Neap:

PHYSICS VCE UNITS 3&4
DIAGNOSTIC TOPIC TESTS 2017

TEST 10: HOW ARE LIGHT AND MATTER SIMILAR? (II)

SUGGESTED SOLUTIONS AND MARKING SCHEME

Question 1 (3 marks)

The emission of light from an atom occurs when electrons fall from higher fixed-energy levels to lower fixed-energy levels releasing the energy difference as photons of light. 1 mark

The electrons initially in their lower fixed-energy states only absorb those photons whose energies are exactly the difference needed to transit to the higher fixed-energy levels. 1 mark

Hence the emission and absorption spectra show those colours of the photons that have the energy difference. 1 mark

Question 2 (15 marks)

a. $\Delta E = 12.1 - 10.2$

$= 1.9 \text{ eV}$ 1 mark

$= 1.9 \times 1.6 \times 10^{-19}$

$= 3.0 \times 10^{-19} \text{ J}$ 1 mark

b. $\Delta E = \dfrac{hc}{\lambda}$

$\lambda = \dfrac{hc}{\Delta E}$

$= \dfrac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{3.0 \times 10^{-19}}$ 1 mark

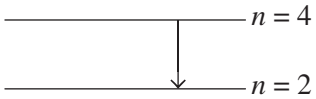
$= 6.63 \times 10^{-7} \text{ m}$ 1 mark

$= 6.63 \times 10^{-7} \times 10^{9} \text{ nm}$

$= 663 \text{ nm}$ 1 mark

Consequential on answer to ***Question 2a.***

c. 2.6 eV is the difference between the $n = 2$ and $n = 4$ energy levels.



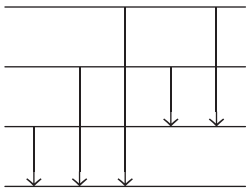
2 marks

1 mark for correct energy levels.
1 mark for arrow pointing down.

d. Red has the lowest frequency and therefore highest wavelength in the visible spectrum of light. 1 mark

656 nm 1 mark

e. The third excited state is $n = 4$.



2 marks

1 mark for correct answer.
1 mark for some form of relevant working.

There are six different energy photons.

f. 11 eV does not represent a difference between any two energy levels. 1 mark

The photon is reflected (elastically scattered) without loss of energy. 1 mark

g. Electrons in the ground state require 13.6 eV to transit to the edge of the atom. 1 mark

Thus the absorbency of a 15 eV photon will cause the electron to be ejected with a kinetic energy of 1.4 eV. 1 mark

Question 3 (5 marks)

a. The electrons bound to the nucleus exist in fixed orbits (quantised states) around the nucleus. 1 mark

These orbits are such that the electron's energy is manifested as a standing wave such that the orbit circumference $2\pi r$ is a whole number of wavelengths, $n\lambda$. 1 mark

Hence the electron shows wave properties since it has a de Broglie wavelength for its energy to be expressed in the form of a standing wave. 1 mark

b. The existence of specific orbits around the nucleus in which the electrons exist can only be explained by the electrons having a de Broglie wavelength and therefore wave nature. 1 mark

Since electrons have a definite mass and behave as particles according to classical physics, their existence in specific orbits represents evidence for the particle and wave nature of matter. 1 mark

Question 4 (4 marks)

a. The series of bright and dark bands are explained as an interference of waves to add constructively (produce bright bands) or to add destructively (produce dark bands). 1 mark

This relies on the photon having a wavelength and therefore wave nature. 1 mark

b. Since a single photon at a time was passing around the very fine needle, even though bright and dark bands were produced, a photon still had to strike somewhere on the screen as a single entity. 1 mark

Thus the photon was behaving as a particle, either landing at a bright band or a dark band. 1 mark

Question 5 (8 marks)

a. This is because they must be anywhere along the vertical line of the slit as their exact position vertically is unknown. 1 mark

b. The reduction of the slit width increases the spread of the bright and dark bands on the screen – a diffraction effect. 1 mark

c. The uncertainty in the position of the electron on the screen is reduced. 1 mark

d. For the pattern to spread vertically, the vertical momentum of the electron must have increased. 1 mark

e. As the slit width is reduced, the vertical velocity and momentum uncertainties must increase by proportion. 1 mark

This is evident from the greater spread of the pattern requiring an increase in velocity. 1 mark

f. The decrease in uncertainty in the vertical position of the electron accompanies the increase in uncertainty in the vertical momentum 1 mark
as per the Heisenberg uncertainty principle $\Delta p \Delta x$ is a minimum value. 1 mark

Question 6 (2 marks)

Classical physics ideas apply reliably when object masses are much larger than subatomic or atomic masses 1 mark
and when they travel much less than the speed of light. 1 mark

Question 7 (8 marks)

a. Electrons are stimulated to rise to a higher energy level. 1 mark
As they return to their original level, they release the energy difference as light of a single colour. 1 mark

b. Electrons that are accelerated through a circular arc by magnetic fields as in a synchrotron 1 mark
release radiation while they are moving in a circular arc. 1 mark

c. When an LED is provided with a voltage, electrons are able to jump the band-gap width 1 mark
and release energy in the form of light where the band gap energy determines the energy and colour of the light emitted. 1 mark

d. An incandescent globe requires electrical energy to operate it.

The electrical energy causes the atoms of the filament to gain kinetic energy and some of the energy is absorbed by the atom's electrons. 1 mark

The electrons rise to a higher energy level and as they return to their original energy level, release the energy difference as light. 1 mark