Experiment 2:

IDENTIFICATION OF A COMPOUND BY PHYSICAL PROPERTIES
(الكشف عن المركب من خلال الخصائص الفيزيائية)

LAB OF GENERAL CHEMISTRY 1, CHEM 0303105

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February 14 2021

Goals:

- To identify a compound based on its physical properties

- To learn how to properly assemble a boiling point apparatus

All substances have properties… Including people!

Example:

People can be identified by their …

Face (shape, expressions)	Voice	Height	Finger prints
Eye color	Hair color	Teeth	DNA

What are properties of substances?

- Every substance has a unique set of properties that allow us to differentiate between them.
  - These properties are classified as **physical properties and chemical properties.**

  - **Physical and chemical properties are used to identify and characterize substances**

- Sometimes we do not know what a substance is, so we must compare different properties of an unknown substance to a known substance.

- **Chemical properties**: the ability of a substance to undergo a chemical reaction, this depends on its chemical environment. Reactions of a substance, either with itself or with another substance are chemical properties.

Physical properties

- **Physical properties:** can be determined or measured **without changing** the composition or identity of the substance.
- These properties include:
  - ✓ solubility,
  - ✓ density, e.g., Au is heavy (19.3 Kg/L), Os: 22.3 g/mL
  - ✓ boiling point, water boils at 100^{o}C
  - ✓ melting point, e.g., water melts at 0^{o}C
  - ✓ color, e.g., Au is yellow, roses are red, water is colorless
  - ✓ odor,
  - ✓ state of the matter: a solid, liquid, or gas such as melting of ice cap or butter
  - ✓ electric properties and magnetic properties.

These properties can be observed/measured without any knowledge of the reactivity of the compound

Physical properties

Intensive properties: properties that are **independent of the amount of substance** being examined. These properties are known as **intensive properties** and are used to identify a substance.

Examples: solubility, melting point, boiling point, color, odor, luster, hardness, conductivity, viscosity and density

Extensive properties: **depend on the amount of substance** present and are not useful in the identification of a substance.

Examples: mass, volume, length, entropy, enthalpy, amount of energy in the substance

In this experiment, we will use three properties to identify a liquid substance: solubility, density and boiling point.

❑ Solubility

- The solubility is the maximum mass of a substance (in g) that dissolves in a fixed amount of solvent (liquid), usually 100 g, at a given temperature.

Or solubility = g substance/100 g solvent

- Solubility depends on chemical structure of both solute and solvent, as the solute and solvent are more similar in chemical structure, the solubility of the solute in that solvent will be higher. **LIKES DISSOLVE LIKES**. Table salt is soluble is water but not in benzene.

LIKES DISSOLVE LIKES:

- **-Polar solvents dissolve polar or ionic substances, e.g., table salt is dissolved in water or MeOH and not in gasoline**

- **-nonpolar solvents dissolve nonpolar solutes, e.g., benzene or or cyclohexane dissolve olive oil.**

❑ Solubility test

❖ In this experiment, we will use three solvents to compare solubilities:

water (H_2O)(polar),

cyclohexane (C_6H_{12})(non-polar), and

ethanol (C_2H_5OH)(weakly polar).

➢ The solubilities will be recorded as soluble (completely dissolved), slightly soluble (partially dissolved), or insoluble.

❖ **The solubility test:**

Add a pinch (about the size of a grain of rice, قرصة) of your solid or 3 drops of the your liquid unknown about 1 mL of the above three different solvents in three different test tubes separately, Stir and wait then record your observation.

