14. We put the subsets inside the supersets. Thus the answer is as shown.

\[ A \subseteq B \subseteq C \]

16. We allow \( B \) and \( C \) to overlap, because we are told nothing about their relationship. The set \( A \) must be a subset of each of them, and that forces it to be positioned as shown. We cannot actually show the properness of the subset relationships in the diagram, because we don’t know where the elements in \( B \) and \( C \) that are not in \( A \) are located—there might be only one (which is in both \( B \) and \( C \)), or they might be located in portions of \( B \) and/or \( C \) outside the other. Thus the answer is as shown, but with the added condition that there must be at least one element of \( B \) not in \( A \) and one element of \( C \) not in \( A \).

\[ A \subseteq B \cap C \]

18. Since the empty set is a subset of every set, we just need to take a set \( B \) that contains \( \emptyset \) as an element. Thus we can let \( A = \emptyset \) and \( B = \{\emptyset\} \) as the simplest example.

20. The cardinality of a set is the number of elements it has.
   a) The empty set has no elements, so its cardinality is 0.
   b) This set has one element (the empty set), so its cardinality is 1.
   c) This set has two elements, so its cardinality is 2.
   d) This set has three elements, so its cardinality is 3.

22. The union of all the sets in the power set of a set \( X \) must be exactly \( X \). In other words, we can recover \( X \) from its power set, uniquely. Therefore the answer is yes.

24. a) The power set of every set includes at least the empty set, so the power set cannot be empty. Thus \( \emptyset \) is not the power set of any set.
   b) This is the power set of \( \{a\} \).
   c) This set has three elements. Since 3 is not a power of 2, this set cannot be the power set of any set.
   d) This is the power set of \( \{a,b\} \).

26. We need to show that every element of \( A \times B \) is also an element of \( C \times D \). By definition, a typical element of \( A \times B \) is a pair \((a,b)\) where \( a \in A \) and \( b \in B \). Because \( A \subseteq C \), we know that \( a \in C \); similarly, \( b \in D \). Therefore \( (a,b) \in C \times D \).

28. By definition it is the set of all ordered pairs \((c,p)\) such that \( c \) is a course and \( p \) is a professor. The elements of this set are the possible teaching assignments for the mathematics department.

30. We can conclude that \( A = \emptyset \) or \( B = \emptyset \). To prove this, suppose that neither \( A \) nor \( B \) were empty. Then there would be elements \( a \in A \) and \( b \in B \). This would give at least one element, namely \((a,b)\), in \( A \times B \), so \( A \times B \) would not be the empty set. This contradiction shows that either \( A \) or \( B \) (or both, it goes without saying) is empty.