

# Particle & Nuclear Physics

## TOPIC QUESTIONS (2)

Level	A 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  $\alpha$ -particles and  $\beta$ -particles are emitted?

	$\alpha$ -particles	$\beta$ -particles
A	1	1
B	2	1
C	1	2
D	2	2

3. An atomic nucleus emits a  $\beta$ -particle.

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

	proton number	nucleon number
<b>A</b>	-1	+1
<b>B</b>	0	-1
<b>C</b>	+1	-1
<b>D</b>	+1	0

4. Which statement concerning  $\alpha$ -particles is correct?
- a. An  $\alpha$ -particle has charge  $+4e$ .
  - b. An  $\alpha$ -particle is a helium atom.
  - c. When  $\alpha$ -particles travel through air, they cause ionisation.
  - D. When  $\alpha$ -particles travel through a sheet of gold foil, they make the gold radioactive
5. The first artificial radioactive substance was made by bombarding aluminium,  $\alpha$ -particles. This produced an unstable isotope of phosphorus,  ${}_{15}^{30}\text{P}$ . What was the by-product of this reaction? 13
- A an  $\alpha$ -particle
  - B a  $\beta$ -particle
  - C a  $\gamma$ -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  $\gamma$ -ray and a  $\beta$ -particle?

	$\gamma$ -ray	$\beta$ -particle
<b>A</b>	high-speed electron	electromagnetic radiation
<b>B</b>	electromagnetic radiation	Helium-4 nucleus
<b>C</b>	electromagnetic radiation	high-speed electron
<b>D</b>	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
<b>A</b>	235	91	144
<b>B</b>	236	92	144
<b>C</b>	237	94	143
<b>D</b>	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
<b>A</b>	0	3
<b>B</b>	1	1
<b>C</b>	1	2
<b>D</b>	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  $\alpha$ -particle emitters. The others are  $\beta$ -particle emitters.

How many nuclides formed in the decay sequence are  $\beta$ -particle emitters?

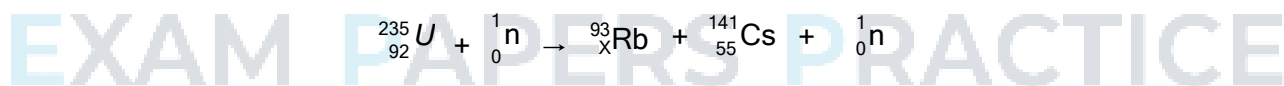
- A 2                      B 4                      C 8                      D 12

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  $\beta$ -particles
- b. emission of four  $\gamma$ -rays
- c. emission of one  $\alpha$ -particle and two  $\beta$ -particles
- d. emission of two  $\alpha$ -particles and eight  $\beta$ -particles

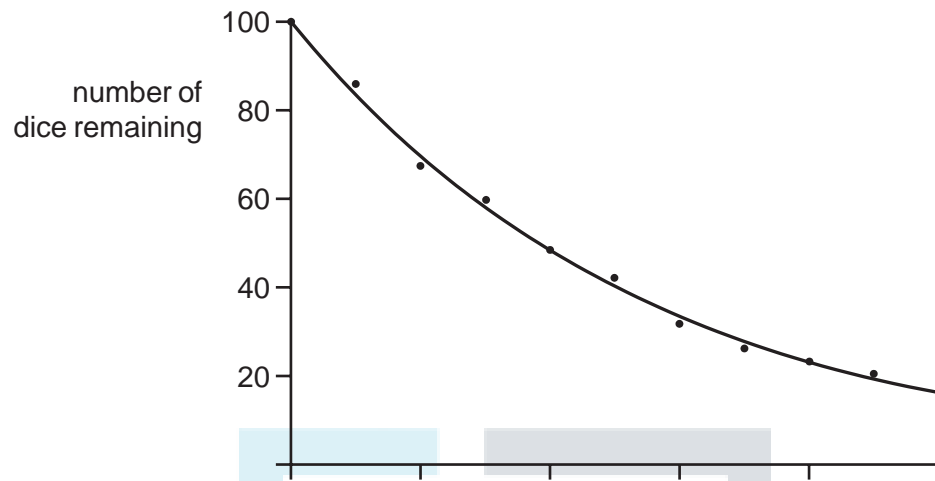
13. The nuclear equation for a fission reaction is shown below.



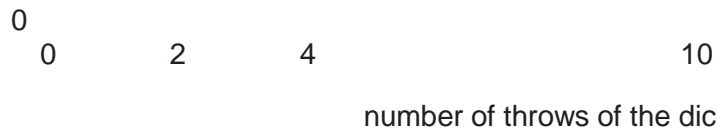
What are the values of X and Y?

	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  $\alpha$ -particle.

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

What could be the products of this nuclear reaction?

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

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.

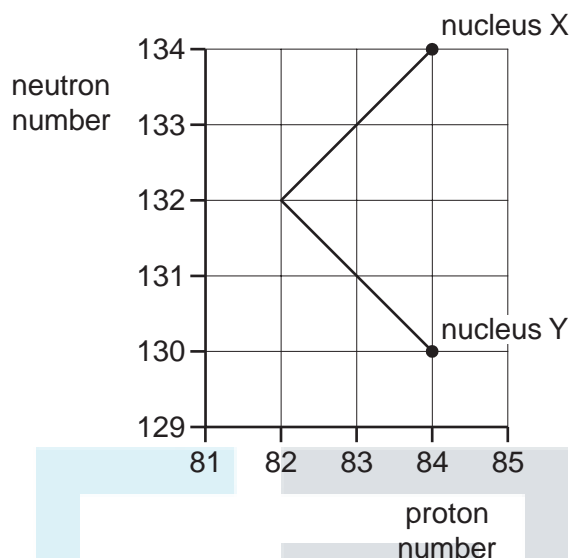
What can be deduced from this information about the emission from the isotope?

