# Name: Date:

Topic: **ATOMIC STRUCTURE AND NUCLEAR PROCESSES AND RADIATION**

**Question 1**

The element Uranium 238 U 92 has a half life of 4.5 x109 yrs. and decays through a series of reactions ending up as 206Pb82 . The first step in the decay involves an alpha decay.

Write an equation for this decay, showing the A and Z values for the decay product.

**( 1 mark )**

**Question 2**

An isotope of phosphorous is radioactive and undergoes β decay according the following equation:

15 P 32 --->16 S 32 + β

The masses of the particles involved are:

15 P 32 = 31.98403 u 16 S 32 = 31.98224 u β = 0.00055 u

1. Calculate the energy released **inboth Joules and MeV** when one atom of the phosphorous decays.

**( 4 marks )**

1. The energy released if the phosphorous decays at a rate of 2.75 x 1017 atoms per second.

**( 2 marks )**

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| **Question 3** | The two nuclear processes of fission and fusion both release vast amounts of energy. Use the diagram shown to explain how energy is released.  **( 2 x 2 marks )** |

**Question 4**

In a nuclear reactor fuelled with uranium, there are five major components;

i) fuel ii) moderator iii) coolant vi) shielding v) control rods

1. Discuss their role in the nuclear process, and give an example of each component.

**( 5 x 3 marks )**

1. Define the terms critical mass and chain reaction in relationship to the process.

**( 2 x 2 marks )**

**Question 5**

Deep space probes such as Voyager, are powered by “ thermionic “ devices which convert the heat from radioactive decay directly into electrical energy. The typical radioisotope used is :

238Pu94 which decays via alpha emission to 234 U 92 .

238 Pu 94 = 238.0495 u, 234 U 92 = 234.0409 u , 4 He 2 = 4.0026 u

1. Write a balanced nuclear equation describing this decay.

**( 1 mark )**

1. Calculate the energy released by one atom of the Pu - 238 decaying if all the energy of

the decay comes from the kinetic energy of the alpha decay.

**( 2 marks )**

1. Calculate the number of decays in 1 second, if the activity of the

Plutonium 1.45 x10 14 Bq .

**( 1 mark )**

1. How much energy does the device release in one second ?

**( 1 mark )**

**Question 6**

In the nuclear reaction below, calculate the atomic and mass number of the produce marked ¥ .

236 U92 ----->141 Ba 56 + ¥ + 3 1 n 0

**( 2 x 1 mark )**

**Question 7**

Draw a small sketch showing how you could separate the types of radiation coming from a source ? Indicate on the diagram the direction of the radiation, and what type it is.

**( 3 x 2 marks )**

**Question 8**

An archaeologist discovers an old igneous rock and uses Potassium - 40 ( K - 40 ) as the radio-active material to calculate the age of the rock. The half- life of K - 40 is 1.3 x109 yrs and it emits a beta particle.

1. List two properties of the beta particle and indicate one method of detecting them.

**( 4 marks )**

1. The activity of the K - 40 in the rock is found to be 12.5 % of its original value. From this data find the age of the rock sample.

**( 2 marks )**

1. Would the staff handling the rock need to take any precautions ? Explain your answer.

**( 2 marks )**

**Question 9**

A worker in the nuclear industry in the 1950's was asked to work in an area in which radiation was emitted. Over a year, he absorbed 4.50 J of energy from the radiation and has a constant body mass of 90.0 kg

1. What was the workers absorbed dose for that year ?

**( 2 marks )**

1. If the quality factor of the radiation is 10, find the dose equivalent for the worker.

**( 2 marks )**

1. List three protective measures that the worker could have used to reduce the absorbed energy ?

**( 3 x 1 mark )**

**Question 10**

PET ( positron emission tomography ) scans can be used to pin-point and map epileptic sites in the brain. A suitable carrier or “ tracer” chemical is tagged with nitrogen - 13 and injected into the blood of the epileptic person. The tracer tends to accumulate at sites in the brain which are, at that instant, most active. The tracer “ maps” these sites. Nitrogen-13 is a positron emitter and it has a half-life of 9.97 minutes.

1. If the original tracer chemical has an activity of 4.00 kBq, calculate the time needed for the activity to drop to 1.00 kBq.

**( 2 marks )**

1. Find the atomic and mass number of the decay product of the Nitrogen – 13

**( 1 mark )**

**Question 11**

a) What two factors determine the damage radiation can do to living things ?

**( 2 marks )**

1. Define absorbed dose.

**( 1 mark )**

1. What does the quality factor of radiation measure ?

**( 1 mark )**

**Question 12**

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|  | A low level radioactive sample is packaged for transport through the mail in the following way:  \* The radioactive material is placed inside asealed aluminium can ( similar to a soft drink canfrom which air is removed.  \* The can is then wrapped in paper.  \* It is then placed inside a cardboard box and finally.  \* The cardboard box is wrapped in plastic.  Assume that the radioactive sample emits alpha, beta and gamma radiation, indicate the how far each type of radiation will penetrate through the package.  **( 3 marks )** |

**Question 13**

a) Explain the term lethal dose – 50

**( 1 mark )**

b) What does the term LD - 50 / 25 mean ?

**( 1 mark )**