Apr 15

Get clickers

FINAL EXAM INFO:
Wednesday, April 22nd from 12:00-1:50 in this room
Practice exam on website

Please don't spill on computers!!!

Discussion: Sparks in the air

$E \sim 3e6\ N/C$ from exp't.

Are e^- jumping gap?

If are, how far will they go?

22.4 l/mol

area is area of N_2 mol

Volume of N_2 molecule

$$22.4\frac{\ell}{\text{mol}}\left(\frac{0.1\text{m}}{\ell}\right)^3\frac{1\text{mol}}{6\times10^{23}\text{molecules}} = 3.7\times10^{-26}\ \text{m}^3/\text{molecule}$$

$$\text{Volume} = \pi r^2 d = \pi d\,(1.5\times10^{-10}\text{m})^2$$

$$\Rightarrow d = 5.3\times10^{-7}\text{m}$$

expect e^- would travel $\sim 5\times10^{-7}$ m before hitting air molecule

1) Air must became a conductor

2) Spark stops when E drops below critical value

3) light

4) heat, noise, ...

Are we ripping e^- out of atoms?

How big a field do we need to do this?

Distance $\sim 1\text{Å} = 10^{-10}\text{m}$

E field due to proton at $\sim$Å

$$E \sim 9e9 \frac{1.6e-19}{(10^{-10})^2} = 1.4e11\ N/C$$

$\Rightarrow$ about 100,000 bigger than needed for spark

Not pulling e^- out of atom

If we had free e^-, would get accelerated then hit N_2 after $\sim 6\times10^{-7}$ m

↳ get ion + electron + original e^-

hit more N_2, get 4e^-, etc.

Energy needed is

$$U_{el} = qV = +e\frac{1}{4\pi\varepsilon_0}\frac{e}{10^{-10}\text{m}} = 2.3e{-}18\text{J}$$

If had free e^-, put in energy

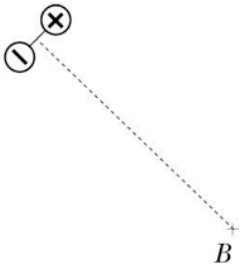
$$q\Delta V = -eEd$$

$$2.3e{-}18\text{ J} = 1.6e{-}18CE\ 6e{-}7\text{m} \Rightarrow E = 3\times10^{7}\text{ N/C}$$

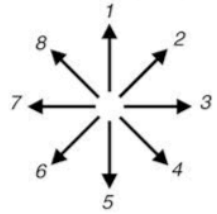
Free e^- Comes from air

We are being bombarded by aliens from outer space.

Q13.4b



An alpha particle (He^{+2}) is placed at location *B*. What is the direction of the force on the alpha particle?



9 zero magnitude

A. 2
B. 4
C. 6
D. 8
E. 9

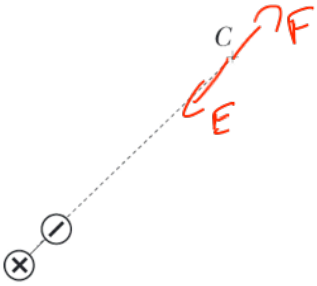
A. Soda

B. Pop

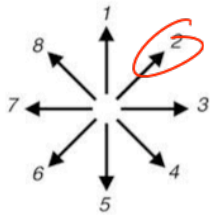
C. Coke

D. Something else

F. Q13.4c

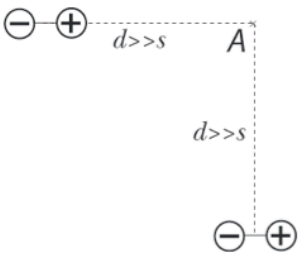


A chloride ion (Cl^-) is placed at location *C*. What is the direction of the force on the chloride ion?

