Physics 1520, Fall 2013
Quiz 3, Version 1, Form: A

Name: Key
Date: _____

Unless otherwise stated, use a coordinate system with $+x$ to the right and $+y$ upward, toward the top edge of the page.

Section 1.

Questions 1–2: Copper has a density of 8960 kg/m^3 and an atomic mass of 63.55 g/mol. One atom of copper has 29 protons and 29 electrons. Avogadro's number is 6.02×10^{23} atoms/mol. A certain copper BB has a volume 5.00×10^{-10} m^3.

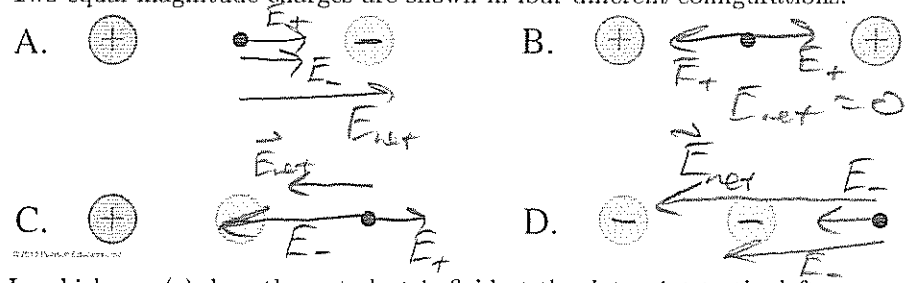
1. How many electrons are in the BB?
   - (a) 1.23×10^{21} electrons
   - (b) 4.24×10^{19} electrons
   - (c) 2.46×10^{19} electrons
   - (d) 2.70×10^{18} electrons
   - (e) 7.82×10^{19} electrons

$$\left(8960\frac{kg}{m^3}\right)\left(5\times10^{-10}\,m^3\right)\left(\frac{1\,mol}{0.06355\,kg}\right)\left(6.02\times10^{23}\frac{atoms}{mol}\right)$$
$$= 4.24\times10^{19}\,atoms\left(\frac{29\ elect}{atom}\right) = 1.23\times10^{21}\,elect.$$

2. If the BB has an electric charge of -2 nC, how many additional electrons did it gain?
   - (a) 3.2×10^{28} electrons
   - (b) 1.25×10^{10} electrons
   - (c) 1.25×10^{19} electrons
   - (d) 2.0×10^{9} electrons
   - (e) 8.0×10^{11} electrons

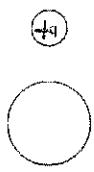
$$\left(-2\times10^{-9}C\right)\left(\frac{1\,elect}{-1.6\times10^{-19}C}\right) = 1.25\times10^{10}\,elect.$$

3. Two equal magnitude charges are shown in four different configurations.



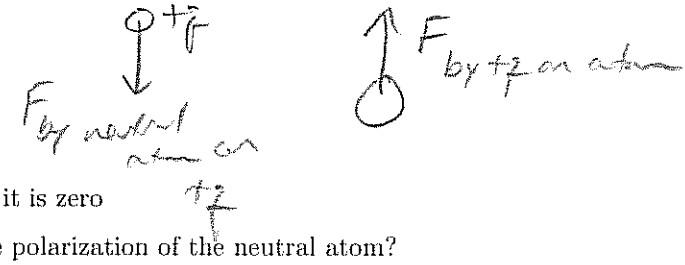
In which case(s) does the *net* electric field at the dot point to the left.
   - (a) A only
   - (b) D only
   - (c) C only
   - (d) C and D
   - (e) A, C, and D

Questions 4–5: A proton $+q$ is near a neutral atom (the circle) as shown below.

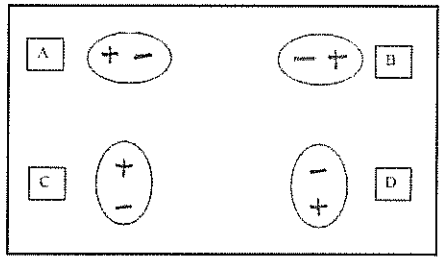


4. What is the direction of the force by the proton on the neutral atom? Attractive.

   (a) to the right, $+x$
   (b) to the left, $-x$
   (c) upward, $+y$
   (d) downward, $-y$
   (e) none of the above because it is zero



5. Which of these diagrams shows the polarization of the neutral atom?



electron cloud attracted to +q.

   (a) A
   (b) B
   (c) C
   (d) D

Questions 6–8: You have four metal disks with charges: $q_A = -8.0\ \mu C$, $q_B = -2.0\ \mu C$, $q_C = +5.0\ \mu C$, and $q_D = +12.0\ \mu C$.

6. Holding them with insulators, you bring two disks together so that they touch. Then you separate them. You measure the resulting charge of each disk and find that it is $+5.0\ \mu C$ per disk. Which two disks did you bring together?

   (a) A and B
   (b) B and C
   (c) C and D
   (d) B and D
   (e) A and D

$Q_{total} = +5 + 5 = 10\mu C$.

