Name _____

Practice Calculations Test Problems

Do-overs Allowed - Show answers with 4 significant figures.

In the following formulas, use $G = 6.67 \times 10^{-11} \frac{\text{N} \cdot \text{m}^2}{\text{kg}^2}$ and $c = 3.00 \times 10^8 \, \text{m/s}$.

1. Calculate the gravitational force in newtons using the formula $F = G \frac{m_1 m_2}{d^2}$ where, $m_1 = 5.3 \times 10^{23} \text{kg}$, $m_2 = 64.9 \, \text{kg}$ and $d = 8.3 \times 10^8 \, \text{m}$.

2. Calculate the dimensionless relativistic factor $\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$ where $v = 2.8 \times 10^8 \, \text{m/s}$.

3. Using $E = m c^2$, calculate the energy in joules released when $3.7 \times 10^{-3} \text{kg}$ is converted to energy.

4. Using $\lambda = \frac{c}{f}$, calculate the wavelength in meters of a photon that has a frequency of $5 \times 10^{15} \, \text{Hz}$.

5. Acetic acid, the active ingredient in vinegar, has a pH of 4.756. Calculate the concentration in mol/L of hydronium ions in vinegar using $[\text{H}_3\text{O}^+] = 10^{-\text{pH}}$.

6. The concentration of hydronium ions in household ammonia is $2.34 \times 10^{-12} \, \text{mol/L}$. Calculate the pH of household ammonia using $\text{pH} = -\log_{10}[\text{H}_3\text{O}^+]$

Practice Calculations Test Problems - Solutions

Do-overs Allowed - Show answers with 4 significant figures.

(Various forms of acceptable answers are shown.)

In the following formulas, use $G = 6.67\times10^{-11}\,\frac{\mathbf{N\cdot m^2}}{\mathbf{kg^2}}$ **and** $c = 3.00\times10^{8}\,\mathbf{m/s}$ **.**

1. Calculate the gravitational force in newtons using the formula $F = G\frac{m_1 m_2}{d^2}$ where, $m_1 = 5.3\times10^{23}\,\text{kg}$, $m_2 = 64.9\,\text{kg}$ and $d = 8.3\times10^{8}\,\text{m}$.

$$\mathbf{F = \left(6.67\times10^{-11}\,\frac{N\cdot m^2}{kg^2}\right)\frac{(5.3\times10^{23}\,kg)\cdot(64.9\,kg)}{(8.3\times10^{8}\,m)^2} = 3.3304\times10^{-3}\,N}$$

2. Calculate the dimensionless relativistic factor $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ where $v = 2.8\times10^{8}\,\text{m/s}$.

$$\boldsymbol{\gamma = \frac{1}{\sqrt{1-\frac{(2.8\times10^{8}\,m/s)^2}{(3.00\times10^{8}\,m/s)^2}}} = \frac{1}{\sqrt{1-\left(\frac{2.8\times10^{8}\,m/s}{3.00\times10^{8}\,m/s}\right)^2}} = 2.7854}$$

3. Using $E = mc^2$, calculate the energy in joules released when $3.7\times10^{-3}\,\text{kg}$ is converted to energy.

$$\mathbf{E = (3.7\times10^{-3}\,kg)\cdot(3.00\times10^{8}\,m/s)^2 = 3.3300\times10^{14}\,\frac{kg\cdot m^2}{s^2} = 3.3300\times10^{14}\,J = 3.3300\times10^{14}\,N\cdot m = 333.00\,TJ}$$

4. Using $\lambda = \frac{c}{f}$, calculate the wavelength in meters of a photon that has a frequency of $5\times10^{15}\,\text{Hz}$.

$$\boldsymbol{\lambda = \frac{3.00\times10^{8}\,m/s}{5\times10^{15}\,Hz} = 6.0000\times10^{-8}\,m = 0.060000\,\mu m = 60.000\,nm}$$

5. Acetic acid, the active ingredient in vinegar, has a pH of 4.756. Calculate the concentration in mol/L of hydronium ions in vinegar using $[H_3O^+] = 10^{-pH}$.

$$\mathbf{[H_3O^+] = 10^{-pH} = 10^{-4.756} = 1.7539\times10^{-5}\,mol/L}$$

6. The concentration of hydronium ions in household ammonia is $[H_3O^+] = 2.34\times10^{-12}\,\text{mol/L}$. Calculate the pH of household ammonia using $pH = -\log_{10}[H_3O^+]$

$$\mathbf{pH = -\log_{10}[H_3O^+] = -\log_{10}(2.34\times10^{-12}\,mol/L) = 11.631}$$

Note: pH has no units, but must be calculated from $[H_3O^+]$ **with units of mol/L .**