

Particle & Nuclear Physics

TOPIC QUESTIONS (2)

Level	AS Level
Subject	Physics
Exam Board	CIE
Paper Type	Multiple Choice

Time Allowed : 50min

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1. Nuclear decay is both spontaneous and random in nature.

Which row gives the correct experimental evidence for these properties?

	spontaneous nature of decay	random nature of decay
A	the decay rate is not affected by pressure	the decay rate is not affected by temperature
B	the decay rate is not affected by pressure	the rate at which radiation is received at a counter fluctuates
C	the decay rate is not affected by temperature	the decay rate is not affected by pressure
D	the rate at which radiation is received at a counter fluctuates	the decay rate is not affected by pressure



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2. Radon $^{222}_{86}\text{Rn}$ is the start of a decay chain that forms bismuth $^{214}_{83}\text{Bi}$ by alpha and beta emission.

For the decay of each nucleus of radon, how many α -particles and β -particles are emitted?

	α -particles	β -particles
A	1	1
B	2	1
C	1	2
D	2	2

3. An atomic nucleus emits a β -particle.

What change does this cause to the proton number and the nucleon number of the nucleus?

	proton number	nucleon number
A	-1	+1
B	0	-1
C	+1	-1
D	+1	0

4. Which statement concerning α -particles is correct?
- a. An α -particle has charge $+4e$.
 - b. An α -particle is a helium atom.
 - c. When α -particles travel through air, they cause ionisation.
 - D. When α -particles travel through a sheet of gold foil, they make the gold radioactive
5. The first artificial radioactive substance was made by bombarding aluminium, α -particles. This produced an unstable isotope of phosphorus, ${}_{15}^{30}\text{P}$. What was the by-product of this reaction? 13
- A an α -particle
 - B a β -particle
 - C a γ -ray
 - D a neutron
6. Isotopes of a given element all have the same
- A charge / mass ratio.
 - B neutron number.
 - C nucleon number.
 - D proton number.

7. Which are the correct descriptions of a γ -ray and a β -particle?

	γ -ray	β -particle
A	high-speed electron	electromagnetic radiation
B	electromagnetic radiation	Helium-4 nucleus
C	electromagnetic radiation	high-speed electron
D	high-speed electron	Helium-4 nucleus

8. A certain nuclide, Uranium-235, has nucleon number 235, proton number 92 and neutron number 143. Data for other nuclides are given below.

Which is an isotope of Uranium-235?

	nucleon number	proton number	neutron number
A	235	91	144
B	236	92	144
C	237	94	143
D	238	95	143

9. In what way do the atoms of the isotopes ${}^1_6\text{C}$, ${}^{13}_6\text{C}$ and ${}^{14}_6\text{C}$ differ?

- A** different charge
- B** different numbers of electrons
- C** different numbers of neutrons
- D** different numbers of protons

10. Protons and neutrons are thought to consist of smaller particles called quarks.

The 'up' quark has a charge of $+\frac{2}{3}e$: a 'down' quark has a charge of $-\frac{1}{3}e$ (elementary charge $(+1.6 \times 10^{-19} \text{ C})$).

How many up quarks and down quarks must a proton contain?

	up quarks	down quarks
A	0	3
B	1	1
C	1	2
D	2	1



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11. The nuclide ${}^{222}_{86}\text{Rn}$ decays in a sequence of stages to form the nuclide ${}^{206}_{82}\text{Pb}$.

Four of the nuclides formed in the sequence are α -particle emitters. The others are β -particle emitters.

How many nuclides formed in the decay sequence are β -particle emitters?

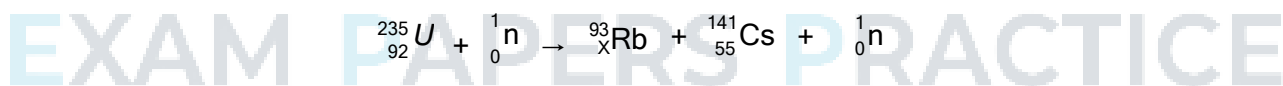
- A 2 B 4 C 8 D 12

12. A uranium-238 nucleus, ${}^{238}_{92}\text{U}$, undergoes nuclear decays to form uranium-234, ${}^{234}_{92}\text{U}$.

Which series of decays could give this result?

