Chapter 4: Atomic Structure

4.1 Democritus’ Idea of the Atom

Practice

Questions

Use the link below to answer the following questions:

http://plato.stanford.edu/entries/democritus/

1. Who influenced the thinking of Democritus?
2. Who were the atomists?
3. How did Democritus explain how we saw objects?
4. What type of atom did Democritus believe the soul was composed of?

Answers

1. Leucippus
2. Believed that there were atoms and void.
3. Atoms came off of matter and entered the eye.
4. Fire atoms.

Review

Questions

1. How did the ancient Greek philosophers spend their time?
2. What approach did they not have for studying nature?
3. Who was the most influential philosopher of that time?
4. What was the major contribution Democritus made to the thinking of his day?
5. List characteristics of atoms according to Democritus.

Answers

1. Debate and discussion
2. Observe nature and experiment.
3. Aristotle.
4. The idea of the atom.
5. Unchangeable, indestructible, always existed.

4.2 Conservation of Mass
Practice

Questions

At the following URL, apply the law of conservation of mass to a scene from a Harry Potter film. Then answer the questions below:

http://www.youtube.com/watch?v=3TsTONmK8 (2:05)

1. What is the mass of the professor in kilograms? What is the mass of the cat in kilograms? (Hint: 1 pound = 0.45 kilograms)

2. The scene must be magic because it defies the law of conservation of mass. Explain why.

Answers

1. Professor = 51.75 kg, cat = 4.95 kg.
2. Because mass cannot be created or destroyed, so it is impossible for something with a mass of 51.75 kg to turn into something with a mass of 4.95 kg.

Review

Questions

2. Describe an example of the law of conservation of mass.

Answers

1. The law of conservation of mass states that, during a chemical reaction, the total mass of the products must be equal to the total mass of the reactants.
2. A specific amount of water would have the same mass even if you turned it from a liquid to a solid or a gas.

4.3 Law of Definite Proportions

Practice

Watch the video (link below) and answer the questions:

http://www.youtube.com/watch?v=nvTB2cMbWU8

1. When was the law of definite proportions developed?
2. Who proposed this law?
3. How many hydrogen atoms are there in a molecule of water?
4. How many oxygen atoms are there in a molecule of water?

**Answers**

1. 1797.
2. Proust.
3. Two.
4. One.

**Review**

**Questions**

1. State the law of definite proportions.
2. Will the composition of water vary depending on its source?
3. Why is this law important?

**Answers**

1. A given chemical compound always contains the same elements in the exact same proportions by mass.
2. No.
3. So we can make reliable predictions about how much materials and what kind will be produced in a given process.

### 4.4 Law of Multiple Proportions

**Practice**

**Questions**

Use the resource below to answer the questions that follow.

1. Who identified the Law of Multiple Proportions?
2. What is significant about this law?
3. How did this law aid in the understanding of atomic structure?
4. What other laws helped in the formation of modern atomic theory?

**Answers**
1. John Dalton
2. It is part of the basis for modern atomic theory.
3. Dalton’s theory states that all matter is composed from different combinations of atoms, which act as indivisible building blocks.
4. The law of definite composition and the law of conservation of mass.

Review

Questions

1. State the law of multiple proportions.
2. In carbon dioxide, how many grams of oxygen would there be if there are 24 grams of carbon?
3. How many grams of carbon would be present in carbon monoxide that contains 2.66 grams of oxygen?

Answers

1. Whenever the same two elements form more than one compound, the different masses of one element that combine with the same mass of the other element are in the ratio of small whole numbers.
2. 64 grams.
3. 1 gram.

4.5 Mass Ratio Calculations

Practice

Questions

Use the link below to answer the following questions:

http://www.ehow.com/how_8326233_calculate-mass-ratio.html

1. What is the mass ratio?
2. What is the hydrogen:water mass ratio
3. How many molecules of water per molecule of oxygen?

Answers

1. The percentage of mass of a product species that was contributed by one or more reactant species.
2. Two grams of hydrogen for every 18 grams of water.
3. Two.

