

Name: Solutions

Date: _____

Quiz name: AP Physics 2 - Test 11 - Modern Physics

1. An atomic particle of mass m moving at speed v is found to have wavelength λ . What is the wavelength of a second particle with three times the speed and twice the mass?

- (A) $3\lambda/2$
(B) $2\lambda/3$
(C) 6λ
(D) $\lambda/6$

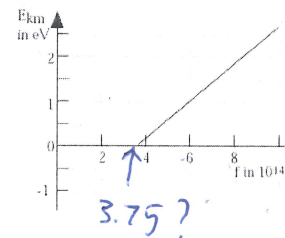
$\lambda = \frac{h}{mv}$
 $\lambda \propto \frac{1}{v}$
 $\lambda \propto \frac{1}{m}$

2. A student performs the photoelectric effect experiment and obtains the data depicted in the accompanying graph of E_{km} (maximum kinetic energy) of photoelectrons v. the frequency of the photons. What is the approximate work function of this material?

- (A) 1.5 eV
(B) 2.0 eV
(C) 2.7 eV
(D) 3.5 eV

$E_{\text{photon}} = hf_{\text{min}}$

$= (4.14 \times 10^{-15}) (3.75 \times 10^{14})$
 $= 1.55 \text{ eV}$



Since answers are in eV and not Joules

3. The diagram to the right shows the lowest four energy levels for an electron in a hypothetical atom. The electron is excited to the -1 eV level of the atom and transitions to the lowest energy state by emitting only two photons. Which of the following energies could not belong to either of the photons?

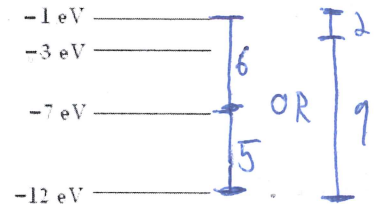
- (A) 2 eV
(B) 4 eV
(C) 5 eV
(D) 6 eV

Could have either

$-1 \rightarrow -7 \rightarrow -12$

OR

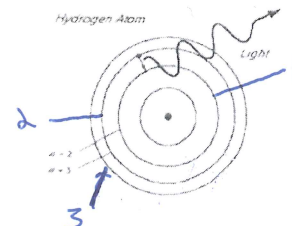
$-1 \rightarrow -3 \rightarrow -12$



4. The diagram shows light being emitted due to a transition from the $n=3$ to the $n=2$ level of a hydrogen atom in the Bohr model. If the transition were from the $n=3$ to the $n=1$ level instead, the light emitted would have

- (A) lower frequency
(B) longer wavelength
(C) greater speed
(D) greater energy

bigger jump from $3 \rightarrow 1$ than from $2 \rightarrow 1$



5. A very slow (not fast enough to apply special relativity) proton has its kinetic energy doubled. What happens to the protons corresponding de Broglie wavelength

- (A) the wavelength is decreased by a factor of $\sqrt{2}$

Velocity is increased by $\sqrt{2}$

$\lambda \propto \frac{1}{v}$
 $\lambda \propto \frac{1}{\sqrt{K}}$
 $\lambda \propto \frac{1}{\sqrt{2K}}$
 $\lambda \propto \frac{1}{\sqrt{2}}$

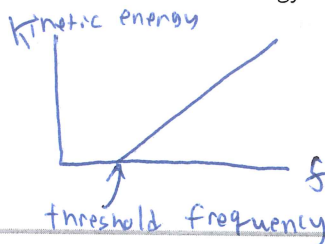
- (B) the wavelength is halved
 (C) the wavelength is increased by a factor of $\sqrt{2}$
 (D) the wavelength is doubled.

$$\lambda = \frac{h}{mv} \times \sqrt{2}$$

$$\times \frac{1}{\sqrt{2}}$$

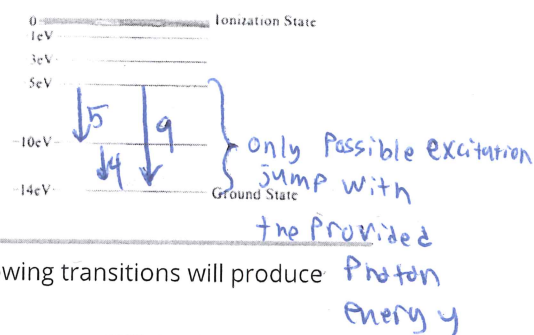
6. Which graph above best shows the maximum kinetic energy K of the photoelectrons as a function of the frequency of incident light?

- (A) A
 (B) B
 (C) C
 (D) D



7. The energy level diagram is for a hypothetical atom. A gas of these atoms initially in the ground state is irradiated with photons having a continuous range of energies between 7 and 10 electron volts. One would expect photons of which of the following energies to be emitted from the gas?

