# Jerusalem Science Contest 2008-2009 -חידון המדע הירושלמי תשס"ח
# Electromagnetic and Ionizing radiation
# Exam 8 — Chapter 31- Light Quanta

**Name:**_____ **Date:**_____

**Raw Score:**_____ **Percentage Score:**_____%

**Proctor for this Examinaton:**_____ **Form:**_____

**MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.**

1) Einstein was awarded the Nobel Prize in physics in 1921 for his work on?
   A) the theory of special relativity
   B) the photoelectric effect
   C) the theory of general relativity
   D) the confirmation of Maxwell's equations
   E) none of the preceding are suitable as a pump source

2) In order for a photoelectron to be ejected an incoming photon must have a certain minimum
   A) momentum
   B) energy
   C) amplitude
   D) velocity
   E) none of the preceding.

3) The expression $\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ is known as the
   A) relativistic correction factor
   B) Dirac factor
   C) Lorenz factor
   D) de Broglie factor
   E) none of the preceding

4) Momentum is directly proportional to which of the following, given ħ as the proportionality constant?
   A) wave number
   B) amplitude
   C) wave length
   D) frequency
   E) none of the preceding

5) According to the uncertainty principle, if a particle's energy is known precisely, what associated physical parameter can not be exactly known?
   A) displacement
   B) time
   C) mass
   D) velocity
   E) none of the preceding

6) Who was the physicist who first formulated the uncertainty principle?
   A) Niels Bohr
   B) Werner Heisenberg
   C) Albert Einstein
   D) Max Planck
   E) none of the preceding

7) A particle traveling at a relativistic velocity will
   A) have a greater frequency than a slower moving particle.
   B) have a greater wavelength than a slower moving particle
   C) have a smaller mass than a slower moving particle
   D) have a smaller momentum than a particle travelling at a slower speed
   E) none of the preceding

8) Laser light is passed through a double slit refractor. Which of the following can be used to show the dual particle/wave nature of this light?
   A) lack of an interference pattern on film after a very short exposure (i.e. a pattern of apparently random dots
   B) the presence of an inerference pattern of long exposure.
   C) both A and B
   D) none of the preceding

9) What are the SI units of minimum uncertainty (ħ)?
   A) kg $m/s^2$
   B) kg $m^2/s$
   C) kg $m^2/s^2$
   D) kg m/s
   E) none of the preceding

10) Why can't the wavelength of a 20 g bullet travelling at 330 m/s be experimentally determined?
   A) The waves are too large to measure, about $10^{34}$ m
   B) Because of the uncertainty pricipal
   C) Objects that large do not have a wavelength
   D) The waves are too small to measure, about $10^{-34}$ m
   E) none of the preceding

11) Which of the following equations show the relationship between the reduced Planck's constant, 'h-bar' (ħ) and Planck's constant, ('h')?
A) $h = \hbar/2\pi$
B) $\hbar = h/2\pi$
C) $\hbar = h/2\pi r$
D) $h = \hbar/2\pi r$
E) none of the preceding

12) A photon of light has both wave and particle properties. An electron
A) always behaves as a wave
B) only behaves as a wave if it is a photoelectron
C) like a photon, has both wave and particle properties
D) only behaves as a particle if it is a photoelectron
E) always behaves as a particle

13) Niels Bohr, one of the founders of quantum physics, referred to the combined wave/particle nature of photons and electrons by what term?
A) Strangeness
B) Supplementation
C) Complemenarity
D) Duality
E) none of the preceding

14) Whose thesis, "Recherches sur la théorie des quanta" (Researches on the quantum theory"), published in 1924, made him the first person to ever be awarded a Nobel prize for aa docatoral dissertation?
A) Louis de Broglie
B) Henri Poincaré
C) Paul Dirac
D) Henri Becquerel
E) none of the preeding

15) Which of the following equations can be used to demonstrate that a gamma ray photon is much more damaging to living tissue than an infrared photon?
A) $c = \lambda\nu$ B) $E = h\lambda$ C) $E = hf$ D) $E = hc/f$ E) $E = mc^2$

16) According to the de Broglie equation, every object in motion has a wavelength. A very massive object traveling at a slow speed would have
A) a wavelength that increased with increasing velocity
B) a very small wavelength
C) a very large wavelength
D) a wavelength that increased with increasing mass
E) an indeterminate wavelength

17) The term "quantum" was first applied to discreet bundles of energy by
A) Heinrich Hertz
B) Albert Einstein
C) Max Planck
D) James Clerk Maxwell
E) none of the preceding

18) Which of the follwing is the correct mathematical representation of the uncertainty principle?

A) $\Delta p \Delta x \geq h$

B) $\Delta p \Delta x \geq \hbar$

C) $\Delta p / \Delta x \geq h$

D) $\Delta p / \Delta x \geq \hbar$

E) none of the preceding

19) The first person to observe the photoelectric effect was

A) Albert Einstein

B) James Clerk Maxwell

C) Max Planck

D) Heinrich Hertz

E) Christian Huygens

20) A photon behaves as a particle

A) when it is in transit (between emission and detection times)

B) when it is being detected

C) when it is being emitted

D) when it is being emitted and when it is being detected

E) none of the time

21) Angular frequency, $\omega$, is equal to $2\pi f$, where $f$ is the frequency (in Hertz ). The angular frequency of a particle is directly proportional to what physical property (with $\hbar$ as the proportionality constant)?

A) velocity

B) mass

C) momentum

D) energy

E) none of the preceding

22) A single photon of green light causes the ejection of a photoelectron when it hits the surface of a particular metal. If the intensity of light is increased

A) there will be no effect

B) the photoelectron will be ejected at a greater velocity

C) more photoelectrons will be ejected

D) the photoelectron will not be ejected

E) none of the preceding.

23) The angular wave number, k, is equal to

A) $\lambda/2\pi$

B) $\lambda/2\pi r$

C) none of the preceding

D) $\pi/2\lambda$

E) $\lambda/2\pi r^2$

24) According to the uncertainty principal, which of the following two properties cannot be simultaneously known with exactitude?
A) mass and velocity
B) energy and momentum
C) velocity and momentum
D) position and angular frequency
E) none of the preceding

25) The minimal amount of energy, $W_0$, required for an electron to leave a surface is called the
A) surface binding energy
B) work function
C) Maxwell's constant
D) binding coefficient
E) none of the preceding