

# **PiXL Independence:**

## **Physics – Student Booklet**

### **KS5**

#### **Topic - Particle Physics**

#### **Contents:**

- I. Level 1- Multiple Choice Quiz – 20 credits
- II. Level 2 - 5 questions, 5 sentences, 5 words – 10 credits each
- III. Level 3 - Physics in The News – 100 credits
- IV. Level 4 - Scientific Poster – 100 credits
- V. Level 5 - Video summaries – 50 credits each

# PiXL Independence – Level 1

## Multiple Choice Questions

### A Level Physics – Particle Physics

#### INSTRUCTIONS

Score: /20

- Read the question carefully.
- Circle the correct letter.
- Answer all questions

1. An isotope is an atom of an element with:
  - a. The same number of protons and neutrons
  - b. The same number protons as electrons
  - c. The same number of protons but differing numbers of electrons
  - d. The same number of protons but differing numbers of neutrons
2. How many protons, neutrons and electrons are there in a Uranium 238 atom?  ${}_{92}^{238}\text{U}$ 
  - a. 92 protons, 146 neutrons, 146 electrons
  - b. 92 protons, 92 neutrons, 146 electrons
  - c. 92 protons, 146 neutrons, 92 electrons
  - d. 146 protons, 92 neutrons, 146 electrons
3. What is the specific charge on a Helium nucleus? (Helium 2 protons and 2 neutrons)
  - a.  $4.79 \times 10^7 \text{ Ckg}^{-1}$
  - b.  $4.79 \times 10^{-7} \text{ Ckg}^{-1}$
  - c.  $2.00 \times 10^8 \text{ Ckg}^{-1}$
  - d.  $2.00 \times 10^{-8} \text{ Ckg}^{-1}$
4. A Calcium ion is formed by removing 2 electrons from an atom ( $A = 40$  and  $Z = 20$ ). What is the specific charge of the Calcium atom?
  - a.  $3.2 \times 10^6 \text{ Ckg}^{-1}$
  - b.  $3.2 \times 10^{-19} \text{ Ckg}^{-1}$
  - c.  $4.8 \times 10^6 \text{ Ckg}^{-1}$
  - d.  $4.8 \times 10^7 \text{ Ckg}^{-1}$
5. What is the correct order of fundamental forces in order of relative increasing strength?
  - a. Weak, Electromagnetic, gravitational, strong
  - b. Electromagnetic, weak, gravitational, strong
  - c. Gravitational, weak, Electromagnetic, strong
  - d. Weak, Electromagnetic, strong, gravitational
6. What is the range of the strong force?
  - a. 3-4  $\mu\text{m}$
  - b. 3-4 nm
  - c. 3-4 pm
  - d. 3-4 fm

7. During a Beta minus decay what can be said of product:
- Mass number and atomic (proton) number decreases by 1
  - Mass number decreases by one atomic (proton) number stays the same
  - Mass number and atomic (proton) number increases by 1
  - Mass number stays the same and atomic (proton) number increases by 1
8. Uranium 238 ( $A = 238$ ,  $Z = 92$ ) undergoes an alpha decay. Which particle is emitted in the process?
- Thorium,  $A = 236$  and  $Z = 90$
  - Thorium,  $A = 234$  and  $Z = 90$
  - Plutonium,  $A = 234$  and  $Z = 94$
  - Plutonium,  $A = 236$  and  $Z = 94$
9. What is produced in the process of pair production?
- 2 protons
  - 2 neutrons
  - 2 photons
  - 2 electrons
10. Hadrons are either:
- Quarks or leptons
  - Particles or antiparticles
  - Muons or neutrinos
  - Barons or mesons
11. Baryons consist of:
- A quark and an antiquark
  - 2 quarks or 2 antiquarks
  - 3 quarks or 3 antiquarks
  - 4 quarks or 4 antiquarks
12. Apart from the tau particle, which is the heaviest lepton?
- Electron
  - Muon
  - Electron neutrino
  - Muon neutrino
13. What is the baryon number of a positron?
- $B = 1$
  - $B = -1$
  - $B = +1/2$
  - $B = 0$
14. Which quantum number does not have to be conserved except in strong interactions?
- Baryon number
  - Charge
  - Lepton number
  - Strangeness

