Station One
Atomic Structure

Procedure:
Analyze each bag and fill in the following chart using the following key:

- **Protons/p^+** – blue beads
- **Neutrons/n^0** – colorless beads
- **Electrons/e^-** – number written on outside of bag with masking tape

Bag	# of p^+	# of n^0	# of e^-	Atomic #	Mass #	Nuclear Charge (charge of nucleus)	Element Symbol	Ion or Atom?	Electron Configuration	Charge on atom or ion
A	6	8	6	6	14	+6	^{14}C	atom	2-4	0
B	11	12	10	11	23	+11	^{23}Na	ion	2-8	+1
C	6	6	6	6	12	+6	^{12}C	atom	2-4	0
D	6	7	6	6	13	+6	^{13}C	atom	2-4	0
E	11	11	11	11	22	+11	^{22}Na	atom	2-8-1	0

Questions:

1. What is the definition of an isotope?

elements w/ same nof. p^+, different nof. n^0

2. Which of the bags are isotopes of one another? How do you know?

A, C, D isotopes

B + E isotopes

Same # of p^+
different # of n^0

3. What is the number of electrons in a completely filled second shell of an atom?
   1) 2
   2) 8
   3) 18
   4) 32

2

4. What is the number of electrons in an atom that has 3 protons and 4 neutrons?

1) 1
2) 3
3) 4
4) 7

2

Same # of p^+ as e^-

5. The table below gives the atomic mass and abundance of the two naturally occurring isotopes of chlorine.

Naturally Occurring Isotopes of Chlorine

Isotopes	Atomic Mass of the Isotope (u)	Natural Abundance (%)
^{35}Cl	34.97	75.76
^{37}Cl	36.97	24.24

Which numerical setup can be used to calculate the atomic mass of the element chlorine?

1) (34.97 u)(75.76) + (36.97 u)(24.24)
2) (34.97 u)(0.2424) + (36.97 u)(0.7576)
3) (34.97 u)(0.7576) + (36.97 u)(0.2424)
4) (34.97 u)(24.24) + (36.97 u)(0.7576)

3

6. Explain, in terms of electrons, why the radius of a potassium atom is larger than the radius of a potassium ion in the ground state.

The potassium atom has 4 e^- shells (2-8-8-1) and the ion only has 3 e^- shells (2-8-8)

7. Which electron configuration represents an atom of chlorine in an excited state?

1) 2-7-7
2) 2-8-7
3) 2-7-8
4) 2-8-8

3

2-8-7 ground state

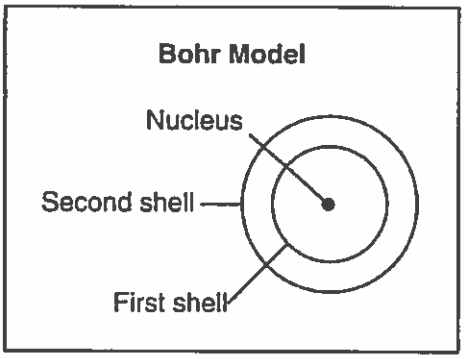
not 17 e^- so not Cl atom

ground state:

2-8-7 (17 e^-)

Base your answers to questions 8-10 on the information below.

The Bohr model of the atom was developed in the early part of the twentieth century. A diagram of the Bohr model for one atom, in the ground state, of a specific element is shown below. The nucleus contains 4 protons and 5 neutrons.



8. State the atomic number and the mass number of this element

   Atomic Number: 4

   Mass Number: 9

9. State the number of electrons in EACH shell in this atom in the ground state.

   First shell: 2

   Second shell: 2

4p+ so 4e- so e- config: 2-2

10. Using the Bohr model, describe the changes in electron energy and electron location when an atom changes from the ground state to the excited state.

electrons must gain/absorb energy and move further away from the nucleus to move from ground to excited state

Station Two
Bonding

Procedure:

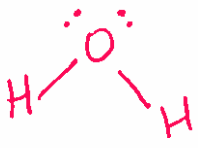
1. Examine the following elements in the "Happy Atoms" Magnetic Model Kit and determine the number of valence electrons for each. Draw a Lewis Dot Diagram for each **atom**.

Hydrogen	Nitrogen	Oxygen	Carbon
# valence electrons: 1	# valence electrons: 5	# valence electrons: 6	# valence electrons: 4
Lewis Dot Diagram: 	Lewis Dot Diagram: 	Lewis Dot Diagram: 	Lewis Dot Diagram: 

2. Using model kits, build the indicated molecules using the "Happy Atoms" Magnetic Model Kit. Ensure every atom (other than hydrogen, which follows the duet rule) obeys the octet rule.
   - ☐ H_2 H–H
   - ☐ N_2
   - ☐ H_2O
   - ☐ CO_2
3. Once you have answered all the questions at the station, disassemble the models. **Pay attention to the magnetic force when you disassemble the models!**

Questions:

1. Draw the Lewis electron dot structures for the MOLECULES of H_2, N_2, H_2O, and CO_2 in the space below. **Be sure to include all lone pairs in your structures.**

H_2	N_2	H_2O	CO_2
			

2. What type of bond holds the atoms together in N_2? Give a reason for your answer.

covalent. e^- are shared.

3. How many pairs of electrons are shared in N_2?

3 (triple bond)

4. Which one of these four molecules is polar? Explain your answer in terms of charge distribution.

H_2O. Charge is distributed asymmetrically.

5. In terms of difference in electronegativity, explain why the O—H bond in water is more polar than the C—O bond in carbon dioxide.

There is a greater difference in electronegativity between C & O than between C & H. This makes the C—O bond more polar than the C—H bond

6. When you were disassembling the models, you were breaking the bonds. Was energy required (absorbed) or released when you did this? How can you tell?

absorbed/required. It took energy for you to pull the bond apart.

7. Which statement explains why a CO_2 molecule is nonpolar?

3

1) Carbon and oxygen are both nonmetals.
2) Carbon and oxygen have different electronegativities
3) The molecule has a symmetrical distribution of charge
4) The molecule has an asymmetrical distribution of charge

8. Given the balanced equation representing a reaction:

$2H_2O + \text{energy} \rightarrow 2H_2 + O_2$

Which statement describes the changes in energy and bonding for the reactant?

2

1) Energy is absorbed as bonds in H_2O are formed
2) Energy is absorbed as bonds in H_2O are broken
3) Energy is released as bonds in H_2O are formed
4) Energy is released as bonds in H_2O are broken

BARF

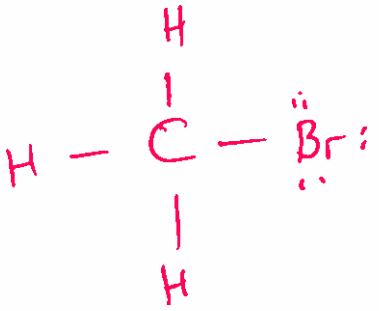
9. Two molecules of HBr collide and then form H_2 and Br_2. During the collision, the bonds in the HBr molecules are

1) Broken as energy is absorbed
2) Broken as energy is released
3) Formed as energy is absorbed
4) Formed as energy is released

1

BARF

10. In the space below, draw a Lewis electron dot diagram for a molecule of bromomethane, CH_3Br.



* include lone pairs on Br! *

Station Three
Kinetics

Procedure:

1. Put on goggles.

2. Measure out 5 mL of the 3.0 M HCl(aq) solution and pour it into a test tube.

3. Add a strip of Mg(s) to the test tube and time how long it takes the reaction to reach completion. Record the time in the space below.

   Time: _____

4. By touching the test tube, determine if the reaction is exothermic or endothermic. Record your answer in the space below.

   Exothermic or endothermic? exo (felt hot)

5. When the reaction is finished, pour the contents of the test tube into the marked waste container and rinse out the test tube with tap water. Return the test tube to the rack when you are done.

Questions:

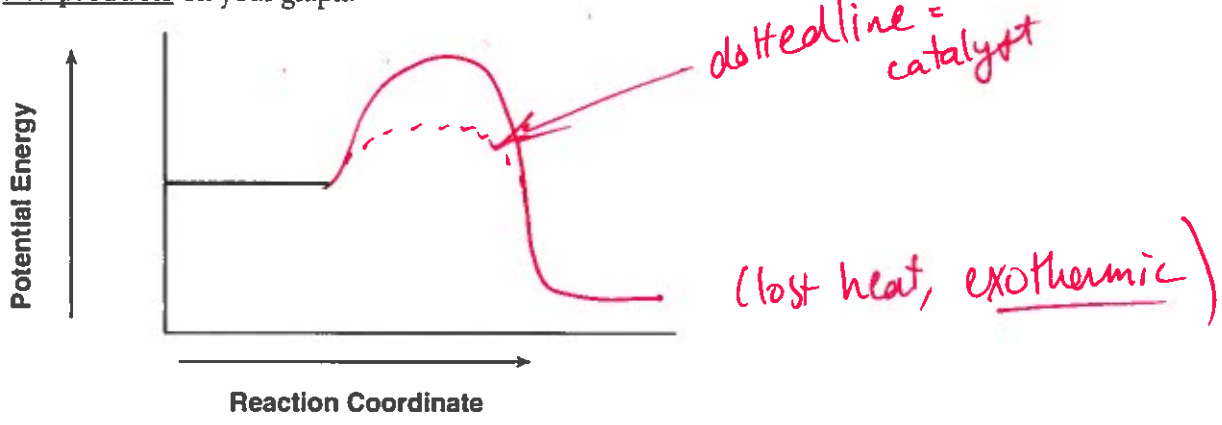
1. Balance the reaction for this process.

   $$\underline{1}\ Mg(s) + \underline{2}\ HCl(aq) \rightarrow \underline{1}\ MgCl_2(aq) + \underline{1}\ H_2(g)$$

2. What general type of reaction is this?

   Single replacement

3. Complete the potential energy diagram for the reaction in the space below. **Label the reactants and products** on your graph.



