Physics 1520, Spring 2013
Quiz 3, 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.

1. Four lightweight balls A, B, C, and D are suspended by threads. Ball A has been touched by a charged rod (with unknown charge). When the balls are brought close together, without touching, the following observations are made:

   –Balls B, C, and D are attracted to ball A.
   –Balls B and D have no effect on each other.
   –Ball B is attracted to Ball C.

   Balls B and D are neutral
   Ball C must be charged,
   Since C is attracted to A, it has the opposite charge.

   Ball C is

   (a) positive
   (b) negative
   (c) neutral
   (d) the same charge as ball A, but may be positive or negative.
   (e) the opposite charge as ball A, but may be positive or negative.

2. Three metal balls are suspended from thin threads. Various objects are then rubbed against other objects (nylon against silk, glass against polyester, etc.) and each of the metal balls is charged by touching them with one of these objects. *It is found that balls 1 and 2 repel each other and that balls 2 and 3 repel each other.* From this we can conclude that

   1 repels 2 (same charge)
   2 repels 3 (same charge)
   So 1 will repel 3 (same charge)

   (a) 1 and 3 carry charges of opposite sign.
   (b) 1 and 3 carry charges of equal sign
   (c) one of the objects carries no charge.

3. Three metal balls are suspended from thin threads. Various objects are then rubbed against other objects (nylon against silk, glass against polyester, etc.) and each of the metal balls is charged by touching them with one of these objects. *It is found that balls 1 and 2 attract each other and that balls 2 and 3 repel each other.* From this we can conclude that

   1 attracts 2 (opposite charge)
   2 repels 3 (same charge)
   1 attracts 3 (opposite charge)

   (a) 1 and 3 carry charges of opposite sign.
   (b) 1 and 3 carry charges of equal sign
   (c) one of the objects carries no charge.

4. When the electric charge on each of two charged particles is doubled, the electric force between them is

   $F = \frac{1}{4\pi\epsilon_0}\frac{2q\,2q}{r^2} = 4\left(\frac{1}{4\pi\epsilon_0}\frac{qq}{r^2}\right)$

   (a) the same.
   (b) doubled.
   (c) quadrupled.
   (d) none of the above

5. In any reaction involving charged particles, the total charge before and after the reaction is always the same. This relationship is known as

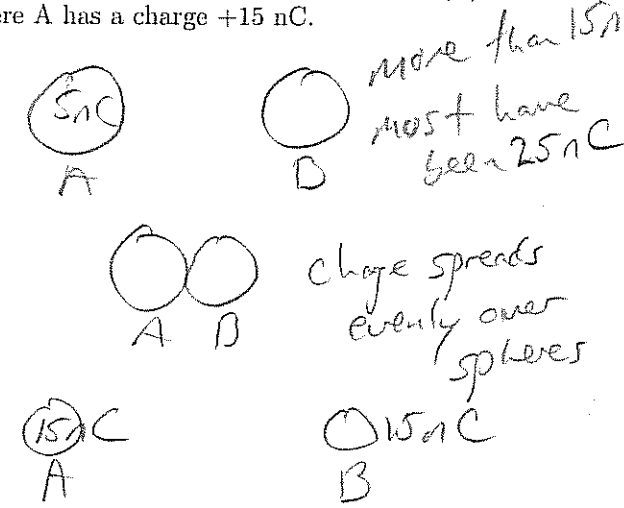
   (a) the law of induction.
   (b) the law of polarization.
   (c) quantization of charge.
   (d) conservation of charge.

Questions 6–9: A charged metal sphere (A) with charge +5 nC touches a second charged metal sphere (B) and then the spheres are separated. After touching sphere B, sphere A has a charge +15 nC.

6. Sphere A

   (a) neither lost nor gained charged particles.
   (b) gained protons.
   (c) lost protons.
   (d) gained electrons.
   (e) lost electrons.

only electrons are transferred



7. Before touching, sphere B was

   (a) positively charged.
   (b) negatively charged.
   (c) neutral.

8. After touching, sphere B is

   (a) positively charged.
   (b) negatively charged.
   (c) neutral.

A increases positive charge. Thus, B decreased in positive charge.

