	Marks
• Imagine a Universe X in which electron spin did not exist. *i.e.* An electron has only a single internal state instead of the two spin states it has in our universe. Assume that all other properties of electrons and nuclei in Universe X are identical to those in our universe.	**3**

What are the atomic numbers of the first two alkali metals in Universe X?

2 and 6

Write down the ground state electron configuration of the atom with atomic number 11 in Universe X.

$1s^1 2s^1 2p^3 3s^1 3p^3 4s^1 3d^1$

How would the energy difference between the 2*s* and 2*p* orbitals compare between our universe and Universe X? Provide a brief explanation of your answer.

For the atom with atomic number 1, there is no difference in energy between the 2*s* and 2*p* orbitals (in both our universe and Universe X).

The energy difference between 2*s* and 2*p* arises because of the difference in shielding for a 2*s* and 2*p* electrons (in both our universe and Universe X).

As there are fewer electrons per orbital in Universe X, the difference in shielding is smaller and so the energy difference would be smaller.

- Imagine a Universe X in which electrons had *three* possible spin states (*i.e.* with electron spin quantum numbers –1, 0 and +1) instead of the two they have in our universe. Assume that all other properties of electrons and nuclei in Universe X are identical to those in our universe.

4

What are the atomic numbers of the first two noble gases in Universe X?

$Z = 3; 1s^3$
$Z = 15: 1s^3 2s^3 2p^9$

Write down the ground state electron configuration of the atom with atomic number 14 in Universe X.

$1s^3 2s^3 2p^8$

How would the energy difference between the 2*s* and 2*p* orbitals in multi-electron atoms compare between our universe and Universe X? Give a brief explanation of your answer.

The difference in energy between 2*s* and 2*p* is caused by the unequal shielding of electron in these orbitals by the 1*s* electrons. When there are no 1*s* electrons, there is no energy difference between 2*s* and 2*p*.

In our universe, there are a maximum of two electrons in 1*s*. In Universe X, there are a maximum of three electrons in 1*s*. As there are more electrons in the 1*s* orbital, there is a larger effect and hence a large energy difference in Universe X.