4. On your potential energy diagram above, sketch how the graph would change if you were to add a catalyst.

Base your answers to questions 5-7 on the information below.

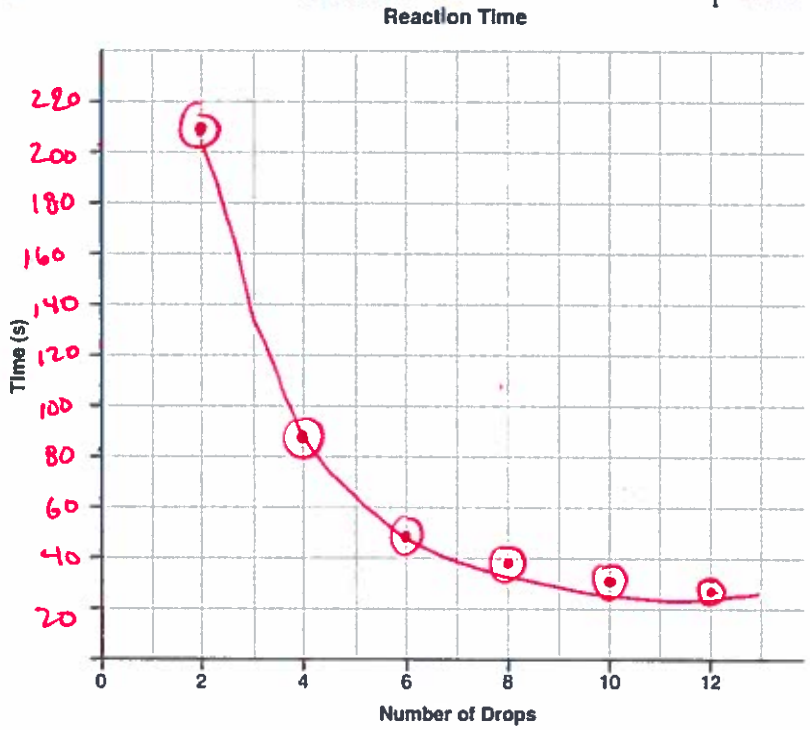
At room temperature, a reaction occurs when $KIO_3(aq)$ is mixed with $NaHSO_3(aq)$ that contains a small amount of starch. The colorless reaction mixture turns dark blue after a period of time that depends on the concentration of the reactants.

In a laboratory, 12 drops of 0.02 M $NaHSO_3(aq)$ solution containing starch were placed in each of six test tubes. A different number of drops of 0.02 M $KIO_3(aq)$ and enough water to maintain a constant volume were added to each test tube and the time for the dark-blue color to appear was measured. The data were recorded in the table below.

Data Table

Test Tube	A	B	C	D	E	F
Number of Drops of 0.02 M $KIO_3(aq)$	2	4	6	8	10	12
Time for Dark-Blue Color to Appear (s)	210.	88	49	39	33	27

5. On the grid in the space below,
   a. Mark an appropriate scale on the axis labeled "Time (s)."
   b. Plot the data from the data table. Circle and connect the points.



6. State how increasing the number of drops of 0.02 M KIO_3 (aq) used in the reaction affects the rate of reaction.

as # of drops increases, rate increases

7. Identify ONE factor, other than the concentration of the reactants, that would affect the rate of this reaction.

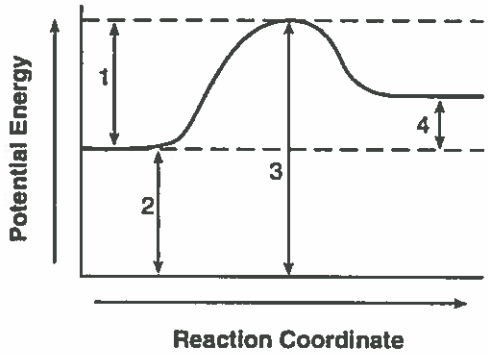
increase/ ~~decrease~~ temperature, add a catalyst
decrease

8. Which expression represents the heat of reaction for a chemical change in terms of potential energy, PE?

2

1) $(PE_{products}) + (PE_{reactants})$
2) $(PE_{products}) - (PE_{reactants})$
3) $(PE_{products}) \times (PE_{reactants})$
4) $(PE_{products}) \div (PE_{reactants})$

9. Given the potential energy diagram for a reaction:



Which interval represents the activation energy for the forward reaction?

1

1) 1
2) 2
3) 3
4) 4

Station Four
Density and Significant Figures

Procedure:

1. Mass the bar of copper using an electronic balance. Record the mass in the space below.

   Mass of copper: _____

2. Fill a graduated cylinder approximately halfway up with tap water. Record the volume to the first decimal place you cannot see in the space below.

   Volume of water in a graduated cylinder: _____

3. Carefully add the copper bar to the graduated cylinder. Try to minimize splashing. Record the new volume of water to the first decimal place that you cannot see in the space below.

   Volume of water and Cu cylinder: _____ (needs one dec. place)

4. Remove the copper bar from the graduated cylinder and dry it off with a paper towel. Empty the water from the graduated cylinder down the drain.

Questions

1. Determine the volume of the Cu cylinder.

2. How many significant figures is the volume reported to?

   1 2

3. How many significant figures is the mass reported to?

   4

4. Determine the density of the Cu cylinder to the correct number of significant figures.

   $D = \frac{m}{V}$

   needs to be to 2 dec. places

5. Using Reference Table S, calculate your percent error.

   look up accepted density for Cu in Table S

   $\%\ error = \frac{meas - acc}{acc} \times 100$

   accepted D = 8.96 g/cm3

Use the information below to answer questions 5-6.

A student is asked to determine the density of an aluminum cylinder. She records the following data:

Mass of Al:	69.11 g ← 4 SF
Volume of water in a graduated cylinder:	10.0 mL
Volume of water and Al cylinder:	35.1 mL

5. Use the student's data to determine the density of the aluminum to the correct number of significant figures.

$V_{Al} = 35.1 - 10.00 = 25.1\ mL$ (3 SF)

$D = \frac{m}{V} = \frac{69.119}{25.1\ mL} = 2.75\ g/mL$ (3 SF)

6. Calculate the student's percent error for the density of aluminum.

$\frac{meas - acc}{acc} \times 100$ Table S!

$\frac{2.75\ g/mL - 2.70\ g/mL}{2.70\ g/mL} \cdot 100 = 1.85\%$

7. An aluminum sample as a mass of 80.01 g and a density of 2.70 g/cm³. According to the data, to what number of significant figures should the calculated volume of the aluminum sample be expressed?

1) 1
2) 2
3) 3
4) 4

3

4 SF

3 SF

round to smaller #!

Station Five
Formulas and Equations, Math of Chemistry

Procedure:

1. Put on goggles.
2. Mass out approximately 5 grams of baking soda ($NaHCO_3$) to the nearest 0.01 gram on an electronic balance into a dixie cup. Record your precise mass of $NaHCO_3$ below.

   Precise mass of $NaHCO_3$: _____

3. Measure out approximately 50 mL of 1.0 M HCl into a beaker.
4. Add the baking soda into the beaker. Record your observations in the space below.

   Observations:

   fizzing/bubbling

5. When the reaction is complete, empty the waste into the designated waste container and rinse out the beaker several times with tap water. Return the beaker to the station.

Questions:

1. Name the compound $NaHCO_3$.

   Table E!

   Sodium Hydrogen Carbonate

2. Determine the gram formula mass of $NaHCO_3$.

   $23.0 + 1.0 + 12.0 + (3 \cdot 16.0)$

   84 g/mol

3. Using your mass of $NaHCO_3$ ~~recorded above~~, determine the number of moles of $NaHCO_3$ reacted.

   Table T: $\#mol = \frac{\text{given mass}}{GFM} \rightarrow \frac{\text{mass from 2}}{84\ g/mol} = mol\ NaHCO_3$ ($\sim 0.060\ mol$)

4. The baking soda and HCl react according to the reaction below.

   $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$

   Using your answer to question 3 above, determine the number of moles of CO_2 produced with your $NaHCO_3$.

   use mol from #3 and MOL RATIOS

   $NaHCO_3$: CO_2 in a 1:1 mol ratio (coefficients)

   so same # of mol CO_2 as mol $NaHCO_3$ ($\sim 0.060\ mol$)

5. What is the percent oxygen in $NaHCO_3$?

$$\%O = \frac{3 \cdot 16}{84} \times 100 = 57.1\%$$

6. Which compound has the highest percent composition by mass of strontium?
   1) $SrCl_2$
   2) SrI_2
   3) SrO
   4) SrS

