Name: ________Answer Key___________ Date: ______________________________

Honors Physics Test #14 Review

Modern Physics

1. Read Topic 6 – Review Book and Chapters 27 & 28 in text.

2. Terms to know: photoelectric effect, photon, Planck's constant, quantum, photon momentum, photon-electron collisions, matter waves, Bohr Model of the atom, electron cloud, energy level diagram, ground state, orbital, relaxed state, excited state, bright-line spectra, emission spectra, absorption spectra, nuclear force, mass-energy relationship, universal mass unit, Standard Model, hadron, lepton, positron, neutrino, baryon, meson, antiparticle, quark, antimatter, four fundamental forces.

3. What is meant by "the dual nature of light?"
   Light behaves as both a wave and a particle
4. What experiments/phenomena support the wave nature of light?
   Diffraction, Interference, Doppler Effect
5. What experiments/phenomena support the particle nature of light?
   Photoelectric Effect, Photosynthesis, Photocell
6. What are some properties of a photon?
   Has momentum, is massless, travels at speed of light
7. Which color photon has the highest frequency? Wavelength? Energy?
   High f = violet   High wavelength = red   High E = violet
8. Which type of photon has the highest frequency? Wavelength? Energy?
   High f = gamma   High wavelength = Radio/Long Radio   High E = gamma
9. How is the momentum of a photon related its wavelength? Frequency?
   Momentum is inversely prop. to wavelength, Momentum is directly prop. to frequency
10. When a photon collides with a particle, what quantities are conserved?
    Momentum and Energy
11. As the speed of an electron increases, what happens to its wavelength?
    Wavelength decreases
    $p = \frac{h}{\lambda}$ so $m \bullet v = \frac{h}{\lambda}$
12. What is the Bohr Model of the atom? What are its major assumptions?
    Quantized energy levels
13. What are spectral lines and what causes them? What are emission and absorption spectra?
    Lines of visible colors of light emitted when atoms change energy level
    Emission shows the colors emitted by the atom, absorption shows everything else
14. When an electron jumps from the ground state to a higher orbital, what happens?
    Absorbs a photon
15. When an electron jumps from a higher orbital to the ground state, what happens?
    Photon is emitted
16. Be able to read energy level diagrams for hydrogen and mercury and calculate the energy released/absorbed during transitions.
17. Be able to read the Standard Model and Classification of Matter charts.
18. What is the difference between a particle and its antiparticle?
    An antiparticle has the same mass, lifetime and spin, but OPPOSITE chage
19. How many quarks make up a baryon? A meson? A lepton?
    Baryon = 3 quarks   Meson = quark + antiquark   Lepton = no quarks
20. What are the possibilities for the charge of a baryon?
    + 2 e   + 1 e   0   - 1 e

21. Be able to calculate the conversion of mass to energy and vice versa.
$E = mc^2$
22. Know the relationship between Energy and frequency or wavelength. Be able to graph.
$E = hf$
23. Explain why a hydrogen atom in the ground state can absorb a 10.2 eV photon, but cannot absorb an 11.0 eV photon.
It needs to absorb photons with specific energies that match the energy level diagrams.
24. What prevents the nucleus of a helium atom from flying apart?
Stong Nuclear Force
25. As an electron in an atom moves in a circular path of constant radius around the nucleus, the total energy of the atom (increases, decreases, remains the same)

26. When a source of dim orange light shines on a photosensitive metal, no photoelectrons are ejected from its surface. What could be done to increase the likelihood of producing photoelectrons?
Change the frequency of the light – orange is not high enough.
27. Infrared electromagnetic radiation incident on a material produces no photoelectrons. When red light of the same intensity is shone on the same material, photoelectrons are emitted from the surface. Using one or more complete sentences, explain why the visible red light causes photoelectric emission, but the infrared radiation does not.
Visible red light has a higher frequency than infrared light, which means is has more energy
28. A metal surface emits photoelectrons when illuminated by green light. This surface must also emit photoelectrons when illuminated by
a. Orange light b. Blue light c. Yellow light d. Red light

Directions: Read each question carefully and record your answers in the space provided. Be sure to show all work! Answers should be in significant figures. You will be graded on proper use of the GUESS method. **These will be the same directions on the test. Practice the GUESS method now.**

29. How much energy, in joules, would be released if two protons were completely converted into energy? Convert your answer to eV and MeV.

$$E = mc^2 = 2(1.67\times10^{-27}kg)(3.00\times10^8 \tfrac{m}{s})^2 = 3.01\times10^{-10}J$$

$$3.01\times10^{-10}J\left(\frac{1eV}{1.60\times10^{-19}J}\right) = 1.88\times10^9 eV$$

$$1.88\times10^9 eV\left(\frac{1MeV}{10^6 eV}\right) = 1880 MeV$$

Since it's two protons you need to double the mass.

