IONISATION ENERGY

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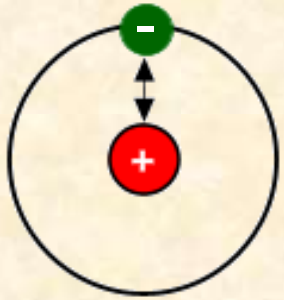
WHAT IS IONISATION ENERGY?

Ionisation Energy is a measure of the amount of energy needed to remove electrons from atoms.

As electrons are negatively charged and protons in the nucleus are positively charged, there will be an attraction between them. The greater the pull of the nucleus, the harder it will be to pull an electron away from an atom.



Attraction between the nucleus and an electron

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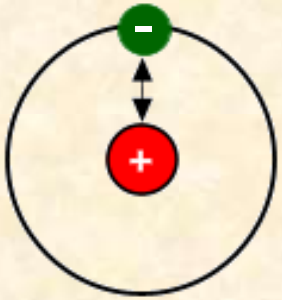


Attraction between the nucleus and an electron

FIRST IONISATION ENERGY - Definition

The energy required to remove ONE MOLE of electrons (to infinity) from ONE MOLE of gaseous atoms to form ONE MOLE of gaseous positive ions.

e.g. $Na(g) \longrightarrow Na^+(g) + e^-$

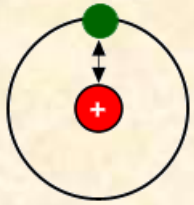
$Al(g) \longrightarrow Al^+(g) + e^-$

Make sure you write in the (g)

WHAT AFFECTS IONISATION ENERGY?

The value of the 1st Ionisation Energy depends on the electronic structure

Hydrogen

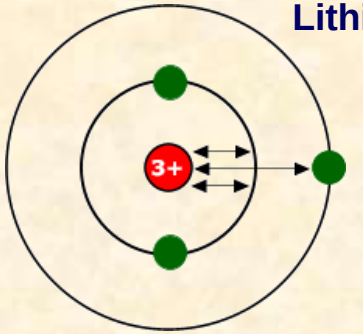


1310 kJ mol^{-1}

Helium

2370 kJ mol^{-1}

Lithium



519 kJ mol^{-1}

The value for helium is higher than that for hydrogen because there are now two protons in the nucleus. The nuclear charge is greater so the pull on the outer electrons is larger. More energy will be needed to pull an electron out of the atom.

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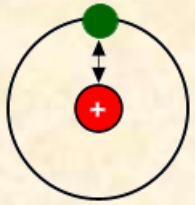

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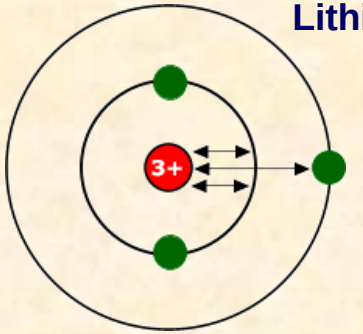

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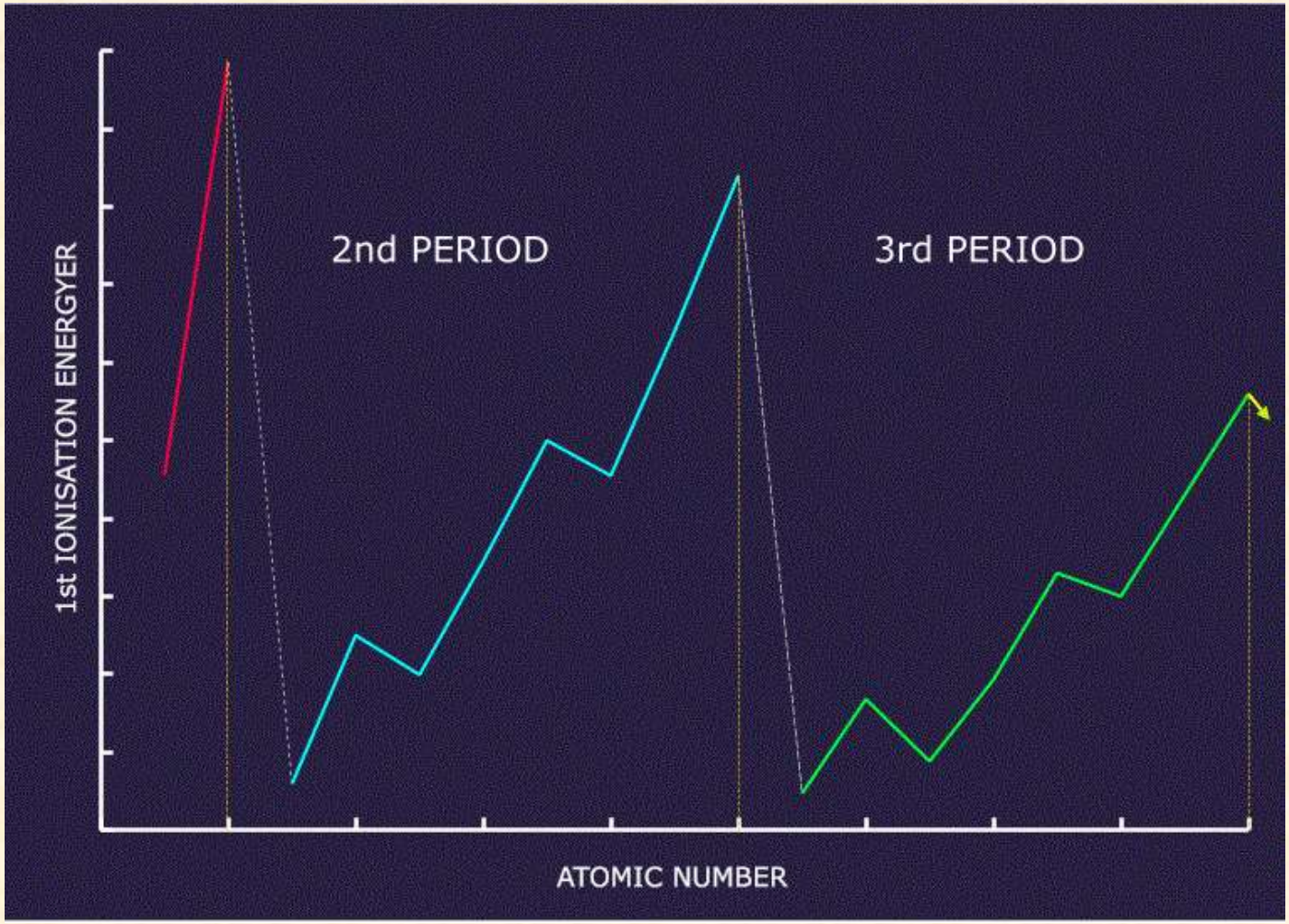
Lithium atoms have 3 protons so you would expect the pull on electrons to be greater. However, the 1st Ionisation Energy of lithium is lower than that of helium because…

- **Filled inner shells exert a SHIELDING EFFECT; lowers the effective nuclear pull**
- **FURTHER AWAY from the nucleus = lower nuclear attraction for an electron**