3 ← Sr is paired w lightest element, so I know most of GFM must be Sr

7. What is the gram formula mass of $Fe(NO_3)_3$?
   1) 146 g/mol
   2) 194 g/mol
   3) 214 g/mol
   4) 242 g/mol

$55.8 + 3(14) + 9(16)$

241.8 g/mol

4

8. Given the balanced equation representing a reaction:

$$Al_2(SO_4)_3 + 6NaOH \rightarrow 2Al(OH)_3 + 3Na_2SO_4$$

6 : 2

The mole ratio of sodium hydroxide to aluminum hydroxide is

NaOH $Al(OH)_3$

6 : 2

3 : 1

   1) 1:1
   2) 1:3
   3) 3:1
   4) 3:7

3

9. Consider the reaction below showing the fermentation of glucose, $C_6H_{12}O_6$, to produce ethanol, C_2H_5OH, and carbon dioxide.

$$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

Conservation of mass

270 g = x g + 132 g

Determine the total mass of ethanol produced when 270. grams of glucose reacts completely to form ethanol and 132 grams of carbon dioxide.

mass products = mass reactants

270 − 132 = 138 g

10. Given the balanced equation representing a reaction

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

What is the number of moles of $H_2O(g)$ formed when 2.0 moles of $NH_3(g)$ reacts completely?
   1) 6.0 mol
   2) 2.0 mol
   3) 3.0 mol
   4) 4.0 mol

Station Six
Acids and Bases - Titration

Procedure:

1. Put on goggles.

2. The buret on the left contains 0.10 M HCl. Record the initial volume reading on the buret in the space below.

   Initial volume reading HCl: _____

3. Add approximately 10 mL of the HCl to the flask. Record the final volume reading on the buret in the space below.

   Final volume reading HCl: _____

4. Add 2 drops of the phenolphthalein indicator to the flask.

5. The buret on the right contains an unknown concentration of KOH. Record the initial volume reading on this buret in the space below.

   Initial volume reading KOH: _____

6. Titrate the KOH into the HCl until the endpoint is reached. Record the final volume reading on the KOH buret in the space below.

   Final volume reading KOH: _____

7. Dispose of the contents of the flask by putting them down the drain (the solution is now neutralized) and rinsing the flask well with tap water. Return the flask to the station.

Questions:

1. Describe one laboratory safety procedure that should be used if a drop of KOH was spilled on the arm of a student while performing this titration.

   - wash arm
   - tell teacher
   - etc.

2. Write the balanced neutralization equation for the reaction between HCl and KOH.

   acid + base → water + salt

   $HCl + KOH \rightarrow H_2O + KCl$

3. Determine the total volumes used for both HCl and KOH.

4. Calculate the molarity of KOH.

0.10M HCl
solve
know 0.10M HCl use $M_A V_A = M_B V_B$ ★ know V_A & V_B from
M_A → 0.10 M
Initial − Final volumes on buret
*should get ~

5. What is the pH of this solution when it is neutralized? What color would the indicator bromthymol blue be at this pH?

Table M
7.
green.

6. According to one acid-base theory, a base is an
   1) H^+ acceptor
   2) H^+ donor
   3) Na^+ acceptor
   4) Na^+ donor

1

7. A substance that dissolves in water and produces hydronium ions as the only positive ions in the solution is classified as
   1) An alcohol
   2) An acid
   3) A base
   4) A salt

acid
2

8. A 10.0 milliliter sample of NaOH(aq) is neutralized by 40.0 milliliters of 0.50 M HCl. What is the molarity of the NaOH?
   1) 1.0 M
   2) 2.0 M
   3) 0.25 M
   4) 0.50 M

base acid
$M_A V_A = M_B V_B$
$0.50M \cdot 40mL = M_B \cdot 10mL$
2

9. When the pH of a solution is changed from 4 to 3, the hydronium ion concentration of the solution
   1) Decreases by a factor of 10
   2) Increases by a factor of 10
   3) Decreases by a factor of 100
   4) Increases by a factor of 100

acid
↓
one step on pH scale, so 10×
4 → 3 → more acidic
2

Station Seven
Heat and Calorimetry

Procedure:

1. Obtain two 250-mL glass beakers. Fill each with 50 mL of tap water.

2. Place one of the beakers on the hot plate. Turn the hot plate up to high. Allow the beaker to heat for at least five minutes on the hot plate. Leave the other beaker on the table.

3. Measure the temperature of each beaker, estimating the last place you cannot see on the thermometer. Record the temperatures below.

☆ Temperature of room water beaker: _____

Temperature of hot water beaker: _____

4. Using gloves, place the hot water beaker on the table. Keeping your thermometer in the beaker, add the beaker of room temperature water to the beaker of hot water. Record the highest temperature reached in the space below. This will happen quickly, so monitor the thermometer carefully.

☆ Highest temperature reached by the water: _____

5. When finished, dump the water down the drain and leave both beakers on the desk top.

Questions

1. Describe the direction of heat energy transfer that took place between the two beakers.

from the hot water to the room temp H_2O.

2. What is the mass of 50 mL of water?

50 g

3. What was the temperature change for the sample of room temperature water?

Subtract 2 starred temps

4. Calculate the number of joules of heat energy that the room temperature water changed.

$q = mC\Delta T$ $q = 50g \cdot 4.18 J/g \cdot ^\circ C \cdot \Delta T$ ↑ your answer from #3

5. Convert your answer from question 4 above to kilojoules.

1000 J in 1 kJ, so ÷ answer from #4 by 1000

6. What is the amount of heat energy released when 50.0 grams of water is cooled from 20.0°C to 10.0°C?

   1) 5.00×10^{2} J
   2) 1.67×10^{5} J
   3) 2.09×10^{3} J
   4) 1.13×10^{6} J

3 ③

$q = mC\Delta T$

$q = 50g \cdot 4.18\ J/g°C \cdot 10°C$

$q = 2090J \rightarrow 2.090 \times 10^{3} J$

Base your answers to questions 7-9 on the information below.

A few pieces of dry ice, $CO_2(s)$, at -78°C are placed in a flask that contains air at 21 °C. The flask is sealed by placing an uninflated balloon over the mouth of the flask. As the balloon inflates, the dry ice disappears and no liquid is observed in the flask.

7. State the direction of heat flow that occurs between the dry ice and the air in the flask.

-78°C 21°C

from the air to the dry ice

(not to cold)

8. Write the name of the process that occurs as the dry ice undergoes a phase change in the flask.

(s → g)

Sublimation

9. Compare the entropy of the CO_2 molecules in the dry ice to the entropy of the CO_2 molecules in the inflated balloon.

solid gas

The entropy is greater in balloon.

(gases have greater entropy than solids)

Station Eight
Equilibrium

Procedure:

1. Use a beaker to place 50 mL of tap water into one 50 mL graduated cylinder; leave the second cylinder empty. The graduated cylinder with 50 mL of water represents "CONCENTRATION OF REACTANTS" and the graduated cylinder with 0 mL of water represents "CONCENTRATION OF PRODUCTS."

2. Place a large straw into each of the graduated cylinders.

3. This step requires two people – one person for each straw. Ensuring that your straw is touching the bottom of the cylinder, cover the straw with your finger to trap the water (this works best if you hold the straw with one hand and use a wetted finger on your other hand to seal the straw at the top).

4. Simultaneously transfer the contents of the straws between cylinders (be careful not to let any water spill).

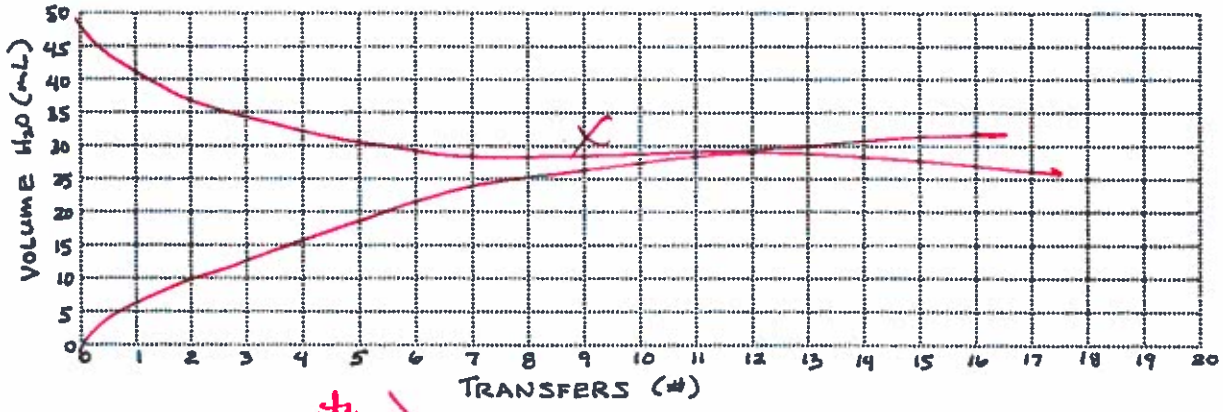
5. Record the new volumes in the graduated cylinders (use the table below).

6. Return your empty straw to its original cylinder. Repeat steps 3 – 5 **until three exchanges after the volumes stop changing**. When done, pour the water down the drain.

Table: Volume after *x* transfers

x	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
mL	50																				
mL	0																				

Plot a graph on the axes below of the volume in both graduated cylinders. Your graph should have two lines: one that starts at 50 mL, and one that starts at 0 mL.