This conversion is on the reference tables.

1 goes with prefix, 10^n goes with base unit

30. A particle has a quark composition of dū. What is its electrical charge in coulombs? What is its classification?

This conversion is on the reference tables.

The classification is Meson

$$-\frac{1}{3}e + -\frac{2}{3}e = -1e\left(\frac{1.60\times10^{-19}C}{1e}\right) = -1.60\times10^{-19}C$$

One quark and one anti-quark
Use the classification of matter chart

ū has opposite charge of u

31. A beam of 5.65×10^{14} Hertz light strikes a metal surface, causing electrons to be ejected. The photoelectrons have a kinetic energy of 1.72×10^{-19} joules. Calculate the work function of the metal.

This is HONORS

$$\phi = hf - KE = (6.63\times10^{-34}J\cdot s)(5.65\times10^{14}Hz) - 1.72\times10^{-19}J = 2.03\times10^{-19}J$$

$KE = E_{photon} - \phi$

32. Calculate the energy of a photon which has a frequency of 3.3×10^{14} Hz.

$$E = hf = (6.63\times10^{-34}J\cdot s)(3.3\times10^{14}Hz) = 2.2\times10^{-19}J$$

Planck's constant, h, is on the reference tables.

33. An electron in a hydrogen atom drops from the n = 3 energy level to the n = 2 energy level.

a. What is the energy, in electronvolts, of the emitted photon?

$$E_{photon} = E_i - E_f = -1.51eV - (-3.40eV) = 1.89eV$$

Look up the hydrogen energy level diagram on the reference tables. Level 3 is initial, level 2 is final.

b. What is the energy, in joules of the emitted photon?

$$1.89eV\left(\frac{1.60\times10^{-19}J}{1eV}\right) = 3.02\times10^{-19}J$$

This conversion is on the reference tables.

c. Calculate the frequency of the emitted radiation.

$$f = \frac{E}{h} = \frac{3.02\times10^{-19}J}{6.63\times10^{-34}J\cdot s} = 4.56\times10^{14}Hz$$

d. Calculate the wavelength of the emitted radiation.

$$\lambda = \frac{v}{f} = \frac{3.00\times10^{8}\,\frac{m}{s}}{4.56\times10^{14}Hz} = 6.58\times10^{-7}m$$

OR

$$\lambda = \frac{hc}{E} = \frac{(6.63\times10^{-34}J\cdot s)(3.00\times10^{8}\,\frac{m}{s})}{3.02\times10^{-19}J} = 6.59\times10^{-7}m$$

34. A carbon nucleus contains six protons and six neutrons and has a mass of 12.0000 u. A proton has a mass of 1.0073 u and a neutron has a mass of 1.0087 u.

a. Calculate is the mass defect of the carbon nucleus.

$$m_{defect} = (m_{proton} + m_{neutron}) - m_{nucleus}$$
$$m_{defect} = [6(1.0073u) + 6(1.0087u)] - 12.0000u$$
$$m_{defect} = 0.0960u$$

This equation needs to be memorized.

b. How much energy does this represent in MeV? In eV?

$$0.0960u\left(\frac{931MeV}{1u}\right) = 89.4MeV = 8.94\times10^{7}eV$$

This conversion is on the reference tables.

c. How much energy does this represent in joules?

$$8.94\times10^{7}eV\left(\frac{1.60\times10^{-19}J}{1eV}\right) = 1.43\times10^{-11}J$$

This conversion is on the reference tables.

35. What is the minimum energy needed to ionize a hydrogen atom in the n = 2 energy state?

(A) 10.2 eV (B) 3.40 eV (C) 1.89 eV (D) 13.6 eV

$E_{photon} = E_i - E_f = -3.40eV - 0.00eV$

36. A photon emitted from an excited hydrogen atom has an energy of 3.02 electronvolts. Which electron energy-level transition would produce this photon?