Review
Questions

1. What does the mass ratio tell us?
2. In the compound CH₄, what is the carbon:hydrogen mass ratio?
3. Methane is CH₄ and ethane is C₂H₆. What is the mass ratio of carbon per gram of hydrogen in the two compounds?

Answers

1. The mass of an element that is found in combination with another element.
2. 12 g C:4 g H or 3:1.
3. For CH₄, the mass ratio is 12 g C:4 grams H or 3 g C/g H. For C₂H₆, we have (2x12) = 24 grams C for (6x1) = 6 grams H or 4 g C/g H. So the mass ratio of C in the two compounds is 4/3 or 1.33 to 1.

4.6 Dalton’s Atomic Theory

Practice

Questions

Use the link below to do the exercise. Read the sections and take the quiz at the end.
http://antoine.frostburg.edu/chem/senese/101/atoms/dalton.shtml

Answers

See answers on web site.

Review

Questions

1. How did the Greek and Roman philosophers study nature?
2. When did John Dalton start teaching school?
3. Did Dalton believe that atoms could be created or destroyed?
4. List the basic components of Dalton’s atomic theory.
5. What parts of the theory are not considered valid any more?

Answers

1. They discussed issues.
2. He was twelve years old.
3. No
4. The general tenets of this theory were as follows:
   o All matter is composed of extremely small particles called atoms.
Atoms of a given element are identical in size, mass, and other properties. Atoms of different elements differ in size, mass, and other properties.

- Atoms cannot be subdivided, created, or destroyed.
- Atoms of different elements can combine in simple whole number ratios to form chemical compounds.
- In chemical reactions, atoms are combined, separated, or rearranged.

5. The second and third points.

4.7 Cathode Ray Tube

Practice

Questions

Use the link below to answer the following questions:

http://www.madehow.com/inventorbios/92/William-Crookes.html

1. What did Crookes start to study in college?
2. Who changed his mind and what did he then focus on?
3. What element did Crookes discover?
4. What did Crookes think was happening in the tube?

Answers

1. Organic chemistry
2. Michael Faraday, physics (optics)
3. Thallium
4. He believed a extragaseous fourth state of matter existed

Review

Questions

1. Who developed the first cathode ray tube?
2. What improvement did Crookes make to the cathode ray tube?
3. How did Crookes show there were particles being emitted?
4. What did Karl Ferdinand Braun invent?
5. What did Wilhelm Roentgen invent?

Answers

1. Heinrich Geissler
2. Better vacuum inside the tube.
3. He put an object between the cathode and the other end of the tube and showed that the object blocked cathode rays.
4. The oscilloscope.
5. X-ray machine.

4.8 Electrons

Practice

Questions

Research the discovery of electrons at the following URLs, and then answer the questions below.

- [http://www.youtube.com/watch?v=ldTxEjA4Jw](http://www.youtube.com/watch?v=ldTxEjA4Jw) (2:54)
- [http://www.aip.org/history/electron/jjhome.htm](http://www.aip.org/history/electron/jjhome.htm)

1. Who discovered electrons? When were they discovered?
2. Outline how electrons were discovered.
3. What was the significance of the discovery of electrons?
4. Where did Thomson think electrons were located in the atom? How does this differ from the modern view of electrons presented above?

Answers

1. The electron was discovered by J.J. Thomson in 1897.
2. Electrons were discovered by running an electrical current inside of an empty glass tube, in a study of cathode rays. Thomson believed the rays to be streams of particles smaller than an atom.
3. It was the first subatomic particle to be discovered.
4. Thomson believed that electrons were located throughout a positively charged atom.

Review

Questions

1. What are electrons?
2. Compare and contrast electrons and protons.
3. Sketch a model of a beryllium atom, which has four protons, five neutrons, and four electrons. Your model should include the placement of electrons at the appropriate energy levels.
4. What are valence electrons? Why are they so important? How many valence electrons does a beryllium atom have (see question 3)?

Answers
1. Electrons are one of the three main types of particles, which compose an atom. They have a charge of -1 and are very small. An atom has equal numbers of protons and electrons.
2. Electrons have a negative charge, while protons have a positive charge. Protons are located within the nucleus, while electrons are found outside the nucleus.
4. Valence electrons are electrons found on the outermost energy level of an atom. They are important because they are the electrons involved in chemical reactions among atoms. Beryllium has two valence electrons.

