

KEY

Name _____ Rec. Instr. _____

Two-Digit Section No. _____ Lab. Instr. _____

Momentum: $p = mv$

Hydrogen Spectrum: $E = -2.180 \times 10^{-18} \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$ Joules

DeBroglie Relation: $p = h/\lambda$

Planck's Constant: $h = 6.63 \times 10^{-34}$ J-s

Photon Energy: $E_{\text{photon}} = h\nu = hc/\lambda$

Speed of light: $c = 3.00 \times 10^8$ m/s

$1 \text{ J-s}^2 = 1 \text{ kg-m}^2$

1. [6 points] Calculate the frequency and energy associated with a photon of wavelength 492 nm.

$$\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{492 \text{ nm} \times 10^{-9} \text{ m/nm}} = 6.10 \times 10^{14} \text{ s}^{-1}$$

$$E = h\nu = 6.63 \times 10^{-34} \text{ J-s} \times 6.10 \times 10^{14} \text{ s}^{-1} = 4.04 \times 10^{-19} \text{ J}$$

2. [6 points] Calculate the frequency of electromagnetic radiation emitted by the hydrogen atom in the electron transition from
- $n = 6$
- to
- $n = 1$
- .

$$E = -2.180 \times 10^{-18} \left(\frac{1}{1^2} - \frac{1}{6^2} \right) = 2.11944 \times 10^{-18} \text{ J}$$

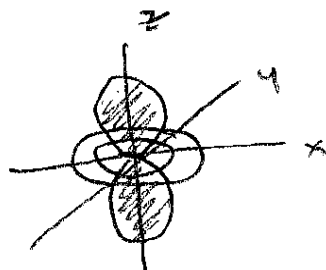
$$\nu = \frac{E}{h} = \frac{2.11944 \times 10^{-18} \text{ J}}{6.63 \times 10^{-34} \text{ J-s}} = 3.20 \times 10^{15} \text{ s}^{-1}$$

3. [6 points] What is the velocity of an
- α
- particle (a helium nucleus, mass =
- 6.667×10^{-24}
- g) that has a de Broglie wavelength of 0.529 Å?

$$p = mv = \frac{h}{\lambda} \quad \text{so} \quad v = \frac{h}{m\lambda}$$

$$v = \frac{6.63 \times 10^{-34} \text{ J-s}}{6.667 \times 10^{-24} \text{ g} \times 0.529 \text{ Å} \times 10^{-10} \text{ m/Å}} = 1.88 \times 10^6 \text{ m/s}$$

4. [12 points] Sketch the shape of an orbital with the quantum numbers
- $n = 3$
- ,
- $l = 2$
- ,
- $m_l = 0$
- ,
- $m_s = +1/2$
- .

 $3d_z^2$ 

Quiz 5

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Momentum: $p = mv$ Hydrogen Spectrum: $E = -2.180 \times 10^{-18} \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$ JoulesDeBroglie Relation: $p = h/\lambda$ Planck's Constant: $h = 6.63 \times 10^{-34}$ J-sPhoton Energy: $E_{\text{photon}} = h\nu = hc/\lambda$ Speed of light: $c = 3.00 \times 10^8$ m/s1 J-s² = 1 kg-m²

1. [6 points] Calculate the frequency and energy associated with a photon of wavelength 656 nm.

$$\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{656 \text{ nm} \times 10^{-9} \text{ m/nm}} = 4.57 \times 10^{14} \text{ s}^{-1}$$

$$E = h\nu = \frac{6.63 \times 10^{-34} \text{ J-s} \times 4.57 \times 10^{14} \text{ s}^{-1}}{1} = 3.03 \times 10^{-19} \text{ J}$$

2. [6 points] Calculate the frequency of electromagnetic radiation emitted by the hydrogen atom in the electron transition from
- $n = 4$
- to
- $n = 3$
- .

$$E = -2.180 \times 10^{-18} \left(\frac{1}{3^2} - \frac{1}{4^2} \right) = 1.0597 \times 10^{-19} \text{ J}$$

$$\nu = \frac{E}{h} = \frac{1.0597 \times 10^{-19} \text{ J}}{6.63 \times 10^{-34} \text{ J-s}} = 1.59834 \times 10^{14} \text{ s}^{-1}$$

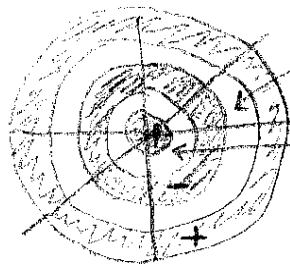
$1.60 \times 10^{14} \text{ s}^{-1}$

3. [6 points] What is the wavelength of a neutron (mass =
- 1.675×10^{-24}
- g) traveling at a speed of 3.90 km/s?

$$\lambda = \frac{h}{p} = \frac{6.63 \times 10^{-34} \text{ J-s}}{1.675 \times 10^{-24} \text{ g} \times 3.90 \times 10^3 \text{ m/s} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{10^3 \text{ m}}{1 \text{ km}}} = 0.101 \text{ nm}$$

$\lambda = 0.101 \text{ nm}$

4. [12 points] Sketch the shape of an orbital with the quantum numbers
- $n = 3$
- ,
- $l = 0$
- ,
- $m_l = 0$
- ,
- $m_s = +1/2$
- .



2 nodal surfaces

e⁻ wavefunction alternates in phase between nodal surfaces.