Name: _____

28.1 The Nucleus and Structure of the Atom

Question: What is inside an atom?

1 Modeling an atom

There are no questions to answer in Part 1.

2 The Atomic Challenge

There are no questions to answer in Part 2.

3 Reflecting on what you learned

a. What do you know about an atom if you know its atomic number?

b. What do you know about an atom if you know its mass number?

c. How many stable isotopes does oxygen have?

d. Find one element on the chart that has no stable isotopes.

e. What element has atoms with 26 protons in the nucleus?

Extra space for notes and performing calculations:

Name:

28.2 Electrons and Quantum States

Question: How do atoms create and interact with light?

1 Modeling the absorption and emission of light

There are no questions to answer in Part 1.

2 Playing the game

There are no questions to answer in Part 2.

3 Pump cards

There are no questions to answer in Part 3.

4 Laser cards and scoring

There are no questions to answer in Part 4.

5 Reflecting on what you learned

a. Research additional sources of information about lasers to find out more about how they work. Using that information, think of an application for a laser that has not been thought of before. Describe your new application of a laser.

b. Write a a short paragraph that describes how fireworks work. Use what you learned from playing the Photons and Lasers game and research additional sources of information to write your paragraph.

c. What is a photon? What do photons have to do with lasers and fireworks?

Name:

28.3 The Quantum Theory

Question: How can a system be quantized?

1 Setting up the experiment

There are no questions to answer in Part 1.

2 Waves on the vibrating string

At certain frequencies the vibrating string will form wave patterns called *harmonics*. The first harmonic has one bump, the second harmonic has two bumps, and so on. The harmonic number is like the *quantum number* for the electron wave in an atom. The first harmonic (fundamental) has quantum number 1. The second harmonic has quantum number 2 and so forth.

Adjust the frequency to obtain the first 8 "quantum numbers" for the string and record the frequency for each one in Table 1. You should fine-tune the frequency to obtain the largest amplitude before recording the data for each harmonic.

Table 1: Frequency and energy data

Quantum # (harmonic #)	Frequency (Hz)	Energy (joules)
1		
2		

a. Suppose the energy of the fundamental wave on the string (quantum # 1) is one joule. Use your data to determine a 'Planck's constant' for the vibrating string.

b. What are the units for your string's Planck's constant?

c. Use your string's Planck's constant to calculate the energies of the other harmonics. Record your calculations in the last column of Table 1.

3 The wavelength of a particle

a. Calculate the wavelength of a steel ball with a mass of 28 grams that is moving at 45 m/sec (100 mph).

b. Is the wavelength you calculated a large or small number compared to the size of the ball?

c. Suppose the ball is confined to a box that has a width of 10 cm. Do you think you need quantum mechanics to describe the motion of the ball in the box? Base your answer on the comparison between the wavelength of the ball and the size of the box.

Name: _____

29.1 Chemistry

Question: What techniques are used to separate heterogeneous mixtures?

1 Designing your procedure

a. Make a list of equipment you will need to carry out your procedure. Submit the list to your instructor. If any items are unavailable, determine an alternative method and resubmit your list.

b. Write out your procedure, step by step. Be sure to include appropriate safety instructions throughout. Remember, your final step is to find the percent composition by mass of your mixture. Show the procedure to your instructor before you proceed.

2 Separating the materials

a. Did you make any changes to your procedure as you went along? If so, describe the changes and why they were made.

b. If you were to separate another batch of this material, would you modify your procedure further? Are there ways you could make it less time-consuming or less expensive? Explain.

3 Finding the percent composition of your sample

Table 1: Percent composition of the mixture

Component	Mass (grams)	Total mass of sample (grams)	Percent composition
Sawdust			
Iron filings			
Sand			
Salt			

a. Find the sum of the percentages in column four. Do they add up to 100 percent? If not, explain why not.

b. Identify at least two sources of experimental error in your procedure. How could you minimize them if you were to repeat the experiment?

Name:

29.2 Chemical Bonds

Question: Why do atoms form chemical bonds?

1 Reviewing atomic structure

There are no questions to answer in Part 1.

