Physics 07 **Chapter 27 Early Atomic Physics**

Name______________________

1) A photon of blue light and a photon of red light are traveling in vacuum. The photon of blue light

A) has a smaller wavelength than a photon of red light and travels with a greater speed.
B) has a longer wavelength than a photon of red light and travels with a greater speed.
C) has a longer wavelength than a photon of red light and travels with the same speed.
D) has a smaller wavelength than a photon of red light and travels with the same speed.

2) If you double the frequency of the light in a laser beam, but keep the number of photons per second in the beam fixed, which of the following statements are correct? (There could be more than one correct choice.)

A) The energy of individual photons doubles.
B) The power in the beam does not change.
C) The energy of individual photons does not change.
D) The wavelength of the individual photons doubles.
E) The intensity of the beam doubles.

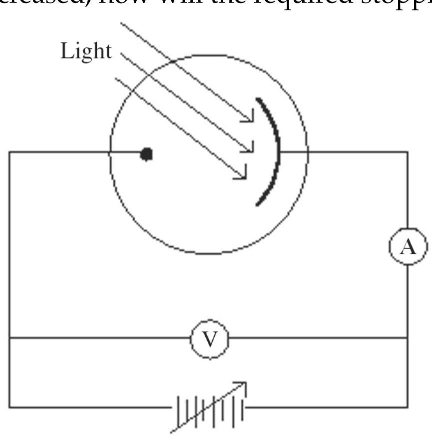
3) Two sources emit beams of light of wavelength 550 nm. The light from source A has an intensity of 10 $\mu W/m^2$, and the light from source B has an intensity of 20 $\mu W/m^2$. This is all we know about the two beams. Which of the following statements about these beams are correct? (There could be more than one correct choice.)

A) The frequency of the light in beam B is twice as great as the frequency of the light in beam A.
B) A photon in beam B has twice the energy of a photon in beam A.
C) Beam B carries twice as many photons per second as beam A.
D) A photon in beam B has the same energy as a photon in beam A.
E) None of the above statements are true.

4) A blue laser beam is incident on a metallic surface, causing electrons to be ejected from the metal. If the frequency of the laser beam is increased while the intensity of the beam is held fixed,

A) the rate of ejected electrons will remain the same but their maximum kinetic energy will increase.
B) the rate of ejected electrons will remain the same but their maximum kinetic energy will decrease.
C) the rate of ejected electrons will increase and their maximum kinetic energy will increase.
D) the rate of ejected electrons will decrease and their maximum kinetic energy will increase.

5) Monochromatic light is incident on a metal surface, and the ejected electrons give rise to a current in the circuit shown in the figure. The maximum kinetic energy of the ejected electrons is determined by applying a reverse ('stopping') potential, sufficient to reduce the current in the ammeter to zero. If the intensity of the incident light is increased, how will the required stopping potential change?



A) It will increase. B) It will remain unchanged. C) It will decrease.

6) If the frequency of a light beam is doubled, what happens to the momentum of the photons in that beam of light?
A) It is increased to four times its original value.
B) It is halved.
C) It is reduced to one–fourth of its original value.
D) It is doubled.
E) It stays the same.

7) If the wavelength of a photon in vacuum is the same as the de Broglie wavelength of an electron, which one is traveling faster through space?
A) The electron because it has more mass.
B) The photon because photons always travel through space faster than electrons.
C) They both have the same speed.

8) Which of the following actions will increase the de Broglie wavelength of a speck of dust? (There could be more than one correct choice.)
A) Decrease its mass.
B) Increase its mass.
C) Decrease its speed.
D) Increase its speed.
E) Decrease its momentum.

9) A proton and an electron are both accelerated to the same final speed. If λ_p is the de Broglie wavelength of the proton and λ_e is the de Broglie wavelength of the electron, then
A) $\lambda_p < \lambda_e$.   B) $\lambda_p = \lambda_e$.   C) $\lambda_p > \lambda_e$.

10) To which of the following values of n does the shortest wavelength in the Balmer series correspond?
A) 7   B) 3   C) 5   D) 1   E) ∞

11) The Paschen series is formed by electron transitions that
A) end on the $n = 1$ shell.
B) end on the $n = 2$ shell.
C) end on the $n = 3$ shell.
D) begin on the $n = 1$ shell.
E) begin on the $n = 3$ shell.

12) The energy difference between adjacent orbit radii in a hydrogen atom
A) increases with increasing values of n.   B) remains constant for all values of n.
C) decreases with increasing values of n.   D) varies randomly with increasing values of n.

13) The distance between adjacent orbits in a hydrogen atom
A) remains constant for all values of n.   B) decreases with increasing values of n.
C) increases with increasing values of n.   D) varies randomly with increasing values of n.

14) An ionized atom having Z protons has had all but one of its electrons removed. If R is the radius of the ground state electron orbit in atomic hydrogen, then what is the radius of the shell of the remaining electron in the ionized atom?
A) ZR B) R/Z^2 C) Z^2R D) R E) R/Z

15) The cosmic background radiation permeating the universe has the spectrum of a 2.7-K blackbody radiator. What is the peak wavelength of this radiation? The constant in Wien's law is 0.0029 m • K.

