Phys 112
Spring 2013

General Physics: Class Exam I

15 February 2013

Name: Solution

Total: /70

Instructions

- There are 7 questions on 5 pages.
- Show your reasoning and calculations and always justify your answers.

Physical constants and useful formulae

Coulomb's constant: $k = 9.0 \times 10^9\,\mathrm{Nm^2/C^2}$

Electron charge: $q_{\mathrm{electron}} = -1.60 \times 10^{-19}\,\mathrm{C}$

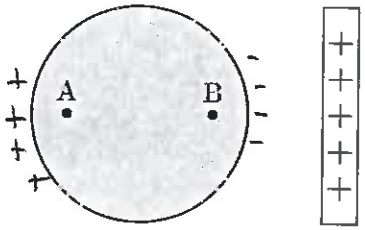
Proton charge $q_{\mathrm{proton}} = +1.60 \times 10^{-19}\,\mathrm{C}$

Electron mass: $m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$

Proton mass: $m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$

Question 1

A positively charged rod is held next to a solid sphere made of a perfect conducting material. The sphere and rod are held fixed.



a) Is the negative charge in the sphere evenly distributed throughout the sphere? Explain your answer. No. Negative charge will be attracted by the rod and move right. The region near A will be positive The region near B negative

b) Is the electric potential at point A the same, larger, or smaller than that at point B? Explain your answer.

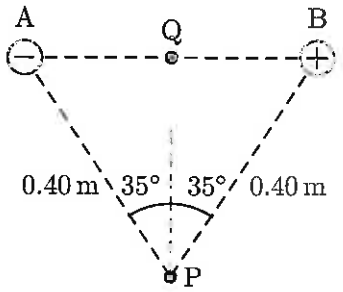
Same. Potential is the same everywhere inside a conductor

/8

Question 2

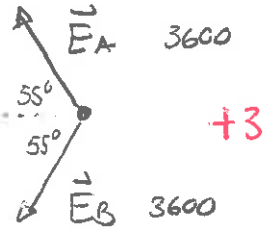
Two fixed charged particles are situated as illustrated. The charges of these particles are

$$q_A = -16.0 \times 10^{-9}\,\text{C} \quad \text{and}$$
$$q_B = +16.0 \times 10^{-9}\,\text{C}.$$



a) Determine the electric field produced by the entire charge distribution at the location labeled P. Describe the direction of the electric field.

$\vec{E} = \vec{E}_A + \vec{E}_B$. The two vectors are illustrated. Using $E = k\frac{|q|}{r^2}$ we can see that their magnitudes will be the same.



+3

So $E_A = E_B$ and +2

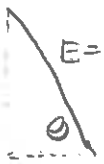
+2 $E_A = k\frac{q_A}{r_A^2} = 9.0\times10^9\,\text{N m}^2/\text{C}^2 \frac{|-16.0\times10^{-9}\,\text{C}|}{(0.40\,\text{m})^2} = 900\,\text{N/C}$

The net field is determined using components

	x	y
$\vec{E}_A$	-517 N/C	737 N/C
$\vec{E}_B$	-517 N/C	-737 N/C
$\vec{E}$	-1034 N/C	0

+4

+2 The electric field points left



$|E_y| = E\sin 55°$
$= 900\sin 55°$
$= 737$

+2

$E_x = E\cos\theta°$
$= 900\cos 55°$
$= 517$

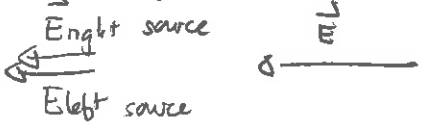
~~angle 55° 35°~~
angle switched (-1)

Question 2 continued ...

b) A student considers the point Q midway between the charges and states that, "The potential at point Q is zero and this means that the electric field at point Q is zero." Is this claim true or false? Explain your answer.

V is clearly zero since the charges contribute equal magnitudes but opposite signs. But $\vec{E} \neq 0$

+3



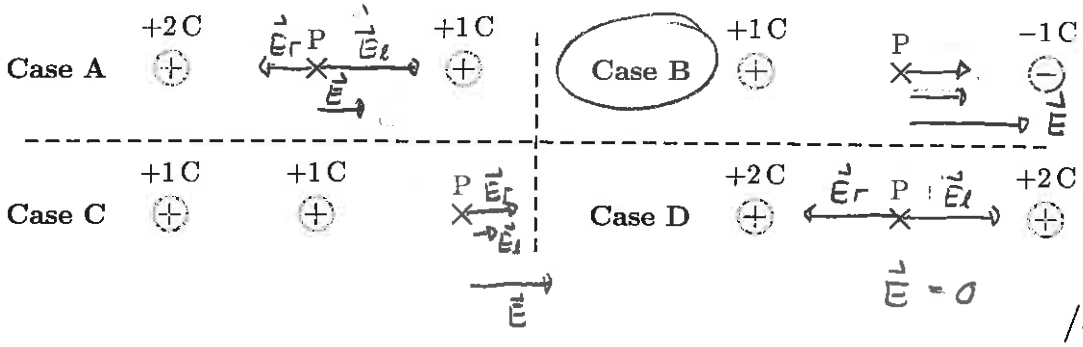
/18

Question 3

Various arrangements of fixed charges are arranged as illustrated. In which case (choose one) is the magnitude of the electric field produced by the charges at point P largest? Note that the charge magnitudes vary.

