Conceptual Questions

32.1 Diagnostics and Medical Imaging

1.

In terms of radiation dose, what is the major difference between medical diagnostic uses of radiation and medical therapeutic uses?

2.

One of the methods used to limit radiation dose to the patient in medical imaging is to employ isotopes with short half-lives. How would this limit the dose?

32.2 Biological Effects of Ionizing Radiation

3.

Isotopes that emit α radiation are relatively safe outside the body and exceptionally hazardous inside. Yet those that emit γ radiation are hazardous outside and inside. Explain why.

4.

Why is radon more closely associated with inducing lung cancer than other types of cancer?

5.

The RBE for low-energy βs is 1.7, whereas that for higher-energy βs is only 1. Explain why, considering how the range of radiation depends on its energy.

6.

Which methods of radiation protection were used in the device shown in the first photo in Figure 32.30? Which were used in the situation shown in the second photo?

(a)

(b)

Figure 32.30 (a) This x-ray fluorescence machine is one of the thousands used in shoe stores to produce images of feet as a check on the fit of shoes. They are unshielded and remain on as long as the feet are in them, producing doses much greater than medical images. Children were fascinated with them. These machines were used in shoe stores until laws preventing such unwarranted radiation exposure were enacted in the 1950s. (credit: Andrew Kuchling) (b) Now that we know the effects of exposure to radioactive material, safety is a priority. (credit: U.S. Navy)

7.

What radioisotope could be a problem in homes built of cinder blocks made from uranium mine tailings? (This is true of homes and schools in certain regions near uranium mines.)

8.

Are some types of cancer more sensitive to radiation than others? If so, what makes them more sensitive?

9.

Suppose a person swallows some radioactive material by accident. What information is needed to be able to assess possible damage?

32.3 Therapeutic Uses of Ionizing Radiation

10.

Radiotherapy is more likely to be used to treat cancer in elderly patients than in young ones. Explain why. Why is radiotherapy used to treat young people at all?

32.4 Food Irradiation

11.

Does food irradiation leave the food radioactive? To what extent is the food altered chemically for low and high doses in food irradiation?

12.

Compare a low dose of radiation to a human with a low dose of radiation used in food treatment.

13.

Suppose one food irradiation plant uses a ^{137}Cs source while another uses an equal activity of ^{60}Co. Assuming equal fractions of the γ rays from the sources are absorbed, why is more time needed to get the same dose using the ^{137}Cs source?

32.5 Fusion

14.

Why does the fusion of light nuclei into heavier nuclei release energy?

15.

Energy input is required to fuse medium-mass nuclei, such as iron or cobalt, into more massive nuclei. Explain why.

16.

In considering potential fusion reactions, what is the advantage of the reaction $^2\mathrm{H} + ^3\mathrm{H} \rightarrow ^4\mathrm{He} + n$ over the reaction $^2\mathrm{H} + ^2\mathrm{H} \rightarrow ^3\mathrm{He} + n$?

17.

Give reasons justifying the contention made in the text that energy from the fusion reaction $^2\mathrm{H} + ^2\mathrm{H} \rightarrow ^4\mathrm{He} + \gamma$ is relatively difficult to capture and utilize.

32.6 Fission

18.

Explain why the fission of heavy nuclei releases energy. Similarly, why is it that energy input is required to fission light nuclei?

19.

Explain, in terms of conservation of momentum and energy, why collisions of neutrons with protons will thermalize neutrons better than collisions with oxygen.

20.

The ruins of the Chernobyl reactor are enclosed in a huge concrete structure built around it after the accident. Some rain penetrates the building in winter, and radioactivity from the building increases. What does this imply is happening inside?

21.

Since the uranium or plutonium nucleus fissions into several fission fragments whose mass distribution covers a wide range of pieces, would you expect more residual radioactivity from fission than fusion? Explain.

22.

The core of a nuclear reactor generates a large amount of thermal energy from the decay of fission products, even when the power-producing fission chain reaction is turned off. Would this residual heat be greatest after the reactor has run for a long time or short time? What if the reactor has been shut down for months?

23.

How can a nuclear reactor contain many critical masses and not go supercritical? What methods are used to control the fission in the reactor?

24.

Why can heavy nuclei with odd numbers of neutrons be induced to fission with thermal neutrons, whereas those with even numbers of neutrons require more energy input to induce fission?

25.

Why is a conventional fission nuclear reactor not able to explode as a bomb?

32.7 Nuclear Weapons

26.

What are some of the reasons that plutonium rather than uranium is used in all fission bombs and as the trigger in all fusion bombs?

27.

Use the laws of conservation of momentum and energy to explain how a shape charge can direct most of the energy released in an explosion in a specific direc-

tion. (Note that this is similar to the situation in guns and cannons—most of the energy goes into the bullet.)

28.

How does the lithium deuteride in the thermonuclear bomb shown in Figure 32.28 supply tritium (^{3}H) as well as deuterium (^{2}H)?

29.

Fallout from nuclear weapons tests in the atmosphere is mainly ^{90}Sr and ^{137}Cs, which have 28.6- and 32.2-y half-lives, respectively. Atmospheric tests were terminated in most countries in 1963, although China only did so in 1980. It has been found that environmental activities of these two isotopes are decreasing faster than their half-lives. Why might this be?