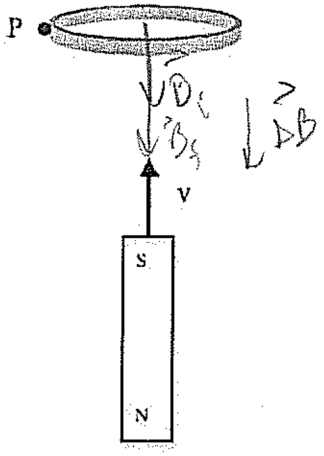
Physics 1520, Fall 2012
Quiz 5, Form: $\boxed{\text{A}}$

Name: Key
Date: ____________

Section 1. Multiple Choice

Questions 1–4: A magnet moves at constant speed toward a wire loop as shown below.



Define $+x$ to the right, $+y$ upward toward the top of the page, and $+z$ outward toward you, perpendicular to the page.

1. At the center of the loop, what is the direction of the magnetic field?

   (a) $+x$
   (b) $-x$
   (c) $+y$
   [✓ (d)] $-y$
   (e) $+z$
   (f) $-z$
   (g) None of the above because it is zero.

   ↓ $\vec{B}$ is toward S pole

2. What is the direction of the change in the magnetic field $\Delta\vec{B}$ at the center of the loop during some time interval Δt?

   (a) $+x$
   (b) $-x$
   (c) $+y$
   [✓ (d)] $-y$
   (e) $+z$
   (f) $-z$
   (g) None of the above because it is zero.

   $\vec{B}$ is increasing so $\Delta\vec{B}$ is in dir. of $\vec{B}$.

3. What is the direction of the induced current I at location P inside the wire?

(a) $+x$

(b) $-x$

(c) $+y$

(d) $-y$

[✓ (e)] $+z$

(f) $-z$

(g) None of the above because it is zero.

$\uparrow -\vec{\Delta B}$

$\downarrow \vec{\Delta B}$

Use R.H.R. with thumb in dir. of $-\vec{\Delta B}$

4. Suppose that the emf induced around the loop at the instant shown is ε. If you replace the loop with a coil of the same radius, but with N turns and repeat the experiment, then the emf induced around the coil at the same instant is

A coil is like N loops in series.

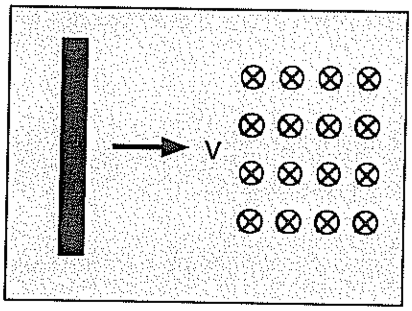
(a) the same, ε

(b) ε/N

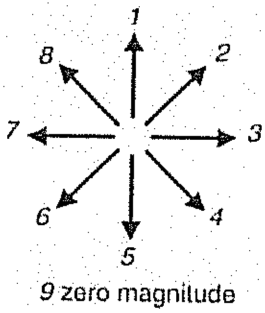
[✓ (c)] $N\varepsilon$

(d) None of the above because it is zero.

Questions 5–9: A wire moves at constant velocity through a region of uniform magnetic field, which is the shaded region shown below.



5. What is the direction of the magnetic force on an *electron* in the wire?



(a) 1

(b) 3

(c) 7

(d) 9

[✓ (e)] 5

R.H.R. thumb – $\vec{v}$

Index finger – $\vec{B}$

middle finger – $\vec{F}$ on $+q$.

$\vec{F}$ on $-q$ is opposite $\vec{F}$ on $+q$.

$\downarrow \vec{F}_{mag}$

6. Which end of the wire will be negatively charged?

   (a) the top end

   [✓ (b)] the bottom end

$\vec{F}_{mag}$ on $-q$ is downward, so $-$ charge piles up on bottom end

7. Once the wire becomes polarized and reaches equilibrium, then the net force on a mobile electron is zero. If the magnetic field is 0.1 T and the wire is 10 cm long, what is the emf across the wire if the wire is moving at a speed of 0.5 m/s?

