

***Physics: Principle and Applications, 7e (Giancoli)***  
**Chapter 31 Nuclear Energy; Effects and Uses of Radiation**

**31.1 Conceptual Questions**

1) A person receives an absorbed dose of protons of 20 millirads. The RBE of protons is 5. What is this person's equivalent dose in rem?

- A) 4 millirem
- B) 15 millirem
- C) 20 millirem
- D) 25 millirem
- E) 100 millirem

Answer: E

Var: 1

2) The chief hazard of radiation damage to living cells is

- A) due to heating.
- B) due to ionization.
- C) due to the creation of chemical impurities.
- D) the creation of new isotopes within the body.
- E) the creation of radioactive material within the body.

Answer: B

Var: 1

3) What is the meaning of the term "critical mass" in regard to nuclear fission?

- A) This is the mass of the "critical" elements in a reactor, i.e., the uranium or plutonium.
- B) This is the minimum amount of fissionable material required to sustain a chain reaction.
- C) This is the amount of mass needed to make a power reactor economically feasible.
- D) This is the amount of material that is just on the verge of becoming radioactive.

Answer: B

Var: 1

4) The main fuel for producing energy in the center of the sun is

- A) helium.
- B) hydrogen.
- C) uranium.
- D) any radioactive material.
- E) oxygen.

Answer: B

Var: 1

5) The energy radiated by a star, such as the sun, results chiefly from

- A) beta decay.
- B) alpha decay.
- C) fission reactions.
- D) fusion reactions.
- E) radioactivity.

Answer: D

Var: 1

### 31.2 Problems

1) The maximum permissible workday dose for occupational exposure to radiation is 18 mrem. A 54-kg laboratory technician absorbs 2.6 mJ of 0.30-MeV gamma rays in a work day. The relative biological effectiveness (RBE) for gamma rays is 1.00. What is the ratio of the equivalent dosage received by the technician to the maximum permissible equivalent dosage?

- A) 0.27
- B) 0.29
- C) 0.32
- D) 0.35
- E) 0.37

Answer: A

Var: 50+

2) The maximum permissible workday dose for occupational exposure to radiation is 11 mrem. A 77-kg laboratory technician absorbs 2.3 mJ of 0.5-MeV gamma rays in a work day. The relative biological effectiveness (RBE) for gamma rays is 1.00. What is the number of gamma-ray photons absorbed by the technician in a workday?

- A)  $3 \times 10^{10}$
- B)  $3 \times 10^9$
- C)  $3 \times 10^8$
- D)  $1 \times 10^9$
- E)  $1 \times 10^8$

Answer: A

Var: 50+

3) A 70-kg researcher absorbs  $4.5 \times 10^8$  neutrons in a work day, each of energy 1.2 MeV. The relative biological effectiveness (RBE) for these neutrons is 10. What is the equivalent dosage of the radiation exposure for this researcher, in millirem?

- A) 1.2 mrem
- B) 0.39 mrem
- C) 0.77 mrem
- D) 3.7 mrem
- E) 12 mrem

Answer: A

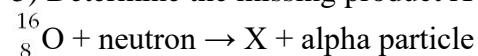
Var: 50+

4) Determine the missing product X in the nuclear reaction  ${}_{92}^{238}\text{U} + {}_0^1\text{n} \rightarrow \text{X} + 2\beta^-$ .

Answer:  ${}_{94}^{239}\text{Pu}$

Var: 1

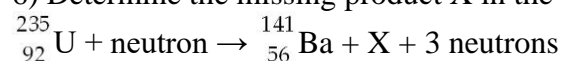
5) Determine the missing product X in the following nuclear reaction:



Answer:  ${}_{6}^{13}\text{C}$

Var: 1

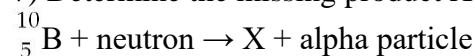
6) Determine the missing product X in the following nuclear reaction:



Answer:  ${}_{36}^{92}\text{Kr}$

Var: 1

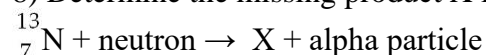
7) Determine the missing product X in the following nuclear reaction:



Answer:  ${}_{3}^{7}\text{Li}$

Var: 1

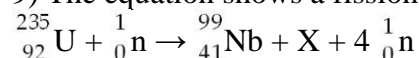
8) Determine the missing product X in the following nuclear reaction:



Answer:  ${}_{5}^{10}\text{B}$

Var: 1

9) The equation shows a fission reaction:



What is the missing term X in the equation?