Note: 1 mL = 20 drops

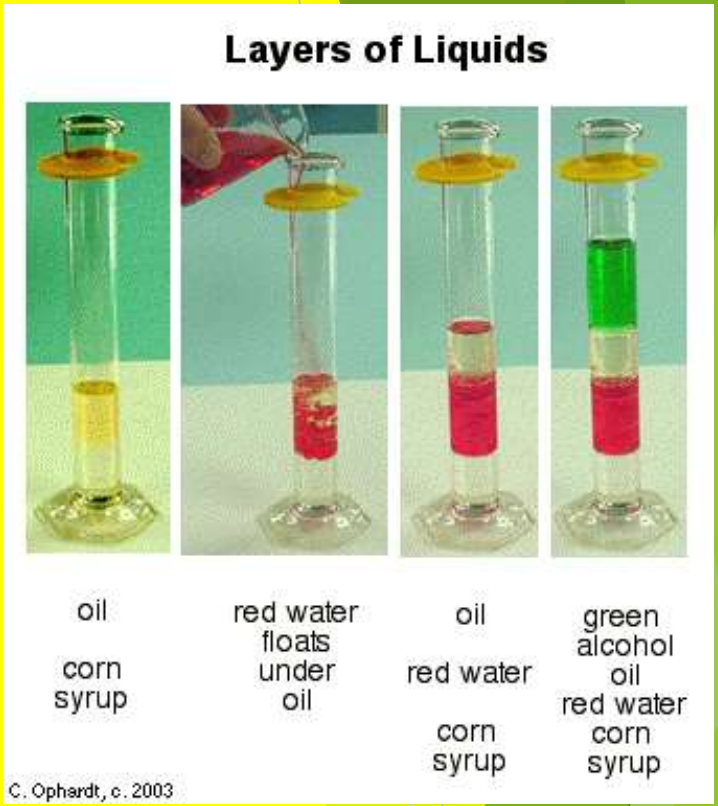
❑ Density of liquid unknown

- The measurement of how much mass of a substance is contained in a given volume.

D = Mass/Volume

- Higher density (heavy) substance means larger mass in certain volume. . If a liquid that is less dense than water is gently added to the surface of the water, it will float on the water.

- We can compare the density of an unknown substance to a known density.
  - ✓ Many substances may have the same density, so other properties are needed to be tested.



IN SUMMARY,
How to determine the density of liquid unknown?

1. Determine the mass of your smallest beaker

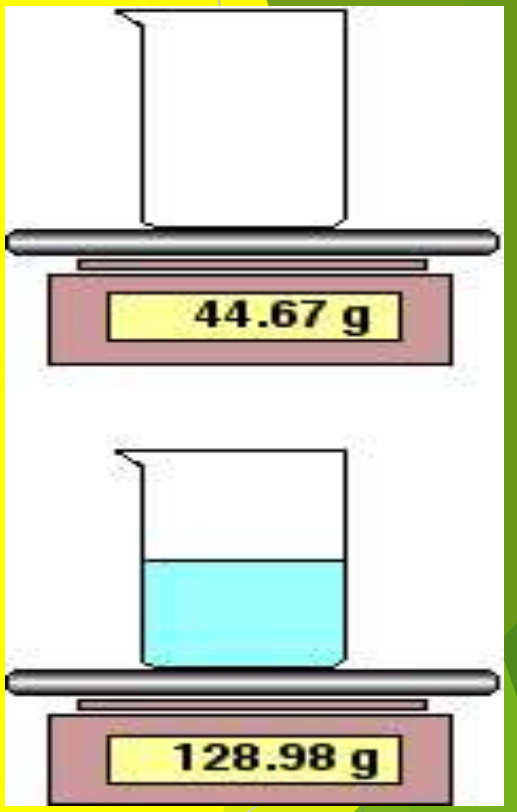
2. Pipet 5 .00 mL of ur liquid into the beaker and measure the combined mass

3. Determine the density of the liquid, D

D = (mass of liquid and beaker – mas of beaker)/volume of liquid

See the following Figure


CHM 151
Density unk
A


44.67 g
128.98 g

❑ *Boiling point, b.p*

- **Is the temperature at which the vapor pressure of a liquid equals the atmospheric pressure.**

➢ The liquid form of a substance is at equilibrium with its vapor, this process occurs at a constant temperature which we call the boiling point.

- Although the boiling point does vary slightly with the prevailing atmospheric pressure, we will use the normal boiling points at one atmosphere pressure. The boiling point of water is 100^{o} C at sea level, but 93.4 °C at height of 1905 m.

