

CHAPTER – 9

ROUTES AND NETWORKS

Questions on Routes/Networks involve different points or locations between which there is some movement or communication. The way the movement or communication is effected is described in the data/conditions. Sometimes, these are also referred to as "Maps" because the routes given resemble a map.

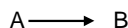
The data given in these types of questions may not always have the word "route" or "network" in them but a network is indicated by some sort of connectivity between two "points." The way the statements are worded is important. The wording includes statements like

- (i) Some poles are connected through wires.
- (ii) Some towers send signals to one another.
- (iii) Some cabins, market, cities, etc. are connected via passages or roads and so on.

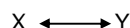
The connectivity between the two "points" can be only one-way or two-way. In one-way connectivity, the flow will be in only one direction whereas in two-way connectivity, the flow will be in both directions between the points.

Read the data carefully and then draw the diagram or network. The words "from" and "to" play an important role in these questions and hence, care should be taken while interpreting the data. While drawing a diagram, arrow marks can be used very effectively to indicate the direction of connectivity as explained below.

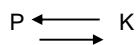
- (i) If the statement mentions that there is a one-way route from city A to B then it can be represented as follows.



- (ii) If the statement mentions that cities X and Y have roads on which you can travel in either direction, it means that it is a two-way connectivity. Then it can be represented as follows.

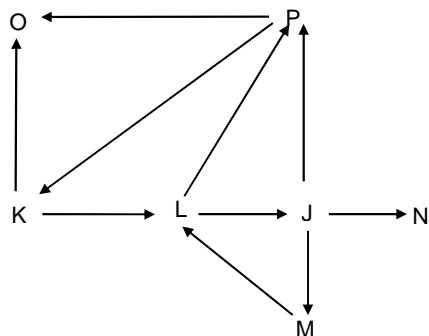


- (iii) If the statement mentions that all the projected roads are one-ways and there is a route from point K to P and then from P to K, then it should be represented as follows.



i.e., from P to K is one route and from K to P is another route.

Now, consider the following network.



In this network, let us say that a person starts from J and he wants to reach K. We want to find out the number of distinct routes he can take without touching any point twice. Starting from J, the possible directions of movement are from J to N, J to M and J to P, but if he goes from J to N then coming back or travelling in some other direction is not possible. Hence, the person has only two options for movement from J (J to M and J to P). Now, if he goes to M, he has to go to L from M. At L, it appears that he has two options – he can go to P or to J. But, since he started from J and as he cannot touch any point twice, he cannot go to J. So, there is only one option at L – that is going to P. So, to reach P from J, there are two options – one directly to P from J and the other via M and L. Once he reaches P, he has only one way of reaching K – along the diagonal PK. If he goes to O from P, then he cannot travel to K from O (the route is one way in the O to K). Thus the total number of ways from J to K is two (JPK and JMLPK).

Thus one has to look at all the possible routes carefully in the manner discussed above.

In the above example, if the route between J and L is two-way and then we have to find out the number of ways to reach O stating from J, the routes we have will be as follows:

JPO, JPKO, JMLPO, JMLPKO, JLPO, JLPKO

This gives us a total of six distinct ways of reaching O from J.

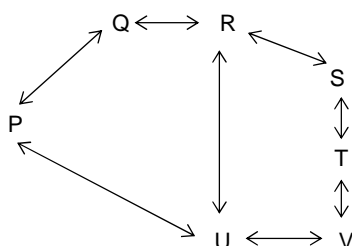
Directions for questions 1 to 5: Read the following information and answer the questions given below.

P, Q, R, S, T, U, V are seven places on a map. The following places are connected by two-way roads: P and Q; P and U; R and U; R and S; U and V; S and T; Q and R; T and V. No other road exists.

