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FACULTY OF EDUCATION

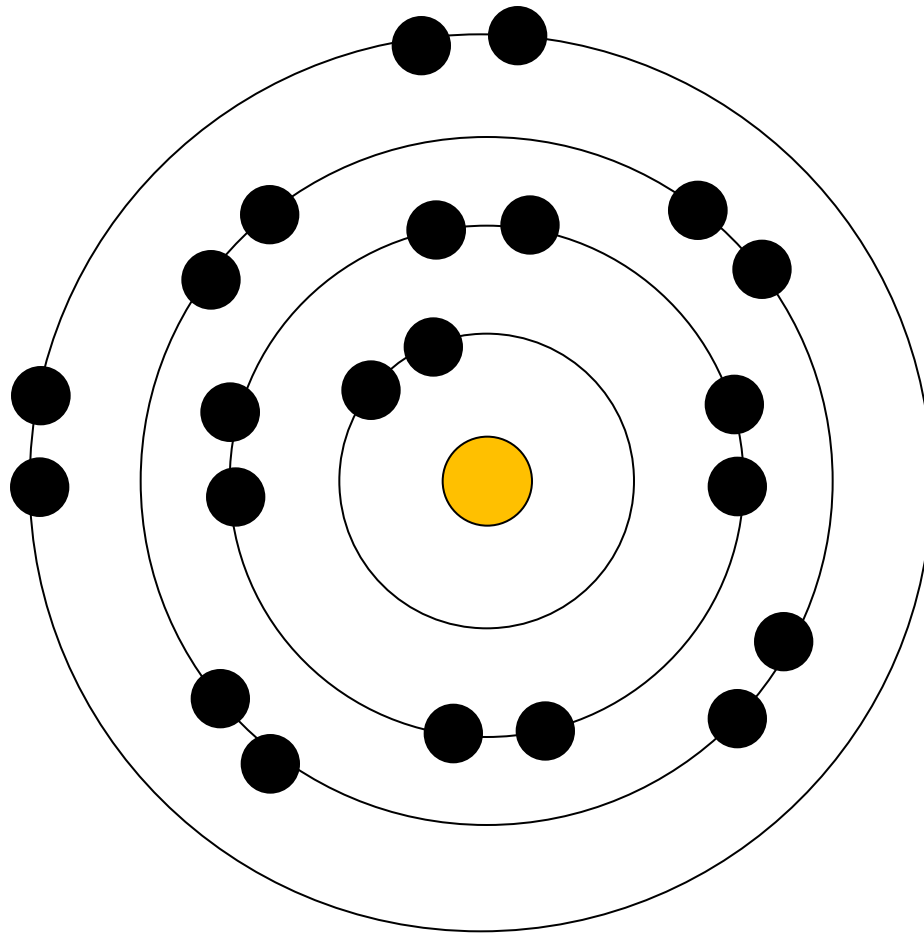
Department of
Curriculum and Pedagogy

Chemistry

Atomic Theory: Model of the Atom

Science and Mathematics
Education Research Group

Model of the Atom



Model of the Atom I

How many electrons, protons, and neutrons does the element with an atomic # of 9 have?

- A. 9 / 19 / 19
- B. 9 / 9 / 10
- C. 19 / 9 / 9
- D. 19 / 19 / 9
- E. 9 / 10 / 9

Solution

Answer: B

Justification: The atomic number of an element tells you the amount of protons and the amount of electrons in an atom. The amount of protons and electrons has to be the same to have a neutral charge.

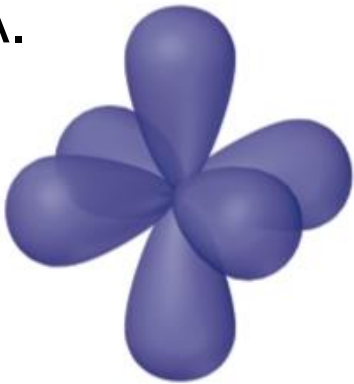
Fluorine is the element with an atomic number of 9. The atomic number tells us that it has 9 electrons and 9 protons.

The atomic mass of fluorine is 19.0 amu. A proton and neutron each have a mass of 1 amu, and since there are 9 protons, there has to be 10 neutrons.