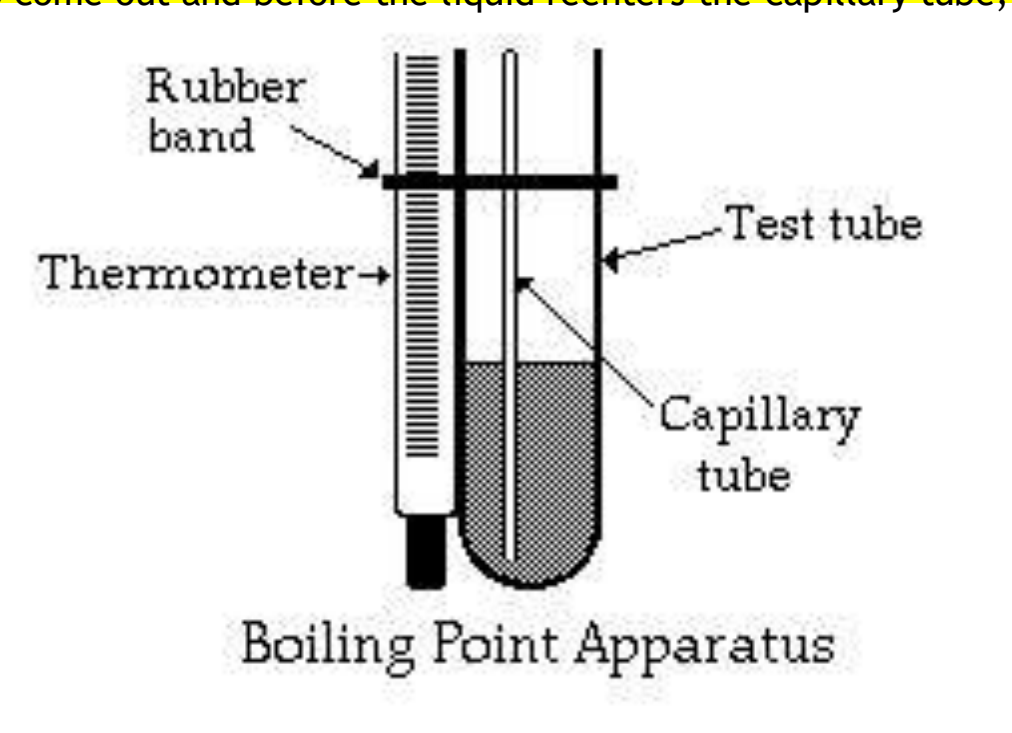
- The magnitude of the boiling point depends on the strength of the intermolecular forces (القوى بين الجزيئات). As the strength of intermolecular forces increases the b.p increases too.
- Liquids that boil at temperature below 100 °C are called VOLATILE liquids. Their boiling point is experimentally determined by the use of water bath *NOT* by heating on a direct flame.

Apparatus for determining the boiling point of a liquid.

- Place 10 drops of the liquid unknown into a 75-mm test tube, position it beside the thermometer bulb using a rubber band. Invert (open end down) a 10-cm capillary tube in the liquid. Place the apparatus in a water bath. Place 2-3 boiling chips (رقائق الغليان.) in the water bath.

- Slowly heat the water bath. When a rapid and continuous stream of bubbles (تيار من الفقاعات) escapes the capillary, discontinue heating the water bath.

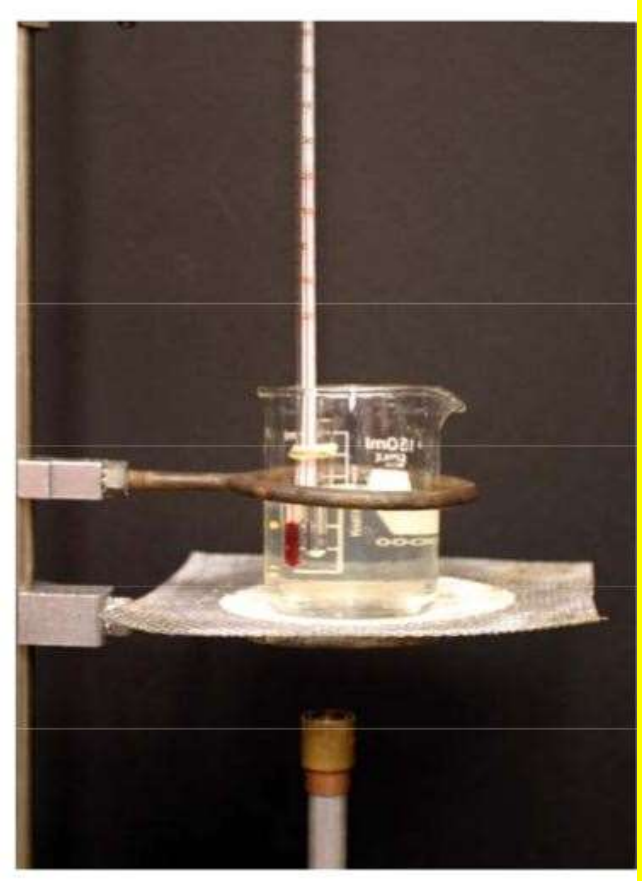
- When the bubbles stop to come out and before the liquid reenters the capillary tube, record the temperature. This the b.p of the liquid.

