Name:…….
Date:……

2. MASS AND VOLUME MEASUREMENTS

Objectives

To overview the metric and SI units of mass and volume measurements. To introduce the laboratory equipment used for mass and volume measurements. To demonstrate the concept of significant figures and its use in stating results of measurements. To introduce the concepts of precision and accuracy.

Pre-lab Assignment

Read the introduction of this lab manual.

2.1. Mass measurement – Analytical and standard laboratory balances

Pre-lab Exercises

*1. What is the definition of the **sensitivity** and **weighing capacity** of a balance?*

What are the usual properties of a standard laboratory balance?

weighing capacity:..... sensitivity: .....

What are the usual properties of an analytical balance?

weighing capacity:..... sensitivity: .....

2. a/ Why is the real mass of an object different from the mass measured in air? Which of these two quantities is smaller?

b/ What factors influence the magnitude of this error?

3. A certified 5-g (x) weight is weighed three times in order to calibrate three different standard laboratory balances. The results:

Measurement	*Balance 1 (g)*	*Balance 2 (g)*	*Balance 3 (g)*
1	*5.05*	*5.17*	*5.16*
2	*5.00*	*5.15*	*4.89*
3	*4.99*	*5.09*	*4.91*

a/ Calculate the difference (Δ) between the average mass ($\bar{x}$) and the real mass (x) for each set of data. (See Pages 4-5)

$\bar{x}_1 =$ $\Delta_1 = \bar{x}_1 - x =$

$\bar{x}_2 =$ $\Delta_2 = \bar{x}_2 - x =$

$\bar{x}_3 =$ $\Delta_3 = \bar{x}_3 - x =$

b/ Compare the different balances based on their accuracy (the difference between the average mass and the real mass).

c/ What is the mean deviation ($\bar{\delta}$) of the different balances? (See Pages 4-5)

$\bar{\delta}_1 =$

$\bar{\delta}_2 =$

$\bar{\delta}_3 =$

d/ Compare the precision of different balances.

Mass measurement – Analytical and standard laboratory balances

Date: .....

Experiment Outline

Select one of the standard objects provided by the instructors and weigh it using a standard laboratory balance. If you use a simple pan-balance, **record which certified weights you used and also the order in which you put them in the measuring pan.**

If you use a digital balance, make sure you use the balance correctly and figure out how taring works on the balance.

Weigh the same standard object using an analytical balance. If you use a simple pan-balance, record which certified weights you used during the measurement (in later laboratory work, recording only the mass is sufficient). **Make sure you can use the balance routinely and confidently for later work!**

1. List the most important features of standard laboratory balances (Summarize the most important properties based on the demonstration of the instructors.)

Weighing a standard object on a standard laboratory balance

Name of the object:.....

Mass of the object: ..... g

2. List the most important features of analytical balances (Summarize the most important properties based on the demonstration of the instructors.)

Weighing a standard object on an analytical balance

Name of the object:.....

Mass of the object: ..... g

Review Exercises and Problems

1. List the most often used SI and metric units of the following physical quantities!

Quantity	**SI unit**	**Metric unit**	**Conversion factor**
length (l)			
volume (V)			
mass (m)			
amount of substance (n)			
density (ρ)			

2. Which unit is larger?

1 kg	.....	1 g	1 dm^3	.....	1 l
1 cm^3	.....	1 ml	1 J	.....	1 cal
1 mg	.....	1 ng	1 Pa	.....	1 bar
1 nm	.....	1 mm	1 g/cm^3	.....	1 t/m^3

2.2. Volume measurement

Date: .....

Experiment Outline

The instructors introduce the most important volume measuring devices, demonstrate their correct use and the proper method for preparing standard solutions. **If you have never used a volumetric flask or pipette before, practice their use by measuring water several times.**

1. Classify the most important volume-measuring devices:

- Not certified measuring devices:

- Certified measuring devices

calibrated for inflow calibrated for outflow

2. Based on the demonstration list the most important steps

- of **using a volumetric pipette**

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Review Exercises and Problems

1. A chemist needs 10 cm^3 of a solution. What accuracy can be achieved using

a.) a measuring cylinder:.....cm^3, b.) a burette:.....cm^3, c.) a pipette:.....cm^3.

2. A chemist needs 50 cm^3 of a solution (ρ= 1.000 g/cm^3). List the six different listed methods in the order of their decreasing accuracy:

a/ 50 cm^3 measured by a measuring cylinder

b/ a 50 cm^3 volumetric flask is filled up and its content poured out into a beaker

c/ a 50 cm^3 volumetric pipette used properly

d/ a 10 cm^3 volumetric pipette used properly five times

e/ a volume-graded beaker is filled up to the 50 cm^3 mark

f/ 50.0000 g solution is measured by an analytical balance

most accurate ⟶ least accurate

....

2.3. Calibration of volumetric measuring equipment

Date: .....

Experiment Outline

The nominal volume of measuring devices is checked by weighing the water that fills (volumetric flask) or flows out of (pipette, burette) the device. Distilled water should be used for the calibration. Before the measurement, the water and all the devices used in the calibration should be kept in the balance room for some time to allow their temperature to reach that of the air in the room. Before the measurement, make sure that the temperature of air and the water used for calibration agree within ±0.5 °C.

***Calibration of pipettes and burettes*:** Determine the mass of the dry weighing dish together with its cap on an analytical balance. Record the temperature of water to a precision of 0.1 °C and fill the pipette or burette to the mark. Let the water flow out to the measuring dish and weigh it again.

Calibration of a volumetric flask: Weigh the empty and dry volumetric flask together with its stopper. Record the temperature of water, fill the volumetric flask to the mark and weigh it again.

Use the standard density table to find the density of water at the measured temperature. Use interpolation if necessary. Calculate the volume from the mass and the density.

Calibrate your pipette following the method described in the experimental outline!

Calibration of a Pipette

Type of the pipette to be calibrated (graduated, single-volume): .....

Temperature in the balance room: .....°C

Temperature of the water used: .....°C

Density of water at .....°C: .....g/cm^3

(Find the appropriate value in a table. Use interpolation if necessary.)

Nominal volume of measured water (V_n): .....cm^3
Mass of measured water (m): .....g

Volume of measured water: $V_m = \frac{m}{\rho} =$ **= ..... cm³**

Difference between the measured and nominal volumes in %:

$$\frac{V_m - V_n}{V_n} \times 100 =$$