1.3

Year 9 · Unit 1 · 1.3 Bohr model · Worksheet C

PhET Build an Atom

Name _____ Class _____ Mark _____ / 20

What you are practising

I can use the simulation to find where each particle sits and its charge, and use atomic number, mass number and the neutron rule.

Worked example $^{12}_{6}C$

protons = Z = 6
neutrons = 12 − 6 = 6
electrons = 6 (neutral atom)

Use these definitions

1. **Atomic number (Z)**: the number of protons in the nucleus. It decides which element the atom is.
2. **Mass number (A)**: the number of protons and neutrons in the nucleus.
3. **Neutrons** = mass number − atomic number = A − Z.
4. In a **neutral atom**, electrons = protons.

Open the simulation

1. Go to **phet.colorado.edu/en/simulations/build-an-atom** and click the play button.
   Direct link: **phet.colorado.edu/sims/html/build-an-atom/latest/build-an-atom_en.html**
2. The start page shows three screens: **Atom**, **Symbol** and **Game**. Click **Atom**.
3. On the right, the **Periodic Table** box is already open. Click the green **+** on **Net Charge** and on **Mass Number** to open them.
4. Bottom right: **Element Name** and **Neutral Atom or Ion** should be ticked. Leave **Nuclear Stability** unticked.
5. Under **Model:** choose **Shells**, not **Cloud**.
6. Drag particles from the **Protons**, **Neutrons** and **Electrons** buckets onto the atom. Drag one back to its bucket to remove it. The orange button bottom right clears the atom. The box top left counts each particle.

Part 1 · Where the particles go

1. Clear the atom. Add **one** particle only, read the displays, then clear it again. Do this for each particle. **[3]**

Particle	Where it goes: nucleus or shell?	**Net Charge** reading: +1, 0 or −1
a proton		
b neutron		
c electron		

Page done? Tick it off ◌

Part 1 · Mass number [2]

2 Check definition 2. Add particles one at a time and watch **Mass Number**. Which **two** particles make it go up? **[1]**

3 Build an atom with 2 protons, 2 neutrons and 2 electrons. **[1]**

Mass Number shows ☐ Element (**Periodic Table** box) ☐

Part 2 · Build it and read the displays [5]

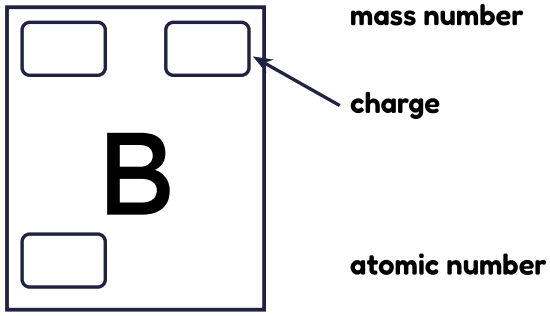
Build each atom on the **Atom** screen. Write what each display shows. Last column: copy the label above the atom (**Neutral Atom**, **Positive Ion** or **Negative Ion**). 1 mark per row, all four cells right.

Build (protons, neutrons, electrons)	**Element**	**Net Charge**	**Mass Number**	**Label**
a 3, 4, 3				
b 2, 4, 2				
c 5, 5, 5				
d Take one electron off c: 5, 5, 4				
e Put it back, add one neutron: 5, 6, 5				

Part 3 · The Symbol screen [3]

4 Click **Symbol** in the bar at the bottom of the screen. Build boron with 5 protons, 6 neutrons and 5 electrons.

Copy the three numbers from the **Symbol** box into the boxes. Then draw arrows from **mass number** and **atomic number** to the right numbers. The charge arrow is done for you. **[2]**



5 Use definition 3 to check the neutrons: **[1]**

neutrons = ☐ − ☐ = ☐

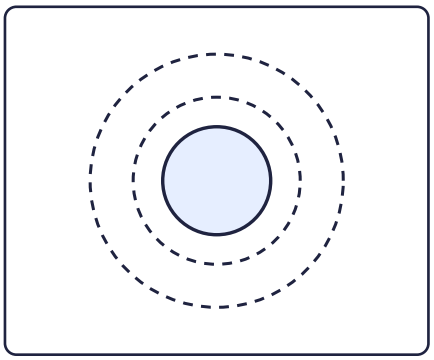
Part 4 · Electrons in shells [3]

6 Back on the **Atom** screen, clear the atom and add electrons one at a time, up to 10. The 1st shell fills up with ____ electrons, then the 2nd shell fills up with ____ electrons. **[1]**

For atoms up to calcium the arrangement is 2, 8, 8, 2: the 3rd shell also holds up to 8. The sim only shows two shells.