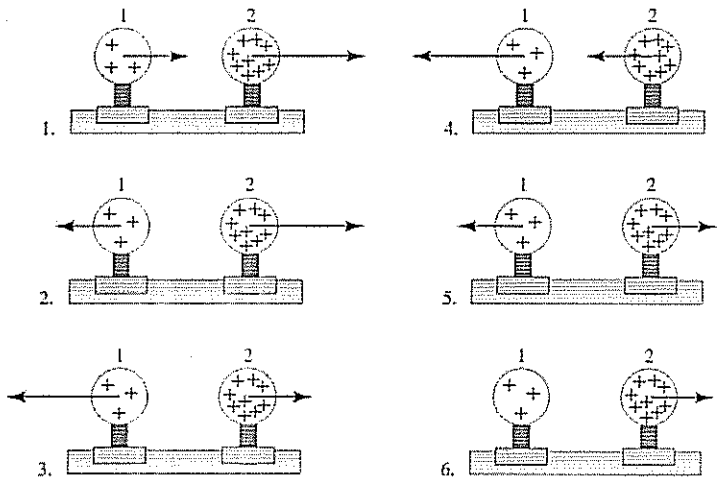
9. How many charged particles were transferred to or from sphere A?

   (a) 1.5×10^9 charged particles
   (b) 3.13×10^{10} charged particles
   (c) 6.25×10^{10} charged particles
   (d) 9.38×10^{10} charged particles
   (e) zero

It gained 10 nC of charge. So it lost electrons with this magnitude of charge.

$$(10 \times 10^{-9}\,C)\left(\frac{1e^-}{1.6 \times 10^{-19}\,C}\right) = 6.25 \times 10^{10} \text{ electrons}$$

10. Two uniformly charged spheres are firmly fastened to and electrically insulated from frictionless pucks on an air table. The charge on sphere 2 is three times the charge on sphere 1. Which force diagram correctly shows the magnitude and direction of the electrostatic force on each puck?

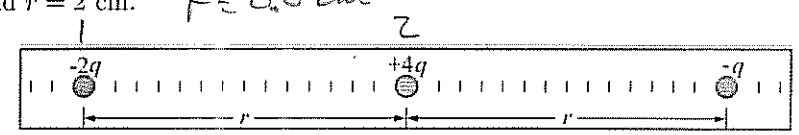


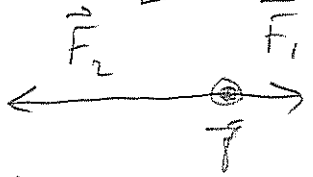
7. none of the above

F on each sphere is the same.

(a) Diagram 1
(b) Diagram 2
(c) Diagram 3
(d) Diagram 4
(e) Diagram 5

Questions 11–12: A configuration of three balls with charges $+4q$, $-2q$, and $-q$ is shown below and $r = 2$ cm. $q = 5\times10^{-6}$ C





11. What is the direction of the net force on the ball with charge $-q$?

(a) to the right ($+x$ direction)
(b) to the left ($-x$ direction)
(c) neither, because the net force is zero

$|\vec{F}_2| > |\vec{F}_1|$ so $\vec{F}_{net}$ ←

12. What is the magnitude of the net force on the ball with charge $-q$?

(a) 280 N
(b) 1970 N
(c) 2250 N
(d) 2530 N
(e) zero

$$|\vec{F}_2| = \left(9\times10^9 \frac{N\cdot m^2}{C^2}\right)\left(\frac{(4q)(q)}{(0.02m)^2}\right) = 2250\ N$$

$$F_{2x} = -2250\ N$$

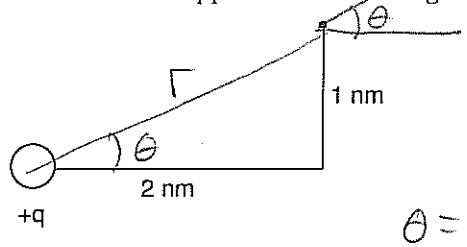
$$|\vec{F}_1| = \left(9\times10^9 \frac{N\cdot m^2}{C^2}\right)\left(\frac{2q(q)}{(0.04m)^2}\right) = 281\ N$$

$$F_{1x} = +281\ N$$

$$F_{net_x} = -2250 + 281\ N = \boxed{-1969\ N}$$

$\vec{E}$ $\vec{E}$ points away from +q.

