16.1 Electric Potential Energy and Electric Potential Difference

1. **MC** The SI unit of electric potential difference is the (a) joule, (b) newton per coulomb, (c) newton-meter, (d) joule per coulomb. (d)

2. **MC** How does the electrostatic potential energy of two positive point charges change when the distance between them is tripled: (a) It is reduced to one third its original value, (b) it is reduced to one ninth its original value, (c) it is unchanged, or (d) it is increased to three times its original value? (a)

3. **MC** An electron is moved from the positive to negative plate of a charged parallel plate arrangement. How does the sign of the change *d* in its electrostatic potential energy compare to the sign of the change in electrostatic potential it experiences: (a) Both are positive, (b) the energy change is positive, the potential change is negative, (c) the energy change is negative, the potential change is positive, or (d) both are negative? (b)

5. **CQ** When a proton approaches another fixed proton, what happens to (a) the kinetic energy of the approaching proton, (b) the electric potential energy of the system, and (c) the total energy of the system? (a) decreases (b) increases (c) remains the same

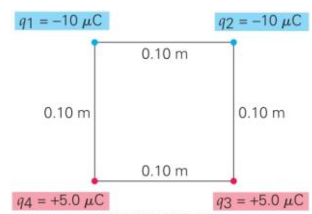
7. **CQ** An electron is released in a region where the electric potential decreases to the left. Which way will the electron begin to move? Explain. to the right

11. ● If it takes $+1.6\times10^{-5}$ J to move a positively charged particle between two charged parallel plates, (a) what is the charge on the particle if the plates are connected to a 6.0-V battery? (b) Was it moved from the negative to the positive plate or from the positive to the negative plate? (a) $2.7\ \mu C$ (b) negative to positive

12. ● What are the magnitude and direction of the electric field between the two charged parallel plates in Exercise 11 if the plates are separated by 4.0 mm? 1.5×10^{3} V/m pointing from positive to negative

13. ● In a dental X-ray machine, a beam of electrons is accelerated by a potential difference of 10 kV. At the end of the acceleration, how much kinetic energy does each electron have if they start from rest? 1.6×10^{-15} J

17. **IE** ●● (a) At one third the original distance from a positive point charge, by what factor is the electric potential changed: (1) $1/3$, (2) 3, (3) $1/9$, or (4) 9? Why? (b) How far from a $+1.0$-μC charge is a point with an electric potential value of 10 kV? (c) How much of a change in potential would occur if the point were moved to three times that distance? (a) (2) 3 (b) 0.90 m (c) -6.7 kV



23. ●● A $+2.0$-μC charge is initially 0.20 m from a fixed -5.0-μC charge and is then moved to a position 0.50 m from the fixed charge. (a) How much work is required to move the charge? (b) Does the work depend on the path through which the charge is moved? (a) $+0.27$ J (b) no

28. ●●● What is the value of electric potential at (a) the center of the square and (b) a point midway between q_1 and q_4 in Fig. 16.25>? (a) -1.3×10^{6} V (b) -1.3×10^{6} V

16.2 Equipotential Surfaces and the Electric Field

30. **MC** On an equipotential surface (a) the electric potential is constant, (b) the electric field is zero, (c) the electric potential is zero, (d) there must be equal amounts of negative and positive charge. (a)

31. **MC** Equipotential surfaces (a) are parallel to the electric field, (b) are perpendicular to the electric field, (c) can be at any angle with respect to the electric field. (b)

32. **MC** An electron is moved from an equipotential surface at $+5.0$ V to one at $+10.0$ V. It is moving generally in a direction (a) parallel to the electric field, (b) opposite to the electric field, (c) in the same direction as the electric field. (b)

36. **CQ** What geometrical shape are the equipotential surfaces between two charged parallel plates? planes, parallel to the plates

41. ● For a $+3.50$-μC point charge, what is the radius of the equipotential surface that is at a potential of 2.50 kV? 12.6 m

42. ● A uniform electric field of 10 kV/m points vertically upward. How far apart are the equipotential planes that differ by 100 V? 1.0 cm

48. ● The potential difference involved in a typical lightning discharge may be up to 100 MV (million volts). What is the gain in kinetic energy of an electron accelerated through this potential difference? Give your answer in both electron-volts and joules. (Assume that there are no collisions.) 1.00×10^{8} eV or 1.60×10^{-11} J

16.3 Capacitance

57. **MC** A capacitor is first connected to a 6.0-V battery and then disconnected and connected to a 12.0-V battery. How does its capacitance change: (a) It increases, (b) it decreases, or (c) it stays the same? (c)

