PiXL Independence:

Physics – Student Booklet

KS5

Topic - Nuclear 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 – Nuclear Physics

INSTRUCTIONS **Score: /20**

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

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1. What was the structure of the atomic model that JJ Thomson's plum pudding suggested?
   a. Negatively charged particles embedded in sphere of uniform negative charge
   b. Negatively charged particles embedded in sphere of uniform positive charge
   c. Positively charged particles embedded in a sphere of uniform positive charge
   d. Positively charged particles embedded in a sphere of uniform negative charge

2. Approximately how many alpha particles were completely back scattered in the Rutherford scattering experiment?
   a. 1 in 100
   b. 1 in 1000
   c. 1 in 10 000
   d. 1 in 100 000

3. What were the conclusions were made about the nucleus of an atom following Rutherford's scattering experiment?
   a. Large, highly concentrated, positive charge consisting of mostly empty space
   b. Large, highly concentrated, negative charge consisting of mostly empty space
   c. Small, highly concentrated, positive charge consisting of mostly empty space
   d. Small, highly concentrated, negative charge consisting of mostly empty space

4. Carbon has a nucleon number of 12.
   What is the radius of the carbon nucleus?
   a. 2.4×10^{-12}m
   b. 3.2×10^{-15}m
   c. 2.5×10^{-15}m
   d. 3.0×10^{-13}m

5. Which of the following is equal to $\frac{radius\ of\ nucleus\ As_{33}^{75}}{radius\ of\ nucleus\ Al_{13}^{27}}$
   a. 1.4
   b. 2.8
   c. 2.5
   d. 1.3

6. How intensity of a source of radiation and distance from the source related?
   a. Intensity α distance from the source
   b. Intensity α distance from the source^2
   c. Intensity α 1/distance from the source
   d. Intensity α 1/distance from the source^2

7. An isotope of Uranium (nucleon number 235, proton number 92).
   What is the nucleon and proton number after the emission of 5 alpha particles and 2 β^- decays?
   a. Nucleon number 255, proton number 100
   b. Nucleon number 243, proton number 72
   c. Nucleon number 215, proton number 84
   d. Nucleon number 227, proton number 72

8. Which quantity is being described here 'the probability that a specific nucleus will decay per unit time'?
   a. Activity
   b. Half life
   c. Decay constant
   d. Rate of change of unstable nucleus

9. Which letter correctly gives the types of radioactive decay in order of increasing ionisation power?
   a. Beta, gamma, alpha
   b. Gamma, beta, alpha
   c. Alpha, beta, gamma
   d. Gamma, alpha, beta

10. The binding energy of a nucleus of lithium 6 atom is 32.0 MeV. What is the energy in Joules?
   a. 5.1×10^{-12}J
   b. 2.0×10^{26}J
   c. 5.1×10^{-18}J
   d. 2.0×10^{-26}J

11. A radioactive isotope has a decay constant of 1.2×10^{-4} s^{-1}. What is the rate of change of N for a sample containing 7.5×10^{20} nuclei?
   a. -9.1×10^{-16} s^{-1}
   b. -9.1×10^{16} s^{-1}
   c. 1.6×10^{-25} s^{-1}
   d. -1.6×10^{25} s^{-1}

12. The half-life of Carbon-14 is 5740 years. Calculate the decay constant in yr^{-1} of Carbon-14
   a. 3.8×10^{-12} yr^{-1}
   b. 3.8×10^{12} yr^{-1}
   c. 1.2×10^{-4} yr^{-1}
   d. 1.2×10^{4} yr^{-1}

13. After 128 days the activity of a radioactive sample has fallen to one sixteenth of its original value. What is the half-life of the radioactive nuclide?
   a. 4 days
   b. 8 days
   c. 16 days
   d. 32 days

14. The energy needed to break a nucleus into its constituent parts is called?
    a. Mass defect
    b. Binding energy
    c. Potential energy
    d. Internal energy

15. The binding energy per nucleon of Fe_{26}^{56} is 8.8MeV. Determine the binding energy of this nuclide in MeV.
    a. 493 MeV
    b. 229 MeV
    c. 0.39 MeV
    d. 0.16 MeV

16. Beta minus decay happens in nuclei with:
    a. too many neutrons
    b. too many protons
    c. too few neutrons
    d. too many electrons.