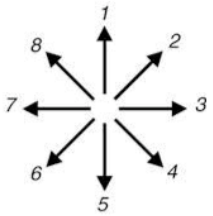


A. 2
B. 4
C. 6
D. 8
E. 9

Q13.4f *Think carefully*



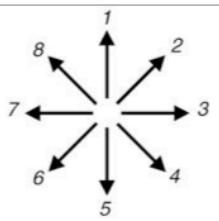
What is the direction of the net electric field at location A?



A. 1
B. 3
C. 5
D. 7
E. 9

Q14.3c

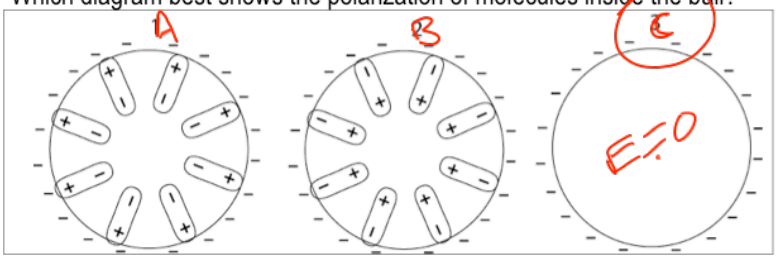
A positive point charge causes a neutral molecule to polarize, as shown below. What is the direction of the *electric force on the point charge,* due to the induced dipole?



9 zero magnitude

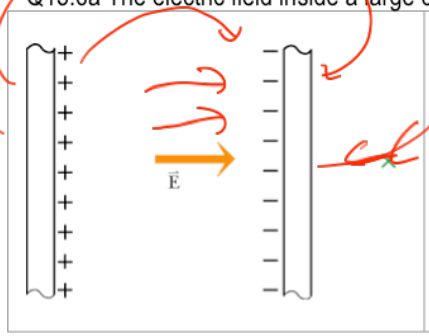
A. 1
B. 3
C. 5
D. 7
E. 9

Q14.4h A solid plastic ball has negative charge uniformly spread over its surface.
Remember that the electric field inside a uniformly charged sphere,
due to the charges on the sphere, is zero.
Which diagram best shows the polarization of molecules inside the ball?



E = 0 inside sphere of uniform charge

Q15.6a The electric field inside a large capacitor is shown at left.



Which arrow best represents the electric field at the "x"?

A

B

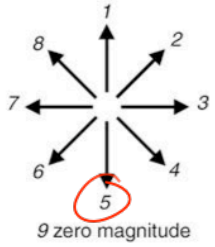
C E-0

D

E

Q15.7b *Think carefully*

A negatively charged hollow plastic sphere is near a negatively charged plastic rod. What is the direction of the net electric field at location *P*, inside the sphere?



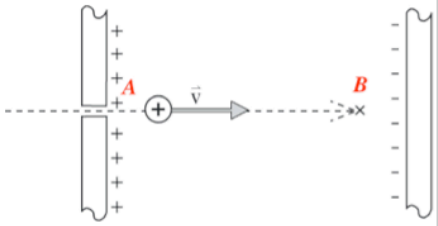
A. 1
B. 5
C. 9

$E = 0$ inside sphere of charge due to those charges

$E \neq 0$ from rod

$\Rightarrow \vec{E}_{tot} = \vec{E}_{sphere} + \vec{E}_{rod} + \dots$

Q16.1a A proton enters a capacitor through a tiny hole. System: everything



Which is true?

A) $\Delta K = 0$ and $\Delta U = 0$

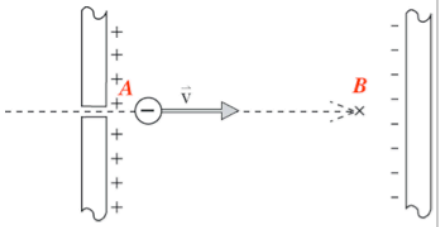
B) $\Delta K < 0$ and $\Delta U > 0$

C) $\Delta K > 0$ and $\Delta U < 0$

D) $\Delta K > 0$ and $\Delta U > 0$

E) $\Delta K < 0$ and $\Delta U < 0$

Q16.1b An electron enters a capacitor through a tiny hole. System: everything



Which is true?

