2009 Paper

- 1
  - in paper
- 2
  - a
    - A photon has energy of $E = hf$, and therefore the Energy of a photon is directly linked to the photon frequency. When the light is incident on a metal plate, each photon is absorbed by an electron, where some of the energy of the photon is used to break from the surface, otherwise known as the work function ϕ. If there is any more energy in the photon, it is stored as kinetic energy. From these facts, we can deduce an equation for this:

      $$E_k = hf - \phi$$

      The reason the emitted electrons have a range of kinetic energies is due to the work function, depending on the depth of the electron it will take more work to bring it to the surface to be emitted.
  - b
    - in paper
  - c
    - in paper
- 3
  - a
    - i
      - electromagnetic - virtual photon
    - ii
      - electron-lepton number, baryon number
  - b
    - i
      - in paper
    - ii
      - weak interaction
    - iii
      - $$\begin{array}{cc} \text{Equation} & p + e^- \rightarrow n + \nu_e \\ \text{Baryon Number} & +1 + 0 \rightarrow +1 + 0 \\ \text{Electron Lepton Number} & +0 + 1 \rightarrow +0 + 1 \end{array}$$
    - iv

        - Because theory is only as good as a thought experiment, once it is conducted in the real world can it be proved.
- 4
    - a
        - The wave-particle duality of electrons means that they can act as both a wave and a particle, depending on the situation.
    - b
        - in paper

2010 Paper

- 1
    - a
        - i
            - The fact it can interact with the strong nuclear force
        - ii
            - 3 quarks or 3 anti-antiquarks
        - iii
            - a quark and anti-quark
    - b
        - the particles share the same mass, however they will opposite properties, such as baryon number
    - c
        - antiproton - C:-1, B:-1, Quark Structure: $\overline{uud}$
    - d
        - i
            - This interaction is that of the weak nuclear force, as it pertains to decay, and strangeness is not conserved.
        - ii
            - baryon number, muon lepton number
- 2
    - a
        - i
            - An atom that is not at its ground state
        - ii
            - high frequency light is shone through the tube as to excite the mercury in the lamp. this then causes the atom to want to rid itself of the excess energy, and so releases it back, usually in lower energy bursts, creating visible light.
        - iii
            - To sread out the light more efficiently

- b
  - in paper
- 3
  - a
    - i
      - the electron
    - ii
      - A- no change
      - Z- +1 to Z
  - b
    - i
      - $n \rightarrow p + \beta^{-} + \overline{\nu_e}$
    - ii
      - The conservation of lepton numbers show that the equation needs to have equal lepton numbers per side, and as there was an electron on the LHS, there must be something equivalent on the RHS.
    - iii
      - People must prove it by experimentation
- 4
  - a
    - i
      - The threshold frequency is the lowest frequency at which the electrons leave the surface, i.e. they have 0 kinetic energy
    - ii
      - The photoelectric effect is not obeserved below the threshold frequency as the energy of the photon will be too low for the electrons to overcome the work function
  - b
    - in paper