(approximate shape)

Questions:

1. Referring back to which graduated cylinder represented reactants or products, what happened to the concentration of reactants as the "reaction" proceeded? What happened to the concentration of products as the reaction proceeded?

increased

decreased

2. Using your graph as a reference, at what point was equilibrium achieved? Mark this point on the graph with an X. How do you know equilibrium was achieved here?

when the amount stopped changing

3. What is equal at equilibrium?

RATES

4. What happens to concentrations at equilibrium?

THEY ARE CONSTANT

5. Given the equation representing a system at equilibrium

$AgCl(s) \leftrightarrow Ag^+(aq) + Cl^-(aq)$

shift LEFT

When the concentration of $Cl^-(aq)$ is increased, the concentration of $Ag^+(aq)$

1

1) Decreases, and the amount of AgCl(s) increases
2) Decreases, and the amount of AgCl(s) decreases
3) Increases, and the amount of AgCl(s) increases
4) Increases, and the amount of AgCl(s) decreases

6. An open flask is half filled with water at 25°C. Phase equilibrium can be reached after

2

1) More water is added to the flask
2) The flask is stoppered (needs a closed system)
3) The temperature is decreased to 15°C
4) The temperature is increased to 35°C

7. Given the equation for a system at equilibrium

shift →

$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g) + \text{energy}$

If only the concentration of $N_2(g)$ is increased, the concentration of

1

1) $NH_3(g)$ increases
2) $NH_3(g)$ remains the same
3) $H_2(g)$ increases
4) $H_2(g)$ remains the same

Shift RIGHT

Base your answers to questions 7 through 9 on the information below.

Common household bleach is an aqueous solution containing hypochlorite ions. A closed container of bleach is an equilibrium system represented by the equation below.

$$Cl_2(g) + 2OH^-(aq) \leftrightarrow ClO^-(aq) + Cl^-(aq) + H_2O(l)$$

8. Compare the rate of the forward reaction to the rate of the reverse reaction for this system.

Rates are equal at equilibrium

9. Explain why the container must be closed to maintain equilibrium.

Prevent $Cl_2(g)$ from escaping

10. State the effect on the concentration of the ClO^- ion when there is a DECREASE in the concentration of the OH^- ion.

ClO^- decreased.

(LeChâtelier shift RIGHT)

Station Nine
Heating and Cooling Curves

Procedure:

1. Remove a test tube containing liquid lauric acid from the hot water bath using test tube tongs and place it in a test tube rack.

2. When the temperature of the lauric acid is around 60°C, record the exact temperature (estimate to the tenths!) at time 0 and start timing.

3. Record the temperature of the lauric acid at one minute intervals. Place the test tube with the thermometer into the test tube rack and try to hold the thermometer steady so it will freeze into this position.

4. Continue taking readings for a total of fifteen (15) minutes. Record your data in the table below.

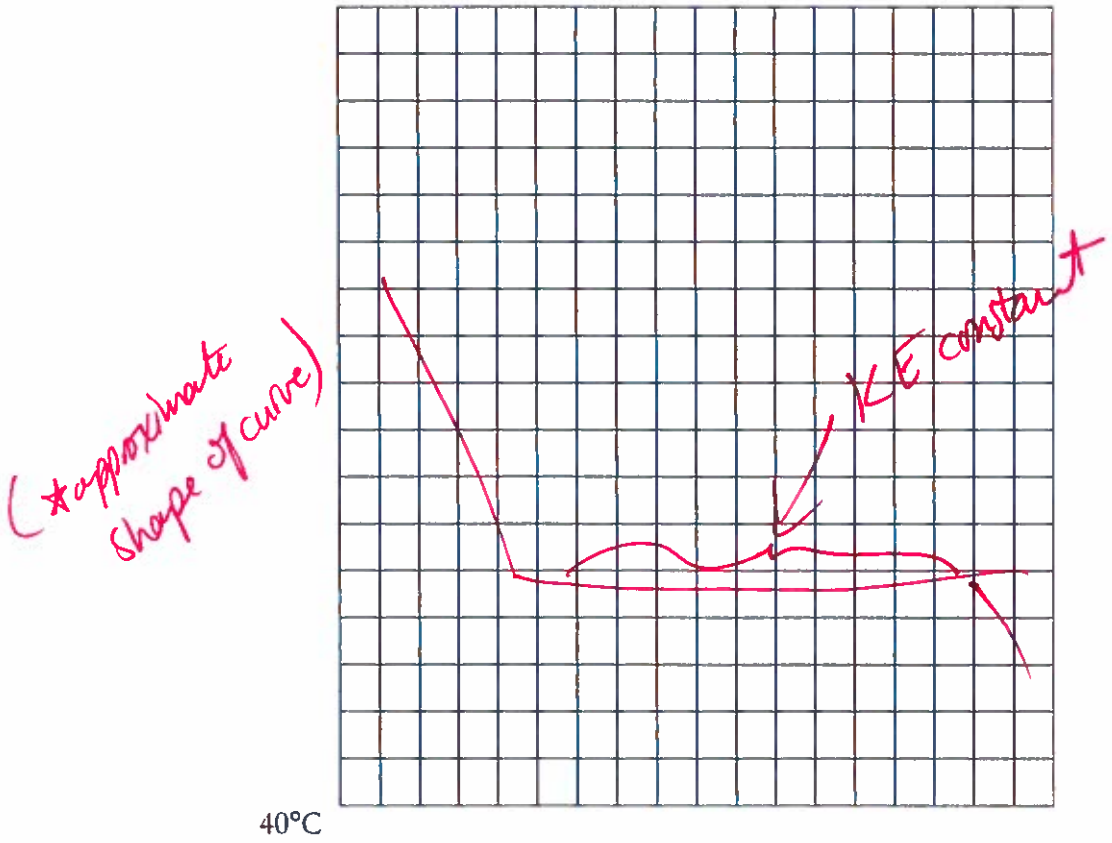
5. Construct a cooling curve for lauric acid with your data.

6. Return your test tube of lauric acid with the thermometer in it to the hot water bath.

Time	Temperature	Time	Temperature	Time	Temperature
0 min		5 min		10 min	
1 min		6 min		11 min	
2 min		7 min		12 min	
3 min		8 min		13 min	
4 min		9 min		14 min	
				15 min	

Graph: graph time (in minutes) on the x-axis. Be sure to indicate a suitable scale.

Graph temperature (in °C) on the y-axis. **Start your y-axis at 40°C**. Be sure to indicate a suitable scale.



Questions:

1. According to your data, what is the freezing point of lauric acid?

   ~42°C

2. Is the potential energy of lauric acid increasing or decreasing during this process?

   decreasing (it's freezing)

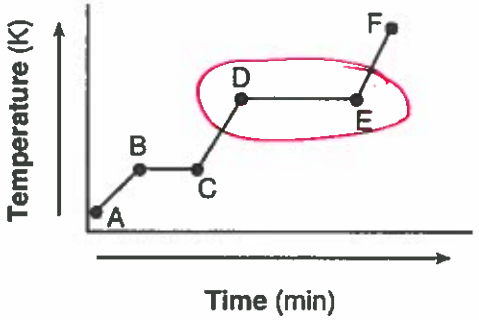
3. Label the regions of your graph where the kinetic energy is remaining constant. Explain how you know that kinetic energy is remaining constant in these regions.

   temp stayed the same

4. Compare the entropy of the lauric acid at the beginning of the cooling curve to the entropy of lauric acid at the end of the cooling curve. Explain.

   The entropy is less at the end. (solid has less entropy than liquid)

5. The heating curve below represents a sample of a substance starting as a solid below its melting point and being heated over a period of time.



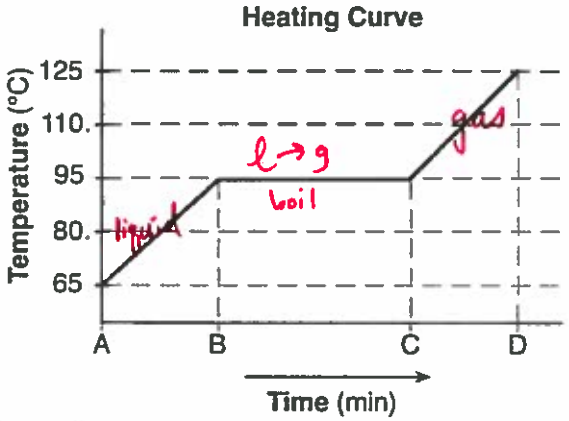
Which statement describes the energy of the particles in this sample during interval DE?

3

1) Both potential energy and average kinetic energy increase.
2) Both potential energy and average kinetic energy decrease.
3) Potential energy increases and average kinetic energy remains the same.
4) Potential energy remains the same and average kinetic energy increases.

Base your answers to questions 7-8 on the information below.

A sample of a substance is a liquid at 65°C. The sample is heated uniformly to 125°C. The heating curve for the sample at standard pressure is shown below.



6. Determine the boiling point of the sample at standard pressure.

95°C

7. State what happens to the potential energy of the particles of the sample during time interval BC.

PE increases

(KE stays the same)

Station Ten
Solutions and Bonding

Procedure:

1. Examine a chloride ion, Cl^- (green), and a water molecule (red is oxygen, white is hydrogen).
2. Bring the two particles together, specifically paying attention to how the water interacts with the magnet portion of Cl^-. Note your observations in the space below.

   OBSERVATIONS:

   Hydrogen end attracts Cl^-

3. Examine a sodium ion, Na^+ (blue), and a water molecule.
4. Bring the two particles together, specifically paying attention to how the water interacts with the magnet portion of Na^+. Note your observations in the space below.