1. The shortest route (the route with the least number of intermediate places) from P to V is
(A) P-R-V (B) P-T-V
(C) P-Q-R-U-V (D) P-U-V
2. How many distinct routes exist from S to U (without touching any place more than once)?
(A) 3 (B) 2 (C) 1 (D) 4
3. The route covering the maximum number of places and going from P to R does not pass through
(A) U (B) T (C) S (D) Q
4. If U to V and S to R are only one-way routes, then which of the following places lose contact with P?
(A) V
(B) T
(C) S
(D) No place loses contact with P
5. If the number of places to which a place is connected directly considered as the measure of importance, then which of the following places is of the highest importance?
(A) Q (B) P (C) R (D) S

Solutions for questions 1 to 5:

The route map of the places is as follows:



- As is seen, P-U-V is the shortest way (with only one intermediate point) from P to V. Choice (D)
- To travel from S to U, the routes available are: S-R-U; S-T-U and S-R-Q-P-U – a total of 3 routes. Choice (A)
- First let us write down the route from P to R with the maximum number of intermediate points. By observation, we find that it is P-U-V-T-S-R. It does not touch Q. Choice (D)
- If U to V and S to R are only one-way routes, from the figure, we find that all places can still be reached from P. Hence, none of the places loses contact with P. Choice (D)
- For each of the places given in the choices, Q, P, R and S, let us see how many places are directly connected.
Q is directly connected to 2 places.
P is directly connected to 2 places.
R is directly connected to 3 places.
S is directly connected to 2 places. Choice (C)

Directions for questions 6 to 9: Read the following information and answer the questions given below.

Five cities P, Q, R, S and T are connected by different modes of transport as follows:

P and Q are connected by boat as well as by rail.

S and R are connected by bus and by boat.

Q and T are connected only by air.

P and R are connected only by boat.

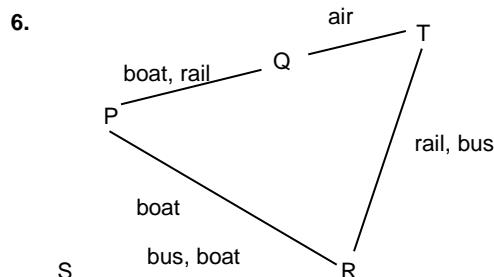
T and R are connected by rail and by bus.

- Which of the following pair of cities are connected by any of the routes directly [without going through any other city]?
(A) P and T
(B) T and S
(C) Q and R
(D) None of these
- Which mode of transport would help one to reach R starting from Q but without changing the mode of transport?
(A) Boat (B) Rail
(C) Bus (D) Air
- If a person visits each of the places starting from P and gets back to P, which of the following places must he visit twice?
(A) Q (B) R (C) S (D) T

- Between which two cities among the pairs of cities given below are there maximum travel options available? (If there is more than one route possible between two cities, consider the route with least number of cities enroute.)

(A) Q and S (B) P and R
(C) P and T (D) Q and R

Solutions for questions 6 to 9:



P and T are connected through Q.

T and S are connected through R.

Q and R are connected through T or P. Q and S are connected through R and P or T. So none of the pairs in the choices are directly connected.

Choice (D)

- From Q to P, he can reach by boat.
From P to R also he can travel by boat.
So, a person should travel by boat to reach R from Q without changing the mode of transport. Choice (A)
- If a person wants to visit all the places and again return to P, then he can go in the order of P → Q → T → R → S and then
S → R → P (OR)
P → R → S and then
S → R → T → Q → P
He must visit R twice. Choice (B)
- One has to travel between any of the two cities with a restriction that if there is more than one possible route, he has to go by the least number of cities enroute. It is better to take the pair of cities given in each of the choices.

Choice (A) Q and S: A person can go from Q to T to R to S (or) Q to P to R to S or vice-versa. In both the routes, there are two cities enroute. We can calculate the number of options in the entire route by multiplying the options available in each segment of the route.

For the route Q-T-R-S, the number of options = $1 \times 2 \times 2 = 4$

For the route Q-P-R-S, the number of options = $2 \times 1 \times 2 = 4$

Choice (B) P and R: The route between P and R has only one mode of travel, that is boat.

