MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.
1) Point charges, $Q_1 = +52 \text{ nC}$ and $Q_2 = -91 \text{ nC}$, are placed as shown. In Fig. 23.1a, an external force transports an electron from point $A$ to point $B$. The work done by the external force is closest to:

A) $-570 \text{ eV}$  
B) $+860 \text{ eV}$  
C) $-860 \text{ eV}$  
D) $+570 \text{ eV}$  
E) $+720 \text{ eV}$

2) A proton with a speed of $3.0 \times 10^5 \text{ m/s}$ falls through a potential difference $V$ and thereby increases its speed to $9.0 \times 10^5 \text{ m/s}$. Through what potential difference did the proton fall?

A) $470 \text{ V}$  
B) $4200 \text{ V}$  
C) $240 \text{ V}$  
D) $4700 \text{ V}$  
E) $3800 \text{ V}$
Figure 23.4

Two large conducting parallel plates $A$ and $B$ are separated by 2.4 m. A uniform field of 1500 V/m, in the positive $x$-direction, is produced by charges on the plates. The center plane at $x = 0.0$ m is an equipotential surface on which $V = 0$. An electron is projected from $x = 0.0$ m, with an initial kinetic energy $K = 300$ eV, in the positive $x$-direction, as shown.

3) In Fig. 23.4, the kinetic energy of the electron as it reaches plate $A$ is closest to:
   
   A) $-2.4 \times 10^{-16}$ J
   B) $-2.9 \times 10^{-16}$ J
   C) $+3.4 \times 10^{-16}$ J
   D) $+2.4 \times 10^{-16}$ J
   E) $-3.4 \times 10^{-16}$ J

Situation 23.1

Two long conducting cylindrical shells are coaxial and have radii of 20 mm and 80 mm. The electric potential of the inner conductor, with respect to the outer conductor, is +600 V.

4) In Situation 23.1, the maximum electric field magnitude between the cylinders is closest to:
   
   A) 14,000 V/m
   B) 26,000 V/m
   C) 10,000 V/m
   D) 18,000 V/m
   E) 22,000 V/m
5) An electron is released from rest at a distance of 9 cm from a proton. How fast will the electron be moving when it is 3 cm from the proton?

A) 106 m/s  
B) 130 m/s  
C) $4.64 \times 10^5$ m/s  
D) $1.06 \times 10^3$ m/s  
E) 75 m/s

6) A conducting sphere 45 cm in diameter carries an excess of charge, and no other charges are present. You measure the potential of the surface of this sphere and find it to be 14 kV relative to infinity. The excess charge on this sphere is closest to:

A) 0.35 nC  
B) 350 nC  
C) 315 nC  
D) 79 nC  
E) 700 nC

7) Each plate of a parallel-plate air capacitor has an area of 0.0040 m², and the separation of the plates is 0.080 mm. An electric field of $5.3 \times 10^6$ V/m is present between the plates. The energy density between the plates is closest to:

A) 84 J/m³  
B) 250 J/m³  
C) 210 J/m³  
D) 170 J/m³  
E) 130 J/m³

8) In Fig. 24.1, the total energy stored in the seven capacitors, in mJ, is closest to:

A) 48  
B) 96  
C) 144  
D) 72  
E) 120

9) The square plates of a 2000-pF capacitor measure 20 mm by 20 mm and are separated by a dielectric that is 0.27 mm thick. The voltage rating of the capacitor is 500 V. The dielectric constant of the dielectric is closest to:

A) 110  
B) 150  
C) 170  
D) 140  
E) 120
Situation 24.1
An air-filled parallel-plate capacitor has round plates and carries a fixed amount of equal but opposite charge on its plates. All the geometric parameters of the capacitor (plate diameter and plate separation) are now doubled.