A)  ${}_{47}^{136}\text{Ag}$

B)  ${}_{51}^{136}\text{Sb}$

C)  ${}_{51}^{139}\text{Sb}$

D)  ${}_{47}^{133}\text{Ag}$

E)  ${}_{51}^{133}\text{Sb}$

Answer: E

Var: 1

10) In the fission reaction  $^{235}_{92}\text{U} + ^1_0\text{n} \rightarrow ^{141}_{54}\text{Ba} + ^{92}_{36}\text{Kr} + x ^1_0\text{n}$ , what is the number  $x$  of neutrons produced?

- A) 0
- B) 1
- C) 2
- D) 3

Answer: D

Var: 1

11) In the nuclear reaction  $^{16}_8\text{O} + ^4_2\text{He} \rightarrow \text{X} + ^{19}_{10}\text{Ne}$ , what is X?

- A) proton
- B) neutron
- C)  $^2_1\text{H}$
- D)  $^3_1\text{H}$
- E) alpha particle

Answer: B

Var: 1

12) In the nuclear reaction  $^{16}_8\text{O} + ^1_0\text{n} \rightarrow \text{X} + ^4_2\text{He}$ , what is X?

- A)  $^{12}_6\text{C}$
- B)  $^{13}_6\text{C}$
- C)  $^{14}_6\text{C}$
- D)  $^{15}_6\text{C}$
- E)  $^{17}_8\text{O}$

Answer: B

Var: 1

13) In the nuclear reaction  $^{38}_{19}\text{K} + ^1_1\text{H} \rightarrow \text{X} + ^{38}_{20}\text{Ca}$ , what is X?

- A) proton
- B) neutron
- C)  $^2_1\text{H}$
- D)  $^3_1\text{H}$
- E) alpha particle

Answer: B

Var: 1

14) In the nuclear reaction  ${}^3_1\text{H} + {}^3_1\text{H} \rightarrow \text{X} + {}^4_2\text{He}$ , what is X?

- A) 2 protons
- B) 2 neutrons
- C)  ${}^2\text{H}$
- D)  ${}^3\text{H}$
- E) alpha particle

Answer: B

Var: 1

15) A proton strikes an oxygen-18 nucleus, producing fluorine-18 and another particle X. What is the other particle X?

- A) neutron
- B) positron
- C) alpha particle
- D) electron
- E) gamma ray

Answer: A

Var: 1

16) A hypothetical particle has a mass of  $510 \text{ MeV}/c^2$ . If such a particle at rest decays into two gamma-ray photons, what is the wavelength of each photon? ( $1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$ ,  $c = 3.00 \times 10^8 \text{ m/s}$ ,  $h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$ )

Answer:  $4.87 \times 10^{-15} \text{ m}$

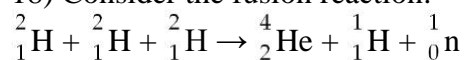
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17) If a  $\Sigma^-$  particle at rest decays into a neutron and a  $\pi^-$ , what is the total kinetic energy of the decay products? The masses of  $\Sigma^-$ , neutron, and  $\pi^-$  are  $1197 \text{ MeV}/c^2$ ,  $940 \text{ MeV}/c^2$ , and  $140 \text{ MeV}/c^2$ , respectively.

Answer: 117 MeV

Var: 1

18) Consider the fusion reaction:



The known atomic masses are

$${}^2_1\text{H}: \quad 2.01410 \text{ u}$$

$${}^4_2\text{He}: \quad 4.00260 \text{ u}$$

$${}^1_1\text{H}: \quad 1.00783 \text{ u}$$

$${}^1_0\text{n}: \quad 1.008665 \text{ u}$$

where  $1 \text{ u} = 1.6605 \times 10^{-27} \text{ kg}$ . What mass of deuterium fuel,  ${}^2_1\text{H}$ , is used up in producing  $5.6 \times 10^{15} \text{ J}$  of energy by this reaction?