4.9 Oil Drop Experiment

Practice

Questions

Use the link below to answer the following questions:

http://www.aip.org/history/gap/Millikan/Millikan.html

1. Why did he take a position at Chicago?
2. How did he first make his mark at Chicago?
3. Was he happy with his situation? Explain your answer.
4. Why did Millikan use oil drops instead of water?
5. What other contributions did Millikan make to science?

Answers

1. He was offered a position by A.A. Micleson.
2. As a teacher and textbook writer.
3. No, because he wanted to spend more time on research.
5. He provided leadership in government support of science.

Review

Questions

1. How did Millikan learn physics in college?
2. What did Millikan use to pick up static charge?
3. Where did the oil drops go to be measured?

Answers
1. There was nobody on the faculty that could teach him.
2. Oil drops.
3. Between two charged plates.

4.10 Protons

Practice

Questions

Do the activity at the URL below for a better appreciation of the size of a proton.


Answers

130 meters, which is slightly larger than a football field.

Review

Questions

1. Describe protons.
2. What is the relationship between protons and elements?
3. Atoms, which are always neutral in electric charge, contain electrons as well as protons and neutrons. An electron has an electrical charge of -1. If an atom has three electrons, infer how many protons it has.
4. Identify the fundamental particles that make up a proton.

Answers

1. A proton is one of the three main particles of an atom. It has a charge of +1, a mass of 1 atomic mass unit (amu) and is found in the nucleus of an atom.
2. Each element has a unique number of protons.
3. Three
4. Quarks and gluons.

4.11 Neutrons

Practice

Questions
Read the article on neutrons at the following URL, and then complete the fill-in statements below.


1. ________ are created when you change the normal number of neutrons in an atom.
2. If many neutrons are added to an atom, it becomes ________.
3. Extra neutrons may be knocked out of the nucleus during the process of ________.
4. The only element that normally lacks neutrons is ________.

**Answers**

1. Isotopes
2. Radioactive
3. Radioactive decay

**Review**

**Questions**

1. What is a neutron?
2. Compare and contrast neutrons and protons.
3. Explain how isotopes of an element differ from one another. Give an example.
4. Identify the fundamental particles that make up a neutron.

**Answers**

1. One of the three main particles in an atom. A neutron does not have a charge, and is located in the nucleus. There are generally the same number of neutrons and protons in an atom.
2. Neutrons and protons are both found in the nucleus, however a proton carries a charge of +1 and a neutron does not carry a charge.
3. Isotopes differ in the number of neutrons found in the nucleus. Carbon atoms generally have six neutrons, but carbon isotopes have either seven or eight neutrons. Carbon with eight neutrons is known as carbon-14 and is used to date fossils.
4. Neutrons are made from quarks and gluons.

**4.12 Thomson’s Atomic Model**
Practice

Questions

Use the link below to answer the following questions:

http://www.universetoday.com/38326/plum-pudding-model/

1. In the plum pudding model of the atom, what are the plums?
2. In this model, what is the dough?
3. What was the major purpose of the plum pudding model?
4. How is this model different from modern models of the atom?

Answers

1. The electrons.
2. The protons.
3. In the positively charged dough.
4. Modern models have a very compact proton nucleus surrounded by electrons.

Review

Questions

1. What is a model?
2. Why are models useful in science?
3. In Thomson’s model of the atom, where were the electrons?
4. What was the positive charge in this model?
5. What kept the electrons in the atom?
6. Whose model replaced Thomson’s?
7. What awards did Thomson receive?

Answers

1. A model gives an idea of what the real thing is.
2. They help us understand basic structures.
3. Embedded throughout the positive sphere.
4. The “dough.”
5. The positive charge.
6. Rutherford.
7. Nobel Prize in Physics (1906), a knighthood (1908).

