

PUBLISHED
5/4/18

① Answer any 3 from 4 questions

Question 1

1. The Semi-Empirical Mass Formula is given by the equation:

$$B = a_v A - a_s A^{-\frac{2}{3}} - a_c Z(Z-1)A^{-\frac{1}{3}} - a_{sym} \frac{(A-2Z)^2}{A} + \delta$$

Where $\delta = \pm a_p A^{-\frac{1}{4}}$ depending on whether the nucleus is even/even, odd/odd, or even/odd.

Explain the origin of the five different terms to the right of the equals sign in this equation. Sketch how the Binding Energy per Nucleon curve changes as the terms are added in. (20 marks)

2. The ^{111}Sn nucleus has a rest mass of 110.90774 g/mol.

- How many protons and neutrons in ^{111}Sn (4 marks)
- Calculate the mass difference in g/mol between ^{111}Sn and its isolated protons and neutrons (4 marks)
- Calculate the binding energy per nucleon in ^{111}Sn . (5 marks)

Question 2

1. Discuss α particles in terms of:

- The nucleons from which they are made. (3 marks)
- What kind of nuclei emit α particles. (3 marks)
- The typical amount of energy carried by α particle decay (3 marks)

2. ^{209}Po emits an α particle. What is the daughter nucleus produced in this reaction? (5 marks)

3. ^{209}Po has a mass of 208.9824 g/mol, and an α particle has a mass of 4.002604 g/mol. If the α particle emitted has an energy of 4.88 MeV, calculate the kinetic energy of the daughter nucleus. (9 marks)

4. Explain why α particles carry a greater health risk than other radiations of the same energy. (10 marks)

Question 3

1. Distinguish between *spontaneous* and *stimulated* fission. (6 marks)

2. Distinguish between *delayed* and *prompt* neutrons in nuclear fission. (6 marks)

3. What is the role of a *moderator* in a nuclear reactor? (6 marks)

4. Explain why so much more energy is available from nuclear *fusion* as opposed to *fission*. (5 marks)

5. Explain why nuclear fusion requires extremely high temperatures to occur. (5 marks)

6. Distinguish between the *r process* and the *s process* in the nucleosynthesis of heavy elements. (5 marks)

Question 4

1. Discuss radiocarbon dating in terms of:

- What is meant by the **half life** of a radioactive isotope? (5 marks)
- What is meant by the **activity** of a radioactive isotope? (5 marks)
- what causes the creation of ^{14}C in the atmosphere? (5 marks)
- what are the limitations in radiocarbon dating? (5 marks)

2. A wooden artifact found in an archaeological site shows a ^{14}C activity of 0.075 Bq per gram of carbon. Modern living wood shows an activity of 0.225 Bq per gram of carbon. Given ^{14}C has a half life of 5730 years, calculate the age of the artifact. (13 marks)