Choice (C) P and T: A person can go by PQT in either way or by PRT in either way. If it is by PQT, then the options are boat-air or rail-air i.e. two ways. If it is by PRT, then the options are boat-rail or boat-bus in either way. Hence, they are only two options.

Choice (D) Q and R: If a person travels between Q and R, then he can go by QTR or by QPR. If he goes by QTR, then the options are air-rail or air-bus, that gives two options or if he goes by QPR, then the options are rail-boat or boat-boat, that will again give us two options.

So, it is very clear that Q and S have maximum number of travel options available between them.

Choice (A)

Directions for question 10: Select the correct alternative from the given choices.

10. Four computers P, Q, A and B are interconnected for the transmission of data. A and B can each send data to both P and Q but B cannot receive data from A. P and Q can have data flow in both directions

between them but they cannot transmit the data so received to B but can otherwise send the data directly to B. Which of the following routes can be followed if B has to receive data from A?

I. AQP B

II. APB

III. AQB

IV. APQB

(A) I and III

(B) II and III

(C) III and IV

(D) I and IV

Solution for question 10:

10. AQP B and APQB can be eliminated because P and Q cannot send the data to B.

The paths AQB and APB do not violate any conditions and hence can be possible routes to send data from A to B.

Choice (B)

Exercise – 9(a)

Directions for questions 1 to 5: Select the correct alternative from the given choices.

- Five boys P, Q, R, S and T stand at various points in a playground. A person O has to supply them with water. O can go directly to P and then to S. O can go directly to Q and then to T. O can go directly to R and then to P or Q. Which of the following is definitely TRUE?
(A) O cannot supply water to all of them without touching at least one person twice.
(B) O can reach all of them without touching any of them twice.
(C) O must touch R to go to S.
(D) O must touch R to go to Q.
- A park has a swimming pool, a lawn, a flower garden, a giant wheel and a canteen. All of them except the swimming pool have direct roads from the entrance. Canteen and Giant wheel are interconnected by the two way route and similarly Giant wheel and Lawn are directly interconnected by the two way route. There are no other interconnected routes. The swimming pool can be reached only if one comes from the flower garden or from the lawn. The giant wheel is between the canteen and the lawn. If one wishes to go to the swimming pool from the giant wheel, without touching the entrance again he has to pass by
(A) Lawn
(B) Canteen or flower garden
(C) Flower garden or giant wheel
(D) Giant wheel
- Towns P, Q, R and S are connected along the sides of a square and also connected diagonally. P, Q, R, S are in clockwise order. Town T is at the intersection of the roads PR and QS. In how many ways can a person start from T in order to go to all other Towns at least once but not coming to the place already travelled?
(A) 4 (B) 12 (C) 16 (D) 8
- In an office, two telephones T_1 and T_2 are connected to fax machines F_1 and F_2 respectively. If the fax machines are not in operation, then both the telephones can be used for voice communication. There are 3 points P, Q and R with which T_1 and T_2 are directly connected. T_1 can be used for F_1 or P – only for fax. T_1 can be used for Q – only for voice communication. T_2 can be used for P or Q or R for voice as well as fax. Which of the following points cannot be reached either by fax or by voice, if T_2 is out of operation?
(A) P or Q (B) Q and R
(C) Q only (D) R only
- A, B, C, D and E are five towns connected as follows: There are three two-way roads between A and B. There are two one-way roads from B to C. There are four two-way roads between B and D. There is only a one-way road from B to E. C and D are connected by a two-way road and similarly D and E are connected by one two-way road. The maximum number of possible ways for a person to go from D to A without touching E is
(A) 3 (B) 18 (C) 14 (D) 12

Directions for questions 6 to 10: These questions are based on the following data.

Four boys P, Q, R, S and four girls J, K, L, M give their notes to one another. P gives his notes to K and M and takes notes from L and R, whereas Q gives his notes to M and K but takes notes from L and J. On the other hand, the persons who exchange their notes are M and J, P and L, M and K; S and Q. No boy and no girl can pass his/her notes in any other way.