10) In Situation 24.1, if the original capacitance was \( C_0 \), the new capacitance is:
   - A) \( C_0/2 \)
   - B) \( C_0/4 \)
   - C) \( 2C_0 \)
   - D) \( 4C_0 \)
   - E) \( C_0 \)

11) Five capacitors are connected across a potential difference \( V_{ab} \) as shown in Fig. 24.2. Because of the dielectrics used, each capacitor will break down if the potential across it exceeds 30.0 V. The largest that \( V_{ab} \) can be without damaging any of the capacitors is closest to:
   - A) 6.00 V
   - B) 579 V
   - C) 150 V
   - D) 30.0 V
   - E) 64 V

12) The network shown is assembled with uncharged capacitors \( X \), \( Y \), and \( Z \), with \( C_X = 7 \, \mu\text{F} \), \( C_Y = 4 \, \mu\text{F} \), and \( C_Z = 1 \, \mu\text{F} \), and open switches, \( S_1 \) and \( S_2 \). A potential difference \( V_{ab} = +120 \, \text{V} \) is applied between points a and b. After the network is assembled, switch \( S_1 \) is closed, but switch \( S_2 \) is kept open. In Fig. 24.4, the energy stored in capacitor \( X \), in mJ, is closest to:
   - A) 0.84
   - B) 2.9
   - C) 100
   - D) 0.42
   - E) 50
Table 25.1

<table>
<thead>
<tr>
<th></th>
<th>Electrical Resistivity</th>
<th>Temperature Coefficient of Resistivity (°C)$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>nichrome</td>
<td>1.0 x 10$^{-6}$ (Ω m)</td>
<td>+0.0004</td>
</tr>
<tr>
<td>carbon</td>
<td>3.5 x 10$^{-5}$</td>
<td>-0.0005</td>
</tr>
</tbody>
</table>

13) Electrical properties of nichrome and carbon at 20°C are given in the table. Nichrome and carbon are available in rods that have a cross-sectional area of 2.2 $\times$ 10$^{-6}$ m$^2$. At a temperature of 20°C, the sum of the resistances of a section of nichrome rod and a section of carbon rod is 0.66 ohms. When the temperature is increased, the increase in the resistance of the nichrome section is exactly offset by the decrease in the resistance of the carbon section. In Table 25.1, the length of the nichrome section, in cm, is closest to:

A) 110  B) 81  C) 120  D) 66  E) 95

Situation 25.1

The voltage and power ratings of a light bulb, which are the normal operating values, are 110 V and 60 W. Assume the filament resistance of the bulb is constant and is independent of operating conditions.

14) In Situation 25.1, the light bulb is operated with a current that is one half of the current rating of the bulb. The actual power drawn by the bulb is closest to:

A) 15 W  B) 25 W  C) 10 W  D) 30 W  E) 20 W

Figure 25.2

The emf and the internal resistance of a battery are as shown.

15) In Fig. 25.2, when the terminal voltage of the battery $V_{ab}$ is equal to 20 V, the current which passes through the battery, including direction, is closest to:

A) 4 A, from $a$ to $b$
B) 5 A, from $b$ to $a$
C) 6 A, from $a$ to $b$
D) 4 A, from $b$ to $a$
E) 5 A, from $a$ to $b$

16) In Fig. 25.2, the power dissipated in an external resistor, which is connected across the terminals of the battery, is equal to 18 W. The terminal voltage of the battery $V_{ab}$ is closest to:

A) 7.2 V  B) 8.4 V  C) 9.6 V  D) 6.0 V  E) 10.8 V
In the circuit shown in Fig. 25.3, a variable resistor $R$ is connected across the terminals of a battery, and an ideal ammeter and ideal voltmeter are also connected. In the figure, $\varepsilon$ is the internal emf of the battery, and $r$ is its internal resistance. All the connecting cables have no appreciable resistance. The ammeter reads 3.10 A when the voltmeter reads 5.08 V, and the voltmeter reads 15.0 V when the ammeter reads 0.00 V.

17) In Fig. 25.3, the internal emf of the battery is closest to:

18) A cylindrical wire has a resistance $R$ and resistivity $\rho$. If its length and diameter are both cut in half, its resistivity will now be:
   [A] $2\rho$   [B] $4\rho$   [C] $\rho$   [D] $\rho/4$   [E] $\rho/2$