CHEMISTRY

BOOKS - CENGAGE CHEMISTRY

RADIOACTIVITY

Work Example

1. $^{238}_{92}$ U emits 8 α - particles and 6 β - particles. Calculate the atomic number and mass number of the resulting end element.

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2. $^{234}_{90}$ Th disintegrates to gives $^{206}_{82}$Pb. Calculat the number of α - and β - particle emitted during this disintegration.

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3. The half life of an isotope of thorium is 3.64 days Calculate the decay constant .

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4. Calculate the half life of a radiocative element whose decay constant is 42.8×10^{-5} per year.

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5. The half life of ^{230}Th is 8×10^{4} years. What is the time required for $(1/10)$ th of the sample of remain intact?

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6. The half life of a radioactive elements is $t_{1/2}$. If a given sample contains 10^3 nuclei , how many nuclei remain intact at the end of $t_{1/2}/2$?

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7. Calculate the binding energy of $^{6}_{3}Li$ assuming the mass of $^{6}_{3}Li$ atoms as 6.01512 amu.

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8. Calculate the binding energy of an α - partcle .

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Mandatory Exercise Set I

1. According to Einstein's relation, what is the energy equivalent of 1 kg of a substance in MeV?

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2. Given that the energy equivalent of 1 amu = 931 MeV. What is the energy corresponding to a mass of 0.034315 amu?

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3. Calculate the nuclear binding energy of an alpha particle from the following data.

Mass of ${}_{1}^{1}H$ atom = 1.007825 amu

Mass of neutron = 1.008665 amu

Mass of ${}_{4}^{2}He$ atom = 4.00260 amu

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4. Isotopes differ in the number of

A. Protons

B. Neutrons

C. Electrons

D. Both (A) and (C)

Answer: B

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5. The relative atomic mass of an isotope of hydrogen containing two neutrons is

A. 2

B. 3

C. 1

D. 4

Answer: B

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6. The elements which emit radioactivity are known as

A. radio elements

B. active elements

C. radioactive elements

D. nuclear elements

Answer: C

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7. The type of radiations emitted by radioactive substance are

A. 2

B. 4

C. 5

D. 3

Answer: D

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8. The radiations emitted by different elements are

A. alpha

B. beta

C. gamma

D. all of above

Answer: D

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9. The spontaneous emission of radioactivity by unstable nuclei is called

A. positive radioactivity

B. artificial radioactivity

C. natural radioactivity

D. negative radioactivity

Answer: C

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10. In case of radioactive nucleus

A. nucleus absorbs another nucleus

B. nucleus always slits into two equal fragments

C. nucleus emits at least one form of radiation

D. nucleus absorbs at least one form of radiation

Answer: C

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11. Number of neutrons in element plutonium is $^{242}_{94}Pu$

A. 336

B. 242

C. 148

D. 94

Answer: C

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12. Which action will most increase a present exposure to radioactivity?

A. eating food that has been stained by gamma rays

B. Staying in a house near a nuclear power plant

C. opening the car gate

D. In high flying aircraft

Answer: B

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13. Which of the following have highest penetrating capacity

A. α-ray

B. β-ray

C. γ-ray

D. all are same

Answer: C

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14. An atom of radium combines with two atoms of chlorine to form $RaCl_2$ molecule. The radioactivity of $RaCl_2$ will be

A. zero

B. one half of the same quantity of Ra

C. one third of the same quantity of Ra

D. as much as that of the same quantity of Ra

Answer: D

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15. ${}_{6}^{11}C$ on decay produces

A. positron

B. β-particle

C. α-particle

D. none

Answer: A

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16. Isodiaphers are atoms having

A. P/n constant

B. $P - n$ constant

C. $(n - P)$ constant

D. $(n - P)$ different

Answer: C

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17. A particle of mass m when annihilated completely gives energy E equal to

A. mc^2

B. mc

C. c^2 / m

D. m / c^2

Answer: A

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18. ^{23}Na is more stable isotope of Na. Find out the process by which $^{24}_{11}Na$ can undergo radioactivity decay.

A. β-emission

B. α-emission

C. γ-emission

D. k-electron capture

Answer: A

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19. Which of the following isotopes is likely to be most stable

A. $^{71}_{30}Zn$

B. $^{66}_{30}Zn$

C. $^{64}_{30}Zn$

D. none

Answer: C

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20. Neutrino was predicted to

A. Conserve mass of nuclear reaction

B. conserve change of nuclear reaction

C. conserve spin of nuclear reaction

D. all of above

Answer: C

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21. Number of neutrons in a parent nucleus x, which gives ${}_{7}^{14}N$ after two successive β-emission would be

A. 6

B. 7

C. 8

D. 9

Answer: D

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22. Which of the following projectiles is the best for bombarding the nuclie?