4.13 Rutherford’s Atomic Model

Practice

Questions

http://www.universetoday.com/38326/plum-pudding-model/
Use the link below to answer the following questions:

http://www.icbse.com/topics/rutherfords-model-atom

1. How thick was the gold foil?
2. What alpha source did he use?
3. How many were deflected straight back?
4. What was one drawback of Rutherford’s theory?

Answers

1. \(10^{-4}\) mm.
2. Radium
3. About one in ten thousand.
4. It didn’t obey the laws dealing with electron revolving around a positively charged nucleus and it did not explain atomic line spectra.

Review

Questions

1. When did Rutherford and coworkers carry out their research?
2. What is an alpha particle?
3. How did Rutherford explain the observation that most alpha particles went straight through the gold foil?
4. What did he say about the particles that were deflected?
5. Describe Rutherford’s nuclear model.

Answers

1. 1911.
2. A helium nucleus.
3. Most of the atom was empty space.
4. The positive charge and mass was concentrated in a very small space inside the atom.
5. Dense nucleus of protons surrounded by cloud of electrons.

4.14 Atomic Nucleus

Practice

Questions

Watch this short video about how the nucleus was discovered, and then answer the questions below.
http://www.youtube.com/watch?v=Q8RuO2ekNGw (0:48)

1. Describe the scientific procedure that was used to discover the nucleus.
2. What evidence led scientists to conclude that atoms consist mostly of empty space with a very small, positively charged mass at the center?
3. Reflect on the method used in the experiment. Why was it important to send positive—as opposed to neutral or negative—particles toward the gold foil?

**Answers**

1. A beam of positive particles from a radioactive source was aimed at a phoshorescent screen. When a piece of gold foil was placed between the beam and the screen, most of the stream was able to pass through with no obstacle.
2. Because most of the positively charged particles were able to pass through with no obstacle it was believed most of the atom was empty space. Because some particles were deflected there must be a positively charged central mass in order for a small number of particles to be deflected.
3. Because the positively charged nucleus deflected the positive particles.

**Review**

**Questions**

1. Describe the nucleus of the atom.
2. Why is the nucleus positive in charge?
3. Explain why the nucleus is very dense.
4. Outline the forces that act on particles in the nucleus.
5. If you made a three-dimensional model of an atom and its nucleus, how would you represent the atom? How would you represent nucleus? Explain your choices.

**Answers**

1. A positively charged region at the center of an atom, which consists of protons and neutrons.
2. It contains protons.
3. The nucleus is very dense since it is extremely small and protons and neutrons have a lot of mass for their size.
4. The strong nuclear force holds together the protons and the neutrons, while electrical charges push the protons away from each other.
5. Answers will vary.
4.15 Atomic Number

Practice

Questions

Use the periodic table of the elements at the first URL below to fill in the blanks in the worksheet at the second URL.

- http://images.pcmac.org/SiSFiles/Schools/AL/BaldwinCounty/SpanishFortMiddle/Uploads/Forms/ANMNWorksheet.pdf

Answers

Use periodic table to check answers.

Review

Questions

1. What is the atomic number of an atom? Why is this number important?
2. Describe the atomic mass unit. What does it represent and what does it equal?
3. The symbol below represents an isotope of helium. How many protons and neutrons does it have?
   \[ ^5_2\text{He} \]
4. All carbon atoms have six protons. Most also have six neutrons, but some have seven or eight neutrons. What is the mass number of a carbon isotope that has seven neutrons?

Answers

1. The number of protons. It is unique for each element
2. One atomic mass unit (amu) is equal to the mass of a proton. It is used to represent the mass of an atom, known as the mass number.
3. 2 protons, 3 neutrons
4. 13

4.16 Mass Number

Practice

Questions

Use the link below to answer the following questions:

http://education.jlab.org/qa/pen_number.html
1. What data in the periodic table tells you the number of protons in an atom?
2. How do you determine the number of neutrons in an atom?
3. What is the mass number for an atom?

**Answers**

1. Atomic number
2. Subtract the atomic number from the atomic weight.
3. The sum of the particle in an atom’s nucleus.

**Review**

**Questions**

1. Who first determined atomic weights for elements?
2. What were the original atomic weights based on?
3. Why were calculations based on numbers of protons not valid for determining atomic weights?
4. A tin atom has an atomic number of 50 and a mass number of 118. How many neutrons are present in this atom?
5. What is the mass number of a cobalt atom that has 27 protons and 30 neutrons?