16) What is the wavelength of the most intense light emitted by a giant star of surface temperature 5000 K? The constant in Wien's law is 0.00290 m • K.

17) The human eye can just detect green light of wavelength 500 nm if it arrives at the retina at the rate of 2×10^{-18} W. How many photons arrive each second? ($c = 3.0 \times 10^{8}$ m/s, $h = 6.626 \times 10^{-34}$ J • s)

18) An 84-kW AM radio station broadcasts at 1000 kHz. How many photons are emitted each second by the transmitting antenna? ($h = 6.626 \times 10^{-34}$ J • s)

19) When it is struck by 240-nm photons, a metal ejects electrons with a maximum kinetic energy of 2.58 eV. What is the work function of this material? ($c = 3.00 \times 10^{8}$ m/s, $h = 6.626 \times 10^{-34}$ J • s, 1 eV = 1.60×10^{-19} J)

20) For a certain metal, light of frequency 7.24×10^{14} Hz is just barely able to dislodge photoelectrons from the metal. ($h = 6.626 \times 10^{-34}$ J • s, 1 eV = 1.60×10^{-19} J, $e = 1.60 \times 10^{-19}$ C)
(a) What will be the stopping potential if light of frequency 8.75×10^{14} Hz is shone on the metal?
(b) What is the work function (in electron-volts) of this metal?

21) A certain photon, after being scattered from a free electron that was at rest, moves at an angle of 120° with respect to the incident direction. If the wavelength of the incident photon is 0.591 nm, what is the wavelength of the scattered photon? ($m_{electron} = 9.11 \times 10^{-31}$ kg, $c = 3.00 \times 10^{8}$ m/s, $h = 6.626 \times 10^{-34}$ J • s)

22) What is the momentum of a photon of light that has a wavelength of 480 nm? ($h = 6.626 \times 10^{-34}$ J • s)

23) Calculate the kinetic energy, in electron-volts, of a neutron that has a de Broglie wavelength of 7.2×10^{-12} m ($m_{neutron} = 1.675 \times 10^{-27}$ kg, 1 eV = 1.6×10^{-19} J, $h = 6.626 \times 10^{-34}$ J • s)

24) A crystal diffracts a beam of electrons, like a diffraction grating, as they hit it perpendicular to its surface. The crystal spacing is 0.18 nm, and the first maximum scattering occurs at 80° relative to the normal to the surface. ($e = 1.60 \times 10^{-19}$ C, $m_{electron} = 9.11 \times 10^{-13}$ kg, $h = 6.626 \times 10^{-34}$ J • s)
(a) What is the wavelength of the electrons?
(b) What potential difference accelerated the electrons if they started from rest?

25) A person of mass 50 kg has a de Broglie wavelength of 4.4×10^{-36} m while jogging. How fast is she running? ($h = 6.626 \times 10^{-34}$ J • s)

26) A proton has a speed of 7.2×10^{4} m/s. What is the energy of a photon that has the same wavelength as the de Broglie wavelength of this proton? m proton = 1.6726×10–27kg, $c = 3.00 \times 10^{8}$ m/s, $h = 6.626 \times 10^{-34}$ J • s)

27) What is the shortest wavelength in the Balmer series?

28) The wavelength of a ruby laser is 694.3 nm. What is the energy difference between the two energy states for the transition that produces this light? ($c = 3.00 \times 10^8$ m/s, 1 eV = 1.60×10^{-19} J, $h = 6.626 \times 10^{-34}$ J • s)

29) A hydrogen atom is in its $n = 2$ excited state when its electron absorbs 9.5 eV in an interaction with a photon. What is the energy of the resulting free electron?

30) In a transition from one vibrational state to another, a molecule emits a photon of wavelength 5.56 μm. What is the energy difference between these two states? ($c = 3.00 \times 10^8$ m/s, $h = 6.626 \times 10^{-34}$ J • s, 1 eV = 1.60×10^{-19} J)

31) The Bohr model of the hydrogen atom predicts an ionization energy of 13.6 eV. Using this model, what would we expect for the ionization energy of the Li^{++} ion, which has 3 protons?

32) Using the Bohr model, what is the radius of the lowest-energy electron orbit in a singly-ionized He atom, which has 2 protons? ($r_1 = 0.0529$ nm for hydrogen)

Answer Key
Testname: CH27_EARLY_ATOM

1) D
2) A, E
3) C
4) A
5) B
6) D
7) B
8) A, C, E
9) A
10) E
11) C
12) C
13) C
14) E
15) 1.1 mm (microwave region)
16) 580 nm
17) 5
18) 1.3×10^{32}
19) 2.60 eV
20) (a) 0.625 V (b) 3.00 eV
21) 0.595 nm
22) 1.4×10^{-27} kg•m/s
23) 16 eV
24) (a) 0.18 nm
(b) 48 V
25) 3.0 m/s
26) 230 keV
27) 365 nm
28) 1.79 eV
29) 6.1 eV
30) 0.223 eV
31) 122 eV
32) 0.0265 nm