Q. 1 What are measurements on which two observers in relative motion always agree?

Ans. Two observers in relative motion will always agree on the speed of light and all non relativistic quantities such as temperature and mass number etc.

Q. 2 Does the dilation means that time really passes more slowly in moving system or that it only seems to pass more slowly?

Ans. According to time dilation, time really passes more slowly in moving system, relative to stationary system as it is experimentally verified. For example a pion (π-meson) when stationary decays in 26 ns but it requires 83 ns when moving at a speed of 0.95c.

Q. 3 If you are moving in a spaceship at a very high speed relative to the Earth, would you notice a difference (a) in your pulse rate (b) in the pulse rate of people on Earth?

Ans. a) No difference in the pulse rate, as observing in its own frame of reference.

b) Pulse rate of people on Earth will decrease, as it is observed from other reference frame.

Q. 4 If the speed of light were infinite, what would the equations of special theory of relativity reduce to?

Ans. Three equations of special theory of relativity reduce to

$m = \dfrac{m_o}{\sqrt{1-v^2/c^2}}$ If c = ∞ then $m = \dfrac{m_o}{\sqrt{1-v^2/\infty}} = m_0$

$t = \dfrac{t_o}{\sqrt{1-v^2/c^2}}$ If c = ∞ then $t = \dfrac{t_o}{\sqrt{1-v^2/\infty}} = t_0$

$l = l_0\left(\sqrt{1-v^2/c^2}\right)$ If c = ∞ then $l = l_0\left(\sqrt{1-v^2/\infty}\right) = l_0$

$E = mc^2$ If c = ∞ then $E = m \times \infty = \infty$

Q. 5 Since mass is a form of energy, can we conclude that a compressed spring has more mass than the same spring when it is not compressed?

Ans. No because the increase in mass takes place at relativistic speeds. In the present case compression or extension in the spring does not involve the relativistic speed. Hence mass of the compressed spring will remain constant.

Q. 6 As a solid is heated and begins to glow, why does it first appear red?

Ans. Red colour has less frequency (or energy) as compared to blue. At low temperature a body emits radiation that is of long wavelength.The longest visible wavelength is of red colour. That is why when a solid is heated it first appear red.

Q. 7 What happens to total radiation from a black body if its absolute temperature doubled? Ans.

$E = \sigma T^4$ When $T' = 2T$; $E' = \sigma (2T)^4 = 16\sigma T^4 = 16E$

So when T is doubled, total radiation from a black body increased by 16 times.

Q. 8 A beam of red light and a beam of blue light have exactly the same energy. Which beam contains the greater number of photons?

Ans. $E = nhf$, $c = f\lambda$ or $f = c/\lambda$

$E = nhc/\lambda$ or $n = E\lambda/hc$

Since energies of Red light and Blue light are same, so h, c & E are constants therefore,

$n = \text{const.} \times \lambda$ or $n \propto \lambda$

The above relation shows that greater wavelength have more number of photons. So red beam of light contains greater number of photons.

Q. 9 Which photon, red, green, or blue carries the most (a) energy and (b) momentum?

Ans. a) $E = hf$ or $E \propto f$

As frequency of Blue photon > frequency of Green photon > frequency of Red photon

Therefore, photons of blue light carry the most energy.

b) $p = h/\lambda$ or $p \propto 1/\lambda$

As wavelength of red photon >wavelength of green photon > wavelength of blue photon

This means that the photons of blue light carry the most momentum.

Q.10 Which has the lower energy quanta? Radiowaves or X-rays

Ans. Radio waves have lower energy quanta, as frequency of radiowaves is less than X-rays.

$E = nhf$ or $E \propto f$

Q.11 Does the brightness of a beam of light primarily depends on the frequency of photons or on the number of photons?

Ans. Primarily brightness of a beam of light depends on the intensity. The intensity of light is directly proportional to the number of photons. Hence if number of photons is greater then the brightness of the beam of light will be greater.

Q.12 When ultraviolet light falls on certain dyes, visible light is emitted. Why does this not happen when infrared light falls on these dyes?

Ans. When ultraviolet light falls on certain dyes some of its energy is absorbed and rest is emitted in the form of visible light. Infrared light has less energy therefore when it falls on the same dyes some of their energy is also absorbed and rest is emitted which fall in the far-infrared region and cannot be seen.

Q.13 **Will bright light eject more electrons from a metal surface than dimmer light of the same colour?**

Ans. Yes. Number of photoelectrons emitted from the metallic surface is directly proportional to intensity of light falling on its surface according to photoelectric effect. Greater the intensity brighter will be the light. Hence more electrons will be ejected with brighter light as compared to the dimmer light.

