Name: Key

AP Physics

Date _____

Modern Physics

1) This question relates to the photoelectric effect. Which graph shows the maximum kinetic energy of the emitted electrons *versus* the frequency of the light?

A) 

B) 

$E = hf$

C) 

threshold f

D) 

E) 

2) This question relates to the photoelectric effect. Which graph shows the total photoelectric current *versus* the intensity of the light for a fixed frequency above the cutoff frequency?

↑ Intensity
↑ current

A) 

B) 

C) 

D) 

E) 

3) ~~Which of the following statements about the number of protons *Z* and the number of neutrons *N* in stable nuclei is true?~~

~~A) All stable nuclei have $Z = N$.~~
~~B) Heavy stable nuclei tend to have $Z < N$.~~
~~C) Only heavy stable nuclei have $Z = N$.~~
~~D) All light stable nuclei have $Z < N$.~~
~~E) All light stable nuclei have $Z > N$.~~

4) A 50,000 W radio station transmits waves of wavelength 4 m. Which of the following is the best estimate of the number of photons it emits per second?

A) 10^{30}
B) 10^{22}
C) 10^{8}
D) 10^{56}
E) 10^{40}

① $E_{tot} = Pt = (50{,}000)(1) = 50{,}00$

② $E_{one} = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\,J\cdot s\,(3\times10^{8}}{4\,m}$

③ $\# = \frac{E_{tot}}{E_{one}} = \frac{50000}{5\times10^{-26}}$

5) A system initially consists of an electron and an incident photon. The electron and the photon collide, and afterward the system consists of the electron and a scattered photon. The electron gains kinetic energy as a result of this collision. Compared with the incident photon, the scattered photon has

$E = \frac{hc}{\lambda}$

A) a smaller frequency
B) a larger frequency
C) a smaller speed
D) the same energy
E) a larger speed

photon ↓E ↑λ ↓f

6) 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?

↑ Intens
↓f or ↑λ

A) ~~Decrease the intensity~~ and wavelength of the light
B) Increase the intensity and wavelength of the light
C) ~~Decrease the intensity~~ and increase the wavelength of the light
D) Increase the intensity and ~~decrease the wavelength~~ of the light
E) None of the above would produce the desired result

7) Radio waves high λ low f low E
Infrared radiation
Visible light red violet
Ultraviolet radiation
Gamma radiation low λ high f high E

↑λ ↑f ↓

$E = hf$

For the five types of electromagnetic radiation listed above, which one of the following correctly describes the way in which wavelength, frequency, and photon energy change as one goes from the top of the list to the bottom?

A) Wavelength: ~~increases~~
Frequency: ~~decreases~~
Photon energy: ~~decreases~~
B) Wavelength: decreases
Frequency: ~~decreases~~
Photon energy: increases
C) Wavelength: ~~increases~~
Frequency: increases
Photon energy: increases
D) Wavelength: decreases
Frequency: increases
Photon energy: increases
E) Wavelength: ~~increases~~
Frequency: ~~decreases~~
Photon energy: increases

glancing collision
inner shell

8) Quantum transitions that result in the characteristic sharp lines of the X-ray spectrum always involve

inner shell electrons

A) protons within the nucleus
B) neutrons within the nucleus
C) electron energy levels that have the same principal quantum number
D) emission of beta particles from the nucleus
E) the inner electron shells

9) Which of the following experiments provided evidence that electrons exhibit wave properties?

I. Millikan oil-drop experiment ← charge of e
II. Davisson-Germer electron-diffraction experiment ✓
III. J. J. Thomson's measurement of the charge-to-mass ratio of electrons q:m not waves

A) II and III only
B) I, II, and III
C) II only
D) I and III only
E) I only

10) Quantities that are conserved in all nuclear reactions include which of the following?

I. Electric charge
II. Number of nuclei ← can turn to energy
~~III.~~ Number of protons

A) II only
B) II and III only
C) I only
D) I, II, and III
E) I and III only

$^{0}_{-1}e$ γ

11) A negative beta particle and a gamma particle are emitted during the radioactive decay of a nucleus of $_{82}^{214}Pb$. Which of the following is the resulting nucleus?