Variation in 1st Ionisation Energy - PERIODS

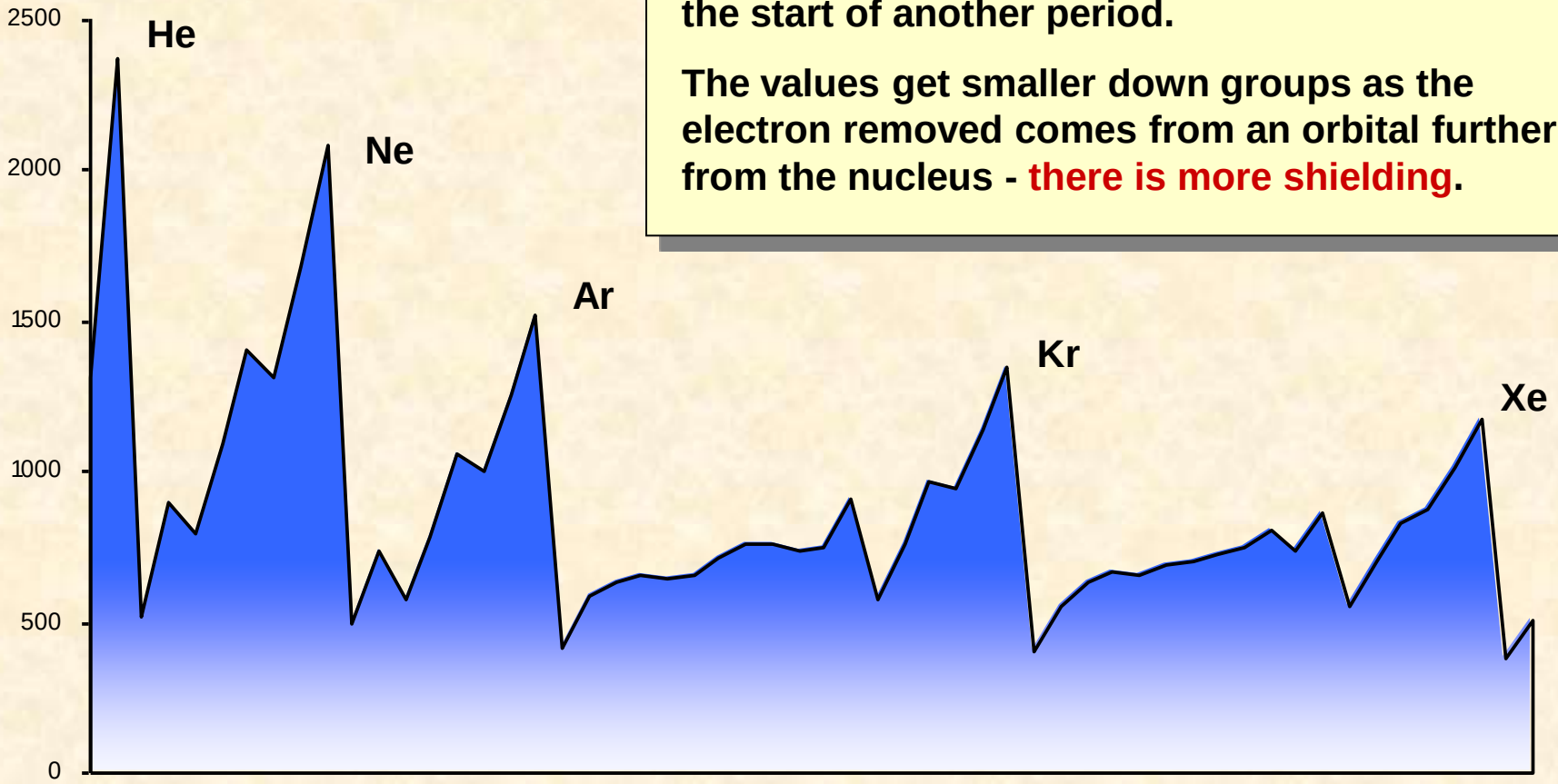


1st Ionisation Energy shows a ‘general increase’ across a given period

Variation in 1st Ionisation Energy - PERIODS

1st Ionisation Energy values show a periodic trend. There is a 'general increase' across a period before the value drops dramatically for the start of another period.

The values get smaller down groups as the electron removed comes from an orbital further from the nucleus - there is more shielding.



Variation in 1st Ionisation Energy - GROUPS

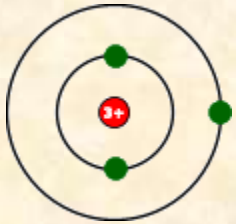
GROUP I Value **decreases down the Group**

despite an increased nuclear charge the outer *s* electron is easier to remove

this is due to increased shielding and greater distance from the nucleus

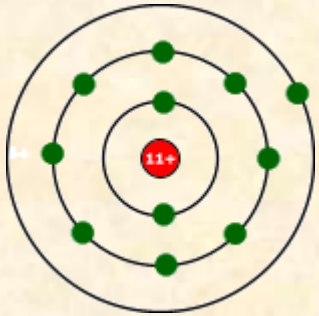
the outer electron is held less strongly and easier to remove

Li



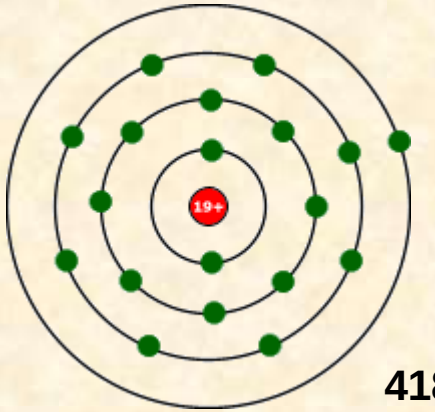
519 kJ mol^{-1}

Na



494 kJ mol^{-1}

K



418 kJ mol^{-1}

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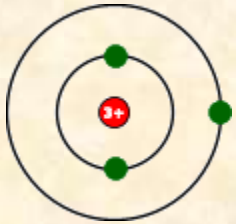

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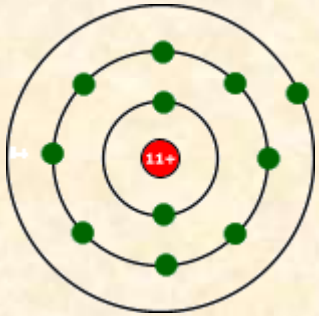

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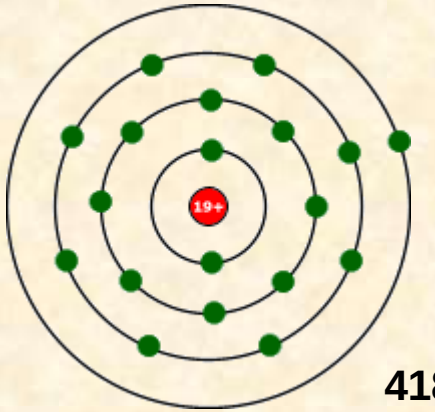


418 kJ mol^{-1}

GROUP II Similar trend to Group I

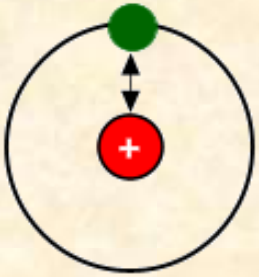
Group II values are greater than their Group I neighbours

increased nuclear charge = stronger pull on electron

more energy required to remove an electron

Variation in 1st Ionisation Energy

HYDROGEN



EXPLANATION

Despite having a nuclear charge of only 1+, **Hydrogen** has a relatively high 1st Ionisation Energy as its electron is closest to the nucleus and has no shielding.