Questions 13–14: Suppose that the charged particle below is a single proton.



$r = \sqrt{2^2 + 1^2} = 2.24\ nm$

$= 2.24 \times 10^{-9}\ m$

$\theta = \tan^{-1}\left(\frac{1}{2}\right) = 26.6°$

13. At the location of the dot, what is the magnitude of the electric field?

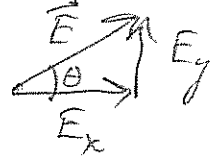
(a) 4.59×10^{-11} N/C
(b) 0.643 N/C
(c) 1.44×10^{9} N/C
(d) 3.6×10^{8} N/C
(e) 2.87×10^{8} N/C

$|\vec{E}| = \left(9 \times 10^9 \frac{N \cdot m^2}{C^2}\right)\left(\frac{1.6 \times 10^{-19} C}{(2.24 \times 10^{-9} m)^2}\right)$

$= 2.87 \times 10^8 \frac{N}{C}$

14. At the location of the dot, what is the x-component of the electric field?

(a) 1.29×10^{8} N/C
(b) 1.44×10^{8} N/C
(c) 1.61×10^{8} N/C
(d) 2.57×10^{8} N/C
(e) 6.45×10^{8} N/C



$E_x = |\vec{E}| \cos\theta$

$= \left(2.87 \times 10^8 \frac{N}{C}\right)(\cos(26.6°))$

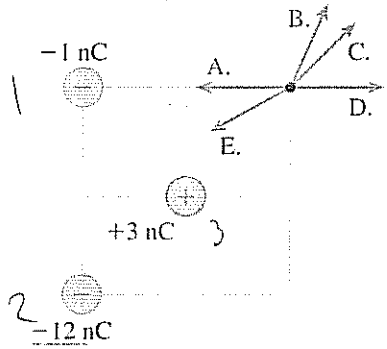
$= 2.57 \times 10^8 \frac{N}{C}$

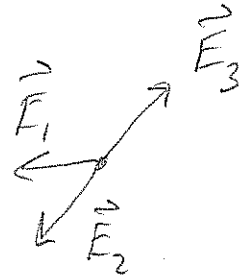
15. What is the angle between the electric field vector at the location of the dot and the $+x$ axis?

(a) zero, because the electric field at the location of the dot points in the $+x$ direction
(b) 63.4°
(c) 35°
(d) 27°
(e) 22°

See picture above.

16. Three charged objects are arranged as shown below.





$|q_2| = 4|q_3|$

but $r_2 = 2r_3$

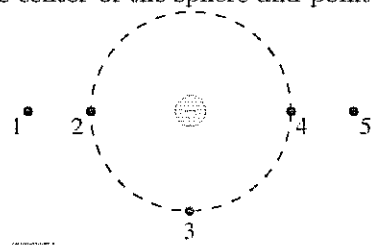
so $|\vec{E}_2| = |\vec{E}_3|$

and $\vec{E}_2$ and $\vec{E}_3$ will cancel.

Which arrow best represents the direction of the electric field vector at the position of the dot?

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

Questions 17–20: Various points around a sphere of charge −10 nC are shown below. Point 5 is 30 cm from the center of the sphere and point 4 is 20 cm from the center of the sphere.



q is negative

V is lower near neg. charge.

17. Which points are at a higher (i.e. greater) electric potential?

(a) Points 1 and 5

(b) Points 2, 3, and 4

(c) None of the above because all of the points are at the same electric potential.

18. What is the electric potential at point 4?

(a) −900 V

(b) −150 V

(c) −300 V

(d) −450 V

(e) −360 V

$V = \left(9\times10^9 \frac{N\cdot m^2}{C^2}\right)\frac{q}{r}$ $\quad q = -10\times10^{-9}\,C$, $r = 0.2\,m$

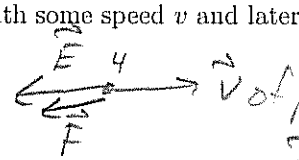
$= -450\,V$

19. A proton is moving to the right at point 4 with some speed v and later passes through point 5. When it passes through point 5, it will have

(a) lost potential energy.