(A) n = 6 to n = 2 (B) n = 2 to n = 6 (C) n = 1 to n = 6 (D) n = 6 to n = 1

$E_p = E_i - E_f$
$= -.38eV - (-3.40eV)$

37. White light is passed through a cloud of cool hydrogen gas and then examined with a spectroscope. The dark lines observed on a bright background are caused by

(A) constructive interference
(B) the hydrogen emitting all frequencies in white light
(C) the hydrogen absorbing certain frequencies of white light
(D) diffraction of white light

The hydrogen absorbs the colors, so they don't go through, leaving dark bands

38. The electron in a hydrogen atom drops from energy level n = 2 to energy level n = 1 by emitting a photon having an energy of approximately

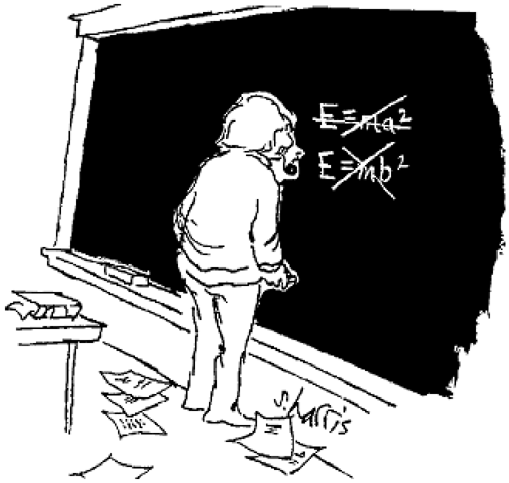
(A) 1.6×10^{-18} J (B) 7.4×10^{-18} J (C) 5.4×10^{-19} J (D) 2.2×10^{-18} J

$E_p = E_i - E_f = -3.40eV - (-13.60eV) = 10.20eV$

$10.20eV\left(\frac{1.60\times10^{-19}J}{1eV}\right)$

39. In the cartoon below, Einstein is contemplating the equation for the principle that

E=mc² calculates how much energy is created when matter converts into energy.



(A) mass always travels at the speed of light in a vacuum
(B) the fundamental source of all energy is the conversion of mass into energy
(C) energy is emitted or absorbed in discrete packets called photons
(D) the energy of a photon is proportional to its frequency.

40. An electron in a hydrogen atom drops from the n = 3 energy to the n = 2 energy level. What is the energy of the emitted photon?

(A) 4.91 eV (B) 3.40 eV (C) 1.89 eV (D) 1.51 eV

$E_{photon} = E_i - E_f = -1.51eV - (-3.40eV)$

41. When yellow light shines on a photosensitive metal, photoelectrons are emitted. As the intensity of the light is decreased, the number of photoelectrons emitted per second

(A) increases (B) decreases (C) remains the same

Lower intensity means fewer photoelectrons because there are fewer photons.

42. After electrons in hydrogen atoms are excited to the n = 3 energy state, how many different frequencies of radiation can be emitted as the electrons return to the ground.

(A) 1 (B) 2 (C) 3 (D) 4

One for level 3 to 1 direction, two for level 3 to 2 then to 1, for a total of 3.

43. The momentum of a photon is inversely proportional to the photon's

(A) weight (B) wavelength (C) mass (D) frequency

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

44. What is the minimum energy required to excite a mercury atom initially in the ground state?

(A) 10.38 eV (B) 4.64 eV (C) 10.20 eV (D) 5.74 eV

At a minimum it goes from level a to b
$E_{photon} = E_i - E_f = -10.38eV - (-5.74eV)$

45. Which combination of quarks would produce a neutral baryon?

(A) uud (B) udd $+\frac{2}{3}e + \frac{2}{3}e - \frac{1}{3}e$ (C) $\bar{u}\bar{u}\bar{d}$ (D) $\bar{u}\bar{d}\bar{d}$

46. A photon of which electromagnetic radiation has the *most* energy?

(A) infrared (B) microwave (C) x-ray (D) ultraviolet

E=hf
Higher frequency means more energy

47. What is the energy of a quantum of light having a frequency of 6.0×10^{14} hertz?

(A) 3.0×10^{8} J (B) 5.0×10^{-7} J (C) 1.6×10^{-19} J (D) 4.0×10^{-19} J

$E = hf = (6.63\times10^{-34} J \cdot s)(6.0\times10^{-19} Hz)$

48. The energy of a photon varies directly with its

$E = hf$

(A) wavelength (B) speed (C) frequency (D) rest mass

49. Which phenomenon is most easily explained by the particle theory of light?

(A) polarization
(B) diffraction
(C) photoelectric effect
(D) constructive interference

The photons act like particles and knock the electrons out. The other three demonstrate the wave nature of light.

