Lab Notes

Note: There is a page of notes to the instructor for each lab, followed by a sample Pre-lab Question page and Sample Report Pages with sample answers to all of the questions and most of the data. It should be noted that if a process other than what is described in the investigation is followed, the data acquired may differ.

#1 Alchemy

Reagents

zinc, powdered	1 g/pair
6 M sodium hydroxide [NaOH]	25 mL/pair
6 M nitric acid [HNO_3]	25 mL/lab

Common Materials

copper token, wire, or piece of plate	1/student
rulers, metric	1/pair
spray can of clear acrylic coating (optional)	1/lab

Laboratory Equipment

balance
caliper
evaporating dish
forceps
hotplate
stirring rod

Special Equipment

(none)

Notes

Pre-1982 pennies are pure copper, but are difficult to clean thoroughly enough to plate out well and produce a satisfactory result.

The best tokens are new and very shiny pennies. Any material on the surface will hinder the adherence of the zinc to the copper. Even slightly darkened areas of finger prints are enough to alter the quality of the finished product. Likewise, a dirty or corroded forcep tip can quickly reverse the plating on the coin where it is grasped.

The sodium hydroxide solution can be less concentrated, but it will slow the reaction.

Caution the students to refrain from heating the zinc/copper surface too long as the coin will melt. Constantly turning the coin while heating is a safer method. The use of a Bunsen instead of a burner hot plate will turn the token to a new color faster, but students run the risk of melting the token. If the students will lower the coin into the flame for only a second on each side and repeat continuously until the gold color appears, then heat each side one more time, they will ensure a complete reaction without misshaping the coin.

Disposal

Wet zinc dust exposed to air can burst into flames. **It is important that students not put wet zinc dust in the trash; it can cause fires in the trash.** The wet zinc solutions should be spread on a metal pan to dry. It must be in a metal pan for the chemical reaction to form zinc oxide. Dry zinc oxide will form which can be buried in a landfill. The used hydrochloric acid should be flushed down the drain with plenty of water.

ALCHEMY PRE-LAB QUESTIONS

1) Legend holds that Archimedes was responsible for proving that a metallurgist had "cut", or diluted, the gold for a Ruler's crown with a lesser metal. Archimedes asked the Ruler for a mass of gold identical to what he had provided to the metallurgist. What measurements and calculations did Archimedes most likely make?
Assuming that the metallurgist was not stupid and the finished crown had the same mass as the originally supplied gold, Archimedes most likely took two volume measurements by liquid displacement – one of the identical mass of gold and one of the crown. Then finding that they were not the same, he deduced that since the smaller volume was the pure gold, the crown was only partially gold and contained a less dense metal. The metallurgist had indeed kept some gold for himself.

2) The alloy produced in this investigation is brass. There are several different types of brass. Use an internet encyclopedia resource to find at least three different types of brass. Describe the differences in proportion and variety of metals used, and the effect on the resulting properties of the brass.
Answers will vary but will most likely include some of the following:

- ***Admiralty*** *brass contains 30% zinc and 1%* tin *that will inhibit dezincification.*
- ***Alpha brasses,*** *also known as* Prince's metal*, with less than 35% zinc, are malleable, can be worked cold, and are used in pressing, forging, or similar processes.*
- ***Alpha-beta brass****, also known as* ***Muntz metal*** *and called* ***duplex brass****, is 35-45 % zinc and is suited for working hot.*
- ***Aluminum brass*** *contains aluminum, which improves its corrosion resistance.*
- ***Arsenical brass*** *contains an addition of* arsenic *and frequently aluminum and is used for* boiler fireboxes*.*
- ***Beta brasses*** *with 45-50 % zinc content can only be worked hot, are harder, stronger, and suitable for casting.*
- ***Bronze*** *is an alloy of* copper *with* tin *and optionally* zinc*,* silicon*,* nickel*, and other metals.*
- ***Calamine brass*** *is a brass alloy manufacturing process from the first millennium BC that was not replaced in Europe until the late 18th century.*
- ***Cartridge brass*** *is a 30% zinc brass with good cold working properties.*
- ***Common brass****, or* ***rivet brass****, is a 37% zinc brass, is inexpensive, and is the standard for working cold.*
- ***Cupronickel*** *is an alloy of copper with* nickel*.*
- ***High brass*** *contains 65% copper and 35% zinc, has a high tensile strength, and is used for* springs*,* screws*,* and rivets*.*
- ***Leaded brass*** *contains addition of* lead*. It has excellent machinability.*
- ***Low brass*** *is a copper-zinc alloy containing 20% zinc with a light golden color, excellent ductility and is used for flexible metal hoses and metal* bellows*.*
- ***Naval brass****, similar to admiralty brass, is a 40% zinc brass and 1% tin.*
- ***Pinchbeck*** *is a brass that closely resembles gold in appearance.*
- ***Red brass*** *is an American term for Cu/Zn/Sn alloy known as* gunmetal*.*
- ***White brass*** *contains more than 50 % zinc and is too brittle for general use.*
- ***Yellow brass*** *is the American term for 33% zinc brass.*

