QUANTUM TUNNELLING MODULE

The following link will take you to the Concord Consortium digital learning resource for Quantum Tunnelling. The module introduces the concepts of quantum tunnelling with real-world interactive examples used to demonstrate the importance of this phenomenon in modern technology.

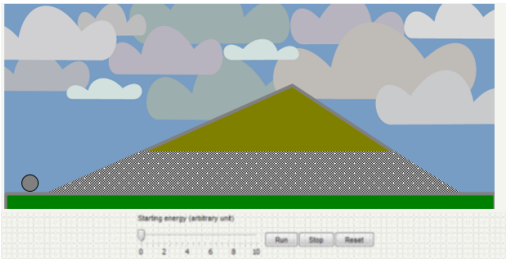
http://concord.org/stem-resources/quantum-tunneling

Throughout the module you will need to read the new information, follow the instructions to complete simulations and respond to the questions on the screen. You will also need to record yours answers on this worksheet.

PART A: *Crossing a barrier at the macroscopic scale*

1. CLIMBING UP A HILL - **What is the minimum energy needed for the ball to go over the top of the hill?**

2. **What will make it harder for the ball to surmount the hill?**

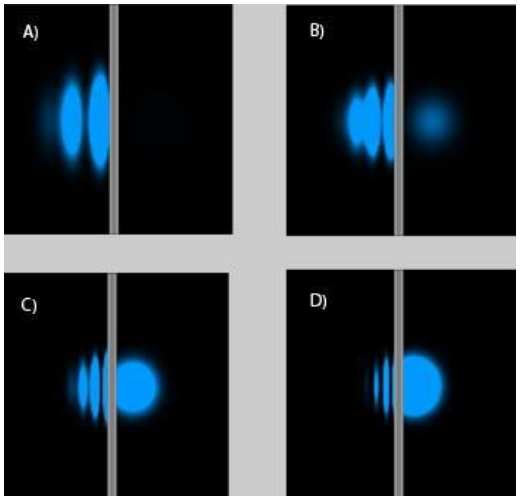


3. GOING THROUGH A TUNNEL - **The ball can easily roll to the other side of the hill through the tunnel. Explain why in terms of energy.**

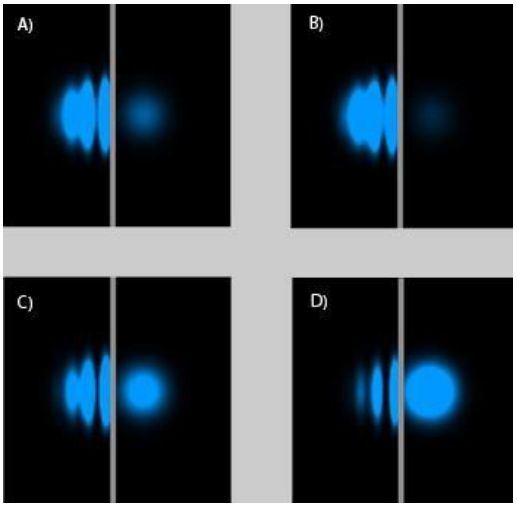
PART B: *Crossing a barrier at the microscopic scale*

4. A TUNNELLING EXPERIMENT – **Draw a sketch of the tunnelling event in which the electron has approximately half a chance of passing through the barrier and half a chance of getting reflected, and explain what you had to do in order to produce the result.**

5. The four images show an electron wave originated on the left side of the container and collided with the vertical, grey barrier in the centre. **Assuming that all the barriers have the same potential energy, in which case does the electron wave have the highest energy?**



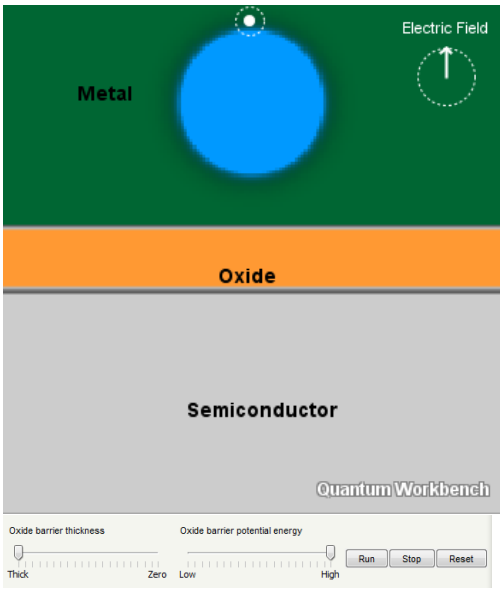
6. The four images show an electron wave originated on the left side of the container and collided with the vertical, grey barrier in the centre. **Assuming that all the electrons have the same energy, which model shows the highest barrier potential?**