50. Protons and neutrons are composed of smaller particles called

(A) baryons (B) bosons (C) quarks (D) alpha particles

Quarks are the smallest known building blocks of matter

51. As the color of light changes from red to yellow, the frequency of the light

(A) increases (B) decreases (C) remains the same

52. Experiments performed with light indicate that light exhibits

Look at the Electromagnetic Spectrum on the reference tables.

(A) particle properties, only
(B) wave properties, only
(C) both particle and wave properties
(D) neither particle nor wave properties

53. What type of nuclear force holds the protons and neutrons in an atom together?

(A) a strong force that acts over a long range
(B) a weak force that acts over a short range
(C) a strong force that acts over a short range
(D) a weak force that acts over a long range

54. What is the minimum energy required to ionize a hydrogen atom in the n = 3 state?

(A) 5.52 eV (B) 12.09 eV (C) 13.60 eV (D) 1.51 eV

$E_{photon} = E_i - E_f = -1.51eV - 0.00eV$

55. Which electron transition in the hydrogen atom results in the emission of a photon of *greatest* energy?

$E_{photon} = E_i - E_f = -3.40eV - (-13.60eV) = 10.20eV$

(A) n = 4 to n = 2 (B) n = 2 to n = 1 (C) n = 3 to n = 2 (D) n = 5 to n = 3

56. If a deuterium nucleus has a mass of 1.53 x 10^{-3} universal mass units less than its components, this mass represents an energy of

(A) 1.42 MeV (B) 1.38 MeV (C) 1.53 MeV (D) 3.16 MeV

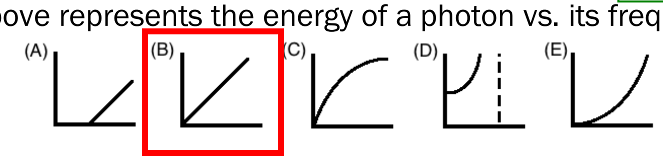
$1.53 \times 10^{-3} u \left(\frac{931 MeV}{1u} \right)$

57. During a collision between a photon and an electron, there is conservation of

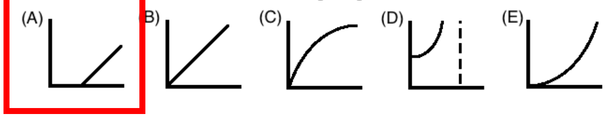
(A) energy, only
(B) both energy and momentum
(C) neither energy nor momentum
(D) momentum, only

Energy and momentum are conserved in a collision. They transfer from one to the other

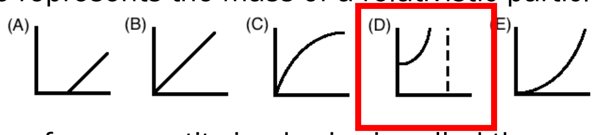
58. Which of the graphs above represents the energy of a photon vs. its frequency?



59. Which of the graphs above represents the maximum kinetic energy of electrons emitted in the photoelectric effect vs. frequency of the incoming light



60. Which of the graphs above represents the mass of a relativistic particle vs. its speed?



61. The smallest discrete value of any quantity in physics is called the

(A) atom (B) molecule (C) proton (D) electron (E) quantum

62. The smallest discrete value of electromagnetic energy is called the

(A) photon (B) proton (C) electron (D) neutron (E) quark

63. Which of the following photons has the highest energy?

(A) x-ray (B) ultraviolet (C) green light (D) microwave (E) radio

64. The photoelectric effect is best explained by the

(A) wave model of light
(B) particle model of light
(C) interference of light waves
(D) diffraction of light waves
(E) Heisenberg uncertainty principle

65. The threshold frequency of zinc for the photoelectric effect is in the ultraviolet range. Which of the following will occur if X-rays are shined on a zinc metal surface?