- Who gives notes to every other person directly or through any other person but does not take anybody's notes?
(A) M (B) S (C) J (D) R
- Which of the following boys gives his notes directly to maximum number of girls?
(A) P (B) Q (C) R (D) S
- If L wants to give her notes to J, then she has to pass her notes through
(A) M (B) Q (C) S (D) P
- Which of the following two persons cannot exchange their notes at all, either directly or through any other person?
(A) L and Q (B) K and J
(C) M and Q (D) L and S
- Which of the following girls cannot take notes from any of the four boys?
(A) J (B) K (C) L (D) M

Directions for questions 11 to 15: These questions are based on the data given below.

Ten Poles P, Q, R, S, T, U, V, W, X and Y are connected by wires through which the current passes either in one direction or in two directions. The poles through which the current passes in two directions are P and T, X and T, R and V, U and W, V and U, whereas the current passes in one direction from T to R, W to P and S, R to S and Q, P and X to U, and finally X to R.

- If the current has to pass from X to Q, then it has to pass through pole
(A) R (B) S (C) V (D) T
- If the current has to pass from pole T to W, then in how many ways can the current pass through?
(A) Two (B) Four
(C) Five (D) Three
- Between which of the following two poles, does the current pass through by at least two such ways that no pole is common and no pole is passed through twice?
(A) X to P (B) X to W
(C) T to W (D) R to U
- The current between which two poles can pass through the maximum number of possible ways?
(A) R to W (B) S to V
(C) P to X (D) X to W

15. Which of the following poles can never pass the current back?
 (A) Q (B) V (C) U (D) W

Directions for questions 16 to 20: Read the data given below carefully and then answer the questions that follow.

Six super markets J, K, L, M, N and O are in six different locations. If a person wants to go from one market to another, then he has to go as per the following directions.

The routes between J and M, K and O are two ways, whereas the routes from M to K and L, N to M, J to N, K to N and L are one way.

16. If a person wants to go from J to K, then he goes in the order of
 (A) J, N and K
 (B) J, M and K
 (C) J, M, L and K
 (D) J, M, L, O and K
17. If a person wants to go from J to O, then in how many ways can he go?
 (A) Two (B) Four
 (C) Five (D) Three
18. Which of the following pairs of markets has exactly two markets in between them?
 (A) L and N
 (B) M and O
 (C) J and O
 (D) None of these
19. Which of the following two markets have maximum possible routes between them?
 (A) K and L (B) M and N
 (C) K and O (D) O and N
20. How many other markets can be visited from market M?
 (A) Four (B) Five
 (C) Three (D) Two

Directions for questions 24 to 26: These questions are based on the following information.

Seven persons Anil, David, Jacob, Naresh, Steyn, Maxwell and Smith know some languages to communicate. The languages they know are as follows:

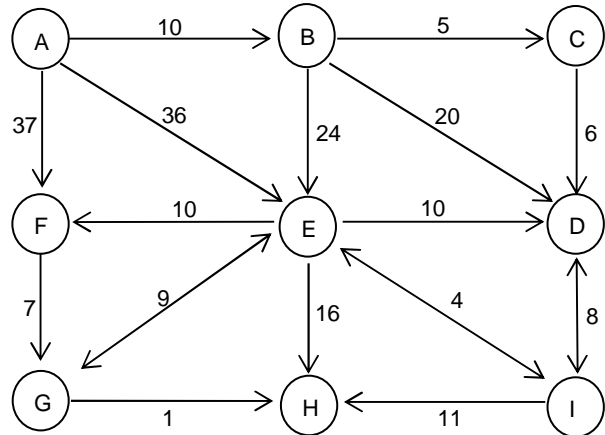
Anil	English	Kannada	Hindi
David	Bengali	Malayalam	English
Jacob	Hindi	Urdu	Odia
Naresh	Telugu	Gujarathi	Punjabi
Steyn	Malayalam	Telugu	Urdu
Maxwell	Marathi	Punjabi	Kannada
Smith	Urdu	Tamil	Hindi

It is known that they know only the above languages to communicate. If a person has to communicate with another person and they do not have any common language, they take the help of the other person from the group, who is called a translator.

