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

Marks
1

Intensive properties

A physical property of a substance such as density that does not depend on the amount of the substance present.

- Describe Rutherford's experiment that showed atoms consisted of a concentrated positive charge with a high mass. Make sure you discuss the observations and the conclusions drawn. **2**

A stream of positively charged alpha particles was fired at a thin sheet of gold foil. Most of the particles passed straight through or were slightly deflected, but the occasional one was reflected back towards the source.

The conclusion drawn was that atoms consist of mostly empty space with a small, dense, positively charged nucleus.

	Marks
• Direct damage to the DNA of skin cells can be brought about by exposure to ultraviolet radiation of wavelength 300 nm. What are the frequency and energy (in kJ mol^{-1}) of this radiation?	**4**

The frequency, ν, and the wavelength, λ of the radiation are related by $c = \nu\lambda$. Hence:

$$\nu = \frac{c}{\lambda} = \frac{2.998 \times 10^{8}\ \mathrm{m\ s^{-1}}}{300 \times 10^{-9}\ \mathrm{m}} = 1 \times 10^{15}\ \mathrm{s^{-1}} = 1 \times 10^{15}\ \mathrm{Hz}$$

The energy of the radiation is given by $E = h\nu = \frac{hc}{\lambda}$. Hence:

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ \mathrm{J\ s})(2.998 \times 10^{8}\ \mathrm{m\ s^{-1}})}{(300 \times 10^{-9}\ \mathrm{nm})} = 6.62 \times 10^{-19}\ \mathrm{J}$$

This is the energy per photon. For a mole, the energy is:

$$E = (6.62 \times 10^{-19}\ \mathrm{J}) \times (6.022 \times 10^{23}\ \mathrm{mol^{-1}}) = 400000\ \mathrm{J\ mol^{-1}} = 400\ \mathrm{kJ\ mol^{-1}}$$

Frequency: **1×10^{15} Hz**	Energy: **400 kJ mol^{-1}**

- Direct damage to the DNA of skin cells can be brought about by exposure to ultraviolet radiation of wavelength 300.0 nm. What are the frequency and energy of this radiation? **2**

The wavelength, λ, is related to the energy and the frequency, ν, by the equations:

$$\nu = \frac{c}{\lambda} \text{ and } E = h\nu = \frac{hc}{\lambda}$$

Therefore with λ = 300.0 nm = 3.000 × 10^{-7} m:

$$\nu = \frac{(2.998\times10^{8}\ \mathrm{m\ s^{-1}})}{(3.000\times10^{-7}\ \mathrm{m})} = 9.993 \times 10^{14}\ \mathrm{s^{-1}}$$

$$E = \frac{(6.626\times10^{-34}\ \mathrm{J\ s})\times(2.998\times10^{8}\ \mathrm{m\ s^{-1}})}{(3.000\times10^{-7}\ \mathrm{m})} = 6.622 \times 10^{-19}\ \mathrm{J}$$

(As the wavelength is given to four significant figures, this limits the accuracy of the answers to also being four significant figures).

Frequency: **9.993 × 10^{14} s^{-1}**	Energy: **6.622 × 10^{-19} J**

- A cook uses a microwave oven to heat up a meal. The wavelength of the radiation is 0.012 m. Calculate the frequency and energy of a photon of this radiation.

Marks 2

The wavelength, λ, is related to the energy and the frequency, ν, by the equations:

$$E = h\nu = \frac{hc}{\lambda} \text{ and } \nu = \frac{c}{\lambda}$$

Therefore with λ = 0.012 m:

$$\nu = \frac{(2.998 \times 10^{8})}{(0.012)} = 2.5 \times 10^{10}\ s^{-1}$$

$$E = \frac{(6.626 \times 10^{-34}) \times (2.998 \times 10^{8})}{(0.012)} = 1.7 \times 10^{-23}\ J$$

(As the wavelength is given to two significant figures, this limits the accuracy of the answers to also being two significant figures).

Frequency: $2.5 \times 10^{10}\ s^{-1}$	Energy: 1.7×10^{-23} J

ANSWER CONTINUES ON THE

- Silicon is essential to the computer industry as a major component of chips. It has three naturally occurring isotopes, the relative abundance of each being given below. Calculate the atomic mass of silicon. **2**

Isotope	Mass of isotope (a.m.u.)	Relative abundance
^{28}Si	27.9769	92.23%
^{29}Si	28.9765	4.67%
^{30}Si	29.9738	3.10%

The relative atomic mass of silicon is the weighted average of the masses of its isotopes:

$$\textbf{atomic mass} = \left(27.9769 \times \frac{92.23}{100}\right) + \left(28.9765 \times \frac{4.67}{100}\right) + \left(29.9738 \times \frac{3.10}{100}\right)$$
$$= 28.09$$

(The relative abundances are given to 4 significant figures and limit the accuracy of the answer.)

Answer: **28.09**

- A mobile phone sends signals at about 850 MHz (1 MHz = 1×10^6 Hz). What is the wavelength of this radiation? **2**

The frequency, ν =850 MHz = 850×10^6 Hz, is related to the wavelength, λ, by the equation:

$$c = \lambda\nu \text{ or } \lambda = \frac{c}{\nu} \text{ where c is the speed of light.}$$

Therefore, wavelength = $\lambda = \dfrac{2.998 \times 10^8 \text{ m s}^{-1}}{850 \times 10^6 \text{ m}} = 0.35 \text{ m}$

Wavelength = **0.35 m**

3

- Complete the entries in the following table.

Element name	Symbol	Mass number	Atomic number	Number of electrons	Number of neutrons	$^{m}_{z}X$
lithium	**Li**	7	3	**3**	**4**	$^{7}_{3}$**Li**
copper	Cu	**64**	**29**	29	**35**	$^{64}_{29}$**Cu**
aluminium	**Al**	**27**	13	**13**	14	$^{27}_{13}$**Al**