

Physics 11

Topic Test: Nuclear Technology

1. (a) Suggest a sequence in which the mercury isotope $_{80}\text{Hg}^{200}$ might be changed into the gold isotope $_{79}\text{Au}^{196}$, 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 emission 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 ${}^7\text{N}^{14}$ is bombarded with 3.0000 MeV alpha particles ${}^8\text{O}^{17}$ is formed and a proton is released. Calculate the amount of energy released in this reaction ${}^2\text{He}^4$, ${}^7\text{N}^{14}$ and ${}^8\text{O}^{17}$ have atomic masses 4.001404, 14.000074 and 16.999133u respectively. m of ${}^1_1\text{P} = 1.007262u$
 $u = 931 \text{ MeV}$

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?

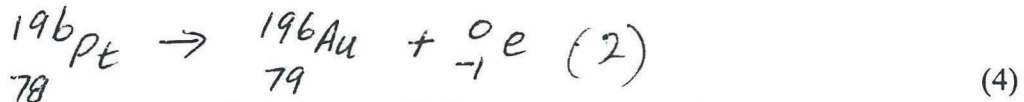
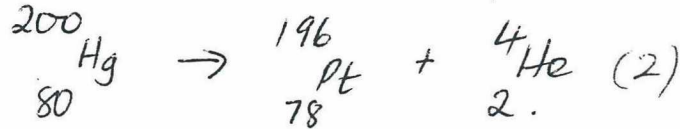
(5)

(4)

Physics 11

Topic Test: Nuclear Technology

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



- (b) Explain the sources of terrestrial radiation.

natural - earth's crust and atmosphere Radiation from the earth (1)

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 X rays with QF 1 (1)

(3)

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

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

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

- (b) How long does it take for 10.6% of the material to decay?

$$\begin{aligned} (1) \quad A_0 &= 100 & A &= A_0 \left(\frac{1}{2}\right)^n & n &= 0.152 \\ A &= 90 & 90 &= 100 \cdot \frac{1}{2}^n & t &= 0.152 \cdot 24 \quad (1) \\ & & & & &= 3.64 \text{ days} \quad (3) \end{aligned}$$

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

$$\begin{aligned} A_0 &= 16 & A &= A_0 \left(\frac{1}{2}\right)^n & T_{\frac{1}{2}} &= \frac{12}{4} = 3 \text{ min} & (3) \\ A &= 1 \quad (1) & 1 &= 16 \left(\frac{1}{2}\right)^n & & & \\ & & n &= 4 & & & (1) \end{aligned}$$

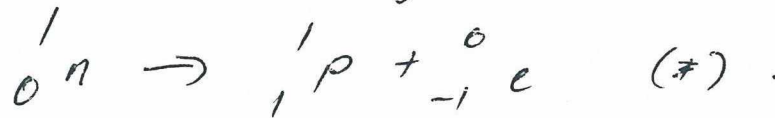
4. (a) α - particles cause more ionisation than do β - particles. β -particles, however are more penetrating. Comment,

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 (2) of their smaller size.

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

β decay.



neutron breaks up into a proton and an e^- (2) (β) $\Rightarrow \beta$ 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 emission of a proton

$$A$$

$$Z - 1$$

For each of the above cases give the atomic number and the mass number (in terms of A and Z) (4)

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,

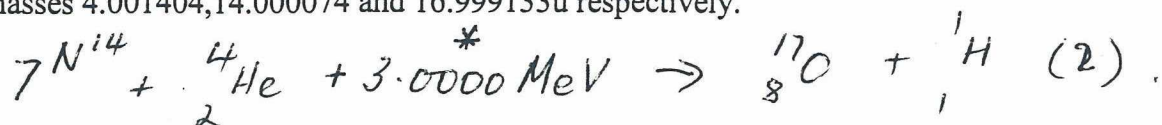
loss of hair, Damage to stomach

damage to CNS, death

(any 4)

(2)

7. When ${}^7\text{N}^{14}$ is bombarded with 3.0000 MeV alpha particles ${}^8\text{O}^{17}$ is formed and a proton is released. Calculate the amount of energy released in this reaction ${}^2\text{He}^4$, ${}^7\text{N}^{14}$ and ${}^8\text{O}^{17}$ have atomic masses 4.001404, 14.000074 and 16.999133u respectively.



$$\begin{aligned} \text{Mass Diff} &= \text{Mass}(\text{reactants}) - \text{mass}(\text{products}) \\ &= (4.001404 + 14.000074) - (16.999133 + 1.007276) \\ &\quad * 0.003222 \quad (2) \\ &= 18.001478 - 18.006409 \\ &= -0.004931 \text{ u} \\ &= -1.591 \text{ MeV absorbed!} \quad (2) \quad (5) \end{aligned}$$

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, modera-
tor etc.