Before touching $Q_{total} = 10\mu C$. So disks are B and D since $q_B + q_D = -2 + 12 = 10\mu C$

7. If you touch disk A and disk B together,

   (a) A will gain electrons
   (b) A will gain protons
   (c) A will lose electrons
   (d) A will lose protons

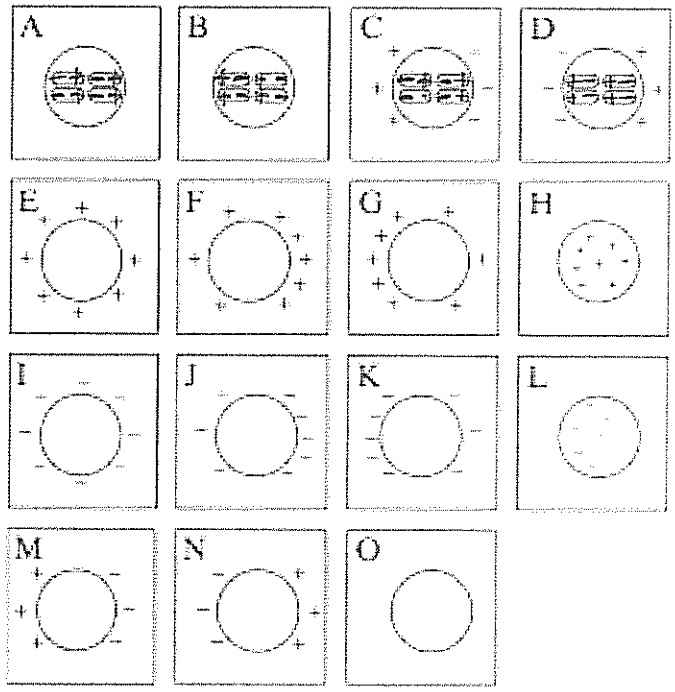
A loses neg. charge so it lost electrons.

8. If you touch disk C and disk D together,

(a) C will gain electrons
(b) C will gain protons
(c) C will lose electrons
(d) C will lose protons

C gains + charge. The only way for a conductor to do this is to lose electrons.

Questions 9–10: Use this image to answer each of the following questions.



9. Which sphere is a neutral insulator in an applied electric field (due to other charges not shown) that is to the right?

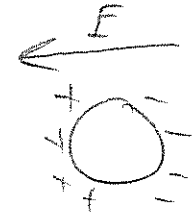
(a) A
(b) B
(c) C
(d) D
(e) O

polarization of atoms

10. Which sphere is a neutral conductor in an applied electric field (due to other charges not shown) that is to the left?

(a) M
(b) N
(c) C
(d) D
(e) O

polarization of sphere with total surface charge = 0



Questions 11–13: Three charged spheres are arranged as shown below. In the figure, $d = 4$ cm and $q = 1$ μC.

11. What is the magnitude of the force by the particle of charge $-2q$ on the particle of charge $-q$?

(a) 5.6 N
(b) 0.45 N
(c) 2.8 N
(d) 22 N
(e) 11 N

$F = \frac{(9\times10^9)(2)(1\times10^{-6})(1\times10^{-6})}{(0.04\,m)^2} = 11.25\,N$ → F_{-2q} on $-q$

12. What is the magnitude of the *net* force on the particle of charge $-q$?

(a) zero
(b) 17 N
(c) 11 N
(d) 22 N
(e) 5.6 N

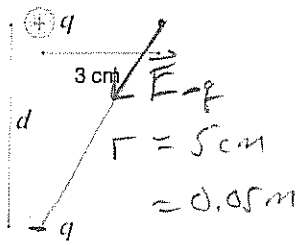
$F_{+q} = \frac{(9\times10^9)(4)(1\times10^{-6})(1\times10^{-6})}{(0.08)^2} = 5.6\,N$ in −x dir.

$F_{Net} = 11.25\,N - 5.6\,N = 5.6\,N$ in +x dir.

13. What is the direction of the *net* force on the particle of charge $-q$?

(a) to the right, $+x$
(b) to the left, $-x$
(c) none of the above because it is zero

Questions 14–16: A dipole made of charged spheres with $q = 8$ nC, $d = 4$ cm is shown below?



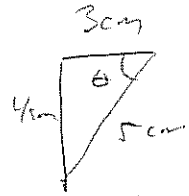
14. What is the magnitude of the electric field due to $-q$ at the location of the dot?