- 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  $\beta$ -emission from a number of identical nuclei in a substance?

- A energy of the  $\beta$ -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?

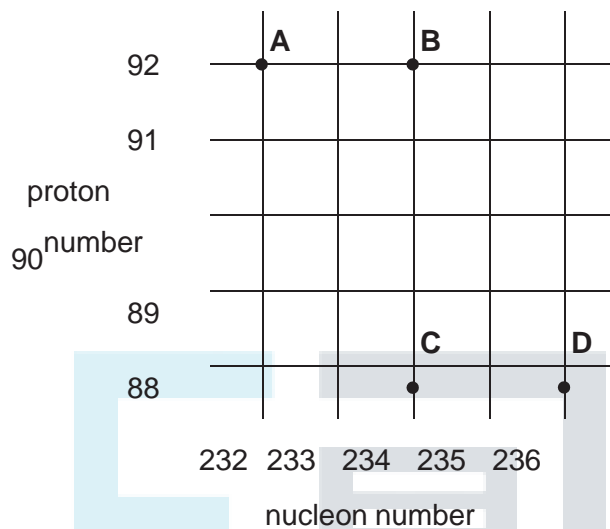
- A one  $\alpha$ -particle followed by one  $\beta$ -particle
  - B one  $\alpha$ -particle followed by two  $\beta$ -particles
  - C two  $\alpha$ -particles followed by two  $\beta$ -particles
  - D two  $\beta$ -particles followed by one  $\alpha$ -particle
19. An experiment in which  $\alpha$ -particles 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?

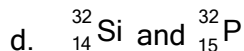
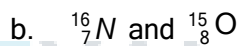
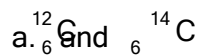
- a. Atomic nuclei occupy a very small fraction of the volume of an atom.
- b. Electrons orbit the atomic nucleus.
- c. Some atoms of the same element contain different numbers of neutrons.
- d. The atomic nucleus contains protons and neutrons.

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

When considering safety precautions, what can be assumed to be the maximum range of  $\alpha$ -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	$c$	$\sim 0.9 c$	$\sim 0.1 c$

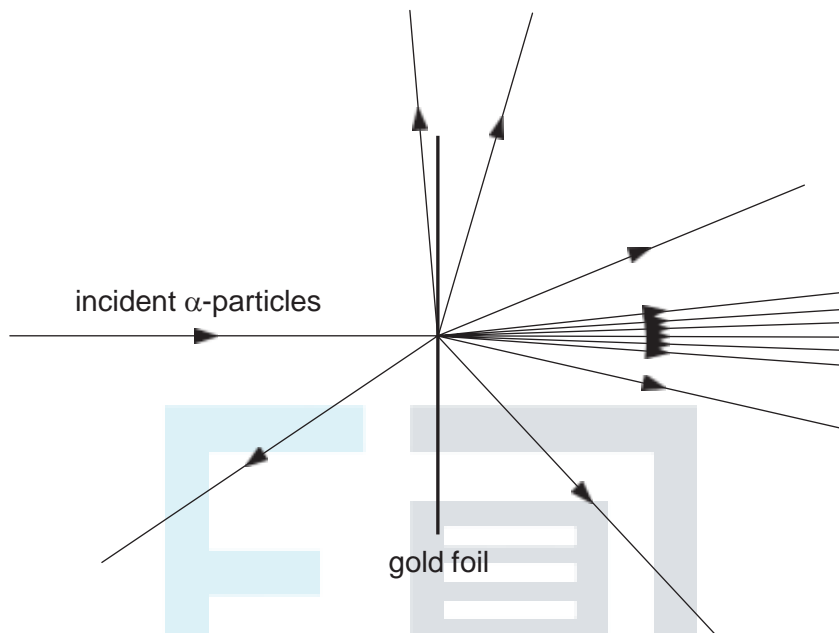
What are the radiations X, Y and Z?

	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  $\alpha$ -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  $\alpha$ -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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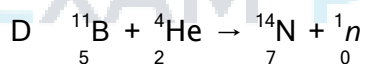
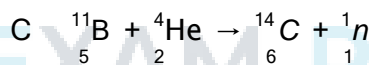
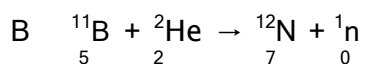
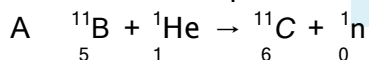
28. Nuclear decay is both spontaneous and random.

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  $\alpha$ -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  $\alpha$ -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  $\alpha$ -particles bounce back
- B most  $\alpha$ -particles are only slightly deflected
- C some  $\alpha$ -particles pass through without any deflection
- D some  $\alpha$ -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

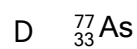
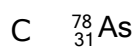
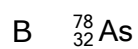
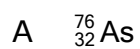
35. Scientists investigating the count rate from a radioactive source observed that the count rate fluctuates.

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  $\beta$ -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  $\alpha$ -particles is correct?

- A An  $\alpha$ -particle has charge  $+4e$ .  
 B An  $\alpha$ -particle is a helium atom.  
 C When  $\alpha$ -particles travel through air, they cause ionisation.  
 D When  $\alpha$ -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  $\alpha$ - and  $\beta$ -emission to bismuth  ${}^{214}_{83}\text{Bi}$ .

For the decay of each nucleus of radon, how many  $\alpha$ - and  $\beta$ -particles are emitted?

	$\alpha$ -particles	$\beta$ -particles
A	1	1
B	2	1
C	1	2
D	2	2