A) $\Delta K = 0$ and $\Delta U = 0$

B) $\Delta K < 0$ and $\Delta U > 0$

C) $\Delta K > 0$ and $\Delta U < 0$

D) $\Delta K > 0$ and $\Delta U > 0$

E) $\Delta K < 0$ and $\Delta U < 0$

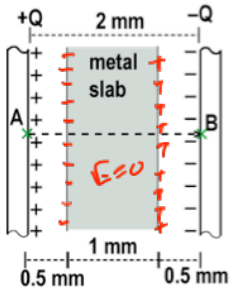
Q16.3c The electric field is uniform in this region. B is at < 0, 0, 0> m.
C is at < 0, –2, 0> m. $\vec{E}$ = < –200, –300, 0> N/C

What is ΔV along a path from B to C?

A) 0 V
B) –300 V
C) –500 V
D) –600 V
E) –1000 V

$\Delta V = -\vec{E} \cdot \Delta\vec{r}$

Q16.5i



In a capacitor $E = (Q/A)/\varepsilon_0$

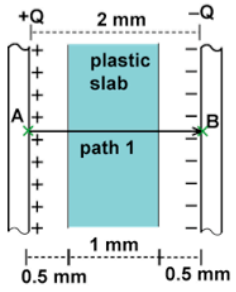
Without the metal slab, $V_B - V_A$ was –1000 volts. Then a metal slab was inserted into the capacitor.

Now $\Delta V = V_B - V_A =$

A) + 1000 volts
B) +500 volts
C) –500 volts
D) –1000 volts
E) Not enough information to tell

$$\Delta V = -\int \vec{E} \cdot d\vec{s}$$

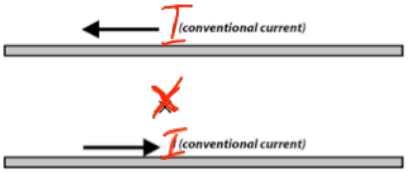
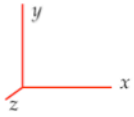
Q16.9a



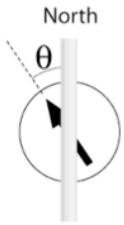
Originally ΔV was –1000 volts. A plastic slab is inserted into the capacitor.
Now $\Delta V = V_B - V_A =$

A. between –500 and –1000 volts
B. between +500 and+ 1000 volts
C. –500 volts
D. +500 volts
E. not enough information to tell

Q17.7c

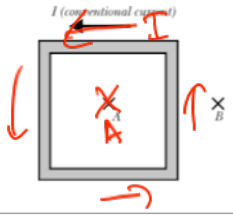
Direction of magnetic field at the observation location?  	A) +z B) –z C) zero magnitude	

Q17.7g

Top view, looking down on the table:  Horiz. component of Earth's magnetic field: 2e–5 tesla	The compass deflects 12 degrees West. What is the magnitude of the magnetic field made by the moving electrons in the wire? A) 9.4e–5 tesla B) 2.0e–5 tesla C) 2.1e–6 tesla D) 4.3e–6 tesla

$B_{wire} = B_{earth} \tan\theta$

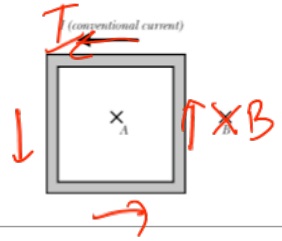
Q17.8a Direction of magnetic field at location A (in plane of square loop)?



