

Name: _____ Date: _____

Answer Key: Feeling the Pressure? Conquer High-Stakes Physics Measurement (Grade 12)

Analyze dimensional consistency and error propagation in complex systems like relativistic momentum and thermodynamic gradients.

1. In a spectroscopic analysis, a researcher measures a wavelength of 589.3 nm. If the theoretical value is 589.0 nm and the instrument has a precision of ± 0.05 nm, how should the discrepancy be categorized?

Answer: A) High precision, low accuracy due to systematic error

The instrument's precision is high (± 0.05 nm), but the measurement significantly deviates from the true value (by 0.3 nm), suggesting a systematic calibration error rather than random fluctuation.

2. To ensure dimensional consistency in the equation for the Stefan-Boltzmann law ($P = \sigma AT^4$), the units for the Stefan-Boltzmann constant (σ) must be _____.

Answer: B) $W \cdot m^{-2} \cdot K^{-4}$

Rearranging $P = \sigma AT^4$ for σ gives $\sigma = P / (AT^4)$. Since Power (P) is Watts (W) and Area (A) is m^2 , the unit becomes $W/(m^2K^4)$ or $W \cdot m^{-2} \cdot K^{-4}$.

3. The 'candela' is an SI base unit defined by the luminous efficacy of monochromatic radiation of frequency 540×10^{12} hertz.

Answer: A) True

This is the formal SI definition of the candela, linking luminous intensity to a specific frequency of green light and a fixed numerical value of luminous efficacy.

4. When calculating the density of a perfectly spherical planetoid where the radius has an uncertainty of 2% and the mass has an uncertainty of 1%, what is the resulting uncertainty in density?

Answer: C) 7%

Density involves mass divided by volume (radius cubed). Using error propagation for powers: %Uncertainty = 1% (mass) + 3 * 2% (radius) = 7%.

5. In the context of the redefinition of SI units in 2019, the kilogram is now defined based on a fixed numerical value of the _____ constant.

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Answer: C) Planck

The mass of the kilogram is now determined by the Planck constant (h), using the Kibble balance to relate mass to electromagnetic force and quantum effects.

6. A measurement of 0.004050 meters possesses six significant figures.

Answer: B) False

Leading zeros are not significant. Only the digits 4, 0, 5, and the trailing 0 are significant, totaling four significant figures.

7. Which of the following derived units can be expressed in SI base units as $\text{kg}\cdot\text{m}^2\cdot\text{s}^{-3}\cdot\text{A}^{-2}$?

Answer: A) Ohm (Ω)

Resistance (Ohm) is Voltage/Current. Voltage is Work/Charge ($\text{kg}\cdot\text{m}^2\cdot\text{s}^{-2}/\text{As} = \text{kg}\cdot\text{m}^2\cdot\text{s}^{-3}\cdot\text{A}^{-1}$). Dividing by Current (A) gives $\text{kg}\cdot\text{m}^2\cdot\text{s}^{-3}\cdot\text{A}^{-2}$.

8. An experimenter using a Michelson interferometer observes a fringe shift corresponding to a distance of 150 'micro-inches'. To convert this to SI meters using scientific notation, the value is _____.

Answer: B) 3.81×10^{-6} m

1 inch = 0.0254 m. 150 micro-inches = 150×10^{-6} inches. $150 \times 10^{-6} * 0.0254 = 3.81 \times 10^{-6}$ meters.

9. In fluid dynamics, the Reynolds number (Re) is calculated as $(\rho v d)/\mu$. Given that it is a dimensionless quantity, what does this imply about the units of the variables?

Answer: C) The product of all units in the expression must simplify to 1

Dimensional analysis requires that for a quantity to be dimensionless, the combined base units of the numerator must exactly match and cancel those of the denominator.

10. Gaussian error distribution (the 'Bell Curve') assumes that measurements are equally likely to be slightly higher or slightly lower than the true value.

Answer: A) True

Standard normal distribution in measurement theory assumes random errors are symmetrical around the mean (the most probable value).