- a. emission of four β -particles
- b. emission of four γ -rays
- c. emission of one α -particle and two β -particles
- d. emission of two α -particles and eight β -particles

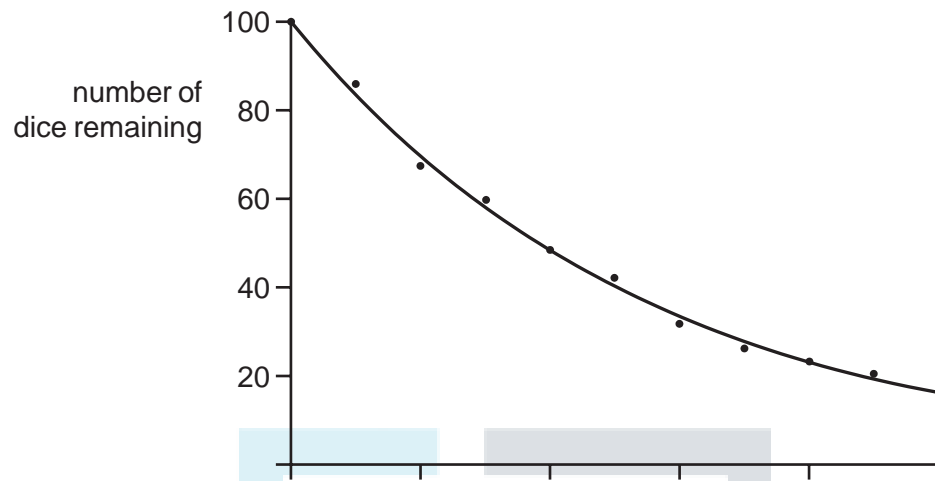
13. The nuclear equation for a fission reaction is shown below.

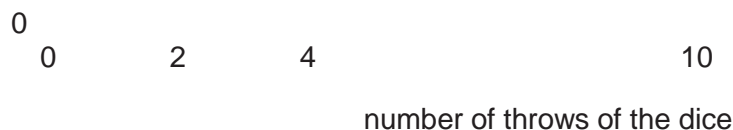


What are the values of X and Y?

	X	Y
A	37	0
B	37	1
C	37	2
D	38	2

14. A class of students used dice to simulate radioactive decay. After each throw, those dice showing a '6' were removed. The graph shows the results.





What could the scatter of points about the best-fit curve represent for actual radioactive decay?

- A background count not being taken into account
- B more than one type of radiation being present
- C the random nature of radioactive decay
- D the spontaneous nature of radioactive decay

15. A different nucleus can be formed by bombarding a stable nucleus with an energetic α -particle.

${}_{11}^{23}\text{Na}$ is bombarded with an energetic α -particle.

What could be the products of this nuclear reaction?

- A ${}_{10}^{25}\text{Ne}$ + neutron
- B ${}_{11}^{25}\text{Na}$ + proton
- C ${}_{12}^{26}\text{Mg}$ + β
- D ${}_{13}^{27}\text{Al}$ + γ

16. A nuclear isotope emits radiation which is detected by a Geiger-Müller tube held at a distance of about 10 cm from the radioactive source. The radiation is stopped completely by a 2 mm thick sheet of lead.

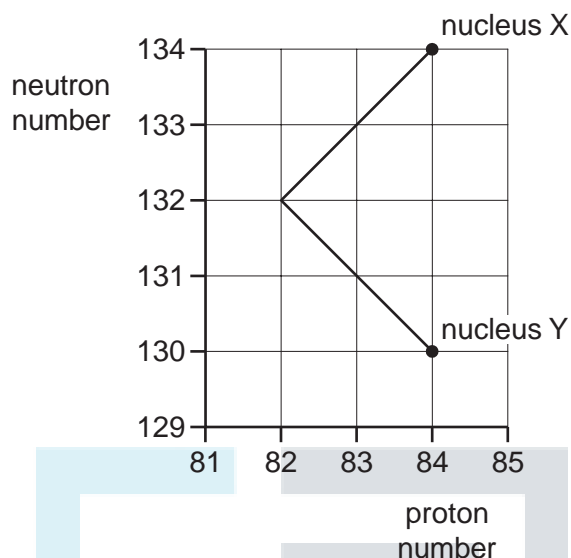
What can be deduced from this information about the emission from the isotope?

- A It could be alpha and beta radiation, but not gamma radiation.
- B It could be alpha and gamma radiation, but not beta radiation.
- C It could be beta and gamma radiation, but not alpha radiation.
- D It could be alpha, beta and gamma radiation.

17. What remains constant during β -emission from a number of identical nuclei in a substance?

- A energy of the β -particles
- B neutron number of the nuclei
- C nucleon number of the nuclei
- D proton number of the nuclei

18. The graph of neutron number against proton number represents a sequence of radioactive decays.



Nucleus X is at the start of the sequence and, after the decays have occurred, nucleus Y is formed.

What is emitted during the sequence of decays?