Q.14 Will higher frequency light ejects greater number of electrons than low frequency light?

Ans. The energy of ejected electrons depends on the frequency of light falling on the metal surface. But number of ejected electrons depends on the intensity of light. Therefore number of ejected electrons does not depend on the frequency of light so higher frequency or lower frequency will not change the number of ejected electrons.

Q.15 When light shines on a surface, is momentum transferred to the metal surface?

Ans. Yes. Since momentum is quantity of motion contained in a body so when photons of light will collide with the electrons of the metal surface they will transfer their momentum. Although greater portion of the incident light is reflected, but still a part of it is absorbed by the shiny surface.

Q.16 Why can red light be used in a photographic dark room when developing films. But a blue or white light cannot?

Ans. Because red light has less frequency as compared to blue or white light therefore it does not interact with the photographic film. Due this reason it will not destroy the image developed on the photographic film.

Q.17 Photon A has twice the energy of photon B. What is the ratio of the momentum of A to that of B?

Ans. We knot that $E = pc$

$E_A = p_A c$ & $E_B = p_B c$

$E_A = 2E_B = 2\, p_B c$

or $p_A c = 2\, p_B c$ or $p_A / p_B = 2/1$

So the ratio between the momentum of photon A and B is 2:1

Q.18 Why don't we observe a Compton effect with visible light?

Ans. In Compton effect some portion of energy of the incident photon is given to the electron and rest is carried by the scattered photon. Therefore incident photon must have sufficient energy (X-rays) to produce the Compton effect. Visible light has less frequency and therefore less energy and Compton effect is not observed with this light.

Q.19 Can pair production take place in vacuum? Explain.

Ans. No, pair production cannot take place in vacuum. It takes place in the electric field in the vicinity of a heavy nucleus. The presence of heavy nucleus is necessary because it takes the recoil energy so that energy and momentum are conserved.

Q.20 Is it possible to create a single electron from energy? Explain.

Ans. No. It is not possible to create single electron from energy. For charge conservation in the universe, creation of two particles with equal and opposite charges is essential. Electron and positron (an anti-particle of electron) are created in pair production.

Q.21 If electrons behaved only like particles, what pattern would you expect on the screen after the electrons passes through the double slit?

Ans. No diffraction and interference will be observed because the diffraction and interference are wave phenomena. Therefore with particle nature of electrons there will be no interference pattern seen on the screen.

Q.22 If an electron and a proton have the same de Broglie wavelength, which particle has greater speed?

Ans. $p = m v = h / \lambda$

or $v = h / m\lambda$

Since h is a constant so if λ is also constant for electron and proton then

$v \propto 1 / m$

As $m_e < m_p$ so speed of electron > speed of proton

Q.23 We do not notice the de Broglie wavelength for a pitched cricket ball. Explain why?

Ans. $\lambda = h / m v$

Since the speed of pitched cricket ball is very small and its mass is relatively larger as compared to electron. So its wavelength is so small that it is not measurable and it shows no effect.

Q.24 If the following particles have the same energy, which has the shortest wavelength? Electron, alpha particle, neutron, proton.

Ans. From the relation

$\lambda = h / mv$

For same energy v & h are constants, so $\lambda \propto 1 / m$

This means wavelength is inversely proportional to mass. Therefore greater mass shorter will be the wavelength. As α-particle has greatest mass, so it has shortest wavelength.

Q.25 When does light behave as a wave? When does it behave as a particle?

Ans. In diffraction, interference and polarization light behave as a wave. In photoelectric effect, Compton effect and pair production, it behaves as a particle.

Q.26 What advantages an electron microscope has over an optical microscope?

Ans.
a. Electron microscope has high resolution of 0.5 to 1 nm as compared to best optical microscope which has resolution 0.2 µm.
b. Electron microscope gives inner details of the specimen whereas optical microscope gives surface details only.
c. Electron microscope gives three dimensional image whereas optical microscope gives two dimensional image.

Q.27 If measurements show a precise position for an electron, can those measurements show precise momentum also? Explain.

Ans. No. According to Uncertainty principle, position and momentum of a particle cannot both be measured simultaneously with perfect accuracy. For a precise position of an electron, the momentum becomes uncertain and vice versa.

$\Delta x \cdot \Delta p \approx h$ or $\Delta p \approx h / \Delta x$

for precise measurement of position $\Delta x = 0$,

$\Delta p \approx h / 0$

or $\Delta p \approx h / 0 \approx \infty$

We cannot measure precisely and simultaneously the momentum of an electron.