Name: _____ **Date:** _____

Answer Key: Cosmic Scale Expedition: 12th Grade Metrology & Precision Quest

Navigate 10 complex scenarios requiring rigorous analysis of SI base units, dimensional consistency, and the fine line between uncertainty and accuracy in research.

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1. During a high-energy particle physics experiment, a researcher calculates the vacuum permittivity but finds the final value is exactly 0.5% higher than the accepted physical constant. However, repeated trials yield the exact same displaced value every time. How should this data be categorized?

Answer: C) Low accuracy and high precision

Precision refers to the consistency of results (the values were identical), while accuracy refers to how close a measurement is to the true or accepted value (there was a 0.5% error).

2. In the derivation of the Stefan-Boltzmann constant, which SI base unit is used to define the thermodynamic temperature and is independent of the properties of any specific substance?

Answer: C) Kelvin

Kelvin is the SI base unit for thermodynamic temperature, defined by the Boltzmann constant rather than the freezing point of water.

3. The SI base unit for mass, the kilogram, is currently defined by a physical platinum-iridium cylinder stored in France known as 'Le Grand K'.

Answer: B) False

As of 2019, the kilogram is no longer defined by a physical artifact but is instead defined in terms of the Planck constant (h).

4. A theoretical physicist proposes a new equation: E = (m * v^3) / r. Using dimensional analysis, determine if this equation is consistent with the SI units for Energy (Joules).

Answer: B) Inconsistent: Resulting units are kgm^2/s^3

Energy has dimensions [M][L]^2[T]^-2. In the formula provided, mass (M) times velocity cubed (L^3/T^3) divided by radius (L) results in [M][L]^2[T]^-3, which is the unit for Power (Watts), not Energy.

5. When measuring the luminous intensity of a monochromatic radiation source at a frequency of 540 x 10^12 hertz, the specific SI unit used is the _____.

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Answer: D) Candela

The Candela (cd) is the SI base unit for luminous intensity in a given direction.

6. In advanced stoichiometry, the mole is defined precisely as the number of atoms found in exactly 0.012 kilograms of Carbon-12.

Answer: B) False

Similar to the kilogram, the mole was redefined in 2019 to be exactly 6.02214076 × 10^23 elementary entities (the Avogadro constant), decoupling it from the mass of Carbon-12.

7. An electrical engineer measures a current of 450 milliamperes (mA) across a resistor. If she needs to convert this to the base unit to calculate power in Watts (W = A * V), which value must she use?

Answer: B) 4.5 x 10^-1 A

Milli denotes 10^-3. Therefore, 450 mA is 450 x 10^-3 A, which simplifies in scientific notation to 0.45 A or 4.5 x 10^-1 A.

8. Which of the following derived units can be fully expressed using only the SI base units: kg, m, and s?

Answer: A) Newton

A Newton is a kgÅ—m/s^2. The other units (Volt, Tesla, Ohm) require the addition of the Ampere (A) as a fourth base unit.

9. When reporting a measurement of 0.004050 meters, how many significant figures are present, and what is the uncertainty of the measurement assuming it is ±1 in the last digit?

Answer: B) 4 sig figs; ±0.000001

Leading zeros are not significant. The digits '4050' are significant (the trailing zero is significant because of the decimal point). The uncertainty is in the last place value shown: 10^-6.

10. A measurement can be highly accurate even if it has very low precision.

Answer: A) True

Accuracy refers to how close the average of measurements is to the true value. If a set of measurements is widely scattered (low precision) but their statistical average is the true value, the result is considered accurate.