2 How many electrons are in the outermost level?

Using the atom building game, build each element in the table. For each element, record the number of electrons in the outermost energy level and the number of unoccupied spaces in the outermost energy level.

element	atomic number	electrons in outermost level	unoccupied spaces in outermost level
hydrogen			
helium			
lithium			
fluorine			
neon			
sodium			
chlorine			
argon			
potassium			

3 What are valence electrons?

a. What do lithium, sodium, and potassium have in common?

b. What do fluorine and chlorine have in common?

c. What do neon and argon have in common?

4 Modeling a chemical bond

a. In order to complete its outermost energy level, do you think sodium will tend to lose its only valence electron, or gain seven? Explain your answer.

b. In order to complete its outermost energy level, do you think chlorine will tend to lose all of its valence electrons or gain one electron? Explain your answer.

c. Why might these two atoms bond together to form a molecule? In your answer, describe what you think might happen when sodium and chlorine form a chemical bond.

5 Determining oxidation numbers

a. Remove the valence electron from sodium. What has happened to the balance of positive and negative charges? What is sodium's oxidation number?

b. Move the electron you took from sodium into the chlorine. What happens to chlorine's charge when it gains the electron from the sodium atom? What is chlorine's oxidation number?

c. When sodium and chlorine form a chemical bond, what is the overall charge of the molecule? Why do you think sodium and chlorine combine in a 1:1 ratio?

Name: _____

29.3 Chemical Reactions

Question: How can you predict the yield of a chemical reaction?

1 Writing the balanced equation for the reaction

There are no questions to answer in Part 1.

2 Determining the masses of reactants and products

Table 1: Masses of reactants and products in atomic mass units

Reactants				Products			
Substance	Mass (amu)	Coefficient	Total mass (amu)	Substance	Mass (amu)	Coefficient	Total mass (amu)
Mg				$MgCl_2$			
HCl				H_2			
Total mass of reactants (amu):				**Total mass of products (amu):**			

a. Does the information in the table support the statement that chemical reactions conserve mass? Explain your answer.

_____

_____

_____

b. What is the importance of coefficients in the equation?

_____

_____

_____

3 Observing the reaction

Safety Tip: Hydrochloric acid can cause burns. Handle it with extreme caution! Wear gloves, goggles, and a lab apron at all times during the Investigation.

a. What evidence did you observe that a gas was produced in the reaction?

_____

_____

b. What evidence did you observe that the magnesium metal was completely used up in the reaction?

_____

_____

c. Is this reaction endothermic or exothermic? Explain your answer.

d. Describe a simple method for measuring the mass of the hydrogen gas produced in the reaction.

4 Predicting the amount of product

a. Suppose you reacted 3.5 grams of magnesium with enough hydrochloric acid so that the magnesium was completely used up. Predict how many grams of hydrogen gas would be produced.

b. How many grams of magnesium would be required to react completely with hydrochloric acid to produce 5.00 grams of hydrogen gas?

5 Doing the experiment

Table 2: Data from the experiment

Measurements (g)	Trial 1	Trial 2	Trial 3	Trial 4
Mass of magnesium strip:				
Mass of beaker with hydrochloric acid:				
Mass of beaker *before* the reaction:				
Mass of beaker *after* the reaction:				
Mass of hydrogen gas produced (**actual yield**):				
Predicted mass of hydrogen gas (**predicted yield**):				

6 Calculating percent yield

Table 3: Percent yield

Trial	Actual yield	Predicted yield	Percent yield
1			
2			
3			
4			

a. How do your actual yields compare with your predicted yields?

b. Explain why there are usually differences between the predicted yield and the actual yield. Give as many reasons as you can.

7 Applying your knowledge

a. Balance the equation for the reaction by placing the correct coefficients in the boxes.

$$\square Al_2O_3 \xrightarrow{\text{heat}} \square Al + \square O_2$$

b. If you heat 50.0 grams of aluminum ore, and the reaction is completed, how many grams of oxygen gas will be released?

c. How many grams of aluminum ore would you need to produce 1.0 kilogram of pure aluminum?

Extra space for notes and performing calculations:

Name:

30.1 Radioactivity

Question: How do we model radioactivity?

1 Probability and chance

There are no questions to answer in Part 1.

