Unit 24 · Nuclear Physics

WORKSHEET

Full marks 37

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 37

1 Key words [4]

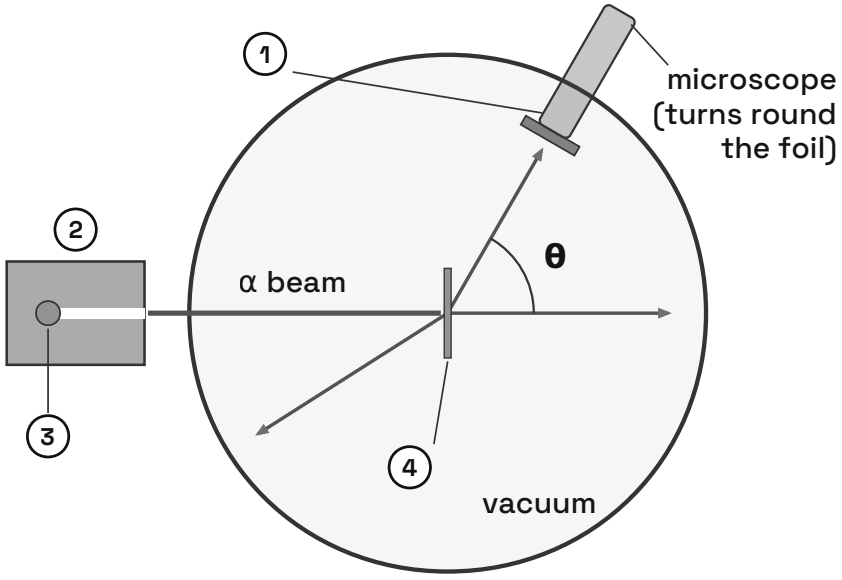
Fill in the blanks with words from the box. Two words in the box are not needed. Each blank carries 0.5 mark.

annihilation	defect	electron	fission	fusion	isobars	isotopes	nucleons	strong	unit

Protons and neutrons are together called _____. Nuclides of the same element, with the same number of protons but different numbers of neutrons, are _____. One twelfth of the mass of a carbon-12 atom is the atomic mass _____. The difference between the total mass of a nucleus's separated nucleons and the mass of the nucleus is its mass _____. The force that holds nucleons together over about 10^{-15} m is the _____ nuclear force. The splitting of a heavy nucleus into two fragments of comparable mass is nuclear _____, and the joining of small nuclei into a larger one is nuclear _____. When a particle meets its antiparticle and both vanish into photons, it is called _____.

2 Label the diagram [2]

The diagram shows Rutherford's alpha-scattering experiment. Write the labels that belong in place of 1 to 4. Each carries 0.5 mark.



1. _____ **2.** _____

3. _____ **4.** _____

3 Multiple choice [5]

Choose the correct option for each of the following questions.

i. In the alpha-scattering experiment, most alpha particles went straight through the gold foil. This showed that: [1]

a. the nucleus is negative
b. the atom is mostly empty space
c. electrons are heavier than alpha particles
d. the nucleus is made of protons and neutrons

ii. The nuclide $^{238}_{92}\mathrm{U}$ has: [1]

a. 92 neutrons and 146 protons
b. 238 neutrons
c. 92 protons and 146 neutrons
d. 146 protons and 92 electrons

iii. A nucleus has 8 times as many nucleons as another. Its radius is: [1]

a. 8 times as large
b. 4 times as large
c. 2 times as large
d. the same

iv. Which nuclei have the greatest binding energy per nucleon? [1]

a. hydrogen-1
b. helium-4
c. iron-56 and nickel-62
d. uranium-235

v. An electron and a positron, nearly at rest, annihilate. Each of the two photons has an energy of about: [1]

a. 1.02 MeV
b. 0.51 MeV
c. 931.5 MeV
d. 0.26 MeV

4 Very short answers [3]

Write very short answers to the following questions.

a. Define binding energy of a nucleus. [1]

b. Why must the gold foil in Rutherford's experiment be very thin? [1]

c. Why are isotopes of an element chemically almost identical? [1]

5 Short answers [6]

Write short answers to the following questions.

a. Why can't gravity be what holds the protons of a nucleus together? [2]

b. Why is it easier to set off fission with a slow neutron than with a slow proton? [2]

c. State the conditions in the multiplication factor k for a chain reaction to be steady, as in a reactor, and to grow, as in a bomb. [2]

6 Long answer [4]

Write a long answer to the following question.

Sketch the graph of binding energy per nucleon against mass number. Use it to explain why both fusion of light nuclei and fission of heavy nuclei give out energy.

7 Numerical problems [10]

Solve the following problems. Show your working. Take 1 u = 1.66×10^{-27} kg = 931.5 MeV, c = 3.0×10^{8} m/s, $r_0 = 1.2 \times 10^{-15}$ m, proton mass 1.007 276 u and neutron mass 1.008 665 u.

a. The nucleus of oxygen-16 ($^{16}_{8}O$) has a mass of 15.990 523 u. Find its mass defect, its binding energy and its binding energy per nucleon. **[3]**

Answer: _____

b. Find the radius of an iron-56 nucleus and its density, taking its mass as 56 u. **[3]**

Answer: _____

c. A nuclear reactor gives out 3.0×10^{9} W of heat. Each fission gives about 200 MeV (1 MeV = 1.6×10^{-13} J). **[4]**

i. How many fissions happen each second?

ii. How much mass is turned into energy in a year (3.15×10^{7} s)?

Answer: _____

8 Think [3]

Fusion gives more energy per kilogram of fuel than fission, yet every nuclear power station today uses fission. Using what you know about nuclei, explain why fusion is so hard to make happen.

9 Activity: Reading the binding energy curve (not marked)

Use the binding energy curve of the unit (binding energy per nucleon against A) to fill in the table.

Nucleus	A	Binding energy per nucleon (MeV)	Total binding energy (MeV)
deuterium	2		
helium-4	4		
iron-56	56		
uranium-235	235		

Which nucleus is the most tightly bound? Which has the largest total binding energy? Why are they not the same nucleus?