A) $_{83}^{214}Bi$
B) $_{81}^{214}Tl$
C) $_{84}^{218}Po$
D) $_{83}^{213}Bi$
E) $_{80}^{210}Hg$

$^{214}_{82}Pb \rightarrow \, ^{0}_{-1}e + \gamma + \text{energy}$

$214 + 0 = 214$

$83 - 1 = 82$

12) Quantum concepts are critical in explaining all of the following EXCEPT

A) the blackbody spectrum photon E
B) Compton scattering photon P
C) the photoelectric effect photon E
D) Rutherford's scattering experiments nucleus/atomic structure
E) Bohr's theory of the hydrogen atom photon E

13) 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?

Duplicate of #6

A) Increase the intensity and the wavelength of the light.
B) Increase the intensity and decrease the wavelength of the light.
C) None of the above would produce the desired result.
D) Decrease the intensity and the wavelength of the light.
E) Decrease the intensity and increase the wavelength of the light.

Questions 14 and 15 refer to the following:

The following reaction is a good example of nuclear fission.

more m less m + Energy

$_{92}^{235}U + _{0}^{1}n \rightarrow _{56}^{138}Ba + _{36}^{95}Kr$ + neutrons + released energy

236 $235 + 1 = 138 + 95$ 233

92 $92 + 0 = 56 + 36$ 92

need 3 neutrons $3\,^{1}_{0}n$

14) The total number of free neutrons in the products of this reaction is

A) 6
B) 2
C) 4
D) 3
E) 5

15) Which of the following statements is always true for neutron-induced fission reactions involving $_{92}^{235}U$?

I. The end products always include Ba and Kr.
II. The rest mass of the end products is less than that of $_{92}^{235}U + _{0}^{1}n$.
III. The total number of nucleons (protons plus neutrons) in the end products is less than that in $_{92}^{235}U + _{0}^{1}n$.

equal

A) III only
B) I and III only
C) I and II only
D) I, II, and III
E) II only

16) Of the following phenomena, which provides the best evidence that particles can have wave properties?

A) The interference pattern produced by neutrons incident on a crystal — particle act like wave
B) The scattering of photons by electrons at rest — photon = particle
C) The alpha-decay of radioactive nuclei
D) The production of x-rays by electrons striking a metal target — electron collision
E) The absorption of photons by electrons in an atom

17) Atoms of isotopes of the same element contain the same number of

A) neutrons but a different number of protons
B) protons but a different number of neutrons
C) protons as neutrons
D) electrons but a different number of protons
E) neutrons as electrons

18) In the Bohr model of the atom, the postulate stating that the orbital angular momentum of the electron is quantized can be interpreted in which of the following ways?

A) Only one electron can exist in each possible electron state.
B) The atom is composed of a small, positively charged nucleus orbited by electrons.
C) An incident photon is completely abosrbed when it causes an electron to move to a higher energy state.
D) An electron has a spin of 1/2.
E) An integral number of electron wavelengths must fit into the electron's circular orbit.

whole λ in orbit

more m — less m + energy

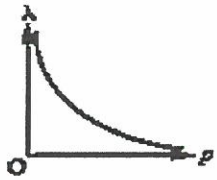
19) The nuclear reaction X → Y + Z occurs spontaneously. If M_X, M_Y, and M_Z are the masses of the three particles, which of the following relationships is true?

A) $M_X > M_Y + M_Z$
B) $M_X < M_Y - M_Z$
C) $M_X - M_Z < M_Y$
D) $M_X < M_Y + M_Z$
E) $M_X - M_Y < M_Z$

20) Which of the following graphs best represents the de Broglie wavelength λ of a particle as a function of the linear momentum *p* of the particle?

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

Inverse

A)


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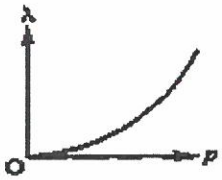

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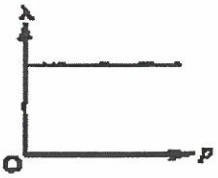

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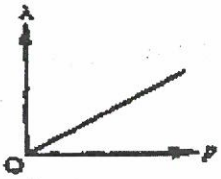
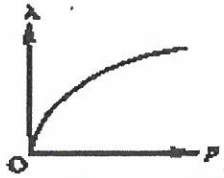


E)


21) $_{1}^{2}H + _{1}^{2}H \rightarrow _{1}^{3}H + _{1}^{1}H + 4$ MeV

made higher value

fused a nucleus

The equation above is an illustration of

A) nuclear disintegration
B) nuclear fission
C) artificially produced radioactive decay
D) nuclear fusion
E) naturally occurring radioactive decay