   OBSERVATIONS:

   Oxygen end attracts Na^+

Questions

1. *(circle one)* LIKE / (OPPOSITE) charges attract.
2. Based on your observations, which side of water, O or H, was attracted to Cl^-?

   H

   Therefore, which side of water, O or H, is slightly positively charged?

   H
3. Based on your observations, which side of water, O or H, was attracted to Na^+?

   O

   Therefore, which side of water, O or H, is slightly negatively charged?

   O
4. Define the term "electronegativity."

   ability of an atom to attract/pull e^- to itself

5. Look up the electronegativities of O and H in Table S.

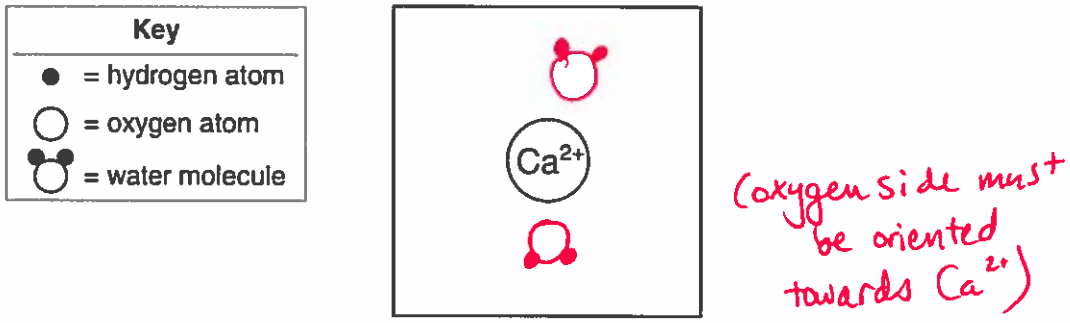
O: 3.4

H: 2.2

6. What is the electronegativity difference in the O—H bond in water?

1.2

7. Using the key and space below, draw two water molecules in the box, showing the orientation of each water molecule toward the calcium ion in solution.



(oxygen side must be oriented towards Ca^{2+})

8. Which statement explains why a C-O bond is more polar than a F-O bond?

1) At STP, carbon has a greater density than fluorine
2) A carbon atom has more valence electrons than a fluorine atom
3) The difference in electronegativity between carbon and oxygen is greater than that between fluorine and oxygen
4) The difference in first ionization energy between carbon and oxygen is greater than that between fluorine and oxygen

3

9. The electronegativity difference between the atoms in a molecule of HCl can be used to determine

1) The entropy of the atoms
2) The atomic number of the atoms
3) The first ionization energy of the atoms
4) The polarity of the bond between the two atoms

4

10. Rubbing alcohol is a product available at most pharmacies and supermarkets. One rubbing alcohol solution contains 2-propanol and water. The boiling point of 2-propanol is 82.3°C at standard pressure. Explain, in terms of electronegativity differences, why a C-O bond is more polar than a C-H bond.

The difference in electronegativity between C & O is larger than the difference in EN. between C & H

Station Eleven
Vapor Pressure, Organic Chemistry, and Intermolecular Forces of Attraction

Procedure:

1. Using a "Happy Atoms" Magnetic Model Kit, create a model for both water, H_2O, and ethanol, C_2H_5OH.

2. Examine the two stoppered flasks in front of you. They are labeled "water" and "ethanol." Put the appropriate models in front of the flasks and use the structure to answer the questions that follow.

3. When done answering the questions, disassemble your models.

Questions:

1. Each flask contains its respective liquid that has been allowed to sit at room temperature for 24 hours. Assume the temperature in our room today is 25°C. Use Reference Table H to determine the vapor pressure of both liquids inside the flasks.

   Vapor Pressure water: ~4 kPa Vapor Pressure ethanol: ~8 kPa

2. If each flask was heated to 75°C, would the vapor pressure increase, decrease, or remain the same? Explain why.

   increase. more liquid would evaporate, creating more vapor, so more vapor pressure.

3. Using Reference Table H, determine which liquid, ethanol or water, has stronger intermolecular forces of attraction.

   water

4. State the class of organic compounds to which ethanol belongs.

   alcohol

5. Examine both structures. State, in terms of molecular polarity, why ethanol is soluble in water.

   Both ethanol and water are polar, and polar substances dissolve polar substances (like dissolves like)

6. At 50.°C and standard pressure, intermolecular forces of attraction are strongest in a sample of

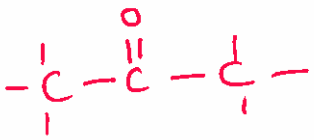
1) ethanoic acid
2) propanone
3) ethanol
4) water

7. Which substance in the table below has the strongest intermolecular forces?

Substance	Molar Mass (g/mol)	Boiling Point (kelvins)
HF	20.01	293
HCl	36.46	188
HBr	80.91	207
HI	127.91	237

1) HF (largest BP)
2) HCl
3) HBr
4) HI

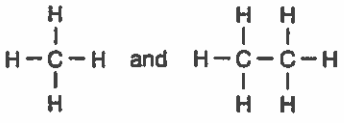
8. Propanone is also listed on Table H. Draw the structural formula for propanone in the space below. use table R



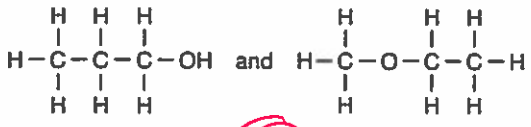
9. State the class of organic compounds to which propanone belongs.

ketone

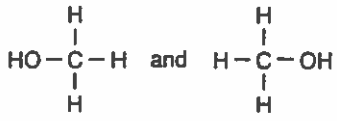
10. Which formulas represent compounds that are isomers of each other?



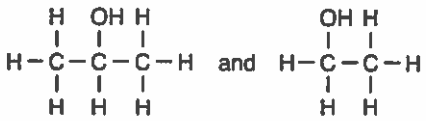
(1)



(3)



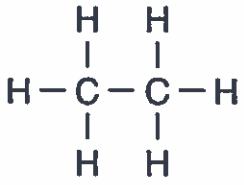
(2)



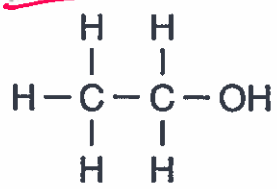
(4)

Same # & type of atoms, different structure.

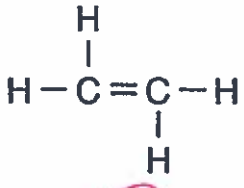
11. Which formula represents an unsaturated hydrocarbon?



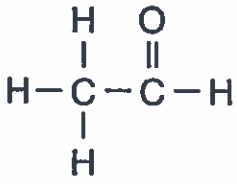
(1)



(3)



(2)



(4)

12. Butanal, butanone, and diethyl ether have different properties because the molecules of each compound differ in their
    1) Numbers of carbon atoms
    2) Numbers of oxygen atoms
    3) Types of functional groups
    4) Types of radioactive isotopes

13. Which term identifies a type of organic reaction?
    1) Deposition
    2) Distillation
    3) Esterification
    4) Sublimation

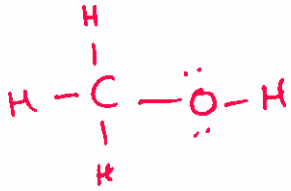
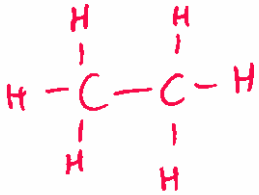
Station Twelve
Solutions, Organic Chemistry, and Hydrogen Bonding (IMFs)

Procedure:

1. Place 10 water molecules in the tray, around the edges (not the middle) of the tray.
2. Place an ethane molecule (gray = C, white = H) in the middle of the tray.
3. Vigorously shake the tray. Record your observations, especially in regards to how the water interacted with the ethane.
   OBSERVATIONS:
   The water is not attracted to the ethane
4. Place 10 water molecules in the tray, around the edges (not the middle) of the tray, as you did in step 1.
5. Place a methanol molecule in the center of the tray and vigorously shake the tray. Record your observations, especially in regards to how the water interacted with the methanol.
   OBSERVATIONS:
   The water IS attracted to the methanol
6. Remove the water molecules, ethane, and methanol, from the tray and place them in the Tupperware container.

Questions:

1. Draw structural formulas for water, methanol, and ethane in the space below. Include all lone pairs. Use your reference table (organic chemistry sections) if you need assistance drawing methanol or ethane.

Water	Methanol	Ethane
		
P / NP? P	P / NP? P	P / NP? NP

2. Label each structure as either POLAR or NONPOLAR.
3. Did the ethane "dissolve" in the water? How could you tell?
   no. no interactions between water & ethane

4. Did the methanol "dissolve" in the water? How could you tell?

yes attraction between H_2O & methanol

5. Molecules with the *(circle one)* (SAME) / DIFFERENT polarities will be soluble, aka dissolve, in each other.

6. Hydrogen bonding takes place between Hydrogen and what three elements? *(Hint: H-bonding is _ _ _!)*

F - O - N

7. *(circle one)* Hydrogen bonding is a (STRONG) / WEAK intermolecular force of attraction.