[Information from Wikipedia]

3) Consider two different forms of brass. Brass A is 65% copper and 35% zinc, and Brass B is 75% copper and 25% zinc. Which form will be most dense? Explain your reasoning.
Brass B will have a greater density since there is more of the more dense copper in the alloy.

4) If the crown fit comfortably, what would be the difference between wearing a brass crown and wearing a gold crown of identical mass?
The pure gold crown would be much smaller in volume.

5) If one of the principles for green chemistry is prevention of waste, especially dangerous waste, would it be greener for several students to use the same steaming alkali solution or for each student to prepare his own?
Less solution that requires disposal is the greener choice. Therefore as many students as possible using the same alkali solution would be preferred, provided it did not prohibitively lengthen the time required for the investigation.

ALCHEMY SAMPLE REPORT SHEET

I. MASS OF ORIGINAL TOKEN: _____*2.50g*_____

II. MASS OF DRY SILVER TOKEN: ___*2.51g-2.53g*_____
Instructor's Initials for silver token: _____

How does the silver token feel? (Is it smoother than the copper token? Are there rough spots?)
If the penny is very clean and bright to begin with, the coating will not change the texture.

Is the surface evenly coated with the zinc or are spots of copper still visible?
Once again, if the penny is very clean and bright to begin with, and providing that it remains in the alkali solution sufficiently long, there should be no visible copper surface.

III. MASS OF COOLED GOLD TOKEN: ___*2.51g-2.53g*_____
Instructor's Initials for gold token: _____

How does the gold token feel?
If it is heated too long, the copper layer with its brass coating will bubble up and become rough. Otherwise, it should remain very smooth.

Is the gold color uniform over the entire coin?
If the silver coating was uniform, that is to say that there was no visible copper surface, then the gold color will also be uniform. Metal is an excellent conductor of heat and the entire coin should reach the temperature required to form the allow at the same time.

IV. DECISION

Do you tell the King the token has really turned to silver and then to gold? Do you tell him the silver-colored token is just zinc-coated copper and that the zinc has diffused into the copper to make brass, a solid solution of copper and zinc?

EXTRA
Don't lose your head because of a wrong decision.
Consider the densities.

☐ Copper to Silver to Gold

☒ Copper to Zinc coating to Brass

V. DENSITY

If you claim the token is not gold, can you prove it by a density calculation?

EXTRA
Density = mass/volume.

Yes. The density of gold is 19.3g/cm^3, so the mass of a gold token would be greater than the experimental token's mass. Therefore, the token is not gold.

Many tokens are not flat but an average thickness can be calculated from the measured mass and radius using the following equation:
$t = m/(\pi r^2 d)$, where r is radius (half the diameter), π is 3.14, *t* is thickness, *d* is density, and *m* is the measured (actual) mass.

Measurements of copper token:

diameter ____*1.9*_____ cm

radius _____*0.95*_____ cm

mass _____*2.50*_____ g

EXTRA densities are:
copper 9.0 g/cm^3
silver 10.5 g/cm^3
gold 19.3 g/cm^3
zinc 7.1 g/cm^3

calculated average thickness _____*0.10*_____ cm

The volume of a token can be calculated from volume (v) = $\pi r^2 t$.
volume of token_____*0.27*_____ cm^3

You can calculate the mass of the token using the equation: mass (*m*) = density (*d*) × volume *(v)*. The token thickness did not change significantly as it changed from copper to silver to gold, so you can calculate the expected masses of a solid silver and a solid gold token using the volume of the copper token and the densities of silver and of gold. You can then compare those masses with the actual masses.

