Name ______________________ Class ______________ Date ______________

Assessment

Chapter Test B

Atomic Physics

MULTIPLE CHOICE

In the space provided, write the letter of the term or phrase that best completes each statement or best answers each question.

______ **1.** What is the frequency of a photon with an energy of 1.99×10^{-19} J? ($h = 6.63 \times 10^{-34}$ J•s)

a. 1.00×10^{14} Hz
b. 2.00×10^{14} Hz
c. 3.00×10^{14} Hz
d. 4.00×10^{14} Hz

______ **2.** Light with an energy equal to three times the work function of a given metal causes the metal to eject photoelectrons. What is the ratio of the maximum photoelectron kinetic energy to the work function?

a. 1 : 1
b. 2 : 1
c. 3 : 1
d. 4 : 1

______ **3.** A monochromatic light beam with a quantum energy value of 3.0 eV is incident upon a photocell. The work function of the photocell is 1.6 eV. What is the maximum kinetic energy of the ejected electrons?

a. 4.6 eV
b. 4.8 eV
c. 1.4 eV
d. 2.4 eV

______ **4.** What causes the bright lines in the emission spectrum of an element to occur?

a. Photons are absorbed when electrons jump from a higher-energy to a lower-energy state.
b. Photons are emitted when electrons jump from a higher-energy to a lower-energy state.
c. Photons are absorbed when electrons jump from a lower-energy to a higher-energy state.
d. Photons are emitted when electrons jump from a lower-energy to a higher-energy state.

______ **5.** What causes the dark lines in the absorption spectrum of an element to occur?

a. Photons are absorbed when electrons jump from a higher-energy to a lower-energy state.
b. Photons are emitted when electrons jump from a higher-energy to a lower-energy state.
c. Photons are absorbed when electrons jump from a lower-energy to a higher-energy state.
d. Photons are emitted when electrons jump from a lower-energy to a higher-energy state.

______ **6.** What observation confirmed de Broglie's theory of matter waves?
a. the photoelectric effect
b. the scattering of alpha particles
c. the diffraction of electrons
d. the spontaneous emission of photons

______ **7.** According to de Broglie, as the momentum of a moving particle is tripled, the corresponding wavelength changes by what factor?
a. $\frac{1}{9}$ **c.** 3
b. $\frac{1}{3}$ **d.** 9

______ **8.** Why is a probability wave required to describe an electron's location?
a. The electron's location can be precisely determined.
b. Electrons violate Heisenberg's uncertainty principle.
c. The electron may be found at various distances from the nucleus.
d. The electron has less probability of being at the first Bohr orbit than at any other distance.

SHORT ANSWER

9. What was Planck's radical assumption about resonators in relation to blackbody radiation?

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10. What are some weaknesses of Rutherford's atomic model?

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11. Starlight passes through a cloud of cool atomic gases. What kind of spectrum will be produced, and what will it look like?

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12. Which electron transitions in the Bohr hydrogen atom will produce photons with the shortest wavelengths?

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13. What causes an aurora, and why does it occur more easily and appear brighter nearer the poles than in equatorial or mid-latitude regions?

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14. You have designed an experiment to measure the momentum of light. Should you use light with long wavelengths or short wavelengths to better observe momentum transfer? Explain your answer.

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15. How does the classical model of standing waves on a vibrating string relate to the model of the Bohr atom in which electrons have specific de Broglie wavelengths?

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16. Why is the uncertainty principle more important for matter at the atomic level than for matter in large objects, such as a book or a car?

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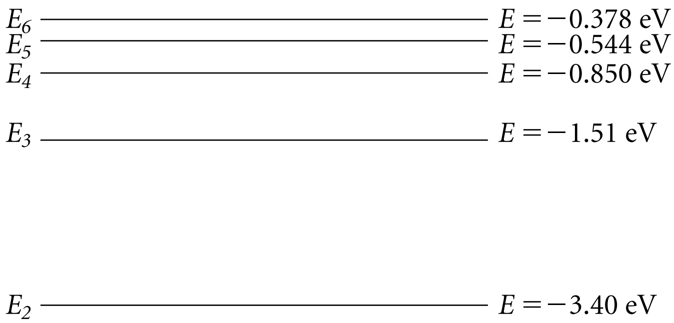
PROBLEM

17. What is the energy of a photon whose frequency is 5.0×10^{14} Hz?
($h = 6.63 \times 10^{-34}$ J•s; 1 eV $= 1.60 \times 10^{-19}$ J)

18. What is the energy of a photon whose wavelength is 312 nm?
($h = 6.63 \times 10^{-34}$ J•s; $c = 3.00 \times 10^{8}$ m/s; 1 eV $= 1.60 \times 10^{-19}$ J)



19. Calculate the frequency of the photon emitted when the electron in a hydrogen atom drops from energy level E_6 to energy level E_3 in the figure above. ($h = 6.63 \times 10^{-34}$ J•s; 1 eV $= 1.60 \times 10^{-19}$ J)

20. What is the de Broglie wavelength of a proton that has a mass of 1.67×10^{-27} kg and is moving at a speed of 2.7×10^{5} m/s?
($h = 6.63 \times 10^{-34}$ J•s)

19. An emission spectrum is a unique series of spectral lines emitted by an atomic gas when a potential difference is applied across the gas.
20. the wave model
21. the particle model
22. The energy of the incoming photons is equal to twice the maximum kinetic energy of the emitted photoelectrons.
23. 1.2 eV

Given

$f = 3.0 \times 10^{14}$ Hz

$h = 6.63 \times 10^{-34}$ J•s

Solution

$E = hf$

$$E = (6.63 \times 10^{-34}\ \text{J•s})(3.0 \times 10^{14}\ \text{Hz})\left(\frac{1\ \text{eV}}{1.60 \times 10^{-19}\ \text{J}}\right)$$