   [✓ (a)] 0.005 V

   (b) 0.01 V

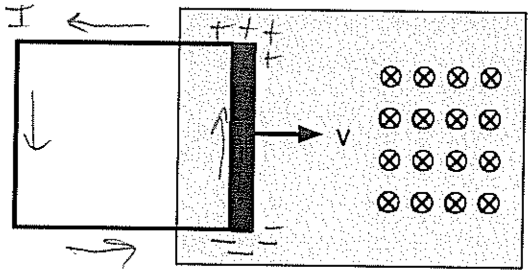
   (c) 0.02 V

   (d) 0.5 V

   (e) zero, because there will be no emf across the wire.

$$\mathcal{E} = vLB$$
$$= (0.5\,\tfrac{m}{s})(0.1\,m)(0.1\,T)$$
$$= 0.005\ V$$

8. Now, suppose you connect the wire to other wires to form a loop and you repeat the experiment, as shown below.



In what direction does current flow around the loop?

   [✓ (a)] counterclockwise

   (b) clockwise

I flows from + terminal to − terminal.

9. If the resistance of the loop is 2 Ω and if the emf if 0.001 V, what is the current through the loop?

   (a) 2×10^{-3} A

   (b) 1×10^{-3} A

   [✓ (c)] 5×10^{-4} A

   (d) 1×10^{-4} A

   (e) 2×10^{-4} A

$$I = \frac{0.001\,V}{2\,\Omega} = 5\times10^{-4}\,A$$

Ohm's law

10. The work function for zinc is about 4.24 eV. What is the maximum wavelength that light falling on the zinc can have for its photons to have enough energy to eject electrons from the zinc?

   (a) 439 nm

   (b) 585 nm

   (c) 877 nm

   [✓ (d)] 292 nm

   (e) 195 nm

$K_{max} = hf - W$

at $K_{max} = 0$, $hf = W$

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

$$\lambda = \frac{hc}{W} = \frac{1240\,eV \cdot nm}{4.24\,eV} = 292\ nm$$

11. If purple light of wavelength 400 nm shines on zinc,

$\lambda > \lambda_{max}$ so no electrons are ejected.

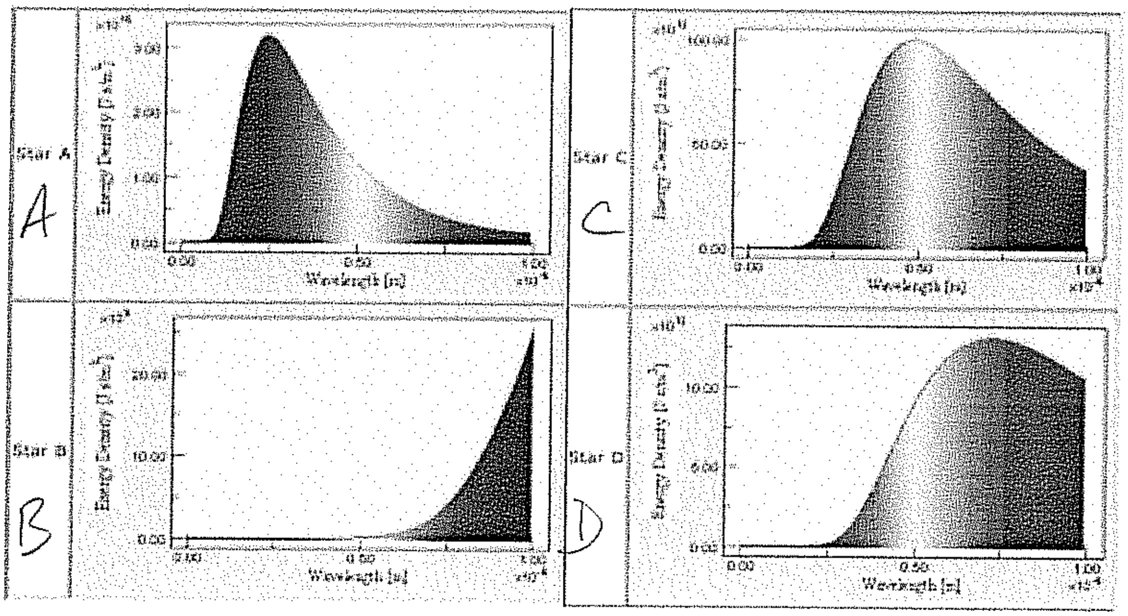
   (a) electrons will be ejected with a maximum kinetic energy of 1.14 eV.

