per person is 300W. A reactor is to be designed to supply power to this town. The efficiency with which thermal power is converted into electric power is aimed at 25%.(a) Assuming 200 MeV of thermal energy to come form each fission event on an average, find the number of events on an place every day. (b) Assuming the fission to take place largely through U^{235}, at what rate will the amount of U^{235} decrease ? Express uour answer in kg per day. (c) Assuming that uranium enriched to 3% in U^{235} will be used, how much uranium is needed per month (30 days)?

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218. A radioactive with half life $T = 693.1$ days. Emits β-particles of average kinetic energy $E = 8.4 \times 10^{-14}$ joule. This radionuclide is used as source in a machine which generates electrical energy with efficiency $\eta = 12.6\,\%$. Number of moles of the nuclide required to generate electrical energy at an initial rate is $P = 441KW$, is $n \times 10^{n}$ then find out value of $\frac{n}{m}(\log_e 2 = 0.6931)N_A = 6.023 \times 10^{23}$

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219. (a) What isotope is produced from the alph-radioactive Ra^{226} as a result of five alpha-disintergrations and four β disintergrations?

(b) How many alpha- and β-decays does U^{238} experience before truning finally into the stable Pb^{206} isotope?

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220. A ratio nuclide with half life $T = 69.31$ second emits $\beta -$ particles of average kinetic energy $E = 11.25eV$. At an instant concentration of $\beta -$ particles at distance, $r = 2m$ from nuclide is $n = 3 \times 10^{13} perm^3$.

(i) Calculate number of nuclei in the nuclide at that instant.

(ii) If a small circular plate is placed at distance r from nuclide such that $\beta -$ particles strike the plate normally and come to rest, calculate pressure experienced by the due to collision of $\beta -$ particles.

$(\text{Mass of } \beta - \text{particle} = 9 \times 10^{-31} kg)$

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221. The number of U^{238} nuclei in a rock sample equal to the number of Pb^{206} atoms. The half life of U^{238} is 4.5×10^9 years. The age of the rock is

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222. Carbon (Z=6) with mass number 11 decays to boron (Z=5).(a) Is it a β^{+} -decay? (b) the half-life of the decay scheme is 20.3 minutes .How much time will elapse before a mixture of 90% carbon-11 and 10% boron-11(by the number pf atoms)converts itself into a mixture of 10% carbon-11 and 90% boron -11?

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223. A radio nuclide consists of two isotopes. One of the isotopes decays by α-emission and other by β-emission with half-lives $T_1 = 405s$ and $T_2 = 1620s$, respectively. At $t = 0$, probabilities of getting α and β-particles from the radio nuclide are equal . Calculate their respective probabilities at $t = 1620s$. If at $t = 0$, total number of nuclei in the radio nuclide are N_0. Calculate the time t when total number of nuclei remained undecayed becomes equal to $N_0 / 2$.

$\log_{10} 2 = 0.3010, \log_{10} 5.94 = 0.7742$ and $x^4 + 4x - 2.5 = 0, x = 0.594$

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224. A small amount of solution containing $.^{24}Na$ radionuclide with activity $A = 2 \times 10^3$ dis/sec. was injected in the blood stream of a man. The activity of $1cm^3$ of blood sample taken $t = 5$ hrs later turned out to be $A' = 16 \text{dis}/\text{min}/\text{cm}^3$. The half life of radionuclide is $T = 15$ hrs. Find the volume of the man's blood.

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225. Radio active phosphorus 32 has a half life of 14 days. A source containing this isotope has an initial activity of 10 m Ci.

(i) What is the activity of the source after 42 days?

(ii) What time elapses before the activity of the source falls to 2.5 mCi?

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226. A radioactive X decays to Y. In the radionuclide, the ratio of mass of element X to that of Y is n at $t = 0$. It is observed that at time $t = t_0$, this ratio becomes equal to $1/n$. Assuming that all the decay products (except $\gamma -$ photons) remain in the sample, calculate half life of X.