**Answers**

1. John Dalton.
2. Comparison to hydrogen.
3. The weight of the neutrons was not included.
4. 68.
5. 57.

**4.17 Isotopes**

**Practice**

**Questions**

At the following URL, watch the video about isotopes of carbon. Then answer the questions below.

http://www.youtube.com/watch?v=BvNHKBq2GW4 (6:42)

1. How does carbon-14 form?
2. Carbon-14 slowly decays over time because it is radioactive. Why does the percent of carbon-14 remain the same in living organisms?
3. How can the percent of carbon-14 in a dead organism be used to estimate the amount of time that has passed since the organism died?

**Answers**

1. It is formed in the atmosphere from cosmic rays.
2. Because it exists in the atmosphere in a certain ratio and so when an organism breathes in or takes in carbon, it takes in a specific ratio of carbon-14 compared to carbon-12, which keeps the percentage stable.
3. Because it decays at a known rate, carbon-14 can be measured to determine how much has decayed and then used to figure out how long it has been since the organism died.

**Review**

**Questions**

1. What are isotopes?
2. Why do different isotopes of an element generally have the same physical and chemical properties?
3. Describe the three isotopes of hydrogen.
4. Relate the concepts of isotope and mass number.
5. All oxygen atoms have eight protons, and most have eight neutrons as well. What is the mass number of an oxygen isotope that has nine neutrons? What is the name of this isotope?
6. Why are many isotopes radioactive?

**Answers**

1. Atoms with different numbers of neutrons compared to protons.
2. Because they have the same number of protons and electrons.
3. Hydrogen has no neutrons, deuterium has one neutron and a mass of 2 amu, and tritium has two neutrons and a mass of 3 amu.
4. The mass number is the sum of its protons and neutrons, because an element always has the same number of protons, the mass can indicate how many neutrons are in an isotope.
5. 17, this is called Oxygen-17.
6. Atoms need a certain ratio of neutrons to protons for the nucleus to be stable. Too many or too few neutrons can make it radioactive, which means it is unstable and will decay in order to have a more stable neutron to proton ratio.

**4.18 Atomic Mass Unit**

**Practice**
Questions

Use the link below to answer the following questions:

http://www.wisegeek.com/what-is-the-atomic-mass-unit.htm#lbss

1. What is the atomic mass unit based on?
2. What is another term for atomic mass unit?
3. What mistake is in the second paragraph?

Answers

1. It is based on 1/12 of the total mass of a carbon-12 atom.
2. A Dalton.
3. Most hydrogen atoms do not contain neutrons.

Review

Questions

1. What instrument is used to measure the mass of atoms?
2. How much does a single oxygen-16 atom weigh in grams?
3. What is the reference standard for atomic mass units?
4. How is an atomic mass unit defined?
5. Why are the numbers for atomic mass of individual atoms not whole numbers?

Answers

1. Mass spectrometer.
2. $2.66 \times 10^{-23}$ g.
3. Carbon-12
4. a mass equal to one twelfth the mass of an atom of carbon-12
5. binding energy affects mass numbers

4.19 Calculating Atomic Mass

Practice

Questions

Click on the link below to get some experience in atomic mass determinations:


Answers

See answers on the web site.
Review

Questions

1. Define atomic mass.
2. What information do you need to calculate atomic mass for an element?
3. Calculate the atomic mass for carbon using the following data:

<table>
<thead>
<tr>
<th>mass number</th>
<th>exact weight</th>
<th>percent abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>12.000000</td>
<td>98.90</td>
</tr>
<tr>
<td>13</td>
<td>13.003355</td>
<td>1.10</td>
</tr>
</tbody>
</table>

Answers

1. The atomic mass of an element is the weighted average of the atomic masses of the naturally occurring isotopes of that element
2. The percent abundance of each isotope.
3. \((12.000000 \times 0.9890) + (13.003355 \times 0.0110) = 12.011 \text{ amu}\)