15. Why can't the following interaction occur?  $K^- + p \rightarrow n + \pi^0$
- Charge is not conserved
  - Baryon number is not conserved
  - Lepton number is not conserved
  - Strangeness is not conserved
16. The virtual photon is the exchange particle responsible for which fundamental force?
- Strong
  - Weak
  - Electromagnetic
  - Gravitational
17. What is the quark composition for a proton?
- udd
  - uds
  - uss
  - uud
18. Electron capture can be represented by the following equation  $p + e^- \rightarrow X + Y$ . What are X and Y?
- $X = p$  and  $Y = K^+$
  - $X = n$  and  $Y = \nu_e$
  - $X = n$  and  $Y = \nu_\mu$
  - $X = n$  and  $Y = \pi^0$
19. Which particle has 3 possible quark compositions?
- Kaon plus
  - Pion minus
  - Pion plus
  - Pion zero
20. How many times larger is a W boson than a proton?
- 10
  - 100
  - 1000
  - 10 000

# PiXL Independence – Level 2

## 5 questions, 5 sentences, 5 words

### A Level Physics – Particle Physics

#### INSTRUCTIONS

- For each statement, use either the suggested website or your own text book to write a 5-point summary. In examinations, answers frequently require more than 1 key word for the mark, so aim to include a few key words.
- It is important to stick to 5 sentences. It is the process of selecting the most relevant information and summarizing it, that will help you remember it.
- Write concisely and do not elaborate unnecessarily, it is harder to remember and revise facts from a big long paragraph.
- Finally, identify 5 key words that you may have difficulty remembering and include a brief definition. You might like to include a clip art style picture to help you remember it.

**Example:** Fundamental particles of matter

<b>QUESTION:</b>	What are fundamental particles?			
<b>Sources:</b>	Website – <a href="http://www.bozemanscience.com/ap-phys-002-fundamental-particles">http://www.bozemanscience.com/ap-phys-002-fundamental-particles</a> Interactive - <a href="https://phet.colorado.edu/sims/html/build-an-atom/latest/build-an-atom_en.html">https://phet.colorado.edu/sims/html/build-an-atom/latest/build-an-atom_en.html</a>			
<ol style="list-style-type: none"><li>1. Atoms are made up of protons, neutrons and electrons.</li><li>2. Protons and neutrons have a relative mass of 1 and electrons are 1/2000th of the mass of protons and neutrons. Protons have a charge of <math>+1.6 \times 10^{-19}\text{C}</math>, electrons have a of <math>-1.6 \times 10^{-19}\text{C}</math> and neutrons have no charge. Electrons are fundamental particles that cannot be broken down further.</li><li>3. Protons and neutrons are made up of quarks.</li><li>4. There are 6 quarks up, down, top, bottom, charm and strange.</li><li>5. Protons are made up 3 quarks 2 up and 1 down. Neutrons are also made up of 3 quarks 1 u and 2 down.</li></ol>				
Electron – a fundamental particle with charge $1.6 \times 10^{-19}\text{C}$ that orbits the nucleus of an atom.	Quark – a fundamental particle that comes in one of 6 types u, d, c, s, t or b	Atomic mass – the number of protons and neutrons in the nucleus of an atom	Lepton - a fundamental particle that comes in ones of 6 types e, $\mu$ , $\tau$ , $\nu_e$ , $\nu_\mu$ and $\nu_\tau$ and can combine to form hadrons	Nucleus – a small and highly concentrated positive charge at the centre of an atom containing protons and neutrons

QUESTION 1:	Explain what alpha decay is.			
Sources:	Website – <a href="https://www.youtube.com/watch?v=KWAsz59F8gA&amp;t=22s">https://www.youtube.com/watch?v=KWAsz59F8gA&amp;t=22s</a> Interactive - <a href="https://phet.colorado.edu/en/simulation/legacy/alpha-decay">https://phet.colorado.edu/en/simulation/legacy/alpha-decay</a>			

QUESTION 2:	Explain what beta decay is.			
Sources:	Website – <a href="https://www.youtube.com/watch?v=Glmej8WpwjU">https://www.youtube.com/watch?v=Glmej8WpwjU</a> Interactive - <a href="https://phet.colorado.edu/en/simulation/legacy/beta-decay">https://phet.colorado.edu/en/simulation/legacy/beta-decay</a>			

QUESTION 3:	What are the conservation laws in nuclear reactions?			
Sources:	<b>Website</b> 1. <a href="http://www.bozemanscience.com/ap-phys-099-conservation-of-nucleon-number">http://www.bozemanscience.com/ap-phys-099-conservation-of-nucleon-number</a> 2. <a href="http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/parint.html">http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/parint.html</a>			