	CALCULATED MASS	ACTUAL MASS
Original Token		*2.50g*
Silver Token	*2.84g*	*2.51-2.53g*
Gold Token	*5.21g*	*2.51-2.53g*

VI. QUESTIONS

1. If the zinc adhered (stuck) to the copper instead of being bonded (chemically joined) to it, would the change to silver color be a chemical change?
   No, this is not a chemical change.

2. If the heating causes the zinc to bond with the copper, is the change to gold color a chemical change?
   Yes, the properties of the metal (color, density of the alloy, etc.) are changed.

3. What happened to the mass of a penny when the U.S. changed the penny's composition from pure copper to a copper-clad zinc coin? (Hint: Consider the densities given in the background material.)
   Provided the overall dimensions of the coin did not change, the mass of the penny decreased because the zinc has a smaller density than the copper.

4. What happened to the mass of a dime when the U.S. changed from pure silver to a silver-copper-silver sandwich?
   The mass of the dime decreased because the copper has a smaller density than the silver.

5. How long would it take a person who received an object "changed into gold" to realize he or she had been the victim of an early magic trick? What would most likely be the first indication?

As soon as something rubbed or scraped the thick alloy coating from the surface, the copper below it would become visible.

#2 Density Layers

Reagents

isopropyl alcohol	10 mL/pair

Common Materials

antifreeze	1 mL/pair
brake fluid	1 mL/pair
30 wt motor oil	1 mL/pair
power steering fluid	1 mL/pair
transmission fluid	1 mL/pair
mineral oil	10 mL/pair
Ajax® laundry detergent (liquid)	10 mL/pair
Downy® fabric softener	10 mL/pair
Karo® syrup (both types: dark and clear)	10 mL/pair
molasses	10 mL/pair
vegetable oil	10 mL/pair
small cork	1/pair
paraffin	1 small piece/pair
thumb-tack	1/pair
plastic paper clip	1/pair
aluminum paper clip	1/pair
a small stopper or pieces of rubber band	1/pair
food coloring - green	1/pair
ice cubes	1/pair

Laboratory Equipment

- 10-mL graduated cylinder
- 50-mL graduated cylinder
- 100-mL graduated cylinder
- long stem funnel
- small test tube
- 250-mL beaker

Special Equipment

(none)

Notes

The smallest rubber stopper issued to the students will suffice for the one called for in the experiment, but an even smaller one would be better.

Disposal

Most automobile fluids are oily and can contaminate water if not disposed of properly. Ethylene glycol is poisonous. Fortunately, service stations are part of our oil-recycling program. Pour the auto fluids into a marked waste container. The solutions of household products can be flushed down the drain.

DENSITY LAYERS PRE- LAB QUESTIONS

1) When you are walking through a parking lot and see a puddle of water with a rainbow effect on the surface, you are observing a thin-film optical phenomenon. Do you suspect the material in the film is miscible or immiscible with the water? Explain your reasoning.
The substance must be immiscible in order for it to form a film on the surface. If it dissolved, there would be no top layer, or film.

2) What is the nature of film on the surface of the water in the first question and what was its likely source?
The particles are not miscible so they are probably long-chain organic molecules. Since it is in a parking lot, it is most likely a petroleum product and could be oil or another auto fluid that has dripped from a car, or gasoline.

3) Assume you had to separate a series of layers of materials that have different densities. Suggest a possible method for separating each of the following:
    a) Solid objects of greater density than the liquid in which they are contained
    The less dense liquid could be poured from the top leaving the more dense solid behind.

    b) Solid objects of less density than the liquid in which they are contained
    The solids could be filtered or they could be skimmed from the surface.

    c) Two immiscible liquids of significantly different densities
    Most of the top layer could be poured from the top, and then the rest could be skimmed. Also, a burette, separatory funnel, or gravy cup could be used.

    d) Two miscible liquids of significantly different densities
    A burette or separatory funnel would be the best choice so that the interface is moved as little as possible.

4) We should be careful not to allow petroleum products to get into our waterways, and yet each time it rains we see evidence of those products in the environment. Can you suggest a creative method to trap these products as they run into street sewers?
It would be very difficult to separate them as they run into the gutters, but a settling basin that held the liquids long enough for them to separate and then allowed the water to drain out of the bottom, holding the less dense petroleum liquids on the surface would work well.

