Part A

1. For a long time people thought that the smallest particles in nature were atoms. We now know that atoms are made of ____________, ____________, and ____________.

2. Mendeleev organised the elements into Groups based on similarities in the way that they behaved chemically. For example, the atoms of the elements within each Group form compounds with oxygen atoms only in specific ratios. Fill in the table below. The first row has been done for you.

<table>
<thead>
<tr>
<th>Group</th>
<th>Oxides Formed Between Each Element and Oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Mendeleev’s Group 1)</td>
<td>Na  Na₂O  Mg  MgO  Al  Al₂O₃  Si  SiO₂</td>
</tr>
<tr>
<td>2 (Mendeleev’s Group 2)</td>
<td>K    Ca   MgO  SiO₂</td>
</tr>
<tr>
<td>3 (Mendeleev’s Group 3)</td>
<td>Rb   Sr   Ga   SiO₂</td>
</tr>
<tr>
<td>4 (Mendeleev’s Group 4)</td>
<td>Ca   Sr   Sn   SiO₂</td>
</tr>
</tbody>
</table>

Part B

3. Label the diagram below.

4. We can tell it is a representation of a ______________ atom because it has _______ protons in its ______________.

   If it had 3 protons in its nucleus it would be a ______________ atom.

5. __________ have a __________ charge, __________ have a __________ charge, and ___________ are neutral.

6. Why do the electrons keep moving around the nucleus instead of flying off away from it?

   ___________________________________________________________________________
   ___________________________________________________________________________
   ___________________________________________________________________________

7. Why don’t the protons, which all have the same positive charge, repel each other and fly apart?

   ___________________________________________________________________________
   ___________________________________________________________________________
   ___________________________________________________________________________

8. What stops us from flying off into space every time we jump into the air?

   (Your three answers above relate to three of the four “fundamental forces of nature”. The other one is called the “weak interaction”, which you might study if you decide to study Physics at university.)

9. The atomic number of an atom (given the symbol ______) is defined as ______________________

10. How does the number of protons in an atom compare to the number of electrons in an atom?

11. Fill in the tables below. (You may need to consult a Periodic Table.)

<table>
<thead>
<tr>
<th>Element</th>
<th>Element Symbol</th>
<th>Atomic Number (Z)</th>
<th>No. of electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>Na</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Fluorine</td>
<td>F</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Carbon</td>
<td>C</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Chlorine</td>
<td>Cl</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>Element Symbol</th>
<th>Atomic Number (Z)</th>
<th>No. of electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>U</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li</td>
<td>Li</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
12. (a) A particular atom has a **mass number** (given the symbol _______) of 56. What does this mean?

13. While all the atoms of any given element have the same number of protons, they don’t all have the same number of neutrons. To distinguish between the isotopes of different atoms, scientists often use “atomic notation”.

How many protons, neutrons, and electrons are in the following atoms.

(a) \(^{19}_{9}\text{F}\)

(b) \(^{20}_{9}\text{F}\)

(c) \(^{1}_{1}\text{H}\)

(d) \(^{11}_{5}\text{B}\) (You may need a Periodic Table. This notation is sometimes used on webpages.)

(e) Ti-48

14. \(^{12}_{6}\text{C}, \(^{13}_{6}\text{C}, \) and \(^{14}_{6}\text{C}\) are all naturally occurring **isotopes** of carbon. Write down three things that they all have in common and describe one thing that is different about them.