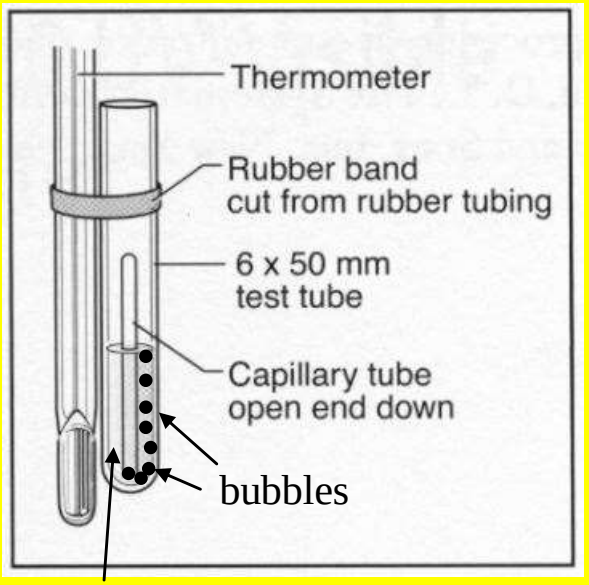


Boiling Point Apparatus

b.p APPARATUS.

In this experiment your unknown substance is a volatile compound, heating should be gentle and by the use of water bath.





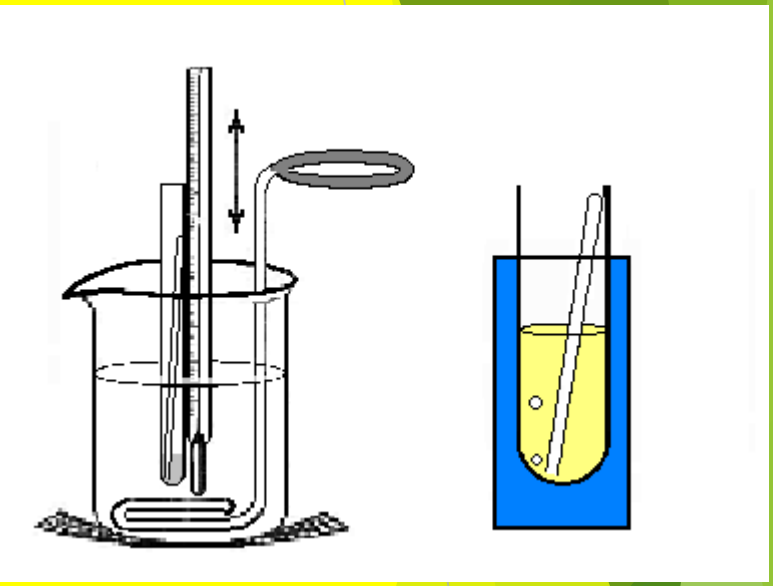
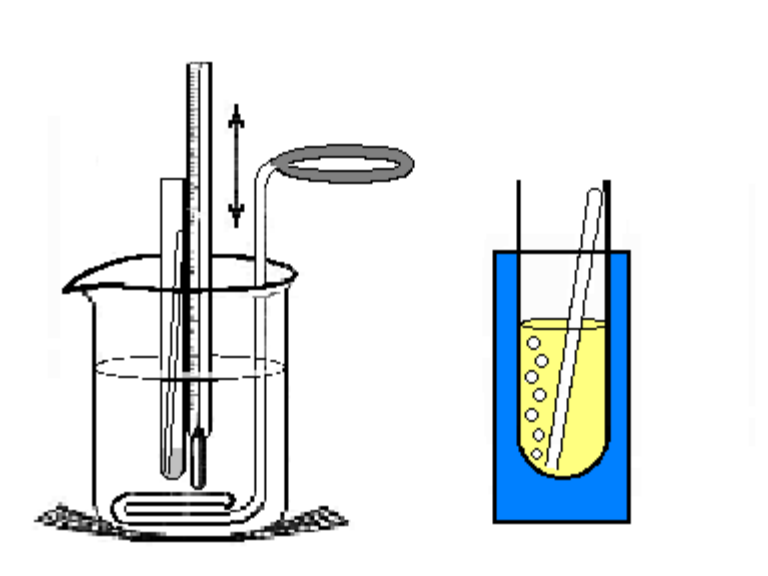
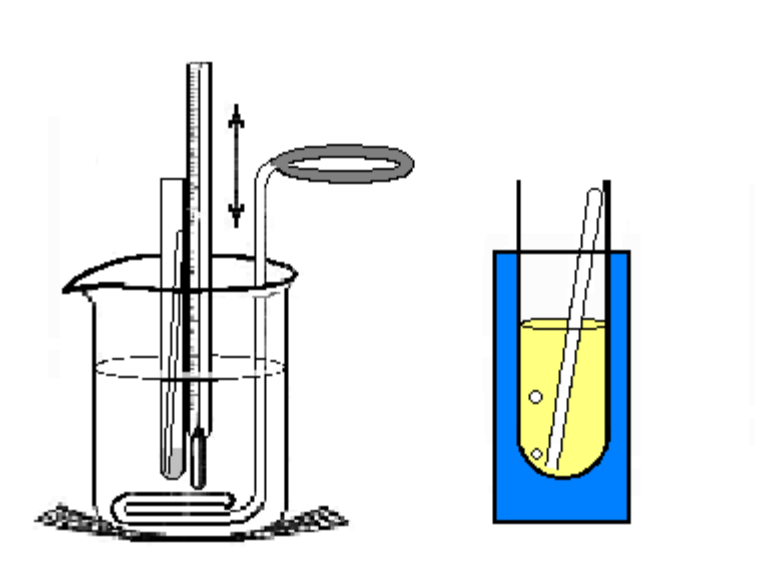