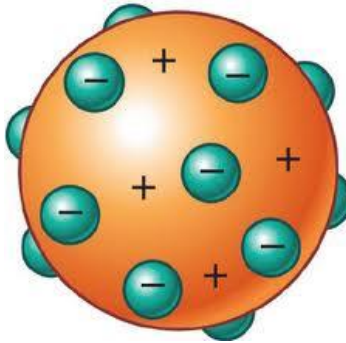
Model of the Atom II

Which of the following models represents the Rutherford-Bohr model?

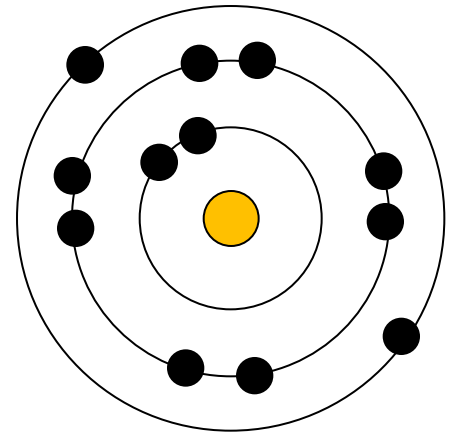
A.



B.



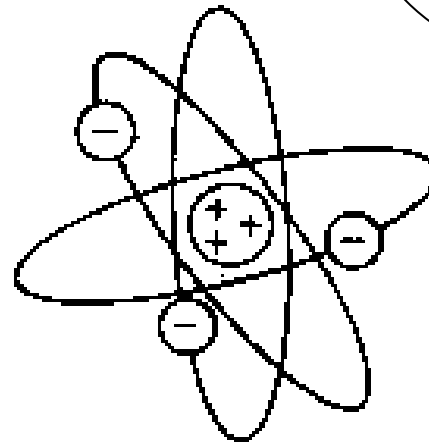
C.



D.



E.



Solution

Answer: C

Justification: The theory of the atom progressed from Dalton's Billiard Ball Model (D) to Thomson's Raisin Bun Model (B) to Rutherford's Planetary Model (E) and then to Bohr's Electron Shell Model.

The Electron shell model is referred to as the Rutherford-Bohr model because Bohr just altered Rutherford's model. Instead of having the electrons orbit around the nucleus like planets around the sun, Bohr said that the electrons move to reside in specific shells around the nucleus and do not orbit (they can move, they just don't circle around the nucleus).

A is a more recent model of the atom that comes from Quantum Mechanics.

Model of the Atom III

What is the electron configuration of the Rutherford-Bohr model?

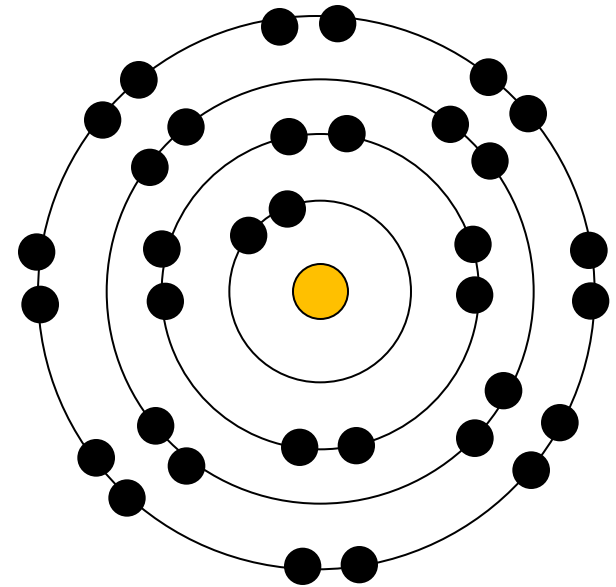
- A. 2, 8, 8, 16
- B. 2, 8, 8, 8
- C. 8, 8, 8, 8
- D. 8, 8, 2, 16
- E. 16, 8, 8, 2

Solution

Answer: A

Justification: Bohr said that a maximum of 2 electrons can reside in the first electron shell. In the second, a maximum of 8. In the third, a maximum of 8. Finally in the fourth shell, a maximum of 16.

There are more shells than just four, however you are only required to know these ones.



