National Council of Examiners for Engineering and Surveying (NCEES) Fundamentals of Engineering (FE) Chemical Practice Exam (Sample)

Study Guide

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Questions

1. **What does the fluids continuity equation express?**
   - A. Energy conservation in fluids
   - B. Mass flow rate conservation in fluids
   - C. Pressure distribution in fluids
   - D. Viscosity variations in fluids

2. **What does the atomic number of an element signify?**
   - A. The total number of neutrons
   - B. The number of electrons in ionized atoms
   - C. The number of protons in an atom
   - D. The average mass of an atom

3. **How does the viscosity of a liquid change as temperature increases?**
   - A. It increases
   - B. It decreases
   - C. It remains constant
   - D. It depends on the liquid type

4. **What happens to a body when the buoyant force is equal to its weight?**
   - A. The body sinks
   - B. The body floats
   - C. The body rises
   - D. The body displaces more water

5. **According to the normality equation, how is normality defined?**
   - A. N = Molarity + (number of H+ or OH-)
   - B. N = (Molarity) x (volume)
   - C. N = (Molarity) x (number of H+ in acid or OH- in base)
   - D. N = Molarity / (number of H+ in acid or OH- in base)

6. What does a passive metal mean in terms of corrosion?

- **A. It undergoes rapid corrosion**
- **B. It forms protective layers that prevent corrosion**
- **C. It requires high temperatures to corrode**
- **D. It cannot be oxidized**

7. What is the charge of the carbonate ion?

- **A. +1**
- **B. -1**
- **C. -2**
- **D. 0**

8. Under what conditions can the compressibility factor be assumed to be 1?

- **A. For all gases at high temperatures**
- **B. For most gases unless at very high pressure or much below ambient temperature**
- **C. Only for noble gases**
- **D. For liquids at high pressure**

9. What characterizes heterogeneous reactions?

- **A. Reactions that occur in a single phase**
- **B. Reactions involving gases only**
- **C. Reactions that include reactants in at least two different phases**
- **D. Reactions with only one reactant**

10. What does the impulse equation represent?

- **A. Impulse = force x distance**
- **B. Impulse = force x time**
- **C. Impulse = mass x acceleration**
- **D. Impulse = mass x velocity**

Answers

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

Explanations

1. What does the fluids continuity equation express?

A. Energy conservation in fluids

B. Mass flow rate conservation in fluids

C. Pressure distribution in fluids

D. Viscosity variations in fluids

The fluids continuity equation expresses the principle of mass flow rate conservation in fluids, which is a fundamental concept in fluid dynamics. This principle states that for an incompressible fluid flowing through a closed system, the mass flow rate must remain constant from one cross-section of the system to another. Essentially, it indicates that the amount of mass entering a particular volume must equal the amount of mass exiting that volume if the fluid density remains unchanged. Mathematically, the continuity equation can be expressed as A1V1 = A2V2, where A represents the cross-sectional area and V represents the fluid velocity. This relationship shows how changes in area affect fluid velocity to maintain mass conservation. Understanding this principle is essential for analyzing fluid systems in engineering applications, as it helps in the design and optimization of various fluid transport systems, such as pipelines and ducts.

2. What does the atomic number of an element signify?

A. The total number of neutrons

B. The number of electrons in ionized atoms

C. The number of protons in an atom

D. The average mass of an atom

The atomic number of an element is defined as the number of protons present in the nucleus of an atom of that element. This fundamental property uniquely identifies an element, as different elements have different numbers of protons. For instance, hydrogen, which has an atomic number of 1, has one proton, while carbon has an atomic number of 6, indicating that it contains six protons. In a neutral atom, the number of protons also equals the number of electrons, which determines the atom's overall charge. However, since the question specifically asks about the atomic number, it is important to highlight that it primarily pertains to protons. The other potential answers do not accurately describe the atomic number. For instance, the total number of neutrons is not related to the atomic number but is indicated by the mass number, which is the sum of protons and neutrons. The number of electrons in ionized atoms can vary depending on the ion's charge, making it an unreliable indicator of atomic number in general. Finally, the average mass of an atom refers to the atomic mass, which is a weighted average based on isotopes and their relative abundances, rather than directly correlating to the number of protons. Thus, the atomic number

