Name: _____ **Date:** _____

Answer Key: Dissect Cosmic Constants: A College Calculus-Based Measurement Quiz

Evaluate dimensional homogeneity and relativistic corrections across non-Euclidean frameworks where standard SI derivations face extreme astrophysical constraints.

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1. When deriving the Planck length contextually, which synthesis of fundamental constants (G, ħ, and c) maintains dimensional consistency for L?

Answer: A) sqrt(Għ/c^3)

Dimensional analysis shows that the square root of (gravitational constant * reduced Planck constant / speed of light cubed) yields the dimension of length (~1.6 x 10^{-35} m).

2. Regarding the 2019 redefinition of SI base units, the value of the _____ is now fixed by defining the numerical value of the Boltzmann constant (k).

Answer: B) Kelvin

The Kelvin was redefined by fixing the Boltzmann constant to exactly 1.380649 × 10^{-23} J/K, linking thermal energy directly to temperature.

3. In a non-inertial reference frame, the measured 'proper time' between two events is a Lorentz invariant and remains unchanged regardless of the observer's velocity.

Answer: A) True

Proper time is the interval measured by a clock in the rest frame of the events; it is a scalar invariant in 4-dimensional Minkowski spacetime.

4. A Josephson Junction is primarily utilized in metrology to realize the SI volt by relating it to which two fundamental physical constants?

Answer: C) The Elementary charge and the Planck constant

The Josephson effect relates voltage to frequency via the Josephson constant (Kj = 2e/h), utilizing the elementary charge and Planck's constant.

5. When examining the systematic error in a high-precision interferometer, the 'Type B' evaluation of uncertainty is based on _____.

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Answer: C) Non-statistical scientific judgment and calibration data

Type B uncertainty evaluation uses available info (spec sheets, previous data) rather than the statistical analysis of current repeated measurements (Type A).

6. Calculate the radiant flux (Watts) of a blackbody source if its luminous intensity is 683 candelas at a frequency of 540 x 10^{12} Hz, assuming monochromatic emission.

Answer: B) 1 W

By definition, the candela is the luminous intensity of a source emitting monochromatic radiation of frequency 540 × 10^{12} Hz with a radiant intensity of 1/683 Watts per steradian.

7. The SI base unit for mass is no longer determined by a physical artifact (the 'Le Grand K') but is instead realized via the Kibble balance and Planck's constant.

Answer: A) True

Since 2019, the kilogram is defined by taking the fixed numerical value of the Planck constant (h) to be 6.62607015 × 10^{-34} kgÅm^{2}Å^{-1}.

8. In fluid dynamics, the Reynolds number is a dimensionless quantity. Which ratio of units correctly yields a dimensionless result for Re = (ρvd)/μ?

Answer: A) (kg/m^3)(m/s)(m) / (kg/(m·s))

Expanding the units: [Density: M/L^3] * [Velocity: L/T] * [Length: L] / [Dynamic Viscosity: M/(L·T)] results in all units canceling out ($M^0L^0T^0$).

9. For a Quantum Hall Effect experiment measuring Resistance (R_H), the Von Klitzing constant (R_k) equates the unit 'Ohm' to the ratio _____.

Answer: A) h / e^2

The Von Klitzing constant is defined as R_k = h/e^2, providing a highly stable and reproducible quantum standard for electrical resistance.

10. Even if a measurement is perfectly precise (zero variance), it can still possess high systematic error if the instrument is poorly calibrated.

Answer: A) True

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Precision refers to the repeatability of the data; a thermometer that consistently reads 50.00C for a 0.00C ice bath is perfectly precise but wildly inaccurate due to bias.