(a) 45,000 N/C
(b) 80,000 N/C
(c) 57,600 N/C
(d) 90,000 N/C
(e) 28,800 N/C

$E = \frac{(9\times10^9)(8\times10^{-9}\,C)}{(0.05\,m)^2} = 28{,}800\,\frac{N}{C}$

15. What is the angle with respect to the horizontal for the electric field due to $-q$ at the location of the dot?

(a) 37°
(b) 45°
(c) 30°
(d) 53°
(e) 60°

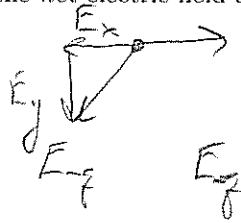


$\tan\theta = \frac{4}{3}$

$\theta = 53.1°$

16. What is the magnitude of the *net* electric field at the location of the dot?

(a) 97,300 N/C
(b) 109,000 N/C
(c) 98,600 N/C
(d) 120,000 N/C
(e) 100,000 N/C

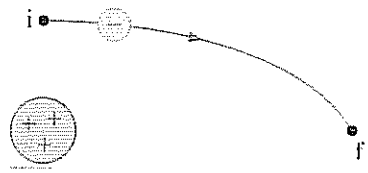


$E_f = \frac{(9\times10^9)(8\times10^{-9}\,C)}{(0.03)^2} = 80{,}000\ \frac{N}{C}$ in +x dir.

$E_{fx} = -28{,}000\cos(53^\circ) = -17{,}332\ \frac{N}{C}$

$E_{fy} = -28{,}000\sin(53^\circ) = -23{,}000\ \frac{N}{C}$

Questions 17–19: In an experiment, an electron travels near a nucleus along the path shown below.



$E_{net\,x} = 80{,}000 - 17{,}332 = 62{,}668\ \frac{N}{C}$

$E_{net\,y} = -23{,}000\ \frac{N}{C}$

$|\vec{E}_{net}| = \sqrt{62{,}668^2 + 23000^2}$

$= \boxed{66{,}800\ \frac{N}{C}}$

17. The potential difference, $\Delta V = V_f - V_i$, is

(a) positive.
(b) negative.
(c) zero.

$V = \frac{ke(q)}{r}$ where q is for nucleus.

So $V_f < V_i$ and ΔV is $-$.

18. As the electron travels from i to f, the potential energy, U, of the system (of electron and nucleus)

(a) increases.
(b) decreases.
(c) remains constant.

$U = qV = -eV$.

U_f is a smaller $-$ number than U_i

so U increases.

19. As it travels from i to f, the kinetic energy of the electron

(a) increases.
(b) decreases.
(c) remains constant.

ΔU is $+$ so

ΔK is $-$. Electron slows down

Questions 20–21: In a particular LEGO kit, a capacitor with a capacitance of 0.5 F is charged by a solar cell. The solar cell produces a potential difference of 4 V across the capacitor. The area of each plate is 0.01 m^2 and they are separated 0.1 mm.

20. How much charge is stored on each capacitor plate?

(a) 0.125 C
(b) 0.5 C
(c) 2.0 C
(d) 8.0 C
(e) 4.0 C

$Q = C\Delta V$

$= (0.5\,F)(4\,V)$

$= 2\,C$

21. What is the dielectric constant K of the insulator that is between the plates?

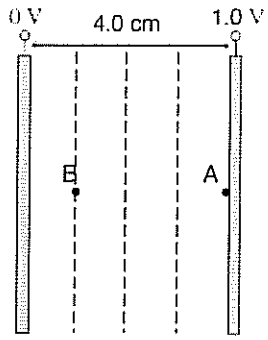
(a) 1.1×10^{13}
(b) 2.3×10^{9}
(c) 4.5×10^{9}
(d) 1.1×10^{9}
(e) 5.6×10^{8}

$C = \frac{K\epsilon_0 A}{d}$ so $K = \frac{Cd}{\epsilon_0 A}$

$= \frac{(0.5\,F)(0.1\times10^{-3}\,m)}{(8.85\times10^{-12})(0.01\,m^2)}$

$= \boxed{5.6\times10^8}$

Questions 22–25: Two electrodes, shown below, are connected to a battery with a potential difference of 1 V. The dotted lines are 1 cm apart.



22. What is the magnitude of the electric field between the plates?

(a) 4 V/m
(b) 50 V/m
(c) 25 V/m
(d) 100 V/m

$|\Delta V| = Ed$

$E = \frac{1V}{0.04m} = 25 \frac{V}{m}$

23. What is the direction of the electric field between the plates?

(a) to the right
(b) to the left
(c) upward
(d) downward
(e) none of the above because it is zero

$\vec{E}$ toward lower V.

Note that V increases linearly from 0 to 1V. Since B is $\frac{1}{4}$ the distance, it is $\frac{1}{4}$ the voltage.

24. What is the electric potential V at point B?

(a) 0 V
(b) 0.25 V
(c) 0.5 V
(d) 0.75 V
(e) 1.0 V

$V_B - V_A = -E_x(x_B - x_A)$

$V_B - 1 = -(-25 \frac{V}{m})(-0.03m)$

$= 1 - 0.75V = \boxed{0.25V}$

25. If an electron travels from point A to point B, what is its change in electric potential energy, ΔU, in eV?

(a) 0
(b) 0.25 eV
(c) 0.5 eV
(d) 0.75 eV
(e) 1.0 eV

$\Delta U = q\Delta V$

$U_f - U_i = q(V_f - V_i)$

$= -e(V_f - V_i)$

$= -e(0.25V - 1V)$

$= e(0.75V)$

$= \boxed{0.75eV}$