   (b) electrons may or may not be ejected depending on the value of the stopping potential.

   [✓ (c)] no electrons will be ejected because the photons do not have enough energy to knock an electron off the metal.

Questions 12–13:

The blackbody curves for four stars are shown below, with the visible region of the electromagnetic spectrum superimposed onto the graph. (Note that real stars have absorption peaks which are not shown in the graphs. Also, keep in mind that the curves would be similar for light bulbs. The fact that the bodies are stars is irrelevant to the questions.) In all pictures $\longrightarrow +\lambda$



12. Which star has the lowest temperature?

    (a) A
    [✓ (b)] B
    (c) C
    (d) D
    (e) They all have the same temperature.

lowest T is highest λ_{peak}, since $\lambda_{peak} \propto \frac{1}{T}$.

13. What would be the color of Star C? (Hint: remember the demonstration that we did with the light bulb in class.)

    (a) yellow
    (b) orange
    (c) red
    (d) blue
    [✓ (e)] white

14. A hydrogen atom is in the state $n = 3$. What minimum energy is needed to remove the electron from the atom when it is in this state?

    [✓ (a)] 1.51 eV
    (b) 1.89 eV
    (c) 3.4 eV
    (d) 10.2 eV
    (e) 13.6 eV

$$E_3 = \frac{-13.6\ eV}{n^2} = -1.51\ eV$$

$E_f = 0$ is when the electron is free (unbound)

$$\Delta E = E_f - E_i = 0 - (-1.51\ eV) = +1.51\ eV$$

15. If a hydrogen atom emits a photon, the radius of the electron's orbit will

- (a) remains the same.
- [✓ (b)] decrease.
- (c) increase.

16. A hydrogen atom is in the state $n = 2$. Monochromatic light of energy 2.86 eV shines on the hydrogen atom. If it absorbs a photon, what state will it be in?

- (a) 1
- (b) 3
- (c) 4
- [✓ (d)] 5
- (e) It will remain in the state $n = 2$ because hydrogen in this state will not absorb a photon of energy 2.86 eV.

$$E_2 = \frac{-13.6\text{ eV}}{2^2} = -3.4\text{ eV}$$

$$E_f = E_i + \Delta E = -3.4\text{ eV} + 2.86\text{ eV} = -0.54\text{ eV}$$

$$E_5 = -\frac{13.6\text{ eV}}{5^2} = -0.54\text{ eV}$$

17. If a hydrogen atom transitions from the n=2 state to the n=1 state, what kind of photon is emitted? (Note that this is not a memorized fact. You should calculate the energy of the emitted photon and use the chart to determine what region of the EM spectrum it is.)

- (a) x-ray
- [✓ (b)] UV
- (c) visible
- (d) radio
- (e) IR

$$\Delta E = E_1 - E_2 = -13.6\text{ eV} - \frac{-13.6\text{ eV}}{2^2}$$

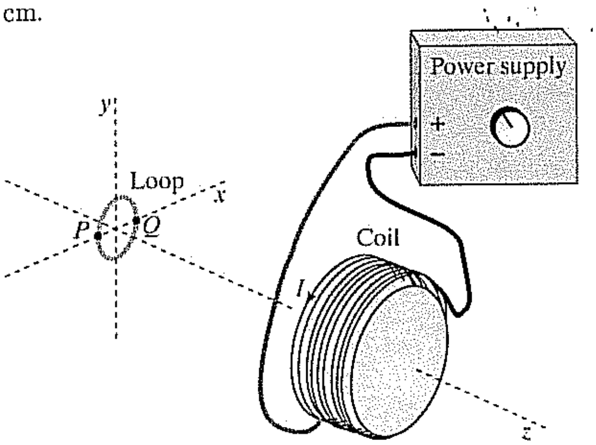
$$= -13.6\text{ eV} + 3.4\text{ eV} = -10.2\text{ eV}$$

$$E_{photon} = |\Delta E| = 10.2\text{ eV}$$

This is U.V.

Section 2. Problem Solving

18. A coil of wire is connected to a power supply, and a current runs in the coil. A single loop of wire is located near the coil, with its axis on the same line as the axis of the coil. The radius of the loop is 3 cm.