QUESTION 4:	What are the four fundamental forces? Which one is responsible for holding the nucleus together and what are its properties?			
Sources:	<b>Website –</b> 1. <a href="https://www.youtube.com/watch?v=FEF6PxWOvsk">https://www.youtube.com/watch?v=FEF6PxWOvsk</a> 2. <a href="http://www.bozemanscience.com/ap-phys-057-strong-nuclear-forces">http://www.bozemanscience.com/ap-phys-057-strong-nuclear-forces</a>			

QUESTION 5:	How are Feynman diagrams drawn for particle interactions?			
Sources:	<b>Website –</b> 1. <a href="https://www.youtube.com/watch?v=rZKfqQ5RT34">https://www.youtube.com/watch?v=rZKfqQ5RT34</a> 2. <a href="https://www.youtube.com/watch?v=hk1cOffTgdk">https://www.youtube.com/watch?v=hk1cOffTgdk</a>			

# PiXL Independence – Level 3

## Physics in The News

### A Level Physics – Particle Physics

#### Fake news

Sensationalized news stories have been around for some time, but with the mass growth of social media, the problem seems to have grown in recent years. At the very least, the US Presidential election has certainly highlighted the impact that misleading information can have. [www.tiny.cc/fakenews2](http://www.tiny.cc/fakenews2)

At home, the Brexit vote also suffered from the circulation of misleading news stories [www.tiny.cc/fakenews3](http://www.tiny.cc/fakenews3)

Therefore, the ability to identify real information, track it back to the source article and make your own judgement is a very important skill. This activity will help you develop that skill.

#### Will the large hadron collider destroy Earth?

News article <https://tinyurl.com/j4jl264>

Discussion article <https://tinyurl.com/yd8b6mzy>

Real article <https://tinyurl.com/y8kow9b7>

#### Task 1:

You need to produce a 1 page essay on whether the large hadron collider could cause an Earth destroying black hole.

Essay section	Activity
Introduction	How does the does first article suggest that experiments at the large hadron collider could destroy the Earth?
Describe	Describe how the Higgs boson and other particle are formed during the particle accelerator collisions at the large hadron collider and describe what scientists are hoping to find.
Explore	Summarise the 3 reasons the final article gives for why experiments at the large hadron collider could not cause destruction of the Earth.
Evaluate	Evaluate the safety of the experiments that are being undertaken at the large hadron collider and the assurances we have of its safety.

# **PiXL Independence – Level 4**

## **Scientific Posters**

### **A Level Physics – Particle Physics**

#### **Scientific Podcasts**

There are several types of evidence you will be asked to produce at university. In addition to the traditional essay and scientific poster, the use of Podcasts is becoming increasingly common. It is actually harder than you think to produce a short concise, detailed and accurate podcast, therefore this task will help you get ahead of the game when you get to university.

#### **Creating your Podcast**

There are lots of pieces of software to create podcasts and edit them, however, the easiest would be the voice recorder on your phone, just check that it runs for long enough and you can save it in a suitable format, e.g. MP3 before you complete your master piece and find you need to do it again! Alternatively, get set up with Audacity which is free and will help you familiarize yourself with it.

The University of Southampton has produced some excellent guidance on creating Podcasts, which you can access at [www.tiny.cc/podcasts3](http://www.tiny.cc/podcasts3) and select the producing academic podcasts link.

Here are three of the key tips:

1. Write out your objective and share it at the start of the podcast.
2. Give it structure like you would in an essay
3. Whilst it is important to plan a structure, sometimes it is harder to listen to someone who is reading than someone who is more naturally talking, therefore, try to have an outline and allow some natural speech.
4. Think about the recording, pick a quiet room and speak a bit louder than normal. Do a few trial runs and check the quality.

#### **Examples**

The naked scientists produce a series of podcasts (and is also a really useful website). Check out an example about a contagious cancer at [www.tiny.cc/taz](http://www.tiny.cc/taz)

# What is the standard model of particle physics?

## Background

Scientists for centuries have imagined all matter to be built from small particles called atoms. Over time the atomic model has been developed with key breakthroughs such as Rutherford scattering and the discovery of even smaller particles within the nucleus. Today physicists are aware of many fundamental particles that are collectively termed the standard model.