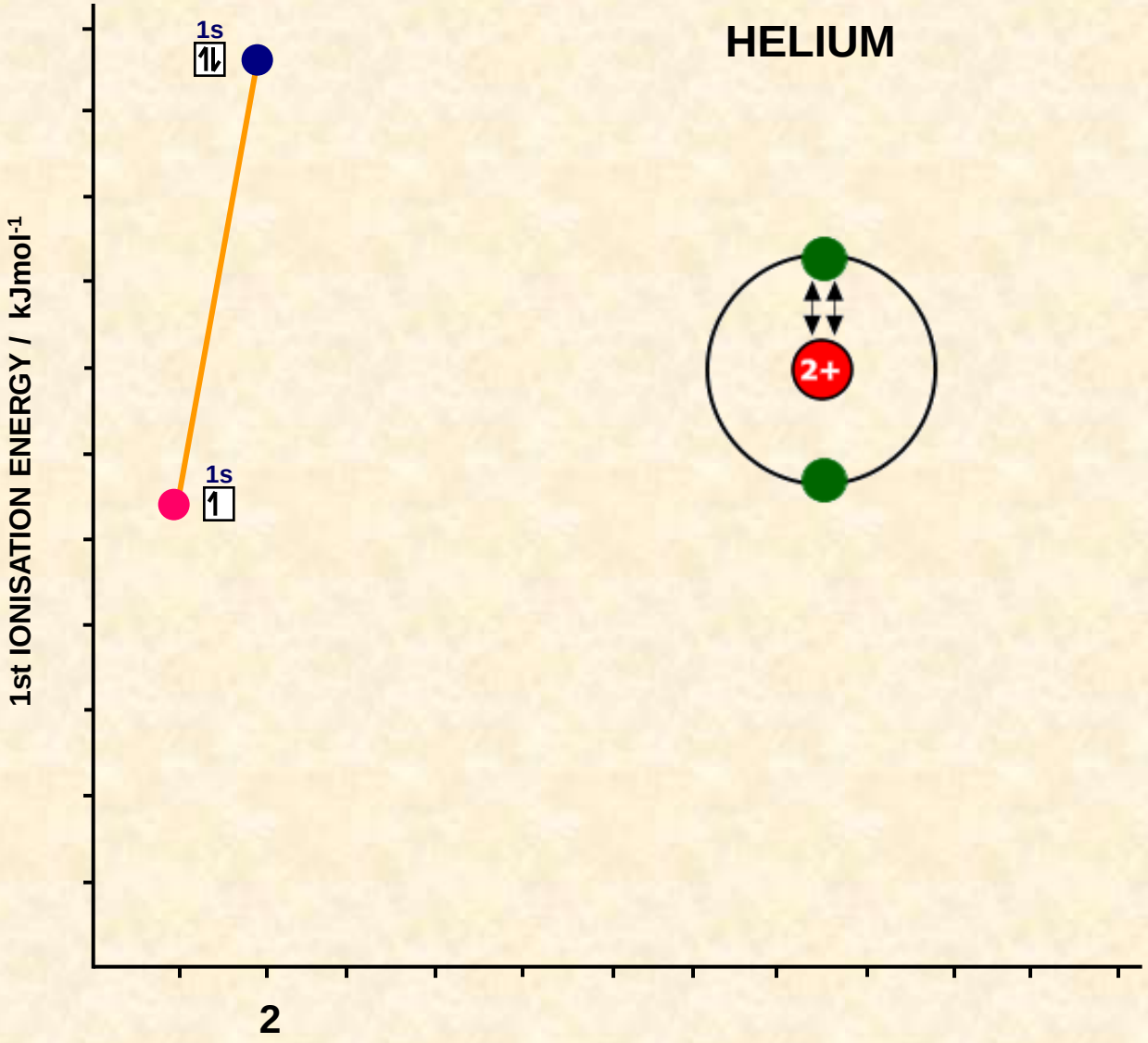
1st IONISATION ENERGY / kJmol^{-1}

1s
1

1

ATOMIC NUMBER

Variation in 1st Ionisation Energy

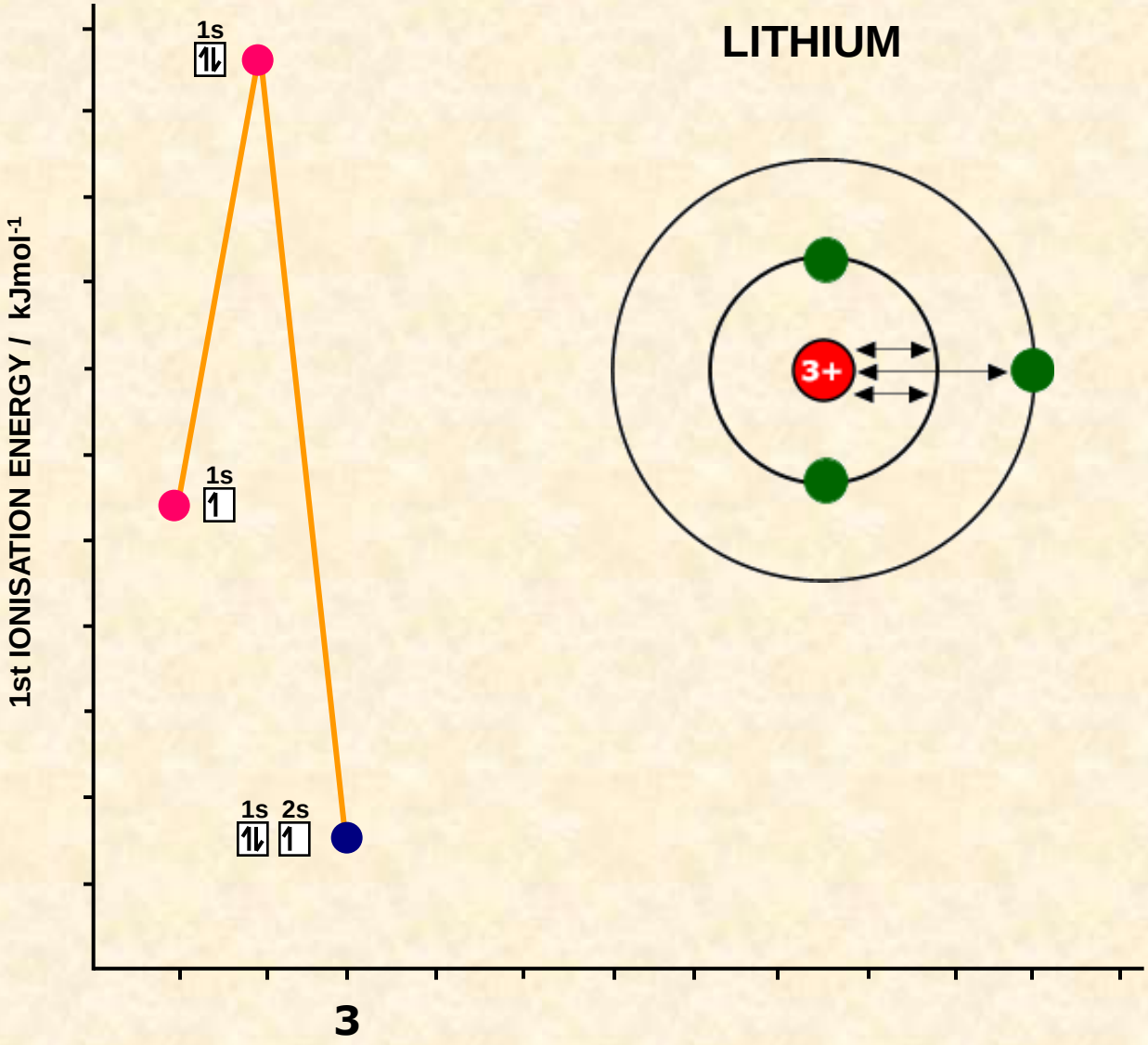


HELIUM

EXPLANATION

Helium has a much higher value because of the extra proton in the nucleus. The additional charge provides a stronger attraction for the electrons making them harder to remove.