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227. The half-life of K^{40} is 1.30×10^{9} y. A sample if $1.00g$ of pure KCI gives 160 counts s^{-1}.Calculate the relative abundance of K^{40}(fraction of K^{40}present) in natural potassium .

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228. In a reactor, an element X decays to a radioactive element Y, at a constant rate r atoms per second. Each decay reaction releases energy E_1. Half life of element Y is equal to T and decays to a stable element. During each decay of Y, energy E_2 is released. If at $t=0$, there was no atom of element Y and all the energy released is used in the reactor for generation of electrical power with efficiency η, calculate electrical power generation in the reactor

(i) at time t and (ii) in steady state.

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229. Find the kinetic energy of the α - particle emitted in the decay $\hat{}\ 238Pu \rightarrow^{234} U + \alpha$. The atomic masses needed are as following:

$\hat{}\ 238Pu238.04955u$

$\hat{}\ 234U234.04095u$

$\hat{}\ 4He4.002603u.$

Neglect any recoil of the residual nucleus.

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230. Calculate the Q-value in the following decays:

(a) $\hat{}\ 19O \rightarrow^{19} F + e + \vec{v}.$

(b) $\hat{}\ 25A1 \rightarrow^{25} Mg + e^{+} + v.$

The atomic masses needed are as follows :

$\hat{}\ 19O19.003576u$

$\hat{}\ 19F18.998403u$

$\hat{}\ 25A124.990432u$

$\hat{}\ 25Mg24.985839u$

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231. Find the maximum energy that a beta particle can have in the following decay

$\hat{} 176Lu \rightarrow ^{176} Hf + e + \overrightarrow{v}.$

Alomic mass of $\hat{} 176Lu$ is $175.942694u$ and that of $\hat{} 176Hf$ is $175.941420u.$

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232. A radioactive sample has 6.0×10^{18} active nuclei at a certain instant. How many of these nuclei will still be in the same active state after two half-lives?

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233. The number of $\hat{} 238U$ atoms in an ancient rock equals the number of $\hat{} 206Pb$ atoms. The half-life of decay of $\hat{} 238U$ is $4.5 \times 10^{9}y.$

Estimate the age of the rock assuming that all the $\hat{} 206Pb$ atoms are formed from the decay of $\hat{} 238U$.

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234. Under certain circumstances, a nucleus can decay by emitting a particle more massive than an α-particle. Consider the following decay processes:

$$._{88}Ra^{223} \rightarrow ._{82}Pb^{209} + ._{6}C^{14}, ._{88}Ra^{223} \rightarrow ._{86}Rn^{219} + ._{2}He^{4}$$

(a) Calculate the Q-values for these decays and determine that both are energetically allowed.

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235. P^{32} beta-decays to S^{32}.Find the sum of the energy of the antineutrino and the kinetic energy of the β-particle. Neglect the recoil of the daughter nucleus. Atomic mass of $P^{32} = 31.974u$ and that of $S^{32} = 31.972u$.

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236. The selling rate of a radioactive isotope is decided by its activity. What will be the second-hand rate of a oe month old $P^{32}(t_{1/2} = 14.3$ days) source if it was originally purchased for 800 rupees?

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237. In an agriculture experiment, a solution containing 1 mole of a radioactive meterial $\left(t_{1/2} = 14.3 days\right)$was injected into the roots of a plants.the plant was allowed 70 hours to settle down and then activity eas measured in its fruit. If the activity measured was $1\mu Ci$ what per cent of activity is transmitted from the root to the fruit in steady state?

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238. Calculate the energy released by $1g$ of natural uranium assuming $200 MeV$ is released in eaech fission event and that the fissionable isotope U^{235} has an abundance of 0.7% by weight in natural uranium.