A) +z
B) –z
C) zero magnitude

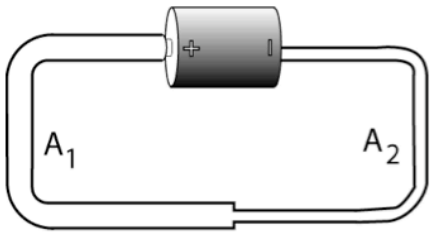
+z out of page

Q17.8b Direction of magnetic field at location B?



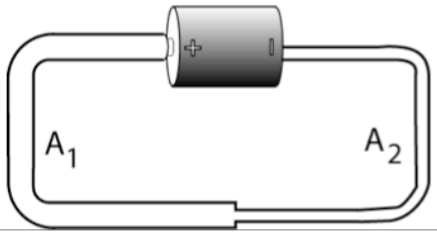
A) +x
B) –x
C) +z
D) –z
E) zero magnitude

Q18.2d Steady state electron current in thick wire *vs.* electron current in thin wire?



A) $i_1 > i_2$
B) $i_1 = i_2$
C) $i_1 < i_2$
D) Not enough information

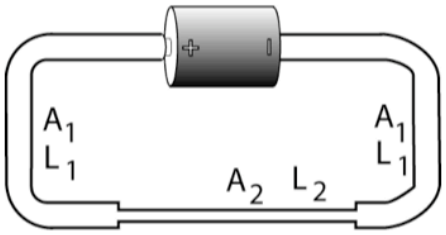
Q18.3b Wires made of same material.
Drift speed of electrons in thick wire vs. drift speed of electrons in thin wire?



A) $v_1 > v_2$
B) $v_1 = v_2$
C) $v_1 < v_2$
D) Not enough information

$i = nAv$

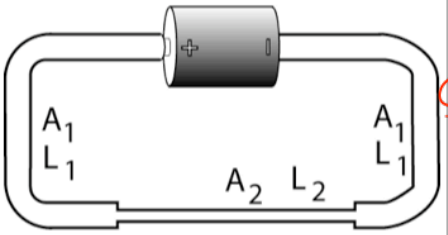
Q18.8a



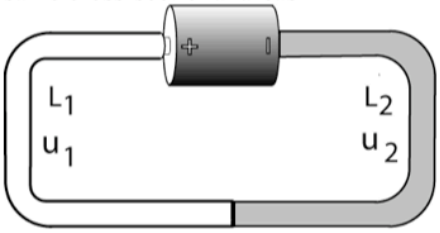
Current conservation (node) eqn:

A) $i_1 = 2*i_2$
B) $2i_1 = i_2$
C) $i_1 = i_2$
D) $i_1 = (A_2/A_1)*i_2$
E) None of the above

Q18.8b

Wires made of same material	Energy conservation (loop) eqn:
	A) +emf – E*(2L_1 +L_2) = 0 B) +emf + E*(2L_1 +L_2) = 0 C) +emf – 2E_1L_1 – E_2L_2 = 0 D) +emf + 2E_1L_1 – E_2L_2 = 0 E) None of the above

Q18.8c

Wires made of different materials, but same cross-sectional areas  	Energy conservation (loop) eqn: A) +emf – $E_1L_1 – E_2L_2 = 0$ B) +emf + $E_1L_1 + E_2L_2 = 0$ C) +emf – $E^*(L_1 + L_2) = 0$ D) +emf + $E^*(L_1 + L_2) = 0$ E) None of the above

Q19.11a

What is the conductivity of copper? Copper has 8e28 electrons/m^3 and the mobility is 4.5e-3 m/s / N/C.	A) 2.84e12 $Am^{-2}/(V/m)$ B) 3.6e26 $Am^{-2}/(V/m)$ C) 5.76e7 $Am^{-2}/(V/m)$ D) 1.21e6 $Am^{-2}/(V/m)$