Variation in 1st Ionisation Energy

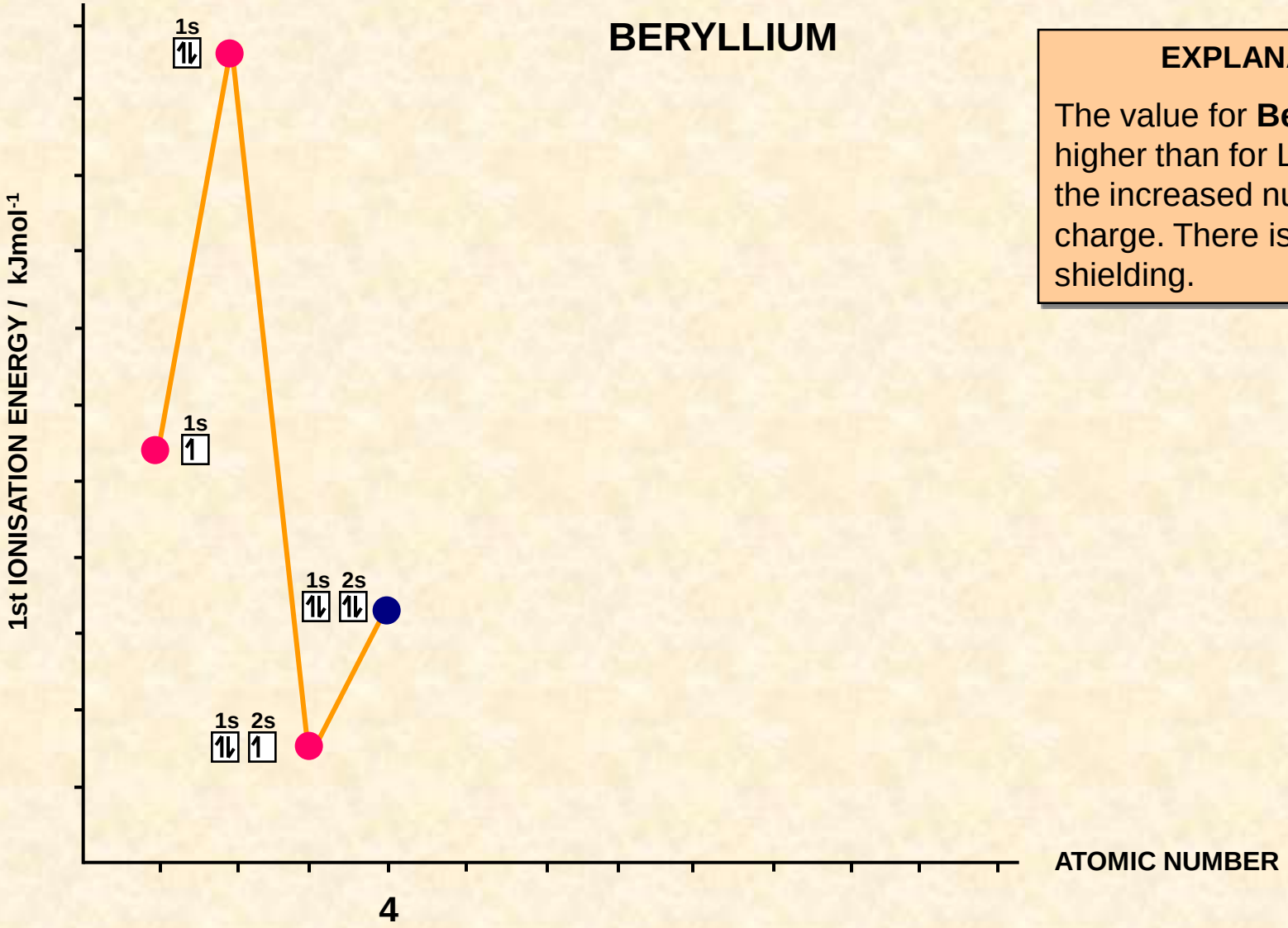


LITHIUM

EXPLANATION

There is a substantial drop in the value for **Lithium**. This is because the extra electron has gone into an orbital in the next energy level. Despite the increased nuclear charge, the effective nuclear charge is less because of the shielding effect of filled inner 1s energy level. The 2s electron is also further away from the nucleus. It is held less strongly and needs less energy for removal.

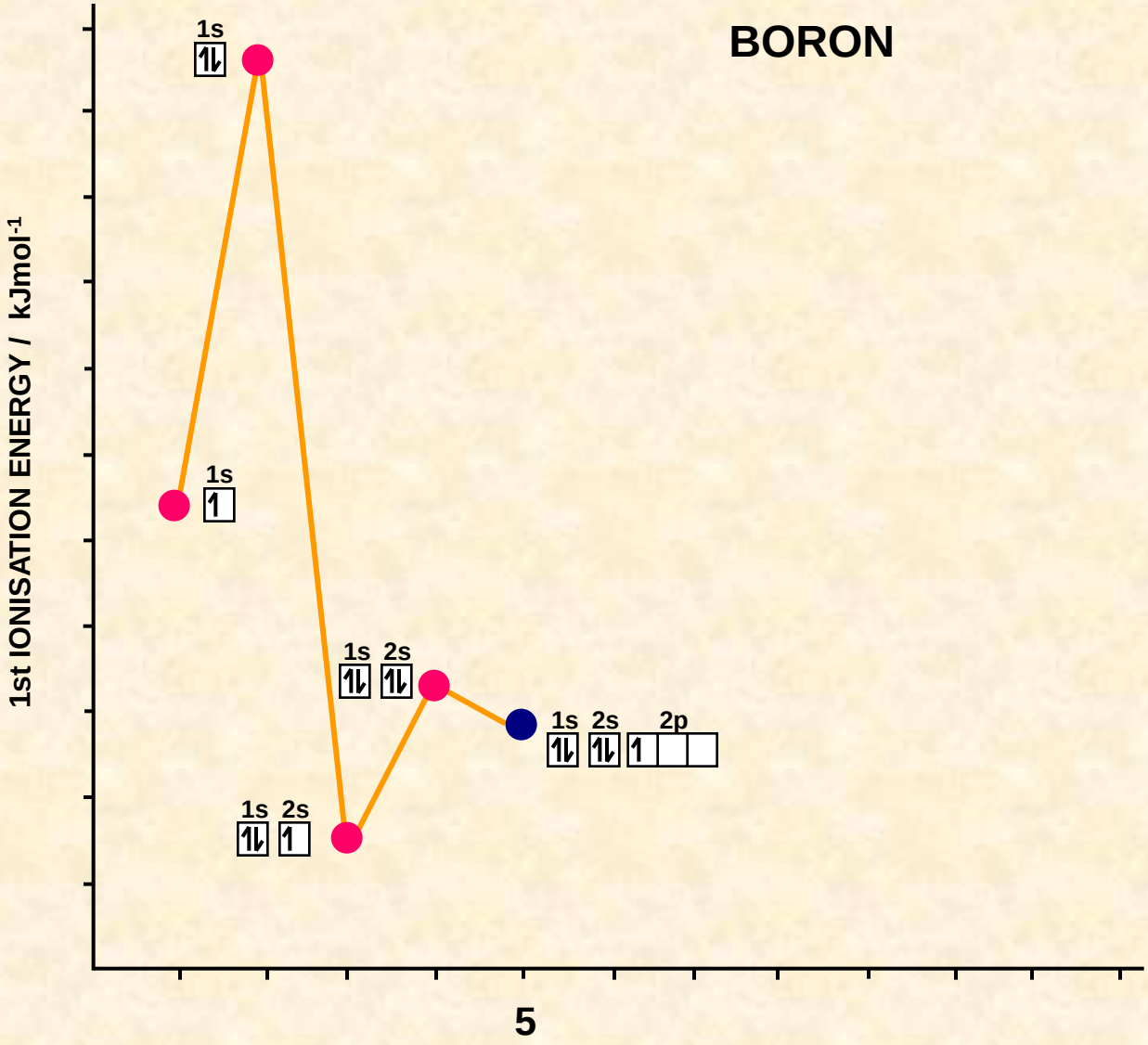
Variation in 1st Ionisation Energy



EXPLANATION

The value for **Beryllium** is higher than for Lithium due to the increased nuclear charge. There is no extra shielding.