Answer:  $1.6 \times 10^1 \text{ kg}$

Var: 50+

19) Consider the nuclear reaction  ${}^{14}_7\text{N} + {}^4_2\text{He} \rightarrow {}^{17}_8\text{O} + {}^1_1\text{H}$ . The known atomic masses are

$${}^{14}_7\text{N}: \quad 14.003074 \text{ u}$$

$${}^4_2\text{He}: \quad 4.002603 \text{ u}$$

$${}^1_1\text{H}: \quad 1.007825 \text{ u}$$

$${}^{17}_8\text{O}: \quad 16.999131 \text{ u}$$

What is the  $Q$ -value (or reaction energy) of this reaction? ( $1 \text{ u} = 931.5 \text{ MeV}/c^2$ )

A) -1.191 MeV

B) -2.020 MeV

C) -6.725 MeV

D) -9.055 MeV

Answer: A

Var: 1

20) Consider the nuclear reaction:  ${}^7\text{Li} + {}^1_0\text{p} \rightarrow {}^4\text{He} + {}^4\text{He}$ . The known atomic masses are

${}^7\text{Li}$ : 7.016005 u

${}^4_2\text{He}$ : 4.002603 u

${}^1_0\text{p}$ : 1.007825 u

What is the  $Q$ -value (or reaction energy) of this reaction? (1 u = 931.5 MeV/ $c^2$ )

A) 13.57 MeV

B) 15.37 MeV

C) 17.35 MeV

D) 17.53 MeV

Answer: C

Var: 1

21) Consider the nuclear reaction  ${}^{14}_7\text{N} + {}^4_2\text{He} \rightarrow {}^{17}_8\text{O} + {}^1_1\text{H}$ . The known atomic masses are

${}^{14}_7\text{N}$ : 14.003074 u

${}^4_2\text{He}$ : 4.002603 u

${}^1_1\text{H}$ : 1.007825 u

${}^{17}_8\text{O}$ : 16.999131 u

What is the  $Q$ -value (or reaction energy) of this reaction? (1 u = 931.5 MeV/ $c^2$ )

A) 1.191 MeV

B) -1.191 MeV

C)  $1.279 \times 10^{-3}$  MeV

D)  $-1.279 \times 10^{-3}$  MeV

Answer: B

Var: 1

22) Consider the nuclear reaction  ${}^3_1\text{H} + {}^3_1\text{H} \rightarrow {}^4_2\text{He} + 2 {}^1_0\text{n}$ . The known atomic masses are

${}^4_2\text{He}$ : 4.002603 u

${}^3_1\text{H}$ : 3.016049u

${}^1_0\text{n}$ : 1.008665 u

What is the energy released (positive) or absorbed (negative) in this nuclear reaction? (1 u = 931.5 MeV/ $c^2$ )

A) 0.0122 MeV

B) -0.0122 MeV

C) 11.3 MeV

D) -11.3 MeV

Answer: C

Var: 1

23) A nuclear explosion results in a mass decrease of 2.10 g. How much energy is released during this explosion? ( $c = 3.00 \times 10^8$  m/s)

A)  $1.89 \times 10^{14}$  J

B)  $6.30 \times 10^5$  J

C)  $1.89 \times 10^{13}$  J

D)  $2.25 \times 10^{12}$  J

Answer: A

Var: 28

24) An electron and a positron, both essentially at rest, annihilate each other, emitting two identical photons in the process. What is the wavelength of these photons? The mass of an electron or positron is  $9.11 \times 10^{-31}$  kg. ( $h = 6.626 \times 10^{-34}$  J · s,  $c = 3.00 \times 10^8$  m/s)

A)  $1.21 \times 10^{-12}$  pm

B) 1.73 pm

C) 2.42 pm

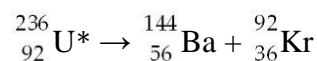
D) 3.07 pm

E) 3.46 pm

Answer: C

Var: 1

25) An excited  ${}_{92}^{236}\text{U}^*$  nucleus undergoes fission into two fragments as follows:



The following atomic masses are known:

$${}_{36}^{92}\text{Kr}: 91.926270 \text{ u}$$

$${}_{56}^{144}\text{Ba}: 143.922845 \text{ u}$$

$${}_{92}^{236}\text{U}^*: 236.045563 \text{ u}$$

What is the reaction energy released during this fission reaction? ( $1 \text{ u} = 931.5 \text{ MeV}/c^2$ )