- A one α -particle followed by one β -particle
- B one α -particle followed by two β -particles
- C two α -particles followed by two β -particles
- D two β -particles followed by one α -particle

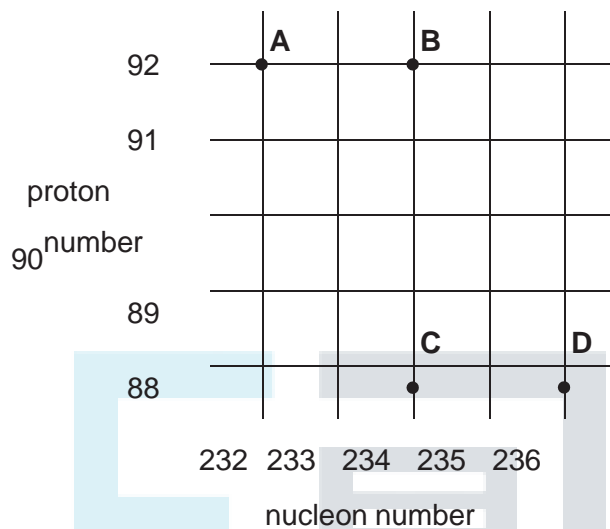
19. An experiment in which α -particles were deflected by a gold foil produced new insights into the structure of the atom.

Which conclusion can be drawn from the results of the experiment?

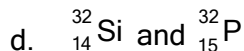
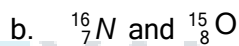
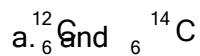
- a. Atomic nuclei occupy a very small fraction of the volume of an atom.
- b. Electrons orbit the atomic nucleus.
- c. Some atoms of the same element contain different numbers of neutrons.
- d. The atomic nucleus contains protons and neutrons.

20. Thorium- ${}_{90}^{234}\text{Th}$ decays by β -emission into a daughter product which in turn decays by further β -emission into a granddaughter product.

Which letter in the diagram represents the granddaughter product?



21. Which two nuclei contain the same number of neutrons?



22. A student conducts an experiment using an α -particle source.

When considering safety precautions, what can be assumed to be the maximum range of α -particles in air?

- A between 0 and 5 mm
- B between 5 mm and 200 mm
- C between 200 mm and 500 mm
- D between 500 mm and 1000 mm

23. The table shows three properties of different types of ionising radiation.

	X	Y	Z
charge	0	$-1 e$	$+2 e$
mass	0	$1840 u$	$4 u$
speed	c	$\sim 0.9 c$	$\sim 0.1 c$

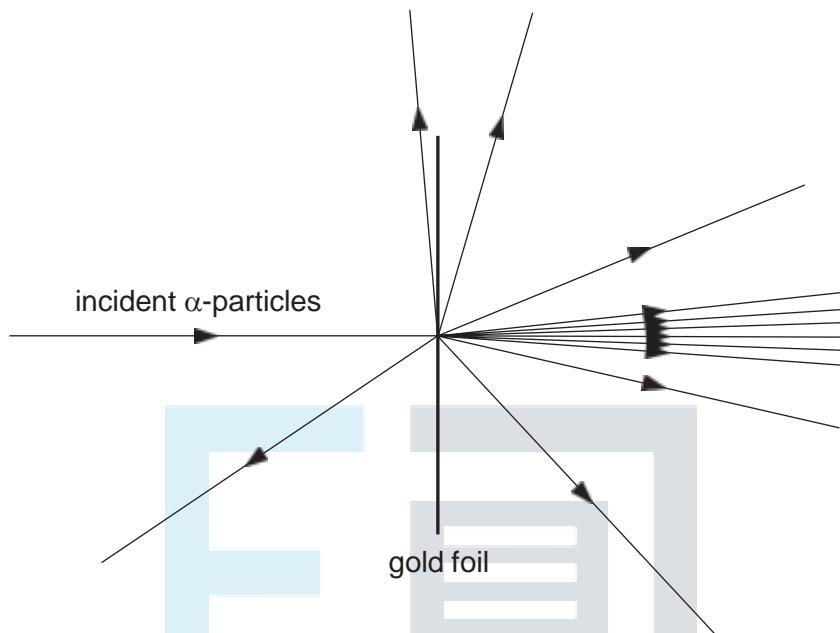
What are the radiations X, Y and Z?

	X	Y	Z
A	alpha	beta	X-ray
B	gamma	alpha	beta
C	gamma	beta	alpha
D	X-rays	alpha	beta

24. Which conclusion can be drawn from the results of the experiment showing the scattering of α -particles by gold foil?

- A Electrons orbit the atomic nucleus in well-defined paths.
- B Nuclei of different isotopes contain different numbers of neutrons.
- C The atomic nucleus contains protons and neutrons.
- D The nucleus is very small compared with the size of the atom.