Variation in 1st Ionisation Energy

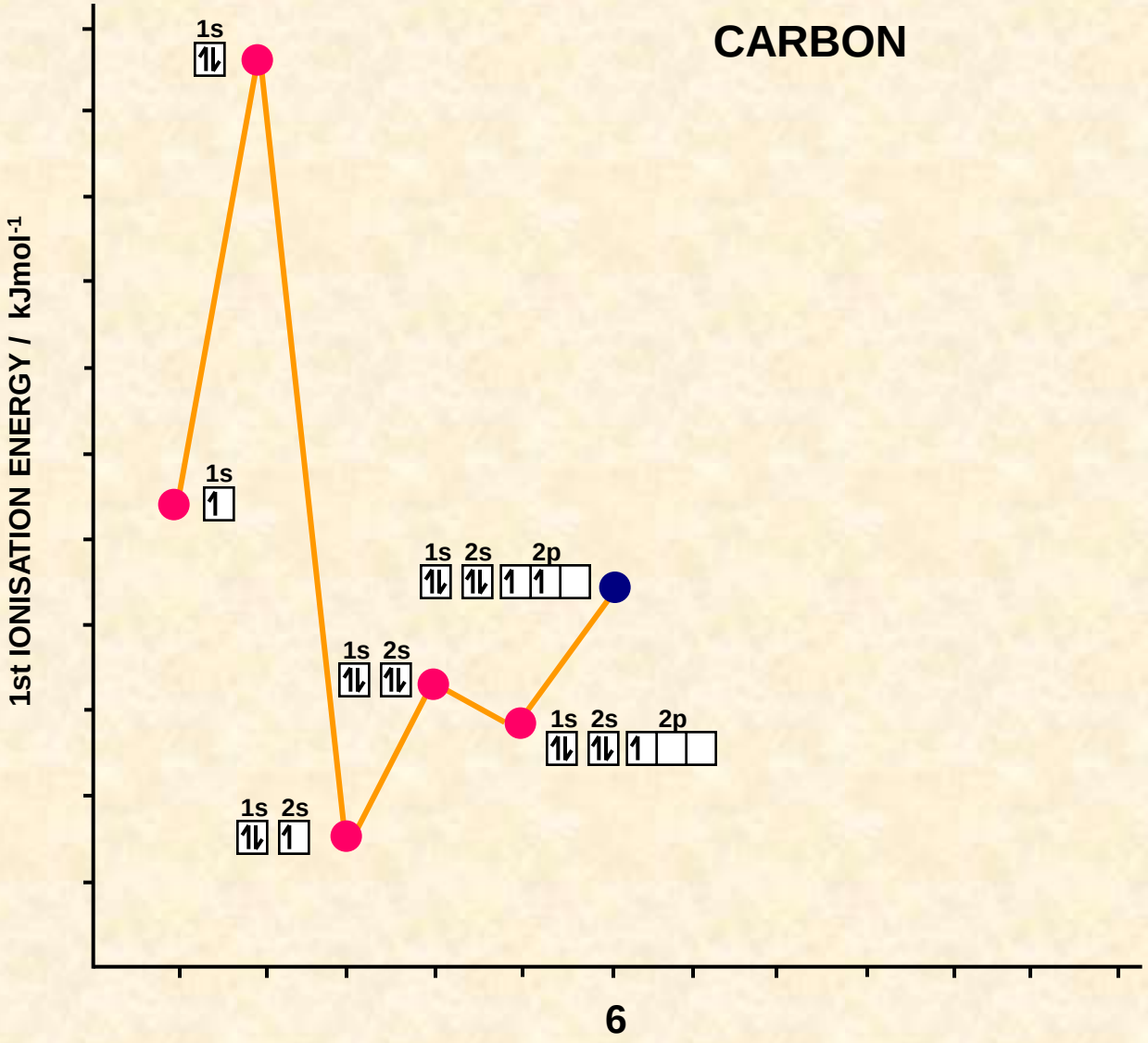


EXPLANATION

There is a **DROP** in the value for **Boron**. This is because the extra electron has gone into one of the 2p orbitals. The increased shielding makes the electron easier to remove

It was evidence such as this that confirmed the existence of sub-shells. If there hadn't been any sub-shell, the value would have been higher than that of Beryllium.

