Atomic Theory Chem (DH) Practice Test (Sample)

Study Guide

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Questions

1. What is an atom primarily defined as?

- **A. The smallest unit of a chemical element**
- **B. A type of particle found only in molecules**
- **C. The basic structure of a metallic compound**
- **D. A group of molecules bonded together**

2. What is the charge of the nucleus of an atom?

- **A. Negative**
- **B. Neutral**
- **C. Positive**
- **D. Varies**

3. What defines an ion?

- **A. An atom with a neutral charge**
- **B. An atom that has gained or lost neutrons**
- **C. An atom that has gained or lost electrons, resulting in a net charge**
- **D. An atom with an equal number of protons and electrons**

4. What did the deflection of alpha particles in Rutherford's experiment indicate?

- **A. The presence of negatively charged particles**
- **B. The existence of a positively charged nucleus**
- **C. The existence of neutral particles**
- **D. The particles were too heavy to penetrate**

5. What does light need to exhibit behavior as a particle?

- **A. High intensity**
- **B. Absence of interference**
- **C. A certain energy threshold**
- **D. A vacuum**

6. How would you describe the flow of a cathode ray in a cathode-ray tube?

- **A. The flow is a circular motion from anode to cathode**
- **B. The flow is a stream of neutrons moving upwards**
- **C. The flow consists of electrons moving from cathode to anode**
- **D. The flow consists of protons moving horizontally**

7. How do isotopes of a given element differ?

- **A. In the number of protons**
- **B. In the number of electrons**
- **C. In the number of neutrons**
- **D. In atomic mass**

8. How are the three p orbitals of an atom's 2p sublevel oriented?

- **A. Along a single axis**
- **B. Mutually perpendicular along the x, y, and z axes**
- **C. In a circular arrangement**
- **D. Randomly oriented in space**

9. Why does the atomic radius decrease as you move from left to right across a period?

- **A. The number of protons increases, pulling electrons closer**
- **B. The number of neutrons increases, reducing electron repulsion**
- **C. The number of electrons decreases, resulting in a smaller size**
- **D. The number of orbitals increases, allowing atoms to expand**

10. In the order of filling atomic orbitals, which orbital comes after 3p?

- **A. 3d**
- **B. 4s**
- **C. 4p**
- **D. 5s**

Answers

1. A
2. C
3. C
4. B
5. C
6. C
7. C
8. B
9. A
10. B

Explanations

1. What is an atom primarily defined as?

A. The smallest unit of a chemical element

B. A type of particle found only in molecules

C. The basic structure of a metallic compound

D. A group of molecules bonded together

An atom is primarily defined as the smallest unit of a chemical element because it retains all the properties of that element. Each atom consists of a nucleus containing protons and neutrons, surrounded by electrons in various energy levels. This definition is fundamental in chemistry because it distinguishes atoms as the building blocks of matter, which can combine to form molecules and compounds. Atoms cannot be broken down into smaller parts while still maintaining their elemental properties, which is a key point in understanding their importance in chemical reactions and the structure of matter. While other options mention aspects related to atoms, they do not accurately define what an atom is. For example, atoms are not merely particles found in molecules; they are the constituents that make up molecules. Additionally, the notion of an atom being a part of metallic compounds or groups of molecules is a misrepresentation of how atoms function in chemistry.

2. What is the charge of the nucleus of an atom?

A. Negative

B. Neutral

C. Positive

D. Varies

The nucleus of an atom is positively charged due to the presence of protons, which carry a positive charge. In addition to protons, the nucleus may also contain neutrons, which are neutral and do not contribute to the overall charge. The positive charge of the nucleus is essential because it attracts negatively charged electrons, which orbit around the nucleus, creating a stable atomic structure. This interaction between the positive nucleus and negative electrons is a fundamental principle of atomic theory, helping to explain the behavior of atoms during chemical reactions. The nucleus's charge remains consistent across different atoms, as the number of protons determines the element, making the correct choice a positive charge.

3. What defines an ion?

A. An atom with a neutral charge

B. An atom that has gained or lost neutrons

C. An atom that has gained or lost electrons, resulting in a net charge

D. An atom with an equal number of protons and electrons

An ion is defined specifically by its charge, which arises from the gain or loss of electrons. When an atom loses one or more electrons, it becomes positively charged and is referred to as a cation. Conversely, if an atom gains electrons, it becomes negatively charged and is known as an anion. This process impacts the balance between protons and electrons within the atom, which are typically equal in a neutral atom. Therefore, the defining characteristic of an ion is indeed the change in the number of electrons, leading to a net charge that differentiates it from a neutral atom.

4. What did the deflection of alpha particles in Rutherford's experiment indicate?

A. The presence of negatively charged particles

B. The existence of a positively charged nucleus

C. The existence of neutral particles

D. The particles were too heavy to penetrate

The deflection of alpha particles in Rutherford's experiment provided significant insight into the structure of the atom. When alpha particles, which are positively charged, were directed at a thin gold foil, most passed through with little or no deflection. However, a small fraction were deflected at large angles, and some even bounced back toward the source. This unexpected deflection indicated that there must be a concentrated area of positive charge within the atom that repels the positively charged alpha particles. This region is much smaller compared to the overall size of the atom, leading Rutherford to propose the existence of a positively charged nucleus at the center of the atom. The deflections observed were due to the strong electrostatic force between the charged alpha particles and the positively charged nucleus, confirming that the nucleus is responsible for the majority of an atom's mass and its positive charge. This groundbreaking conclusion laid the foundation for modern atomic theory, shifting the focus from the previously proposed "plum pudding" model to one that recognizes the nucleus as the core of the atom surrounded by electrons in a relatively vast amount of empty space.