8. Which phrase describes a molecule of CH_4, in terms of molecular polarity and charge distribution?

3

1) Polar with an asymmetrical distribution of charge
2) Polar with a symmetrical distribution of charge
3) Nonpolar with an asymmetrical distribution of charge
4) Nonpolar with an asymmetrical distribution of charge

9. The boiling points, at standard pressure, of four compounds are given in the table below.

Boiling Points of Four Compounds

Compound	Boiling Point (°C)
H_2O	100.0
H_2S	−59.6
H_2Se	−41.3
H_2Te	−2.0

Which type of attraction can be used to explain the unusually high boiling point of H_2O?

2

1) Ionic bonding
2) Hydrogen bonding
3) Polar covalent bonding
4) Nonpolar covalent bonding

10. Which compound has the strongest hydrogen bonding between its molecules?

3

1) HBr
2) HCl
3) HF
4) HI

H ; FON or H - NOF

11. Which Group 16 element combines with hydrogen to form a compound that has the strongest hydrogen bonding between its molecules?

H-FON or H-NOF

1) Oxygen
2) Selenium
3) Sulfur
4) Tellurium

1

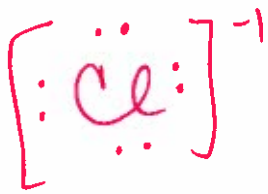
At standard pressure, water has unusual properties that are due to both its molecular structure and intermolecular forces. For example, although most liquids contract when they freeze, water expands, making ice less dense than liquid water. Water has a much higher boiling point than most other molecular compounds having a similar gram-formula mass.

12. State the type of intermolecular force responsible for the unusual boiling point of $H_2O(l)$ at standard pressure.

hydrogen bonding

Hi FON
or
H-NOF

13. Draw a Lewis electron-dot diagram for a chloride ion, Cl^-. *(hint: you must consider and include the charge in your structure)*



(must show 8 v.e. and the -1 charge)

Station Thirteen
Electrochemistry

Procedure:

1. Create a voltaic cell using copper and zinc using the equipment at the station. You only need ~50 mL of a solution in each half cell.

2. Create a second voltaic cell using aluminum and copper using the equipment at the station.

3. Measure the voltage of both cells by turning the voltmeter to "DCV 20." The red wire is connected to the cathode and the black wire is connected to the anode. Record your voltages in the space below.

   Voltage of Cu/Zn cell: _____

   Voltage of Cu/Al cell: _____

4. When finished, remove the electrodes and dry them with paper towels. Return the solutions to the appropriate beakers, and place the salt bridge in the Tupperware container. Turn off the voltmeter.

Questions

1. Identify the anode in **BOTH** the Cu/Zn cell and the Cu/Al cell. Explain how you identified the anode for both cells.

   Anode in Cu/Zn cell and explanation: Zn. Zn is above/more reactive than Cu

   Anode in Cu/Al cell and explanation: Al. Al is more reactive than Cu

2. Describe the direction of the flow of electrons in the Cu/Zn cell.

   from Zn to Cu (anode to cathode)

3. Write a balanced half reaction for the process that occurs in the **cathode** in the Cu/Al cell.

   $Cu^{2+} + 2e^- \rightarrow Cu$

4. State the purpose of the salt bridge.

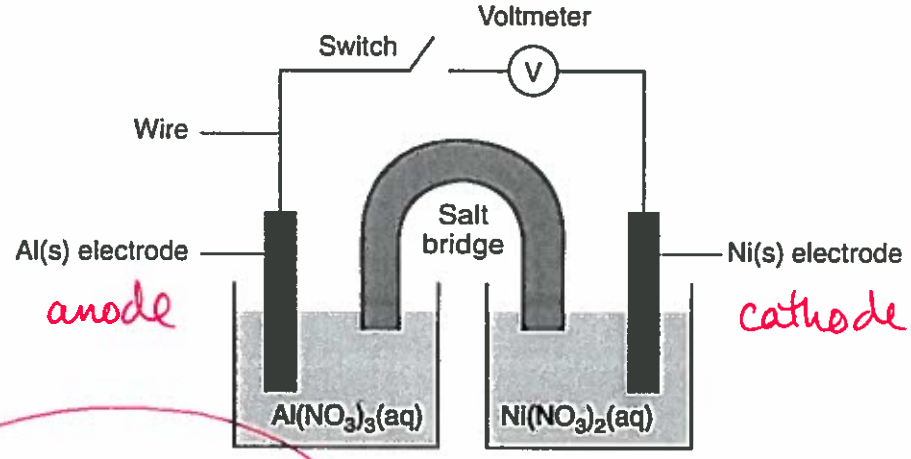
   balance charge / flow of ions

5. Consider the Cu/Zn cell. Explain, in terms of Zn atoms and Zn ions, why the mass of the Zn electrode DECREASES as the cell operates.

Zn atoms (solid) become Zn^{2+} ions, which are aqueous. The atoms dissolve into ions.

Base your answers to questions 6-9 on the information below.

A student constructs an electrochemical cell during a laboratory investigation. When the switch is closed, electrons flow through the external circuit. The diagram and equation below represent this cell and the reaction that occurs.



$$2Al(s) + 3Ni^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Ni(s)$$

6. State the direction of electron flow through the wire when the switch is closed.

from Al to Ni.

7. Write a balanced half-reaction equation for the oxidation that occurs when the switch is closed.

$Al(s) \rightarrow Al^{3+}(aq) + 3e^-$

8. Determine the number of moles of Al(s) needed to completely react with 9.0 moles of $Ni^{2+}(aq)$ ions.

2:3 ratio of $Al(s) : Ni^{2+}(aq)$ (coefficients)

$$9.0 \text{ mol } Ni^{2+} \left| \frac{2 \text{ mol Al}}{3 \text{ mol } Ni^{2+}} \right. = 6.0 \text{ mol Al}$$

9. State, in terms of energy, why this cell is a voltaic cell.

electrical energy is created (from chemical energy)

$Mg^0 \rightarrow Mg^{2+} + 2e^-$

10. What occurs when a magnesium atom becomes a magnesium ion?
    1) Electrons are gained and the oxidation number increases
    2) Electrons are gained and the oxidation number decreases
3 3) Electrons are lost and the oxidation number increases
    4) Electrons are lost and the oxidation number decreases

11. Energy is required to produce a chemical change during
    1) Chromatography
2 2) Electrolysis
    3) Boiling
    4) Melting

12. Which balanced equation represents a redox reaction?
1 1) $\overset{0}{Mg} + \overset{0}{Cl_2} \rightarrow \overset{+2}{Mg}\overset{-1}{Cl_2}$ ★ charge must change! ★
    2) $CaO + H_2O \rightarrow Ca(OH)_2$
    3) $HNO_3 + NaOH \rightarrow H_2O + NaNO_3$
    4) $NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$

13. In a redox reaction, the number of electrons lost is equal to the number of
    1) Protons lost
    2) Neutrons lost
4 3) Neutrons gained
    4) Electrons gained

14. At which electrode does oxidation occur in a voltaic cell and in an electrolytic cell?
    1) The anode in a voltaic cell and the cathode in an electrolytic cell
    2) The cathode in a voltaic cell and the anode in an electrolytic cell
3 3) The anode in both a voltaic cell and an electrolytic cell
    4) The cathode in both a voltaic cell and an electrolytic cell

Station Fourteen
Solutions

Procedure:

1. Mass out 8.0 grams of $NaNO_3$ using dixie cups.
2. Measure out 100 mL of tap water and place it in a beaker.
3. Dissolve the $NaNO_3$ in the tap water. Record your observations in the space below.

   Observations:

4. When finished answering the questions, pour the solution down the drain and rinse out the beaker well with tap water.

Questions

1. Name $NaNO_3$.

   Sodium nitrate

2. Identify the solvent in your solution.

   water

3. We will assume that the solution is the same temperature as room temperature, 25°C. Using Reference Table G, determine if your solution is saturated, unsaturated, or supersaturated.

   unsaturated

4. Describe a lab process that would allow you to recover the dissolved $NaNO_3$ from the solution.

   evaporate the water

   (filtration will NOT work → $NaNO_3$ is soluble, so it will pass thru the filter paper)

5. Compare the freezing point of this solution to the freezing point of a solution containing 20.0 grams of $NaNO_3$ in 100 mL of water.

   The freezing point of the 8.0g $NaNO_3$ solution is higher than the freezing point of the 20.0g $NaNO_3$ soln.
   (the more solute, the lower the FP, the higher the BP)

6. Compared to distilled water, an aqueous salt solution has
   1) better electrical conductivity
   2) poorer electrical conductivity
   3) a lower boiling point at standard pressure
   4) a higher freezing point at standard pressure

7. A mixture consists of sand and an aqueous salt solution. Which procedure can be used to separate the sand, salt, and water from each other?
   1) Evaporate the water, then filter out the salt.
   2) Evaporate the water, then filter out the sand.
   3) Filter out the salt, then evaporate the water.
   4) Filter out the sand, then evaporate the water.