Variation in 1st Ionisation Energy

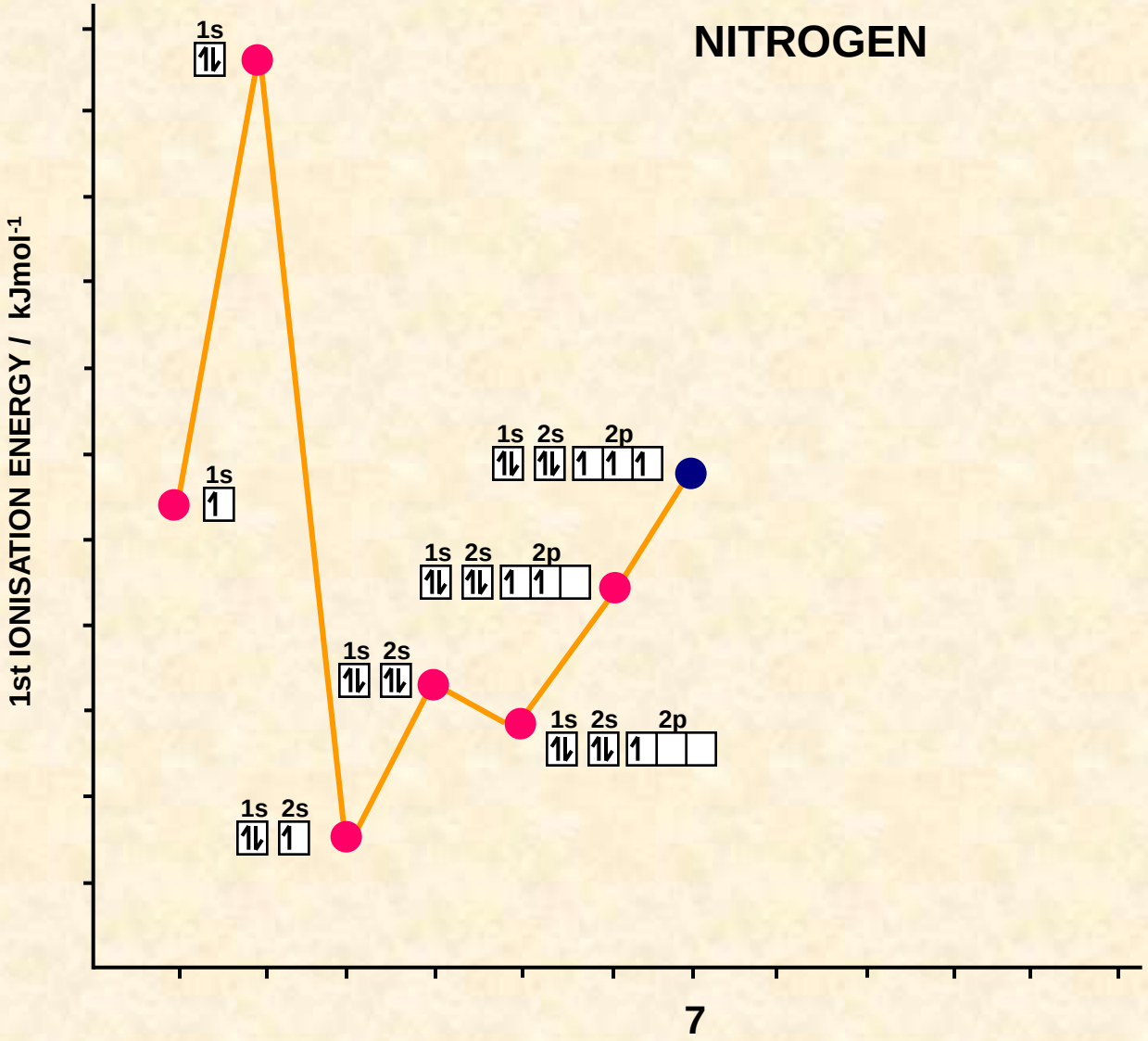


EXPLANATION

The value increases again for **Carbon** due to the increased nuclear charge.

The extra electron does not pair up with the previous one in the same orbital but occupies another of the 2p orbitals. This gives a lower energy configuration because there is less repulsion between the negatively charged particles. This is known as **Hund's Rule**.

Variation in 1st Ionisation Energy

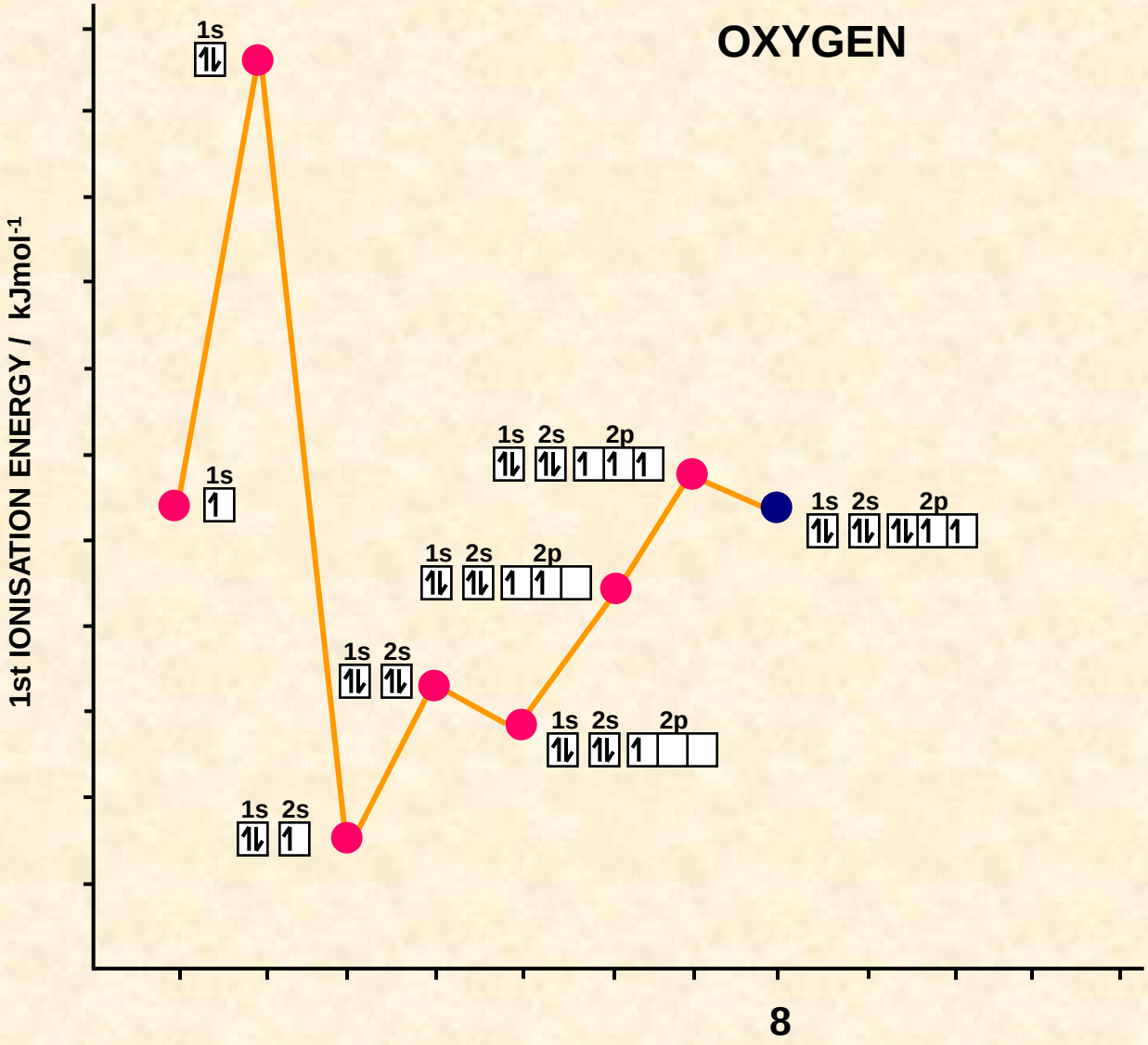


EXPLANATION

The value increases again for **Nitrogen** due to the increased nuclear charge.

As before, the extra electron goes into the vacant 2p orbital. There are now three unpaired electrons.

