Marks 3

- In the spaces provided, briefly explain the meaning of the following terms.

Effective nuclear charge

The force of attraction experienced by the outer electrons of an atom. It's a combination of the magnitude of the nuclear charge mitigated by shielding by the inner electrons. Effective nuclear charge increases to the top right of the periodic table.

Atomic emission spectrum

Unique for each element, the spectrum represents emission of light of disctrete frequencies corresponding to the energy differences between electron energy levels in an atom.. It results from the movement of electrons from a higher energy level to a lower one.

Core electrons

Inner shell electrons that are not involved in bonding.

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Marks 5

- The yellow light emitted from an excited sodium atom has a wavelength of 590 nm. What is the energy of one photon of this light and one mole of photons? Specify appropriate units with your answers.

The energy of a photon is related to its wavelength through Planck's equation:

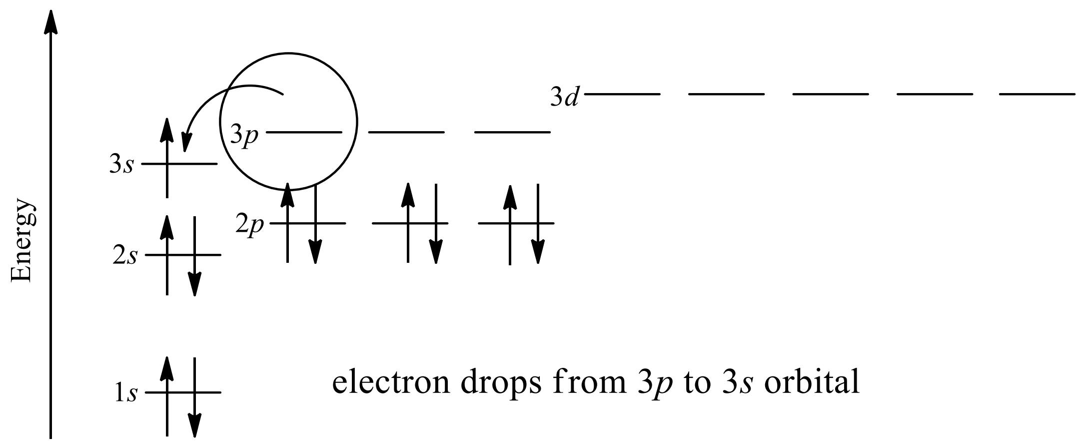
$$\boldsymbol{E = hc / \lambda}$$
$$\mathbf{= (6.626 \times 10^{-34}\ J\ s) \times (2.998 \times 10^{8}\ m\ s^{-1}) / (590 \times 10^{-9}\ m)}$$
$$\mathbf{= 3.4 \times 10^{-19}\ J}$$

The energy of 1 mol is therefore:

$$\mathbf{\boldsymbol{E} = (3.4 \times 10^{-19}\ J) \times (6.022 \times 10^{23}\ mol^{-1}) = 200\ kJ\ mol^{-1}}$$

Energy	of one photon: **3.4×10^{-19} J**	of 1 mol of photons: **200 kJ mol^{-1}**

The yellow light is associated with the longest wavelength transition as the atom returns to the ground state electron configuration. Fill in the following energy level diagram for sodium and indicate the transition associated with the emission of yellow light.



A quantum mechanical model of an atom can explain the emission spectrum of sodium, but the Bohr model of the atom cannot. Why?

A quantum mechanical model includes subshells, but a Bohr model does not. The yellow light is associated with electron movement between subshells.

The emission spectrum of sodium contains many more lines than would be predicted from Bohr's model.

	Marks
• ^{11}C is used in positron emission tomography – PET. It is synthesised by bombarding a ^{14}N target with protons. Write a nuclear equation for the formation of ^{11}C and thus identify the by-product of this synthesis.	**2**
$^{14}_{7}N + ^{1}_{1}p \rightarrow ^{11}_{6}C + ^{4}_{2}He$	
^{11}C undergoes positron decay with a half life of 20.3 minutes. Write a nuclear equation to identify the product of this decay reaction.	
$^{11}_{6}C \rightarrow ^{0}_{1}\beta^{+} + ^{11}_{5}B$	

Marks
2

- Glucose labelled with ^{11}C is used to monitor brain function in positron emission tomography (PET) scans. Identify the missing particles in the following nuclear reactions showing the synthesis and decay of ^{11}C.

$$ {}^{14}_{7}\mathrm{N} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{11}_{6}\mathrm{C} + \boxed{{}^{4}_{2}\mathrm{He}} $$

$$ {}^{11}_{6}\mathrm{C} \rightarrow \boxed{{}^{11}_{5}\mathrm{B}} + {}^{0}_{1}e $$

- Complete the following table, providing the ground state electron configuration for each of the following species. **3**

Species	Ground state electron configuration
chlorine atom	$\mathbf{1}\boldsymbol{s}^2\ \mathbf{2}\boldsymbol{s}^2\ \mathbf{2}\boldsymbol{p}^6\ \mathbf{3}\boldsymbol{s}^2\ \mathbf{3}\boldsymbol{p}^5$
magnesium ion	$\mathbf{1}\boldsymbol{s}^2\ \mathbf{2}\boldsymbol{s}^2\ \mathbf{2}\boldsymbol{p}^6$
arsenic(V) ion	$\mathbf{1}\boldsymbol{s}^2\ \mathbf{2}\boldsymbol{s}^2\ \mathbf{2}\boldsymbol{p}^6\ \mathbf{3}\boldsymbol{s}^2\ \mathbf{3}\boldsymbol{p}^6\ \mathbf{4}\boldsymbol{s}^0\ \mathbf{3}\boldsymbol{d}^{10}$

- Complete the following table, providing the ground state electron configuration for each of the following species. **3**

Species	Ground state electron configuration
nitrogen atom	**$1s^2$ $2s^2$ $2p^3$ or [He] $2s^2$ $2p^3$**
chloride ion	**$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ or [Ne] $3s^2$ $3p^6$**
manganese(II) ion	**$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^0$ $3d^5$ or [Ar] $4s^0$ $3d^5$**

Marks
2

- Give the full electron configuration for the ground state K atom.

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

What are the three quantum numbers that describe the orbital that contains the electron furthest from the nucleus in the K atom?

n = **4**	l = **0**	m_l = **0**