## Source articles:

<https://www.youtube.com/watch?v=HVxBdMxgVX0>

<https://www.youtube.com/watch?v=edgsmtUH954>

<https://physics.info/standard/>

## Task

At university interviews, you will often be asked to discuss ethical issues in science. This is one example that you could discuss. Read the articles on the standard model otherwise known as the particle zoo. Then produce a podcast using the guidance below.

<b>Describe</b>	Describe the early model of the atom and how Rutherford's scattering experiment gave evidence for a different model of the atom.
<b>Explain</b>	Explain the structure of the atom, name the particles within an atom and state what each of these particle is made up of.  List the 6 types of quark and lepton and give examples of the types of the particles that are comprised of these.
<b>Discuss</b>	Discuss how over time these particles have been detected and whether it is possible that more particle may be discovered?

# PiXL Independence – Level 5

## Video summaries

### A-level Physics – Particle Physics

#### Cornell Notes

At A level and University, you will make large amounts of notes, but those notes are only of use if you record them in a sensible way. One system for recording notes is known as the Cornell notes system. This method encourages you to select relevant information, rather than trying to write a transcript of everything said. More importantly, it forces you to spend a few minutes reviewing what you have written, which has been scientifically proven to aid learning and memory retention.

The ideal is to write everything on one page, but some students may prefer to type and others will to handwrite their notes. Whichever option you use, remember the aim is to summarise and condense the content with a focus on the objectives that you are trying to learn and understand.

#### There are three main sections to the Cornell notes

- 1 **Cue/ Objectives** – This can be done before or after the lecture. You may have been provided with the objectives or you may need to decide what they were or you may want to make the link to your learning if this is an additional task or lecture you are viewing, such as this video.
- 2 **Notes** – In this space you record concisely, simply the things you are LESS likely remember - **The NEW knowledge**.
- 3 **Summary** – The most important step that is carried out after the lecture or video. This helps to reinforce learning.

#### Background

The following TED talks present two topics that link to your learning. Both videos describe the theoretical existence of the Higgs boson, its importance in the standard model and how it was discovered.

#### Source article:

**Video 1 – Higgs boson what you don't know.**

**Ted Ed talks :** [https://www.youtube.com/watch?v=sw4\\_9xhGzjo](https://www.youtube.com/watch?v=sw4_9xhGzjo)

This further TED ed video may help to understand the role of the Higgs boson  
<https://ed.ted.com/lessons/the-higgs-field-explained-don-lincoln>

#### Video 2 – The discovery of the God particle

**Ted Ed talks:** [https://www.youtube.com/watch?v=Pv\\_DtHuj5Ds](https://www.youtube.com/watch?v=Pv_DtHuj5Ds)

**Task:**

**You need to produce a set of Cornell notes for one of the videos given above.  
Use the following objective to guide your note taking, this links to your learning.**

- 1 Discuss the implications of the Higgs boson and how it fits in the standard model.
- 2 What problems did the Higgs boson solve?
- 3 Why is the Higgs boson's existence so important?

Objectives  
What are the main learning outcomes that have been shared with you?  
This will help guide you to taking the RIGHT notes during the video.

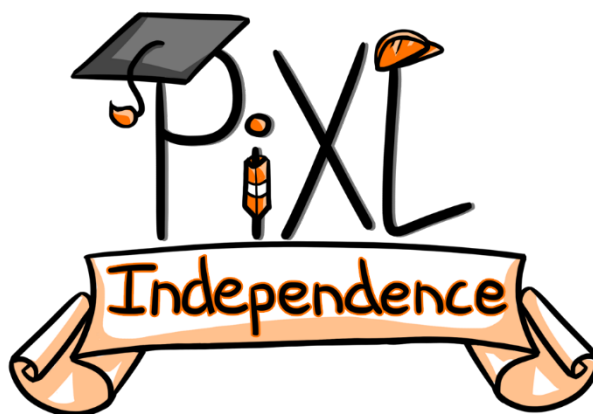
Title  
Date

Sketch down note and key words  
Do not write in full sentences whilst you listen, put quick sketches, single words, mind maps, short hand etc.  
To help train you for university, try not to pause the video because you could not pause a live lecture (However, a lecture may give more natural pauses for you to catch up).

Summary (after the video)  
What are your main points of learning from this video.  
This is your chance to make sense of your notes.  
Make clear connections to the things you need to know







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