UNIT – 7
SET THEORY

CHAPTER 37
SETS

37.1 REVIEW

Set	A set is a collection of well-defined objects.
1. The collection of tall students of your class is not well-defined, so it **does not form a set.** 2. The collection of students of your class **with heights between 135 cm and 160 cm** is well-defined, so it forms a set.	
Elements	The objects (numbers, names, etc.) used to form a set is called elements or members of the set.
In general, a set is represented by capital letters of English alphabet. The elements of the set are written inside curly braces and separated by commas. (i) If A is the set of names : John, Geeta, Amit and Rohit; then : set A = {John, Geeta, Amit, Rohit}. (ii) If V is the set of vowels of English alphabet then, set V = {a, e, i, o, u}.	
Using '$\in$' and $\notin$	The symbol '$\in$' stands for 'belongs to' and the symbol '$\notin$' stands for 'does not belong to'.
If an element x belongs to set A, we write : $x \in A$ and if 'x' does not belong to set A, we write $x \notin A$.	

37.2 REPRESENTATION OF A SET

There are mainly *two* ways of representing a set.

(i) Roster or Tabular Form (ii) Rule Method or Set–Builder Form.

1. *Roster* (or Tabular) *Form*

In this form, the elements of the set are enclosed in curly braces { } after separating them by commas.

For example, if a set A consists of numbers 2, 5, 7, 9 and 15, it is written as :

A = {2, 5, 7, 9, 15}.

More examples :

(i) The set of integers *i.e.* Z = {......., –2, –1, 0, 1, 2, 3, ...}

(ii) The set of whole numbers *i.e.* W = {0, 1, 2, 3, 4, ...}

(iii) The set of natural numbers *i.e.* N = {1, 2, 3, 4, ...}

1. The order in which the elements of a set are written is not important. *i.e.* {a, b, c}, {b, a, c} and {c, b, a} represent the same set.
2. An element of a set is written only once. *i.e.* (i) {2, 3, 3, 2, 4, 2} = {2, 3, 4} (ii) The set of letters in the word ALLAHABAD = {a, l, h, b, d}

2. *Set-Builder* Form (Rule Method)

In this form, the actual elements of the set are not written, but a statement or a formula or a rule is written in the briefest possible way to represent the elements of the set.

e.g. Let A be the set of natural numbers less than 7, then in set-builder form it is written as :

$A = \{ x : x \in N \text{ and } x < 7 \}$

and is read as "A is the set of x such that x is a natural number and x is less than 7."

The symbol ':' is read as *such that.*

More examples :

1. $A = \{2, 3, 4, 5\}$ [Roster or Tubular Form]
   $= \{x : x \in N, 2 \leq x < 6\}$ [Set-builder Form]

For x representing the nautral numbers 2, 3, 4 and 5 ; we can also write $1 < x < 6$ or $2 \leq x \leq 5$ or $1 < x \leq 5$.

2. $C = \{1, 3, 5, 7, 9, 11\}$ [Roster Form]
   $= \{x : x = 2n - 1, n \in N \text{ and } n \leq 6\}$
   or $\{x : x = 2n + 1, n \in W \text{ and } n \leq 5\}$ [Set-builder Form]
3. $D = \{x : x = 2n, n \in N \text{ and } n \leq 4\}$ [Set-builder Form]
   $= \{2 \times 1, 2 \times 2, 2 \times 3, 2 \times 4\}$
   $= \{2, 4, 6, 8\}$ [Roster Form]

TEST YOURSELF

1. Set of letters of the word JALLANDHAR = ...
2. Roster form of set $A = \left\{\frac{1}{2}, \frac{2}{3}, \frac{3}{4}, \frac{4}{5}, \frac{5}{6}, ...\right\}$
   Set-builder form of set A = ...
3. Set-builder form of set $B = \{x : x = n^2, n \in W \text{ and } 4 < n \leq 8\}$
   Roster form of set B = ...
4. $5x - 3 \geq 12$ and $x \in N$
   $\Rightarrow x =$ ...., ..., ..., ..., ..., ..., ..., ..., ..., ...
   and $A = \{x : 5x - 3 \geq 12 \text{ and } x \in N\}$ = ...

Example 1 :

Write the following sets in the set-builder form :

(i) $\{x : x = \frac{2n}{n+2}, n \in W \text{ and } n < 3\}$ (ii) $\{x : x = 5y - 3, y \in Z \text{ and } -2 \leq y < 2\}$

(iii) $\{x : x \in W \text{ and } 8x + 5 < 23\}$

Solution :

(i) Since, $n \in W$ and $n < 3 \Rightarrow n = 0, 1$ and 2

$\therefore$ **Set in set-builder form** $= \{\frac{2\times 0}{0+2}, \frac{2\times 1}{1+2}, \frac{2\times 2}{2+2}\} = \{0, \frac{2}{3}, 1\}$ **(Ans.)**

(ii) $y \in Z$ and $-2 \le y < 2 \Rightarrow y = -2, -1, 0$ and 1

$\therefore$ **Set in set-builder form** $= \{5 \times -2 - 3, 5 \times -1 -3, 5 \times 0 - 3, 5 \times 1 - 3\}$

$= \{-13, -8, -3, 2\}$ **(Ans.)**

(iii) $8x + 5 < 23 \Rightarrow 8x < 18$ and $x < 2{\cdot}25$

$\because$ $x \in W$ and $x < 2{\cdot}25 \Rightarrow x = 0, 1$ and 2

$\therefore$ **Set in set-builder form** $= \{0, 1, 2\}$ **(Ans.)**

Example 2 :

Express the following sets in set-builder form :

(i) $\{\frac{7}{8}, \frac{8}{9}, \frac{9}{10}, \frac{10}{11}, \frac{11}{12}\}$ (ii) $\{0, 3, 6, 9, 12, 15, 18\}$

(iii) $\{\frac{1}{3}, \frac{1}{9}, \frac{1}{27}, \frac{1}{81}, \frac{1}{243}\}$ (iv) $\{x : x^2 - 6x - 7 = 0\}$

Solution :

(i) $\{\frac{7}{8}, \frac{8}{9}, \frac{9}{10}, \frac{10}{11}, \frac{11}{12}\} = \{\frac{7}{7+1}, \frac{8}{8+1}, \frac{9}{9+1}, \frac{10}{10+1}, \frac{11}{11+1}\}$

$= \{x : x = \frac{n}{n+1}, n \in N \text{ and } 7 \le n \le 11\}$ **(Ans.)**

(ii) $\{0, 3, 6, 9, 12, 15, 18\} = \{3 \times 0, 3 \times 1, 3 \times 2, 3 \times 3, 3 \times 4, 3 \times 5, 3 \times 6\}$

