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. **Which process occurs at the cathode in a galvanic cell?**
   - **A. Oxidation**
   - **B. Reduction**
   - **C. Electrolysis**
   - **D. Corrosion**

2. **Which principle is illustrated by the constant molar overflow assumption?**
   - **A. The flow rates for both phases fluctuate significantly**
   - **B. The flow rates for liquid and vapor remain constant throughout the process**
   - **C. The flow rates have a direct correlation to temperature**
   - **D. Flow rates differ based on the composition of the mixture**

3. **Which of the following describes the total energy conservation principle?**
   - **A. Total KE equals total PE**
   - **B. Total energy before collision equals total energy after collision**
   - **C. Only kinetic energy is conserved**
   - **D. Potential energy is always zero**

4. **When control blocks are in series, how do their transfer functions combine?**
   - **A. Their transfer functions add**
   - **B. Their transfer functions multiply**
   - **C. Their transfer functions subtract**
   - **D. Their transfer functions remain unchanged**

5. **How can you determine the amount of condensation using a psychrometric chart?**
   - **A. By using T1 and RH2 to find humidity ratio 2**
   - **B. By moving from the saturation line to T3 on the chart**
   - **C. By using T1 and RH1 to find humidity ratio 1 and then T2 on saturation line**
   - **D. By calculating the difference between T1 and T2**

6. **When balancing combustion equations, what should be added to the right side when considering excess air?**
   - **A. Only the nitrogen produced**
   - **B. Oxygen and its stoichiometric coefficient multiplied by the % excess air**
   - **C. Only oxygen**
   - **D. The total combustion products**

7. **Which of the following conditions is necessary for the equilibrium constant to be valid?**
   - **A. The reaction must be a single phase**
   - **B. The concentrations of reactants and products must be constant**
   - **C. The reaction must proceed to completion**
   - **D. The temperature must remain constant**

8. **What does heat flux represent in the context of heat transfer?**
   - **A. The total heat transfer**
   - **B. The rate of heat transfer per unit area**
   - **C. The difference in temperature**
   - **D. The total area of heat exchange**

9. **Which factor is used to characterize the toughness of a material in mechanical testing?**
   - **A. Yield strength**
   - **B. Ultimate tensile strength**
   - **C. Charpy impact strength**
   - **D. Fatigue limit**

10. **What is an important aspect of calculating the relationship between distance, velocity, and acceleration?**
   - **A. Velocity is always equal to distance**
   - **B. Acceleration is the derivative of distance with respect to time**
   - **C. Distance and acceleration are inversely related**
   - **D. Velocity is not related to distance**

Answers

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

Explanations

1. Which process occurs at the cathode in a galvanic cell?

A. Oxidation

B. Reduction

C. Electrolysis

D. Corrosion

In a galvanic cell, the process that occurs at the cathode is reduction. The cathode is defined as the electrode where the reduction reaction takes place, meaning that it is the site where electrons are gained by the ions. When a substance is reduced, it undergoes a decrease in oxidation state, which is typically accompanied by the gaining of electrons. In a galvanic cell, the anode is where oxidation occurs, and this reaction involves the loss of electrons. The electrons produced at the anode flow through an external circuit to the cathode, where they are accepted by the reducible species present. This flow of electrons from the anode to the cathode is what generates electrical energy in galvanic cells. The choices regarding electrolysis and corrosion do not pertain to the functions of the electrodes in a conventional galvanic cell. Electrolysis refers to the process of using electrical energy to drive a non-spontaneous chemical reaction and typically occurs in electrolytic cells rather than galvanic cells. Corrosion involves the deterioration of metals due to electrochemical processes and can involve both oxidation and reduction but is not a specific process tied to the function of the cathode in a galvanic cell. Hence, the clear distinction of reduction occurring at the cath

2. Which principle is illustrated by the constant molar overflow assumption?

A. The flow rates for both phases fluctuate significantly

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The constant molar overflow assumption is based on the premise that the flow rates for both the liquid and vapor phases remain constant throughout the process. This principle is crucial in many chemical engineering applications, particularly when analyzing systems involving phase changes, such as distillation, absorption, or other separation processes. Under the constant molar overflow assumption, the liquid and vapor phases are treated as if they flow at steady rates, which simplifies calculations and modeling. This allows for a more straightforward analysis of mass and energy balances within the system. It assumes that the amount of liquid and vapor does not change as they pass through any specific section of the system, which is key for determining how substances interact and change phases during the operation. This concept is beneficial because it helps engineers make predictions about the behavior of the system without needing to account for variations in flow rates, thus enabling more efficient designs and operational parameters.