2 Simulating radioactive decay

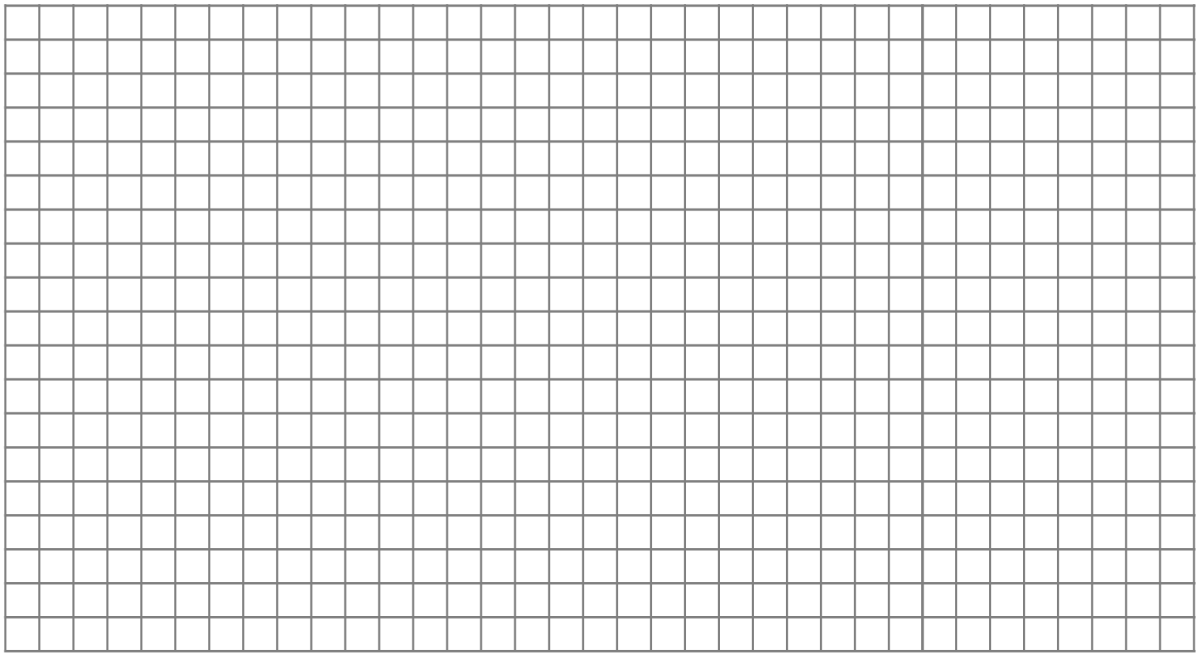
Table 1: Coin toss decay simulation

	Heads	Tails	Na^{25} Atoms	Mg^{25} Atoms
Start			100	0
First toss (1 half life)				
Second toss (2 half lives)				

a. Make a graph showing the number of Na^{25} atoms and the number of Mg^{25} atoms on the vertical axis. Put time on the *x*-axis, with each toss of the coins representing one minute.