(b) gained potential energy.

(c) the same potential energy.



since $\vec{F}$ is opp. $\vec{v}$, the proton slows down and loses KE. Thus, it gains PE.

20. If the proton's speed at point 4 is 2×10^5 m/s and it is moving to the right, what is its speed at point 5? The mass of a proton is 1.67×10^{-27} kg.

(a) 9.2×10^4 m/s

(b) 1.3×10^5 m/s

(c) 1.1×10^5 m/s

(d) 1.7×10^5 m/s

(e) 1.5×10^5 m/s

Use Cons. of E.

$\Delta E = 0$

$\Delta K + \Delta U = 0$

$K_f - K_i = -q\Delta V$

$K_f = K_i - q\Delta V$

$= \frac{1}{2}mv_i^2 - (1.6\times10^{-19}C)(V_5 - V_4)$

$= \frac{1}{2}(1.67\times10^{-27}kg)(2\times10^5\frac{m}{s}) - (1.6\times10^{-19}C)(-300V - -450V)$

$= 3.34\times10^{-17}J - 2.4\times10^{-17}J = 9.4\times10^{-18}J$

$V_5 = (9\times10^9)\left(\frac{-10\times10^{-9}C}{0.3m}\right)$

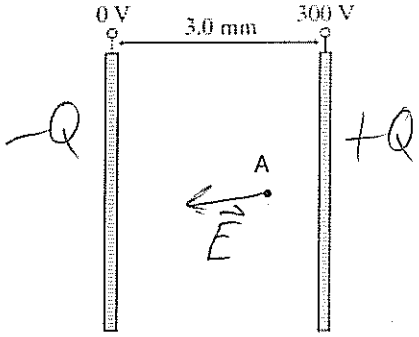
$= -300\,V$

$K_f = \frac{1}{2}mv_f^2$

$v_f = \sqrt{\frac{2K_f}{m}}$

$= 1.06\times10^5\frac{m}{s}$

Questions 21–24: Two capacitor plates are separated 3 mm, as shown below.



21. What is the direction of the electric field at point A?

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

$\vec{E}$ points toward lower potential.

22. What is the magnitude of the electric field at point A?

(a) 0.9 V/m
(b) 900 V/m
(c) 1×10^5 V/m
(d) 2×10^5 V/m
(e) 3×10^5 V/m

$|\vec{E}| = \frac{|\Delta V|}{|\Delta x|} = \frac{300\ V}{0.003\ m} = 1 \times 10^5 \frac{V}{m}$

23. What is the potential at point A if this point is 1 mm from the 300-V plate?

(a) 50 V
(b) 200 V
(c) 100 V
(d) 300 V
(e) 250 V

2 mm from 0-V plate.

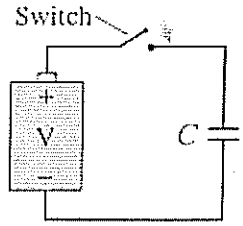
$|\Delta V| = |\vec{E}|\Delta x = \left(1 \times 10^5 \frac{V}{m}\right)(0.002\ m) = 200\ V$

24. If an electron is released from rest at point A, with which plate will it eventually collide?

(a) Neither, because the electron will travel upward or downward through the capacitor and will not collide with a plate.
(b) Neither, because the electron will remain at rest.
(c) The 0 V plate.
(d) The 300 V plate.

It travels toward plate with positive charge. $\vec{F}$ on electron is opposite $\vec{E}$.

25. Initially, the switch in the figure below is open and the capacitor is uncharged. $V = 6\ V$ and $C = 9\ \mu F$. How much charge flows through the switch after the switch is closed?



(a) 0.45 μC
(b) 1.5 μC
(c) 9 μC
(d) 15 μC
(e) 54 μC

$$Q = C\Delta V_{cap}$$

$$= (9\times10^{-6}\,F)(6\,V)$$

$$= 54\times10^{-6}\,C$$

$$\mu C$$

$$= 54\,\mu C$$