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Q. No. ~~1~~ **1**: **→ Speed limit**: Speed limit would be  $50ms^{-1}$ . It would be impossible for material objects to attain such speed.

**→ Relativistic factors**: Effects of relativity would be much more noticeable at lower speeds compared to our reality. Time Dilation, length contraction and increased mass would become much more visible.

**→ Communication Delay**: With slower speed communication would experience significant delays.

**→ Technology and Internet**: Internet latency would be much higher, browsing and streaming content would be much lower.

**→ Daily Perception**: Human perception of events would not change directly as our sensory senses aren't tied to speed <sup>of</sup> light.

**→ CONCLUSION**: Altering speed would have far more consequences.

Q. No. ~~2~~ **2** Stars that appear **bluish** have higher surface temperature.

**→ EXPLANATION:**

**Wein's displacement law** states "As temperature of black body increases, the peak wavelength emitted by it becomes shorter."

**Mathematically**:  $\lambda_{max} T = \text{constant}$   $T = \frac{\text{constant}}{\lambda_{max}}$

**For stars of red colour**:  $\lambda = 700nm$ ,  $T = 4140K$

**For stars of blue colour**:  $\lambda = 475nm$ ,  $T = 6100K$

Thus,  $\lambda_{blue} < \lambda_{red}$  and  $T_{blue} > T_{red}$ .

**→ CONCLUSION:**

Therefore, looking at the stars, we can determine which one will have higher surface temperature by judging its colour.



Q. No. 3 No, not necessarily.

→ **REASON:** Specific details of photoelectric effect can vary depending upon properties of material.

(i) **WORK FUNCTION:** Different metals have different work functions and this influences the ease with which electrons can be emitted. **Mathematically:**  $\Phi = hf_0 = \frac{hc}{\lambda_0}$

(ii) **Threshold Frequency:** Photoelectric effect occurs when frequency of light is greater than a certain threshold frequency. This frequency is related to the work function of a material.

(iii) **Surface Properties and Electron Binding Energies:** Surface properties and electron binding energies affect photoelectric effect and these vary from material to material.

→ **CONCLUSION:** If threshold frequency, work function of one metal are less, then electrons are emitted for same conditions for another metal otherwise no.

Q. No. 4 No, a light bulb at 2500K doesn't produce as white light as Sun at 6000K

→ **EXPLANATION:**

**Stefan Boltzman Law states** "Radiant heat energy emitted from a unit area of black body in one second is directly proportional to fourth power of its absolute temperature."

**Mathematically:**  $E = \sigma \times T^4$

**Light bulb:** Being relatively cooler, radiates less total energy and has spectrum that may be skewed towards longer wavelengths resulting in warmer, yellowish appearance.

**Sun:** Sun radiates higher energy and emits a spectrum that includes a significant amount of visible light resulting in white light appearance.



Q. No. 5: Beam of red light contains greater number of photons.

**→ EXPLANATION:**

**Wavelength:** wavelength of red light is greater than wavelength of blue light  $\lambda_{red} > \lambda_{blue}$

**Energy:** Energy of both is same.

**Mathematically:**

$E = hf = h \frac{c}{\lambda}$  for 'n' photons,

$E_n = n \frac{hc}{\lambda}$  here 'h' and 'c' are constant and  $E_n$  is same thus  $E_n \propto n \frac{1}{\lambda}$

**Photons:** Thus to balance equation, photons of blue light are less than that of red beam

$n_{red} > n_{blue}$

**→ CONCLUSION:** It's a matter of wavelength as energies are same thus photons vary to keep energy same.

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Q. No. 6 If rest mass of photon isn't taken as zero, apparent mass becomes infinite as photon travels with the speed of light.

**→ Mathematically:**

$m = \frac{m^0}{\sqrt{1 - \frac{v^2}{c^2}}}$  ( $c = v$ )

$m = \frac{m^0}{\sqrt{1 - \frac{c^2}{c^2}}}$

$m = \frac{m^0}{\sqrt{1 - 1}}$

$m = \frac{m^0}{\sqrt{0}}$

$m = \frac{m^0}{0}$  where  $\frac{1}{0} = \infty$

thus  $m = \infty$

**alternate method:**

$m = \frac{m^0}{\sqrt{1 - \frac{v^2}{c^2}}}$  (putting  $c = v$ )

$m = \frac{m^0}{\sqrt{1 - \frac{c^2}{c^2}}}$

$m^0 = m \sqrt{1 - \frac{c^2}{c^2}}$  (by cross multiplication)

$m^0 = m \sqrt{1 - 1}$

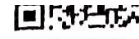
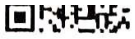
$m^0 = m(0)$

$m^0 = 0$  Therefore rest mass of photon is zero.

**→ CONCLUSION:** In order to escape from the mathematical controversy ( $m = \infty$ ) we take rest mass of photon to be zero

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Q. No. 7: **→ REASON:** Due to larger wave length of visible light, Compton's effect cannot be observed.

**→ EXPLANATION:**

**Compton Scattering** is more pronounced at shorter wavelengths and higher energies like x-rays

**Small change in wavelength for visible light:**

Visible light photons have lower energy as compared to x-rays and have low frequency as well. Thus smaller change in wavelength is observed upon collision with electrons which isn't noticeable as compared to interactions with high energy photons

**→ CONCLUSION:** Compton scattering is universal, its effects become more prominent in high energy <sup>region of electro</sup> magnetic spectrum.

Q. No. 8: Speed of electron will be greater.

**→ EXPLANATION:**

**According to De Broglie's Hypothesis:** wavelength of wave associated with moving particle is

$$\lambda = h/mv \text{ or } v = \frac{h}{m\lambda} \text{ since } \lambda \text{ is same thus}$$

**Mathematically:**  $v \propto \frac{1}{m}$  (i)

**Mass of proton:** 1836 times mass of electron.

thus  $m_e < m_p$  (ii)

**Result:** comparing (i) and (ii) we conclude that

$$v_e > v_p$$

**→ CONCLUSION:** Since momenta are equal, and mass of proton is 1836 times greater than the mass of electron, velocity of electron must be much greater than velocity of proton to maintain equality <sup>of mom</sup> entum.



Q. No: 9 **Electron**, having much smaller mass, has **greater** de-Broglie wavelength.

→ **Mathematical calculations:**

We know that  $eV = \frac{1}{2}mv^2$  or  $2eV = mv^2$  (multiplying by  $m$ )  
 $2meV = m^2v^2$  (taking under root)

$$\sqrt{2eVm} = mv \quad (i)$$

From de Broglie's equation:  $\lambda = \frac{h}{mv}$  (ii)

Putting value of  $mv$  from (i) in (ii) we get

$$\frac{h}{\sqrt{2eVm}} = \lambda \quad \text{where } V, e \text{ are same for both and } h \text{ is constant.}$$

$$\text{Thus } \lambda \propto \frac{1}{\sqrt{m}} \quad (iii)$$

→ **CONCLUSION:** as  $m_e < m_p$  therefore by equation (iii) we can conclude that  $\lambda_e > \lambda_p$ .

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Q. No: 10 **1. Wavelength Variation:** UV radiation has shorter wavelengths as compared to visible light allowing it to penetrate skin more deeply and damage DNA

**2. Cellular Impact:** UV radiation is absorbed by skin cells, leading to the production of free radicals that harm cellular structures while visible light generally has less energy and doesn't cause same level of damage.

**3. Immune Suppression:** UV radiation can suppress the immune system in the skin making it less effective in protecting against infections a concern not shared with visible light.

**4. Collagen Breakdown:** UV radiation causes collagen causing premature aging and wrinkles.

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