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## Question 1: Photoelectric Effect and I-V Characteristics

- The **photoelectric effect** is the emission of electrons from a metal surface when light of a certain minimum frequency (threshold frequency) falls on it.
- The **work function** ( $\phi$ ) is the minimum energy required to remove an electron from the metal surface.
- **Energy of incident photons** is given by:

$$E = \frac{hc}{\lambda}$$

where  $h = 6.626 \times 10^{-34}$  J.s,  $c = 3 \times 10^8$  m/s, and  $\lambda$  is the wavelength of light.

- The **maximum kinetic energy** of emitted electrons is given by Einstein's photoelectric equation:

$$K_{\max} = E - \phi$$

where  $E$  is the energy of incident photons and  $\phi$  is the work function.

- The **I-V characteristic curve** represents how current varies with applied voltage. The saturation current depends on the number of photoelectrons emitted, and stopping potential is related to  $K_{\max}$ .
- **Analysis of the given options:**
  - The work function is highest for metal **r** and lowest for **p**, meaning **p** will have the highest kinetic energy and stopping potential.
  - The correct graph should reflect this trend.

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## Question 2: Velocity of Photoelectrons

- When two identical photocathodes receive light of frequencies  $f_1$  and  $f_2$ , the **kinetic energy** of emitted photoelectrons is given by:

$$K_{\max} = hf - \phi$$

- Applying the kinetic energy formula in velocity terms:

$$\frac{1}{2}mv^2 = hf - \phi$$

so,

$$v^2 = \frac{2h}{m}(f - f_0)$$

- Using this equation for two different frequencies and eliminating  $\phi$ , we get expressions for differences and sums of velocities.

- The given options use mathematical transformations of this equation to compare  $v_1^2 - v_2^2$  or  $v_1 \pm v_2$ .
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### Question 3: Speed of Electrons in an X-ray Tube

- In an **X-ray tube**, electrons are accelerated through a potential difference  $V$  before striking the target.
- The **maximum kinetic energy** of electrons is given by:

$$eV = \frac{1}{2}mv^2$$

where:

- $e = 1.6 \times 10^{-19}$  C (charge of an electron),
  - $V = 15$  kV = 15000 V,
  - $m = 9.11 \times 10^{-31}$  kg (mass of an electron).
- Solving for  $v$ :

$$v = \sqrt{\frac{2eV}{m}}$$

- The numerical value is approximately  $7.26 \times 10^7$  m/s.
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### Summary of Concepts

1. **Photoelectric effect:** Work function, photon energy, stopping potential, and I-V characteristics.
2. **Kinetic energy of photoelectrons:** Dependence on light frequency and velocity comparisons.
3. **Electron speed in X-ray tubes:** Use of energy conservation and kinetic energy formula.

These are fundamental concepts in **modern physics**, especially in understanding **quantum mechanics and wave-particle duality**.