AP PHYSICS 2 • EXERCISE SHEET

15.1 Quantum Theory and Wave-Particle Duality

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

Objective

Build the skills to answer exam questions on **quantum theory and wave-particle duality**.

You must be able to:

- describe a **photon** 光子 as a quantum of light with energy $E = hf$
- explain **wave-particle duality** 波粒二象性: light and matter show both behaviours
- relate a particle's momentum to its **de Broglie wavelength** 德布罗意波长 $\lambda = h/p$

1 Worked examples

Study these first. Each one shows the method for a question type used later.

The photon

Light is delivered in quanta called **photons**, each with energy $E = hf$, where $h = 6.63 \times 10^{-34}$ J s.

Wave-particle duality

Light and matter each show **wave** behaviour (interference, diffraction) and **particle** behaviour (photons, collisions), depending on the experiment.

De Broglie wavelength

Every particle has a wavelength $\lambda = \dfrac{h}{p}$.

2 Practice

2.1 Find the energy of a photon of frequency 6.0×10^{14} Hz ($h = 6.63 \times 10^{-34}$). [2]

2.2 State the equation for the de Broglie wavelength. [1]

2.3 State what "wave-particle duality" means. [1]

3 Exam-style questions

3.1 The energy of a photon is [1]

- **A** hf
- **B** h/f
- **C** hp
- **D** $\frac{1}{2}mv^2$

3.2 The de Broglie wavelength of a particle is [1]

- **A** hp
- **B** h/p
- **C** p/h
- **D** hf

3.3 A photon has a wavelength of 500 nm ($c = 3.0 \times 10^8$, $h = 6.63 \times 10^{-34}$).

(a) Find its frequency. [2]

(b) Find its energy. [2]

4 Go further

- work through the **15.1 Quantum Theory and Wave-Particle Duality** lesson on the **Learn** page;

- read the **Modern Physics** section of the AP Physics 2 handout on the **Know** page.

Solutions

2.1 $E = hf = (6.63 \times 10^{-34})(6.0 \times 10^{14}) = 4.0 \times 10^{-19}$ J.

2.2 $\lambda = \dfrac{h}{p}$.

2.3 that light and matter each behave both as waves and as particles.

3.1 A.

3.2 B.

3.3 (a) $f = \dfrac{c}{\lambda} = \dfrac{3.0 \times 10^{8}}{500 \times 10^{-9}} = 6.0 \times 10^{14}$ Hz. (b) $E = hf = (6.63 \times 10^{-34})(6.0 \times 10^{14}) = 4.0 \times 10^{-19}$ J.