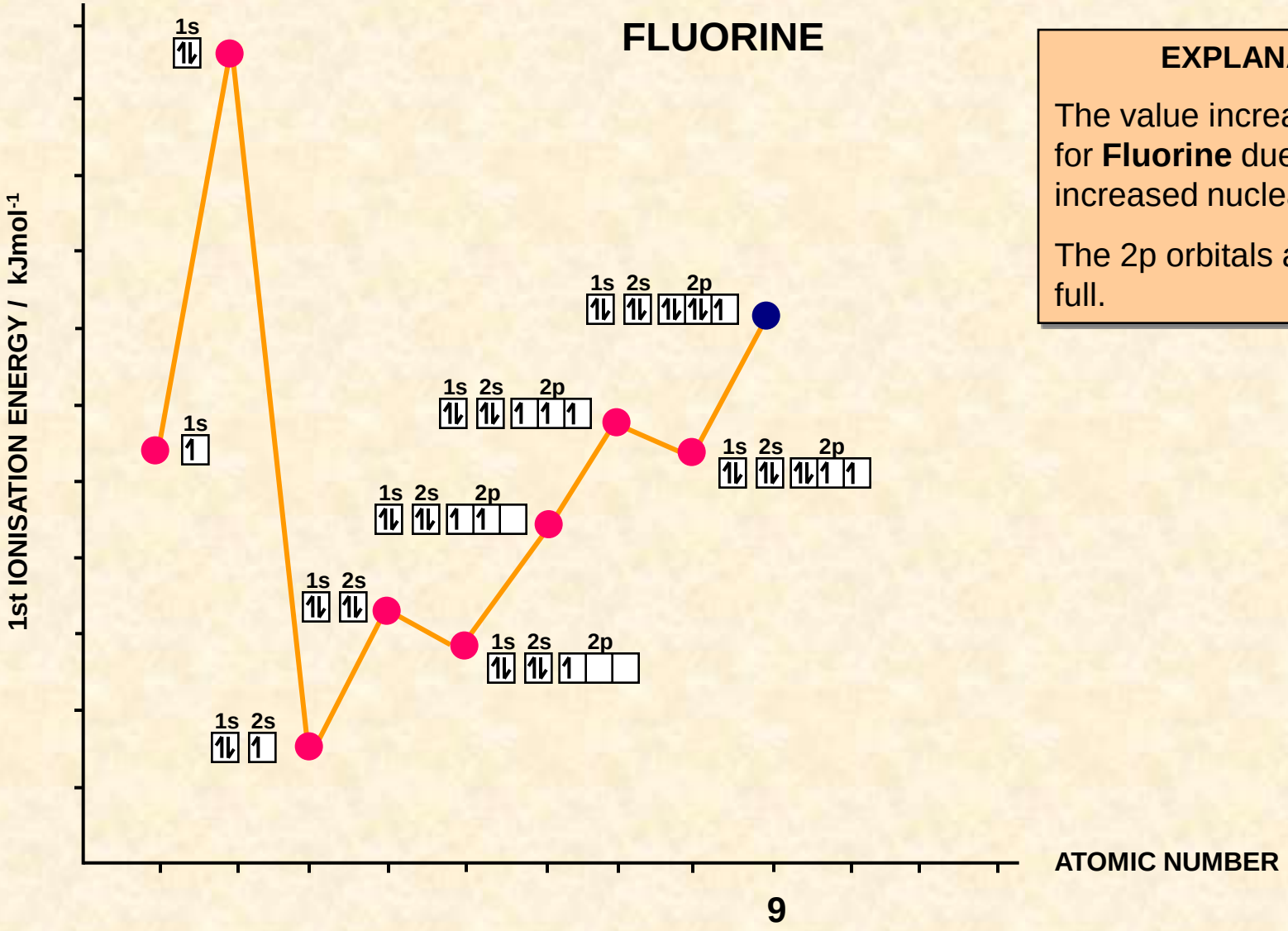
Variation in 1st Ionisation Energy



EXPLANATION

There is a **DROP** in the value for **Oxygen**. The extra electron has paired up with one of the electrons already in one of the 2p orbitals. The repulsive force beteen the two paired-up electrons means that less energy is required to remove one of them.

Variation in 1st Ionisation Energy

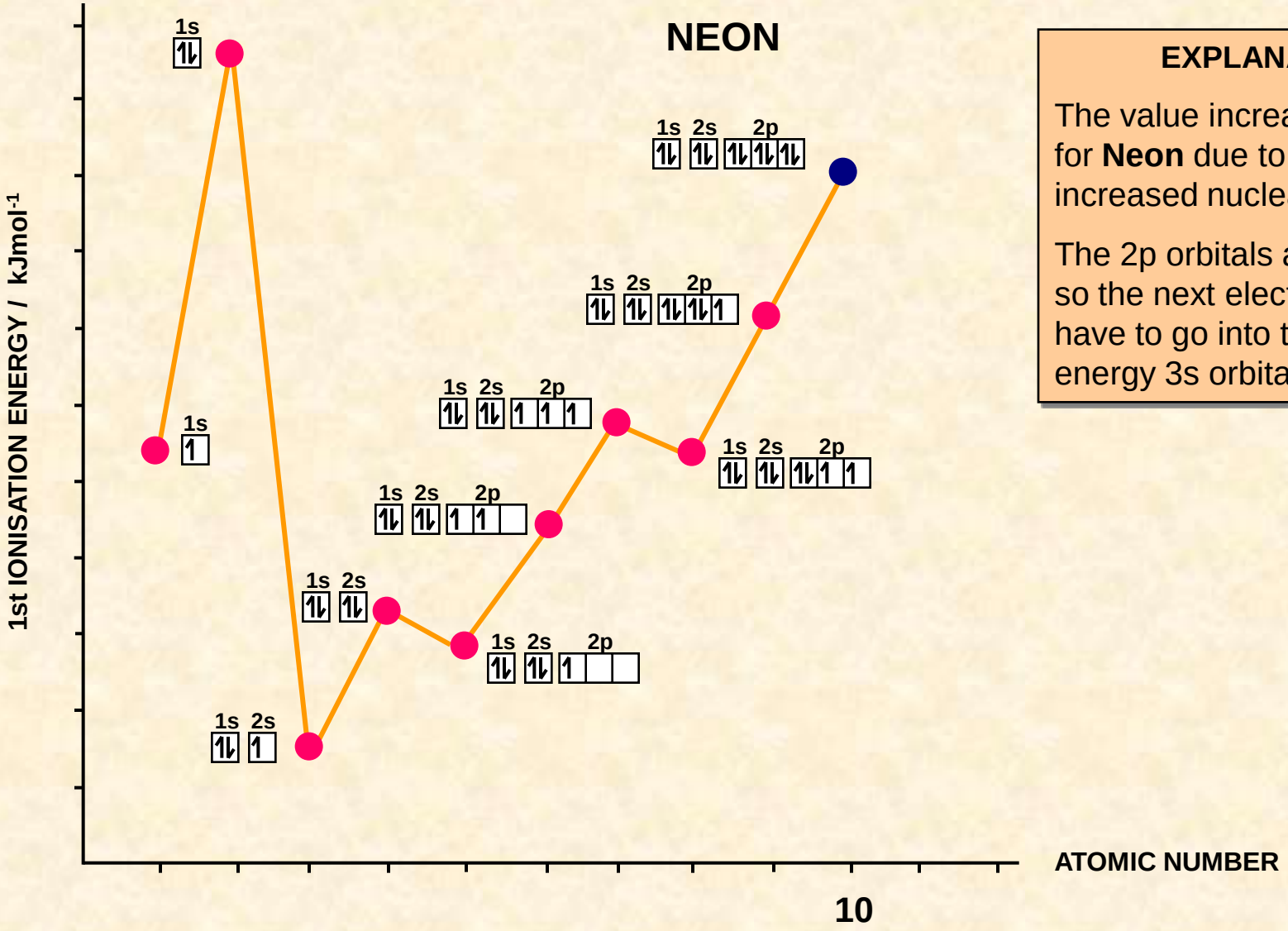


EXPLANATION

The value increases again for **Fluorine** due to the increased nuclear charge.

The 2p orbitals are almost full.