Show field vectors in all cases (+3)

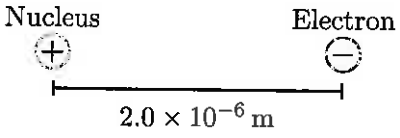
Some/incorrect.



/5

Question 4

An electron and a nucleus, consisting of *two protons*, are separated by a distance of 2.0×10^{-10} m. Determine the electric potential produced by the nucleus at the location of the electron **and** the electric potential energy of the electron in this configuration.



$V = k \frac{q_{nucleus}}{r}$ +2 $\quad q_{nucleus} = 2 \times +1.6 \times 10^{-19} C = 3.2 \times 10^{-19} C$ +2

$V = 9.0 \times 10^{9} \frac{N m^2}{C^2} \frac{3.2 \times 10^{-19} C}{2.0 \times 10^{-10} m} = 14.4 V$ +2

/10

$U_{elec} = q_{probe} V = -1.6 \times 10^{-19} \times 14.4 V = -2.3 \times 10^{-18} J$ +2

q_{probe}: +2 (electron)

Question 5

A positvely charged particle, Zog, is held fixed. Another charged particle, X, is given a brief kick and moves toward Zog. Consider the motion of X after the kick.

$V = k\,q/r$ smaller r. $\Rightarrow$ larger V

a) Which of the following (choose one) is true regarding the change in electric potential seen by X? +5

i) $\Delta V > 0$ is X is positive, $\Delta V < 0$ is X is negative,
ii) $\Delta V < 0$ is X is positive, $\Delta V > 0$ is X is negative,
iii) $\Delta V > 0$ regardless of X's charge.
iv) $\Delta V < 0$ regardless of X's charge.

r decreases $\Rightarrow \Delta V > 0$
only source (Zog) matters.

b) Which of the following (choose one) is true regarding the change in electric potential energy seen by X? +5

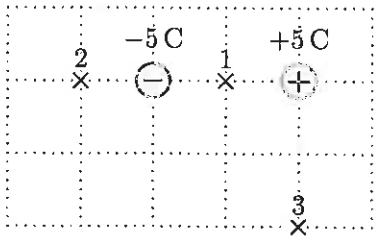
i) $\Delta U_{\text{elec}} > 0$ is X is positive, $\Delta U_{\text{elec}} < 0$ is X is negative,
ii) $\Delta U_{\text{elec}} < 0$ is X is positive, $\Delta U_{\text{elec}} > 0$ is X is negative,
iii) $\Delta U_{\text{elec}} > 0$ regardless of X's charge.
iv) $\Delta U_{\text{elec}} < 0$ regardless of X's charge.

$\Delta U_{elec} = q\,\Delta V$ (+ve)
if -ve $\Rightarrow \Delta U_{elec}$ -ve

/10

Question 6

Two charged particles are held fixed as illustrated. Which of the following (choose one) correctly ranks the electric potentials at the indicated points? Note that negative is always less than positive.



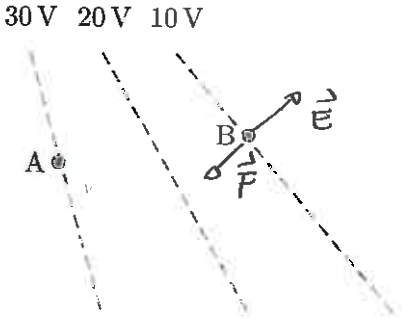
a) $V_1 = V_2 = V_3$
b) $V_1 > V_2 > V_3$
c) $V_1 = V_2 > V_3$
d) $V_3 > V_1 > V_2$
e) $V_2 > V_1 > V_3$

$V_1 = 0$
V_2 is negative since 2 is closer to −5C
V_3 is positive since 3 closer to pos +5C

/5

Question 7

Hidden source charges produce the illustrated equipotentials. Another charged particle of mass 0.50 kg and charge −4.0 C moves through the location labeled A with speed 20 m/s. The particle reaches the location labeled B.



a) Determine the speed of the particle when it reaches B.

+2 $\Delta K + q\Delta V = 0$

$\Rightarrow \Delta K = -q\Delta V \Rightarrow K_f - K_i = -q(V_f - V_i)$

+4.5 $\Rightarrow \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = -q(V_f - V_i)$

$\Rightarrow mv_f^2 - mv_i^2 = -2q(V_f - V_i)$

$\Rightarrow v_f^2 - v_i^2 = -\frac{2q}{m}(V_f - V_i) = -\frac{2(-4.0\,C)}{0.50\,kg}(10V - 30V)$ +2

$v_i = 20\,m/s$
$v_f = ?$
$V_i = 30V$
$V_f = 10V$

$\Rightarrow v_f^2 = v_i^2 - 320\,m^2/s^2$

$= (20\,m/s)^2 - 320\,m^2/s^2 = 80\,m^2/s^2 \Rightarrow v_f = \sqrt{80\,m^2/s^2}$ +2

$= 8.9\,m/s$

b) Indicate the direction of the electric field produced by the sources at B **and** of the force acting on the particle when it is at B.

$\vec{E}$ perpendicular + downhill to equip +2 downhill only +1

$\vec{F} = q\vec{E} = -4.0\vec{E}$

$\Rightarrow \vec{F}$ opp to $\vec{E}$ +1

/14