(A) No electrons will be emitted from the metal
(B) Electrons will be released from the metal but have no kinetic energy.
(C) Electrons will be released from the metal and have kinetic energy
(D) Electrons will be released from the metal but will immediately be recaptured by the zinc atoms
(E) Electrons will simply move from one zinc atom in the metal to another zinc atom in the metal

66. Which of the following is true of the momentum of a photon?

(A) It is proportional to the wavelength of the photon
(B) It is inversely proportional to the wavelength of the photon
(C) It is inversely proportional to the square of the wavelength of the photon
(D) It is proportional to the mass of the photon
(E) It is equal to the energy of the photon

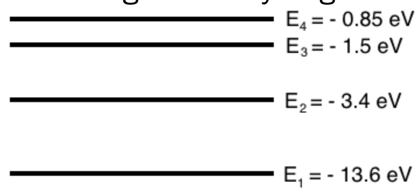
67. Which of the following is true for the de Broglie wavelength of a moving particle

(A) It is never large enough to measure
(B) It is proportional to the speed of the particle
(C) It is inversely proportional to the momentum of the particle
(D) It is equal to Planck's constant
(E) It has no effect on the behavior of electrons

68. An emission spectrum is produced when

(A) electrons in an excited gas jump up to a higher energy level & release photons
(B) electrons in an excited gas jump down to a lower energy level & release photons
(C) electrons are released from the outer orbitals of an excited gas
(D) an unstable nucleus releases energy
(E) light is shined on a metal surface and electrons are released

69. the Consider the electron energy level diagram for hydrogen below



An electron in the ground state of hydrogen atom has an energy of -13.6 eV, and 0 eV is the highest energy level present in a hydrogen atom. Which of the following energies is NOT a possible energy for a photon emitted from hydrogen?

(A) 1.9 eV (B) 13.6 eV (C) 0.65 eV (D) 11.1 eV (E) 10.2 eV

70. The mass of an object increases as its speed increases. This increase comes from

(A) nuclear binding energy
(B) electron energy in the ground state
(C) potential energy being converted to mass by $E = mc^2$
(D) kinetic energy being converted to mass by $E = mc^2$
(E) the lower pressure on the mass

71. The pilot of a spaceship traveling at 90% the speed of light (0.9c) turns on its laser headlights just as it passes a stationary observer. Which of the following statements is true?

(A) The pilot will measure the speed of light coming out of the headlights as c, and the observer will measure the speed of light as 0.9c
(B) The pilot will measure the speed of light coming out of the headlights as c, and the observer will measure the speed of light as 1.9c
(C) The pilot will measure the speed of light coming out of the headlights as 0.9c, and the observer will measure the speed of light as 1.9 c
(D) The pilot will measure the speed of light coming out of the headlights as 1.9c, and the observer will measure the speed of light as 0.9 c
(E) The pilot will measure the speed of light coming out of the headlights as c, and the observer will measure the speed of light as c

72. Two identical precise clocks are started at the same time. One clock is taken on a trip at a very high speed, and the other is left at rest on earth. When the traveling clock returns to earth, it shows that one hour has passed. Which of the following could be the time that has passed on the earth-bound clock?

(A) 30 minutes (B) 45 minutes (C) 59 minutes (D) 1 hour (E) 2 hours

Answers:

29. 3.01×10^{-10} J
1.88 x 10^9 eV
1880 MeV
30. – 1.60×10^{-19} C,
Meson
31. 2.03×10^{-19} J
32. 2.2×10^{-19} J
33. a. 1.89 eV
b. 3.02×10^{-19} J
c. 4.56×10^{14} Hz
d. 6.58×10^{-7} m
34. a. 0.0960 u
b. 89.4 MeV
8.94×10^7 eV
c. 1.43×10^{-11} J
35. B
36. A
37. C
38. A
39. B
40. C
41. B
42. C
43. B
44. B
45. B
46. C
47. D
48. C
49. C
50. C
51. A
52. C
53. C
54. D
55. B
56. A
57. B
58. B
59. A
60. D
61. E
62. A
63. A
64. B
65. C
66. B
67. C
68. B
69. D
70. D
71. E
72. E