A. α-particle

B. Proton

C. Deuteron

D. Neutron

Answer: D

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23. An alpha particle is also known as

A. an electron

B. a positron

C. a helium nucleus

D. a photon

Answer: C

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24. When an alpha particle emitted from an unstable nucleus, the mass number of the nucleus

A. increases by 2

B. increases by 4

C. decreases by 4

D. decreases by 2

Answer: C

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Mandatory Exercise Set Ii

1. Define radioactivity. Give the names of two naturally occurring radioactive elements.

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2. How would you distinguish between

(a) Stable and unstable nucleus.

(b) Nuclear and chemical reaction.

(c) $\alpha -$ and $\beta -$ particles.

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3. Give the charge and mass of $\alpha -$, $\beta -$, and $\gamma -$ rays.

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4. Distinguish between the emission of α and $\beta -$ rays.

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5. Identify the following:

(a) The particle with highest ionising power.

(b) The one which affects photographic plate the least.

(c) The one which is a secondary radiation.

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6. Explain why the penetrating power of α-particles is the lowest among three radiations.

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7. What is the position of daughter nucleus in the periodic table in relation to the parent nucleus if an α-particle is lost from the parent?

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8. Nucleus, although positively charged, emits negatively charged β-particles. Explain the reason.

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9. What are isotopes? Give two examples.

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10. Calculate the atomic number and mass number of the resulting element, when $^{235}_{92}U$ emits 6 α-particles and 4 β-particles.

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11. Calculate the number $\alpha -$ and $\beta -$ particles emitted in the following reaction $^{230}_{90}Th \rightarrow {}^{206}_{82}Pb$

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12. Write the balanced nuclear equations for the following processes:

(a) Alpha emission of $^{162}_{75}Re$

(b) Beta emission of $^{157}_{63}Eu$

(c) Positron emission of $^{165}_{73}Ta$

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13. What particle is produced in the following decay reactions?

(a) ${}^{24}_{11}Na \rightarrow {}^{24}_{12}Mg + ?$

(b) ${}^{135}_{60}Nd \rightarrow {}^{135}_{59}Pr + ?$

(c) ${}^{170}_{78}Pt \rightarrow {}^{166}_{76}Os + ?$

(d) ${}^{218}_{85}At \rightarrow {}^{214}_{83}Bi + ?$

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14. Mention three uses of radio-isotopes.

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15. The radioactivity is observed in the elements with

A. high atomic number

B. high mass number

C. unstable nucleus

D. all of these

Answer: D

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16. An electric field can deflect

A. X-rays

B. γ-rays

C. α-rays

D. All of these

Answer: C

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17. The heaviest particle emitted during radioactive decay is

A. α

B. β

C. γ

D. n

Answer: A

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18. The order of penetrating power is

A. $\alpha > \beta > \gamma$

B. $\gamma > \beta > \alpha$

C. $\beta > \alpha > \gamma$

D. $\alpha = \beta > \gamma$

Answer: B

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19. A radioactive nucleus spontaneously decays by which of the following process?

A. Alpha decay

B. Beta decay

C. Gamma decay

D. All of these

Answer: D

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Mandatory Exercise Set Iii

1. What is meant by decay constant?

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2. Distinguish between half life and average life period.

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3. The half life of indium-111, a radioactive isotope used in studying the distribution of white blood cells, is $t_{1/2} = 2.805$ days. What is the decay constant of ^{111}In ?

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4. Decay constant of thallium -201, a radioisotope used for parathyroid imaging is 0.228 days^{-1}. What is the half life of ^{201}Tl ?

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5. Name the three biological effects of radiation.

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6. What are the hazards of radioactive radiations?

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7. 10 mg of a radioactive sample having a half lifeof 2 years is taken. How much of it will remain unaffected at the end of 4 years?

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8. How is artificial radioactivity different from natural radioactivity?

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9. Give the names of four artificially transmuted radioactive elements.

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10. The most stable isotope is one having

A. $t_{1/2} = 6.7$ years

B. $t_{1/2} = 8 \times 10^3$ years

C. $t_{1/2} = 5760$ years

D. $t_{1/2} = 2.35 \times 10^5$ years

Answer: D

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11. The number of radioactive atoms disintegrating per unit time is called

A. decay constant

B. rate of disintegration

C. average life

D. half life

Answer: A

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12. The time taken by a radioactive substance with a long half-life period to completely disintegrate is

A. 1

B. 0

C. infinite

D. none of these

Answer: C

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13. $^{234}_{92}U$ undergoes beta decay. What would be the products of this reactions?

