Biomedical Admissions Test (BMAT)

Section 2: Physics

Questions by Topic

P7: Radioactivity

P7: Radioactivity - Question by Topic

Mark scheme and explanations at the end

1 Which of the following statements are true?

1 Nuclear fission is the basis of energy production in nuclear power plants.
2 Following nuclear fission, new elements are formed from the original one.
3 Nuclear fission results in the production of free neutrons and photons.

A 1 only
B 2 only
C 3 only
D 1 and 2 only
E 1 and 3 only
F 2 and 3 only
G All of the statements
H None of the statements

2 Which of the following statements is true with respect to radioactive decay?

1 In radioactive decay, half life is dependent on the external environment.
2 Half life is the same for all radioactive elements.
3 The rate of decay is dependent on the number of radioactive nuclei you have remaining.

A 1 only
B 2 only
C 3 only
D None of the statements

3 What form of radioactive decay is shown in the following reaction?

$$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}x$$

A Beta negative
B Beta positive
C Alpha decay
D Gamma decay

4 A radioactive element with mass number 235 and atomic number 89 undergoes alpha decay. What is the mass and atomic number of the new element after 5 alpha particles have been released?

	Mass Number	Atomic Number
A	215	82
B	220	65
C	215	79
D	224	79
E	200	80

5 A radioactive element has a half life of 68 days. After 1020 days it has a count rate of 45.

What was the original count rate?

A 505,123
B 745,346
C 1010,246
D 1,474,560

6 Which one of the following statements regarding radioactive decay is correct?

A Radioactive decay is a highly predictable process.
B Radioactive decay occurs until a stable isotope is formed.
C Radioactive decay always produces gamma rays.
D None of the above.

7 Which of the following statements about nuclear fission is true?

A Nuclear fission is the basis of many nuclear weapons.
B Nuclear fission rate is controlled by carbon control rods in nuclear reactors.
C Uranium-235 is the fuel commonly used in nuclear reactors.
D All of the above

8 A rod of radioactive material is placed in an area with a background radiation of 2000Bq. When the object is placed in this area it has a radiation reading of 32000Bq. After 600 days the area had a radiation reading of 2000Bq again despite the rod being left there undisturbed.

What is the maximum half life of the nuclear rod?

A 40 days
B 75 days
C 90 days
D 150 days
E Can't tell - more information needed.

Solutions

1 G is the answer

Statement 1 is correct as nuclear fission is the process that occurs in nuclear reactors where Uranium-235 is split to release energy.

Statement 2 is correct as nuclei split into new, smaller nuclei in fission.

Statement 3 is correct as fission does result in the release of free neutrons and photons

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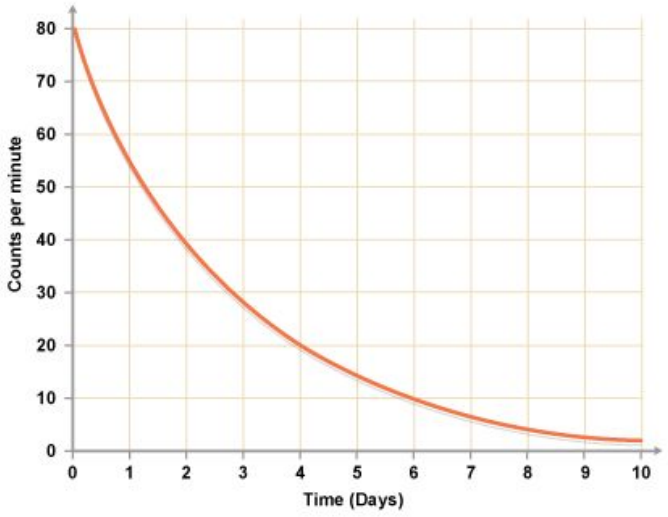
2 C is the answer

Half life is an innate quality of your radioactive material. It is independent of environmental factors such as temperature and pressure. Different nuclei have different half lives. The rate of radioactive decay is exponential which means it is proportional to the amount of radioactive material you have. As the material decays, the rate of decay decreases. This produces a graph like the one below.



Statement 1 is incorrect as half life is independent of external factors

Statement 2 is incorrect as different elements have different half lives

Statement 3 is correct as radioactive decay is exponential and therefore dependent on the number of nuclei you have remaining

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3 **A is the answer**

This is an example of beta negative decay with a high energy, negatively charged particle (electron) being produced. Hence, the mass number remains unchanged and the atomic number increases by 1.

> Exam tip: the different types of radioactive decay are important to remember as they are regularly examined. Examples of the different types are shown below:
>
> Alpha decay: $^{219}_{86}Rn \rightarrow ^{215}_{84}Po + ^{4}_{2}\alpha$
>
> Beta negative decay: $^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}\beta$
>
> Beta positive decay: $^{10}_{6}C \rightarrow ^{10}_{5}B + ^{0}_{1}e^{-}$

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4 **C is the answer**

An alpha particle consists of two protons and two neutrons He_2^4 . Therefore, for every alpha particle emitted the mass number of the original element decreases by four and the atomic number decreases by two. This means that the mass number of your element will decrease by 20 and the atomic number will decrease by 10.

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5 **D is the answer**

1040 days represents 15 half lives of 68 days:

$$1040 \div 68 = 15$$

The original count rate can be calculated by either:

$$45 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \text{ or}$$

$$45 \times 2^{15} = 1,474,560$$

***

6 **B is the answer**

Radioactive decay is a spontaneous process and is not highly predictable. Not all forms of radioactive decay produce gamma rays, other forms of radiation can be produced. Radioactive decay does continuously occur until a stable isotope forms.

Statement 1 is incorrect as radioactive decay is a random process

Statement 2 is correct as radioactive decay does continuously occur until a stable isotope forms

Statement 3 is incorrect as only gamma decay produces gamma rays. Other sorts of energy is released in other types of radioactive decay.

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7 **D is the answer**

All of these statements are correct in regards to nuclear fusion:

Statement 1 is correct as nuclear fission is the basis for many nuclear weapons.

Statement 2 is correct as carbon control rods are used to absorb neutrons to control the rate of a chain reaction in nuclear fission reactors.

Statement 3 is correct as Uranium-235 is the most common fuel used in nuclear reactors.

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8 **D is the answer**

For a sample with radioactivity of 32000 Bq to decay down to the background rate of 2000Bq requires 4 half lives in 600 days:

Half life 1: 32000Bq → 16000Bq
Half life 2: 16000Bq → 8000Bq
Half life 3: 8000Bq → 4000Bq
Half life 4: 4000Bq → 2000Bq

This means the maximum half life of the material is 600/4 = 150 days.