AP CHEMISTRY • EXERCISE SHEET

3.12 Properties of Photons

Name: _____ Class: _____ Date: _____ **Total: 13 marks**

Objective

Build the skills to answer exam questions on the **properties of photons** —energy, frequency, and wavelength.

You must be able to:

- use $E = h\nu$ and $c = \lambda\nu$
- convert between energy, frequency, and wavelength
- find the energy of a photon or a mole of photons

1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

■ **The photon equations**

$$E = h\nu, \qquad c = \lambda\nu, \qquad E = \frac{hc}{\lambda},$$

with $h = 6.63 \times 10^{-34}$ J s and $c = 3.00 \times 10^{8}$ m s^{-1}.

■ **Frequency from wavelength**

For $\lambda = 500$ nm $= 5.00 \times 10^{-7}$ m:

$$\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^{8}}{5.00 \times 10^{-7}} = 6.00 \times 10^{14} \text{ Hz}.$$

■ **Energy of one photon**

$$E = h\nu = (6.63 \times 10^{-34})(6.00 \times 10^{14}) = 3.98 \times 10^{-19} \text{ J}.$$

■ **Energy per mole**

Multiply by Avogadro's number: $E_{\text{mol}} = E \times 6.022 \times 10^{23}$. Here $\approx 2.4 \times 10^{5}$ J/mol = 240 kJ/mol.

2 Practice

Now apply the methods above.

2.1 Write the equation linking a photon's energy and frequency. [1]

2.2 Find the frequency of light with $\lambda = 6.00 \times 10^{-7}$ m. [2]

2.3 Find the energy of a photon of frequency 5.0×10^{14} Hz. [2]

3 Exam-style questions

3.1 The energy of a photon is [1]

- **A** inversely proportional to frequency
- **B** proportional to frequency
- **C** independent of frequency
- **D** proportional to wavelength

3.2 A laser emits light of wavelength 650 nm.

(a) Convert to metres and find the frequency. [3]

(b) Find the energy of one photon. [2]

3.3 Explain why UV photons are more damaging to skin than visible photons, in terms

of photon energy. [2]

4 Go further

You are now ready for the real exam questions on this subtopic:

- work through the **3.12 Properties of Photons** lesson on the **Learn** page;
- read the **Properties of Photons** section of the AP Chemistry handout on the **Know** page.

Solutions

2.1 $E = h\nu$.

2.2 $\nu = \dfrac{3.00 \times 10^{8}}{6.00 \times 10^{-7}} = 5.00 \times 10^{14}$ Hz.

2.3 $E = (6.63 \times 10^{-34})(5.0 \times 10^{14}) = 3.3 \times 10^{-19}$ J.

3.1 B —$E = h\nu$, proportional to frequency.

3.2 (a) 650 nm $= 6.50 \times 10^{-7}$ m; $\nu = \dfrac{3.00 \times 10^{8}}{6.50 \times 10^{-7}} = 4.62 \times 10^{14}$ Hz. (b) $E = h\nu = (6.63 \times 10^{-34})(4.62 \times 10^{14}) = 3.06 \times 10^{-19}$ J.

3.3 UV light has a shorter wavelength and higher frequency, so by $E = h\nu$ each UV photon carries more energy —enough to break bonds/damage molecules that visible photons cannot.