(1) In cartesian coordinates $D$ is the region
\[
\begin{align*}
(x - a)^2 + (y - a)^2 &\leq a^2 \\
-1 &\leq z \leq 3
\end{align*}
\]
This translates to the cylindrical coordinates
\[
\begin{align*}
r^2 - 2ar\cos\theta + 2a\sin\theta &\leq a^2 \\
-1 &\leq z \leq 3
\end{align*}
\]
(2) The region $D$ is
\[
\begin{align*}
\rho &\leq 2a \\
-a &\leq \rho \sin\phi \cos\theta \leq a
\end{align*}
\]
(3) (i) True. For any $c \in C$ there exists $b \in B$ such that $g(b) = c$, since $g$ is surjective. Since $f$ is surjective there exists $a \in A$ such that $f(a) = b$ and hence $(g \circ f)(a) = c$. It follows that $g \circ f$ is surjective.
(ii) False. Consider the counter example given by the domains $A = \{1\}$, $B = \{0, 1\}$ and $C = \{1\}$ and the functions $f, g$ defined by $f(1) = 1$ and $g(0) = g(1) = 1$. Then $g \circ f : A \to C$ is surjective (since $g(f(1)) = 1$), but $f$ is not surjective since $0 \in B$ has no preimage.
(iii) True. For any $c \in C$ there exists $a \in A$ such that $g(f(a)) = c$ since $g \circ f$ is surjective. Since $f(a) \in B$ we learn that $g$ is surjective.
(4) We take $f$ to be
\[
f(x) = \begin{cases} c, & x \in S \\ c - 1, & x \notin S \end{cases}
\]
(5) (2.1.34)
(a) We take $F$ to be
\[
F(x, y, z) = \begin{cases} 1, & x^2 + xy - xz = 2 \\ 0, & x^2 + xy - xz \neq 2 \end{cases}
\]
(b) We take $f$ to be
\[
f(x, y) = \frac{x^2 + xy - 2}{x},
\]
defined for any $(x, y)$ such that $x \neq 0$.
(6) (2.2.9) The limit does not exist. Along the line $y = -x$ the limit is 0 and along the line $y = x$ the limit is 2.
(7) (2.2.11) The limit does not exist. Along the line $y = 0$ the limit is 2 and along the line $x = 0$ the limit is 1.

(8) (2.2.13) The limit exists and is 0.

\[
\lim_{(x,y) \to (0,0)} \frac{x^2 + 2xy + y^2}{x + y} = \lim_{(x,y) \to (0,0)} \frac{(x + y)^2}{x + y} = \lim_{(x,y) \to (0,0)} x + y = 0.
\]

(9) (2.2.15) The limit exists and is 0.

\[
\lim_{(x,y) \to (0,0)} \frac{x^4 - y^4}{x^2 + y^2} = \lim_{(x,y) \to (0,0)} \frac{(x^2 + y^2)(x^2 - y^2)}{x^2 + y^2} = \lim_{(x,y) \to (0,0)} x^2 - y^2 = 0.
\]

(10) (2.2.31)

\[
\lim_{(x,y,z) \to (0,0,0)} \frac{xyz}{x^2 + y^2 + z^2} = \lim_{\rho \to 0} \frac{\rho^3 \sin^2 \phi \cos \theta \sin \theta \cos \phi}{\rho^2} = 0.
\]

(11) (2.2.35) The function is continuous because it is a polynomial.

(12) (2.2.42) The function $g$ is clearly continuous at any point $(x, y) \neq (0, 0)$. So for $g$ to continuous $c$ must be the limit $\lim_{(x,y) \to (0,0)} g(x, y)$. We compute

\[
\lim_{(x,y) \to (0,0)} \frac{x^3 + xy^2 + 2x^2 + 2y^2}{x^2 + y^2} = \lim_{(x,y) \to (0,0)} \frac{x^3 + xy^2}{x^2 + y^2} + 2 = \lim_{r \to 0} \frac{r^3 (\cos^3 \theta + \cos \theta \sin^2 \theta)}{r^2} + 2 = 2,
\]

so $c = 2$ is the value that makes $g$ continuous.