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239. A radioactive nucleus Xdecay to a nucleus Y with a decay with a decay Concept $\lambda_x = 0.1s^{-1}, \gamma$ further decay to a stable nucleus Z with a decay constant $\lambda_y = 1/30s^{-1}$ initialy, there are only X nuclei and their number is $N_0 = 10^{20}$. Set up the rate equations for the population of X, Y and Z The population of Y nucleus as a function of time is given by $N_y(1) = N_0\lambda_x l(\lambda_x - \lambda_y)((\exp(-\lambda_y t))$ Find the time at which N_y is maximum and determine the populations X and Z at that instant.

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240. Calculate the Q-values of the fusion reaction

$He^4 + He^4 = Be^8$

In such a fusion energetically favourable? Atomic mass of Be^8 is 8.0053u and that of $He^4$is 4.0026 u.

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241. Calculate the energy that can be obtained from 1 kg of water through the fusion reaction

$H^2 + H^2 \rightarrow H^3 + p.$

Assume that 1.5×10^{-2} % of natural water is heavy water D_2O(by number of molecules) and all the deuterium is used for fusion.

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242. what kinetic energy must an α-particle possess to split a deuteron H^2 whose binding energy is $E_b = 2.2 MeV$?

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243. An alpha particles kinetic energy $T = 5.3 MeV$ initiates a nuclear reaction $Be^9(\alpha, n)C^{12}$ with energy yield $Q = +5.7 MeV$. Find the kinetic energy of the nerutron outgoing at right angle to the motion direction of the alpha-particles.

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244. Assuming the radius of a nucleus to be equal to $R = 1.3A^{1/3} \times 10^{-15} m$. Where A is its mass number, evaluate the density of nuclei and the number of nucleons per unit volume of the nucleus. Take mass of one nucleon $= 1.67 \times 10^{-27} kg$

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245. A radioactive nucleus can decay by two different processes. The half-life for the first process is t_1 and that for the second process is t_2. Show that the effective half-life t of the nucleus is given by

$$\frac{1}{t} = \frac{1}{t_1} + \frac{1}{t_2}.$$

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246. In the decay $Cu^{64} \rightarrow Ni^{64} + e^{+} + v$,

the maximum kinetic energy carried by the netrino which was emitted together with a positron of kinetic energy 0.150 meV? (a) what is the energy of the neutrino which was emitted togather with a positron of kinetic energy 0.150 MeV ? .(b)What is the momentum of this neutrino in kg m s^{-1}?Use the formula applicable to photon.

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247. Over what distance in free space will the intensity of a $5eV$ neutron beam reduced by a factor one - half ?

$\left[T_{1/2} = 12.8 \text{ min}\right]$

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248. In a neutron induced fission of $._{92}U^{235}$ nucleus, usable energy of $185MeV$ is released. If $._{92}U^{235}$ reactor is continuously operating it at a power level of $100MW$ power, how long will it take for $1kg$ of uranium to be consumed in this reactor?

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249. Assuming 1 metric ton of coal gives heat of combustion equal to 8 kcal and a single fission of $.^{235}U$ releases 200 MeV. Calculate the minimum consumption in kg of $.^{235}U$ to be heat equivalent ot 100 ton of coal

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250. sion giving 0.1 % of its original mass released as energy.

(a) How much energy is released by an atomic bomb that contains $10kg$ of $.^{235}U$.

(b) If 1 ton TNT releases 4×10^9 joule. What is the TNT equivalent of the bomb ?

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251. A point source emitting alpha particles is placed at a distance of 1 m from a counter which records any alpha particle falling on its $1cm^2$ window. If the source contains 6.0×10^{16}active nuclei and the counter records a rate of 50000 counts//second, find the decay constant. Assume that the source emits alpha particles fall nearly normally on the window.

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252. A deuterium reaction that occurs in an experimental fusion reactor is in two stage:

(a) Two deuterium $\left(._1^2 D\right)$ nuclei fuse together to form a tritium nucleus, with a proton as a by product written as $D(D, p)T$.

(b) A tritium nucleus fuses with another deuterium nucleus to form a helium $._2^4 He$ nucleus with neutron as a by - product, written as T (D,n) $._2^4 He$.

