**Models of Particle Models Roberta@Tevlin.ca**

1. **Grade 9: The Particle Model of Matter**
2. The particle model uses space and speed to explain the difference between solids, liquids and gases. Show the positions of five particles. Add arrows whose lengths represent their speeds.

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1. Make a set of three tableaux that clearly show the differences between a solid, liquid and gas.
2. Examine the three materials as physical models of the particle model. Which has the highest ‘melting point’? Which one best demonstrates the formation of crystals, viscosity or ductility? Explain your answers.

Glass marbles

Magnetic marbles

Lego

1. Explore <https://phet.colorado.edu/en/simulation/states-of-matter-basics>
2. **Grade** **9 or 10: The Lego (Atomic) Model of Matter**

The **particle model** is able to explain physical properties and changes. However, it doesn’t explain what happens in a **chemical** reaction. The Lego model can explain three laws of chemical reactions.

1. **The Law of Conservation of Mass**: Weigh your Lego particles. How does the mass of the reactant compare to the mass of the products?
2. **The Law of Constant Proportions**: Divide the mass of the large pieces by the mass of the small pieces. Which groups have the same molecules? How are compounds different from mixtures?
3. **The Law of Multiple Proportions**: Each different Lego compound has a different ratio of big to little mass. Compare each compound’s ratio to compound A by dividing the larger ratio by the smaller one. Repeat for compound C. Which values are very close to a whole number? Explain why this occurs.
4. **Grade 9 or 12: Rutherford’s gold foil experiment**: Rutherford, shot small positive particles – called alpha particles - at a thin gold foil. Most went through. About 1 in 8,000 came back.
5. Model this by releasing a ball on a track that is 30 cm away from the curved base of a wine glass. Try and get the ball to come straight back onto the track. What do you have to do to be successful? What aspects of the challenge were like Rutherford’s experiment? What aspects of the challenge were very different from Rutherford’s experiment?



1. Make a set of three tableaux that show the very different behaviours of a set of alpha particles with identical velocities heading toward a gold nucleus. Show the particles when they are very far from the nucleus, at their closest position and a short distance after this.
2. Sketch the very different paths of the three alpha particles below. Include arrows to indicate their speeds at various points. Make sure that energy is conserved. Go to <http://phet.colorado.edu/en/simulation/rutherford-scattering>to check your diagram**.**
3. **Grade 9: Molecular Bonds**
4. The non-metal elements just need a few extra electrons to become stable. One way that they do this is by ‘sharing’ electrons. Imagine that you and your fellow students are hydrogen atoms. You each have a pen in your right hand to represent your one electron. Each student wants one more electron so it will be like helium. Turn to a neighbour and grab their ‘electron’ with your left hand without letting go of your own electron. What happens? Draw it in the space on the left as a Bohr-Rutherford diagram and as a ball and stick model.
5. How would you have to change things to act out and draw what happens with F and Cl?
6. How can you act out and draw what happens with O? Draw this in the middle space.
7. How can you act out what happens with N? Draw the result in the space above right.
8. **Grade 9 Ionic Bonds:** You are going to model the formation of sodium chloride. Each student will be randomly assigned to be either sodium or chlorine. Sodium has an electron card that it wants to get rid of and chlorine wants to get one of these. Find someone to react with and transfer the electron. Once this is done, the sodium students are positive and want to surround themselves with four chlorine students. The chlorine students are negative and want to surround themselves with four sodium students. Act out what happens.
9. Draw the 2-D arrangement of Na and Cl ions in a solid. How will the 3-D version be different?
10. Ionic compounds form crystals with flat faces and sharp edges. Why?
11. Ionic compounds will not conduct electricity unless they are melted or dissolved in water. Why?
12. Ionic compounds have much higher melting points than molecular compounds. Why?
13. Ionic compounds are very brittle. Why?
14. **Grade 12 Quantum Physics**
15. Wave-Particle Duality: The Challenge of Quantum Reality (PI Resource) <https://resources.perimeterinstitute.ca/products/the-challenge-of-quantum-reality?variant=17148646726>
16. The Quark Model: Taming the Particle Zoo (PI Resource) <https://resources.perimeterinstitute.ca/products/taming-the-particle-zoo?variant=36262299334>
17. Randomness of Radioactivity

Radioactive decay was discovered over a century ago. It is a quantum process.

1. Suppose you have 100 computers (students, radioactive atoms) and you graph how many are still working each following year. What will the graph look like?

A) B) C) D)

Suppose you have 100 students?

Suppose you have 100 radioactive atoms?

The pattern of radioactive decay is very different because the decay is not a result of the atoms wearing down. Instead, the process is completely random. That’s how we know it is quantum.

1. You will simulate radioactive decay with 100 dice. When the dice are rolled, a ‘one’ means that it has decayed and is removed. Fill in your predictions of how many undecayed dice you will have after each round.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Round | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Predicted |  |  |  |  |  |  |  |  |  |
| Actual |  |  |  |  |  |  |  |  |  |

1. The half-life is the time it takes for half of the atoms to decay and it is characteristic for a given nucleus. Predict the half-life for the dice.
2. Roll the dice and fill in the actual values. Explain any differences with the predictions.
3. How is this randomness different from the randomness of radioactive decay?
4. How is this like the double-slit experiment?
5. Explore the randomness and quantum tunneling of alpha decay. <http://phet.colorado.edu/en/simulation/alpha-decay>