$= \{x : x = 3n, n \in W \text{ and } x \le 6\}$ **(Ans.)**

(iii) $\{\frac{1}{3}, \frac{1}{9}, \frac{1}{27}, \frac{1}{81}, \frac{1}{243}\} = \{\frac{1}{3^1}, \frac{1}{3^2}, \frac{1}{3^3}, \frac{1}{3^4}, \frac{1}{3^5}\}$

$= \{x : \frac{1}{3^n}, n \in N \text{ and } n \le 5\}$ **(Ans.)**

(iv) Since, $x^2 - 6x - 7 = 0$

$\Rightarrow$ $x^2 - 7x + x - 7 = 0$ *i.e.* $x(x - 7) + 1(x - 7) = 0$

$\Rightarrow$ $(x - 7)(x + 1) = 0$ *i.e.* $x - 7 = 0$ or $x + 1 = 0$

$\Rightarrow$ $x = 7$ or $x = -1$

$\therefore$ $\{x : x^2 - 6x - 7 = 0\} = \{7, -1\}$ **(Ans.)**

EXERCISE 37 (A)

1. Write the following sets in roster (Tabular) form :
   (i) $A_1 = \{x : 2x + 3 = 11\}$
   (ii) $A_2 = \{x : x^2 - 4x - 5 = 0\}$
   (iii) $A_3 = \{x : x \in Z, -3 \le x < 4\}$
   (iv) $A_4 = \{x : x$ is a two digit number and sum of the digits of x is $7\}$
   (v) $A_5 = \{x : x = 4n, n \in W \text{ and } n < 4\}$
   (vi) $A_6 = \{x : x = \frac{n}{n+2}; n \in N \text{ and } n > 5\}$
2. Write the following sets in set-builder (Rule Method) form :
   (i) $B_1 = \{6, 9, 12, 15, ...\}$
   (ii) $B_2 = \{11, 13, 17, 19\}$
   (iii) $B_3 = \left\{\frac{1}{3}, \frac{3}{5}, \frac{5}{7}, \frac{7}{9}, \frac{9}{11}, ...\right\}$
   (iv) $B_4 = \{8, 27, 64, 125, 216\}$
   (v) $B_5 = \{-5, -4, -3, -2, -1\}$
   (vi) $B_6 = \{....., -6, -3, 0, 3, 6, ...\}$
3. (i) Is $\{1, 2, 4, 16, 64\} = \{x : x$ is a factor of $32\}$? Give reason.
   (ii) Is $\{x : x$ is a factor of $27\} \ne \{3, 9, 27, 54\}$? Give reason.
   (iii) Write the set of even factors of 124.
   (iv) Write the set of odd factors of 72.
   (v) Write the set of prime factors of 3234.
   (vi) Is $\{x : x^2 - 7x + 12 = 0\} = \{3, 4\}$?
   (vii) Is $\{x : x^2 - 5x - 6 = 0\} = \{2, 3\}$?

4. Write the following sets in Roster form :
   (i) The set of letters in the word 'MEERUT'.
   (ii) The set of letters in the word 'UNIVERSAL'.
   (iii) $A = \{x : x = y + 3, y \in N \text{ and } y > 3\}$.
   (iv) $B = \{p : p \in W \text{ and } p^2 < 20\}$.
   (v) $C = \{x : x$ is a composite number and $5 \le x \le 21\}$

5. List the elements of the following sets :
   (i) $\{x : x^2 - 2x - 3 = 0\}$
   (ii) $\{x : x = 2y + 5 ; y \in N \text{ and } 2 \le y < 6\}$
   (iii) $\{x : x$ is a factor of $24\}$
   (iv) $\{x : x \in Z \text{ and } x^2 \le 4\}$
   (v) $\{x : 3x - 2 \le 10 \text{ and } x \in N\}$
   (vi) $\{x : 4 - 2x > -6, x \in Z\}$

37.3 CARDINAL NUMBER OF A SET

The number of elements in a set is called its **cardinal number.**

e.g. (i) If $A = \{c, d, f\}$, then cardinal number of set A is 3 and we write $n(A) = 3$.
(ii) If $B = \{2, 4, 5, 6\}$, then $n(B) = 4$ and so on.

37.4 TYPES OF SETS

1. Finite Set :

A set with finite (limited) number of elements in it, is called a **finite set.**

e.g. (i) Set of boys in your class.
(ii) $\{x : x$ is a member of a particular family$\}$.
(iii) $\{3, 4, 5, \ldots\ldots\ldots, 100\}$ and so on.

2. Infinite Set :

A set, which is not finite, is called an **infinite set.** That is, a set with never ending number of elements is an infinite set.

e.g. (i) $\{x : x$ is a living thing$\}$.
(ii) $\{x : x \in W \text{ and } x > 1000\}$ and so on.

3. Singleton or Unit Set :

A set, which has only one element in it, is called a **singleton** or **unit set.**

e.g. (i) $\{x : x$ is President of India$\}$
(ii) Set of whole numbers between 6 and 8.
(iii) $\{x : 2x - 1 = 3\}$ and so on.

4. Empty or Null Set :

The set, which has no element in it, is called the **empty** or **null set.**
The empty set is denoted by the Danish letter '$\varnothing$' and is pronounced as 'oe'.
$\therefore$ **Empty set** $= \{\ \} = \varnothing$.

Examples :
(i) The set of all odd numbers between 7 and 9.
(ii) $\{x : x \in N \text{ and } x < 1\}$ and so on.

> 1. The cardinal number of the empty set is 0, i.e. $n(\varnothing) = 0$.
> 2. The set $\{0\}$ is not an empty set, since it contains zero as its element.
> 3. The set $\{\varnothing\}$ is also not empty, since it contains $\varnothing$ as its element.

5. Joint or overlapping Sets :

Two sets are said to be **joint** or **overlapping sets,** if they have atleast one element in common.

e.g. Set A = {5, 7, 9, 11} and set B = {6, 9, 12, 15} are joint (overlapping) sets as number 9 is common to both the sets.

6. Disjoint Sets :

Two set are said to be **disjoint,** if they have no element in common.

e.g. (i) Set A = {5, 7, 9, 11} and set B = {4, 6, 8, 10} are disjoint, as they have no element in common.

(ii) If A = {x : x is a student of Sophia Girls' School} and B = {x : x is a student of St. Mary's Academy}, then clearly sets A and B are disjoint.

