At a glance

Artificial atoms, or quantum dots, are being touted by many as the next big thing in TV technology, promising brighter, more life-like images. Scientists at The University of Oxford are working on methods of using quantum dots to produce a stream of identical single photons with the hope of using this to provide un-hackable data protection, quantum computers and powerful microscopes. This activity is suitable as a follow-on lesson after students have studied energy levels and photon emission and asks them to explain what quantum dots are and how they can be used.

Learning Outcomes

- Students apply knowledge of energy levels and photon emission to explain quantum dots
- Students state some applications of single photon emitters

Each student will need

- Copy of the pupil worksheet
- Access to the internet
- Mobile device (optional)
Possible Lesson Activities

1. Starter activity
   - In a darkened room, carry out demonstrations to show fluorescence. This can be carried out using a blacklight and various fluorescent objects including tonic water. Refer to the weblink below for further ideas.
   - Ask students to suggest explanations for what is happening. Elicit understanding about energy levels and photon emissions.
   - Give students a copy of page 1 of the pupil worksheet and ask them to read it to check their understanding of energy levels. The information introduces quantum dots, otherwise known as artificial atoms.
   - Show the class the animation ‘Run for your Light’ which explains how single photons can be produced using quantum dots and what they are used for.

2. Main activity: Finding out about quantum dots
   - Introduce the task - students will research into quantum dots and their role as single proton emitters and then produce a 15 second video (15 seconds being the maximum time allowed for videos on apps such as Instagram). In order to explain the concept this concisely they will need a very good understanding of the subject.
   - Give each student a copy of page 2 of the pupil worksheet which contains some information to find out, a weblink or QR code where they can go to find it and space to write down the information. You may wish students to work in pairs so they can share the task.
   - Students then plan what they will say in their video. If they have access to their mobile phones they can record their video, making sure they stick to the time limit. If this technology is not available, then ask them to present to the class. One person can be in charge of a timer to make sure their explanation is 15 seconds long.

3. Plenary
   - Ask a set of true or false questions to test understanding of quantum dots
     - The larger the band gap, the higher the frequency of protons produced
       TRUE - the larger the band gap, the higher the energy of the photons produced and so the higher the frequency.
     - Quantum dots that emit red light are smaller than those which emit blue light
       FALSE - Red quantum dots are larger than blue (because their band gap is smaller)
     - Quantum dots can only emit photons in the visible light region of the EM spectrum
       FALSE - they can be engineered with fluorescence emission from UV to near IR.
     - Quantum dots could be used for medical imaging and more efficient solar cells
       TRUE - they have many potential applications

http://www.oxfordsparks.ox.ac.uk/run-for-your-light
Weblinks

Run for your Light animation
http://www.oxfordsparks.ox.ac.uk/run-for-your-light

https://www.youtube.com/watch?v=z7aqJpKfPC0

Video which outlines the use of quantum dots in TVs. This could be shown at the start of the lesson if students are unfamiliar with the technology.

http://www.rsc.org/Education/EiC/issues/2006July/ExhibitionChemistry.asp

Instructions for demonstrations to show fluorescence

Weblinks used in the pupil worksheet:

http://www.bbc.co.uk/education/guides/zppnn39/revision/1
BBC Bitesize revision on semiconductors

http://www.dummies.com/how-to/content/what-is-a-quantum-dot.html
Simple information on quantum dots

https://www.youtube.com/watch?v=cXNzfR1qaHU
Video clip explaining quantum dots