Analytical Chemistry Cumulative Examination

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In making scientific measurements, the correct specification of units is essential. The questions on this exam all concern the definition of various scientific units.

1. (20 pts) The SI (for Système Internationale) units are recommended for most scientific quantities. List the 7 base SI units including the name of the physical quantity (for example, mass), the name of the unit (for example, kilogram), and symbol (for example, kg).

2. (30 pts) Other SI units can be derived from the base units. Give the names of the derived units and their expressions in terms of the SI base units for the following physical quantities:

a) Energy
b) Force
c) Power
d) Electric charge
e) Electric Potential Difference
f) Electrical Resistance

3. (25 pts) An important quantity in absorption photometry is the absorbance, *A*, which is defined by Beer's law as

$$Log\frac{P_0}{P} = A = \varepsilon \ell c$$

where P_0 is the radiant power of the light incident on the sample, *P* is the radiant power of light transmitted after passing through a sample of thickness ℓ, *c* is the concentration of analyte, and ε is the molar absorptivity.

a) What are the units of *P*?
b) What are the units of absorbance?
c) If ℓ and *c* are expressed in SI units, what are the SI units of the molar absorptivity?
d) Beer's law can also be defined in terms of the intensity, *I*, of the light. What are the SI units for *I*?
e) If Beer's law is defined in terms of intensity instead of radiant power, how will that affect the units of molar absorptivity?

4. (25 pts) Absolute infrared intensities are seldom measured but they can be useful in analytical chemistry as a way to estimate the concentration of an analyte. They can also be used to obtain fundamental molecular parameters. The absolute intensity, A_n, of the fundamental transition of mode *n* of a molecule is given by:

$$A_n = 2\pi^2 N_A g_n \omega_n \mu_n^2 / 3\varepsilon_0 hc$$

where g_n is the degeneracy of the mode, ω_n is the frequency in wavenumber, μ_n is the transition dipole moment, h is Planck's constant, c is the speed of light, and ε_0 is the permittivity of vacuum. (Note the different used of the symbols c and ε_0 here from the way they were used in problem 3.) The permittivity of vacuum appears in many problems in electrodynamics and electrostatics such as in Coulomb's law relating the force between two charges, Q_1 and Q_2, separated by a distance r:

$$F = \frac{1}{4\pi\varepsilon_0} \frac{Q_1 Q_2}{r^2}$$

a) (15 pts) What are the SI units for absolute IR intensity?
b) (10 pts) Briefly describe how you would measure the absolute IR intensity of a single ro-vibrational line of a gas phase molecule.