8. An aqueous solution has a mass of 490 grams containing 8.5×10^{-3} gram of calcium ions. The concentration of calcium ions in this solution is
   1) 4.3 ppm
   2) 17 ppm
   3) 8.5 ppm
   4) 34 ppm

$ppm = \frac{\text{mass solute}}{\text{mass sol'n}} \times 1{,}000{,}000$

$ppm = \frac{8.5 \times 10^{-3}\,g}{490\,g} \times 1{,}000{,}000$

9. Compared to the boiling point and the freezing point of water at 1 atmosphere, a 1.0 M $CaCl_2(aq)$ solution at 1 atmosphere has a
   1) lower boiling point and a lower freezing point
   2) lower boiling point and a higher freezing point
   3) higher boiling point and a lower freezing point
   4) higher boiling point and higher freezing point

10. A 1-gram sample of a compound is added to 100 grams of $H_2O(l)$ and the resulting mixture is then thoroughly stirred. Some of the compound is then separated from the mixture by filtration. Based on Table F, the compound could be
   1) AgCl → means its insoluble
   2) $CaCl_2$
   3) NaCl
   4) $NiCl_2$

11. In a laboratory investigation, a solution that contains 13.2 grams of $Pb(NO_3)_2$ reacts completely with a solution that contains 12.0 grams of NaI, producing 18.4 grams of PbI_2 and an undetermined mass of a second product, $NaNO_3$. This reaction is represented by the balanced equation below.

$$Pb(NO_3)_2 + 2NaI \rightarrow PbI_2 + 2NaNO_3$$

Identify the compound produced that is insoluble in water.

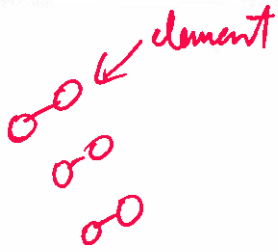
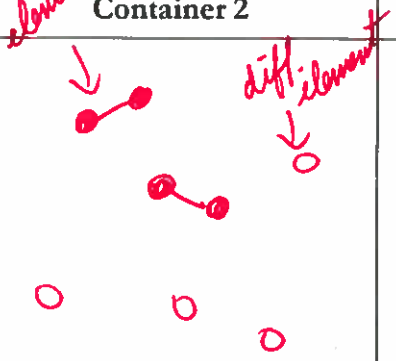
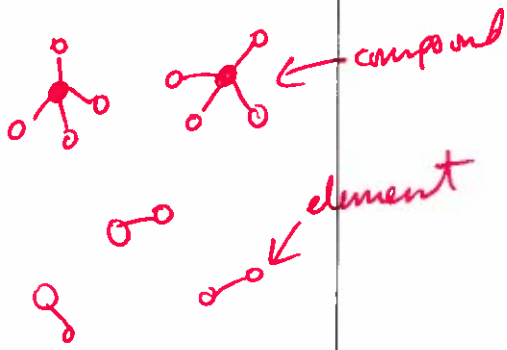
PbI_2 (use Table F)

Station Fifteen
Matter: Elements/Compounds/Mixtures; Physical/Chemical Properties

Procedure:

1. For each container, sketch a picture of the contents in the space below using the colored pencils.

2. For each container, identify whether it is an element, a compound, a mixture of elements, a mixture of compounds, or a mixture of elements and compounds.

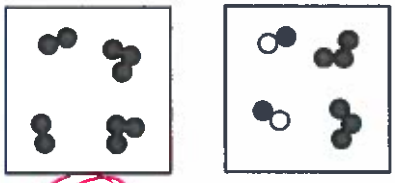
Container 1	Container 2	Container 3
		
Circle the correct classification: a. Element b. Compound c. Mixture of elements d. Mixture of compounds e. Mixture of elements and compound	Circle the correct classification: a. Element b. Compound c. Mixture of elements d. Mixture of compounds e. Mixture of elements and compound	Circle the correct classification: a. Element b. Compound c. Mixture of elements d. Mixture of compounds e. Mixture of elements and compound

3. Ensure all the samples are back in their correct container and you have put the colored pencils back in their box.

Questions

1. Which diagram represents a mixture of different molecular forms of the same element?

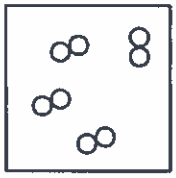
Key
● = atom of element X
○ = atom of element Z



(1)

(3)

(2)



(4)

2. Which statement describes a chemical change?
   1) Alcohol evaporates
   2) Water vapor forms snowflakes
   3) Table salt (NaCl) is crushed into powder
   4) Glucose ($C_6H_{12}O_6$) and oxygen produce CO_2 and H_2O

3. A mixture of sand and table salt can be separated by filtration because the substances in the mixture differ in
   1) Boiling point
   2) Density at STP
   3) Freezing point
   4) Solubility in water

4. Which sample of matter is classified as a substance?
   1) Air
   2) Ammonia
   3) Milk
   4) Seawater

5. At STP, oxygen exists in two forms, $O_2(g)$ and $O_3(g)$. These two forms of oxygen have
   1) Different molecular structures and different properties
   2) Different molecular structures and the same properties
   3) The same molecular structure and different properties
   4) The same molecular structure and the same properties

6. Consider the reaction:

$$Al(s) + CuSO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + Cu(s)$$

charge on Cu^{+2}! need roman numerals if metal has multiple charges

a. Name $CuSO_4$

copper (II) sulfate

b. Explain why the equation represents a chemical change.

a new compounds are formed

Base your answers to questions 7-8 on the information below.

Iron has been used for thousands of years. In the air, iron corrodes. One reaction for the corrosion of iron is represented by the balanced equation below.

Equation 1: $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

In the presence of water, iron corrodes more quickly. This corrosion is represented by the unbalanced equation below.

Equation 2: $Fe(s) + O_2(g) + H_2O(l) \rightarrow Fe(OH)_2(s)$

7. Identify one substance in the passage that can NOT be broken down by a chemical change.

Fe or O_2

8. Using equation 1, describe ONE chemical property of iron.

iron corrodes

Base your answers to questions 9-11 on the information below.

soluble

A laboratory technician is given the table below and a sample of one of the three substances listed in the table. The technician makes an aqueous solution with a portion of the sample. When a conductivity tester is lowered into the solution, the lightbulb on the tester glows brightly. Another portion of the sample is placed in a heat-resistant container that is placed in an oven at 450°C. The sample melts.

so MP is below 450°C

Some Properties of Three Substances

Property	Substance		
	Sodium nitrate	**Potassium chromate**	**Sulfur**
Solubility in water at 20.°C	Soluble	Soluble	Insoluble
Electrical conductivity of aqueous solution	Good	Good	Not applicable
Melting point (°C)	307	974	115

9. Identify the substance given to the technician.

Sodium nitrate

10. State evidence that made it necessary to use more than one property to identify the substance given to the technician.

2 substances were soluble / 2 substances were good conductors, so need more tests to differentiate

11. Explain, in terms of ions, why an aqueous solution of potassium chromate conducts an electrical current.

Solutions will conduct if they have a moving charge. Potassium chromate (aqueous) contains ions (charged particles) that can move (b/c aqueous).

Station Sixteen
Gases

Procedure:

1. Open the pHet simulation website for gases on the laptop. Pump the bike handle to add gas particles to the chamber.

2. Add heat to the gas particles. Observe the behavior of the gas particles. What has changed because of the addition of heat? How has it changed (increased or decreased)? Explain this.

increase pressure.
Particles more faster, collide w container more frequently.

3. Make the volume of the chamber larger. Observe the behavior of the gas particles. What has changed because of this increase in volume? How has it changed (increased or decreased)? Explain this.

lower pressure.
larger volume, so fewer collisions w container.

4. Pump more gas particles into the chamber. Observe the behavior of the gas particles. What has changed because of the addition of more gas particles? How has it changed (increased or decreased)? Explain this.

More pressure.
More gas, more collisions.

5. Click the Reset button.

Questions

1. If you had added a second gas sample to the chamber in the simulation, what would have happened to the pressure of the system? Explain.

Increase, more collisions.

2. What happened to the kinetic energy of the gas sample when you increased the temperature?

Increases.

3. A rigid cylinder with a movable piston contains a sample of gas. At 300. K, this sample has a pressure of 240. kilopascals and a volume of 70.0 milliliters. What is the volume of this sample when the temperature is changed to 150. K and the pressure is changed to 160. kilopascals?

3

1) 35.0 mL
2) 70.0 mL
3) 52.5 mL
4) 105 mL

$\frac{240\ kPa \cdot 70\ mL}{300\ K} = \frac{160\ kPa \cdot V_2}{150\ K}$

4. Under which conditions of temperature and pressure does a real gas behave most like an ideal gas?

2

1) 37 K and 1 atm
2) 347 K and 1 atm
3) 37 K and 8 atm
4) 347 K and 8 atm

high temp
low Pressure

5. According to the kinetic molecular theory for an ideal gas, all gas particles

1

1) are in random, constant, straight-line motion
2) are separated by very small distances relative to their sizes
3) have strong intermolecular forces
4) have collisions that decrease the total energy of the system

6. Which gas sample at STP has the same number of molecules as a 2.0-liter sample of $Cl_2(g)$ at STP?

2

1) 1.0 L of $NH_3(g)$
2) 2.0 L of $CH_4(g)$
3) 3.0 L of $CO_2(g)$
4) 4.0 L of $NO(g)$

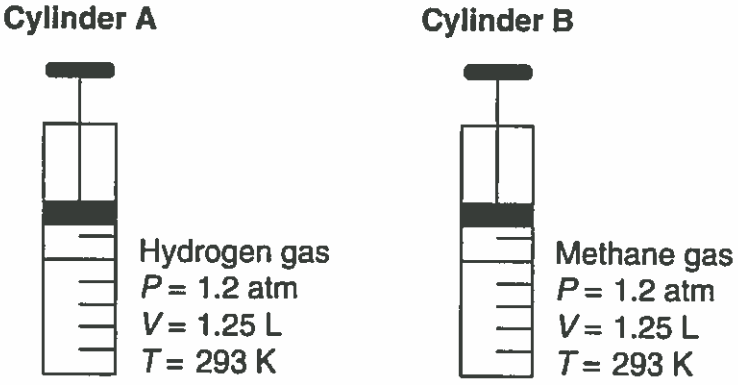
7. According to the kinetic molecular theory, which statement describes an ideal gas?