22) A proton collides with a nucleus of $_7{}^{14}N$. If this collision produces a nucleus of $_6{}^{11}C$ and one other particle, that particle is

A) a deuteron
B) an α particle
C) a β particle
D) a neutron
E) a proton

23) The scattering of alpha particles by a thin gold foil was measured by Geiger and Marsden. The Rutherford model of the atom was proposed in order to explain why

A) more particles scattered through angles greater than 90° than through angles less than 90°
B) the most common scattering angle was about 180°
C) no particles passed through the foil undeflected
D) the fraction of particles scattered through large angles was too large to be explained by previous models of the atom
E) the most common scattering angle was about 90°

24) A nucleus of tritium contains 2 neutrons and 1 proton. If the nucleus undergoes beta decay, emitting an electron, the nucleus is transmuted into

A) a triton
B) the nucleus of an isotope of lithium
C) the nucleus of an isotope of helium
D) an alpha particle
E) a deuteron

25) Which of the following statements is true of a beta particle?

A) It has a mass of about 1,840 times that of a proton.
B) It has a charge equal and opposite to that of an alpha particle.
C) It is more penetrating than a gamma ray of the same energy.
D) Its speed in a vacuum is 3×10^8 m/s.
E) It can exhibit wave properties.

Questions 26 and 27 refer to the following:

An electron and a positron, each of mass 9.1×10^{-31} kilogram, are in the same general vicinity and have very small initial speeds. They then annihilate each other, producing two photons.

26) What is the approximate energy of each emerging photon?

A) 0.51 MeV
B) 4.0 MeV
C) 2.0 MeV
D) 6.6 MeV
E) It cannot be determined unless the frequency of the photon is known.

27) What is the angle between the paths of the emerging photons?

A) 30°
B) 45°
C) 0°
D) 180°
E) 90°

28) Which color of light emitted from an atom would be associated with the greatest change in energy of the atom?

A) violet
B) blue
C) red
D) yellow
E) green

29) $_{92}{}^{235}U + {}_0{}^1n \rightarrow 3\,{}_0{}^1n + {}_{56}{}^{142}Ba + \_\_\_\_\_$

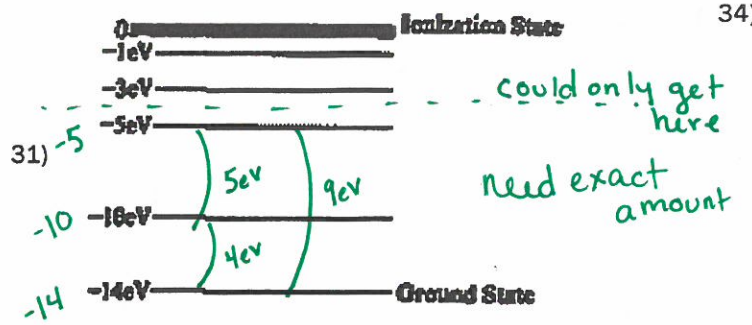
The additional product of the nuclear fission reaction shown above is

A) $_{35}{}^{92}Br$
B) $_{36}{}^{93}Kr$
C) $_{37}{}^{94}Rb$
D) $_{36}{}^{91}Kr$
E) $_{37}{}^{93}Rb$

30) Electrons that have been accelerated from rest through a potential difference of 150 volts have a de Broglie wavelength of approximately 1 Angstrom (10^{-10} meter). In order to obtain electrons whose de Broglie wavelength is 0.5 Angstrom (5×10^{-11} meter), what accelerating potential is required?

A) 75 V
B) 22,500 V
C) 300 V
D) 600 V
E) 37.5 V

31)



The energy level diagram above 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?

relax back

A) 1, 3, 5, and 10 eV only
B) 4, 5, and 9 eV only
C) 1, 5, 7, and 10 eV only
D) Since the original photons have a range of energies, one would expect a range of emitted photons with no particular energies.
E) 1, 2, and 3 eV only

32) Forces between two objects which are inversely proportional to the square of the distance between the objects include which of the following?

