# SACE Stage 2 Physics Practice Exam (Sample)

## Study Guide

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# Questions

1. **What does the potential difference in an X-ray tube achieve?**

   **A. It generates heat within the tube**

   **B. It decelerates electrons before hitting the target**

   **C. It accelerates the electrons, providing them kinetic energy**

   **D. It influences the color of the emitted X-rays**

2. **Which condition leads to constructive interference?**

   **A. When path difference is an odd multiple of half a wavelength**

   **B. When path difference is a whole wavelength**

   **C. When the amplitudes of both waves cancel out**

   **D. When the frequencies of both waves differ**

3. **What occurs during stimulated emission?**

   **A. An excited atom releases a photon in a random direction**

   **B. An energized atom drops to a higher state**

   **C. An incoming photon causes an atom to emit a photon in the same direction**

   **D. An atom absorbs energy from two incident photons**

4. **What are eddy currents?**

   **A. Currents that flow in open circuits**

   **B. Currents induced in small swirls within a conductor**

   **C. Currents that can only flow in liquid metals**

   **D. Currents that are always constant**

5. **What phenomenon describes the emission of electrons when light hits a material?**

   **A. Photoelectric effect**

   **B. Photochromic effect**

   **C. Thermal emission**

   **D. Electromagnetic induction**

**6. What is terminal velocity defined as?**

- **A. The speed of an object when the air resistance and gravity forces are equal**
- **B. The speed an object achieves when it stops falling**
- **C. The maximum height reached by a falling object**
- **D. The speed of an object without air resistance**

**7. What is ionization energy?**

- **A. The energy needed to split an atom**
- **B. The minimum energy required to remove an electron from an atom**
- **C. The energy released during an atomic absorption**
- **D. The energy associated with molecular bonding**

**8. What is required for a population inversion to occur in a set of atoms?**

- **A. More atoms in a lower energy state**
- **B. More atoms in a higher energy state than in a lower-energy state**
- **C. The lower energy state must be metastable**
- **D. A continuous absorption of energy**

**9. What is a diffraction grating?**

- **A. A surface that prevents light from passing through**
- **B. A device with multiple slits that produces light spectra**
- **C. An optical element that creates shadow patterns**
- **D. A tool to measure the speed of light**

**10. In what direction do electric field lines point with respect to positive and negative charges?**

- **A. Away from positive charges and towards negative charges**
- **B. Towards positive charges and away from negative charges**
- **C. In all directions equally**
- **D. Towards the center of positive charges**

# Answers

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

# Explanations

### 1. What does the potential difference in an X-ray tube achieve?

- A. It generates heat within the tube
- B. It decelerates electrons before hitting the target
- C. It accelerates the electrons, providing them kinetic energy
- D. It influences the color of the emitted X-rays

**The potential difference in an X-ray tube is crucial for its operation as it accelerates electrons from the cathode towards the anode. As the potential difference, or voltage, increases, it creates a stronger electric field that acts on the electrons. This acceleration enhances the kinetic energy of the electrons, enabling them to gain sufficient speed and energy as they travel through the tube. Upon striking the target material at the anode, these high-energy electrons interact with the atoms in the target, resulting in the production of X-rays. While other options address aspects of the X-ray tube's operation, they do not accurately describe the primary role of the potential difference. For example, while heat is generated as a by-product when electrons collide with the anode, it is not the primary purpose of the potential difference. The deceleration of electrons is not a function of the potential difference; rather, it is the electrons that are accelerated towards the target. Lastly, the color or wavelength of the emitted X-rays is determined by the energy of the electrons but is not directly influenced by the potential difference itself. The core function of the potential difference is indeed to accelerate the electrons, thereby providing them with the essential kinetic energy needed for X-ray production.**

### 2. Which condition leads to constructive interference?

- A. When path difference is an odd multiple of half a wavelength
- B. When path difference is a whole wavelength
- C. When the amplitudes of both waves cancel out
- D. When the frequencies of both waves differ