7. Equivalent Sets :

Two sets are said to be **equivalent,** if they contain the same number of elements.

e.g. Set A = {a, b, c} and set B = {x, y, z} are equivalent as n(A) = n(B) and we write $A \leftrightarrow B$.

8. Equal Sets :

Two sets are **equal,** if both the sets have same (identical) elements.

e.g. If A = {1, 2, 3, 4, 5} and B = {x : x ∈ N and x < 6} ; then clearly A = B.

1. In equivalent sets, the number of elements are equal, whereas in equal sets, the elements are the same.
2. Equal sets are always equivalent, whereas the equivalent sets are not necessarily equal.

TEST YOURSELF :

5. If A = {x : x ∈ Z and $-3 \le x < 5$} [Set-builder form]
   = ... [Roster form]
   n(A) = ...
6. State, as finite, infinite, singleton set or null set :
   (a) The set B = {x : x ≤ 5 and x ∈ Integers} ....
   (b) The set P = {x : x ≤ 5 and x ∈ Whole numbers} ....
   (c) The set A = {x : 4 ≤ x < 5 and x ∈ W} ....
   (d) The set E = {x : 4 < x < 5 and x ∈ N} ....
7. State, as joint (overlapping) sets or disjoint sets :
   (a) A = {x : x < 5} and B = {x : x > 5} ....
   (b) A = {x : x ≤ 5} and B = {x : x ≥ 5} ....
8. State, as equivalent sets or equal sets :
   (a) A = {4, 5, 6, 7} and B = {x ∈ N : 8 ≤ x < 12} ....
   (b) P = {x ∈ W : 3 < x ≤ 8} and Q = {4, 5, 6, 7, 8} ....

EXERCISE 37 (B)

1. Find the cardinal number of the following sets :
   (i) A_1 = {–2, –1, 1, 3, 5}
   (ii) A_2 = {x : x ∈ N and 3 ≤ x < 7}
   (iii) A_3 = {p : p ∈ W and 2p –3 < 8}
   (iv) A_4 = {b : b ∈ Z and –7 < 3b – 1 ≤ 2}

2. If P = {p : p is a letter in the word 'PERMANENT'}, find n(P).
3. State, which of the following sets are finite and which are infinite :
   (i) $A = \{x : x \in Z \text{ and } x < 10\}$
   (ii) $B = \{x : x \in W \text{ and } 5x - 3 \le 20\}$
   (iii) $P = \{y : y = 3x - 2, x \in N \text{ and } x > 5\}$
   (iv) $M = \{r : r = \frac{3}{n}\ ; n \in W \text{ and } 6 < n \le 15\}$
4. Find, which of the following sets are singleton sets :
   (i) The set of points of intersection of two non-parallel straight lines on the same plane.
   (ii) $A = \{x : 7x - 3 = 11\}$
   (iii) $B = \{y : 2y + 1 < 3 \text{ and } y \in W\}$
5. Find, which of the following sets are empty :
   (i) The set of points of intersection of two parallel lines.
   (ii) $A = \{x : x \in N \text{ and } 5 < x \le 6\}$.
   (iii) $B = \{x : x^2 + 4 = 0 \text{ and } x \in N\}$.
   (iv) C = {even numbers between 6 and 10}.
   (v) D = {prime numbers between 7 and 11}.
6. (i) Are the sets $A = \{4, 5, 6\}$ and $B = \{x : x^2 - 5x - 6 = 0\}$ disjoint ?
   (ii) Are the sets $A = \{b, c, d, e\}$ and B = {x : x is a letter in the word 'MASTER'} joint ?
7. State, whether the following pairs of sets are equivalent or not :
   (i) $A = \{x : x \in N \text{ and } 11 \ge 2x - 1\}$ and $B = \{y : y \in W \text{ and } 3 \le y \le 9\}$.
   (ii) Set of integers and set of natural numbers.
   (iii) Set of whole numbers and set of multiples of 3.
   (iv) $P = \{5, 6, 7, 8\}$ and $M = \{x : x \in W \text{ and } x \le 4\}$.
8. State, whether the following pairs of sets are equal or not :
   (i) $A = \{2, 4, 6, 8\}$ and $B = \{2n : n \in N \text{ and } n < 5\}$
   (ii) $M = \{x : x \in W \text{ and } x + 3 < 8\}$ and $N = \{y : y = 2n - 1, n \in N \text{ and } n < 5\}$
   (iii) $E = \{x : x^2 + 8x - 9 = 0\}$ and $F = \{1, -9\}$
   (iv) $A = \{x : x \in N, x < 3\}$ and $B = \{y : y^2 - 3y + 2 = 0\}$
9. State whether each of the following sets is a finite set or an infinite set :
   (i) The set of multiples of 8.
   (ii) The set of integers less that 10.
   (iii) The set of whole numbers less than 12.
   (iv) $\{x : x = 3n - 2, n \in W, n \le 8\}$
   (v) $\{x : x = 3n - 2, n \in Z, n \le 8\}$
   (vi) $\{x : x = \frac{n-2}{n+1}, n \in W\}$
10. Answer, whether the following statements are **true** or **false**. Give reasons.
   (i) The set of even natural numbers less than 21 and the set of odd natural numbers less than 21 are equivalent sets.
   (ii) If E = {factors of 16} and F = {factors of 20}, then E = F.
   (iii) The set A = {integers less than 20} is a finite set.
   (iv) If A = {x : x is an even prime number}, then set A is empty.
   (v) The set of odd prime numbers is the empty set.
   (vi) The set of squares of integers and the set of whole numbers are equal sets.
   (vii) If $n(P) = n(M)$, then $P \leftrightarrow M$.
   (viii) If set P = set M, then $n(P) = n(M)$.
   (ix) $n(A) = n(B) \Rightarrow A = B$.

37.5 SUBSET

If all the elements of the set A belong to the set B, the set A is said to be the subset of the set B.

And, if all the elements of the set B belong to the set A, the set B is said to be subset of the set A.

e.g. (i) If $A = \{5, 6, 7\}$ and $B = \{2, 3, 4, 5, 6, 7\}$; then all the elements of the set A belong to the set B; therefore the set A is subset of the set B and we write : $A \subseteq B$.

(ii) If A = {x : x is a student of your school} and B = {x : x is a student of class VIII of your school}; then all elements (students) of the set B belong to the set A; therefore B is subset of A and we write : $B \subseteq A$.

1. The notation '$A \subseteq B$' is read as : **A is subset of B** or **A is contained in B**.
2. '$B \subseteq A$' is read as : **B is subset of A** or **B is contained in A**.

