First Letter Last Name

Name:_____ Student#:_____

Lecture Section: ☐201 (Sossi) ☐202 (Rieger) ☐203 (Bates) ☐204 (Rottler)

Physics 102 Midterm 1 – February 4, 2010

Simple Scientific Calculator – No graphing calculators 1 8x11 formula sheet permitted
Time: 60 minutes *No cell phones on desk*
Show all your work *Pen preferred, no remarking if in pencil!*

Q1 (10)	Q2 (10)	Q3 (10)	Q4 (10)	Q5 (10)	Total (50)

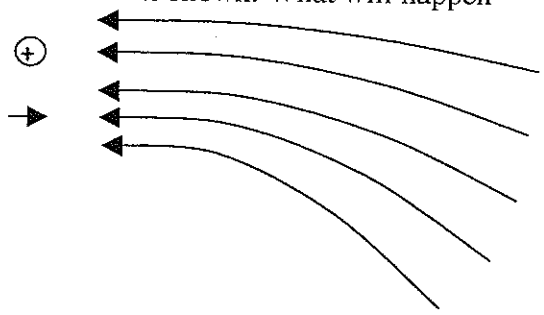
Question 1– Short Answer/Multiple Choice Circle the correct answer if appropriate (2 marks each part)

1.1. Two spheres with charges Q1 and Q2 are hanging from insulating strings as shown. The angles that the two strings make with the vertical direction are the same. What can you say about the two spheres? Choose all that apply.

A. Q1 and Q2 must have equal magnitude and the same sign
B. Q1 and Q2 must have equal magnitude but opposite sign
C. The two spheres must have equal mass
D. Q1 and Q2 must have different magnitudes and opposite sign
E. Q1 and Q2 must have different magnitudes and the same sign
F. None of the above statements applies.

1.2. A proton is entering a region with a non-uniform electric field as shown. What will happen next?

A. The proton is deflected downward
B. The proton is deflected upward
C. The proton is accelerated to the right
D. The proton slows down.



1.3. An electric dipole is held in a non-uniform electric field as shown. When released, the dipole will (choose all that apply)

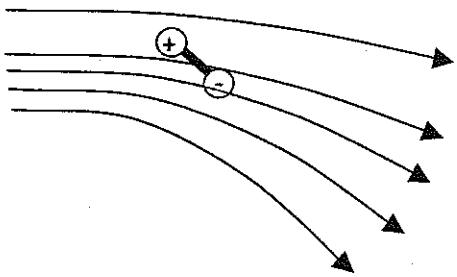
A. Rotate clockwise

B. Rotate counter-clockwise

C. Move to the left

D. Move to the right

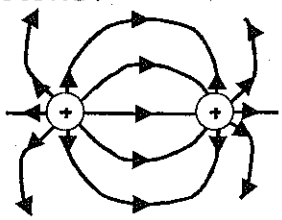
E. Stay in place.



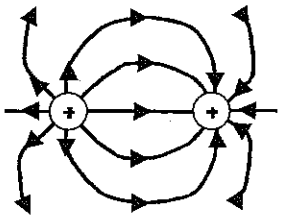
1.4

Which sketch best shows the E field around 2 protons?

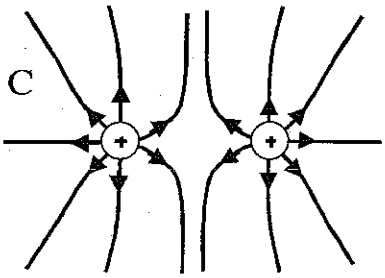
A



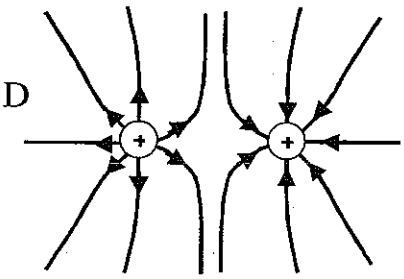
B



C



D



1.5. What mass of Carbon-14 (half-life =5730 years) do you need to provide a decay rate of 400 Bq?

Question 2a (2 marks)

The material used in nuclear bombs is ^{239}Pu with a half life of about 20,000 years, How long must you wait for a buried stockpile to decay to 2% of its original ^{239}Pu mass?