Compute (a) the energy released in each of the two stages, (b) the energy released in the combined reaction per deutrium. (c) What percentage of the mass energy of the initial deuterium is released. Given,

$._{1}^{2}D = 2.014102 amu$

$._{1}^{3}T = 3.016049$

$._{2}^{4}He = 4.002603 amu$.

$._{1}^{1}H = 1.007825 amu$

$._{0}^{1}n = 1.00665 amu$

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253. If the nucleus of hydrogen fuses with a nucleus of lithium to form two helium nuclei,

(a) write down the nuclear reaction equation

(b) find the release of energy in joule per fusion

(c) find the number of hydrogen atoms equired to generate 9.8 J

Mass of hydrogen, lithium and helium atoms are 1.0078 amu, 7.017 amu and 4.0036 amu respectively.

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254. Find the energy required for separation of $a_{10}Ne^{20}$ nucleus into two α-particles and a_6C^{12} nucleus if it is known that the binding energies per nucleon in $._{10}\,Ne^{20}$, $._{2}\,He^{4}$ and $._{6}\,C^{12}$ nuclei are equal to 8.03, 7.07 and $7.68MeV$ respectively.

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255. How many alpha and beta particles are emitted when uranium $._{92}^{238}\,U$ decays to lead $._{82}^{206}\,Pb$?

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256. Assuming the splitting of U^{235} nucleus liberates $200MeV$ energy, find

(a) the energy liberated in the fission of 1 kg of U^{235} and

(b) the mass of the coal with calorific value of $30kJ/g$ which is equivalent to $1kg$ of U^{235}.

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257. The mean lives of a radioactive substance are 1620 years and 405 years for α emission and β emission respectively. Find out the time during which three fourth of a sample will decay if it is decaying both by α-emission and β-emission simultaneously. $(\log_e 4 = 1.386)$.

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258. The disintegration rate of a certain radioactive sample at any instant is 4750 disintegrations per minute. Five minutes later the rate becomes 2700 per minute. Calculate

(a) decay constant and (b) half-life of the sample

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259. A radioactive nucleus undergoes a series of deacy according to the scheme.

$$A \xrightarrow{\alpha} A_1 \xrightarrow{\beta^-} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{\gamma} A_4$$

If the mass number and atomic number of A are 180 and 172 respectively, what are these numbers for A_4.

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260. There is a stream of neutrons with kinetic energy of 0.0327 eV. If half life of neutrons is 700s, what fraction of neutrons will decay before they travel a distance of 10m? Take mass of neutron =$1.675 \times 10^{-27} kg$.

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261. A radioactive element decays by β^- emission. If mass of parent and daughter atom are m_1 and m_2 respectively, calculate energy liberated during the emission. Mass of an electron = m.

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262. In the chemical analysis of a rock the mass ratio of two radioactive isotopes is found to be $100 : 1$. The mean lives of the two isotopes are 4×10^9 years and 2×10^9 years, respectively. If it is assumed that at the time of formation the atoms of both the isotopes were in equal propotional, calculate the age of the rock. Ratio of the atomic weights of the two isotopes is $1.02 : 1$.

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263. What is the power output of a $._{92} U^{235}$ reactor if it is takes 30 days to use up $2kg$ of fuel, and if each fission gives $185MeV$ of usable energy ?.

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264. The binding energies per nucleon for deuteron ($._1 H^2$) and helium ($._2 He^4$) are $1.1MeV$ and $7.0MeV$ respectively. The energy released when two deutrons fuse to form a helium nucleus ($._2 He^4$) is........

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265. A nuclear reactor generates $P = 20MW$ power at efficiency $\eta = 60\%$ by nuclear fission of a radio-nuclide whose half life is $T = 2.2$ years. If each fission releases energy $E = 200MeV$, calculate time during which $\mu = 10$ mole of the radionuclide will be consumed completely. (Avogadro number , $N = 6 \times 10^{23}$, $\log_e 2 = 0.693$, $1\text{year} = 3.15 \times 10^7 s$)

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266. It is proposed to use the nuclear fusion reaction,

$._1^2 H +_1^2 H \rightarrow_2^4 He$

in a nuclear reactor $200MW$ rating. If the energy from the above reaction is used with a 25 per cent efficiency in the reactor, how many grams of deuterium fuel will be needed per day?(The masses of $._1^2 H$ and $._2^4 He$ are 2.0141 atomic mass units and 4.0026 atomic mass units respectively.)