More examples :

1. If $P = \{x : x \in N$ and x is divisible by $2\}$ and $Q = \{x : x \in N$ and x is divisible by $4\}$, then $Q \subseteq P$.

Reason : $P = \{2, 4, 6, 8, 10, 12, 14, ...\}$ and $Q = \{4, 8, 12, 16, ...\}$ Clearly, all the elements of the set Q belong to the set P; therefore $Q \subseteq P$.

2. $N \subseteq W$; since every natural number is also a whole number.
   For the same reason : $N \subseteq Z$ (integers) and $W \subseteq Z$.
   (i) Every set is a subset of itself, *i.e.* $A \subseteq A$, $B \subseteq B$, $E \subseteq E$ and so on.
   (ii) Empty set $\varnothing$ is a subset of every set, *i.e.* $\varnothing \subseteq A$, $\varnothing \subseteq B$, $\varnothing \subseteq P$ and so on.
   (iii) If $A \subseteq B$ and $B \subseteq A$, then $A = B$. Conversely, if $A = B$, then $A \subseteq B$ and $B \subseteq A$.

37.6 PROPER SUBSET

The set A is said to be a proper subset of set B if,

(i) all elements of set A are contained in set B and

(ii) there exists at least one element in B which is not in A.

Symbolically, we write it as **$A \subset B$** and read as **'A is proper subset of B'**.

e.g. (i) If $A = \{5, 6, 7\}$ and $B = \{3, 5, 6, 7, 8\}$, then $A \subset B$.

(ii) The set of natural numbers (N) is a proper subset of the set of whole numbers (W) *i.e.* $N \subset W$.

37.7 NUMBER OF SUBSETS AND PROPER SUBSETS OF A GIVEN SET

If a set has n elements;

(i) the number of subsets of it $= 2^n$ and

(ii) the number of proper subsets of it $= 2^n - 1$.

	$\varnothing$	{a}	{a, b}	{a, b, c}
1. Number of elements	0	1	2	3
2. No. of subsets	$2^0 = 1$	$2^1 = 2$	$2^2 = 4$	$2^3 = 8$
3. No. of proper subsets :	$2^0 - 1 = 0$	$2^1 - 1 = 1$	$2^2 - 1 = 3$	$2^3 - 1 = 7$
4. Subsets :	$\varnothing$	$\varnothing$ and {a}	$\varnothing$, {a}, {b} and {a, b}	$\varnothing$, {a}, {b}, {c}, {a, b}, {a, c}, {b, c} and {a, b, c}
5. Proper subsets	Nil	$\varnothing$	$\varnothing$, {a} and {b}	$\varnothing$, {a}, {b}, {c}, {a, b} {a, c} and {b, c}.

No set is proper subset of itself.

37.8 SUPER SET

If set A is a subset of set B, then B is called the **super set** of A and we write it as **$B \supseteq A$**, which is read as **'B *is super set of* A'**.

37.9 UNIVERSAL SET

It is the set which contains all the sets under consideration as its subsets. A universal set is denoted by ξ (pxi) or U.

e.g. If A = {5, 6, 7, 8}, B = {1, 3, 5, 7} and C = {4, 6, 8, 10}, then the universal set for these sets may be taken as :

$$\{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$$

For the given sets, the choice of a universal set is not unique.

	Sets under consideration	Universal Set
1.	(i) A = {2, 4, 6, 7}	$\{x : x \in W$ and $x \leq 16\}$
	(ii) B = {3, 5, 7, 9, 11}	or, $\{x : x \in W\}$
	(iii) C = {0, 4, 8, 12, 16}	or, $\{x : x \in Z\}$
		or, $\{x : x \in Z, 0 \leq x < 17\}$, etc.
2.	(i) D = {Students of class 9 of your school}	{Students of your school}
	(ii) {Basketball players in your school}	or, {Students of your town}
	(iii) {Students of primary section of your school}	or, {x : x is a student}, etc.
	(iv) {Students of secondary section of your school}	

Example 3 :

Given the universal set, $\xi = \{x : x \in N, 15 < x \leq 26\}$, list the elements of the following sets :

(i) $A = \{x : x > 20\}$ (ii) $B = \{x : x \leq 21\}$

Solution :

Since, the universal set, ξ = {16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26},

$\therefore$ (i) **A** $= \{x : x > 20\}$ [Take the elements of ξ which are greater than 20]

= **{21, 22, 23, 24, 25, 26}** **(Ans.)**

And, (ii) **B** $= \{x : x \leq 21\}$

= **{16, 17, 18, 19, 20, 21}** **(Ans.)**

37.10 COMPLEMENT SET

The complement of a set A is the set of all elements in the universal set which are not in set A. It is denoted by A′ and is read as 'complement of A' or 'A-dashed'.

e.g. (i) If universal set = {1, 2, 3, 4, 5, 6} and set A = {2, 3, 5}, then
Complement of set A = A′ = {1, 4, 6}

(ii) If $S = \{x : x \in N\}$ and A = {even natural numbers}, then A′ = {odd natural numbers}.

1. A set and its complement are disjoint, *i.e.* they do not have any common element. (In the example given above, the set A and its complement A′ are disjoint).
2. The complement of the empty set is universal set, i.e. $\varnothing' = \xi$.
3. The complement of a universal set is the empty set, i.e. $\xi' = \varnothing$.

TEST YOURSELF

9. Let set A = {1, 3, 5}; then n(A) = ...
(a) The number of subsets of A = ...
(b) The subsets of A = ...
(c) The number of proper subsets of A = ...
(d) The proper subsets of A = ...

10. If A = {2, 4, 6, 8, 10, 12} and B = {4, 8, 12}, then
(a) A is .... of B and (b) B is .... of A.

11. If the universal set = {x ∈ W; 3 < x < 12}, A = {5, 7, 9} and B = {4, 6, 8, 10}; then :
(a) Complement of set A = A′ = ...
(b) Complement of set B = B′ = ...

