Use with textbook pages 289–293.

Isotopes

1. What is an isotope?

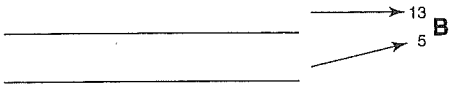
_____

2. Atomic number + number of neutrons = _____

3. Number of protons + number of neutrons = _____

4. Mass number – atomic number = _____

Use the following standard atomic notation of an isotope to answer questions 5 to 7.



5. Label the mass number and the atomic number.

6. What is the name of this isotope? _____

7. Determine the number of subatomic particles for this isotope:

   (a) number of protons = _____

   (b) number of electrons = _____

   (c) number of neutrons = _____

8. In each of the following cases, what element does the symbol X represent and how many neutrons are in the nucleus?

   (a) $^{21}_{10}X$ Element = _____

   Number of neutrons = _____

   (b) $^{32}_{16}X$ Element = _____

   Number of neutrons = _____

   (c) $^{230}_{89}X$ Element = _____

   Number of neutrons = _____

   (d) $^{234}_{90}X$ Element = _____

   Number of neutrons = _____

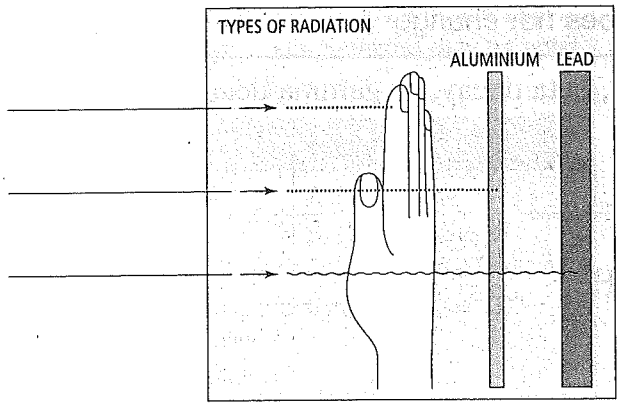
9. Complete the following table. The first row has been completed to help guide you.

Isotope	Standard atomic notation	Atomic number	Mass number	Number of protons	Number of neutrons
carbon-14	$^{14}_{6}C$	6	14	6	8
		27	52		
nickel-60					
			1 4	7	
thallium-201					
	$^{226}_{88}Ra$				
				82	126

Use with textbook pages 294–297.

Alpha, beta, and gamma radiation

1. Label the following diagram. Identify the penetrating power of the three forms of radioactive decay products: alpha particle, beta particle, and gamma ray.



2. Indicate whether the description is referring to an alpha particle, a beta particle, or a gamma ray. The description can refer to more than one of the forms of radiation.

(a) ${}^{0}_{0}\gamma$ _____

(b) ${}^{0}_{-1}\beta$ or ${}^{0}_{-1}e$ _____

(c) ${}^{4}_{2}\alpha$ ${}^{4}_{2}\mathrm{He}$ _____

(d) has a charge of 0 _____

(e) has a charge of 1- _____

(f) has a charge of 2+ _____

(g) is a helium nucleus _____

(h) is a high-speed electron _____

(i) is emitted from the nucleus _____

(j) is emitted only during beta decay _____

(k) is emitted only during alpha decay _____

(l) can be stopped by aluminum foil _____

(m) is emitted only during gamma decay _____

(n) is affected by electric and magnetic fields _____

(o) is not affected by electric and magnetic fields _____

(p) is a high energy wave with short wavelengths _____

(q) is the highest energy form of electromagnetic radiation _____

(r) has low penetrating power (can be stopped by a single piece of paper) _____

(s) has the greatest penetrating power (can only be stopped by lead or concrete) _____

Use with textbook pages 286–299.

Radioactive decay and nuclear equations

Remember the following two rules when working with nuclear equations:

I. The sum of the mass numbers does not change.

II. The sum of the charges in the nucleus does not change.

Identify each nuclear equation as alpha decay, beta decay, or gamma decay, and then complete the nuclear equation.