17. The mass defect for Calcium 40 is 0.36137u. How much energy is this equivalent to?
    a. 337 MeV
    b. 126 MeV
    c. 3.88×10^{-4}MeV
    d. 3.30×10^{10}MeV

18. On a graph of nucleon number, N (y axis) versus proton number, Z (x axis), the region above the line indicates particles which will undergo which type of decay?
    a. Alpha decay
    b. Beta plus decay
    c. Beta minus decay
    d. Nuclear fission

19. Complete the following nuclear equation $Mg_{12}^{23} \rightarrow Na_{Y}^{X} + e_{+1}^{0}$
    a. X = 23, Y = 13
    b. X = 23, Y = 11
    c. X= 22, Y = 12
    d. X = 22, Y = 13

20. The mass defect of a Nitrogen 14 nucleus is 0.11261u. Calculate the binding energy per nucleon?
    a. 105 MeV
    b. 14.1 MeV
    c. 7.49 MeV
    d. 1.25 MeV

PiXL Independence – Level 2
5 questions, 5 sentences, 5 words
A Level Physics – Nuclear 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: Nuclear Fission

QUESTION:	**How is energy released at a nuclear power station?**
Sources:	**Website –** **1.** https://www.youtube.com/watch?v=MGj_aJz7cTs **2.** https://www.youtube.com/watch?v=1U6Nzcv9Vws&t=18s **Interactive -** https://phet.colorado.edu/en/simulation/legacy/nuclear-fission

1. **Fuel rods within the reactor core contain Uranium-235 which undergoes a nuclear fission reaction.**
2. **The Uranium -235 nucleus splits into 2 daughter nuclei and 3 neutrons and releases energy.**
3. **The daughter nuclei move off at high speed, transferring their kinetic energy to the moderator which is usually water.**
4. **The water also slows the 3 neutrons down so that they are able to cause the fission of other Uranium-235 nuclei in a chain reaction.**
5. **The reaction is controlled using control rods made from Cadmium or Boron that absorbs surplus neutrons.**

Chain reaction – when neutrons released by nuclear fission cause other nuclei to fission	**Fuel rods – contain Uranium -235 or Plutonium-239**	**Moderator – usually water, used to slow the neutrons and cause further fission reactors**	**Thermal neutron – a neutron in a nuclear reactor that has been slowed enough in the moderator to cause further fission reactions**	**Critical mass – the amount of fuel needed for a fission reaction to continue at a steady rate**

QUESTION 1:	**How does Rutherford scattering of alpha particles demonstrate the existence of the atomic nucleus?**
Sources:	**Website –** https://www.youtube.com/watch?v=thnDxFdkzZs **Interactive -** https://phet.colorado.edu/en/simulation/rutherford-scattering

QUESTION 2:	**What are the penetrating powers of alpha, beta and gamma radiation?**
Sources:	**Website –** **1.** https://www.youtube.com/watch?v=9j62CVRwZPc **(Plutonium-239 is an alpha source, Strontium-90 is a beta source and Radium-226 is a gamma source)** **2.** http://www.physicslovers.com/radioactivity/properties-of-a-b-and

QUESTION 3:	**How can the half-life of a radioactive sample be calculated?**
Sources:	**Website –** 1. https://www.youtube.com/watch?v=c6Du3f-abFE 2. https://www.youtube.com/watch?v=HRwey6cwGHo 3. http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/halfli2.html

QUESTION 4:	**What is the mass defect of a nucleus and how is this quantity used to calculate binding energy?**
Sources:	**Website –** **1.** https://www.youtube.com/watch?v=b7upbQtJeno **2.** https://www.youtube.com/watch?v=m4bmC77iHg4

QUESTION 5:	**What is the difference between nuclear fission and nuclear fusion?**
Sources:	**Website –** **1.** https://tinyurl.com/ybbeqcqb **2.** https://www.youtube.com/watch?v=FU6y1XIADdg&t=243s

PiXL Independence – Level 3
Physics in The News
A Level Physics – Nuclear 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

At home, the Brexit vote also suffered from the circulation of misleading news stories 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.

Radiation form Japan's stricken nuclear plant detected in the UK

News article https://tinyurl.com/y9ogy8sp

NHS article https://tinyurl.com/y8lgxokm

Discussion article https://tinyurl.com/66ls9vn and https://tinyurl.com/gt2crta

Real article https://tinyurl.com/yaftnyr6

Task:

You need to produce a 1-page essay on the risk to the UK posed by the nuclear incident at the Fukushima nuclear power plant in Japan in 2011.