A. $^{4}_{2}He + ^{230}_{90}Th$

B. $^{4}_{2}He + ^{238}_{96}cm$

C. $_{-1}{}^{0}e + ^{234}_{93}Np$

D. $_{-1}{}^{0}e + ^{234}_{91}Pa$

Answer: D

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14. Which of the following are not true about beta decay?

A. atomic number decreases

B. electron releases

C. number of neutron decreases

D. number of proton increases

Answer: A

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15. Which of the following would be attracted toward a positively charged sheet of metal?

A. alpha particle

B. beta particle

C. gamma ray

D. none

Answer: B

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16. The rate of radioactive decay is increased by

A. increased heat

B. increased pressure

C. change in physical state

D. none of the above

Answer: D

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17. The emission of a gamma ray from a nucleus results in

A. a decrease in the atomic number

B. an increase in the atomic number

C. decrease in mass number

D. none

Answer: D

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18. Half-life period of a metal is 20 days. What fraction of metal does remain after 80 days

A. 1

B. $1/16$

C. $1/4$

D. $1/8$

Answer: B

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19. The protons in a nucleus stay together due to the

A. electrostatic force of attraction

B. nuclear force

C. gravitational force

D. binding forced

Answer: B

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20. Half life of a radioactive substance with progress of time

A. increase

B. decrease

C. remain same

D. none

Answer: C

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21. Isotope A has a half life measured in minutes where as isotope B has a half life of millions of years. Which is more radioactive?

A. Isotope A

B. Isotope B

C. both are equal

D. depends on no of neutron in nucleus

Answer: A

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22. If 12 g of sample is taken and 6 g of a sample decay in 1 hr. The amount of sample showing decay in next hour is

A. 6 g

B. 3 g

C. 2 g

D. 1 g

Answer: B

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23. Two isotopes P and Q, radioactive in nature atomic weight of P and Q are 10 and 20, P and Q are mixed in equal amount (weight). After 20 days their weight ratio is found to be 1 : 4, $t_{1/2}(P) = 10$ day, find $t_{1/2}(Q) = ?$

A. zero

B. 5 day

C. 20 day

D. infinite

Answer: D

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24. If mass of neutron were halved and mass of electron becomes double atomic mass of ${}_{8}^{16}O$ would be

A. 16

B. 8

C. 12

D. 32

Answer: C

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25. Two element P and have half lives of 10 and 15 minute respectively. Freshly prepared sample of mixture containing equal number of atoms is allowed to decay for 30 min. The ratio

of number of atoms of P and Q left m mixture is

A. 0.5

B. 2

C. 3

D. 1

Answer: A

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26. The number of neutrons in the element L in the following nuclear change is

$$^{238}_{92}M \rightarrow {}^{X}_{Y}N + {}^{4}_{2}He$$

$$^{X}_{Y}N \rightarrow {}^{A}_{B}L + 2B^{\oplus}$$

A. 146

B. 144

C. 140

D. 142

Answer: A

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27. Total number of a and B-particle given out during nuclear transformation as $^{238}_{92}U \rightarrow {}^{214}_{82}Pb$

A. 2

B. 4

C. 6

D. 8

Answer: D

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Consolidated Exercise

1. ^{14}C disintegrates by the loss of a beta particle and has a half life period of 5670 years. The number of disintegrations per second per kilogram of freshly cut wood is 270 while that of an antique chair is 220.

(a) Calculate the disintegration constant of ^{14}C.

(b) Calculate the age of the chair.

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2. An old piece of wood has 25.6% as much as ^{14}C as ordinary wood today has. Find the age of the wood. Half life period of ^{14}C is 5760 years.

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3. The amount of C-14 isotope in a piece of wood is found to be 1/16th of its amount

present in a fresh piece of wood. Calculate the age of wood. Half life period of C-14 is 5760 years.

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4. Match the entries of column A with appropriate entries of column B and column C

Column A	Column B	Column C
(1) α-rays	(i) Travel with the same velocity as that of light	(a) Inversely proportional to the time required for number of atoms of a sample to reduce to (1/e) times the initial concentration
(2) β-rays	(ii) SI unit of rate of decay	(b) $\frac{1}{10^6}$ Rd = $\frac{1}{3.7\times10^{10}}$
(3) γ-rays	(iii) Travel with velocity of (1/20)th of that of light	(c) Possess very low ionising power
(4) λ	(iv) Travel with velocity of 3% to 99% of that of light	(d) Produce large effect on photographic plate but little effect on ZnS screen
(5) Bq	(v) Is the disintegration constant	(e) Possess very low penetrating power

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Multiple Choice Questions With One Or More Than One Correct Answer

1. Which of the following statement(s) about radioactivity is/are correct?

A. It is a nuclear property.

B. It does not involve rearrangement of electrons.

C. Its rate is affected by change in temperature and/or pressure.

D. It is not affected by presence of other elements.

Answer: A::B::D

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2. A radioactive element X has atomic number of100. It decays directly into an element Y which decays directly into an element Z. In both the processes charged particles are

emitted. Which of the following statements could be true?

