Name: _____ **Date:** _____

Answer Key: Metrology Mastery: A High-Stakes Senior Science Seminar

Can you navigate the nuances of dimensional analysis and error propagation? Defend your data through 10 advanced measurement evaluation scenarios.

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1. A research team measuring the Planck constant reports a high degree of precision but realizes the cryostat thermometer was improperly calibrated by 0.5 K. Which statement best evaluates their data's validity?

Answer: B) The results are precise but inaccurate due to a systematic error in the instrumentation.

Improper calibration leads to systematic error, which shifts all measurements in a consistent direction, affecting accuracy while potentially maintaining high precision (consistency).

2. In the context of the 2019 SI redefinition, the kilogram is no longer defined by a physical artifact but is instead derived from the fixed numerical value of the _____.

Answer: C) Planck constant

The kilogram was redefined in 2019 using the Planck constant (h) via the Kibble balance, removing the reliance on the 'Le Grand K' physical prototype.

3. Dimensional analysis can be used to prove that a derived physical equation is definitively correct in its description of reality.

Answer: B) False

Dimensional analysis only ensures dimensional homogeneity; it cannot account for dimensionless constants (like 2 or pi) or the actual physical truth of the relationship.

4. When calculating the volume of a cylinder ($V = \pi r^2 h$) where the radius r has a 2% uncertainty and the height h has a 1% uncertainty, what is the total propagated percentage uncertainty in the volume?

Answer: B) 5%

For products and powers, percentage uncertainties are added. Since r is squared, its uncertainty is doubled (2% * 2 = 4%), then added to the 1% from h, totaling 5%.

5. A fundamental unit that measures the luminous intensity in a given direction is the _____, which uniquely depends on the human eye’s sensitivity.

Name: _____ **Date:** _____

Answer: C) Candela

The candela (cd) is the SI base unit for luminous intensity, defined by the luminous efficacy of monochromatic radiation of a specific frequency.

6. A measurement of 0.005060 meters contains exactly four significant figures.

Answer: A) True

Leading zeros are not significant. The digits 5, 0, 6, and the trailing 0 (because of the decimal point) are all significant.

7. Which of the following is considered a derived unit rather than a base unit in the SI system?

Answer: C) Newton

The Newton (N) is a derived unit ($kg·m/s^2$). The Ampere, Mole, and Kelvin are all SI base units.

8. In high-precision particle physics, the term _____ describes the scatter of the data and is often quantified using the standard deviation of the mean.

Answer: B) Random error

Random error causes fluctuations and scatter in readings, which is measured by precision/standard deviation, unlike systematic error which affects accuracy.

9. The radian and steradian are mathematically considered dimensionless derived units in the SI system.

Answer: A) True

Since a radian is the ratio of arc length to radius (m/m), it is dimensionless, though it is used as a supplementary unit for clarity.

10. An astrophysicist calculates the age of a star to be 10.2 Gigayears. Express this value in SI base units using proper scientific notation.

Answer: B) 3.22 x 10^17 s

The SI base unit for time is the second. (10.2 x 10^9 years) * (365.25 days) * (24 hours) * (3600 seconds) equals approximately 3.22 x 10^17 seconds.