1. (ai) B

   (aii) D

   (b) B

   (c) A

   (d) B

   (e) B

   (f) C

   (g) D

2. (a)

$$\int_d^D \mathbf{E} \cdot d\mathbf{l} = V_o$$
$$\int_d^D \frac{\rho}{2\pi\epsilon_o r} dr = V_o$$
$$\frac{\rho}{2\pi\epsilon_o} \log r \Big|_d^D = V_o$$
$$\rho = \frac{V_o 2\pi\epsilon_o}{\log \frac{D}{d}}$$

   (b)

$$\begin{aligned} E &= \frac{\rho}{2\pi\epsilon_o r} \\ &= \frac{V_o 2\pi\epsilon_o}{\log \frac{D}{d}} \frac{(d+D)/4}{2\pi\epsilon_o} \\ &= \frac{V_o(d+D)}{4\log \frac{D}{d}} [V/m] \end{aligned}$$

3. (a) Because $E = \frac{Q}{4\pi\epsilon_o r^2}\hat{r}$ the flux is 4 times greater when the distance is 1/2 times. But the sign reverses when the surface is below the charge so $\Psi_E = -40C$

   (b) $\mathbf{E} \cdot d\mathbf{S} = 0$ so $\Psi_E = 0$.

   (c)

$$\begin{aligned} \mathbf{E} \cdot d\mathbf{S} &= |E||dS| \cos\theta \\ &= |E||dS| \cos \pi/4 \\ &= |E|dS|/\sqrt{2} \end{aligned}$$

   The distance r was originally 2m. Now it is $2\sqrt{2}$ m so the E is reduced 2 times since $r^2 = 8$ vs 4. So $\Psi_E = 10/(2\sqrt{2}) = \frac{5\sqrt{2}}{2}C$

4. (a) $\nabla \cdot \mathbf{D} = \rho = 0$. In free space, $\mathbf{D} = \epsilon_o \mathbf{E}$ so $\nabla \cdot \mathbf{E} = 0$. Now $\nabla \cdot \mathbf{E} = 2xz + 2z + \frac{\partial f}{\partial z} = 0$ so $\frac{\partial f}{\partial z} = -2xz - 2z$. One possible function is $f = -xz^2 - z^2 = -z^2(x+1)$. The most general function is $f = -z^2(x+1) + h(x,y)$.

   (b) Electrostatics require $\nabla \times \mathbf{E} = \frac{\partial \mathbf{B}}{\partial t} = 0$. Hence,

$$\nabla \times \mathbf{E} = < \frac{\partial h}{\partial y} - 2y, z^2 - \frac{\partial h}{\partial x} + x^2, 0 >$$

   For the particular f that was found (h=0), we get a nonzero x and y component for curl E. Even if we include a nonzero h, we can't make the y component of curl E be zero. $\frac{\partial h}{\partial x} = x^2 + z^2$ is not possible when h can only depend on x and y. Hence, this is NOT an electrostatic field.

5. (1) B

   (2) E (B can be considered correct as well due to typesetting error)

   (3) AE

   (4) F (D can be considered correct as well due to typesetting error)