Figure. Boiling point apparatus

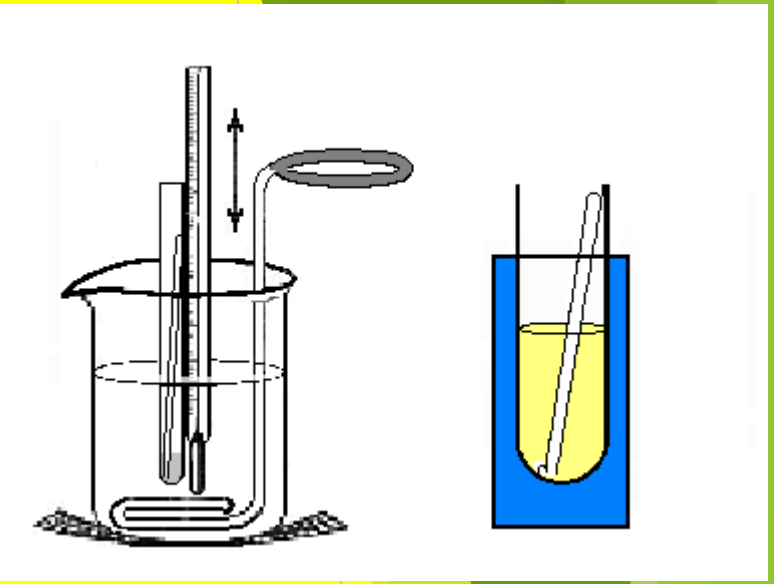
✓ While the system is being heated, bubbles will come out of the open end of the capillary tube.



When a rapid and continuous stream of bubbles comes out of the small capillary tube and passes through the liquid, discontinue heating and allow the apparatus to cool.



The stream of bubbles will slow as the apparatus cools.



When the bubbles stop coming out of the capillary tube and just before the liquid enters it, read the temperature on the thermometer. This temperature is the boiling point of the liquid.

Table 1. Physical properties of some common liquids.

Compound	Density g/mL	Boiling point °C	Solubility H_2O	C_6H_{12}	C_2H_5OH
acetone	0.79	56	s	s	s
2-butanone	0.805	80	s	s	s
cyclohexane	0.79	80.7	i	-	s
cyclohexene	0.81	83	i	s	s
ethanol	0.79	79	s	s	-
ethylacetate	0.90	77	sls	s	s
heptane	0.684	98	i	s	s
n-hexane	0.66	68	i	s	s
1-hexene	0.67	63	i	s	s
2-propanol	0.79	83	s	s	s
methanol	0.79	65	s	s	s
n-propanol	0.805	97	s	s	s
water	1.00	100	-	i	s

Symbols used: s = soluble, sls = slightly soluble, and i = insoluble

Data Analysis

- ✓ Tabulate your data and **compare** your results with the values in Table 1.
- ✓ **Determine the identity of the unknown liquid** and calculate the percent error in your values for density and boiling point.