1. $^{32}_{15}P$ ----> $^{32}_{16}S$ + _____ _____
2. $^{218}_{84}Po$ ----> _____ + $^{4}_{2}He$ _____
3. _____ ----> $^{35}_{18}Ar$ + $^{0}_{-1}e$ _____
4. $^{24}_{12}Mg^*$ ----> _____ + $^{0}_{0}\gamma$ _____
5. $^{234}_{91}Pa$ ----> _____ + $^{4}_{2}\alpha$ _____
6. $^{141}_{58}Ce$ ----> _____ + $^{0}_{-1}e$ _____
7. $^{216}_{84}Po$ ----> _____ + $^{0}_{-1}\beta$ _____
8. $^{20}_{9}F$ ----> $^{20}_{10}Ne$ + _____ _____
9. $^{58}_{26}Fe^*$ ----> $^{58}_{26}Fe$ + _____ _____
10. _____ ----> $^{221}_{87}Fr$ + $^{4}_{2}\alpha$ _____
11. $^{149}_{64}Gd^*$ ----> _____ + $^{0}_{0}\gamma$ _____
12. $^{226}_{88}Ra$ ----> $^{222}_{86}Rn$ + _____ _____
13. _____ ----> $^{212}_{82}Pb$ + $^{0}_{-1}\beta$ _____
14. $^{214}_{83}Bi$ ----> $^{210}_{81}Tl$ + _____ _____
15. _____ ----> $^{254}_{98}Cf$ + $^{0}_{0}\gamma$ _____

Use with textbook pages 286–299.

Atomic theory, isotopes, and radioactive decay

Match the Descriptor on the left with the best Scientist on the right. Each Scientist may be used more than once.

Descriptor	Scientist
1. _____ discovered X-rays **2.** _____ identified polonium and radium **3.** _____ first to identify alpha, beta, and gamma radiation **4.** _____ discovered the nucleus and created a model of the atom **5.** _____ discovered that uranium salts emitted rays that darkened photographic plates	**A.** Marie Curie **B.** Henri Becquerel **C.** Ernest Rutherford **D.** Wilhelm Roentgen

6. Which of the following electromagnetic radiations has the highest frequency and energy?

A. X-rays

B. gamma rays

C. microwaves

D. ultraviolet radiation

7. The number of neutrons in an atom is found by

A. adding the atomic number to the mass number

B. subtracting the mass number from the atomic number

C subtracting the atomic number from the mass number

D. adding the number of protons to the number of electrons

8. What is used to tell different isotopes of a particular element apart?

A. the mass number

B. the atomic number

C. the number of protons

D. the number of electrons

9. One isotope of polonium is $^{212}_{84}Po$. Any other isotope of polonium must have

A. 84 protons

B. 128 protons

C. 84 neutrons

D. 128 neutrons

10. How many protons, neutrons, and electrons are in the isotope calcium-42, $^{42}_{20}Ca$?

	Protons	Neutrons	Electrons
A.	20	22	20
B.	20	20	22
C.	22	22	20
D.	22	20	20

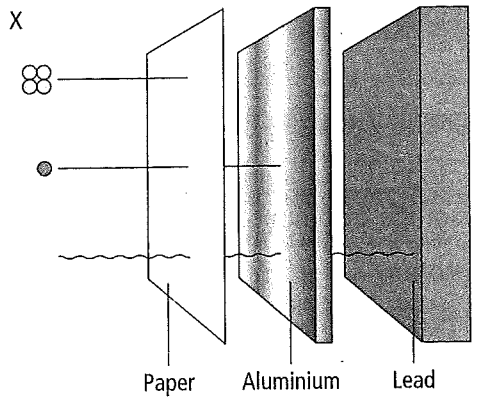
Use the following standard atomic notation for the lithium isotope to answer question 11.

$^{7}_{3}Li$

11. What does each part of the standard atomic notation shown above represent?

	"3"	"7"
A.	atomic number	mass number
B.	mass number	atomic number
C.	number of neutrons	number of protons
D.	number of protons	number of electrons

Use the following diagram showing the penetrating power of a type of radiation to answer question 12.