EXERCISE 37 (C)

1. Find all the subsets of each of the following sets :
   (i) A = {5, 7} (ii) B = {a, b, c}
   (iii) C = {x : x ∈ W, x ≤ 2}
   (iv) {p : p is a letter in the word 'poor'}
2. If C is the set of letters in the word 'cooler', find:
   (i) set C (ii) n(C)
   (iii) number of its subsets
   (iv) number of its proper subsets
3. If T = {x : x is a letter in the word 'TEETH'}, find all its subsets.
4. Given the universal set = {–7, –3, –1, 0, 5, 6, 8, 9}, find :
   (i) A = {x : x < 2} (ii) B = {x : –4 < x < 6}
5. Given the universal set = { x : x ∈ N and x < 20}, find :
   (i) A = {x : x = 3p ; p ∈ N}
   (ii) B = {y : y = 2n + 3, n ∈ N}
   (iii) C = {x : x is divisible by 4}
6. Find the proper subsets of {x : x^2 – 9x – 10 = 0}.
7. Given, A = {Triangles}, B = {Isosceles triangles}, C = {Equilateral triangles}. State whether the following are **true** or **false**. Give reasons.
   (i) A ⊂ B (ii) B ⊆ A
   (iii) C ⊆ B (iv) B ⊂ A
   (v) C ⊂ A (vi) C ⊆ B ⊆ A.
8. Given, A = {Quadrilaterals}, B = {Rectangles}, C = {Squares}, D = {Rhombuses}. State, giving reasons, whether the following are **true** or **false**.
   (i) B ⊂ C (ii) D ⊂ B
   (iii) C ⊆ B ⊆ A (iv) D ⊂ A
   (v) B ⊇ C (vi) A ⊇ B ⊇ D
9. Given, universal set = {x : x ∈ N, 10 ≤ x ≤ 35}, A = {x ∈ N : x ≤ 16} and B = {x : x > 29}. Find:
   (i) A′ (ii) B′
10. Given, universal set = {x ∈ Z : – 6 < x ≤ 6}, N = {n : n is a non-negative number} and P = {x : x is a non-positive number}. Find :
   (i) N′ (ii) P′
11. Let M = {letters of the word REAL} and N = {letters of the word LARE}. Write sets M and N in roster form and then state whether;
   (i) M ⊆ N is true.
   (ii) N ⊆ M is true.
   (iii) M = C is true.
12. Write two sets A and B such that A ⊆ B and B ⊆ A. State the relationship between sets A and B.

   A ⊆ B and B ⊆ A ⇒ A = B

37.11 SET OPERATIONS

1. Union of two sets

The union of two sets A and B consists of all the elements which belong either to set A or to set B or to both the sets. It is denoted by A ∪ B and is read as 'A *union* B' or 'A *cup* B'.

e.g. (i) If A = {5, 6, 7} and B = {6, 8}, then A ∪ B = {5, 6, 7, 8}.

(ii) If E = {numbers divisible by 2} and F = {numbers divisible by 3}, then

$A \cup B$ = {numbers divisible by either 2 or 3 or both}.

1. Union of two sets is commutative *i.e.* $A \cup B = B \cup A$; $E \cup F = F \cup E$ and so on.
2. Union of sets is associative *i.e.* for any three sets A, B and C.
   $A \cup (B \cup C) = (A \cup B) \cup C$.
3. Since each element of set A is contained in $A \cup B$, therefore, $A \subset (A \cup B)$.
4. If $A \subset B$, then $A \cup B = B$.
5. The union of a set and its complement is the universal set, *i.e.*
   $A \cup A' = \xi$, $B \cup B' = \xi$ and so on.
6. The union of a set and the empty set is the set itself, *i.e.* $A \cup \varnothing = A$, $B \cup \varnothing = B$ and so on. Similarly, the union of a set and the universal set is the universal set, *i.e.* $A \cup \xi = \xi$, $B \cup \xi = \xi$, etc.

2. Intersection of two sets

The intersection of two sets A and B is the set of *elements which are common* to both the sets A and B. It is denoted by $A \cap B$ and is read as 'A *intersection* B' or 'A *cap* B'.

e.g. (i) If A = {5, 6, 7} and B = {6, 8], then $A \cap B$ = {6}.

(ii) If E = {numbers divisible by 2} and F = {numbers divisible by 3}. then

$E \cap F$ = {numbers divisible by 2 and 3 both} = {numbers divisible by 6}.

1. Intersection of two sets is commutative, *i.e.* $A \cap B = B \cap A$; $M \cap N = N \cap M$, etc.
2. Intersection of sets is associative, *i.e.* $A \cap (B \cap C) = (A \cap B) \cap C$
3. Since all the elements of set $A \cap B$ are contained in set A, therefore $A \cap B$ is a subset of A *i.e.* $(A \cap B) \subset A$. Similarly, $(A \cap B) \subset B$.
4. If A and B are two disjoint sets, then $A \cap B = \varnothing$.
   Conversely, if $A \cap B = \varnothing$, the sets A and B are disjoint.
5. If $A \cap B \neq \varnothing$, the sets A and B are joint or overlapping sets.
6. $A \cap A' = \varnothing$.
7. The intersection of a set with the empty set is the empty set.
   i.e. $A \cap \varnothing = \varnothing$, $B \cap \varnothing = \varnothing$, etc.
8. The intersection of a set with the universal set is the set itself, *i.e.* $A \cap \xi = A$, $B \cap \xi = B$ and so on.

Example 4 :

If A = {factors of 24} and B = {factors of 36} ; find : (i) $A \cap B$, (ii) $A \cup B$.

Solution :

Given : A = {factors of 24} = {1, 2, 3. 4, 6, 8, 12, 24}

and, B = {factors of 36} = {1, 2, 3, 4, 6, 9, 12, 18, 36}

$\therefore$ (i) $\mathbf{A \cap B}$ = {elements common in both A and B}

= **{1, 2, 3, 4, 6, 12}** **(Ans.)**

and, (ii) $\mathbf{A \cup B}$ = {elements which belong either to A or B or both}

= **{1, 2, 3, 4, 6, 8, 9, 12, 18, 24, 36}** **(Ans.)**

37.12 DIFFERENCE OF TWO SETS

If A and B are two given sets, then their difference A – B is the set of those elements which belong to set A but not to set B.

i.e. $A - B = \{x : x \in A \text{ and } x \notin B\}$

e.g. Let A = {b, c, d, e} and B = {a, b, c}, then A – B = {d, e} and B – A = {a}.

TEST YOURSELF

12. If A = {factors of 18} = ...

and, B = {factors of 27} = ...; then :

(a) $A \cup B$ = ... (b) $A \cap B$ = ...

(c) $A - B$ = ... (d) $B - A$ = ...

13. Let $P = \{x \in W : x < 6\}$ = ...

$Q = \{x \in N : x < 6\}$ = ...

and, $R = \{x \in W : 2 < x \leq 8\}$ = ...; then :

(a) $P \cup Q$ = ... (b) $(P \cup Q) \cup R$ = ...

(c) $Q \cap R$ = ... (d) $P \cap (Q \cap R)$ = ...