3. How does the viscosity of a liquid change as temperature increases?

- A. It increases
- B. It decreases
- C. It remains constant
- D. It depends on the liquid type

The viscosity of a liquid typically decreases as the temperature increases. This behavior can be understood through the kinetic theory of liquids. As temperature rises, the thermal energy of the molecules also increases. This increased energy leads to greater molecular motion, allowing the molecules to overcome intermolecular forces that resist flow. As a result, the liquid becomes less viscous, or "thinner," facilitating easier movement among the molecules. For many common liquids, this trend is consistent, making it a reliable observation in thermodynamics and fluid mechanics. The specific decrease in viscosity with temperature can vary among different liquids, but the general trend holds true across a wide range of cases. Understanding this relationship is essential in various applications, such as process engineering, where the flow characteristics of fluids are crucial for designing efficient systems.

4. What happens to a body when the buoyant force is equal to its weight?

- A. The body sinks
- B. The body floats
- C. The body rises
- D. The body displaces more water

When the buoyant force acting on a body is equal to its weight, the body is in a state of equilibrium in a fluid. This condition means that the upward force exerted by the fluid (buoyant force) counterbalances the downward gravitational force (weight) on the body. In this state, the body neither sinks nor rises, which results in it floating at a certain level within the fluid. The buoyant force arises from the pressure difference between the top and bottom of the submerged body due to the weight of the fluid above it. When these forces are equal, the net force acting on the body is zero, leading to stable floating conditions. This concept is governed by Archimedes' principle, which states that the buoyant force on a submerged object is equal to the weight of the fluid that the object displaces. It is essential to understand that when a body floats, it displaces a volume of fluid equal to its weight, which is why the situation is one of balance rather than movement up or down in the fluid.

5. According to the normality equation, how is normality defined?

A. N = Molarity + (number of H+ or OH-)

B. N = (Molarity) x (volume)

C. N = (Molarity) x (number of H+ in acid or OH- in base)

D. N = Molarity / (number of H+ in acid or OH- in base)

Normality is defined as the concentration of a solution in terms of equivalent solute per liter of solution. Specifically, it reflects the reactivity of the solute in relation to acid-base reactions or redox reactions. The equation for normality indicates that it is calculated by multiplying the molarity of the solution by the number of equivalents (H+ ions in acids or OH- ions in bases) that each molecule can produce in reactions. When considering option C, it accurately states that normality (N) is equal to the molarity multiplied by the number of H+ ions in acids or OH- ions in bases. This captures the essence that normality accounts for the active species that participate in reactions. For example, sulfuric acid (H2SO4) has two equivalents of H+ ions per molecule, so its normality would be twice the molarity. Other options do not correctly convey the definition of normality. For instance, the first option mistakenly adds molarity and the number of equivalents instead of multiplying them, which does not align with the definition of normality. The second option mentions volume, which is not a factor in calculating normality directly from molarity. The last option inversely relates molarity to the number of

6. What does a passive metal mean in terms of corrosion?

A. It undergoes rapid corrosion

B. It forms protective layers that prevent corrosion

C. It requires high temperatures to corrode

D. It cannot be oxidized

A passive metal refers to a type of metal that develops a protective oxide layer on its surface, which helps to prevent further corrosion. This passive film acts as a barrier that inhibits the electrochemical reactions necessary for corrosion to occur. Many metals, such as aluminum, stainless steel, and titanium, exhibit this behavior when they are exposed to an oxidizing environment. The protective layer that forms is often stable and adheres tightly to the metal, which is crucial because it reduces the rate at which the underlying metal can be oxidized. The passive state can be enhanced through processes like anodization, which increases the thickness of the oxide layer, thereby enhancing corrosion resistance. The other options address different aspects of corrosion and metal behavior. Rapid corrosion typically describes active metals, high temperatures relate to thermodynamic factors influencing corrosion rates, and the idea that a metal cannot be oxidized contradicts the natural oxidation processes that all metals undergo under certain conditions.