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267. A nucleus X, initially at rest , undergoes alpha dacay according to the equation ,

$$_(92)^A X \to_Z^{228} Y + \alpha$$

(a) Find the value of A and Z in the above process.

(b) The alpha particle produced in the above process is found to move in a circular track of radius $0.11m$ in a uniform magnetic field of 3 Tesla find the energy (in MeV) released during the process and the binding energy of the parent nucleus X

Given that : $m(Y) = 228.03u, m\left(_(0)^1 n\right) = 1.0029u.$

$m\left(_(2)^4 He\right) = 4.003u, m\left(_(1)^1 H\right) = 1.008u$

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268. A small quantity of solution containing Na^{24} radio nuclide $(half - l \text{ if } e = 15h)$ of activity $1.0 microcurie$ is injected into the blood of a person. A sample of the blood of volume $1cm^3$ taken after $5h$ shows an activity of 296 disintegrations per minute. Determine the total volume of the blood in the body of the person. Assume that the radioactive solution mixes uniformly in the blood of person.

(1 curie $= 3.7 \times 10^{10}$ disintegrations per second)

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269. At a given instant there are 25% undecayed radioactive nuclei in a sample. After $10s$ the number of undecayed nuclei reduces to 12.5%. Calculate

(a) mean life of the nuclei,

(b) the time in which the number of undecayed nuclei will further reduce to6.25% of the reduced number.

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270. In an ore containing Uranium, the ratio of U^{238} to Pb^{206} nuceli is 3. Calculate the age of the ore, assuming that alll the lead present in the ore is the final stable, product of U^{238}. Take the half-like of U^{238} to be 4.5×10^9 years. In $(4/3) = 0.288$.

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271. A nuclear explosion is designed to deliver $1MW$ of heat energy, how many fission events must be required in a second to attain this power level. If this explosion is designed with a nuclear fuel consisting of uranium 235 to run a reactor at this power level for one year, then calculate the amount of fuel needed. You can assume that the calculate the amount of energy released per fission event is $200MeV$.

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272. Consider the beta decay

$\hat{} \; 198Au \rightarrow^{198} Hg* + B\eta^{-1} + \overrightarrow{v}$.

where $\hat{} \; 198Hg^{*}$ represents a mercury nucleus in an excited state at energy $1.088MeV$ above the ground state. What can be the maximum kinetic energy of the electron emitted? The atomic mass of $\hat{} \; 198Au$ is $197.968233u$ and that of $\hat{} \; 198Hg$ is $197.966760u$.

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273. A nucleus at rest undergoes a decay emitting an a particle of de - Broglie wavelength $\lambda = 5.76 \times 10^{-15} m$ if the mass of the daughter nucleus is 223.610 amu and that of alpha particle is $4.002 a\mu$, determine the total kinetic energy in the final state Hence , obtain the mass of the parent nucleus in amu (1 amu = 931.470 MeV / e^2)

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274. Suppose, the daughter nucleus in a nuclear decay is itself radioactive. Let λ_p and λ_d be the decay constants of the parent and the daughter nuclei. Also, let N_p and N_d be the number of parent and daughter nuclei at time t. Find the condition for which the number of daughter nuclei becomes constant.

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275. Potassium-40 can decay in three modes .It can decay by β^- -emission,β^+ -emission or electron capature. (a) Write the equation showing the end products. (b) Find the Q-value in each of the three cases. Atomic masses of Ar_{18}^{40},$K_{19}^{40}$and Ca_{20}^{40} are 39.9624 u,39.9640 u,and 39.9626 u respectively.

