Physics 212, Spring 2009
Quiz 6, Form: A

Name: Key

Date:

Magnitude of the charge of an electron or proton: $e = 1.6 \times 10^{-19}$ C.

Planck's constant: $h = 6.626 \times 10^{-34}$ J s $\quad h = 4.136 \times 10^{-15}$ eV s

Speed of light: $c = 3 \times 10^{8}$ m/s

Rydberg constant: $R_H = 1.097 \times 10^{7}$ m^{-1}

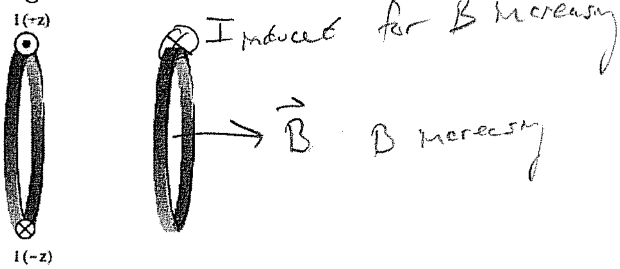
Wien's constant: $b = 2.09 \times 10^{-3}$ m K

1 eV $= 1.6 \times 10^{-19}$ J

Section 1. Multiple Choice

1. The theory explaining the experimental results of the photoelectric effect is historically significant because it showed that
   - (a) light is an electromagnetic wave.
   - (b) light interferes.
   - (c) electrons are bound to nuclei to make up atoms.
   - (d) light is made up of particles, called photons.
   - (e) electrons interfere and thus can be treated as waves.

Questions 2–4: A primary coil has current flowing through it as shown below.



You connect an ammeter to the secondary coil (i.e. pickup coil) and measure the induced current through the secondary coil.

2. If the current in the primary coil is constant, then the direction of the induced current in the top of the secondary coil is
   - (a) out of the page, in the +z direction.
   - (b) into the page, in the −z direction.
   - (c) None of the above because the induced current is zero.

3. If the current in the primary coil increases, then the direction of the induced current in the top of the secondary coil is
   - (a) out of the page, in the +z direction.
   - (b) into the page, in the −z direction.
   - (c) None of the above because the induced current is zero.

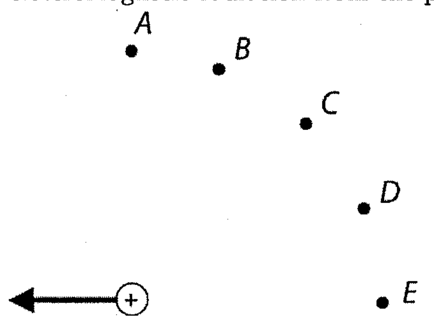
4. If you have a constant current in the primary coil and then you suddenly disconnect the primary coil from the battery so that its current quickly drops to zero, ~~then~~ at the moment you disconnect the primary coil, ~~then~~ the direction of the induced current in the top of the secondary coil is
   - (a) out of the page, in the +z direction.
   - (b) into the page, in the −z direction.
   - (c) None of the above because the induced current is zero.

5. Which of these photons has the longest wavelength?
   - (a) gamma ray
   - (b) x-ray
   - (c) ultraviolet
   - (d) visible
   - (e) infrared
   - (f) radio

$c = \lambda f$

6. Radio waves have a longer wavelength than visible light. As a result, the frequency of radio waves is
   - (a) ~~higher~~ greater than the frequency of visible light.
   - (b) smaller than the frequency of visible light.
   - (c) the same as the frequency of visible light.

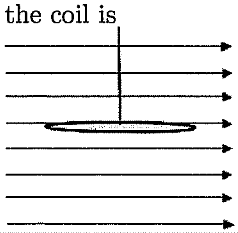
7. A proton is accelerated in the direction shown below. As a result, an electromagnetic pulse is emitted. At which point will there be NO electromagnetic radiation from the proton?



   - (a) A
   - (b) B
   - (c) C
   - (d) D
   - (e) E

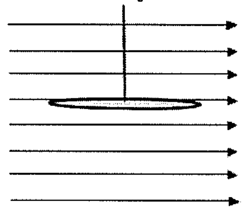
Questions 8–9: A spinning coil in a magnetic field is used as an electric generator. The induced voltage (i.e. emf) across the coil has a maximum of 3 V and a minimum of −3 V as the coil rotates. In general, the emf is given by the function $\epsilon = 3\sin(\omega t)$.

8. At an instant when the coil is in the orientation shown below, the *magnetic flux* through the coil is



   - (a) zero.
   - (b) equal to the maximum possible flux
   - (c) greater than zero, but not equal to the maximum possible flux.