For measuring the b.p (boiling points) of unknown liquids, use

- **Water bath for liquid substances with b.p < 100^{o}C**
- **Oil bath for liquid substances with b.p > 100^{o}C**

Safety Precautions

- -The unknown liquids used in this experiment are flammable. Although the danger of fire is greatly reduced by the use of small samples, it is not eliminated. Keep all liquid samples away from open flames.

- Avoid inhaling vapors from volatile liquids. The vapors from the liquids used in this experiment may be irritating and can be toxic if exposed to the vapors for long periods of time. These problems are minimized by using small amounts of the liquids. If you are bothered by the odors of any liquids, work in the fume hood.

- Avoid skin contact with the volatile liquids.

CLEANING GLASSWARE

- -A chemist is very concerned about contaminants causing errors in experimental data. Cleanliness is extremely important in minimizing errors in the precision and accuracy of data.

- *-Glassware should be clean before you begin an experiment and should be cleaned again immediately after completing the experiment.*

- **CLEANUP:** Rinse or clean the GLASSWARE such as the test tubes twice with tap water and twice with deionized water, (Technique 2).

- -What is the criterion for clean glassware?.

Answer: no water droplets adhere to the clean part of the glassware, for example

clean pipet should have no water droplets adhering to its inner wall

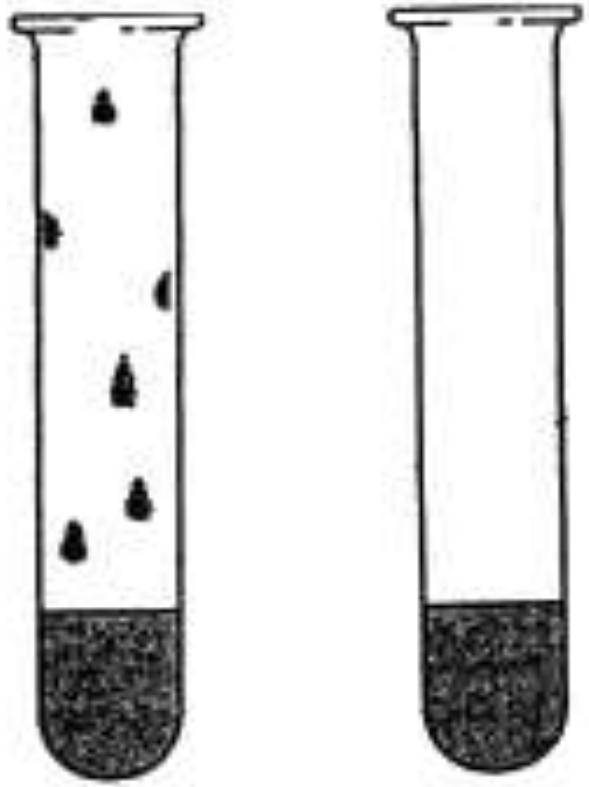


Figure T.2b Water droplets (left) do *not* adhere to the wall of clean glassware (right).

Prelabortaory Assignment. Identification of a compound by physical properties

1) What physical property, measurable in this experiment, distinguishes cyclohexane from cyclohexene.
2) Define: solubility, b.p, and sensity
3) What is the relationship between intermolecular forces acting between molecules and the boiling point of the substances?
4) A student's liquid unknown boils at about 69^{o}C,is insoluble in water, but soluble in ethanol. It's measured density is 0.65 g/mL, Which substance in Table 1 is the unknown?

Post lab questions

Laboratory Questions

Circle the questions that have been assigned.

1. How does atmospheric pressure affect the boiling point of a liquid? Ask your instructor.
2. If several drops of liquid unknown (Part B) cling to the pipet wall after delivery, will the density of the unknown liquid be reported too high or too low? Explain.
3. a. In Part D.2, suppose the boiling point is recorded when bubbles are rapidly escaping the capillary tube. Will the boiling point of the liquid be recorded too high or too low? Explain.
   b. If the boiling point is recorded when the liquid enters the capillary tube (after the heat is removed), will it be recorded too high or too low? Explain.