5) Motor oils are an environmental hazard. Are vegetable oils an environmental hazard?
Vegetable oils are biodegradable materials whereas petroleum products remain in the environment for many years and can be poisonous.

6) If ethylene glycol is soluble in water, is it more dangerous to the environment? Is it more difficult to remove from the environment?
Soluble compounds move throughout the environment with the water in which they are dissolved, therefore ethylene glycol is likely to spread through soils and water systems once it gets into any water way. (However, ethylene glycol is biodegradable and breaks down in 10-14 days.)

DENSITY LAYERS SAMPLE REPORT SHEET

I. AUTO LIQUIDS

List the fluids in order of decreasing density (most dense first).

_*antifreeze*_____

__*brake fluid*_____

__*transmission fluid*_____

__*30 wt motor oil* __ _____

__*manual power steering fluid*__ Instructor's initials: _____

II. ICE ON LIQUIDS

At what position is the ice originally?

The ice will come to rest between the laundry detergent and the alcohol.

After Procedure 8, where is the liquid water that came from the melted ice

It will be in solution with the liquid of most similar density, the fabric softener.

III. HOUSEHOLD LIQUIDS *(the following is sample data only)*

Mass of 10-mL graduated cylinder *28.07* g

Mineral Oil

Mass of cylinder and oil *36.66* g Volume *10* mL

minus mass of cylinder - *28.07* g Density *8.59* g = *0.859* g/mL

10 mL

Mass of oil *8.59* g

Isopropyl alcohol

Mass of cylinder and alcohol *35.64* g Volume *7.7* mL

minus mass of cylinder - *28.07* g Density *7.57* g = *0.983* g/mL

7.7 mL

Mass of alcohol *7.57* g

Ajax laundry detergent

Mass of cylinder and Ajax® *34.15* g Volume *9.4* mL

minus mass of cylinder - *28.07* g Density *6.08* g = *0.647*g/mL

9.4 mL

Mass of Ajax® *6.08* g

Downy fabric softener

Mass of cylinder and Downy® *34.76* g Volume *6.7* mL

Minus mass of cylinder - *28.07* g Density *6.69* g = *0.999* g/mL

6.7 mL

Mass of Downy® *6.69* g

Karo

Mass of cylinder and Karo® *41.07* g Volume *9.5* mL

minus mass of cylinder - *28.07* g Density *13.0* g = *1.37* g/mL

9.5 mL

Mass of Karo® *13.0* g

Molasses

Mass of cylinder and Molasses *39.13* g Volume *7.8* mL

minus mass of cylinder - *28.07* g Density *11.06* g = *1.42* g/mL

7.8 mL

Mass of molasses *11.06* g

OBJECT	ESTIMATED DENSITY	OBJECT	ESTIMATED DENSITY
Thumb-tack	*1.4* g/mL	Aluminum paper clip	*0.75* g/mL
Rubber stopper/band	*1.3* g/mL	Plastic paper clip	*0.65* g/mL
Paraffin	*0.6* g/mL	Cork	*0.5* g/mL

III. QUESTIONS

1. Why shouldn't the auto liquids be poured down the drain?
   The liquids can contaminate water and some are poisonous.

2. Of the automobile fluids, which ones mix well together? Which fluids form separate layers?
   The antifreeze and brake fluid mix well. The power steering fluid does not mix.

3. After observing the difference in the densities of the auto liquids, explain why is it important that the liquids used in an automobile be uncontaminated?
   The liquids do not mix entirely, and all have different densities. This will cause the improper functioning of an automobile.

4. What does it mean if an object sinks to the bottom of a cylinder filled with a liquid?
   This means that the object is greater than or equal in density than the liquid.

5. What does it mean if an object floats on top of a liquid?
   This means that the object is less dense than the liquid.

6. Karo® and molasses are mostly sugar in water. Why do they form separate layers?
   They form separate layers because they have different proportions of sugar and water which makes their densities different.

7. Based upon your calculations in part III, which of the household liquids will initially float on water?
   The Ajax, Downy, alcohol, and mineral oil will float.

8. What can be inferred about the relative densities of ice and water from the ice-on-liquids procedure? Give an estimate of the value of the density of ice.
   Ice is less dense than water. Bodies of water are therefore insulated as they freeze on top first.