Variation in 1st Ionisation Energy

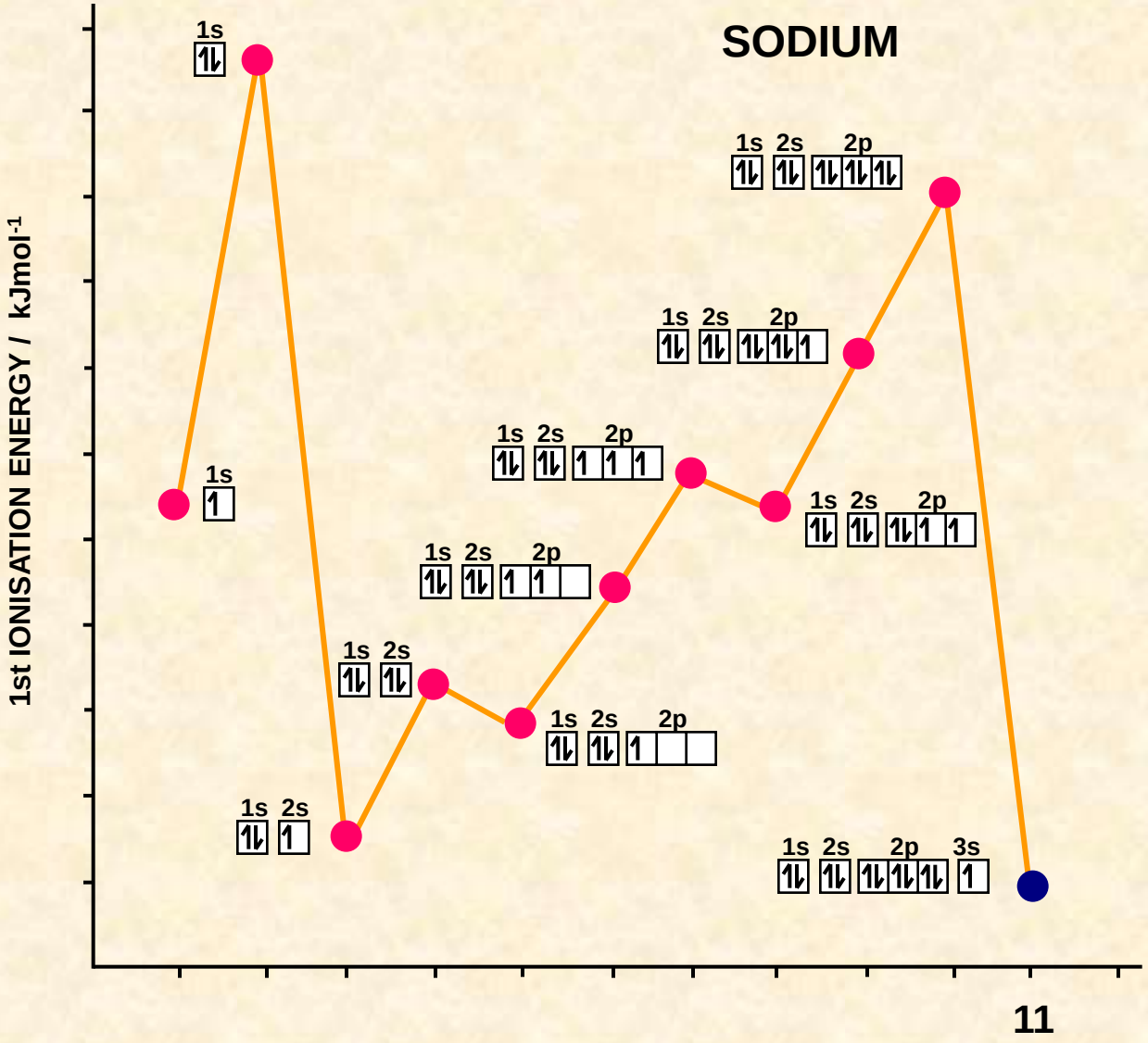


EXPLANATION

The value increases again for **Neon** due to the increased nuclear charge.

The 2p orbitals are now full so the next electron in will have to go into the higher energy 3s orbital.

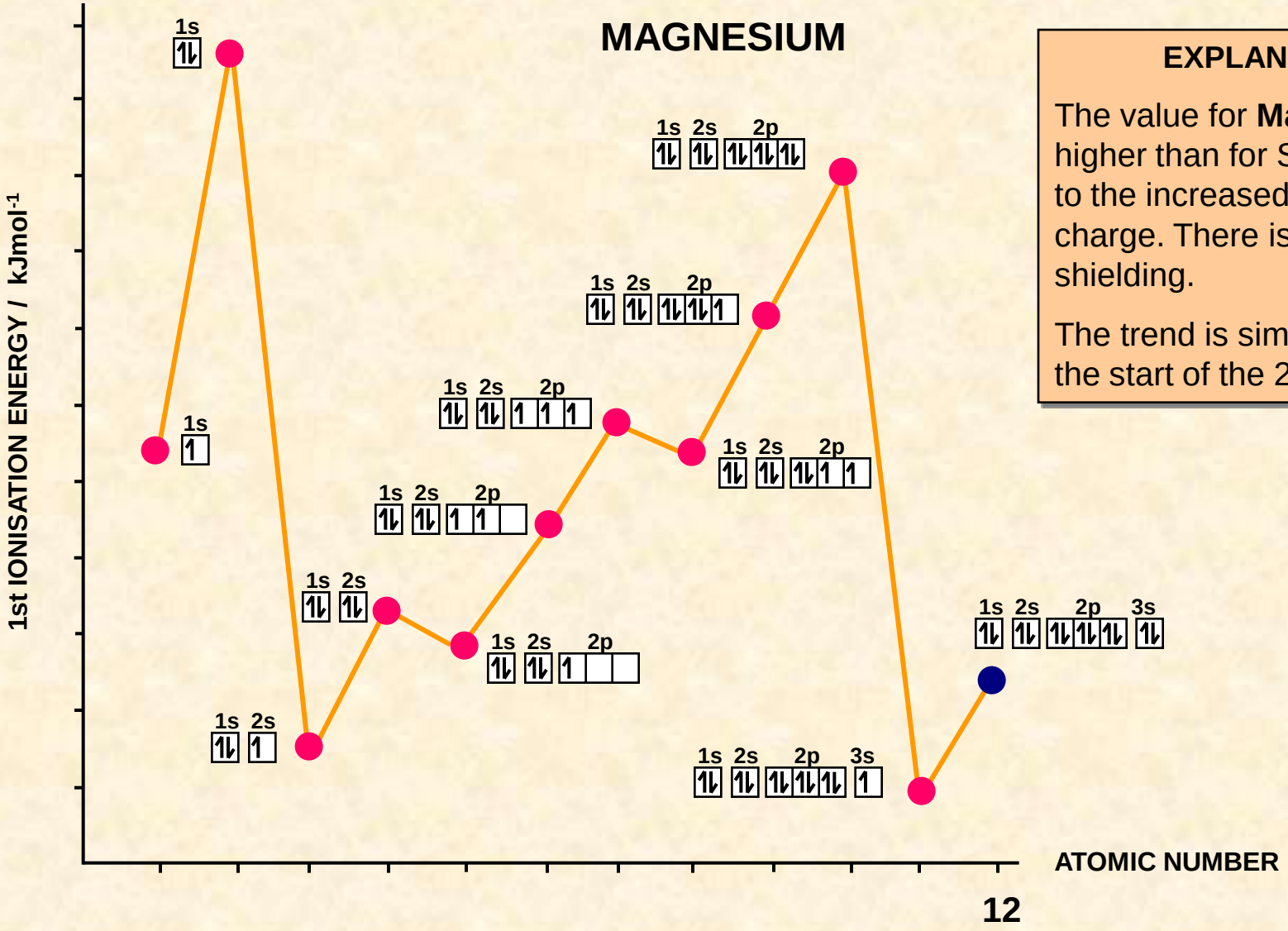
Variation in 1st Ionisation Energy



EXPLANATION

There is a substantial drop in the value for **Sodium**. This is because the extra electron has gone into an orbital in the next energy level. Despite the increased nuclear charge, the effective nuclear charge is less because of the shielding effect of filled inner 1s, 2s and 2p energy levels.

Variation in 1st Ionisation Energy



EXPLANATION

The value for **Magnesium** is higher than for Sodium due to the increased nuclear charge. There is no extra shielding.

The trend is similar to that at the start of the 2nd period.

IONISATION ENERGY

THE END