Model of the Atom IV

How many valence electrons does sulphur have?

- A. 16
- B. 6
- C. 14
- D. 2
- E. None of the above

Solution

Answer: B

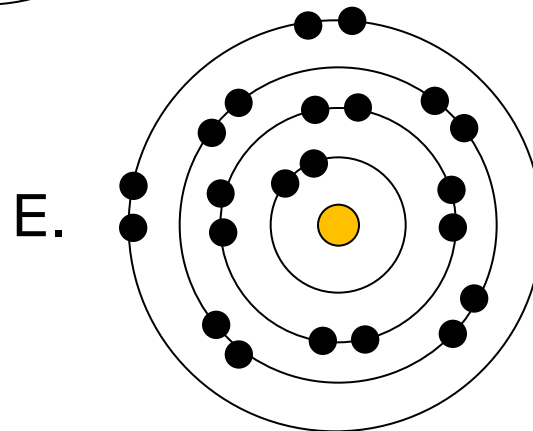
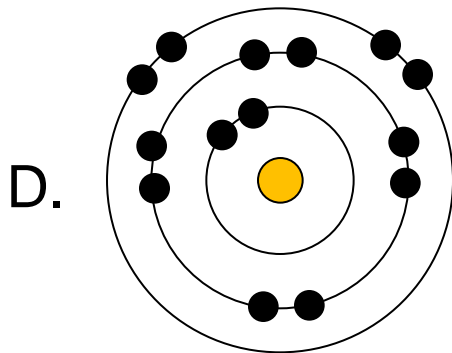
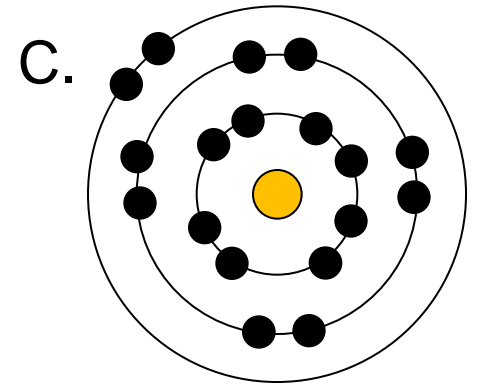
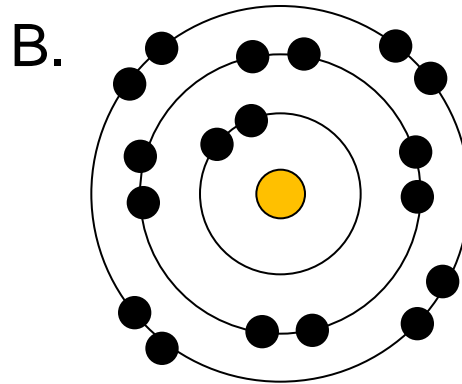
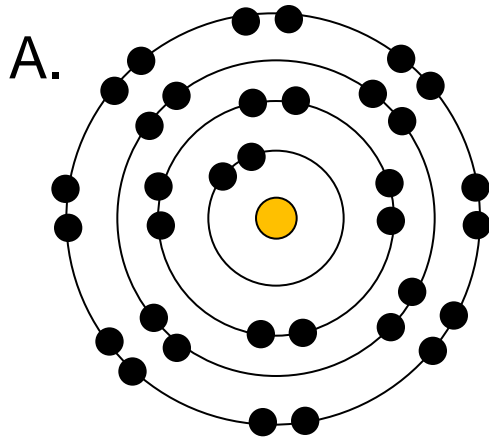
Justification: Valence electrons are the electrons in the outer most shell of the atom. All of the inner shells have to be filled before electrons will fill an outer shell.

Sulphur has 16 electrons in total. Thus 2 electrons will fill the first shell and 8 electrons will fill the second. This leaves 6 electrons for the third shell.

Thus the valence shell is the third shell, which contains 6 valence electrons.

Model of the Atom V

Which model corresponds to silicon?



Solution

Answer: D

Justification: Silicon has 14 electrons. To draw the Rutherford-Bohr model you:

- 1) Draw the first shell and use some of the atom's electrons to fill this shell. Remember, the first shell can only have 2 electrons.
- 2) There are 12 electrons left. Draw the second shell and use some of the electrons to fill the shell. Remember, the second shell can only have 8 electrons.
- 3) There are 4 electrons left (not enough to fill another shell) so draw the third shell and the remaining electrons will fill this shell.