At time t_1 the magnetic field at the center of the loop, due to the coil, is 0.6 T and constant due to current in the coil.

(a) At this time, what is the magnetic flux in the loop?

$$\Phi = BA\cos(0) = BA = (0.6T)\pi(0.03m)^2 = \boxed{1.70 \times 10^{-3}\ T\cdot m^2}$$

(b) At this time, what is the emf induced around the loop?

$\mathcal{E}_{mf} = 0$ Since Φ is constant (i.e. not changing)

(c) At a later time t_2, the current in the coil begins to decrease such that in one second, the change of the magnetic field at the surface of the loop is −0.25 T. At this instant, what is the emf around the loop? (Just report the absolute value of the emf.)

$$\mathcal{E} = \left|\frac{\Delta\Phi}{\Delta t}\right| = \frac{\Delta(BA\cos(0))}{\Delta t} = A\left|\frac{\Delta B}{\Delta t}\right| = \pi r^2\left(\frac{0.25T}{1s}\right)$$

$$= \pi(0.03m)^2\left(\frac{0.25T}{s}\right) = \boxed{7.07 \times 10^{-4}\ V}$$

(d) If the resistance of the loop is 0.5 Ω, what is the current in the loop?

hm's
Law

$$I = \frac{\mathcal{E}}{R} = \frac{7.07\times10^{-4}\ V}{0.5\ \Omega} = \boxed{1.4 \times 10^{-3}\ A}$$

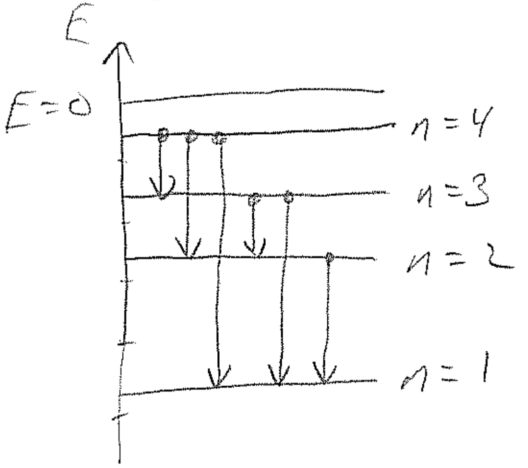
$$= 1.4\ mA$$

19. (a) A hypothetical atom has the following energy states and can initially be in any of the states.

-0.6 eV (n=4)
-1.4 eV (n=3)
-2.8 eV (n=2)
-4.7 eV (n=1)

Sketch an energy level diagram. Draw one vertical arrow for each possible transition that corresponds to an emitted photon. (Make sure that the arrows are pointed the correct direction to show emission.) Make a table with n_i, n_f, and ΔE for each transition. This table will help you answer the next two questions.

6 transitions



n_i	n_f	$\|\Delta E\|$
4	3	$\|-1.4 - -0.6\| = 0.8$ eV
4	2	$\|-2.8 - -0.6\| = 2.2$ eV
4	1	$\|-4.7 - -0.6\| = 4.1$ eV
3	2	$\|-2.8\text{eV} - -1.4\text{eV}\| = 1.4$ eV
3	1	$\|-4.7\text{eV} - -1.4\text{eV}\| = 3.3$ eV
2	1	$\|-4.7\text{eV} - -2.8\text{eV}\| = 1.9$ eV

(b) What is the highest energy photon that it can emit?

4.1 eV (see table)

This is $n=4$ to $n=1$

(c) What are the energies and wavelengths of the emitted photons that are in the visible region of the spectrum (see the given table)? Give the wavelengths in nm and energies in eV. Also, indicate which color each photon will be.

Visible: 1.8 eV to 3.1 eV
violet red

2.2 eV has $\lambda \approx \frac{hc}{E} = \frac{1240 \text{ eV}\cdot\text{nm}}{2.2 \text{ eV}}$

$\approx$ 564 nm
Green (or yellow)

1.9 eV has $\lambda =$ 653 nm
Red

So 2 visible photons:
2.2 eV $(4 \rightarrow 2)$ and 1.9 eV $(2 \rightarrow 1)$

(d) What physicist suggested that light is a particle (later called a photon) and proposed that its energy is $E = hf$?

Einstein