5. What does light need to exhibit behavior as a particle?

A. High intensity

B. Absence of interference

C. A certain energy threshold

D. A vacuum

Light exhibits behavior as a particle when it has a certain energy threshold because this concept aligns with the principles of quantum mechanics, particularly the photoelectric effect. This phenomenon occurs when light of sufficient energy strikes a material and causes the emission of electrons. The energy of the photons (light particles) must be above a specific threshold for the interaction to result in the ejection of electrons. This threshold energy is typically associated with the frequency of the light; as per Planck's equation, higher frequency (or shorter wavelength) light corresponds to higher energy photons. In the context of the question, the other choices do not directly relate to light's particle-like behavior. High intensity refers to the number of photons and does not influence their particle characteristics. The absence of interference relates to wave behavior, which is different from particle behavior. A vacuum is not a requirement for light to behave as a particle; light can exhibit particle characteristics in various media as long as the energy threshhold is met. Therefore, the energy threshold is the key factor that allows light to display its particle nature.

6. How would you describe the flow of a cathode ray in a cathode-ray tube?

A. The flow is a circular motion from anode to cathode

B. The flow is a stream of neutrons moving upwards

C. The flow consists of electrons moving from cathode to anode

D. The flow consists of protons moving horizontally

The flow in a cathode-ray tube is accurately described as a stream of electrons moving from the cathode to the anode. In these tubes, a high voltage is applied, causing electrons to be emitted from the cathode, which is the negatively charged electrode. These emitted electrons then travel through a vacuum towards the positively charged anode. Since electrons carry a negative charge, they are attracted to the positive charge of the anode, leading them to move in a straight line towards it. This process is fundamental in understanding the behavior of cathode rays and forms the basis of many applications, including early television sets and oscilloscopes, where controlled streams of electrons are used to create images or display signals.

7. How do isotopes of a given element differ?

A. In the number of protons

B. In the number of electrons

C. In the number of neutrons

D. In atomic mass

Isotopes of a given element are defined by their differences in the number of neutrons within the atomic nucleus. This distinction in neutron count leads to variations in the atomic mass of these isotopes, but it is the neutron difference that fundamentally identifies them as isotopes of the same element. While the number of protons determines the identity of an element and the number of electrons typically matches the number of protons in a neutral atom, isotopes retain the same atomic number because they have the same number of protons—making the neutron count the key differentiating factor. As a result, isotopes will exhibit different physical properties and stability based on the varying number of neutrons, affecting their overall atomic mass.

8. How are the three p orbitals of an atom's 2p sublevel oriented?

A. Along a single axis

B. Mutually perpendicular along the x, y, and z axes

C. In a circular arrangement

D. Randomly oriented in space

The three p orbitals in an atom's 2p sublevel are oriented mutually perpendicular along the x, y, and z axes. This arrangement reflects the geometrical symmetry of the p orbitals, which are often visualized as having a lobular shape with a nodal plane where the probability of finding an electron is zero. Each of the three p orbitals—2p_x, 2p_y, and 2p_z—aligns along one of the three Cartesian axes, allowing them to occupy different spatial regions around the nucleus. This specific orientation allows for the maximization of electron density in different directions while minimizing electron-electron repulsions when the atom is part of a larger molecular structure. By being mutually perpendicular, the 2p orbitals can effectively interact with other atomic orbitals, which is essential in the formation of chemical bonds and the overall molecular geometry. This clear and defined orientation is a fundamental characteristic of the p sublevel and is essential for understanding the behavior of electrons in atoms.

9. Why does the atomic radius decrease as you move from left to right across a period?

A. The number of protons increases, pulling electrons closer

B. The number of neutrons increases, reducing electron repulsion

C. The number of electrons decreases, resulting in a smaller size

D. The number of orbitals increases, allowing atoms to expand

The atomic radius decreases as you move from left to right across a period primarily because the number of protons in the nucleus increases. This increase in nuclear charge attracts the electrons more strongly towards the nucleus. As each successive element in a period has an additional proton, the effective nuclear charge felt by the outermost electrons increases. Although additional electrons are added as well, they enter the same electron shell, which doesn't significantly shield the increased positive charge of the nucleus. Consequently, this results in a stronger attraction that pulls the electrons closer, effectively reducing the atomic radius. The other options do not accurately explain the trend. For instance, neutrons, while they contribute to the overall mass of the atom, do not directly affect the size of the atomic radius since they do not carry a charge. Similarly, the atomic radius does not decrease due to a reduction in the number of electrons or an increase in the number of orbitals; both of those factors would not result in the observed trend of decreasing atomic size across a period. Therefore, the increase in the number of protons and its effect on electron attraction is the driving factor behind the reduction in atomic radius.

10. In the order of filling atomic orbitals, which orbital comes after 3p?

A. 3d

B. 4s

C. 4p

D. 5s

The correct answer is 4s. The order in which atomic orbitals are filled is determined by the Aufbau principle, which states that electrons occupy the lowest energy orbitals available before filling higher energy ones. In this context, after the 3p orbitals are filled, the next orbital to fill is the 4s orbital. This is because the 4s orbital has a lower energy than the 3d orbital. As a result, even though the 3d orbitals are in the same principal quantum number period as the 4s, they are higher in energy and are filled after the 4s orbital. Understanding this filling order is crucial for predicting the electron configurations of elements in the periodic table and recognizing how these configurations influence the chemical properties of the elements.