Skill and Practice Sheet Answers

10A Structure of the Atom

1. Answers are:

lithium	3	7
carbon	6	12
hydrogen	1	1
hydrogen (a radioactive isotope, 3H, called tritium)	1	3
beryllium	4	9

2. Answers are:
   a. hydrogen-2: 1 proton, 1 neutron
   b. scandium-45: 21 protons, 24 neutrons
   c. aluminum-27: 13 protons, 14 neutrons
   d. uranium-235: 92 protons, 143 neutrons
   e. carbon-12: 6 protons, 6 neutrons
3. Most of an atom's mass is concentrated in the nucleus. The number of electrons and protons is the same but electrons are so light they contribute very little mass. The mass of the proton is 1,835 times the mass of the electron. Neutrons have a bit more mass than protons, but the two are so close in size that we usually assume their masses are the same.
4. Yes, it has a proton (+1) and no electrons to balance charge. Therefore, the overall charge of this atom (now called an ion) is +1.
5. This sodium atom has 10 electrons, 11 protons, and 12 neutrons.

10B Atoms and Isotopes

Part 1 Answers:

1. protium has 0 neutrons; deuterium has 1 neutron; tritium has 2 neutrons
2. Answers are:
   a. 3
   b. Lithium
   c. 7
   d. $^{7}_{3}\mathrm{Li}$

Part 2 Answers:

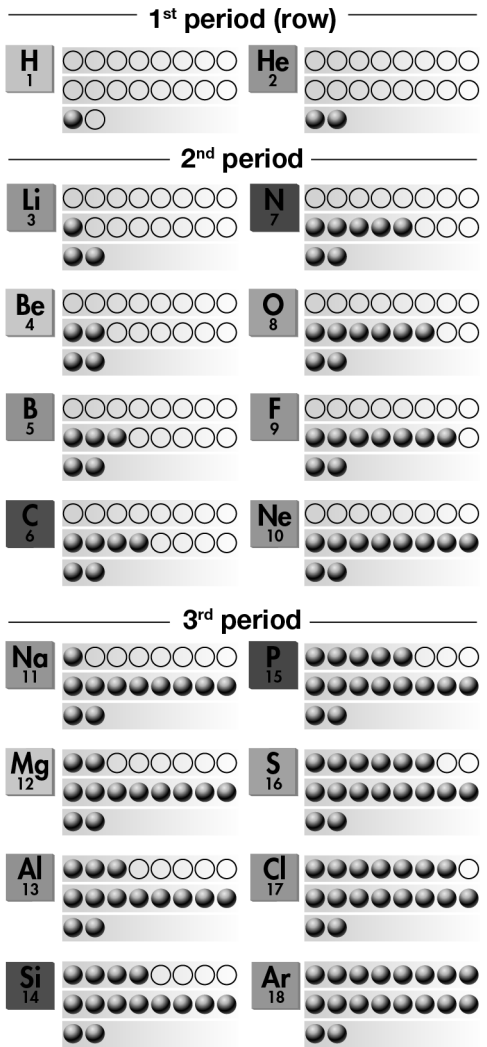
1. Bromine-80
2. Potassium-39 has 20 neutrons.
3. Lithium-7
4. Neon-20 has 10 neutrons.

10C The Periodic Table

Note: Students use library or Internet resources to complete this skill sheet.

1. Fluorine
2. Argon
3. Manganese
4. Phosphorous
5. Technetium
6. The atomic number tells the number of protons in an atom of the element.
7. Iron, 55.8 amu
8. Cesium, 132.9 amu
9. Silicon, 28.1 amu
10. Sodium, 23.0 amu
11. Bismuth, 209.0 amu

12. The atomic mass tells the average mass of all known isotopes of an element, expressed in amu.
13. The atomic mass isn't always a whole number because it is an average mass of all known isotopes.
14. The mass of an electron is too small to be significant.
15. Alkali metals
16. Any two of the following:
soft, silvery, highly reactive, combines in 2:1 ratio with oxygen
17. Any three of the following:
F, Cl, Br, I, At
18. They are toxic gases or liquids in pure form, highly reactive, and form salts with alkali metals.
19. In the far right column
20. They rarely form chemical bonds with other atoms.
21. See figure, below