25. A thin gold foil is bombarded with α -particles as shown.



The results of this experiment provide information about the

- A binding energy of a gold nucleus.
- B energy levels of electrons in gold atoms.
- C size of a gold nucleus.
- D structure of a gold nucleus.

26. A counter recording radioactive decays from a radioactive source gives the following counts in equal intervals of time.

time / min	counts
0-10	424
10-20	395
20-30	413
30-40	363
40-50	366
50-60	294
60-70	301
70-80	253
80-90	212

What can be deduced from these readings?

- A that radioactivity is random and that the half-life is 90 minutes
- B that radioactivity is random and that the half-life is uncertain
- C that radioactivity is spontaneous and that the half-life is 90 minutes
- D that radioactivity is spontaneous and that the half-life is uncertain

27. What is not conserved in nuclear processes?

- A charge
- B momentum
- C the total number of neutrons
- D the total number of nucleons



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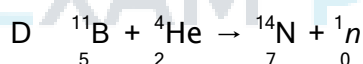
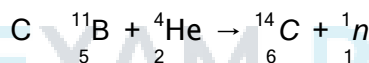
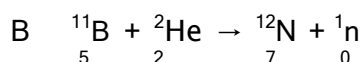
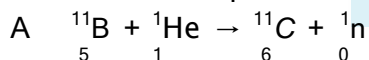
28. Nuclear decay is both spontaneous and random.

When the count rate of a radioactive isotope is measured, the readings fluctuate. Which row describes what the fluctuations demonstrate?

	spontaneous nature	random nature
A	no	no
B	no	yes
C	yes	no
D	yes	yes

29. When boron-11 (${}^{11}_{5}\text{B}$) is bombarded with α -particles, a new nucleus is formed and a neutron is released.

Which nuclear equation could represent this reaction?



30. What is not conserved in nuclear processes?

- A energy and mass together
- B nucleon number
- C neutron number
- D charge

31. It was once thought that the mass of an atom is spread uniformly through the volume of the atom.

When α -particles are directed at a piece of gold foil, the results led scientists to believe instead that nearly all the mass of the gold atom is concentrated at a point inside the atom.

Which effect is possible only if nearly all the mass of the gold atom is concentrated at a point?

- A a few α -particles bounce back
- B most α -particles are only slightly deflected
- C some α -particles pass through without any deflection
- D some α -particles are absorbed

32. Which pair of nuclei are isotopes of one another?

	nucleon number	number of neutrons
A	186	112
	180	118
B	186	112
	182	108
C	184	110
	187	110
D	186	110
	186	112

33. What is the approximate mass of an alpha particle?

- A 10^{-28} kg
- B 10^{-26} kg
- C 10^{-24} kg
- D 10^{-22} kg

34. An actinium nucleus has a nucleon number of 227 and a proton number of 89. It decays to form a radium nucleus, emitting a beta particle and an alpha particle in the process.

What are the nucleon number and the proton number of this radium nucleus?

	nucleon number	proton number
A	223	87
B	223	88
C	224	87
D	225	86

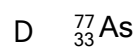
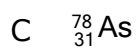
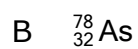
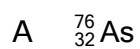
35. Scientists investigating the count rate from a radioactive source observed that the count rate fluctuates.

What do these fluctuations imply about the nature of radioactive decay?

- A It involves atomic nuclei.
- B It is predictable.
- C It is random.
- D It is spontaneous.

36. The symbol ${}_{32}^{77}\text{Ge}$ represents a nucleus of germanium that decays to a nucleus of arsenic by emitting a β -particle.

What is the symbol of this arsenic nucleus?



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37. Each of the nuclei below is accelerated from rest through the same potential difference. Which one completes the acceleration with the lowest speed?

- A ${}^1_1\text{H}$ B ${}^4_2\text{He}$ C ${}^7_3\text{Li}$ D ${}^9_4\text{Be}$

38. Which statement concerning α -particles is correct?

- A An α -particle has charge $+4e$.
 B An α -particle is a helium atom.
 C When α -particles travel through air, they cause ionisation.
 D When α -particles travel through a sheet of gold foil, they make the gold radioactive.

39. Where are electrons, neutrons and protons found in an atom?

	electrons	neutrons	protons
A	in the nucleus	in the nucleus	orbiting the nucleus
B	in the nucleus	orbiting the nucleus	in the nucleus
C	orbiting the nucleus	in the nucleus	orbiting the nucleus
D	orbiting the nucleus	in the nucleus	in the nucleus

40. Radon ${}^{222}_{86}\text{Rn}$ decays by α - and β -emission to bismuth ${}^{214}_{83}\text{Bi}$.

For the decay of each nucleus of radon, how many α - and β -particles are emitted?

	α -particles	β -particles
A	1	1
B	2	1
C	1	2
D	2	2