12. What does "X" represent?

A. a gamma ray

B. a beta particle

C. an alpha particle

D. a high-speed electron

13. Which type of radioactive decay process results in no change to the nucleus?

A. beta decay

B. alpha decay

C. gamma decay

14. The symbol $^{4}_{2}\mathrm{He}$ is equivalent to which of the following?

A. $^{0}_{-1}e$

B. $^{0}_{-1}\beta$

C. $^{0}_{0}\gamma$

D. $^{4}_{2}\alpha$

15. Which of the following represents a beta decay?

A. $^{131}_{53}\mathrm{I} \rightarrow {}^{131}_{54}\mathrm{Xe} + {}^{0}_{-1}e$

B. $^{60}_{28}\mathrm{Ni}^{*} \rightarrow {}^{60}_{28}\mathrm{Ni} + {}^{0}_{0}\gamma$

C. $^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{86}\mathrm{Rn} + {}^{4}_{2}\alpha$

D. $^{231}_{91}\mathrm{Pa} \rightarrow {}^{227}_{89}\mathrm{Ac} + {}^{4}_{2}\mathrm{He}$

Use the following incomplete nuclear equation to answer question 16.

$^{144}_{60}\mathrm{NdI} \rightarrow \text{——} + {}^{4}_{2}\alpha$

16. What is product of this decay process?

A cobalt-58

B. cerium-58

C. cerium-140

D. samarium-62

Use with textbook pages 302–309.

Radioactive decay

1. Define the following terms.

(a) half-life _____

(b) decay curve _____

(c) parent isotope _____

(d) daughter isotope _____

2. Complete the following tables.

Half-Life	Percent of parent isotope	Percent of daughter isotope
0		
1		
2		
3		
4		

Half-Life	Fraction of parent isotope	Fraction of daughter isotope
0		
1		
2		
3		
4		

3. A rock sample contains 120 g of a radioactive isotope. The radioactive isotope has a half-life of 5 years.

(a) Complete the following table.

Half-Life	Time (a)	Mass (g)
0	0	
1	5	
2	10	
3	15	
4	20	
5	25	

(b) How much of the radioactive isotope if left after 25 years have passed? _____

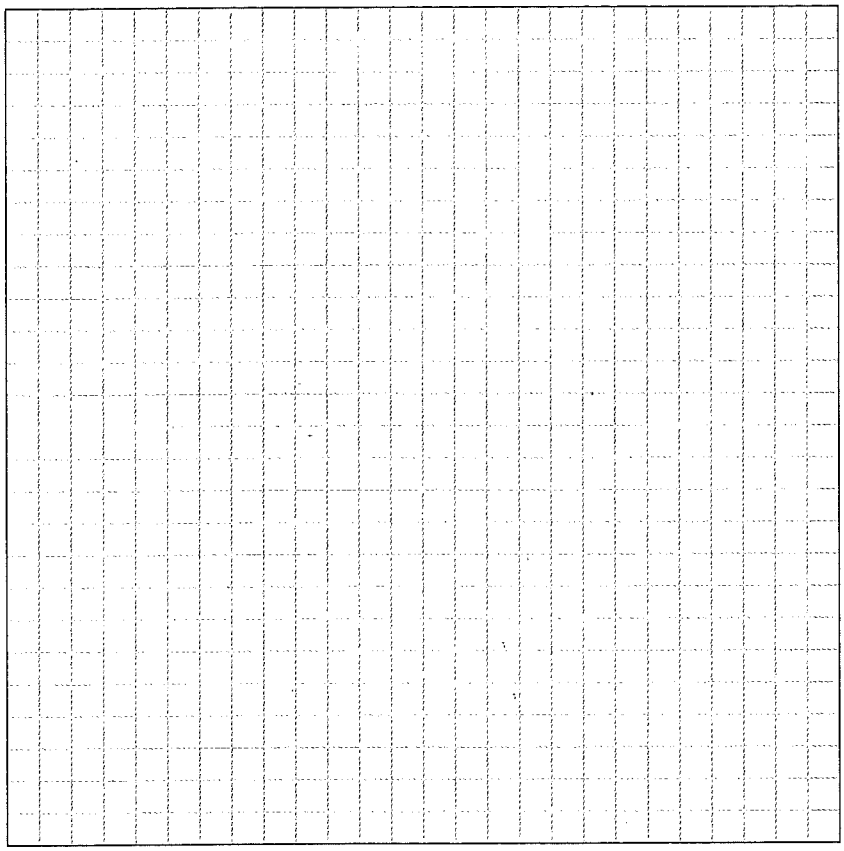
(c) How many half-lives have passed if there is only 15 g of the parent isotope left?

