

- When you shine white light through a triangular glass prism,
    - white light emerges, unbent.
    - the colors are dispersed according to wavelength. Red light, having the longest wavelength, bends the most.**
    - the prism scatters the blue light, and only red light emerges.
    - Don't do it!! Do the words Bermuda Triangle mean *nothing* to you?
  - When you see a rainbow in the sky,
    - sometimes the red band is on top, sometimes the blue band is. It's completely random.
    - the primary will have red on top, blue on bottom. The secondary will have blue on top, red on bottom.**
    - the primary will have blue on top, red on bottom. The secondary will have red on top, blue on bottom.
    - both the primary and secondary rainbows will have the same color order: VIB G ROY, from top to bottom.
  - True** or false: The Earth's atmosphere is not transparent to all frequencies of electromagnetic waves.
  - Why don't humans have x-ray vision—like Superman?
    - Some humans do. The ability see x-rays is uncommon, but there are plenty of people who have x-ray vision.
    - You cannot see what cannot be seen! There is no known method for detecting x-rays, so there is no way for any eye (human or otherwise) to see x-rays.
    - X-rays cannot penetrate the Earth's atmosphere. Eyes (human or otherwise) would not evolve to see wavelengths which are not abundant at the Earth's surface.**
  - Your polarized sunglasses are great for driving, since they diminish reflected glare from the highway. The fact that light can be polarized proves that
    - light is a longitudinal wave.
    - light is a transverse wave.**
    - particles of light can pass through glass.
    - it's dangerous to drive without eye protection. You should probably wear a helmet, as well.
  - True** or false: Light is a particle.
  - True** or false: Light is a wave.
  - What is the photoelectric effect?
    - The observation that oscillating an electric charge creates an electromagnetic wave.
    - The observation that a beam of electrons will fog unexposed (and well-shielded) photographic film.
    - When a photograph is bombarded with electrons, it gets yellowed and dingy. That's why old-timey photographs are all sepia-toned.
    - When a metallic foil is bombarded with photons of light of a particular frequency, electrons are ejected. But using a different frequency has no effect.**
- For questions 9–11 below, use the following choices:
- a wave property only.
  - a particle property only.
  - both wave and particle behavior.
- Reflection of light is **both wave and particle behavior**.
  - Interference of light is **a wave property only**.
  - The photoelectric effect is **a particle property only**.
  - The atomic theory of matter
    - revolutionized physics when Bohr proposed the quantum atom in the 1950s.
    - is relatively new, originating with Werner Heisenberg in the 1920s.
    - is one of Einstein's great achievements from his best year, 1905.
    - is over 2000 years old; Democritus proposed the existence of atoms in about 350 BC.**
  - When Democritus proposed the atomic theory of matter, he suggested that
    - atoms were tiny, spherical particles of matter too small to be seen. These atoms could not be split into smaller pieces.**
    - the four fundamental elements were earth, air, fire, and water. Anything could be made by mixing these four substances in various ratios and combinations.
    - the weight ratio of hydrogen to oxygen in water was always 1:8.
    - the compound Pb = peanut butter was composed of equal parts peanuts and butter.
  - Which of the following ideas is not one of Dalton's atomic hypotheses?
    - Indivisible minute particles called atoms make up all matter.
    - All the atoms of an element are exactly alike in shape and mass, but the atoms of different elements differ from one another in their masses.
    - Atoms chemically combine in definite whole-number ratios to form chemical compounds.
    - Atoms are neither created nor destroyed in chemical reactions.
    - These ideas are all part of Dalton's work on atoms.**
  - What are cathode rays?
    - A beam of radioactive isotopes.
    - A beam of positively-charged helium nuclei.
    - A glowing green beam of high energy electrons.**
    - So, this Star Lord steals an orb, and has adventures with a green assassin, a talking tree, a genetically enhanced raccoon, and Drax. When the orb gets opened, the Infinity Stone inside explodes in a violent cascade of deadly cathode rays.
  - The electron was discovered
    - in 1789 by Benjamin Franklin, during his famous kite-flying experiment.
    - in 1897 by J.J. Thomson, who determined that cathode ray particles were too small to be ions.**
    - in 1911 by Ernest Rutherford, who was intent on disproving Bohr's planetary model.
    - in 1987 by Hunter S. Thomson, who chronicled this work in *Fear and Loathing in Las Vegas*.
  - Which of the following devices does not use a cathode-ray tube?
    - Television.
    - Computer monitor.
    - Oscilloscope.
    - Mobile phone.**
  - True or **false**: Thomson's discovery of the electron proved that atoms are tiny, indivisible spheres—just like Democritus predicted in 350 BCE!