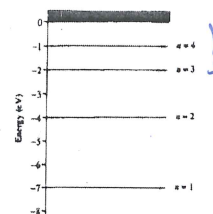
- (A) 1, 2, and 3 eV only
 (B) 4, 5, and 9 eV only
 (C) 1, 3, 5, and 10 eV only
 (D) 1, 5, 7, and 10 eV only



8. A hypothetical atom has four energy states as shown. Which of the following transitions will produce the photon with the longest wavelength?

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

Smallest frequency \rightarrow Smallest energy
 \rightarrow Smallest gap



Multiple correct

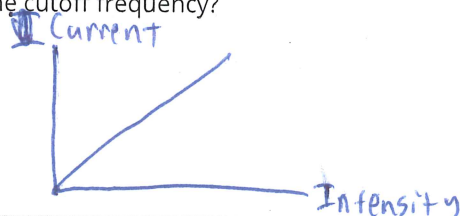
9. In an experiment, light of a particular wavelength is incident on a metal surface, and electrons are emitted from the surface as a result. To produce more electrons per unit time but with less kinetic energy per electron, the experimenter should do which of the following?

- (A) Increase the intensity of the light.
 (B) Decrease the intensity of the light.
 (C) Increase the wavelength of the light.
 (D) Decrease the wavelength of the light.

more electrons \rightarrow higher intensity
 less Energy \rightarrow smaller frequency \rightarrow larger wavelength

10. Which graph above shows the total photoelectric current versus the intensity of the light for a fixed frequency above the cutoff frequency?

- (A) A
 (B) B
 (C) C
 (D) D



11. Which of the following lists types of electromagnetic radiation in order from least to greatest energy per photon?

- (A) ultraviolet, infrared, red, green, violet
 (B) red, green, violet, infrared, ultraviolet



infrared, red, green, violet, ultraviolet

ultraviolet, violet, green, red, infrared

← this

In a nuclear reactor, uranium fissions into krypton and barium via the reaction.

12. What are the nucleon number A and atomic number Z of the resulting krypton nucleus?



A: 92

Z: 36



A: 90

Z: 36



A: 94

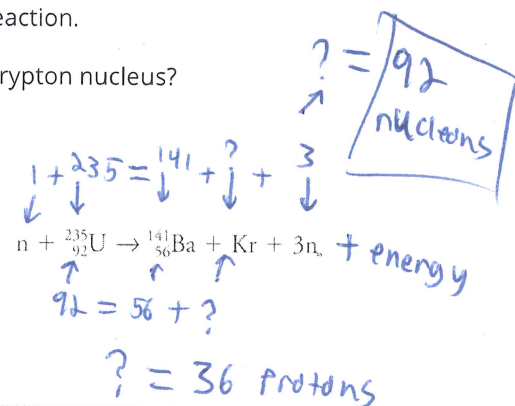
Z: 36



A: 92

Z: 33

of neutrons + protons # of protons



In a nuclear reactor, uranium fissions into krypton and barium via the reaction.

13. How much mass is converted into the kinetic energy of the resulting nuclei?



1 amu



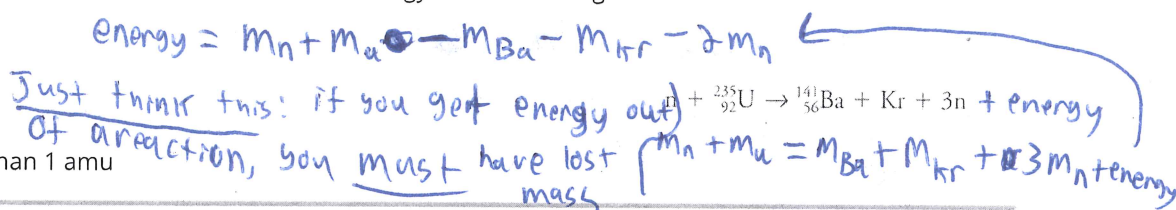
2 amu



zero



much less than 1 amu



14. The figure shows the wave functions $\Psi(x)$ of a particle moving along the x-axis. Which of the following statements correctly interprets this graph?



The particle is oscillating in charge from positive to negative.



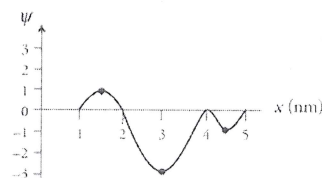
The lowest probability of finding the particle is at 3.0 nm.



There is an equal probability of finding the particle at 1.5 nm as at 4.5 nm.



The length of the particle is 4 nm.



