Physics 11

Topic Test: Nuclear Technology

1. (a) Suggest a sequence in which the mercury isotope $_{80}Hg^{200}$ might be changed into the gold isotope $_{79}Au^{196}$, and write the nuclear equations for the reactions involved.

(4)

(b) Explain the sources of terrestrial radiation.

(3)

2 What does the term Quality factor mean? Explain with an example.

(3)

3. The half-life of thorium -234 is 24days.

(a) What fraction of the element remains after 192 days.

(2)

(b) How long does it take for 10.0% of the material to decay?

(3)

(c) If one-sixteenth of the original amount of a radioactive material remains after 12.0 minutes, what is the half of the material?

life

(3)

4. (a) α – particles cause more ionisation than do β– particles. β–particles, however are more penetrating . Comment,

(2)

(b) How is β–decay possible if the nucleus does not contain electrons?

(2)

5. A nucleus of atomic number Z and mass number A undergoes a transmutation as follows

(a) emission of an α–particle

(b) emission of a β–particle

(c) absorption of a neutron followed by emmission of a proton

(4)

For each of the above cases give the atomic number and the mass number (in terms of A and Z) – of the nucleus

6. The effects of radiation on humans are classed as somatic and genetic.
(a) What are somatic effects?

(2)

(b) Outline four symptoms that occur with increasing radiation doses.

(2)

7. When $_7N^{14}$ is bombarded with 3.0000 MeV alpha particles $_8O^{17}$ is formed and a proton is released. Calculate the amount of energy released in this reaction $_2He^4$,$_7N^{14}$ and $_8O^{17}$ have atomic masses 4.001404,14.000074 and 16.999133u respectively. m of $_1^1P$ = 1·007262 u
u = 931 MeV

(5)

8. Nuclear fission is the basis for both the atomic bomb and the nuclear reactor. What is the essential difference between the reactor and the bomb?

(4)

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1. (a) Suggest a sequence in which the mercury isotope $_{80}Hg^{200}$ might be changed into the gold isotope $_{79}Au^{196}$, and write the nuclear equations for the reactions involved.

$^{200}_{80}Hg \rightarrow {}^{196}_{78}Pt + {}^{4}_{2}He$ (2)

$^{196}_{78}Pt \rightarrow {}^{196}_{79}Au + {}^{0}_{-1}e$ (2)

(4)

(b) Explain the sources of terrestrial radiation.

Radiation from the earth (1).

natural - earths crust and atmosphere

artificial - man made

(3)

2 What does the term Quality factor mean? Explain with an example.

Quality factor reflects the amount of damage that the radiation does to live tissue. (2)

Example alpha particles have a QF of 20 when compared to γ rays with QF 1 (1)

(3)

3. The half-life of thorium -234 is 24days.

(a) What fraction of the element remains after 192 days.

$N_{(\frac{1}{2})} = \frac{192}{24} = 8$ (1) Fraction $= \frac{1}{2^8} = \frac{1}{256}$ (1).

(2)

(b) How long does it take for 10.0% of the material to decay?

(1) $A_0 = 100$, $A = 90$

$A = A_0(\frac{1}{2})^n$

$90 = 100 \cdot \frac{1}{2}^n$ (1)

$n = 0.152$

$t = 0.152 \cdot 24$ (1)

$= 3.64$ days.

(3)

(c) If one-sixteenth of the original amount of a radioactive material remains after 12.0 minutes, what is the half life of the material?

$A_0 = 16$, $A = 1$ (1)

$A = A_0(\frac{1}{2})^n$

$1 = 16(\frac{1}{2})^n$ (1)

$n = 4$

$T_{\frac{1}{2}} = \frac{12}{4} = 3\,min$ (1).

(3)

4. (a) α – particles cause more ionisation than do β– particles. β–particles, however are more penetrating . Comment,

α particles have a much larger mass than β particles and thus are able to cause ionization of e^- because of their momentum
β particles are able to penetrate further because of their smaller size. (2)

(b) How is β–decay possible if the nucleus does not contain electrons?

β decay.

$${}^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e \quad (\neq)$$

neutron breaks up into a proton and an e^- (2) (≠) => β particle

5. A nucleus of atomic number Z and mass number A undergoes a transmutation as follows

(a) emission of an α–particle

$A-4$

$Z-2$

(b) emission of a β–particle

A

$Z+1$

(c) absorption of a neutron followed by emmission of a proton

A

$Z-1$

(4)

For each of the above cases give the atomic number and the mass number (in terms of A and Z)

6. The effects of radiation on humans are classed as somatic and genetic.

(a) What are somatic effects?

Having to do with the body other than the reproductive organs. (2)

(b) Outline four symptoms that occur with increasing radiation doses.

Reduction of white blood cell count
Nausea, vomiting, diarrhoea,
loss of hair, Damage to stomach
damage to ~~e~~ CNS, death (any 4) (2)

7. When $_7N^{14}$ is bombarded with 3.0000 MeV alpha particles $_8O^{17}$ is formed and a proton is released. Calculate the amount of energy released in this reaction $_2He^4$,$_7N^{14}$ and $_8O^{17}$ have atomic masses 4.001404,14.000074 and 16.999133u respectively.

$$_7^{14}N + {}_2^4He + 3.0000\,MeV \rightarrow {}_8^{17}O + {}_1^1H \quad (2).$$

MASS Diff = Mass(reactants) − mass(products).

= (4·001404 + 14000074) − (16·999133 + 1·007276)
* 0·003222 (2).

= 18·00470 − 18·006406.

= −0·001709u ?

= −1·591 MeV absorbed! (2) (5)

8. Nuclear fission is the basis for both the atomic bomb and the nuclear reactor. What is the essential difference between the reactor and the bomb?

Reactor

chain reaction is controlled

non critical mass.

no radiation danger

moderator, control rods used etc

Nuclear bomb.

uncontrolled

critical mass

very dangerous

(4)

no use of control rods, moderator etc.

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