Unit 23 · Quantization of Energy

WORKSHEET

Full marks 34

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 34

1 Key words [4]

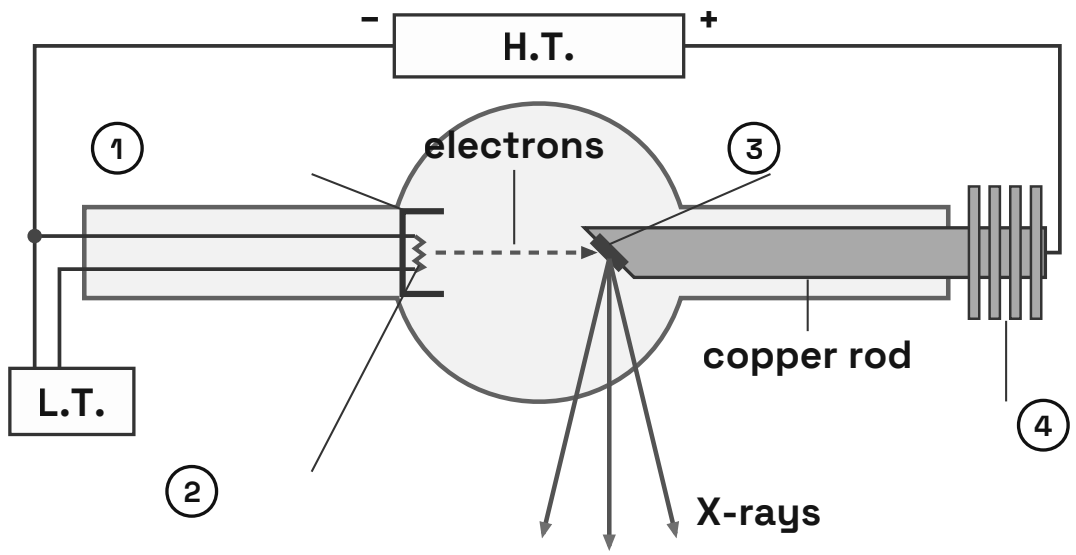
Fill in the blanks with words from the box. Two words in the box are not needed. Each blank carries 0.5 mark.

Balmer	**Bragg's law**	**Compton effect**	**de Broglie**	**hard**	**ionization energy**
stationary orbit	**thermionic emission**	**uncertainty principle**	**wave number**		

In Bohr's model an electron goes round in a _____ without radiating. The energy needed to remove the electron from a hydrogen atom in its ground state is its _____. The number of waves in one meter, $1/\lambda$, is the _____. Lines of hydrogen that end on the level n = 2 form the _____ series. The wavelength h/mv of a moving particle is its _____ wavelength. It is impossible to know both the exact position and the exact momentum of a particle at once: this is the _____. X-rays whose wavelength is short and which go through matter easily are called _____ X-rays. The equation $2d\sin\theta = n\lambda$ is _____.

2 Label the diagram [2]

The diagram shows a Coolidge X-ray tube. Write the label that belongs in place of 1 to 4. Each carries 0.5 mark.



1. _____ 2. _____

3. _____ 4. _____

3 Multiple choice [5]

Choose the correct option for each of the following questions.

i. In Bohr's model, the radius of the fourth orbit of hydrogen is about (the Bohr radius is 0.53 Å): [1]

a. 2.1 Å **b.** 1.06 Å
c. 8.5 Å **d.** 0.13 Å

ii. The energy needed to ionize a hydrogen atom whose electron is in the level n = 2 is: [1]

a. 13.6 eV **b.** 10.2 eV
c. 3.4 eV **d.** 6.8 eV

iii. An electron is accelerated from rest through 100 V. Its de Broglie wavelength is about: [1]

a. 12.3 Å **b.** 1.23 Å
c. 0.123 Å **d.** 123 Å

iv. An X-ray tube works at 30 kV. The shortest wavelength of its X-rays is about ($h = 6.63 \times 10^{-34}$ J s): [1]

a. 4.1 Å **b.** 0.41 Å
c. 0.041 Å **d.** 0.21 Å

v. Raising the current through the filament of a Coolidge tube, the voltage unchanged: [1]

a. gives more X-rays of the same wavelengths **b.** gives X-rays of shorter wavelength
c. gives harder X-rays **d.** has no effect on the X-rays

4 Short answers [6]

Write short answers to the following questions.

a. Why is the energy of an electron in a hydrogen atom negative? [2]

b. How does the wave nature of the electron explain Bohr's stationary orbits? [2]

c. Why is a crystal used to study the diffraction of X-rays, not an ordinary grating? [2]

5 Long answer [4]

Write a long answer to the following question.

Using Bohr's postulates, show that the radius of the nth orbit of hydrogen is in proportion to n^2, and explain how jumps between the orbits give the lines of hydrogen's spectrum.

6 Numerical problems [10]

Solve the following problems. Show your working. Take $h = 6.63 \times 10^{-34}$ J s, $c = 3.0 \times 10^{8}$ m/s, $e = 1.6 \times 10^{-19}$ C, the mass of an electron 9.1×10^{-31} kg and Rydberg's constant 1.097×10^{7} m^{-1}.

a. The electron of a hydrogen atom jumps from the level $n = 5$ to $n = 2$. Find i. the energies of the two levels, ii. the energy of the photon given out, iii. its wavelength, and iv. the series it belongs to and the part of the spectrum it is in. [4]

Answer:

b. An X-ray tube works at 40 kV with a current of 5.0 mA. Find i. the number of electrons striking the target each second, ii. the power brought to the target, and iii. the heat produced each second if 1 % of it becomes X-rays. [3]

Answer:

c. X-rays of wavelength 1.5 Å fall on a crystal whose planes are 2.0 Å apart. Find the glancing angles of the first and second order reflections. Is there a third order? **[3]**

Answer: _____

7 Think **[3]**

A cricket ball of 0.15 kg is bowled at 30 m/s. Find its de Broglie wavelength. Why do we never see a cricket ball diffract, though an electron does?

8 Activity: Models of the hydrogen atom (Activity 23.1) (not marked)

Open PhET's free *Models of the Hydrogen Atom* simulation. Choose the Bohr model and shine monochromatic light of each wavelength below on the atom.

Wavelength	Absorbed? Which jump?
656 nm	
486 nm	
500 nm	

Why is 500 nm never absorbed?