P30 Unit D UA pt A KEY!

1. a.) Cathode Ray tubes consist of an evacuated tube with two electrodes placed inside. A high potential difference is placed between the electrodes creating a cathode ray.

b.) This device led Thomson to hypothesise that the cathode ray was made of particles called electrons. The electrons were produced in the same way regardless of the metal used in the electrode.

2. $\vec{F}_c = \vec{F}_B$

$\frac{mv^2}{r} = qvB$

$\frac{q}{m} = \frac{v}{Br} = \frac{4.5 \times 10^6 \text{ m/s}}{(5.7 \times 10^{-1} \text{ T})(0.98057397 \text{ m})} = \underline{\underline{8.05 \times 10^6 \text{ C/kg}}}$

For Ti^{4+} → $\frac{q}{m} = \frac{4(1.6 \times 10^{-19} \text{ C})}{\left[\frac{47.87 \text{ g/mol}}{6.022 \times 10^{23} \text{ atoms/g}}\right]} = 8.05 \times 10^3 \text{ C/g}$

$= \underline{\underline{8.05 \times 10^6 \text{ C/kg}}}$

3. Dalton → Billiard Ball → n/A → atoms are not indivisable

Thomson → Plum Pudding → q/m ratio → electrons are not at rest

Rutherford → Gold Foil Alpha Scattering → Planetary model → accelerating electrons should always release EMR.

Bohr → Electron Energy level model → Emission/Absorption → only works perfectly for hydrogen.

4. Maxwell showed that accelerated, charged particles release EMR. Rutherford's classical model (planetary model) had electrons moving in circles (accelerated motion), which ~~was~~ should emit EMR. As atoms do not sponaneous emit EMR, Maxwell concluded that Rutherford's model was incorrect.

Rutherford's model was replaced with Bohr's quantum model in which electrons in stationary states will not emit EMR.

5. Energy difference between states = energy of photon.

$$\Delta E = \frac{hc}{\lambda} = \frac{(4.14 \times 10^{-15} eVs)(3 \times 10^{8} m/s)}{(633 \times 10^{-9} m)} = \underline{\underline{1.96 eV}}$$

6. a.) The larger the vertical distance between the two levels in a transition, the greater the energy of photon (and smaller the λ) produced.

Therefore, the smallest λ is produced by the largest energy transition.

4, 2, 1, 3

Smallest λ ⟶ largest λ

largest ΔE smallest ΔE

b. 4 → $5eV = \frac{hc}{\lambda}$ $\lambda = 248nm$

2 → $3eV = \frac{hc}{\lambda}$ $\lambda = 414nm$

1 → $2eV = \frac{hc}{\lambda}$ $\lambda = 621nm$

3 → $1.5eV = \frac{hc}{\lambda}$ $\lambda = 828nm$

7. a) Transition up from n_2 to n_4 requires 8.0eV. The high speed electron has enough energy to transfer this 8.0eV to the atomic electron while still having 0.200eV remaining.

b.) $\Delta E = (-1.5eV) - (-12eV)$
$= 10.5eV$

$10.5eV = \frac{hc}{\lambda}$

$\lambda = 226nm$

c.) UV.

8. a.) The negative sign indicates an amount of energy that must be absorbed by the electron ~~to~~ in order to ionize.

b.) As an electron moves farther from the nucleus, it experiences a smaller electric force. The smaller the force, the less energy it requires to ionize.

c.) $n = \infty$ means an energy level where the electron ionizes.

d.) 5.5eV

9. a) $\vec{E} = \frac{V}{d} = \frac{100V}{0.05m} = 2.00 \times 10^3 \, N/C$ [downwards]

b) drop 1 → uniform motion

$\vec{F_e} = \vec{F_g}$

$q\vec{E} = m\vec{g}$

$q(2000\frac{N}{C}) = (4.5\times10^{-6}kg)(9.81m/s^2)$

$q = \underline{\underline{2.2\times10^{-8}C}}$

drop 2 → accelerated motion

$\vec{F_{net}} = \vec{F_e} + \vec{F_g}$

$m\vec{a} = q\vec{E} + m\vec{g}$

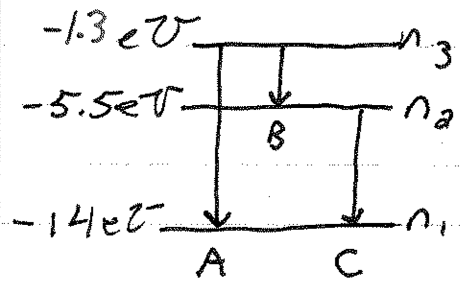
$(1.5\times10^{-6}kg)(1.17m/s^2) = q(2000\frac{N}{C}) + (1.5\times10^{-6}kg)(-9.81 m/s^2)$

