

CHEM1001 Answers to Problem Sheet 2

1.

element	symbol	mass number	atomic number	number of electrons	number of neutrons	${}_Z^mX$
helium	He	4	2	2	2	${}_2^4\text{He}$
carbon	C	12	6	6	6	${}_6^{12}\text{C}$
magnesium	Mg	24	12	12	12	${}_{12}^{24}\text{Mg}$
fluorine	F	19	9	9	10	${}_9^{19}\text{F}$

2. The wavelength (λ), frequency (ν) and the speed of light (c) are linked:

$$\lambda \nu = c$$

This can be rearranged to give:

$$\nu = c / \lambda$$

$$\lambda = 700 \text{ nm} = 700 \times 10^{-9} \text{ m and so:}$$

$$\nu = (2.998 \times 10^8 \text{ m s}^{-1}) / (700 \times 10^{-9} \text{ m}) = \underline{4.28 \times 10^{14} \text{ s}^{-1}}$$

3. Rearranging $\lambda \nu = c$ gives:

$$\lambda = c / \nu$$

For the lower frequency:

$$\lambda = (2.998 \times 10^8 \text{ m s}^{-1}) / (3 \times 10^9 \text{ s}^{-1}) = \underline{0.1 \text{ m or } 10 \text{ cm}}$$

For the upper frequency:

$$\lambda = (2.998 \times 10^8 \text{ m s}^{-1}) / (3 \times 10^{12} \text{ s}^{-1}) = \underline{0.0001 \text{ m or } 1 \times 10^{-4} \text{ m}}$$

4. The energy of electromagnetic radiation with frequency ν is given by:

$$E = h\nu$$

where $h = 6.626 \times 10^{-34} \text{ J s}$ (Planck's constant).

(a) For $\nu = 1.00 \times 10^{16} \text{ s}^{-1}$,

$$E = (6.626 \times 10^{-34} \text{ J s}) (1.00 \times 10^{16} \text{ s}^{-1}) = \underline{6.63 \times 10^{-18} \text{ J}}$$

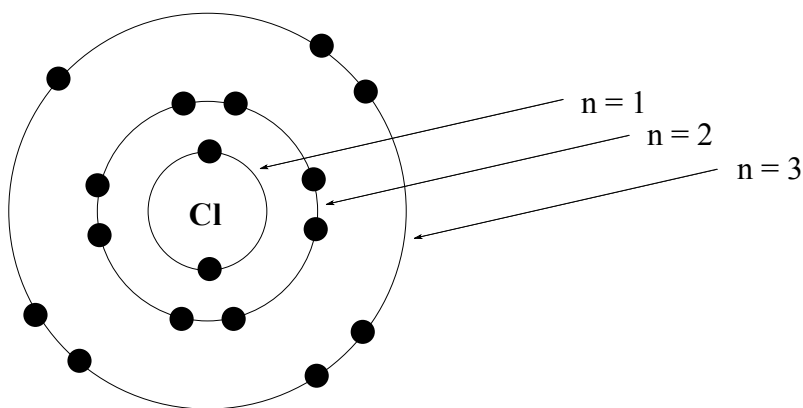
This energy is greater than $1.93 \times 10^{-18} \text{ J}$ so the radiation is ionizing

(b) For $\nu = 3 \times 10^{13} \text{ s}^{-1}$,

$$E = (6.626 \times 10^{-34} \text{ J s}) (3 \times 10^{13} \text{ s}^{-1}) = \underline{2 \times 10^{-20} \text{ J}}$$

This energy is less than $1.93 \times 10^{-18} \text{ J}$ so the radiation is not ionizing

5.



6. (a) **Allotropes** - the different structural forms in which an element can occur. Examples include diamond, graphite and fullerene for carbon and O_2 and O_3 for oxygen.

(b) **Isotopes** – atoms of the same element with different numbers of neutrons. Examples include ^{12}C , ^{13}C and ^{14}C all of which have 6 protons and electrons but have, respectively, 6, 7 and 8 neutrons.

7. There is an attractive force that exists between protons and neutrons*. This acts like ‘glue’ – it helps to overcome the repulsions between the positively charged protons. As the atomic number increases, the number of protons increases and so more and more neutrons are needed to hold the nucleus together.

8. The three most common types of radioactive decay are:

- α -decay: loss of a $^4_2\text{He}^{2+}$ particle
- β -decay: loss of an electron (called a β -particle)
- γ -decay: loss of high-energy electromagnetic radiation

* You may have come across this force, called the ‘strong nuclear force’ in Physics. If not, do not worry. You do not need to remember this.