15. Fill in the table below. You will need a periodic table.

<table>
<thead>
<tr>
<th>Element</th>
<th>Isotope</th>
<th>Atomic Notation (^{AX}_{Z})</th>
<th>Number of protons (Atomic Number, Z)</th>
<th>Number of nucleons (Mass Number, A)</th>
<th>Number of neutrons</th>
<th>Number of electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>lithium</td>
<td>lithium-7</td>
<td>(^{7}_{3}\text{Li})</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lithium-6</td>
<td></td>
<td></td>
<td>8</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>uranium</td>
<td></td>
<td></td>
<td>17</td>
<td>9</td>
<td>235</td>
<td>92</td>
</tr>
</tbody>
</table>

16. Draw a representation of a Lithium-6 atom, labelling the three types of subatomic particles that make it up.
17. Two balloons are rubbed on cloth and it is then found that they repel one another. Why does this happen?
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

18. At a simple level, electricity is the flow of electrons from atom to atom in a wire. Describe what happens, however, when a really high voltage is applied between two metal plates in a vacuum tube.
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____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
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19. How does the mass of an electron compare with the mass of a proton?
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____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

20. Describe and draw a diagram of Thomson’s (incorrect) “Plum Pudding” model of the atom (which he proposed before protons and neutrons were discovered).
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____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
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21. What is an alpha particle, and where do they come from?
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____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

22. Uranium-238 is an alpha-particle emitter. Write down the nuclear equation which express what happens when the uranium atom ejects an alpha particle.
____________________________________________________________________________________
____________________________________________________________________________________

23. Complete the following nuclear equations. You will need a periodic table.

\[ ^{210}_{84}\text{Po} \rightarrow ^{206}_{82}\text{Pb} + ^{4}_{2}\text{alpha} \]

\[ ^{241}_{95}\text{Am} \rightarrow ^{237}_{93}\text{Rn} + ^{4}_{2}\text{alpha} \]

\[ ^{238}_{94}\text{Pu} \rightarrow ^{234}_{92}\text{U} + ^{4}_{2}\text{alpha} \]

24. How are alpha particles similar to helium atoms and how are they different?
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
Part E

25. Briefly describe Rutherford’s Gold Foil Experiment and explain how it led to the discovery that most of the atom’s mass is concentrated in a small “nucleus”.

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_____________________________________________________________________________________

_____________________________________________________________________________________

_____________________________________________________________________________________

_____________________________________________________________________________________

26. Approximately how large is an atom compared to its nucleus.

_____________________________________________________________________________________

_____________________________________________________________________________________

_____________________________________________________________________________________

_____________________________________________________________________________________

_____________________________________________________________________________________

27. In 1913, Henry Moseley found a way of calculating the amount of positive charge in the nucleus of the atoms of each element. How did he do this?

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_____________________________________________________________________________________

28. In 1917, Earnest Rutherford discovered that the nucleus of a hydrogen atom is made of

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29. Neutrons were discovered in the year ____________________________

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30. Why did it take so long for neutrons to be discovered?

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_____________________________________________________________________________________

_____________________________________________________________________________________

31. Mendeleev used trends in the order of the elements to predict properties of undiscovered elements. He used the elements’ atomic weights, but the trends work better if atomic number is used instead. Plot the data in the table and then determine the density of Hafnium.

<table>
<thead>
<tr>
<th>Element</th>
<th>Symbol</th>
<th>Atomic Number (Z)</th>
<th>Density (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ytterbium</td>
<td>Yb</td>
<td>69</td>
<td>6.9</td>
</tr>
<tr>
<td>Lutetium</td>
<td>Lu</td>
<td>70</td>
<td>9.84</td>
</tr>
<tr>
<td>Hafnium</td>
<td>Hf</td>
<td>72</td>
<td>16.7</td>
</tr>
<tr>
<td>Tantalum</td>
<td>Ta</td>
<td>73</td>
<td>19.4</td>
</tr>
<tr>
<td>Tungsten</td>
<td>W</td>
<td>74</td>
<td>21.0</td>
</tr>
<tr>
<td>Rhenium</td>
<td>Re</td>
<td>75</td>
<td>22.6</td>
</tr>
</tbody>
</table>

Question 30 relates to a trend in a physical property—density—of the elements. Most of the trends in the physical and chemical properties of the elements relate not just to the number of protons in the nucleus, but, just as importantly, to the way the electrons are arranged within atoms in so-called “electron shells”, so that’s what we’ll be looking at in our next episode.