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276. Natural water contains a small amount of tritium $\left(H_1^3\right)$. This isotope beta -decays with a half-life of 12.5 years.A mountaineer while climbing towards a difficult peak finds debris of some earlier unsuccessful attempt.Among other things he finds a sealed bottle of whisky.On returm he analyses the whisky and finds that it contains only 1.5 per cent of hte H_1^3 radioactivity as compared to a recently purchased bottle marked '8 years old' .Estimate the time of that unsuccessful attempt.

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277. Hg_{80}^{197} decay to Au_{79}^{197} through electron capture with a decay constant of 0.257 per day.(a)What other particle or particles are emitted in the decay?(b) assume that the electron is captured from the K shell. Use Moseley's law $\sqrt{v} = a(Z - b)$with a $a = 4.95 \times 10^7 s^{-1/2}$ and b=1 to find the wavelenghth of the K_a x-ray emitted following the electron capature.

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278. A radioactive isotope is being produced at a constant rate $dN/dt = R$ in an experiment. The isotope has a half-life $t_{1/2}$.Show that after a time $t > > t_{1/2}$,the number of active nuclei will become constant. Find the value of this constant.

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279. Consider the situation of the previous problem.suppose the production of the radioactive isotope starts at t=0. Find the number of active nuclei at time t.

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280. A body of mass m_0 is placed on a smooth horizontal surface . The mass of the body is decreasing exponentially with disintegration constant , λ . Assuming that the mass is ejected backwards with a relative velocity u . If initially the body was at rest , the speed of body at time t is

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281. Radioactive isotopes are produced in a nuclear physics experiment at a constant rate $dN/dt = R$ .An inductor of inductance 100 mH, a resistor of resistance 100Ω and a battery are connected to form a series circuit.the circuit is switched on at the instant the production of radioactive isotope starts. It is found that i/N remains constant in time where i is the current in the circuit at time t and N is the number of active nuclei at time t. Find the half-life of the isotope.

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282. A charged capacitor of capacitance C is discharged through a resistance R. A radioactive sample decays with an average-life τ.Find the value of R for which the ratio of the electrostatic field energy stored in the capacitor to the activity of the radioactive sample remains constant in time.

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283. A small bottle contains powered beryllium Be & gaseous radon which is used as a source of α-particles. Netrons are produced when $\alpha -$ particles of the radon react with beryllium. The yield of this reaction is $(1/4000)$ i.e. only one α-particle out of induced the reaction. Find the amount of radon (Rn^{222}) originally introduced into the source, if it prouduces 1.2×10^6 neutrons per second after 7.6 days. [$T_{1/2}$ of $R_n = 3.8$ days]

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284. The energy of alpha particles emitted by $.^{210}Po$ is 5.3 MeV. The half life of this alpha emitter is 138 days.

(a) What mass of $.^{210}Po$ is needed to power a thermoelectric cell of 1 W ouput if the efficiency of energy conservation is 8 percent?

(b) What would be the power output after 1 year ?

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285. $.^{238}U$ decays with a half-life of 4.5×10^{9} years, the decay series eventaully ending at $.^{206}Pb$, which is stable. A rock sample analysis shows that the ratio of the number of atoms of $.^{206}Pb$ to $.^{238}U$ is 0.0058. Assuming that all the $.^{206}Pb$ is prodduced by the decay of $.^{238}U$ and that all other half-lives on the chain are negligilbe, the age of the rock sample is $(1n1.0058 = 5.78 \times 10^{-3})$.

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286. A number N_0 of atoms of a radio active element are placed inside a closed volume. The radioactive decay constant for the nucleus of this element is λ_1. The daughter nucleus that form as a result of the decay process are assumed to be radioactive too with a radioactive decay constant λ_2. Determine the time variation of the number of such nucleus. Consider two limiting cases $\lambda_1 > > \lambda_2$ and $\lambda_1 < < \lambda_2$.

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287. A sample of 100 millicurie of krypton gas consists of a mixture of the active isotope $.^{85} Kr$ & the stable isotope $.^{84} Kr$. If the volume of the mixtures $10cm^3$ at STP & half-life of $.^{85} Kr$ is 10 years. Calculate the % by weight of $.^{85} Kr$ present in the mixture.