Title: _____

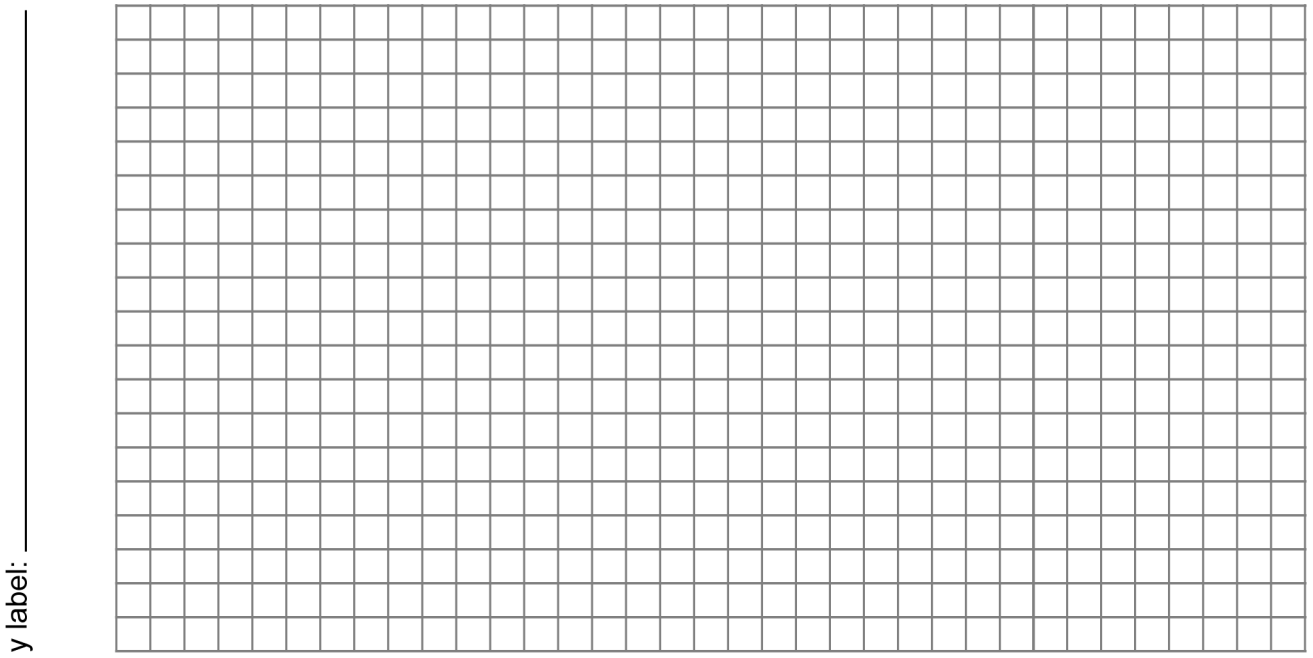
y label: _____



x label: _____

b. Add the data from your entire lab or class for each toss. For example, if there are six groups, the class data set would represent the decay of 600 atoms. Make the same graph with the class data.