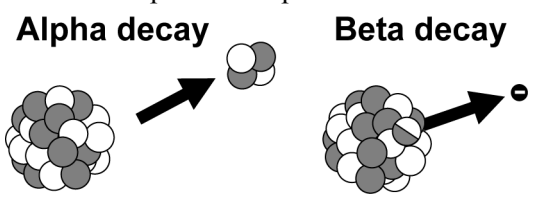


22. as above
23. as above
24. as above
25. as above

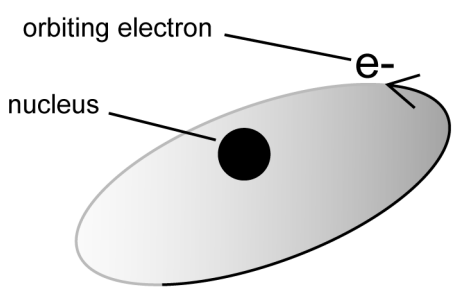
26. Hydrogen
27. Fluorine
28. Carbon
29. Sodium
30. Chlorine

10D Ernest Rutherford

1. Alpha particle: a particle that has two protons and two neutrons (also known as a helium nucleus). Beta particle: An electron emitted by an atom when a neutron splits into a proton and an electron.



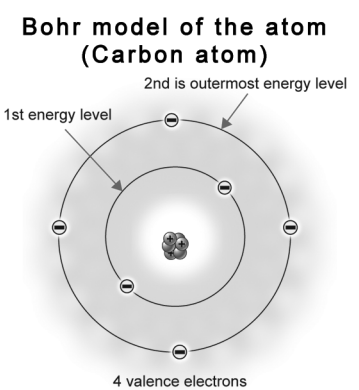
2. For one atom to turn into another kind of atom, the number of protons in the nucleus must change. This can happen when an alpha particle is ejected (two protons are lost then) or when a neutron splits into a proton and an electron (in that case the number of protons increases by one).
3. Diagram:



4. Rutherford's planetary model suggested that an atom consists of a tiny nucleus surrounded by a lot of empty space in which electrons orbit in fixed paths. Subsequent research has shown that electrons don't exist in fixed orbitals. The Heisenberg uncertainty principle tells us that it is impossible to know both an electron's position and its momentum at the same time. Scientists now discuss the probability that an electron will exist in a certain position. Computer models predict where an electron is most likely to exist, and three-dimensional shapes can be drawn to show the most likely positions. The sum of these shapes produces the charge-cloud model of the electron.
5. In the game of marbles, players "shoot" one marble at a group of marbles and then watch the deflection as collisions occur. This is a lot like what Rutherford was doing on a much, much smaller scale. Rutherford's comment is reflective of his typical self-deprecating humor. While "playing with marbles," he discovered the proton.
6. Answers will vary. Students may wish to write about one of the following discoveries: Rutherford first described two different kinds of particles emitted from radioactive atoms, calling them alpha and beta particles. He also proved that radioactive decay is possible. He developed the planetary model of the atom, and was the first to split an atom.

10E Niels Bohr

1. Both Rutherford and Bohr described atoms as having a tiny dense core (the nucleus) surrounded by electrons in orbit. Bohr described the nature of the electrons' orbits in much greater detail.
2. Niels Bohr described electrons as existing in specific orbital pathways, and explained how atoms emit light.
3. In Bohr's model of the atom, the electrons are in different energy levels. Bohr's model of the atom is shown at right:



4. An electron absorbs energy as it jumps from an inner orbit to an outer one. When the electron falls back to the inner orbit, it releases the absorbed energy in the form of visible light.

5. Answers will vary. You may wish to ask students to research world events from the end of World War II to Bohr's death in 1962. Students should look for events that may have raised concerns in Bohr's mind about the potential use/misuse of nuclear weapons. They might also choose to research Bohr's own comments on the subject.

10F Radioactivity

1. In the answers below, "a" is alpha decay and "b" is beta decay.

a. Answers are:

$^{238}_{92}U$ a→ $^{234}_{90}Th$ b→ $^{234}_{91}Pa$ b→ $^{234}_{92}U$ a→ $^{230}_{90}Th$ a→

$^{226}_{88}Ra$ a→ $^{222}_{86}Rn$ a→ $^{218}_{84}Po$ a→ $^{214}_{82}Pb$ b→ $^{214}_{83}Bi$ b→

$^{214}_{84}Po$ a→ $^{210}_{82}Pb$ b→ $^{210}_{83}Bi$ b→ $^{210}_{84}Po$ a→ $^{206}_{82}Pb$

b. Answers are:

$^{240}_{94}Pu$ b→ $^{240}_{95}Am$ a→ $^{236}_{93}Np$ a→ $^{232}_{91}Pa$ b→ $^{232}_{92}U$ a→

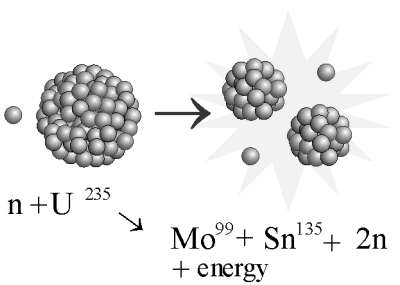
$^{228}_{90}Bi$ a→ $^{224}_{88}Ra$ b→ $^{224}_{89}Ac$ a→ $^{220}_{87}Fr$ a→ $^{216}_{85}At$ a→