19. What is the “plum pudding” (or blueberry muffin) model of the atom?
- A) The interpretation is strictly literal: all matter is made of atoms, which are tiny, delicious baked goods.
  - B) An atom is a positive particle completely coated by a thin layer of negative electrons.
  - C) An atom is a negative matrix (muffin) with positive particles (blueberries) randomly dispersed throughout.
  - D) An atom is a positive matrix (muffin) with negative electrons (blueberries) randomly dispersed throughout.**

20. What are alpha particles?
- A) A beam of radioactive isotopes.
  - B) A beam of positively-charged helium nuclei.**
  - C) A glowing green beam of high energy electrons.
  - D) So, this Star Lord steals an orb, and has adventures with a green assassin, a talking tree, a genetically enhanced raccoon, and Drax. When the orb gets opened, the Infinity Stone inside explodes in a violent cascade of deadly cathode rays.

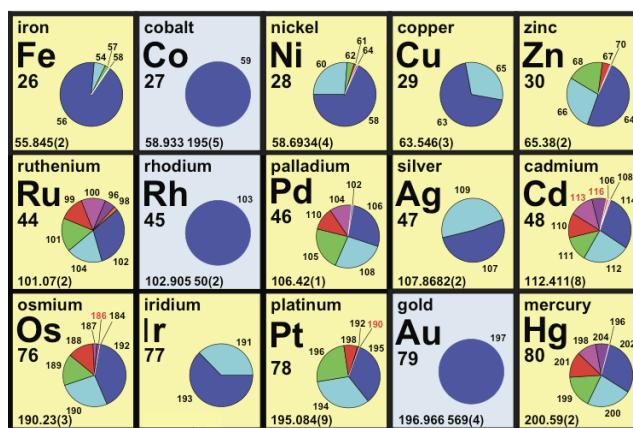
21. If you throw a tennis ball at the wall, you expect it to bounce back (and you also expect it to obey the law of reflection,  $\theta_i = \theta_f$ ). What happens if you throw alpha particles at a thin gold foil?
- A) The particles burn a hole right through the foil and continue to travel in a straight line.
  - B) The particles bounce off the foil like tiny little tennis balls, obeying the law of reflection.
  - C) The particles pass right through the foil as if it wasn't there at all. The emerge on the other side of the undamaged gold foil like nothing happened.**
  - D) They disappear mysteriously. It's the one and only known example of violating the laws of matter and energy conservation.

22. **True** or false: If you bombard a thin gold foil with alpha particles, most of them will bounce straight back in the direction from where they came.

23. What is the difference between an isotope and an ion?
- A) An ion is created when a proton is added to a nucleus.
  - B) An isotope is created when neutrons are added or removed from a nucleus.**
  - C) An ion is created when two isotopes fuse to form a new nucleus.
  - D) An isotope is formed when an electron is stripped from its orbit.

24. The isotope carbon-13 can be written  ${}^6_{13}\text{C}$ . This means that it has
- A) 6 protons and 13 neutrons.
  - B) 6 protons and 7 neutrons.**
  - C) 7 protons and 6 neutrons.
  - D) 13 protons and 6 neutrons.