EXERCISE 37 (D)

1. Given $A = \{x : x \in N \text{ and } 3 < x \leq 6\}$ and $B = \{x : x \in W \text{ and } x < 4\}$. Find :
   (i) sets A and B in roster form
   (ii) $A \cup B$ (iii) $A \cap B$
   (iv) $A - B$ (v) $B - A$
2. If $P = \{x : x \in W \text{ and } 4 \leq x \leq 8\}$ and $Q = \{x : x \in N \text{ and } x < 6\}$. Find :
   (i) $P \cup Q$ and $P \cap Q$.
   (ii) Is $(P \cup Q) \supset (P \cap Q)$?
3. If A = {5, 6, 7, 8, 9}, $B = \{x : 3 < x < 8 \text{ and } x \in W\}$ and $C = \{x : x \leq 5 \text{ and } x \in N\}$. Find :
   (i) $A \cup B$ and $(A \cup B) \cup C$
   (ii) $B \cup C$ and $A \cup (B \cup C)$
   (iii) $A \cap B$ and $(A \cap B) \cap C$
   (iv) $B \cap C$ and $A \cap (B \cap C)$
   Is $(A \cup B) \cup C = A \cup (B \cup C)$?
   Is $(A \cap B) \cap C = A \cap (B \cap C)$?
4. Given A = {0, 1, 2, 4, 5}, B = {0, 2, 4, 6, 8} and C = {0, 3, 6, 9}. Show that :
   (i) $A \cup (B \cup C) = (A \cup B) \cup C$ *i.e.* the union of sets is associative.
   (ii) $A \cap (B \cap C) = (A \cap B) \cap C$ *i.e.* the intersection of sets is associative.
5. If $A = \{x \in W : 5 < x < 10\}$, B = {3, 4, 5, 6, 7} and $C = \{x = 2n ; n \in N \text{ and } n \leq 4\}$. Find :
   (i) $A \cap (B \cup C)$ (ii) $(B \cup A) \cap (B \cup C)$
   (iii) $B \cup (A \cap C)$ (iv) $(A \cap B) \cup (A \cap C)$
   Name the sets which are equal.
6. If P = {factors of 36} and Q = {factors of 48} ; find :
   (i) $P \cup Q$ (ii) $P \cap Q$
   (iii) $Q - P$ (iv) $P' \cap Q$
7. If A = {6, 7, 8, 9}, B = {4, 6, 8, 10} and $C = \{x : x \in N : 2 < x \leq 7\}$; find :
   (i) $A - B$ (ii) $B - C$
   (iii) $B - (A - C)$ (iv) $A - (B \cup C)$
   (v) $B - (A \cap C)$ (vi) $B - B$
8. If universal set ξ = {a, b, c, d, e, f, g, h}, A = {b, c, d, e, f}, B = {a, b, c, g, h} and C = {c, d, e, f, g}; find :
   (i) $B - A$ (ii) $C - (B \cap A)$
   (iii) $(B - C)'$ (iv) $C' - B'$
   Is $(B - C)' = C' - B'$?
9. If $A = \{x : x^2 \leq 16\}$, $B = \{x : \frac{x}{3} - 2 < 3\}$ and the universal set is W, the set of whole numbers.
   (i) Find : sets A and B
   (ii) Verify : $A' \cap B = B - (A \cap B)$.
10. If A = {1, 2, 3, 4, 5}, B = {2, 4, 6, 8} and C = {3, 4, 5, 6} ; verify :
    (i) $A - (B \cup C) = (A - B) \cap (A - C)$
    (ii) $A - (B \cap C) = (A - B) \cup (A - C)$.

37.13 DISTRIBUTIVE LAWS

1. *The union is distributive over the intersection of two sets.*

   i.e. if A, B and C are three sets then, $A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$

   e.g. Let $A = \{2, 5, 8, 11\}$, $B = \{2, 4, 6, 8\}$ and $C = \{5, 6, 7, 8\}$ then $B \cap C = \{6, 8\}$

   and $A \cup (B \cap C) = \{2, 5, 8, 11\} \cup \{6, 8\} = \{2, 5, 6, 8, 11\}$ I

   Similarly, $(A \cup B) \cap (A \cup C) = \{2, 4, 5, 6, 8, 11\} \cap \{2, 5, 6, 7, 8, 11\}$

   $= \{2, 5, 6, 8, 11\}$ II

   From I and II, it is verified that $A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$

2. *The intersection is distributive over the union of two sets.*

   i.e. $A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$

   It can be verified in the same way, as described above in law 1.

37.14 DE-MORGAN'S LAWS

1. *The complement of union of two sets is equal to the intersection of their complements.*

   i.e. for any two sets A and B,

   the complement of union of A and B = intersection of the complements of A and B.

   i.e. $(A \cup B)' = A' \cap B'$.

   e.g. Let $\xi = \{x \in N : 5 < x \leq 15\}$, A = {even numbers} and B = {multiples of 3}.

Clearly, $\xi = \{6, 7, 8, 9, 10, 11, 12, 13, 14, 15\}$

$A = \{6, 8, 10, 12, 14\}$

and $B = \{6, 9, 12, 15\}$

$A \cup B = \{6, 8, 9, 10, 12, 14, 15\}$

$(A \cup B)' = \{7, 11, 13\}$ I

$A' = \{7, 9, 11, 13, 15\}$

$B' = \{7, 8, 10, 11, 13, 14\}$

$A' \cap B' = \{7, 11, 13\}$ II

From I and II, it is verified that : $(A \cup B)' = A' \cap B'$.

2. *The complement of intersection of two sets is equal to the union of their complements.*

   i.e. for any two sets A and B, $(A \cap B)' = A' \cup B'$.

   It can also be verified in the similar manner as described above in law 1.

37.15 CARDINAL PROPERTIES OF SETS

1. For any two sets A and B,

   $n(A \cup B) = n(A) + n(B) - n(A \cap B)$

   If A and B are disjoint sets, *i.e.* if $A \cap B = \varnothing$, then $n(A \cap B) = 0$ and

   $n(A \cup B) = n(A) + n(B)$

2. $n(A - B) = n(A) - n(A \cap B) = n(\text{only } A)$

   $n(B - A) = n(B) - n(A \cap B) = n(\text{only } B)$

3. $n(A') = n(\xi) - n(A)$ or $n(A) + n(A') = n(\xi)$

   $n(B') = n(\xi) - n(B)$ or $n(B) + n(B') = n(\xi)$

   $n(A \cup B)' = n(\xi) - n(A \cup B)$ and so on.