$\sigma = |q| n \mu$

Q19.11b

How much higher is the conductivity of copper than that of nichrome? n_{copper} = 8.0e28 electrons/m^3 $n_{nichrome}$ = 9.0e28 electrons/m^3 u_{copper} = 4.5e-3 m/s / N/C $u_{nichrome}$ = 7e-5 m/s / N/C	A) $\sigma_{copper} = 57\ \sigma_{nichrome}$ B) $\sigma_{copper} = 1.75e\text{-}2\ \sigma_{nichrome}$ C) $\sigma_{copper} = 72\ \sigma_{nichrome}$ D) $\sigma_{copper} = 100\ \sigma_{nichrome}$

$$\frac{\sigma_{copper}}{\sigma_{nichrome}} = \frac{(|q| n u)_{copper}}{(|q| n u)_{nichrome}}$$

Q19.11c

Many commercial resistors are made of carbon, which has a very low conductivity, σ_{carbon} = 3e4 $Am^{-2}/(V/m)$. A 5 mm long carbon resistor with a cross-sectional area of 0.1 mm^2 has a resistance of about 1.7 ohms. How long would a copper wire of the same diameter have to be to obtain the same resistance? (σ_{copper} = 5.8e7 $(\Omega m)^{-1}$)	A) 1 m B) 10 mm C) 10 m D) 0.1 m

$$R = \frac{L}{\sigma A}$$

Q19.13a
What is the definition of power of any element in an electrical circuit?

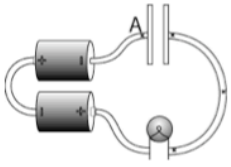
A. the current through the element divided by the voltage across it
B. the product of the current through and the voltage across the element
C. the voltage across the element squared
D. the resistance of the element times the voltage across it

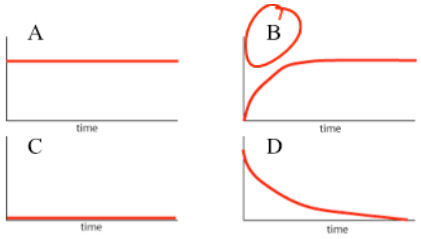
Q19.14e

For a real (non-ideal) battery, $\Delta V_{\text{battery}} = \text{emf} - r_{\text{internal}} I$, not simply $\Delta V_{\text{battery}} = \text{emf}$. When a thick copper wire is placed across a fresh 1.5 V alkaline battery (a "short circuit"), the current is about 6 A. What is the internal resistance of the battery? (Hint: what is the approximate potential difference across the battery, or along the wire, in this situation?)	A) 0.1 Ω B) 0.25 Ω C) 1.5 Ω D) 6 Ω E) 9 Ω

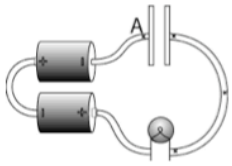
$0 = \mathcal{E}_{emf} - r_{in} I$

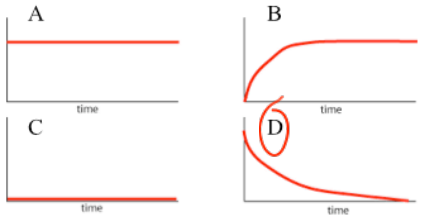
Q19.16a Capacitor initially uncharged. Which graph shows the magnitude of the POTENTIAL DIFFERENCE across the CAPACITOR while CHARGING?



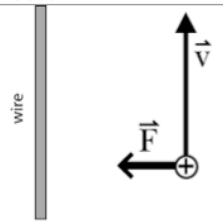


Q19.16b Capacitor initially uncharged. Which graph shows the magnitude of the POTENTIAL DIFFERENCE across the LIGHT BULB FILAMENT while CHARGING?





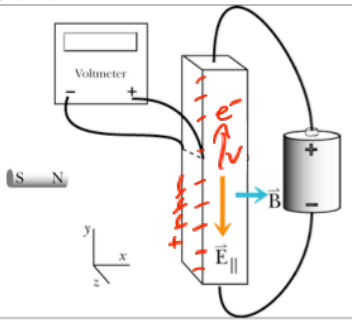
Q20.1d A proton moving in the +y direction experiences a magnetic force in the –x direction.