25. Compare the mass and charge of carbon isotopes  ${}^{12}\text{C}$  and  ${}^{14}\text{C}$ .
- A) Both should be electrically neutral (6 protons, 6 electrons) and have the same atomic mass
  - B) Both should be neutral, but the 14C should be more massive by two neutrons.**
  - C) Both should have the same mass, but the 14C should have two extra positive charges.
  - D) Both should have the same mass, but the 12C should have two extra negative charges.



26. Nucleus A contains 29 protons and 34 neutrons. Nucleus B contains 29 protons and 36 neutrons.
- A) A is a copper nucleus, but B is a krypton nucleus.
  - B) A is a selenium nucleus, and B is a copper nucleus.
  - C) Both nuclei are isotopes of copper.**
  - D) Neither nucleus actually exists.
27. Examine the element iridium (Ir). How many protons are in an iridium nucleus?
- A) 193
  - B) 191
  - C) 116
  - D) 114
  - E) 77**
  - F) None of these
28. The atomic weight of iridium will be
- A) exactly 77 amu.
  - B) exactly 191 amu.
  - C) between 191 and 193, closer to 191 amu.
  - D) between 191 and 193, closer to 193 amu.**
  - E) exactly 193 amu.
29. If you can only have whole numbers of atomic particles (protons, neutrons, and electrons), why do the atomic weights (in amu) always have decimal values?
- A) They don't; the atomic mass of any element will be a whole number as well.
  - B) Because an electron is about 1/10 as massive as a proton, so every  $e^-$  adds 0.1 amu to the atomic weight.
  - C) The  $e^-$  are negligible, but different isotopes of the same element have different weights because of the differing neutron numbers.**
30. Compare the emission (or bright-line) spectra for hydrogen and helium.
- A) Hydrogen has only one electron, so it has only one line (at 656nm). Helium has two electrons, so it has the 656nm line, and a second line at 435nm. The number of electrons matches the number of emission lines.
  - B) Both spectra have several emission lines, but they are not the same lines at the same frequencies.**
  - C) The spectra are identical. Both H and He have four emission lines at precisely the same wavelengths.
  - D) Trick question! Hydrogen can only form absorption lines, and helium can only form emission lines.
31. Compare the absorption (dark-line) and emission (bright-line) spectrum for mercury (Hg).
- A) Absorption and emission lines for any given element occur at exactly the same frequencies.**
  - B) Absorption lines occur in the infrared and ultraviolet parts of the spectrum. Emission lines are visible.
  - C) Both absorption and emission lines can be visible, but they never occur at the same wavelength.
  - D) There is no comparison, because the lines are totally random. If you saw an unlabeled spectrum, you would have no way to know which element it came from.

32. True or **false**: The periodic table is ordered by rows, but there is no order to the columns.
33. **True** or false: The leftmost column of elements on the periodic table are highly reactive.
34. True or **false**: Most elements have full valence shells, and as a result exhibit strongly non-metallic characteristics.
35. A metallic material
- A) has a full outermost (valence) shell, making it difficult to combine with other elements to form compounds.
  - B) has an unfilled valence shell. If there are 1, 2, or 3 valence  $e^-$ , metals will lose  $e^-$  and become (+) when ionized.**
  - C) has an unfilled valence shell. If there are 5, 6, or 7 valence  $e^-$ , metals will gain  $e^-$  and become (-) when ionized.
  - D) might gain or lose  $e^-$  when ionized. There are no rules to predict whether any atom will become (+) or (-).
36. Noble gases
- A) have full valence shells.
  - B) are colorless, odorless, and tasteless.
  - C) have colorful emission spectra when excited.
  - D) are non-reactive and do not form compounds with other elements.
  - E) All of the above!**
37. Why are there only 118 elements on the periodic table?
- A) Because that is how many have been discovered. There are an infinite number of elements, but you can't add them to the table before they have been discovered or created in the lab.
  - B) Because there is an upper limit to how many protons you can have in a nucleus. Eventually the nucleus gets too big for the strong force to keep it bound together.**
  - C) Because there is an upper limit to how many neutrons you can have in a nucleus. Heavier nuclei require more neutrons, but if you add too many, they will begin to repel each other.