**Constructive interference occurs when two waves meet and combine to form a wave of greater amplitude. This phenomenon occurs under certain conditions regarding their relative phase positions as they overlap. When the path difference between the two waves is a whole wavelength, they arrive at the same point in phase, meaning that their peaks (crests) and troughs align perfectly. This alignment results in the addition of the wave amplitudes, thus leading to a wave with greater intensity. The significance of having a whole wavelength (0, 1, 2, etc.) as the path difference is crucial, as it ensures that the waves reinforce each other rather than cancel out. In contrast, when the path difference is an odd multiple of half a wavelength, the waves are out of phase. This results in destructive interference, where the crest of one wave meets the trough of the other, leading to cancellation and reduced amplitude. The amplitudes of both waves cancelling out directly pertains to destructive interference rather than constructive interference. Lastly, differing frequencies between waves typically lead to a complex pattern of interference that does not strictly result in constructive or destructive interference, but rather varying results over time. Understanding these principles can help clarify why the condition of having a path difference that corresponds to a whole wavelength leads**

## 3. What occurs during stimulated emission?

A. An excited atom releases a photon in a random direction

B. An energized atom drops to a higher state

C. An incoming photon causes an atom to emit a photon in the same direction

D. An atom absorbs energy from two incident photons

During stimulated emission, an incoming photon interacts with an excited atom, prompting it to release a second photon that has the same energy, frequency, and phase as the incoming one. This emitted photon travels in the same direction as the incoming photon, creating a coherent wave. The phenomenon is fundamental in laser operation, where this process leads to the amplification of light through multiple stimulated emissions, resulting in a highly focused and coherent beam. The other choices describe different processes that do not accurately depict stimulated emission. An excited atom releasing a photon in a random direction refers to spontaneous emission, where the direction of the emitted photon is isotropic and not influenced by external photons. The reference to an energized atom dropping to a higher state is incorrect as atoms cannot drop to a higher state; they can either stay in an excited state or fall to a lower energy state. Lastly, the absorption of energy from two incident photons does not occur in the context of stimulated emission; instead, photons can interact with atoms through processes such as pair production or two-photon absorption, which are distinct from the concept of stimulated emission.

## 4. What are eddy currents?

A. Currents that flow in open circuits

B. Currents induced in small swirls within a conductor

C. Currents that can only flow in liquid metals

D. Currents that are always constant

Eddy currents are indeed currents that are induced within conductors due to changing magnetic fields. When a conductor experiences a change in the magnetic field around it, such as when it is in motion relative to a magnetic field, circular loops of electrical current can form inside the conductor. These currents create their own magnetic fields and can lead to energy losses through heat due to resistance in the material. This phenomenon is utilized in various applications, such as induction heating and braking systems in trains. In this context, it is important to differentiate eddy currents from other types of currents. For example, currents flowing in open circuits would not be influenced significantly by a magnetic field in the same way that eddy currents are. Moreover, while liquid metals can conduct electricity and may also experience currents, this is not a defining characteristic of eddy currents, which can occur in solid conductors as well. Lastly, eddy currents are not constant; they vary depending on changes in the magnetic field and the conductivity of the material in which they are induced.

## 5. What phenomenon describes the emission of electrons when light hits a material?

**A. Photoelectric effect**

**B. Photochromic effect**

**C. Thermal emission**

**D. Electromagnetic induction**

The emission of electrons when light strikes a material is accurately described by the photoelectric effect. This phenomenon occurs when photons, or light particles, collide with electrons in a material, usually metals, and transfer enough energy to dislodge these electrons from the atomic structure of the material. The crucial aspect of the photoelectric effect is that it demonstrates the particle-like properties of light. Specifically, it shows that light must have a certain threshold frequency or energy to release electrons from the material. If the energy of the photons is below this threshold, no electrons will be emitted regardless of the intensity of the light. This phenomenon has been pivotal in confirming the quantum theory of light. The other options, while related to different physical principles, do not pertain to the emission of electrons due to light exposure. The photochromic effect refers to the reversible change in color of materials due to light exposure, thermal emission involves the release of energy as heat, and electromagnetic induction relates to the generation of voltage in a conductor within a changing magnetic field. These concepts are distinct and do not involve the direct emission of electrons as a result of light interaction.

## 6. What is terminal velocity defined as?

**A. The speed of an object when the air resistance and gravity forces are equal**

**B. The speed an object achieves when it stops falling**

**C. The maximum height reached by a falling object**

**D. The speed of an object without air resistance**

Terminal velocity is defined as the speed of an object when the forces acting on it, specifically air resistance and gravitational force, are equal in magnitude, resulting in a net force of zero. At this point, the object ceases to accelerate and continues to fall at a constant velocity. Understanding how terminal velocity works is crucial in physics. When an object falls through a fluid like air, it experiences a downward gravitational force and an upward drag force due to the fluid. Initially, the object accelerates downwards, but as its speed increases, the drag force also increases until it balances the weight of the object. This balance results in a constant speed—this speed is known as terminal velocity. Other choices present concepts that do not accurately describe terminal velocity. For example, stopping while falling, maximum height reached, and behavior without air resistance are not relevant to the definition of terminal velocity, which specifically pertains to falling objects reaching a steady state due to the balance of forces.