Model of the Atom VI

Which element corresponds to a full valence third electron shell?

- A. Mg
- B. Ca
- C. Ne
- D. Ar
- E. Kr

Solution

Answer: D

Justification: Having a full valence electron shell means that the outer most shell will have the maximum amount of electrons possible.

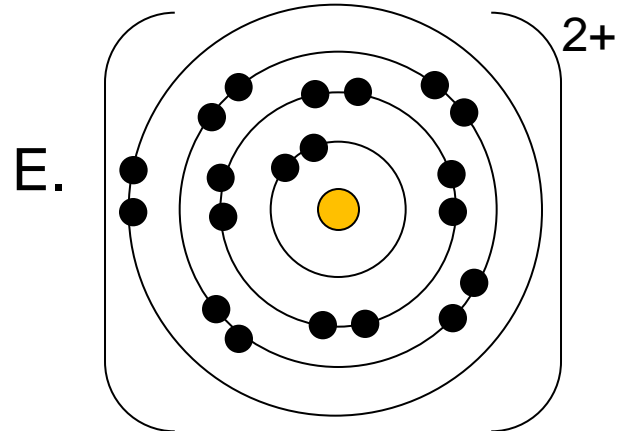
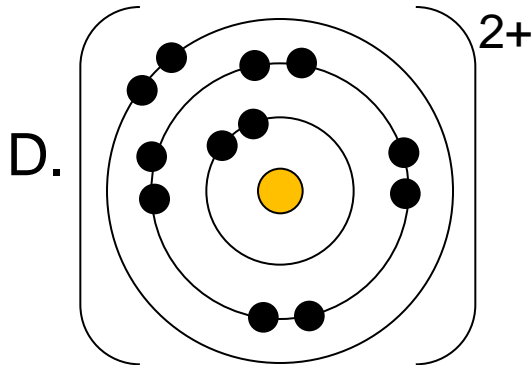
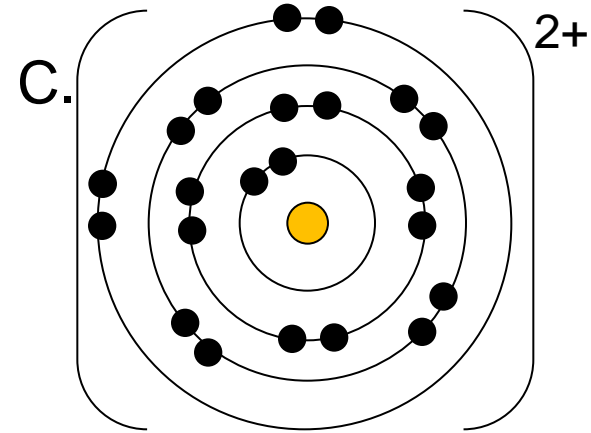
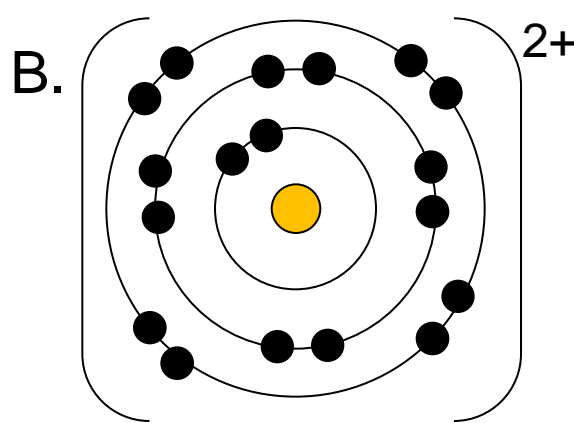
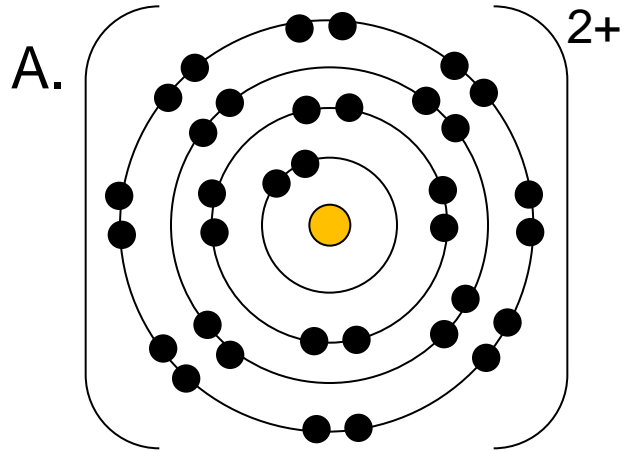
This question says that the third electron shell is the valence shell. Thus, the elements that have the third electron shell as their valence shell are all of those in Group 3. From the answers, this includes Mg (A) and Ar (D).