7. What is the charge of the carbonate ion?

A. +1

B. -1

C. -2

D. 0

The carbonate ion, which has the chemical formula CO_3^{2-}, carries a charge of -2. This can be understood by examining the structure and the oxidation states of the elements involved. In the carbonate ion, carbon has an oxidation state of +4, while each oxygen atom typically has an oxidation state of -2. Given that there are three oxygen atoms, the total contribution from the oxygen is -6. To balance the total charge of the ion to reflect its overall -2 charge, the carbon must therefore have a +4 oxidation state. When you add up the contributions from each atom (one +4 from carbon and three -2 from oxygen), you obtain a net charge of -2, confirming the charge of the carbonate ion. Recognizing the typical charges of common polyatomic ions is important for solving related problems in chemistry, especially in the context of chemical reactions and compound formation.

8. Under what conditions can the compressibility factor be assumed to be 1?

A. For all gases at high temperatures

B. For most gases unless at very high pressure or much below ambient temperature

C. Only for noble gases

D. For liquids at high pressure

The compressibility factor (Z) is a dimensionless number that indicates how much a real gas deviates from the ideal gas behavior, where it equals 1. The correct scenario in which the compressibility factor can be reasonably assumed to be 1 is for most gases under conditions of low pressure and moderate temperatures. At high temperatures, gases tend to behave more ideally due to increased kinetic energy, which overcomes intermolecular forces. However, it is important to note that the assumption of Z being 1 can fail at very high pressures, where interactions between molecules become significant, or at temperatures much lower than ambient, where gas behavior diverges from ideal due to condensation effects or decreased molecular motion. Thus, for most gases, unless they are at very high pressure or extreme low temperatures, the compressibility factor can be approximated as 1, allowing for simplifying calculations in various chemical engineering applications.

9. What characterizes heterogeneous reactions?

A. Reactions that occur in a single phase

B. Reactions involving gases only

<u>C. Reactions that include reactants in at least two different phases</u>

D. Reactions with only one reactant

Heterogeneous reactions are characterized by the presence of reactants in at least two different phases, which could include combinations of solids, liquids, and gases. This distinction is significant because the phase of the reactants affects how the reaction occurs and its rate. For example, in a heterogeneous catalysis scenario, a solid catalyst interacts with gaseous or liquid reactants, leading to a reaction that is influenced by the surface area of the solid and the concentration of the reactants in the other phases. This contrasts with homogeneous reactions, where all reactants are in the same phase, allowing for more uniform interaction among the molecules. The differentiation between phases plays a crucial role in reaction dynamics, kinetics, and the pathways through which reactions proceed, making this aspect fundamental for understanding various chemical processes, particularly in industrial applications. The other options misrepresent the nature of heterogeneous reactions. Reactions that occur in a single phase refer to homogeneous reactions, while focusing solely on gases does not encompass the wider range of phase interactions present in heterogeneous systems. Furthermore, the concept of a reaction involving only one reactant does not align with the definition of heterogeneous reactions, which typically involve multiple substances interacting across different phases.

10. What does the impulse equation represent?

A. Impulse = force x distance

<u>B. Impulse = force x time</u>

C. Impulse = mass x acceleration

D. Impulse = mass x velocity

The impulse equation is defined as the product of the average force exerted on an object and the time duration over which that force acts. This relationship is crucial in understanding how forces influence the motion of an object. When a force is applied to an object for a specified duration of time, it changes the object's momentum, which is the product of its mass and velocity. Impulse specifically quantifies this change in momentum. Mathematically, impulse is expressed as: Impulse = Force × Time This relationship is derived from Newton's second law, which states that force is the rate of change of momentum. By integrating force over time, you can determine the total impulse imparted to the object, which is equal to the change in momentum experienced by the object as a result of the applied force acting over a certain period. Since impulse directly relates to the changes that occur during interactions involving forces and time, this makes the equation representative of how dynamics operate in real-world scenarios, such as collisions or any interactions where force is applied over a period. This understanding is fundamental in fields like mechanical and chemical engineering, where controlling dynamics and understanding system responses to forces is key.