7 Draw the boron atom from Part 3 (5 protons, 6 neutrons, 5 electrons) as a Bohr diagram. Write the protons and neutrons in the nucleus. Draw the electrons as crosses.

The sim spreads the outer electrons out its own way. On paper use the house rule: one at N, E, S and W before any pair; the 1st shell's two sit as a pair at the top. **[2]**



Arrangement ____

Explain

8 Atom c (5, 5, 5) showed a **Net Charge** of 0. Atom d (5, 5, 4) showed +1. Use the charges of the particles to explain why taking away an electron makes the charge +1. **[2]**

Who is right?

In Part 2 you added a neutron to boron (row e).

Sam: "The mass number went from 10 to 11, so adding the neutron made a different element."

Nadia: "It is still boron. The element depends only on the number of protons, and that is still 5."

9 Who is right? Give one reading from the simulation that shows it. **[2]**

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Answers

Part 1 · Where the particles go [5]

1 One mark per row.

Particle	Where it goes	Net Charge reading
a proton	nucleus	+1
b neutron	nucleus	0
c electron	shell	−1

(3) Protons and neutrons together form the nucleus.

2 Protons and neutrons **(1)**. Electrons do not change the mass number: mass number = protons + neutrons.

3 Mass Number 4; element helium **(1)**.

Part 2 · Build it and read the displays [5]

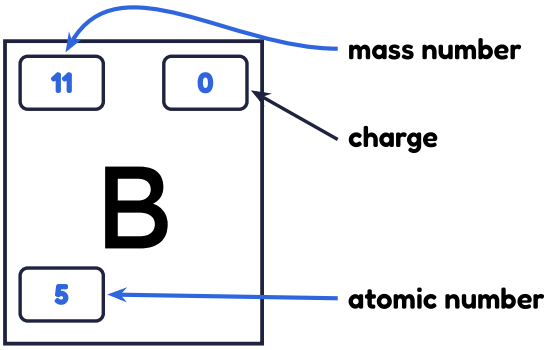
Build	Element	Net Charge	Mass Number	Label
a 3, 4, 3	Lithium	0	7	Neutral Atom
b 2, 4, 2	Helium	0	6	Neutral Atom
c 5, 5, 5	Boron	0	10	Neutral Atom
d 5, 5, 4	Boron	+1	10	Positive Ion
e 5, 6, 5	Boron	0	11	Neutral Atom

1 mark per row **(5)**. Rows c, d and e are all boron: 5 protons each time.

Part 3 · The Symbol screen [3]

4 Numbers 11, 0 and 5 in the right boxes **(1)**. Arrows: mass number to 11 (top left), atomic number to 5 (bottom left) **(1)**.

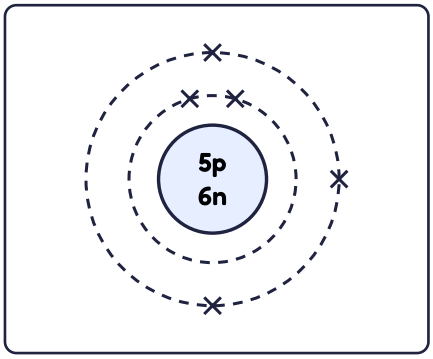
5 neutrons = 11 − 5 = 6 **(1)**. This matches the 6 neutrons you built.



Part 4 · Electrons in shells [3]

6 1st shell **2**, 2nd shell **8** **(1)**.

7 Nucleus labelled 5p, 6n; two crosses as a pair at the top of the 1st shell; three single crosses at N, E and S of the 2nd shell **(1)**. Arrangement **2, 3** **(1)**.



Explain [2]

8 Each proton is +1 and each electron is −1; neutrons have no charge. With 5 protons and 5 electrons the charges cancel: +5 − 5 = 0 **(1)**. With 4 electrons there is one more positive charge than negative: +5 − 4 = +1, so it is a positive ion **(1)**.

Who is right? [2]

9 Nadia **(1)**. After adding the neutron the **Periodic Table** box still shows B and the name above the nucleus is still Boron; the **Symbol** box still has atomic number 5 **(1)**. A neutron changes the mass number only. Atoms of the same element with different numbers of neutrons are isotopes.

How to revise this

Look at the four definitions on page 1. Cover them. Write them out from memory. Check. Then rebuild only the rows you got wrong in the simulation and read the displays again.