I. Gravitational force between two celestial bodies
II. Electrostatic force between two electrons
III. Nuclear force between two neutrons

A) II and III only
B) I, II, and III
C) III only
D) I only
E) I and II only

33) The work function for a metal is ϕ. What is the threshold frequency of incident light required for the emission of photoelectrons from a cathode made of that metal?

nok

A) $\phi/(hc)$
B) ϕ/h
C) $(hc)/\phi$
D) h/ϕ
E) ϕh

$K = hf - \phi$

$f = \frac{\phi}{h}$

34) Two monochromatic light beams, one red and one green, have the same intensity and the same cross-sectional area. How does the energy of each photon and the number of photons crossing a unit area per second in the red beam compare with those of the green beam?

$\uparrow\lambda$ $\downarrow\lambda$

A) **Energy of Photon:** less for red
Number of Photons: ~~less for red~~
B) **Energy of Photon:** ~~same~~
Number of Photons: ~~same~~
C) **Energy of Photon:** ~~greater for red~~
Number of Photons: greater for red
D) **Energy of Photon:** ~~greater for red~~
Number of Photons: ~~less for red~~
E) **Energy of Photon:** less for red
Number of Photons: greater for red

$E = \frac{hc}{\lambda}$ $\uparrow\lambda \Rightarrow \downarrow E$

less red

Same Intensi
Same total

more red to get same value

35) Correct statements about the binding energy of a nucleus include which of the following?

binding energy = mass defect

I. It is the energy needed to separate the nucleus into its individual protons and neutrons.

II. It is the energy liberated when the nucleus is formed from the original nucleons.

III. It is the energy equivalent of the apparent loss of mass of its nucleon constituents.

A) I and II only
B) II and III only
C) III only
D) I, II, and III
E) I only

36) In an x-ray tube, electrons striking a target are brought to rest, causing x-rays to be emitted. In a particular x-ray tube, the maximum frequency of the emitted continuum x-ray spectrum is f_0. If the voltage across the tube is doubled, the maximum frequency is

A) $f_0/\sqrt{2}$
B) $2f_0$
C) f_0
D) $f_0/2$
E) $\sqrt{2}\, f_0$

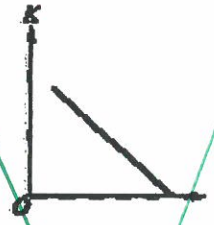
$U_e = E_{photon}$

$qV = hf$

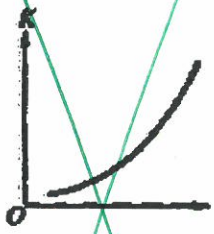
$f = \frac{qV}{h} = \frac{(1)(2)}{(1)}$

37) This question relates to the photoelectric effect. Which graph best shows the maximum kinetic energy K of the photoelectrons as a function of the frequency of incident light

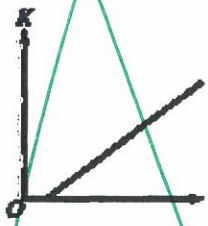
A)



B)



C)



D)

E)

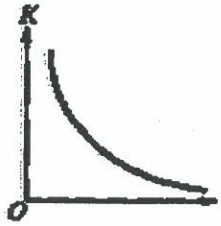
Duplicate #1

38) The question relates to the photoelectric effect. Which graph best shows the maximum kinetic energy K of the photoelectrons as a function of the intensity of incident light?

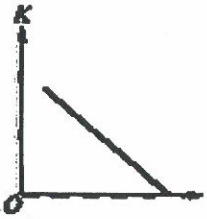
$K = hf - \phi$

Intensity
↑ # photon
not their K

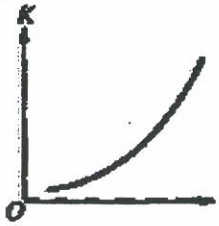
A)



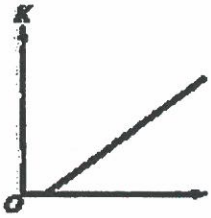
B)



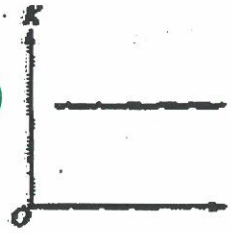
C)



D)



E)



1) C
2) B
3) ~~B~~
4) A
5) A
6) B
7) D
8) E
9) C
10) C
11) A
12) D
13) A
14) D
15) E
16) A
17) B
18) E
19) A
20) A
21) D
22) B
23) D
24) C
25) E
26) ~~X~~ A
27) D
28) A
29) D
30) D
31) B
32) ~~E~~
33) B
34) E
35) D
36) B
37) C
38) E