3

1) The gas particles are diatomic
2) Energy is created when the gas particle collide
3) There are no attractive forces between the gas particles
4) The distance between the gas particles is small, compared to their size

Base your answers to questions 8-10 on the following information.

Cylinder A has a movable piston and contains hydrogen gas. An identical cylinder, B, contains methane gas. The diagram below represents these cylinders and the conditions of pressure, volume, and temperature of the gas in each cylinder.



8. Compare the total number of gas molecules in cylinder A to the total number of gas molecules in cylinder B.

They are the same

9. State a change in temperature and a change in pressure that will cause the gas in cylinder A to behave more like an ideal gas.

Change in temperature: increase

Change in pressure: decrease

10. In the space below, show a numerical setup for calculating the volume of the gas in cylinder B at STP.

1 atm, 273 K

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{1.2\,\text{atm} \cdot 1.25\,\text{L}}{293\,\text{K}} = \frac{1.0\,\text{atm} \cdot V_2}{273\,\text{K}}$$

Station Seventeen
Periodic Table

Questions

Base your answers to questions 1-4 on the information below, which is also shown in a large scale at the station.

Before atomic numbers were known, Mendeleev developed a classification system for the 63 elements known in 1872, using oxide formulas and atomic masses. He used an R in the oxide formulas to represent any element in each group. The atomic mass was listed in parentheses after the symbol of each element. A modified version of Mendeleev's classification system is shown in the table below.

Modified Version of Mendeleev's Table

Group →		I	II	III	IV	V	VI	VII
Oxide formulas		R_2O	RO	R_2O_3	RO_2	R_2O_5	RO_3	R_2O_7
Series	1	H(1)						
	2	Li(7)	Be(9.4)	B(11)	C(12)	N(14)	O(16)	F(19)
	3	Na(23)	Mg(24)	Al(27.3)	Si(28)	P(31)	S(32)	Cl(35.5)
	4	K(39)	Ca(40)		Ti(48)	V(51)	Cr(52)	Mn(55)
	5	Cu(63)	Zn(65)			As(75)	Se(78)	Br(80)
	6	Rb(85)	Sr(87)	Yt(88)	Zr(90)	Nb(94)	Mo(96)	
	7	Ag(108)	Cd(112)	In(113)	Sn(118)	Sb(122)	Te(125)	I(127)
	8	Cs(133)	Ba(137)	Di(138)	Ce(140)			

1. Identify one characteristic used by Mendeleev to develop his classification system of the elements.

oxide formulas / atomic masses

(in reading)

2. Based on Mendeleev's oxide formula, what is the number of electrons lost by each atom of the elements in Group III?

3

R_2O_3

$R = +3$ $O = -2$

if $R = +3$, then $3e^-$ lost

3. Based on Table J, identify the LEAST active metal listed in Group I on Mendeleev's table.

Ag

4. Explain, in terms of chemical reactivity, why the elements in Group 18 on the modern Periodic Table were NOT identified by Mendeleev at that time.

Group 18 elements are very unreactive.

5. Which property decreases when the elements in Group 17 are considered in order of increasing atomic number?

4

1) atomic mass
2) melting point
3) atomic radius
4) electronegativity

Table S

6. Which term refers to how strongly an atom of an element attracts electrons in a chemical bond with an atom of a different element?

2

1) entropy
2) electronegativity
3) activation energy
4) first ionization energy

7. At STP, which substance has metallic bonding?

4

1) ammonium chloride
2) iodine
3) barium oxide
4) silver

metal

8. In the formula XF_2, the element represented by X can be classified as a

2

1) Group 1 metal
2) Group 2 metal
3) Group 1 nonmetal
4) Group 2 nonmetal

Base your answers to questions 9-11 on the information below.

There are six elements in Group 14 on the Periodic Table. One of these elements had the symbol Uuq, which was a temporary, systematic symbol. This element is now known as flerovium.

9. Identify an element in Group 14 that is classified as a metalloid.

Si or Ge

10. Explain, in terms of electron shells, why each successive element in Group 14 has a larger atomic radius, as the elements are considered in order of increasing atomic number.

each successive element in Group 14 has one more e⁻ shell than the last.

11. State the expected number of valence electrons in an atom of the element flerovium in the ground state.

4

12. Explain, in terms of electrons, why the radius of a potassium atom is larger than the radius of a potassium ion in the ground state.

K atom: 2-8-8-1
K ion: 2-8-8
(+1)

The atom has more e⁻ shells than the ion.

13. Explain, in terms of atomic structure, why Group 18 elements on the periodic table rarely form compounds.

Group 18 elements have 8 valence electrons, which is stable and unreactive.

Station Eighteen
Nuclear Chemistry

Procedure:
NOTE: **Orange** colored pieces represent **neutrons**. **Brown or yellow** pieces represent **protons**.

1. From the bowl of candy pieces, **set aside** 2 "neutrons" and 2 "protons."
   a. What type of radiation will this 2 neutron/2 proton particle represent?

      alpha

   b. Write this particle in standard isotopic notation (showing mass#, atomic#, and symbol). This is a "reactant."

      $^{4}_{2}He$ or $^{4}_{2}\alpha$

2. With a medicine cup, scoop a flat, full cup of candy pieces, then dump it out on a paper towel. Count the "protons" and "neutrons."

   a. How many "protons" are in this atom? _____

   b. How many "neutrons" are in this atom? _____

   c. What "element" nucleus does this model? _____

   d. What is the mass number of this "element"? _____

   e. Write this particle in standard isotopic notation. This is a "reactant."

   answers will vary

3. Place the mix of "protons" and "neutrons" from the heavier element back into your cup.

4. Now, you will bombard your two particles together by smashing them into one another! Place your 2 "protons" and 2 "neutrons" that you set aside on top of the candy in the cup. Push them to the bottom of the cup with your fingers. ALLOW PIECES TO FALL OUT!!!!

5. Answer the following questions based on your results.

   a. How many "protons" fell out? _____

   b. How many "neutrons" fell out? _____

   c. Which element does this represent? _____

   answers will vary

d. What is the mass number of this "element"? _____

e. How many "protons" remain in the cup? _____

f. How many "neutrons" remain in the cup? _____

g. Which "element" does this represent? _____

h. What is the mass of this "element"? _____

answers will vary

6. Write the symbols for the two particles that now remain (the one that fell outside the cup, and the one that remained in the cup) using standard isotopic notation. These two particles are your "products."

Questions

1. Write a balanced nuclear decay equation for the nuclear reaction using your "reactants" (from Procedure Steps 1 and 2) and your "products" (from Procedure Step 6) in the space below.

2. What type of nuclear reaction is this? How do you know?

artificial transmutation
2 reactants bombarding together

3. Explain how this activity illustrates the Law of Conservation of Mass.

The total # of p^+ and n^0 did not change from reactants to products

4. Which list of nuclear emissions is arranged in order from the greatest penetrating power to the least penetrating power?

1) alpha particle, beta particle, gamma ray
2) alpha particle, gamma ray, beta particle
3) gamma ray, alpha particle, beta particle
4) gamma ray, beta particle, alpha particle

4

5. Nuclei of U-238 atoms are

4

1) stable and spontaneously absorb alpha particles
2) stable and spontaneously emit alpha particles
3) unstable and spontaneously absorb alpha particles
4) unstable and spontaneously emit alpha particles

6. After decaying for 48 hours, $\frac{1}{16}$ of the original mass of a radioisotope sample remains unchanged. What is the half-life of this radioisotope?

2

1) 3.0 h
2) 12 h
3) 9.6 h
4) 24 h

Time: Total: 48h, one ½: X

Mass: Initial: 1, Final: 1/16

1 →① ½ →② ¼ →③ ⅛ →④ 1/16

4 ½ lives in 48h

so one ½ life: $\frac{48}{4}$

Base your answers to questions 7-10 on the information below.

A breeder reactor is one type of nuclear reactor. In a breeder reactor, uranium-238 is transformed in a series of nuclear reactions into plutonium-239.

The plutonium-239 can undergo fission as shown in the equation below. The X represents a missing product in the equation.

$$^{1}_{0}n + {}^{239}_{94}Pu \rightarrow X + {}^{94}_{36}Kr + 2\,{}^{1}_{0}n$$

$^{1}_{0}n + {}^{1}_{0}n$

7. Determine the number of neutrons in an atom of the uranium isotope used in the breeder reactor.

238 U

from PT → 92

146

146 n°

8. Based on Table N, identify the decay mode of the plutonium radioisotope produced in the breeder reactor.

look up Pu-239 in Table N

α

9. Compare the amount of energy released by 1 mole of completely fissioned plutonium-239 to the amount of energy released by the complete combustion of 1 mole of methane.

Much more energy released in fission than combustion

10. Write a notation for the nuclide represented by missing product X in this equation.

$^{144}_{58}Ce$