A) 150 MeV

B) 160 MeV

C) 170 MeV

D) 180 MeV

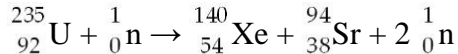
E) 190 MeV

Answer: D

Var: 1



26) When a neutron collides with a uranium-235 nucleus it can induce a variety of fission reactions. One such reaction is



The following mass values are known:

$${}_{54}^{140}\text{Xe}: 139.921620 \text{ u}$$

$${}_{38}^{94}\text{Sr}: 93.915367 \text{ u}$$

$${}_{92}^{235}\text{U}: 235.043924 \text{ u}$$

$${}_0^1\text{n}: 1.008665 \text{ u}$$

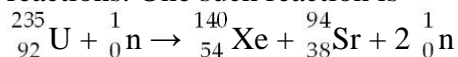
How much energy is released in this reaction? (1 u = 931.5 MeV/c<sup>2</sup>)

- A) 185 MeV
- B) 202 MeV
- C) 32.6 MeV
- D) 65.7 MeV
- E) 98.6 MeV

Answer: A

Var: 1

27) When a neutron collides with a uranium-235 nucleus it can induce a variety of fission reactions. One such reaction is



The following mass values are known:

$${}_{54}^{140}\text{Xe}: 139.921620 \text{ u}$$

$${}_{38}^{94}\text{Sr}: 93.915367 \text{ u}$$

$${}_{92}^{235}\text{U}: 235.043924 \text{ u}$$

$${}_0^1\text{n}: 1.008665 \text{ u}$$

What mass of uranium is needed to produce a 10-kiloton yield? (1 u = 931.5 MeV/c<sup>2</sup> = 1.66054 × 10<sup>-27</sup> kg, 1-kiloton yield = 5.0 × 10<sup>12</sup> J)

- A) 0.57 kg
- B) 0.66 kg
- C) 6.58 kg
- D) 3.85 kg
- E) 1.10 kg

Answer: B

Var: 1

28) Two deuterium nuclei,  ${}^2_1\text{H}$ , fuse to produce a tritium nucleus,  ${}^3_1\text{H}$ , plus an ordinary hydrogen nucleus,  ${}^1_1\text{H}$ . A neutral deuterium atom has a mass of 2.014102 u; a neutral tritium atom has a mass of 3.016050 u; a neutral hydrogen atom has a mass of 1.007825 u; a neutron has a mass of 1.008665 u; and a proton has a mass of 1.007277 u. How much energy is released in this fusion process? ( $1 \text{ u} = 931.5 \text{ MeV}/c^2$ )

- A) 3.03 MeV
- B) 3.53 MeV
- C) 4.03 MeV
- D) 4.53 MeV
- E) 6.58 MeV

Answer: C

Var: 1

29) If a 2.0-MeV neutron released in a fission reaction loses half its kinetic energy in each moderator collision, how many collisions are needed to reduce its kinetic energy to 1/25 eV?

- A) 6
- B) 18
- C) 26
- D) 30
- E) 4

Answer: C

Var: 1

30) If a nuclear fission reactor produces an average power of 1.0 GW over the course of a year, what mass of  ${}^{235}\text{U}$  is used up for a 365-day year if 200 MeV are released per fission reaction? ( $1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$ ,  $m_{\text{neutron}} \approx m_{\text{proton}} = 1.67 \times 10^{-27} \text{ kg}$ )

- A) 0.35 kg
- B) 1.75 kg
- C) 390 kg
- D)  $1.1 \times 10^8 \text{ kg}$
- E)  $3.3 \times 10^8 \text{ kg}$

Answer: C

Var: 1

31) When  ${}^{235}\text{U}$  undergoes fission, the average energy per fission event is 200 MeV. How much energy is released in the total fission of 2.0 g of  ${}^{235}\text{U}$ ? ( $1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$ ,  $m_{\text{neutron}} \approx m_{\text{proton}} = 1.67 \times 10^{-27} \text{ kg}$ )

- A)  $1.6 \times 10^{11} \text{ J}$
- B)  $3.9 \times 10^{13} \text{ J}$
- C)  $1.6 \times 10^5 \text{ J}$
- D)  $3.9 \times 10^{10} \text{ J}$

Answer: A

Var: 6