_____

(d) How many years have passed if there is only 7.5 g of the parent isotope left?

_____

(e) Use the data in the table to graph a decay curve. Label the *x*-axis with Time (a) and the *y*-axis with Mass (g).



4. A rock sample contains 80 g of a radioactive isotope with a half-life of 20 years.

(a) Complete the following table.

Half-Life	Time (a)	Mass of parent isotope (g)	Mass of daughter isotope (g)
0	0		
1	20		
2	40		
3	60		
4	80		
5	100		

(b) How much of the parent isotope is left after 4 half-lives? _____

(c) How much of the parent isotope is left after 100 years? _____

(d) How much of the daughter isotope is present after 60 years? _____

(e) How much time has passed if 77.5 g of the daughter isotope is present? _____

(f) What is the ratio of parent isotope to daughter isotope after 2 half-lives? _____

Use with textbook pages 302–309.

Calculating half-life

1. A radioactive isotope has a half-life of 10 minutes.

   (a) What fraction of the parent isotope will be left after 30 minutes?

   _____

   (b) What percent of the parent isotope will be left after 40 minutes?

   _____

   (c) What fraction of the daughter isotope will be present after 20 minutes?

   _____

   (d) What percent of the daughter isotope will be present after 50 minutes?

   _____

2. A 36 g sample of a radioactive isotope decayed to 4.5 g in 36 minutes. How much of the original parent isotope would remain after the first 12 minutes?

   _____

3. The half-life of a particular radioactive isotope is 8 hours. What percent of the parent isotope would remain after 1 day? _____

4. A radioactive isotope sample has a half-life of 4 days. If 6 g of the sample remains unchanged after 12 days, what was the initial mass of the sample?

   _____

5. Suppose the ratio of a radioactive parent isotope to a stable daughter isotope within a rock sample is 1:3. The half-life of the parent isotope is 710 million years. How old is the rock sample? _____

6. A rock sample was dated using potassium-40. Measurement indicates that 1/8 of the original parent isotope is left in the rock sample. How old is the rock sample?

   _____

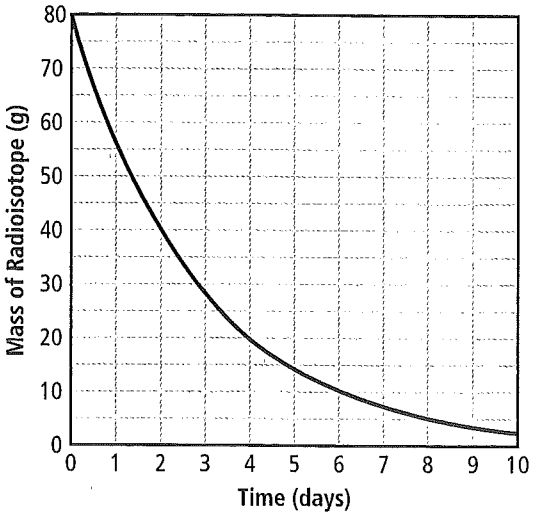
7. When a sample of lava solidified, it contained 28 g of uranium-238. If that lava sample was later found to contain only 7 g of U-238, how many years had passed since the lava solidified? _____

8. After 25 years, the number of radioactive cobalt atoms in a sample is reduced to $\frac{1}{32}$ of the original count. What is the half-life of this isotope? _____

9. The half-life of Sr-90 is 28 years. If an 80 g sample of Sr-90 is currently in a sample of soil, how much Sr-90 will be present in the soil 84 years later? _____

Use with textbook pages 305–309.