Mg only has 2 valence electrons where Ar has 8. The answer is Ar because 8 is the maximum amount of electrons possible for the third shell.

Notice that all of the Group 18 elements will have full valence electron shells.

Model of the Atom VII

Which model corresponds to a Ca^{2+} ion?



Solution

Answer: B

Justification: The charge of 2+ on the calcium indicates that the calcium atom has lost 2 electrons (taking away 2 negative charges from the atom leave a total of a positive 2 charge on the ion).

Thus the number of electrons that the ion has is 18.

Notice how the third electron shell is now the valence shell and it is full.

Model of the Atom VIII

How many electrons will phosphorus gain/lose as an ion?

- A. Gain 1
- B. Lose 1
- C. Gain 2
- D. Lose 2
- E. Gain 3
- F. Lose 3

Solution

Answer: E

Justification: Atoms will lose or gain electrons to try to have a full valence electron shell.

Phosphorous has 5 valence electrons in the third electron shell. Thus, it could either lose 5 electrons (and become P^{+5}) to have a full second electron shell; or it could gain 3 electrons (and become P^{-3}) to have a full third electron shell.

An atom will lose or gain the least amount of electrons possible, thus phosphorous will gain 3 electrons and become P^{-3} .

Model of the Atom IX

An atom or ion is considered stable if it is not likely to react. Reactions occur due to the exchange of electrons.

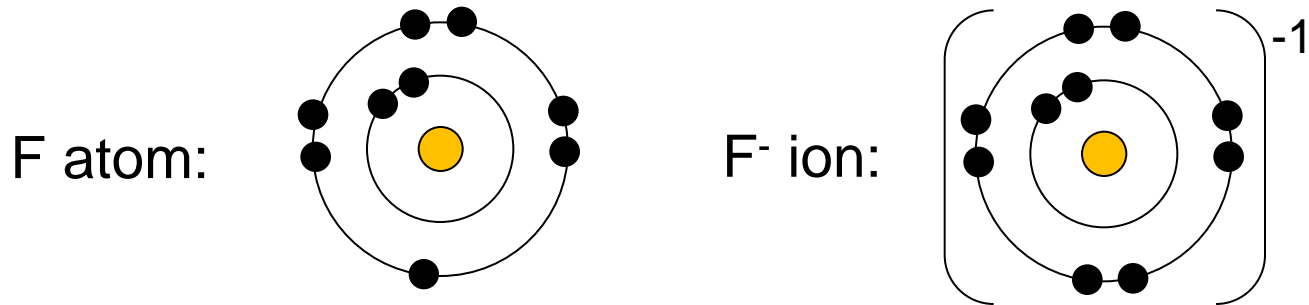
Compare a fluorine atom and a fluorine ion. Which is more stable and why?

- A. Atom because the elements in the periodic table are atoms.
- B. Atom because it has all of its valence electrons.
- C. Ion because it has a full valence electron shell.
- D. Ion because it has extra electrons which make it easier for the ion to hold itself together.
- E. Both have the same stability because they are the same element.

Solution

Answer: C

Justification: The fluorine atom and ion are shown below.



The F atom has 7 valence electrons meaning that the electron shell needs 1 more electron to make it full. The F ion has 8 valence electrons, so it's valence electron shell is full.

Since atoms will accept or lose electrons to have a full valence shell, the F atom will be very likely to react to get the 1 electron that it needs. The F⁻ ion on the other hand will be stable because it's valence electron shell is full.