15 The nucleus - fission, fusion, and decay – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	**中文**	**Write it 3 times** (English)		
nucleus	原子核			
Fission	裂变			
Fusion	聚变			
radioactive decay	放射性衰变			
alpha	阿尔法衰变			
beta	贝塔衰变			
gamma	伽马衰变			
half-life	半衰期			

Recall

You already know some nuclear physics:

- Atoms have a tiny, dense **nucleus** of protons and neutrons.
- Some atoms are **radioactive** and give off radiation.
- Nuclear power and the Sun both release huge amounts of energy.

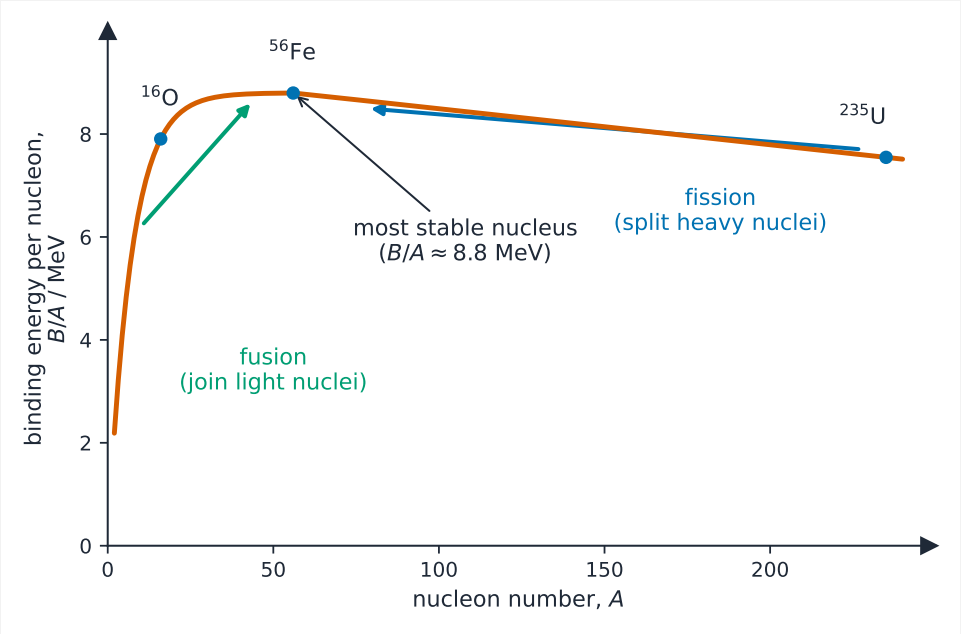
This sheet explains where that energy comes from. Each idea has a worked example.

New ideas

1 Energy from the nucleus

The **nucleus** 原子核 stores enormous energy. Two processes release it:

- **Fission** 裂变 splits a heavy nucleus into lighter pieces (nuclear reactors).
- **Fusion** 聚变 joins light nuclei into a heavier one (the Sun).



2 Mass becomes energy

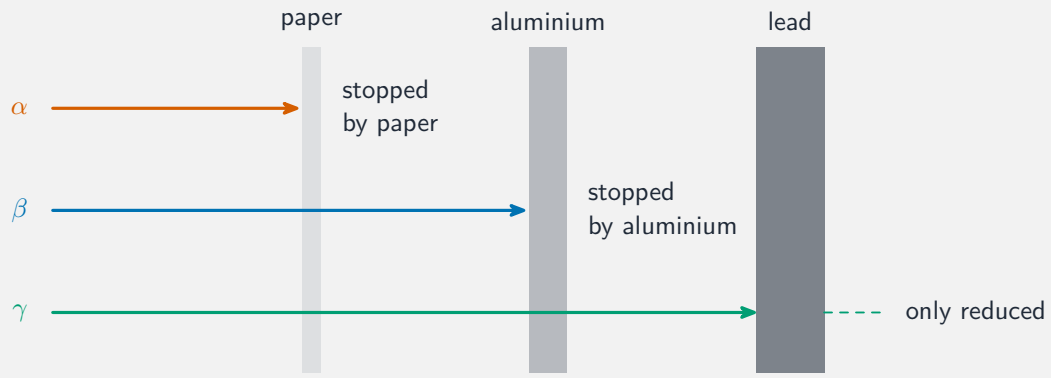
Both release energy because the products have slightly **less mass** than the starting materials, converted by Einstein's equation

$$E = mc^2.$$

Worked example. If a reaction loses 1.0×10^{-3} kg of mass, it releases $E = mc^2 = 1.0 \times 10^{-3} \times (3.0 \times 10^8)^2 = 9.0 \times 10^{13}$ J –a tiny mass, an enormous energy.

3 Radioactive decay

Unstable nuclei undergo **radioactive decay** 放射性衰变, emitting three kinds of radiation:



- **alpha** 阿尔法衰变–a helium nucleus (stopped by paper),
- **beta** 贝塔衰变–a fast electron (stopped by aluminium),
- **gamma** 伽马衰变–a high-energy photon (needs thick lead).

4 Half-life

Decay is random, but a sample halves every **half-life** 半衰期: after each half-life, half of the remaining nuclei have decayed.

Worked example. A sample has a half-life of 8.0 days. After 24 days that is $24/8.0 = 3$ half-lives, so the fraction left is $\left(\frac{1}{2}\right)^3 = \frac{1}{8}$ (about 12.5%).

Watch out: in every decay, the total **mass number** and total **charge** are conserved –use this to balance a decay equation and find the new nucleus.

Practice

Try these in order. The methods are all above.

2.1 State the difference between nuclear fission and nuclear fusion. [2]

2.2 A nuclear reaction loses 2.0×10^{-4} kg of mass. Find the energy released ($c = 3.0 \times 10^8$ m/s). [3]

2.3 Name the three types of radioactive decay, in order of increasing penetrating power. [2]

2.4 A sample has a half-life of 5.0 years. What fraction remains after 15 years? [3]

2.5 State the two quantities that are always conserved in a radioactive decay. [1]