What is the direction of conventional current in the wire?

A) +y
B) –y
C) I = 0
D) Not enough information

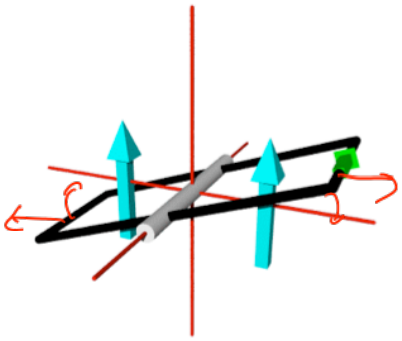
Q20.4d



If mobile charges are negative, sign of voltmeter reading?
(Voltmeter reads positive if + lead is connected to higher potential location)

A. positive
B. negative
C. zero

Q20.8a

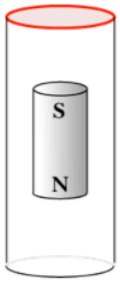


Cyan: applied magnetic field.
Green: conventional current

Direction of magnetic torque?

A) +z (counter-clockwise)
B) –z (clockwise)
C) zero magnitude
D) my answer doesn't match any of the above

Q22.2d A bar magnet falls through a long aluminum tube.



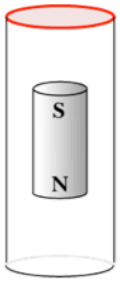
Consider a circular path around the tube above the falling magnet. What is the direction of $-d\vec{B}/dt$?

A) +y (up)
B) –y (down)
C) zero magnitude

B: ↓ ↓ B_f ↑ ΔB

$-\frac{dB}{dt}$ down

Q22.2e A bar magnet falls through a long aluminum tube.



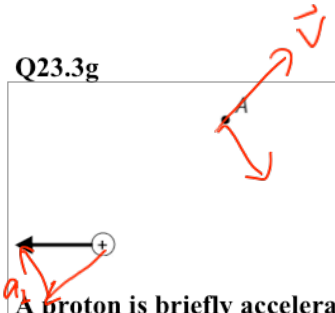
What is the direction of conventional current at the location shown, as seen from above?

A) clockwise
B) counter-clockwise
C) zero magnitude

Q23.2h

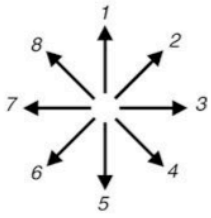
A pulse of electromagnetic radiation is detected at location A. In the pulse, the electric field is in the –x direction and the magnetic field is in the –z direction. **What is the direction of propagation of this pulse of radiation?**	**A) +y** **B) –y** **C) +z** **D) –z** **E) No direction**

Q23.3g



A proton is briefly accelerated in the direction shown.

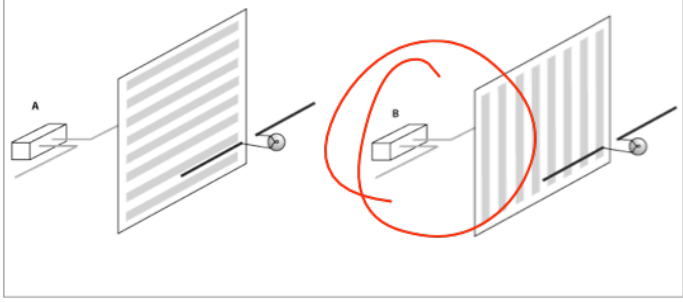
What is the direction of the radiative electric field that will be detected at location A?



A. 2
B. 4
C. 6
D. 8
E. Something else

$$E = -\frac{q\,q_L}{\cdots}$$

Q23.6b



In which situation will the bulb light?

A) A
B) B
C) Both
D) Neither

superconductor

Expells B fields