Marks 3

- Gamma emission involves the radiation of high energy γ photons and accompanies most types of radioactive decay processes. γ photons typically have wavelengths less than 0.1 Å. Calculate the energy of a photon with wavelength λ = 0.1 Å. Give your answer in J per photon and kJ mol^{-1}.

The energy of a photon with wavelength λ is given by:

$$E = hc / \lambda$$

If λ = 0.1 Å = 0.1 × 10^{10} m, the energy is

$$E = (6.634 \times 10^{-34} \text{ J s})\times(2.998 \times 10^{8} \text{ m s}^{-1})/(0.1 \times 10^{-10} \text{ m}) = 2.0\times10^{-14} \text{ J per photon}$$

or

$$E = (2.0 \times 10^{-14})\times(6.02 \times 10^{23}) = 1.2 \times 10^{10} \text{ J mol}^{-1} = 1.2 \times 10^{7} \text{ kJ mol}^{-1}$$

E = **2.0 × 10^{-14}** J per photon	E = **1.2 × 10^{7}** kJ mol^{-1}

Why is high energy or gamma radiation called ionising radiation?

The radiation has sufficient energy to ionise atoms in living tissues. The free radicals thus formed are highly reactive (due to having unpaired electrons) and cause unwanted chemical reactions in the tissues. This in turn can lead to cell damage, destruction of DNA, etc.

- What are two of the key results arising from a wavelike description of matter? 2

Electrons in atoms and molecules can only have certain energies.
Energy is quantized, leading to spectroscopy and physical properties like colour.
The positions of electrons in atoms and molecules are not known precisely and are described by orbitals.

- Each of the following electron configurations represents an atom in an excited state. Identify the element and write its ground state electron configuration. 2

Electron configuration of excited state	Element	Electron configuration of ground state
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4\ 4s^1$	**Chlorine**	$\mathbf{1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5}$
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3\ 4p^1$	**Chromium**	$\mathbf{1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5}$