Question 2b (2 marks)

We have a sample containing ^{11}C atoms (half life = 20.4 min) and ^{13}N atoms (half life = 9.96 min). Initially there are three times as many ^{13}N atoms than ^{11}C atoms. What is the ratio 30 min later?

Question 2c (6 marks)

i) Calculate the binding energy per nucleon for ^{17}F, ^{18}F, ^{19}F. Clearly show your work.

The atomic masses of the nuclides are:

$^{17}_{9}F = 17.002094u$ $^{18}_{9}F = 18.000937u$ $^{19}_{9}F = 18.998404u$ $^{1}_{1}H = 1.007825$

$m_H = 1.007826u$, $m_n = 1.008665u$, $m_e = 0.000549u$

Binding Energy per nucleon ^{17}F: _____

Binding Energy per nucleon ^{18}F: _____

Binding Energy per nucleon ^{19}F: _____

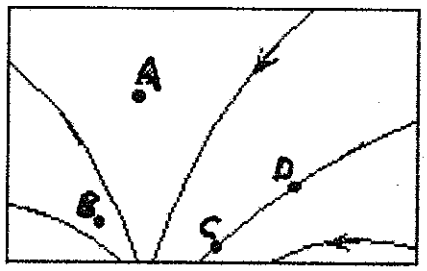
ii) Which isotope is likely to be the most stable? Explain your reasoning!

Question 3a (2 marks)

Electric field lines for an unknown charge distribution are shown at right.

i)

Rank the magnitude of the electric field at the four points A, B, C, D, If the field at any point is zero, indicate that explicitly.

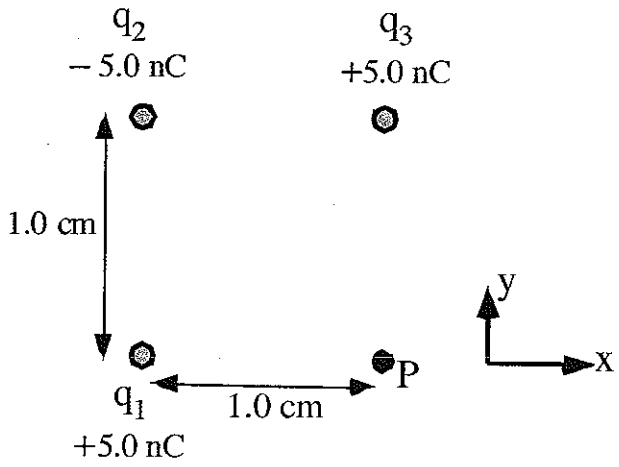


Largest _____ _____ _____ _____ Smallest

ii) Briefly explain below how you determined your ranking.

Question 3b (8 marks)

Three charges of equal magnitude are located on the corners of a square as shown.



i) What is the electric field at point P; express your answer as magnitude and direction as well as in unit vector form.

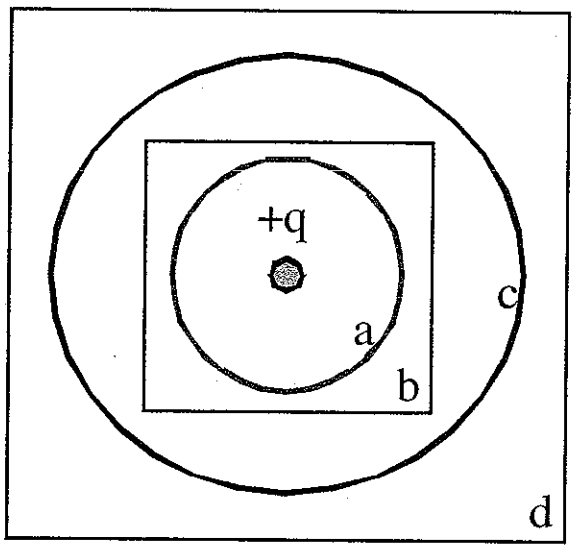
$|\vec{E}_P|$ = _____ θ_{E_P} = _____

$\vec{E}_P$ = _____

ii) What charge do you have to place at P to make the electric field zero at the centre of the square?