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288. A stationary $._{82}^{200} Pb$ nucleus emits an α-particle with kinetic energy $T_\alpha = 5.77MeV$. Find the recoil velocity of a daughter nucleus. What fraction of the total energy liberated in this decay is accounted for by the recoil energy of daughter nucleus ?

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289. Energy evolved from the fusion reaction $2_1^2H =_1^4 He + Q$ is to be used for the production of power. Assuming the efficiency of the process to be 30%. Find the mass of deuterium that will be consumed in a second for an output of $50MW$.

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290. Find the amount of heat generated by $1mg$ of Po^{210} preparation during the mean life period of these nuclei if the emitted alpha particles are known to possess kinetic energy $5.3MeV$ and practically all daughter nuclei are formed directly in the ground state.

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291. To investigate the beta-decay of Mg^{23} radionuclide, a counter was activated at the moment $t = 0$. It registered N_1 beta particles by a moment $t_1 = 2\,\text{sec}$, and by a moment $t_2 = 3t_1$ the number of registered beta particles was 2.66 times greater. the mean life of the given nuclei is

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292. Find the decay constant of $.^{55}Co$ radio nuclide if its activity is known to decrease $4\,\%$ per hour. The decay product is non-radioactive.

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293. Taking into account the motion of the nucleus of a hydrogen atom , find the expressions for the electron's binding energy in the ground state and for the Rydberg constant. How much (in percent) do the binding energy and the Rydberg constant , obtained without taking into account corresponding values of these of these quantities?

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294. And α-particle with kinetic enregy $T_{\alpha} = 7.0 MEV$ is scattered elastically by an initially stationary $.^{6} Li$ nucleus. Find the kinetic energy of the recoil nucleus if the angle of divergence of the two particles is $\theta = 60^{\circ}$. Take masses of α partice and lithium as m and M respectively.

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295. A neutron makes a head-on elastic collision with a stationary deuteron. The fraction energy loss of the neutron in the collision is

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296. Find the energy of the reaction $.^{14} N(\alpha, p).^{17} O$, if the kinetic energy of the incoming α-particle is $T_{\alpha} = 4.0 MeV$ & the proton outgoing at an angle $\theta = 60^{\circ}$ to the motion direction of the α-particle has a kinetic energy $T_{p} = 2.09 MeV$.

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297. Find the greatest possible angle through which a deuteron is scattered as result of elastic collision with an initially stationary proton ? Take m_1 & m_2 as masses of a proton & a deuterium.

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298. The element curium $._{96}^{248}Cm$ has a mean life of $10^{13}s$. Its primary decay modes are spontaneous fission and α-decay, the former with a probability of 8% and the later with a probability of 92%, each fission releases $200MeV$ of energy. The masses involved in decay are as follows

$._{96}^{248}Cm = 248.072220u$,

$._{94}^{244}P_u = 244.064100u$ and $._2^4He = 4.002603u$. Calculate the power output from a sample of 10^{20} Cm atoms. ($1u = 931MeV/c^2$)

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299. Nuclei of radioactive element A are being produced at a constant rate. α. The element has a decay constant λ. At time $t = 0$, there are N_0 nuclei of the element.

(a) Calculate the number N of nuclei of A at time t.

(b) IF $\alpha = 2N_0\lambda$, calculate the number of nuclei of A after one half-life time of A and also the limiting value of N at $t \rightarrow \infty$.

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300. The mean path length of α-particles in air under standard conditions is defined by the formula $R = 0.98 \times 10^{-27} V_0^3 cm$, where $V_0 (cm / s)$ is the initial velocity of an α-particle. Using this formula, final for an α-particle with initial kinetic energy $7.0 MeV$.

(a) Its mean path length.

(b) The average number of ion pairs formed by the given α-particle over the whole path R as well as over its first half. Assuming the ion pair formation energy to be equal to 34 eV.

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