Question:

Two metal plates of area A and separated by a distance d are placed in parallel near each other to form a capacitor with capacitance C. The plates are connected to a voltage source with potential V and allowed to charge completely. The voltage is then removed, and the plates moved so that they are now separated by a distance $2d$. Which of the following statements is true?

a. The charge on the plates has changed, and the electric field between them has increased.
b. The charge on the plates is the same, and the potential between them has decreased.
c. The potential between the plates has increased, and the electric field between them has decreased.
d. The capacitance of the plates has decreased, and the energy stored in the capacitor has increased.
e. The capacitance of the plates has decreased, and the electric field between them has decreased.

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Answer:

The correct answer is *d*. Once the plates are removed from the voltage source, they have a charge $Q = CV$. Moving the plates farther apart decreases their capacitance by a factor of 2 according to $C = \frac{A}{d}\varepsilon_0$. Although the capacitance has of the system has changed, the amount of charge stored on the plates has not: we conclude that the potential between the plates V must have *increased* as a result of the inverse relationship between C and V in $Q = CV$. The electric field between the two plates is described by the relationship $V = -Ed$, and because V and d have both increased by a factor of 2, we conclude that the electric field E between the plates is unchanged. The energy stored in the capacitor can be calculated as a function of any two of Q, C, and V. In this case, $U_C = \frac{1}{2}QV$ reveals that, because V has increased, the energy stored in the capacitor has increased as well. From a Conservation of Energy perspective, this extra energy arises as a result of the Work done in moving the two plates farther apart.

The only answer consistent with the above analysis is *d*.

Plan for Today (AP Physics 1)

- In class review day
- Go over AP Problems
- Study for Test tomorrow

Describe and calculate binding energy

- Mass Defect = difference in masses between starting products and ending products
- Binding energy is the energy released when particles are split apart OR the energy needed to break particles apart
- You can find per nucleon by taking the total binding energy and dividing by the number of nucleons
- Binding energy = E = mc^2 where m is the mass defect
  - If m is in amu, then for c^2, you can use 931.5 (then your energy is in MeV)

Describe half life and how to calculate the decay constant and find reactivity after some period of time

- Half life is theoretical time period for one half of the radioactive substance to decay
- $T_{1/2}$ = ln(2)/λ
- λ is the decay constant
- Reactivity = activity = R
- R = change in amount/change in time
- R = λ * N

Discuss the types of exposure you might encounter in the course of a year and what background radiation is

- Background radiation – radiation we encounter in our everyday lives
- Radiation coming from radioactive substances we encounter
- Exposure from xrays, flight, smoke detectors, power plants, where you live, etc (see dose sheet)
- Some radiation is normal and not considered harmful

If a nuclear spill which generated alpha particles occurred near you, describe the measures you would take. How does the answer change if it is beta or gamma?

- Alpha particles are stopped by paper or just a few inches of air
- So keep your distance or be covered
- Beta is stopped by something like aluminum foil so keep more distance and be covered by something sturdier
- Gamma radiation is the most penetrating – would want to have a lead vest or something

Describe radiocarbon dating

- Carbon-14 is naturally occurring in all living substances and is radioactive
- After a living thing dies, carbon-14 will start to decay
- By looking at what percent is left, we can figure out how old the bones/sample is/are

Plot the decay process of uranium or find daughter elements for alpha and beta decay

- Alpha decay is a helium nucleus being released
- The mass number decreases by 4 and the atomic number decreases by 2
- Beta minus decay is a neutron splitting into a proton and electron
- The mass number stays the same and the atomic number increases by 1
- Be able to keep track or follow a sequence

Additional Test Hints

- Be able to analyze a graph showing amount of a radioactive substance over time
- Know the differences between alpha, beta, and gamma and how they can be stopped
- Be able to find the mass number and atomic number of an atom
- Be able to calculate kinetic energy and momentum in a nuclear reaction
- Be able to convert to moles
- Be able to find the mass defect and binding energy
- Be able to make conversions between values per reaction and values per mole, mass, etc.