58. **MC** A capacitor is first connected to a 6.0-V battery and then disconnected and connected to a 12.0-V battery. How does the charge on one of its plates change: (a) It increases, (b) it decreases, or (c) it stays the same? (a)

59. **MC** A capacitor is first connected to a 6.0-V battery and then disconnected and connected to a 12.0-V battery. By how much does the electric field strength between its plates change: (a) two times, (b) four times, or (c) it stays the same. (a)

60. **MC** A capacitor has the distance between its plates cut in half. By what factor does its capacitance change: (a) It is cut in half, (b) it is reduced to one fourth its original value, (c) it is doubled, or (d) it is quadrupled? (c)

61. **MC** A capacitor has the area of its plates reduced. How would you adjust the distance between those plates to keep the capacitance constant: (a) increase it, (b) decrease it, or (c) changing the distance cannot ever make up for the plate area change? (b)

66. ● A parallel-plate capacitor has a plate area of $0.50\ \text{m}^2$ and a plate separation of 2.0 mm. What is its capacitance? 2.2×10^{-9} F

67. ● What plate separation is required for a parallel-plate capacitor to have a capacitance of 5.0×10^{-9} F if the plate area is $0.40\ \text{m}^2$? 0.71 mm

68. **IE** ● (a) For a parallel-plate capacitor, a larger plate area results in (1) a larger, (2) an equal, (3) a smaller capacitance. (b) A 2.5×10^{-9} F parallel-plate capacitor has a plate area of $0.425\ \text{m}^2$. If the capacitance is to double, what is the required plate area? (a) (1) a larger (b) $0.850\ \text{m}^2$

16.4 Dielectrics

74. **MC** Putting a dielectric in a charged parallel-plate capacitor that is not connected to a battery (a) decreases the capacitance, (b) decreases the voltage, (c) increases the charge, (d) causes a discharge because the dielectric is a conductor. (b)

75. **MC** A parallel-plate capacitor is connected to a battery. If a dielectric is inserted between the plates, (a) the capacitance decreases, (b) the voltage increases, (c) the voltage decreases, (d) the charge increases. (d)

76. **MC** A parallel-plate capacitor is connected to a battery and then disconnected. If a dielectric is then inserted between the plates, what happens to the charge on its plates: (a) The charge decreases, (b) the charge increases, or (c) the charge stays the same? (c)

80. ● A capacitor has a capacitance of 50 pF, which increases to 150 pF when a dielectric material is between its plates. What is the dielectric constant of the material? $\kappa = 3.0$

81. ● A 50-pF capacitor is immersed in silicone oil $(\kappa = 2.6)$. When the capacitor is connected to a 24-V battery, what will be the charge on the capacitor and the amount of stored energy? 3.1×10^{-9} C; 3.7×10^{-8} J

16.5 Capacitors in Series and in Parallel

85. **MC** Capacitors in series have the same (a) voltage, (b) charge, (c) energy storage. (b)

86. **MC** Capacitors in parallel have the same (a) voltage, (b) charge, (c) energy storage. (a)

87. **MC** Capacitors 1, 2, and 3 have the same capacitance value *C*. 1 and 2 are in series and their combination is in parallel with 3. What is their effective total capacitance. (a) *C*, (b) 1.5*C*, (c) 3*C*, or (d) $C/3$? (b)

88. **CQ** Under what conditions would two capacitors in series have the same voltage? equal capacitance

89. **CQ** Under what conditions would two capacitors in parallel have the same charge? equal capacitance

90. **CQ** If you are given two capacitors, how should you connect them to get (a) maximum equivalent capacitance and (b) minimum equivalent capacitance? (a) parallel (b) series

93. **IE** ● (a) Two capacitors can be connected to a battery in either a series or parallel combination. The parallel combination will draw (1) more, (2) equal, or (3) less energy from a battery than the series combination. Why? (b) When a series combination of two uncharged capacitors is connected to a 12-V battery, $173\ \mu\text{J}$ of energy is drawn from the battery. If one of the capacitors has a capacitance of $4.0\ \mu\text{F}$, what is the capacitance of the other? (a) (1) more (b) $6.0\ \mu\text{F}$

94. ●● For the arrangement of three capacitors in >Fig. 16.28, what value of C_1 will give a total equivalent capacitance of $1.7\ \mu\text{F}$? $1.2\ \mu\text{F}$