Decay curves



1. Use the decay curve to answer the questions.

   (a) What is the half-life of the isotope?

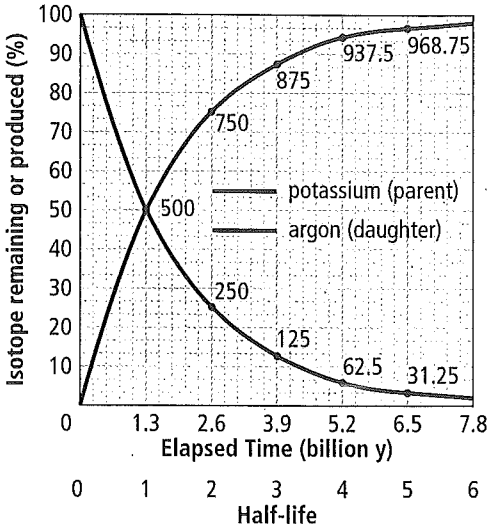
   _____

   (b) How much of the parent isotope remains after 4 days? _____

   (c) How much of the daughter isotope is present after 6 days? _____

   (d) What fraction of the parent isotope remains after 8 days? _____

   (e) How long does it take for the parent isotope to decay to 5 g? _____



2. Use the decay curve to answer the questions.

   (a) What is the common isotope pair for this decay curve? _____

   (b) What is the half-life of the parent isotope?

   _____

   (c) What does the intersection of the two lines represent? _____

   (d) What fraction of the daughter isotope is present after 5.2 billion years have passed?

   _____

   (e) What is the ratio of parent isotope to daughter isotope after 2.6 billion years have passed? _____

Use with textbook pages 302–309.

Half-life

Match the Term on the left with the best Descriptor on the right. Each Descriptor may be used only once.

Term	Descriptor
1. _____ half-life **2.** _____ decay curve **3.** _____ parent isotope **4.** _____ daughter isotope	**A.** the stable product of radioactive decay **B.** the isotope that undergoes radioactive decay **C.** a curved line on a graph that shows the rate at which radioisotopes decay **D.** the time required for half the nuclei in a sample of a radioactive isotope to decay

5. Radiocarbon dating can be used to determine the age of which of the following?

I.	a rock sample
II.	the fossil of a fern plant
III.	the skeleton of a dead bear

A. I and II only

B. I and III only

C. II and III only

D. I, II, and III

6. After how many half-lives are there equal amounts of parent and daughter isotopes?

A. 1 **C.** 3

B. 2 **D.** 4

7. The half-life of Ni-28 is six days. What fraction of a sample of this isotope will remain after 18 days?

A. 1/2 **C.** 1/8

B. 1/4 **D.** 1/16

8. The half-life of a particular radioactive isotope is 6 hours. What percent of the daughter isotope would be present after 1 day?

A. 50% **C.** 87.5%

B. 75% **D.** 93.75%

9. A 24 g sample of a radioactive isotope decayed to 1.5 g in 48 minutes. How much of the original parent isotope remained after 24 minutes?

A. 3 g **C.** 12 g

B. 6 g **D.** 18 g

10. A radioactive isotope sample has a half-life of 5 days. If 8 g of the sample remains unchanged after 20 days, what was the initial mass of the sample?

A. 32 g **C.** 128 g

B. 64 g **D.** 256 g

11. If the half-life of an isotope is 8000 years and the amount of that isotope present in an igneous rock is only $\frac{1}{4}$ of the original amount, how old is the rock?

A. 8000 years old

B. 16 000 years old

C. 24 000 years old

D. 32 000 years old

12. What is the advantage of using a radioisotope with a short half-life for medical diagnostic purposes?

A. the radioactivity is easy to monitor

B. the radioactivity lasts for a long time

C. the radioactivity does not stay in the body

D. the radioactivity induced by the radioisotope is stronger