9. If the coil is in the orientation shown below, the *induced emf* is



   - (a) 3 V
   - (b) 0
   - (c) Between 0 and 3 V.

10. A small current flows through a flashlight bulb; however, the filament is not hot enough to give off visible light. What light does it mostly give off?
    - (a) gamma ray
    - (b) x-ray
    - (c) ultraviolet
    - (d) infrared
    - (e) radio

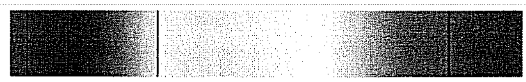
11. Which physicist explained the photoelectric effect, for which he won the Nobel Prize?
    - (a) Albert Einstein
    - (b) Isaac Newton
    - (c) Neils Bohr
    - (d) Louis deBroglie
    - (e) Max Planck

12. Two hydrogen atoms are both in the ground state. Hydrogen atom A absorbs a photon of energy 12.09 eV. Hydrogen atom B absorbs a photon of energy 10.2 eV. Which atom is in a higher energy state after absorbing a photon?

    $|\Delta E| = E_{photon}$

    - (a) Atom A
    - (b) Atom B
    - (c) Neither, they will be in the same energy state after absorbing the different photons.

13. What type of spectrum is this?



    - (a) an absorption spectrum
    - (b) an emission spectrum

14. A hydrogen atom emits a photon of energy 0.66 eV. What is the frequency of the photon?

(a) 9.96×10^{32} Hz
(b) 0.66 Hz
(c) 4.5×10^{8} Hz
(d) 188 Hz
(e) 1.6×10^{14} Hz

15. Which of these photons will have the highest energy?

(a) gamma ray
(b) x-ray
(c) ultraviolet
(d) visible
(e) infrared
(f) radio

16. What is the temperature of a star that has a peak wavelength of 500 nm?

(a) 6130 K
(b) 5000 K
(c) 3720 K
(d) 4180 K
(e) 8370 K

17. If a hydrogen atom starts in the state $n = 5$ and transitions to the state $n = 2$, the atom

(a) absorbed a photon.
(b) emitted a photon.
(c) did not absorb or emit a photon.

18. What is the energy of a hydrogen atom that is in its ground state (i.e. lowest energy state)?

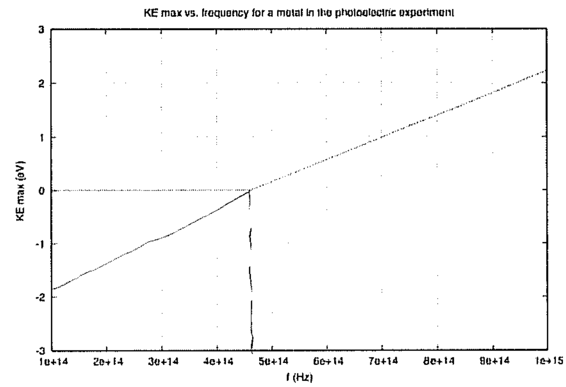
(a) 0
(b) −1.51 eV
(c) −3.4 eV
(d) −13.6 eV
(e) −15.1 eV

19. Suppose that you increase the current through a light bulb and watch it change from orange to yellow to white. As the filament gets hotter, what happens to the peak wavelength of its radiated light?

(a) It remains the same.
(b) It increases.
(c) It decreases.

Questions 20–22:

20. In the photoelectric effect, light shines on a metal. At low frequencies, no electrons are ejected from the metal. Then, at a certain minimum frequency, electrons are ejected from the metal. A graph of the maximum KE of the ejected electrons as a function of frequency is shown below.



Use the graph to determine (approximately) the work function of the metal?

(a) 0 eV
(b) −0.5 eV
(c) 2.2 eV
(d) −3.0 eV
(e) −1.9 eV

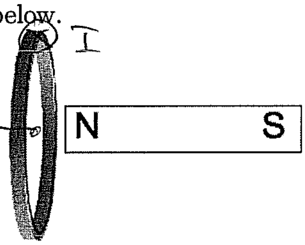
21. For the graph in the previous question, what does the slope of the line equal?

(a) Planck's constant
(b) the speed of light
(c) Wien's constant
(d) Rydberg Constant
(e) The work function.

22. For the graph in the previous question, approximately what mimimim frequency is required to knock off an electron from the metal?

   (a) 1.0×10^{14} Hz
   (b) 4.6×10^{14} Hz
   (c) 7.0×10^{14} Hz
   (d) 1.0×10^{15} Hz
   (e) zero

23. A magnet is held close to the wire coil shown below.



B is decreasing

If the magnet is moved away from the coil (in the +x direction), the induced current in the coil *at the top of the coil* will flow

   (a) into the page (in the $-z$ direction)
   (b) out of the page (in the $+z$ direction)
   (c) None of the above because the induced current in the coil will be zero in this case.