Question 4a (4 marks)

The figure shows the cross-section of two Gaussian spheres (a and c) and 2 Gaussian cubes (b and d) that are centered on a point charge, +q



i) Rank the net flux through the four surfaces. Use = if appropriate.

Largest _____ _____ _____ _____ Smallest

ii) Rank the magnitude of the Electric Field on the surfaces. Use = if appropriate

Largest _____ _____ _____ _____ Smallest

iii) Are the magnitudes of the fields, uniform or variable along each surface? Explain!

Question 4b (6 marks)

A long wire carrying uniform linear charge density λ=+50.0mC/m runs parallel to and 10cm above the surface of a thin flat plastic sheet that has a uniform surface charge density $\eta = -100\ mC/m^2$. Recall that for a line of charge $E = \frac{\lambda}{2\pi\varepsilon_0 r}$, *where* $\lambda = Q/L$

i) On the diagrams below, indicate the direction of the electric field due to the wire and the sheet by drawing in electric field lines.

Front view

Side view

ii) Find the location of all points where an alpha particle would feel no force due to these charged objects.

Question 5a (2 marks)

Tritium is an isotope of hydrogen and undergoes a β^- decay with a half-life of 12.33 years. Like C-14 it is produced in the atmosphere because of cosmic rays and can be used in radioactive dating.

Can tritium dating be used to reliably date a sample that is 700 years old? Explain!

Question 5b (2marks)

Is it possible for two samples of the same radioactive nuclide to have different activities? Explain!

Question 5c (2marks)

Uranium–238 undergoes an alpha decay to Thorium–234. Another possibility is that Uranium-238 just emits a single proton. This hypothetical decay is:

$$^{238}_{92}U \rightarrow ^{237}_{91}Pa + ^{1}_{1}H$$

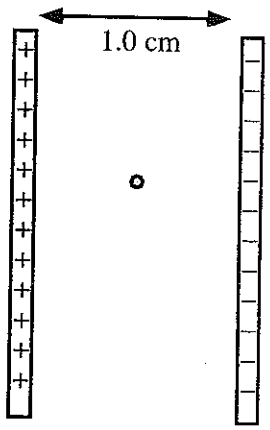
The atomic masses of the nuclides are:

$^{238}_{92}U = 238.05078u$, $^{237}_{91}Pa = 237.05114u$, $^{1}_{1}H = 1.00783u$

Is this decay possible? Explain

Question 5d (4 marks)

Devices such as electron microscopes are based on a beam of fast electrons. The fast electron beam is produced by a hot wire (similar to the filament in a light bulb) that releases electrons inside an electric field. The electron beam escapes the field through a small hole in one of the charged plates.
For such a device, the electric field between the two oppositely charged metal plates is 15000 N/C and the plates are separated by 1.0 cm.
i)) If an electron is released at a point midway between the plates, which plate will it hit and with what speed?



ii) If instead a proton is released at a point midway between the plates, which plate will it hit and with what speed?

Numerical Answers to Midterm 1 (09w) – Feb 2010

Question 1

1.1 C

1.2 D

1.3 A and C

1.4 C

1.5 2.42×10^{-12} kg

2a 1.13×10^{5} years

2b $N_N/N_C = 1.03$

2c F-17 7.54 MeV
F-18 7.63 MeV
F-19 7.78 MeV
F-19 most stable

3a B>C>D>A

3b $\vec{E} = \left(2.91 \times 10^{5}\hat{i} - 2.91 \times 10^{5}\hat{j}\right) N/C$

$|E| = 4.1 \times 10^{5} N/C \qquad \theta = -45°$ (with respect to + x axis)

–5.0 nC at P

4a a=b=c=d

a>b>c>d

uniform on spheres a and b, variable on cubes b and d

4b Must have E=0, so on a line parallel to wire and 15.9 cm above the wire.

5a No half-life is too short with respect to the time

5b Yes if they have different numbers of atoms

5c No mass of products greater than mass of reactants

5d positive , v= 5.13×10^{6} m/s, negative v=1.20×10^{5} m/s