ATOMIC STRUCTURE AHL (HL only)

Please ensure that you have also completed the Core (SL & HL) questions

1. (a) Give the definition of *first ionisation energy*:

[2]

The energy required to remove one electron from every atom in one mole of atoms... ✓

in the gaseous state. ✓

could also be equation e.g $A(g) \rightarrow A^+(g) + e^-$

(b) State the electron configurations of sodium and potassium. State **and explain** how the first ionisation energy of sodium compares with potassium.

[3]

$1s^2 2s^2 2p^6 3s^1$ (Na) both $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ (K) ✓

(allow shorthand e.g [Ar]4s')

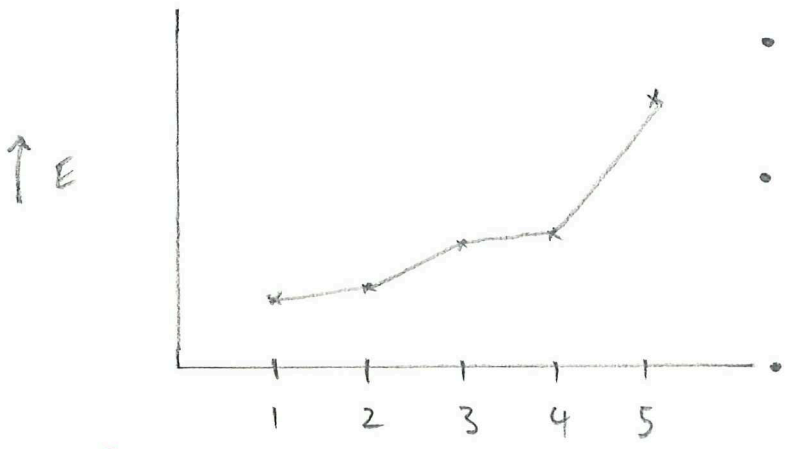
(Potassium has a lower 1st IE than sodium because...)

✓ Electron removed is further from nucleus / in a higher energy level / experiences less attraction to nucleus...

✓ and is subject to greater shielding

(c) Describe how the first five successive ionisation energies of silicon vary (you may wish to sketch a graph to illustrate your answer).

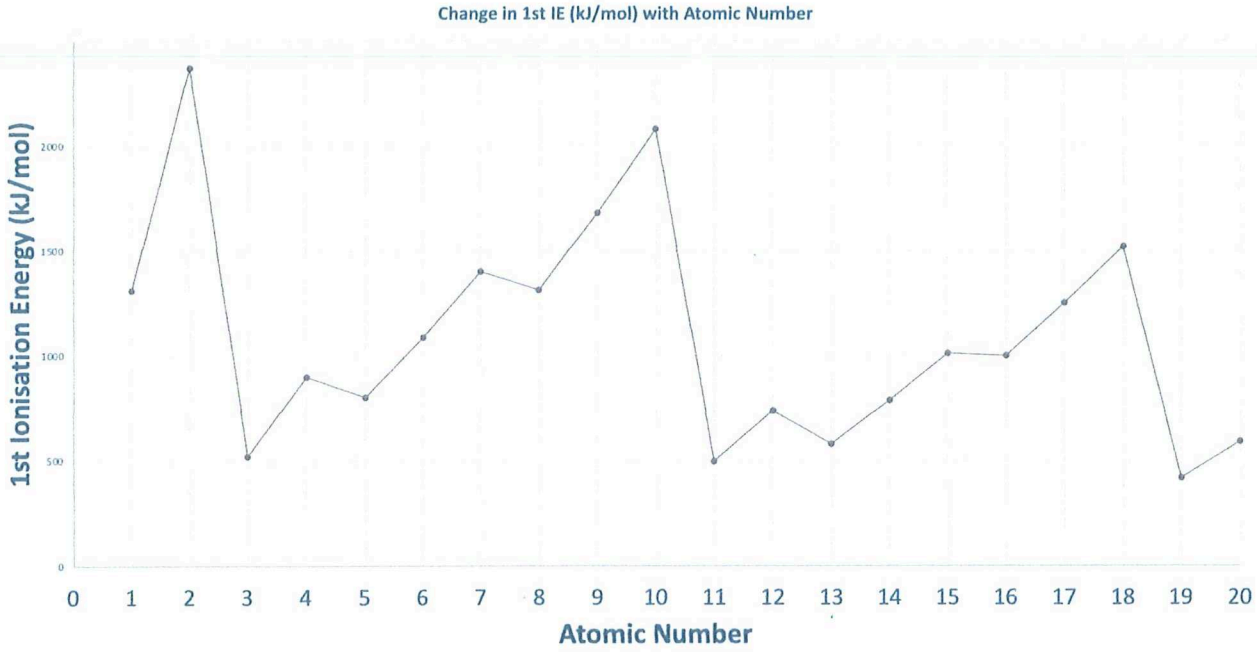
[3]



- Successive increases across all five ✓
- larger increases between 2→3 and 4→5 ✓
- biggest increase 4→5 ✓

(can all be gained by diagram)

2. The chart below shows the first ionisation energies of the elements for the first twenty elements in the period table.