$q = \underline{\underline{8.2\times10^{-9}C}}$

c) By looking at the smallest difference between oil drops with similar charges, Millikan noticed the differences were always multiples of the same amount: 1.6×10^{-19} C.

10. The quantum (de Broglie) model expands on Bohr's model. Both models contain energy levels and transitions of electrons, but de Broglie's model considers the electrons to exist as waves instead of particles.

11.



$\lambda_A \Rightarrow E = \frac{hc}{\lambda}$ $12.7eV = \frac{hc}{\lambda} = 9.8\times10^{-8}m = \underline{\underline{98nm}}$

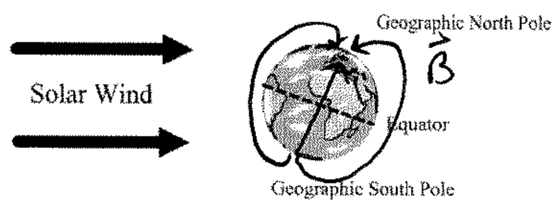
$\lambda_B \Rightarrow 4.2eV = \frac{hc}{\lambda}$ $\lambda = \underline{\underline{296nm}}$

$\lambda_C \Rightarrow 8.5eV = \frac{hc}{\lambda}$ $\lambda = \underline{147nm}$

Use the following information to answer the next question:

The northern lights that are visible in Alberta skies on many winter nights are produced when free electrons in the solar wind are trapped within Earth's magnetic field.

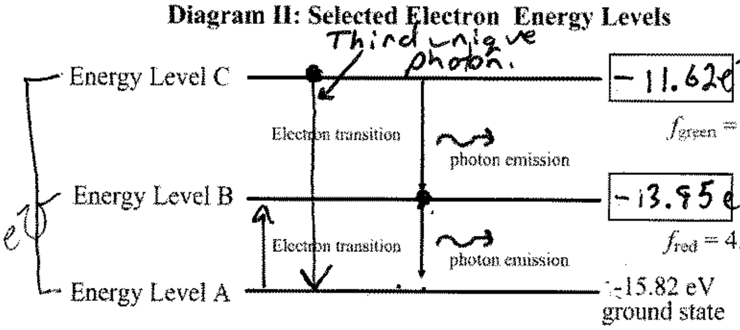
Diagram I: Solar Wind and Earth



These free electrons can collide with atomic oxygen in the upper atmosphere. As a result of these collisions, atoms of oxygen become excited and electrons in lower energy levels move to higher energy levels. Electron transitions toward the ground state result in the emission of photons, two of which correspond to red and green light.

The following diagram shows the three energy levels of atomic oxygen involved in the production of green- and red-coloured northern lights.

Diagram II: Selected Electron Energy Levels



In addition to the two photons identified above, a third, unique photon can be emitted by atomic oxygen after it has been excited to energy level C.

12. Using the physics principles of magnetic fields, electromagnetic radiation, conservation and atomic energy levels, **analyze** the production of the northern lights.

- **Draw** several magnetic field lines on diagram I to show the shape, strength and direction of the Earth's magnetic field.
- **Determine** the energy of the photon of red light and the energy of the photon of green light.
- **Determine** the value of the energy levels B and C.
- **Determine** the minimum speed of a free electron that would excite atomic oxygen from energy level A to energy level B. **State** clearly the conservation law used in your determination.
- **Draw** an arrow on diagram II to show the electron transition that corresponds to the emission of the third, unique photon.
- **Determine** the wavelength of the third, unique photon and **identify** the region of the electromagnetic spectrum to which this photon belongs.