TEST YOURSELF

14. If A = {2, 3, 5, 7}, B = {2, 5, 8, 11} and C = {1, 3, 5}; find :

(a) $B \cap C$ = ... (b) $A \cup (B \cap C)$ = ...

(c) $A \cup B$ = ... (d) $A \cup C$ = ...

(e) $(A \cup B) \cap (A \cup C)$ = ...

(f) n(A) = ... n(B) = ... $n(A \cap B)$ = ... and
$n(A) + n(B) - n(A \cap B)$ = ...

(g) $n(A \cup B)$ = ...

15. From the results, as obtained above, answer the following :

(a) Are $A \cup (B \cap C)$ and $(A \cup B) \cap (A \cup C)$ equal sets ? ....
Is this type of result always true ? ....

(b) Are the values of $n(A) + n(B) - n(A \cap B)$ and $n(A \cup B)$ equal ? ....
Is this type of result always true ? ....

EXERCISE 37 (E)

1. Given A = {x ∈ N : x < 6}, B = {3, 6, 9} and C = {x ∈ N : 2x – 5 ≤ 8}. Show that :
   (i) $A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$
   (ii) $A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$

2. If ξ = {x : x ≤ 10, x ∈ N}, A = {x : x ≥ 4}, and B = {x : 2 < x < 7} ; find :
   (i) $(A \cup B)'$ (ii) $(A \cap B)'$
   (iii) $A' \cup B'$ (iv) $A' \cap B'$
   Name the equal sets.

3. State, **true** or **false** :
   (i) $A \cup (B \cap A) = (A \cup B) \cap A$
   (ii) $P \cap (Q \cup R) = (P \cap Q) \cup R$
   (iii) $(P \cup Q) \cap (P \cup R) = P \cup (Q \cap R)$
   (iv) If $A \cap B = \varnothing$, then $A' \cup B' = \xi$
   (v) If $A \cup B = \xi$, then $A' \cap B' = \varnothing$

4. If ξ = {x : 5 ≤ x < 20, x ∈ N} ; A = {a : a is a multiple of 3} ; B = {b : b is an even number} C = {c : c ≤ 13} ; then show that :
   (i) $B \cap (A' \cup C') = B \cap (A \cap C)'$
   (ii) $A \cup (B' \cap C') = A \cup (B \cup C)'$

5. If ξ = {x : x ≤ 12, x ∈ N} ; A = {even number} ; B = {m : m is divisible by 3} and C = {x : 3 < x ≤ 9}, then verify that :
   (i) $A - (B \cup C)' = A - (B' \cap C')$
   (ii) $A - (B' \cup C') = A - (B \cap C)'$

6. Given, ξ = {Natural numbers between 25 and 45} ; A = {even numbers} and B = {multiples of 3}. Find :
   (i) n(A) + n(B) (ii) $n(A \cup B) + n(A \cap B)$
   (iii) n(A – B) (iv) $n(A' \cap B)$
   Is $n(A) + n(B) = n(A \cup B) + n(A \cap B)$?
   Is $n(A - B) = n(A' \cap B)$?

7. If n(A) = 40, n(B) = 27 and $n(A \cap B)$ = 15 ; find :
   (i) $n(A \cup B)$ (ii) n(B – A)
   (iii) n(only A) (iv) $n[(A \cup B) - A]$

8. If n(ξ) = 30, n(A) = 22, n(B) = 15 and $n(A \cup B)$ = 25 ; find :
   (i) $n(A \cap B)$ (ii) n(A′)
   (iii) n(B′) (iv) $n(A \cap B)'$

9. Given, ξ = {x ∈ N : 10 < x ≤ 30}, A = {x : x < 20} and B = {x : 15 < x < 25}. Verify that :
   (i) $(A \cup B)' = A' \cap B'$
   (ii) $A \cup (B' \cup A') = A \cup (B \cap A)'$

10. Let universal set ξ = {x : x ∈ W and 1 ≤ x < 10}, set A = {x : x is an even number}, set B = {x : 4 ≤ x ≤ 7} and C = {x : 2 < x ≤ 5}. Verify the following :
    (i) $(A \cup B)' = A' \cap B'$ (ii) $(A \cap B)' = A' \cup B'$
    (iii) $A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$
    (iv) $A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$

ANSWERS

TEST YOURSELF

1. {J, a, l, n, d, h, r} **2.** $\{x : x = \frac{n}{n+1}, n \in N\}$ **3.** $\{5^2, 6^2, 7^2, 8^2\}$ = {25, 36, 49, 64} **4.** x = 3, 4, 5, 6, 7, 8, ... and A = {3, 4, 5, 6, 7, ...} **5.** {–3, –2, –1, 0, 1, 2, 3, 4} and n(A) = 8 **6.** (a) infinite (b) finite (c) singleton (finite) set (d) null set **7.** (a) disjoint sets (b) joint sets **8.** (a) equivalent sets

(b) equal sets **9.** n(A) = 3 (a) $2^3 = 8$ (b) ϕ, {1}, {3}, {5}, {1, 3}, {1, 5}, {3, 5}, {1, 3, 5} (c) $2^3 - 1 = 8 - 1 = 7$ (d) ϕ, {1}, {3}, {5}, {1, 3}, {1, 5}, {3, 5} **10.** (a) super set (b) subset **11.** (a) {4, 6, 8, 10, 11} (b) {5, 7, 9, 11} **12.** A = {1, 2, 3, 6, 9, 18}, B = {1, 3, 9, 27} (a) {1, 2, 3, 6, 9, 18, 27} (b) {1, 3, 9} (c) {2, 6, 18} (d) {27} **13.** P = {0, 1, 2, 3, 4, 5}, Q = {1, 2, 3, 4, 5}, R = {3, 4, 5, 6, 7, 8} (a) {0, 1, 2, 3, 4, 5,} (b) {0, 1, 2, 3, 4, 5, 6, 7, 8} (c) {3, 4, 5} (d) {3, 4, 5} **14.** (a) {5} (b) {2, 3, 5, 7} (c) {2, 3, 5, 7, 8, 11} (d) {1, 2, 3, 5, 7} (e) {2, 3, 5, 7} (f) n(A) = 4, n(B) = 4, n{A∩B} = 2, n(A) + n(B) – n(A∩B) = 4 + 4 – 2 = 6, (g) 6 **15.** (a) yes; yes (b) yes; yes

EXERCISE 37(A)