(a) Explain why there is an overall increase in ionisation energy between elements 3 and 10.

[2]

Nuclear charge is increasing across the period ✓ but electrons are added to the same energy level ✓ (so nuclear – electron attraction increases)

(b) Explain why there is a decrease is ionisation energy between elements 4 and 5.

[1]

Element 5 (Boron) has its electron in a higher/ (new) sub-level (2p) ✓ which is slightly further from the nucleus and experiences less attraction.

PTO

(c) Explain why there is a decrease in ionisation energy between elements 15 and 16.

[2]

Element 16 (sulfur) has its outer electron paired-up in the 3p orbital... (phosphorus does not) ✓ this causes greater electron-electron repulsion ✓ so the electron experiences less attraction to the nucleus.

(d) Explain why there is a large decrease in ionisation energy between elements 10 and 11

[3]

Element 11 (sodium) has its outer electron in a new/higher energy level (n=3)... ✓ which is further from the nucleus, so experiences less attraction... ✓ and the electron is shielded by inner complete energy levels. ✓

3. The successive ionisation energies of an element in period 3 are shown in the table:

Ionisation Energy ($kJ\ mol^{-1}$)	1st	2nd	3rd	4th	5th
	578	1817	2745	11578	14831

(a) Identify the period 3 element represented. Explain your answer.

[2]

There is a very large increase in IE between the 3rd & 4th... ✓ so the element is likely to be aluminium (Al) ✓ (the jump corresponds to removal from a lower energy level)

(b) Predict a value for the 6th ionisation energy.

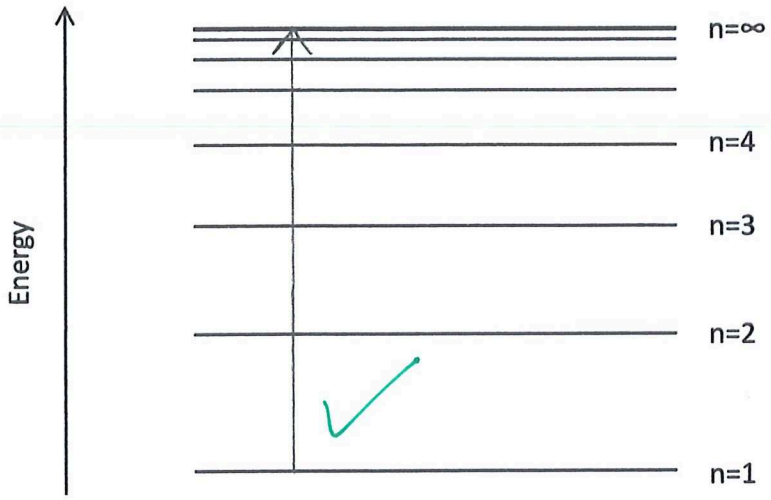
[1]

approx 18200 $KJmol^{-1}$ ✓ (14831 + 3253 = 18,084) but will be higher

(allow 18084 — 20000)

(difference between 11578 and 14831 is 3253)

4. The diagram below represents some of the electronic energy levels in a hydrogen atom.



(a) Draw an arrow on the diagram to represent the electron transition for the ionisation of an atom of hydrogen in the ground state. $(n=1 \rightarrow n=\infty)$ [1]

(b) The wavelength of the convergence point in the hydrogen emission spectrum is 9.12×10^{-8}m. Using the appropriate values for the speed of light (*c*) and Planck's constant (*h*) given in the data booklet, calculate the value for the first ionisation energy of hydrogen. **Show your working.** [3]

$E = h\nu$ and $c = \nu\lambda$ $(\nu = c/\lambda)$

So $E = hc/\lambda$

using correct values ✓

$E = (6.63\times10^{-34} \times 3.00\times10^{8}) / 9.12\times10^{-8}$

$= 2.18\times10^{-18}$ J ✓ for one electron

So per mole $2.18\times10^{-18} \times 6.02\times10^{23}$

$= 1312360$ J mol^{-1}

$= 1312$ ✓ kJ mol^{-1}

working required for all three marks.

Total Marks 23 (35 minutes)