____ - ____ - ____ = ____ /10

Unit 1 Part 10: Practice Free Response 1

Directions: The suggested time is about 15 minutes for answering the constructed response section of the chemistry test. The parts within a question may not have equal weight. For calculations, show all your work in the spaces provided after each part. Pay particular attention to the proper use of units. Be sure your final answer is rounded to the correct number of significant figures. Make sure your work is legible. Illegible work will receive a grade of zero.

Question 1 [10 POINTS]

In the first century BCE, King Hiero II of Syracuse commanded that a golden crown be made to honor the gods. Once he had the crown, however, he suspected that the goldsmith had replaced some of the gold with an equal weight of a less valuable substance (silver, ew). To be certain, before punishing the goldsmith, he asked a local mathematician, Archimedes, to determine whether the crown was genuine. When Archimedes figured out how to do so, he was so excited that he ran naked through the streets of Syracuse.

A. Archimedes filled his bathtub with 20.97 L of water. He then dropped the crown into the tub and found that the water level rose to 22.20 L. He determined the mass of the crown to be 1.91 kg. The density of pure gold is 19.32 g/cm³.

    i. What is the volume of the crown? [1 POINT]

$$\text{volume of crown} = (V \text{ of water} + \text{crown}) - (V \text{ of water})$$
$$V \text{ of crown} = 22.20\,L - 20.97\,L$$
$$\boxed{V \text{ of crown} = 1.23\,L}$$

    ii. What is the density of the crown in kg/L? [1 POINT]

$$D = \frac{mass}{volume} = \frac{1.91\,kg}{1.23\,L} = 1.5528 \approx \boxed{1.55\,\frac{kg}{L}}$$

    iii. *Using dimensional analysis*, determine the density in g/cm³. [3 POINTS]

remember 1 cm³ = 1 mL

NOTE: There are several acceptable methods here!

$$1.91\,kg \times \frac{1000\,g}{1\,kg} = 1910\,g$$

$$1.23\,L \times \frac{1000\,mL}{1\,L} \times \frac{1\,cm^3}{1\,mL} = 1230\,cm^3$$

$$D = \frac{M}{V}$$
$$= \frac{1910\,g}{1230\,cm^3}$$
$$\boxed{D = 1.55\,\frac{g}{cm^3}}$$

B. Using the density of gold as the accepted value, what was Archimedes' percent error? [1 POINT]

$$\% \text{ error} = \frac{accepted - experimental}{accepted} \times 100$$

$$= \frac{19.32\,\frac{g}{cm^3} - 1.55\,\frac{g}{cm^3}}{19.32\,\frac{g}{cm^3}} \times 100$$

CONTINUED ON REVERSE SIDE 👉

$$= \frac{17.77}{19.32} \times 100 = \boxed{91.98\,\% \text{ error}}$$

C. Should Hiero punish the goldsmith for a counterfeit crown, or thank him for a job well done? Justify your answer. [1 POINT]

Punish him! The percent error was <u>WAY</u> larger than 5%. The crown is <u>not</u> made of gold.

D. If Archimedes splashed some water out of the tub while measuring the volume of the crown, would his calculated density for the crown increase, decreases, or remain the same? Mathematically justify your answer. [2 POINTS]

Density would <u>increase</u>.

Volume of crown = (V of water + crown) − (V of water)
                         decreases

The volume of (water + crown) would decrease, so the volume of the crown alone would decrease. Since $D = \frac{M}{V}$, lower V means higher D.

E. After completing the experiment as outlined above, the Archimedes cut the crown in half. Will the density of the cut metal pieces be smaller, larger, or equal to the density of the original crown? Explain. [1 POINT]

Remain the <u>same</u>.

Density is an <u>in</u>tensive property, so it is <u>in</u>dependent of the amount of matter.