3. Which of the following describes the total energy conservation principle?

- A. Total KE equals total PE
- B. Total energy before collision equals total energy after collision
- C. Only kinetic energy is conserved
- D. Potential energy is always zero

The total energy conservation principle states that the total energy of an isolated system remains constant over time. This principle implies that energy can neither be created nor destroyed, but can only change forms. When considering the context of collisions, the principle asserts that the total energy present in the system before the collision is equal to the total energy present after the collision. This includes all forms of energy, such as kinetic energy, potential energy, thermal energy, and any other forms that may be present in the system. In the context of option B, it clearly captures the essence of energy conservation: that regardless of energy transformations that occur during the collision, the sum of all forms of energy remains unchanged. This is a fundamental concept in both classical mechanics and thermodynamics. Other options do not adequately reflect the total energy conservation principle. For example, the first choice suggests a relationship strictly between kinetic energy (KE) and potential energy (PE), which does not encompass all forms of energy. The third option misleadingly indicates that only kinetic energy is conserved, omitting potential energy and other forms. Finally, the statement that potential energy is always zero is inaccurate as potential energy can vary based on a system's configuration, such as the height in a gravitational field. Collectively, these

4. When control blocks are in series, how do their transfer functions combine?

- A. Their transfer functions add
- B. Their transfer functions multiply
- C. Their transfer functions subtract
- D. Their transfer functions remain unchanged

When control blocks are connected in series, the overall transfer function of the system is found by multiplying the individual transfer functions of each block. This reflects how the output of one block becomes the input for the next block in the series. Each block applies its own transformation to the input signal, and the effect of these transformations combines multiplicatively. For example, if you have two transfer functions, represented as H1(s) and H2(s), the total transfer function H(s) for the series connection would be expressed as H(s) = H1(s) * H2(s). This multiplication preserves the system dynamics and appropriately represents the cumulative effect of the control blocks in influencing the final output based on the inputs. Therefore, the multiplication of transfer functions in series is fundamental to control theory and helps in analyzing complex systems systematically.

5. How can you determine the amount of condensation using a psychrometric chart?

- A. By using T1 and RH2 to find humidity ratio 2
- B. By moving from the saturation line to T3 on the chart
- C. By using T1 and RH1 to find humidity ratio 1 and then T2 on saturation line
- D. By calculating the difference between T1 and T2

To determine the amount of condensation using a psychrometric chart, it's essential to correctly utilize the defined properties and relationships represented on the chart. The correct answer emphasizes the importance of first finding the initial state of the air using temperature \(T1 \) and relative humidity \(RH1 \) to establish the humidity ratio (or moisture content) at that point. Once you have identified the initial state (at point 1), you then can find the saturation line corresponding to temperature \(T2 \) to identify the conditions under which condensation occurs. By plotting \(T2 \) on the saturation line, you can determine the humidity ratio at saturation. The difference between the humidity ratio at the initial state (Point 1) and the saturation state (Point 2) gives you the amount of condensation that occurs when the air is cooled to that temperature. This approach effectively utilizes the capabilities of the psychrometric chart to analyze changes in state, including condensation, by considering both the initial conditions and the saturation point relevant to the new temperature. Thus, determining condensation involves establishing both the humidity ratios at the initial point and the saturation state.

6. When balancing combustion equations, what should be added to the right side when considering excess air?

- A. Only the nitrogen produced
- B. Oxygen and its stoichiometric coefficient multiplied by the % excess air
- C. Only oxygen
- D. The total combustion products

When balancing combustion equations with the consideration of excess air, it is essential to accurately represent all reactants and products involved in the reaction. In combustion, stoichiometric coefficients are important because they dictate the ratio of each substance that reacts and is produced. In the context of excess air, the combustion process often requires more air than the theoretical amount needed for complete combustion of the fuel. The excess air can be quantified as a percentage, and this percentage must be incorporated into the balanced equation. By adding oxygen and its stoichiometric coefficient multiplied by the percentage of excess air to the right side of the equation, you effectively account for the additional oxygen available for combustion beyond what is theoretically required. This adjustment is crucial because it ensures that the combustion equation reflects the actual conditions under which the combustion occurs, including the additional oxidizer present due to excess air. This method highlights the importance of correctly balancing the contributions from both the theoretical oxygen requirement and the additional amount due to excess air, thereby producing a complete and accurate representation of the combustion products.