A. Y has an atomic number 101

B. Z has an atomic number 99

C. Y has an atomic number 102

D. Z has an atomic number 100

Answer: A::B::D

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3. Half-life period for a radio isotope is

A. always constant

B. independent of initial concentration

C. variable

D. independent of final concentration

Answer: A::B::D

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4. Decrease in atomic number is observed during

A. α-emission

B. β-emission

C. positron emission

D. γ-emission

Answer: A::C::D

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Challenging Exercise

1. Find the binding energy of ${}_{26}^{56}Fe$. Atomic mass of ${}^{56}Fe$ is 55.9349 amu and that of ${}^{1}H$ is 1.00783 amu. Mass of free neutron = 1.00867 amu.

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2. A certain element has a density of 10 g cm^{-3} and half life of 140 days. Over a period of 140 days, the average number of alpha

emissions per day is found to be 12×10^{12} , from a sample of initial mass 1 μg. Estimate the number of atoms in 1 cm^3 of the element assuming that all the atoms were radioactive initially.

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3. Calculate the kinetic energy of the a-particle emitted in the decay of $^{238}Pu \rightarrow {}^{234}U + a$

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4. Half life of a radioactive sample is 22 years. What is the time required for 90% of the sample to disintegrate?

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5. Americium-241 (A = 95), a radioisotope used in smoke detectors, decays by a series of 12 reactions involving sequential loss of $\alpha, \alpha, \beta, \alpha, \alpha, \beta, \alpha, \alpha, \alpha, \beta, \alpha,$ and β-particles. Identify each intermediate nuclide

and final stable product nucleus (use periodic table for reference).

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6. The rate constant for the radioactive decay of C-11 is 0.0341 min^{-1}. How long will it take for a sample of C-11 to decrease to 1/4 of its original activity?

A. 20.3 min

B. 29.3 min

C. 40.6 min

D. 58.6 min

Answer: A

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Olympiad And Ntse Level Exercises

1. Match the items in Column I with that in Column II.

Column I	Column II
(A) Artificial radioactivity	(P) Nucleus of helium
(B) Carbon dating	(Q) Produced when electrons strike metal surface
(C) α-rays	(R) Age of dead animals or plants
(D) β-rays	(S) Irene Curie and Joliot

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2. Which of the following has the maximum penetrating power?

A. α-particle

B. Proton

C. γ-particle

D. Positron

Answer: C

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3. Which of the following nuclear changes is incorrect?

A. ${}_{20}Ca^{40} + {}_{0}n^{1} \rightarrow {}_{19}K^{40} + {}_{1}H^{1}$

B. ${}_{12}Mg^{24} + \alpha \rightarrow {}_{14}Si^{27} + {}_{0}n^{1}$

C. $_{48}Cd^{113} + _0n^1 \rightarrow _{48}Cd^{112} + _{-1}e^0$

D. $_{20}Co^{43} + \alpha \rightarrow _{21}Si^{46} + _1H^1$

Answer: C

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4. The phenomenon of radioactivity is associated with

A. Decay of nucleus

B. Fussion of nucleus

C. Emission of electrons or protons

D. Rearrangement in the extra nuclear electron

Answer: A

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5. If $_{92}U^{235}$ assumed to decay only by emitting two α- and one β-particles, the possible product of decay is

A. ${}_{89}Ac^{231}$

B. ${}_{89}Ac^{235}$

C. ${}_{89}Ac^{236}$

D. ${}_{89}Ac^{227}$

Answer: D

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6. Neutrons are more effective projectiles than protons because they

A. Are attracted by the nuclei

B. Are not repelled by the nuclei

C. Travel with high speed

D. None of these

Answer: B

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7. A method which uses radioactivity for determining the age of prehistoric materials is called

A. Carbon dating

B. Deuterium dating

C. Radium dating

D. Uranium dating

Answer: A

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8. How many α-particles are emitted in the nuclear transformation:

$$_{84}Po^{215} \rightarrow {}_{82}Pb^{211} + ?\,{}_{2}He^{4}$$

A. 0

B. 1

C. 2

D. 3

Answer: B

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9. The radioisotope used in the treatment of cancer is

A. C-12

B. Co-60

C. I-31

D. P-31

Answer: C

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10. Hydrogen bomb is based on the principle of

A. Nuclear fission

B. Nuclear fusion

C. Nuclear explosion

D. Chemical reaction

Answer: B

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