$E = \boxed{1.2\ \text{eV}}$

24. 1.13 eV

Given

$E_6 = -0.378$ eV

$E_3 = -1.51$ eV

Solution

$E = E_{initial} - E_{final} = E_6 - E_3$

$E = -0.378\ \text{eV} - (-1.51\ \text{eV}) = \boxed{1.13\ \text{eV}}$

25. 3.1×10^{-10} m, or 0.31 nm

Given

$m = 1.67 \times 10^{-27}$ kg

$v = 1.3 \times 10^{3}$ m/s

$h = 6.63 \times 10^{-34}$ J•s

Solution

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

$$\lambda = \frac{(6.63 \times 10^{-34}\ \text{J•s})}{(1.67 \times 10^{-27}\ \text{kg})(1.3 \times 10^{3}\ \text{m/s})}$$

$= 3.1 \times 10^{-10}\ \text{m} = \boxed{0.31\ \text{nm}}$

Atomic Physics

CHAPTER TEST B (ADVANCED)

1. c

Solution

$E = hf$

$$f = \frac{E}{h} = \frac{1.99 \times 10^{-19}\ \text{J}}{6.63 \times 10^{-34}\ \text{J•s}}$$

$E = \boxed{3.00 \times 10^{14}\ \text{Hz}}$

2. b
3. c

Solution

$KE_{max} = hf - hf_t$

$KE_{max} = 3.0\ \text{eV} - 1.6\ \text{eV} = \boxed{1.4\ \text{eV}}$

4. b
5. c
6. c
7. b
8. c
9. Planck proposed that resonators could only absorb and then reemit discrete amounts of light energy called quanta.
10. The constantly accelerated electrons in Rutherford's model of the atom would continuously radiate electromagnetic waves, and therefore would be unstable. Also, his model did not explain spectral lines.
11. The resulting spectrum is an absorption spectrum, which appears as a nearly continuous spectrum with dark lines where light of given wavelengths is absorbed by the gases in the cloud.
12. The transitions from any of the excited energy levels to the ground state will produce photons with the greatest energy, and therefore the shortest wavelengths.
13. Earth's magnetic field draws charged particles from the sun toward the poles, where the particles collide with atoms in Earth's atmosphere. These atoms give up the energy acquired in the collisions as spontaneous emission of photons, producing an aurora. Because there are more collisions near the poles, more light is emitted, producing a brighter aurora more often.
14. Light of short wavelengths is better. Momentum transfer is most easily observed in particle collisions, and photons that have shorter wavelengths behave more like particles than do photons with longer wavelengths.

15. The standing wave is stable because there is no interference between the incident and reflected wave. This occurs when there are an integral number of wavelengths for the wave along the string. This is comparable to electrons in a Bohr atom, which only have stable orbits when there are an integral number of electron wavelengths along the path of the orbit.

16. The interaction of light and microscopic particles is so slight that the position and the momentum of a large object are imperceptibly affected, whereas the effect of interactions between light or microscopic particles and other microscopic particles can be relatively large.

17. 2.1 eV

Given

$f = 5.0 \times 10^{14}$ Hz

$h = 6.63 \times 10^{-34}$ J•s

Solution

$E = hf$

$$E = (6.63 \times 10^{-34} \text{ J•s})(5.0 \times 10^{14} \text{ Hz})\left(\frac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}}\right)$$

$$E = \boxed{2.1 \text{ eV}}$$

18. 3.98 eV

Given

$\lambda = 312$ nm

$h = 6.63 \times 10^{-34}$ J•s

$c = 3.00 \times 10^{8}$ m/s

Solution

$E = hf$

$c = f\lambda$

$$E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34} \text{ J•s})(3.00 \times 10^{8} \text{ m/s})}{312 \text{ nm}}\left(\frac{10^9 \text{ nm}}{1 \text{ m}}\right)\left(\frac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}}\right)$$

$$\text{E} = \boxed{3.98 \text{ eV}}$$

19. 2.73×10^{14} Hz

Given

$E_6 = -0.378$ eV

$E_3 = -1.51$ eV

$h = 6.63 \times 10^{-34}$ J•s

Solution

$E = hf$

$E = E_{initial} - E_{final} = E_6 - E_3$

$$f = \frac{E_6 - E_3}{h} = \frac{(-0.378 \text{ eV} - (-1.51 \text{ eV}))}{6.63 \times 10^{-34} \text{ J•s}}\left(\frac{1.60 \times 10^{-19} \text{ J}}{1 \text{ eV}}\right) = \left(\frac{1.13 \text{ eV}}{6.63 \times 10^{-34} \text{ J•s}}\right)\left(\frac{1.60 \times 10^{-19} \text{ J}}{1 \text{ eV}}\right)$$

$$f = \boxed{2.73 \times 10^{14} \text{ Hz}}$$

20. 1.5×10^{-12} m, or 1.5 pm

Given

$m = 1.67 \times 10^{-27}$ kg

$v = 2.7 \times 10^{5}$ m/s

$h = 6.63 \times 10^{-34}$ J•s

Solution

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

$$\lambda = \frac{(6.63 \times 10^{-34} \text{ J•s})}{(1.67 \times 10^{-27} \text{ kg})(2.7 \times 10^{5} \text{ m/s})}$$

$$= 1.5 \times 10^{-12} \text{ m} = \boxed{1.5 \text{ pm}}$$

Subatomic Physics

CHAPTER TEST A (GENERAL)

1. d
2. a
3. c
4. d
5. a
6. b
7. b
8. c
9. b
10. a

Solution

Mass number of X = 240 − 236 = 4

Atomic number of X = 94 − 92 = 2

The emitted particle is a helium-4 nucleus, or an alpha particle.