1. The work function of a metal is 2.5 eV. What is the minimum frequency of light required to eject electrons from the metal?
   a) 6.0×1014 Hz
   b) 8.0×1014 Hz
   c) 4.0×1014 Hz
   d) 1.2×1015 Hz
   *(Planck's constant ( h =* $6.63 \times 10^{-34}$ *J · s, 1 eV =* $1.6 \times 10^{-19}$ *J*

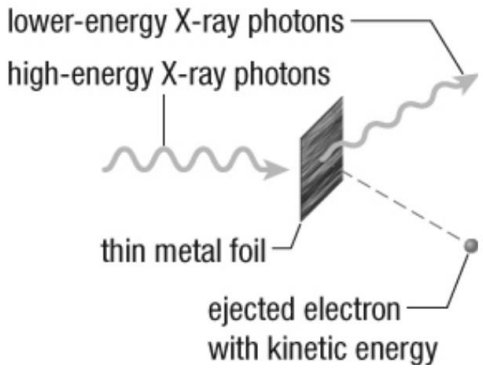
2. Which of the following experiments provided evidence for the quantization of energy?
   a) Michelson-Morley experiment
   b) Rutherford gold foil experiment
   c) Photoelectric effect
   d) Young's double-slit experiment

3. The energy levels of an atom are E1=−13.6 eV, E2=−3.4 eV, E3=−1.5 eV. If an electron transitions from E3 to E1, the wavelength of the emitted photon is closest to:
   a) 102 nm
   b) 122 nm
   c) 434 nm
   d) 656 nm
   *(Speed of light ( c = 3.00 *10^8 m/s, h = 6.63 * 10^-34 J·s*

4. Which concept is central to the theory of special relativity?
   a) Wave-particle duality
   b) All inertial frames of reference are equivalent
   c) Electrons are confined to specific energy levels
   d) Light behaves only as a wave

5. What does the equation $\Delta E = mc^2$ imply about the nature of mass and energy?
   a) Energy can be converted into mass, and mass can be converted into energy.
   b) Only energy can be converted into mass.
   c) Energy and mass are unrelated.
   d) The speed of light is irrelevant to energy-mass equivalence.

6. What does this diagram represent?




   a) Compton effect

b) photoelectric effect

c) Wien's law

d) none of the above

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6. a) Explain how the photoelectric effect supports the particle theory of light.
   b) Calculate the maximum kinetic energy of electrons ejected from a metal with a work function of 2.3 eV when illuminated by light of wavelength 400 nm.
7. The energy levels of hydrogen are quantized. Describe how this phenomenon leads to the emission spectrum of hydrogen and explain why it consists of discrete lines.
8. Calculate the momentum of a $4.10 * 10^2$ nm photon of violet light.
9. A spacecraft is traveling at 0.8c relative to an observer on Earth.
   a) If 1 second passes on the spacecraft, how much time passes for the observer on Earth?
   b) Explain how this calculation demonstrates time dilation.

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9. An electron is accelerated through a potential difference of 150 V.
   a) Calculate the de Broglie wavelength of the electron.
   b) Discuss how this wavelength compares to the size of an atom and what it implies about the wave properties of electrons.
10. A radioactive isotope of uranium decays to thorium by emitting an alpha particle.
    a) Write the nuclear equation for this reaction.
    b) The alpha particle has a kinetic energy of 5.3 MeV. Calculate its velocity.
    *(Mass of alpha particle $m_\alpha = 6.64 \times 10^{-27}$ kg)*

11. A spaceship goes past a planet at a speed of 0.80c. An observer on the planet measures the length of the moving spaceship as 40 m. He also says that his planet has a diameter of 2.0x106m.
    a) How long does the woman on the spaceship measure the ship to be?

    b) What does the woman on the spaceship measure the diameter of the planet to be?

    c) According to the man on the planet, the spaceship takes 8.0 s to reach the next planet in his solar system. How long would the woman on the spaceship say it took?

12. Imagine playing golf in a world where the speed of light is only 3.4 m/s. Golfer A hits a ball down a flat horizontal green for a distance that he measures as 75.0 m. Golfer B, driving in a cart, happens to pass by just as the ball is hit. Golfer A stands and watches while golfer B moves along the green, beside the ball at a constant speed of 2.8 m/s.

    a) Which golfer will measure the proper time interval for the motion of the ball? Justify your response (no calculation necessary). [A – 2 marks]