PART C: *Tunnelling Leakage in Computer Chips*

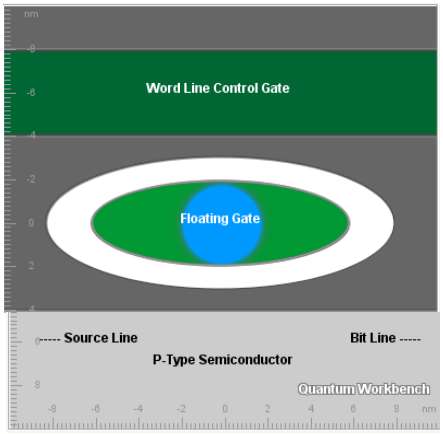
7. EXPERIMENTING WITH TUNNELLING LEAKAGE THROUGH AN OXIDE LAYER – **What will reduce the tunnelling leakage?**

8. **Electrons inside the electrical wires of your home appliances do not tunnel through the plastic insulation to give you an electric shock. Why?**



PART D: *Tunnel injection and release in flash memory*

9. WRITING AND ERASING A BIT THROUGH ELECTRON TUNNELLING – **Using your observations of the simulation, explain why the floating gate can be used to store information.**



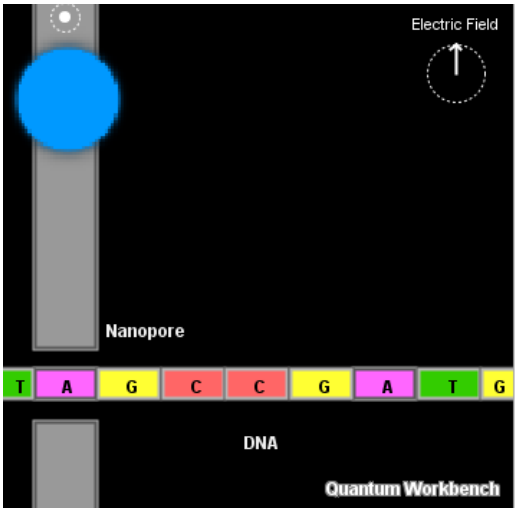
PART E: *DNA Sequencing*

10. A TUNNELLING PROBE TO READ DNA BASES – **Draw a sketch of the setup showing a strong tunnelling current between a base and the probe and showing a weak tunnelling current between a base and the probe**

STRONG **WEAK**

11. Which base does the probe read when there is a strong tunnelling current?

12. Imagine you were to design a fast DNA sequencing machine using the tunnelling technology. **How many different types of probes would be needed? How would you set them up?**

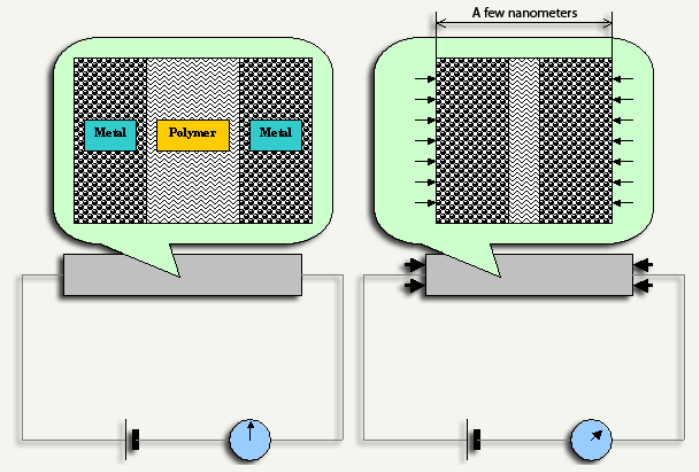


PART E: ***Quantum Tunnelling Summary***

13. Explain what tunnelling is.

14. Why does a computer chip designer have to care about electron tunnelling?

15. Quantum tunnelling composites are composite materials of interweaving metals and insulating elastic polymers (see the above image). The composites do not normally conduct electricity. But when pressed, they can. Can you explain why?



16. For a chemical reaction to happen, electrons of certain molecules need to cross an energy barrier (the required energy is called the **activation energy**: see the image to the left) in order to transfer to other locations to make new chemical bonds. Quantum tunnelling is a mechanism used by some enzymes to enhance reaction rates. **Use what you learned from this module to explain why electron tunnelling can accelerate chemical reactions.**