A neutron is shot into a uranium atom, producing a nuclear reaction:

15. A neutron is shot into a uranium atom, producing a nuclear reaction:



The reaction products include two neutrons.



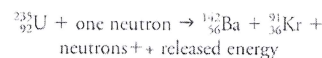
Combining uranium with a neutron is characteristic of nuclear fusion.



The released energy in the reaction is equal to the kinetic energy of the neutron shot into the uranium.



The combined mass of uranium-235 and a neutron will be greater than the sum of the mass of the reaction products.



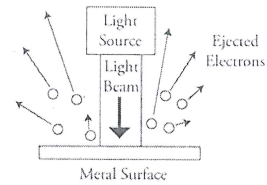
Energy was created, so mass must have been lost

A beam of ultraviolet light shines on a metal plate, causing electrons to be ejected from the plate as shown in the figure. The velocity of the ejected electrons varies from nearly zero to a maximum of 1.6×10^6 m/s. If the brightness of the beam is increased to twice the original amount, what will be the effect on the number of electrons leaving the metal plate and the maximum velocity of the electrons?

- 16.

Increasing brightness will only increase the amount of electrons emitted but will not affect the maximum kinetic energy.

- (A) # of electrons: increases
vel of electrons: increases
- (B) # of electrons: increases
vel of electrons: unchanged
- (C) # of electrons: unchanged
vel of electrons: increases
- (D) # of electrons: unchanged
vel of electrons: unchanged

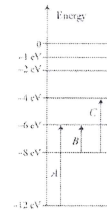


Scientists shine a broad spectrum of electromagnetic radiation through a container filled with gas toward a detector. The detector indicates that three specific wavelengths of the radiation were absorbed by the gas. The figure shows the energy level diagram of the electrons that absorbed the radiation. Which of the following correctly ranks the wavelengths of the absorbed electromagnetic radiation?

17.

- (A) $A = B > C$
- (B) $A > B = C$
- (C) $A > B > C$
- (D) $B > C > A$

94P A > 94P C > 94P B
~~50~~ $f_A > f_C > f_B$
 $\lambda_A < \lambda_C < \lambda_B$



18. James travels at high speed from the Earth to the star Alpha Centauri, four light years away. In James's frame

- (A) the trip takes more time than it does in the Earth's frame.
- (B) James travels to Alpha Centauri over a length that is shorter than four light years.
- (C) clocks on Earth and on Alpha Centauri are synchronized.
- (D) Alpha Centauri travels to James over a length that is shorter than four light years.

length contraction

19. The definition of the Theory of Special Relativity is:

- (A) The speed of light is the same in all inertial reference frames
- (B) Nothing can travel faster than the speed of light
- (C) The laws of physics are the same in all inertial reference frames
- (D) An observer will witness effects such as length contraction, time dilation, and mass increasing of an object he/she is observing

All the other statements are consequences of this Postulate

20. A 30-year-old astronaut goes off on a long-term mission in a spacecraft that travels at speeds close to that of light. The mission lasts exactly 20 years as measured on Earth. Biologically speaking, at the end of the mission, the astronaut's age would be

- (A) exactly 30 years.
- (B) less than 50 years.
- (C) exactly 50 years.
- (D) exactly 25 years.
- (E) more than 50 years.

time dilation

21. Observer A sees a ruler moving by in a relativistic rocket and measures its length to be L_A . Observer B moves along with the rocket and measures the length of the ruler to be L_B . What is true about these two length measurements?

- (A) $L_A < L_B$
- (B) $L_A > L_B$
- (C) $L_A = L_B$

length contraction

- (D) L_A could be greater or smaller than L_B depending on the direction of the motion

22. You are moving at a speed $2/3 c$ toward Randy when he shines a light toward you. At what speed do you see the light approaching you?

- (A) ☒ c
(B) ☐ $c/3$
(C) ☐ $4c/3$
(D) ☐ $2c/3$

light must move at speed c
in all inertial reference frames

23. According to the equation $E = mc^2$, an object turns into energy when it reaches the speed of light.

- (A) ☐ True
(B) ☒ False

24. A proton and an alpha particle are both accelerated to the same final speed. If λ_p is the de Broglie wavelength of the proton and λ_a is the de Broglie wavelength of the alpha particle, then

- (A) ☐ $\lambda_p = \lambda_a$
(B) ☒ $\lambda_p > \lambda_a$
(C) ☐ $\lambda_p < \lambda_a$

$$m_a \approx 4m_p$$

$$m_a > m_p$$

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

↑
bigger mass would mean smaller wavelength. So alpha particle has the smaller wavelength.

alpha particle is the nucleus of helium: 2 protons and 2 neutrons.