1. (i) {4} (ii) {5, –1} (iii) {–3, –2, –1, 0, 1, 2, 3} (iv) {16, 25, 34, 43, 52, 61, 70} (v) {0, 4, 8, 12} (vi) $\left\{\frac{3}{4}, \frac{7}{9}, \frac{4}{5}, \frac{9}{11}, \ldots\right\}$ **2.** (i) {x : x = 3n + 3; x ∈ N} (ii) {x : x is a prime number between 10 and 20} (iii) {x : x = $\frac{n}{n+2}$, where n is an odd natural number} (iv) {x : x = n^3; n ∈ N and 2 ≤ n ≤ 6} (v) {x : x ∈ Z, – 5 ≤ x ≤ – 1} (vi) {x : x = 3n, n ∈ Z} **3.** (i) No, 64 is not a factor of 32 (ii) Yes, 54 is not a factor of 27 (iii) {2, 4, 62, 124} (iv) {1, 3, 9} (v) {2, 3, 7, 11} (vi) Yes (vii) No **4.** (i) {m, e, r, u, t} (ii) {u, n, i, v, e, r, s, a, l} (iii) {7, 8, 9, 10, ...} (iv) {0, 1, 2, 3, 4} (v) {6, 8, 9, 10, 12, 14, 15, 16, 18, 20, 21} **5.** (i) 3 and – 1 (ii) 9, 11, 13 and 15 (iii) 1, 2, 3, 4, 6, 8, 12 and 24 (iv) –2, –1, 0, 1 and 2 (v) 1, 2, 3 and 4 (vi) 4, 3, 2, 1, 0, –1, ...

EXERCISE 37(B)

1. (i) 5 (ii) 4 (iii) 6 (iv) 3 **2.** 7 **3.** (i) Infinite (ii) Finite (iii) Infinite (iv) Finite **4.** All **5.** (i), (iii) and (v) **6.** (i) No (ii) Yes **7.** (i) Not equivalent; (ii) Equivalent; as both have infinite numbers of elements (iii) Equivalent; as both have infinite numbers of elements (iv) Not equivalent **8.** (i) Equal (ii) Not equal (iii) Equal (iv) Equal **9.** (i) Infinite (ii) Infinite (iii) Finite (iv) Finite (v) Infinite (vi) Finite **10.** (i) True, since both the sets have 10 elements (ii) False, since E = {1, 2, 4, 8, 16} and F = {1, 2, 4, 5, 10, 20} (iii) False; since A = {19, 18, ..., 0, –1, –2,.. .....} (iv) False, since A = {2} (v) False, since the given set has 3, 5, 7, 11, etc (vi) False (vii) True (viii) True (ix) False, the sets are equivalent

EXERCISE 37(C)

1. (i) ϕ, {5}, {7}, {5, 7} (ii) ϕ, {a}, {b}, {c}, {a, b}, {a, c}, {b, c}, {a, b, c} (iii) ϕ, {0}, {1}, {2}, {0, 1}, {0, 2}, {1, 2}, {0, 1, 2} (iv) ϕ, {p}, {o}, {r}, {p, o}, {p, r}, {o, r}, {p, o, r} **2.** (i) C = {c, o, l, e, r} (ii) 5 (iii) 32 (iv) 31 **3.** ϕ, {t}, {e}, {h}, {t, e}, {t, h}, {e, h}, {t, e, h} **4.** (i) {–7, –3, –1, 0} (ii) {–3, –1, 0, 5} **5.** (i) {3, 6, 9, 12, 15, 18} (ii) {5, 7, 9, 11, 13, 15, 17, 19} (iii) {4, 8, 12, 16} **6.** ϕ, {10}, {–1} **7.** (i) False, since each triangle is not isosceles (ii) True (iii) True, since each equilateral triangle is isosceles also (iv) True (v) True (vi) True **8.** (i) False (ii) False (iii) True (iv) True (v) True (vi) False **9.** (i) {x ∈ N : 17 ≤ x ≤ 35} (ii) {x : 10 ≤ x ≤ 29} **10.** (i) {–5, –4, –3, –2, –1} (ii) {1, 2, 3, 4, 5, 6} **11.** M = {r, e, a, *l*} and N = {*l*, a, r, e}; (i) Yes (ii) Yes (iii) Yes

EXERCISE 37(D)

1. (i) A = {4, 5, 6}, B = {0, 1, 2, 3} (ii) {0, 1, 2, 3, 4, 5, 6} (iii) ϕ (iv) {4, 5, 6} (v) {0, 1, 2, 3} **2.** (i) P ∪ Q = {1, 2, 3, 4, 5, 6, 7, 8} and P ∩ Q = {4, 5} (ii) Yes **3.** (i) {4, 5, 6, 7, 8, 9} and {1, 2, 3, 4, 5, 6, 7, 8, 9} (ii) {1, 2, 3, 4, 5, 6, 7} and {1, 2, 3, 4, 5, 6, 7, 8, 9} (iii) {5, 6, 7} and {5} (iv) {4, 5} and {5}, yes ; yes **5.** (i) {6, 7, 8} (ii) {3, 4, 5, 6, 7, 8} (iii) {3, 4, 5, 6, 7, 8} (iv) {6, 7, 8}. A ∩ (B ∪ C) = (A ∩ B) ∪ (A ∩ C) and (B ∪ A) ∩ (B ∪ C) = B ∪ (A ∩ C) **6.** (i) {1, 2, 3, 4, 6, 8, 9, 12, 16, 18, 24, 36, 48} (ii) {1, 2, 3, 4, 6 12} (iii) {8, 16, 24, 48} (iv) {8, 16, 24, 48} **7.** (i) {7, 9} (ii) {8, 10} (iii) {4, 6, 10} (iv) {9} (v) {4, 8, 10} (vi) ϕ **8.** (i) {a, g, h} (ii) {d, e, f, g} (iii) {c, d, e, f, g} (iv) {a, b, h} ; No. **9.** (i) A = {0, 1, 2, 3, 4} B = {0, 1, 2, 3, ..., 14}

EXERCISE 37(E)

2. (i) {1, 2} (ii) {1, 2, 3, 7, 8, 9, 10} (iii) {1, 2, 3, 7, 8, 9, 10} (iv) {1, 2}; (A ∪ B)′ = A′ ∩ B′ and (A ∩ B)′ = A′ ∪ B′. **3.** (i) True (ii) False (iii) True (iv) True (v) True **6.** (i) 16 (ii) 16 (iii) 7 (iv) 3; Yes; No. **7.** (i) 52 (ii) 12 (iii) 25 (iv) 12; B – A = (A ∪ B) – A **8.** (i) 12 (ii) 8 (iii) 15 (iv) 18