24. For the previous question, if you hold the magnet at rest at the position shown, the induced current in the coil *at the top of the coil* will flow

   (a) into the page (in the $-z$ direction)
   (b) out of the page (in the $+z$ direction)
   (c) None of the above because the induced current in the coil will be zero in this case.

25. Suppose that the nearest cell tower is 1600 m (i.e. 1 mile) from you. How long does it take for radio waves from your cell phone to travel to the cell tower? (For simplicity assume that the radio waves travel through a vacuum.)

   (a) 1.9×10^{5} s
   (b) 1600 s
   (c) 5.3×10^{-6} s
   (d) 0.053 s
   (e) 0.16 s

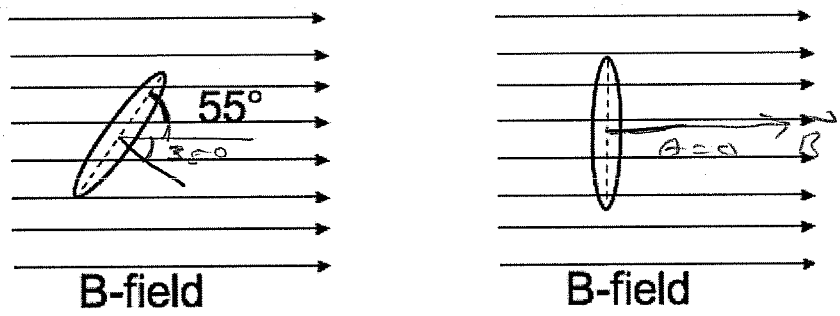
$c = \frac{d}{t}$

$t = \frac{d}{c} = \frac{1600 \text{ m}}{3 \times 10^{8} \text{ m/s}}$

$=$

Section 2. Problem Solving

26. A circular coil of wire of 100 turns and radius 2 cm is in a uniform magnetic field with a magnitude of 0.48 T. At a certain instant, the plane of the coil makes an angle of 55 degrees with respect to the magnetic field. If in 0.02 s, the coil rotates so that the plane is perpendicular to the magnetic field, as shown below, what is the induced emf around the coil?



$N = 100$

$R = 0.02\,m$

$B = 0.48\,T$

$\theta_i = 35°$

$\theta_f = 0°$

$\Delta t = 0.02\,s$

+5

$\mathcal{E} = -\frac{\Delta \Phi}{\Delta t}$ +5

$= -\frac{(\Phi_f - \Phi_i)}{\Delta t}$

$= -\frac{(NBA\cos\theta_f - NBA\cos\theta_i)}{\Delta t}$

$= -NBA\frac{(\cos\theta_f - \cos\theta_i)}{\Delta t}$ +5

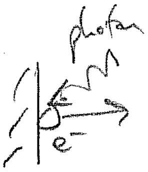
$= -\frac{(100)(0.48)(\pi)(0.02)^2(\cos 0 - \cos 35)}{0.02\,s}$

$\boxed{\mathcal{E} = -0.55\,V}$ +5

25

27. Magnesium metal has a work function of 5.9×10^{-19} J. What minimum frequency light is required to knock off an electron from the surface of the metal?

$$\phi = 5.9 \times 10^{-19}\, J$$



$$KE_{max} = hf - \phi$$

min. KE_{max} is 0 so

$$0 = hf - \phi$$

$$hf = \phi$$

$$f = \frac{\phi}{h} = \frac{5.9 \times 10^{-19}\, J}{6.626 \times 10^{-34}\, Js}$$

$$f_{min} = \boxed{8.9 \times 10^{14}\, Hz}$$

$$\lambda_{min} = \frac{c}{f} = 337\, nm$$

(10)

28. If light of wavelength 315 nm shines on magnesium, what is the speed of the ejected electron?

$$KE_{max} = hf - \phi$$

$$= \frac{hc}{\lambda} - \phi$$

$$= \frac{(6.626 \times 10^{-34}\, Js)(3 \times 10^{8}\, \frac{m}{s})}{(315 \times 10^{-9}\, m)} - 5.9 \times 10^{-19}\, J$$

$$= 6.31 \times 10^{-19}\, J - 5.9 \times 10^{-19}\, J$$

$$= 4.1 \times 10^{-20}\, J$$

$$KE = \frac{1}{2} m v^2$$

So $$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2(4.1 \times 10^{-20})}{9.11 \times 10^{-31}\, kg}} = \boxed{3.0 \times 10^{5}\, \frac{m}{s}}$$

(15)