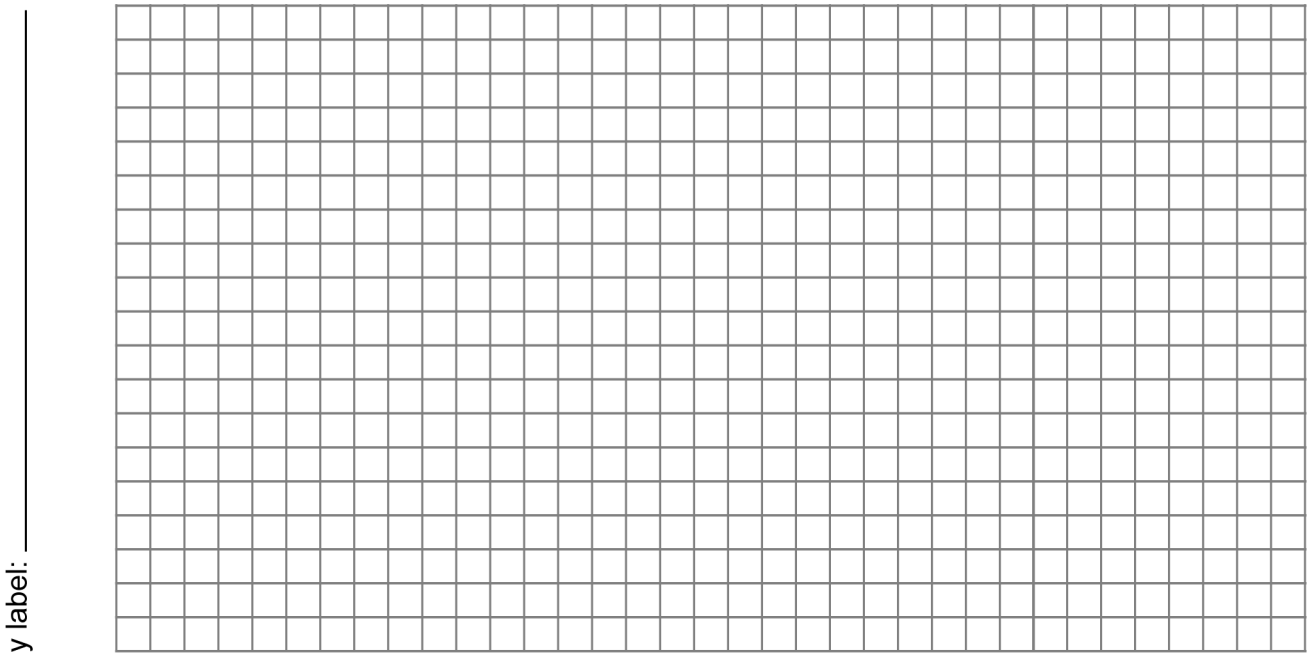
Title: _____



x label: _____

c. How does the class graph compare with any single group graph for 100 atoms? Sketch what the graph would look like for 10^{20} atoms, a typical number of atoms in a sample of matter.

Title: _____



x label: _____

Extra space for notes and performing calculations:

Name: _____

30.2 Radiation

Question: What are some types and sources of radiation?

1 Intensity and energy

a. A bright lamp emits a power of 100 watts of light and infrared radiation. Calculate the intensity of radiation from the lamp at a distance of 1 meter and at a distance of 10 meters.

b. How far would you have to be from a source of radiation for the intensity to decrease by a factor of 1,000 compared with the intensity at a distance of 1 meter?

c. The intensity of radiation from the sun is about 1,000 W/m^2 at Earth's surface. Use the inverse square law to estimate the intensity of solar radiation on the planet Mercury.

2 Types of radiation

There are no questions to answer in Part 2.

3 Sources and risks from ionizing radiation

a. Name one form of nonionizing radiation you experience every day. _____

b. Identify one source of ionizing radiation that is charged particles. _____

c. Identify one source of ionizing radiation that is neutral particles. _____

d. Identify one source of ionizing radiation that is electromagnetic radiation. _____

e. If all three forms of ionizing radiation had the same energy and intensity, which would be most difficult to stop: charged particles, neutral particles, or electromagnetic radiation? _____

4 Cosmic rays

a. List three types of radiation present in cosmic rays.

b. Give the intensity of at least one form of cosmic ray radiation in W/m^2.

c. Identify two sources of cosmic rays.

d. Are cosmic rays ionizing or nonionizing radiation or do cosmic rays include both types?

5 Radiation detectors

a. Research and identify a detector of radiation.

b. What physical principle does the detector use to sense the radiation?

c. What forms of radiation can the detector sense?

d. What forms of radiation cannot be sensed by the detector?

e. Where is the detector used?

6 Dosimetry

a. If a person were to receive the same energy from neutrons, alpha particles, and gamma rays which would have the highest dose in rems?

b. What is the average annual dose in rems you receive from background radiation in the environment?

c. What is the average dose limit allowed for people who work in nuclear reactors?

Extra space for notes and performing calculations:

Name: _____

30.3 Nuclear Reactions and Energy

Question: How do we describe nuclear reactions?

1 Nuclear reactions

a. Demonstrate the fusion reaction $Li^6 + He^4 = ?$, using the Atomic Building Game board. What element is represented on the model after the reaction?

b. Collect enough marbles (signifying protons, neutrons, and electrons) to build Li^6. Then collect enough marbles to build B^{11}. Place all the marbles in the correct places on the model. What element is represented? Was this activity an example of fusion or fission?

c. An impact with a fast neutron can cause fission even in elements that have low mass numbers. Use the Atom Building Game board to figure out six different ways the fission reaction $n + O^{16} = ?$ can divide the oxygen-16 nucleus. Each reaction must use up all the protons, electrons, and neutrons, including the extra neutron you added to start the reaction. Write down the six possible fission reactions you found.

d. Suppose you split a uranium-238 atom. If you have to break it into two pieces, name isotopes of two elements that could be formed. Be sure that your two isotopes use up all the neutrons and protons in the uranium. Use the periodic table to determine if either of the two isotopes are stable, or are one or both radioactive?

2 Playing Nuclear Reactions

There are no questions to answer in Part 2.

3 Scoring points

There are no questions to answer in Part 3.

4 Additional rules

There are no questions to answer in Part 4.