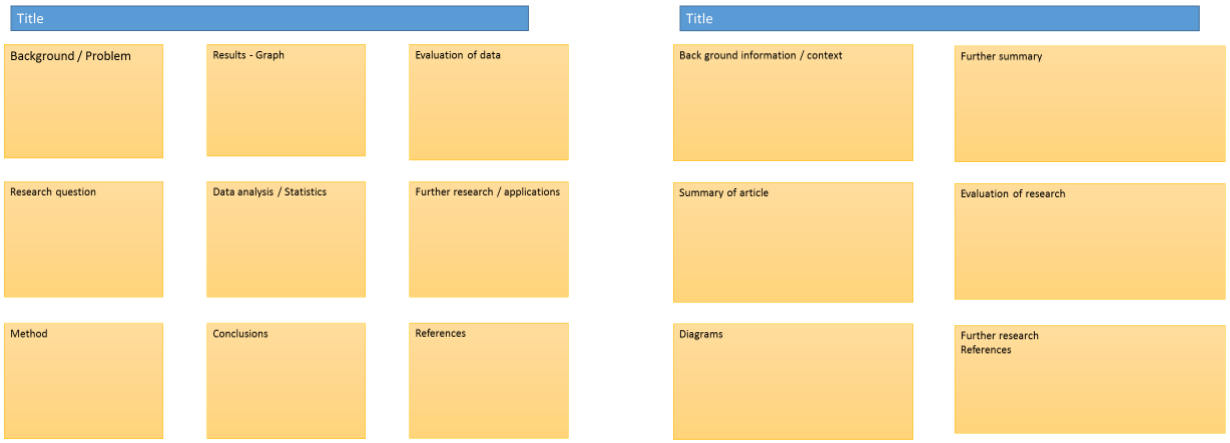
Essay section	Activity
Introduction	Outline the nature of the incident that occurred at the Fukushima nuclear power station in 2011. The second discussion article is useful here.
Describe	Describe the risks associated to people by exposure to ionising radiation and the types of radiation that were emitted in the incident.
Explore	Explore the dose of ionising radiation that would pose a risk of harm or death to a person.
Evaluate	Evaluate the relative risk posed to residents of the UK from the incident in 2011.

PiXL Independence – Level 4
Scientific Posters
A Level Physics – Nuclear Physics

Scientific Posters - Scientists communicate research findings in three main ways. Primarily, they write journal articles much like an experiment write up. These are very concise, appraise the current literature on the problem and present findings. Scientists then share findings at conferences through talks and scientific posters. During a science degree, you would practice all three of these skills.

Scientific posters are a fine balance between being graphically interesting and attracting attention and sharing just the right amount of text to convey a detailed scientific message. They are more detailed than a talk and less detailed than a paper.
Use this information to help structure your poster – www.tiny.cc/posterskills
More detailed guidance is available at : www.tiny.cc/posterskills2

Creating your poster
It is easiest to create a poster in PowerPoint, however you need to add custom text boxes rather than using the standard templates.



Posters need to be eye catching, but readable from a distance. If you use PowerPoint, start with a 4:3 slide (for easier printing, it can then be printed on A3) and use a 14-16 pt font. The first box could be larger to draw people in. You can use a background image, but pick a simple one that is of high quality. Select text box fill and select change the transparency to maintain the contrast and partially show the picture.
You can experiment with different layouts and you should include images. Avoid a chaotic layout, posters are read from top left column downwards.
Remember to include the authors and references.
Finally, look at the examples given on the University of Texas website which also offers an evaluation of each www.tinyurl.com/postereg

The future of nuclear power

Background
Nuclear power is responsible for generating 18.5% of the UK annual supply of electricity. Currently nuclear power is generated by the process of induced nuclear fission in enriched Uranium fuel rods. There is another type of nuclear reaction that releases larger amounts of energy, leaves no radioactive waste or carbon emissions and uses deuterium which is abundant in sea water - nuclear fusion, so why aren't we using this instead?

Source articles:
https://www.youtube.com/watch?v=mZsaaturR6E

https://www.ted.com/talks/steven_cowley_fusion_is_energy_s_future

https://www.youtube.com/watch?v=WSh08UdAunU

Use other sources as necessary.

Task:
Produce a scientific poster on the future of nuclear power.

Recall	State how the process of nuclear fusion releases energy and give examples of nuclear fusion reactions and where these occur.
Describe	Describe the economic and environment benefits of using nuclear fusion power to the ways that global energy demands are currently met.
Compare	Compare the process of nuclear fission and nuclear fusion and describe the advantages and disadvantages of each.
Evaluate	Evaluate the likelihood of developing a nuclear fusion reactor that can be used on Earth to meet global energy demand in 2030.

PiXL Independence – Level 5
Video summaries
A-level Physics – Nuclear 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. The first is two scientists outlining their argument for or against nuclear energy. The second video discusses the need for nuclear power and gives data on the ever-increasing global demand for power.

Source article:
Video 1 – The nuclear power debate
Ted Ed talks: https://www.youtube.com/watch?v=UK8ccWSZkic

Video 2 – How bad is it really? Nuclear technology facts and feelings
Ted Ed talks: https://www.youtube.com/watch?v=oTKl5X72NIc

Task:

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

1 Briefly describe the process of generating electricity using nuclear fission.
2 Outline the main arguments for against nuclear power.
3 Summarise the arguments for each case and give a justified conclusion on whether you feel nuclear power should be expanded.

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

Objectives:	**Title:** **Date:**
Summary:	

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