7. Which of the following conditions is necessary for the equilibrium constant to be valid?

A. The reaction must be a single phase

B. The concentrations of reactants and products must be constant

C. The reaction must proceed to completion

D. The temperature must remain constant

The validity of the equilibrium constant is indeed dependent on the condition that the concentrations of reactants and products must be constant. In chemical equilibrium, the rates of the forward and reverse reactions are equal, resulting in no net change in the concentration of reactants and products over time. This static condition allows for the definition of the equilibrium constant, which is expressed as the ratio of the concentrations of the products to the reactants, raised to the power of their respective stoichiometric coefficients. Although other factors may impact the dynamics of the reaction, the concept of equilibrium specifically requires that the system has reached a state where the concentrations of all species involved are unchanging. This is essential to accurately calculate the equilibrium constant, which reflects the ratio of concentrations at equilibrium and not during the transient phases of the reaction. Understanding that the concentrations remain constant at equilibrium helps clarify the fundamental principles of chemical reactions and equilibria, making it a crucial concept for chemical engineers and professionals in the field.

8. What does heat flux represent in the context of heat transfer?

A. The total heat transfer

B. The rate of heat transfer per unit area

C. The difference in temperature

D. The total area of heat exchange

Heat flux is defined as the rate of heat transfer per unit area and is a critical concept in heat transfer analysis. It quantifies how much thermal energy passes through a given area over a specific period of time. This measurement is essential in various engineering applications, such as thermal insulation design, HVAC system performance, and various processes in chemical engineering, where understanding the rate of heat transfer can help optimize operations and improve energy efficiency. In this context, heat flux is typically expressed in units like watts per square meter (W/m^2), allowing engineers to analyze and compare heat transfer rates in different systems or components. The concept of heat flux emphasizes the relationship between the amount of heat being transferred and the area through which it is transferred, providing insight into the efficiency of heat transfer processes. The other options relate to heat transfer but do not accurately reflect what heat flux specifically represents. Total heat transfer refers to the cumulative amount of heat transferred over time, temperature difference indicates driving force for heat transfer and total area of heat exchange describes the physical dimensions of heat transfer surfaces. Understanding these distinctions is crucial for accurately applying principles related to heat transfer in practical scenarios.

9. Which factor is used to characterize the toughness of a material in mechanical testing?

A. Yield strength

B. Ultimate tensile strength

C. Charpy impact strength

D. Fatigue limit

Toughness is a material property that describes its ability to absorb energy and plastically deform without fracturing. It combines both strength and ductility, making it a critical characteristic for materials that will experience impact or dynamic loading. Charpy impact strength is specifically designed to measure this toughness by evaluating how much energy a material can absorb during fracture when subjected to a sudden load. In a Charpy test, a notched specimen is broken by a swinging pendulum, and the energy absorbed in the fracture process is recorded. A higher Charpy impact strength indicates a tougher material, capable of withstanding greater impact forces before failing. In contrast, yield strength primarily indicates the stress at which a material begins to deform plastically. Ultimate tensile strength measures the maximum stress a material can withstand while being stretched or pulled before necking occurs. The fatigue limit evaluates the maximum stress level a material can endure for an infinite number of load cycles without failing. While these properties provide valuable information about a material's performance under various loading conditions, they do not directly measure toughness in the same way the Charpy impact strength does.

10. What is an important aspect of calculating the relationship between distance, velocity, and acceleration?

A. Velocity is always equal to distance

B. Acceleration is the derivative of distance with respect to time

C. Distance and acceleration are inversely related

D. Velocity is not related to distance

The correct answer centers on the definition and mathematical relationship between distance, velocity, and acceleration in kinematics. Acceleration, which describes how the velocity of an object changes over time, is indeed the derivative of velocity; in a more foundational sense, it can be expressed as the second derivative of distance with respect to time. This reflects how a change in the distance traveled over a period of time produces a change in velocity, which itself can be an indicator of acceleration. Understanding this relationship is crucial, particularly in various applications across physics and engineering, where calculating motion parameters can inform everything from machinery design to transportation systems. By differentiating the distance function over time, one obtains velocity, and differentiating velocity again gives acceleration. This fundamental concept governs many principles of motion analysis and allows engineers to apply mathematical models to predict behavior under various conditions. In contrast, the other statements do not accurately convey the correct relationships or definitions within this context, thereby reinforcing the significance of option B in the study of motion.