## 7. What is ionization energy?

A. The energy needed to split an atom

B. The minimum energy required to remove an electron from an atom

C. The energy released during an atomic absorption

D. The energy associated with molecular bonding

Ionization energy is defined as the minimum energy required to remove an electron from an atom in its gaseous state. This energy is crucial in understanding how atoms interact with one another, particularly in the formation of ions and in chemical reactions. When energy is supplied to an atom, it can overcome the attractive force that keeps the electron bound to the positively charged nucleus. Once this energy threshold is met, the electron can be ejected, resulting in the formation of a positively charged ion. This concept is foundational in atomic physics and chemistry, as it directly influences an element's reactivity and its position in the periodic table. Elements with lower ionization energies tend to lose electrons more easily, while those with higher ionization energies hold onto their electrons more tightly. This is why ionization energy is indicative of an element's chemical behavior. The other options do not accurately reflect the concept of ionization energy. For instance, the idea of splitting an atom relates more to nuclear processes, while atomic absorption refers to the energy transitions an electron undergoes when it absorbs energy without being removed from the atom. Additionally, molecular bonding pertains to how atoms share or transfer electrons, which is a different aspect of atomic behavior than what ionization energy represents.

## 8. What is required for a population inversion to occur in a set of atoms?

A. More atoms in a lower energy state

B. More atoms in a higher energy state than in a lower-energy state

C. The lower energy state must be metastable

D. A continuous absorption of energy

For a population inversion to occur, it is necessary to have more atoms populated in a higher energy state compared to the lower energy state. This condition is crucial because, in a typical system at thermal equilibrium, most atoms occupy the lower energy states due to the principles of statistical mechanics. When a sufficient number of atoms transitions to a higher energy state, an inversion is created whereby the number of excited atoms exceeds those in the ground state. This is essential for the operation of lasers, where stimulated emission of photons relies on having more atoms available in a higher energy state to produce coherent light. The presence of this condition enables a more dynamic interaction between the excited atoms and incoming photons, facilitating processes like stimulated emission, which reinforces the laser action. Population inversion is foundational in laser technology and is a critical aspect of achieving lasing conditions.

## 9. What is a diffraction grating?

A. A surface that prevents light from passing through

B. A device with multiple slits that produces light spectra

C. An optical element that creates shadow patterns

D. A tool to measure the speed of light

A diffraction grating is a device designed to disperse light into its constituent colors or wavelengths by using multiple closely spaced slits. When light encounters a diffraction grating, it interferes with itself as it passes through these slits, leading to the formation of a spectrum. This occurs because different wavelengths of light are bent at different angles when they pass through the slits, allowing them to separate and produce distinct spectral lines.  The functionality of a diffraction grating is critical in various applications, such as spectroscopy, where it is used to analyze the spectral content of light emitted or absorbed by substances. This capability to produce detailed light spectra is what distinguishes diffraction gratings from other optical elements.

## 10. In what direction do electric field lines point with respect to positive and negative charges?

A. Away from positive charges and towards negative charges

B. Towards positive charges and away from negative charges

C. In all directions equally

D. Towards the center of positive charges

Electric field lines are used to represent the strength and direction of the electric field produced by charges. They always originate from positive charges and terminate at negative charges. This representation is based on the nature of electric force; a positive charge experiences a force that moves it away from other positive charges (hence the lines point away from positive charges) and towards negative charges, which exert an attractive force.  The pattern of these lines provides a visual understanding of how electric fields operate. The greater the density of the lines, the stronger the electric field in that region. Since electric fields are defined by their influence on charged particles, a positive charge moves away from other positives due to repulsion and is attracted to negatives. This concept highlights that the lines emanate from positive and converge towards negative charges, clearly illustrating the interaction between different types of charge.  The correct understanding of electric field lines is fundamental in analyzing electrical interactions, and recognizing that they flow away from positive charges and towards negative charges is a key principle of electrostatics.