$^{212}_{83}Bi$ b→ $^{212}_{84}Po$ a→ $^{208}_{82}Pb$ b→ $^{208}_{83}Bi$

2. Answers are:
   a. During 11 minutes, fluorine-18 would experience 6 half-lives.
   b. 0.16 gram would be left after 11 minutes (660 seconds).
3. The amount after 28,650 years would be 0.0313*m* (or 1/32*m*) where *m* is the mass of the sample.
4. For one-fourth of the original mass to be left, there must have been time for two half-lives. Therefore, the half-life for this radioactive isotope is 9 months.
5. Answers are:
   a. 0.8 W/m^2
   b. 3.6×10^{13} reactions per second

10G Lise Meitner

1. Ludwig Boltzmann was a pioneer of statistical mechanics. He used probability to describe how properties of atoms (like mass, charge, and structure) determine visible properties of matter (like viscosity and thermal conductivity).
2. They discovered protactinium. Its atomic number is 91 and atomic mass is 231.03588. It has 20 isotopes. All are radioactive.
3. The graphic at right illustrates fission (n = a neutron):



4. Some topics students may research and describe include nuclear power plants, nuclear weapons, nuclear-powered submarines or aircraft carriers.
5. Meitner's honors included the Enrico Fermi award, and element 109, meitnerium, named in her honor.
6. Students should include the following pieces of evidence in their letters:
   Meitner suggested tests to perform on the product of uranium bombardment.
   Meitner proved that splitting the uranium atom was energetically possible.
   Meitner explained how neutron bombardment caused the uranium nucleus to elongate and eventually split.

10H Marie and Pierre Curie

1. Sample answer: Marie (or Marya, as she was called) had a strong desire to learn and had completed all of the schooling available to young women in Poland. She was part of an illegal "underground university" that helped young women prepare for higher education. Perhaps her own thirst for knowledge fueled her empathy for the peasant children, who were also denied the right to an education.

2. Marie Curie proposed that uranium rays were an intrinsic part of uranium atoms, which encouraged physicists to explore the possibility that atoms might have an internal structure.
3. Marie and Pierre worked with uranium ores, separating them into individual chemicals. They discovered two substances that increased the conductivity of the air. They named the new substances polonium and radium.
4. Answers include nuclear physics, nuclear medicine, and radioactive dating.
5. Marie Curie thought carefully about how to balance her scientific career and the needs of her children. When the children were young, Pierre's father lived with the family and took care of the children while their parents were working. Marie spent a great deal of time finding schools that best fit the individual needs of her children and at one point set up an alternative school where she and several friends took turns tutoring their children. When her daughters were in their teens, Marie included them in her professional activities when possible. Irene, for example, helped her mother set up mobile x-ray units for wounded soldiers during the war.

10l Rosalyn Sussman Yalow

1. There are some striking similarities in the lives of Rosalyn Yalow and Marie Curie. As young women, both were outstanding math and science students. Even though Yalow was 54 years younger than Marie Curie, both faced limited higher education opportunities because they were women. Undaunted, each earned a doctorate degree in physics. Both Yalow and Curie's research focused on radioactive materials. Curie's work was at the forefront of discovery of how radiation works, while Yalow's work was to develop a new application of radiation. Both women were particularly interested in the medical uses of radiation. Each was committed to using their scientific discoveries to promote humanitarian causes. Both women won Nobel Prizes for their work (Marie Curie won two!).
2. RIA is a technique that uses radioactive molecules to measure tiny amounts of biological substances (like hormones) or certain drugs in blood or other body fluids.
3. Using RIA, they showed that adult diabetics did not always lack insulin in their blood, and that, therefore, something must be blocking their insulin's normal action. They also studied the body's immune system response to insulin injected into the bloodstream.
4. The issue of patents in medical research remains a hotly debated issue in our society. Proponents of patents, especially for new drugs, claim that because very few new drugs make it through the extensive safety and effectiveness trials required for FDA approval, research costs are very high. Patents, they claim, are the only means of recouping these research costs. On the other side of the issue, critics say that the profit motive drives research into certain types of medicines—tending to be drugs for chronic illnesses, so that patients will take the drugs for a long time. Research into drugs (like new antibiotics) that are generally taken only for a short period of time tends to be less of a priority. You may wish to have students research the pros and cons of the patent system and write a position paper or hold a class discussion or debate on the topic.