24. If David has to communicate with Maxwell, how many minimum translators does he require?

Directions for questions 21 to 23: These questions are based on the following information:

Nine signals A to I are connected with several one-way routes and two-way routes as shown below. The number beside each line in the diagram represents the distance between two signals.



Note : All distances are given in kilometers.

21. What is the minimum distance required to travel from A to H?
22. What is the maximum distance required to travel by a person starting from signal B and going to signal G without passing through any signal more than once?
23. In how many ways can one travel from signal A to I without passing through any city more than once?

25. If Anil wants to communicate with Smith using the languages he knows apart from Hindi, in how many ways he can communicate (The person who wishes to communicate cannot be a translator)

26. How many different pairs of persons can communicate with each other without the help of a translator?

Directions for questions 27 to 30: These questions are based on the following information.

In a road network, there are seven roads each of which connects a different pair of cities among G, H, P, Q, R and S. Some of these roads are one-way roads and the rest are two-way roads. All the one-way roads are east west roads and one can traverse these one-way roads only towards the west. Further the following information is known:

- (i) City Q is connected to cities G and R.
- (ii) City S is connected to cities G and H.
- (iii) City P is connected to cities R and H.
- (iv) Except the cities G and H, each city is connected with only two roads, one a one-way road and the other a two-way road.
- (v) S is the eastern-most city and is to the east of R.
- (vi) No city has more than three other cities to its west.
- (vii) Only one incoming road is leading to Q which is from its east.

27. Which of the following is definitely false?
 (A) R is to the west of P.
 (B) G is connected by two two-way roads.

- (C) H is to the south-east of G.
 (D) P is to the south-west of R.

28. What is the highest number of cities one will pass through to reach city H from city R, without passing through any city more than once?

- (A) Two
 (B) Three
 (C) Four
 (D) There is no route available.

29. What is the highest possible number of cities one will pass through to reach city P from city S, without passing through any city more than once?

- (A) Two
 (B) Three
 (C) Four
 (D) There is no route available

30. If only one more city is allowed to have more than two roads, and a new road is laid without violating any other conditions, which of the following can be the possible road?

- I. A one-way road between H and Q
 - II. A two-way road between P and G
 - III. A two way road between Q and H
 - IV. A two way road between P and Q
- (A) Only I (B) Only II
 (C) Either III or IV (D) None of the above.

Exercise – 9(b)

Directions for questions 1 to 5: Read the given data carefully and answer the questions that follow.

Seven mobile phones P, Q, R, S, T, V and W can send the messages to one another. Some of the phones can only send the message but cannot receive. The messages which can only be sent are from P to R then to Q, R to T then to V, P to T then to S and then to W. Whereas, the messages can be received either ways between Q and V, P and W, and P and Q.

1. If the phone R is switched off, and a person wants to send message from P to V, then he has to send it to phone
 (A) W (B) T
 (C) Q or T (D) S
2. If phone V can now send the message to phone T, then in how many ways can a person send messages from phone V to P?
 (A) Two (B) One (C) Three (D) Four
3. If phone T is out of order for a day, then which of the following phones cannot receive any message?
 (A) W (B) Q (C) S (D) V
4. In how many ways can a person pass the message from phone W to V?
 (A) Two (B) Three
 (C) Seven (D) Four
5. What is the maximum number of phones can a person use if he wants to send a message from Q to V?
 (A) Three (B) Four (C) Two (D) Five

Directions for questions 6 to 10: These questions are based on the data given below.

Ten towers – Tos, Kos, Lot, Net, Dot, Rod, Hok, Set, Tit and Luna can pass signals to one another, if anything goes wrong in that area. The signal passing system in one-way is from tower Dot to Rod and Luna, Lot to Net and Hok, Hok to Tit and Dot, Luna to Kos and Lot. The signal passing system in two-ways is between Set and Tos, Luna and Rod, Kos and Tos, Set and Luna, Lot and Dot.

6. If tower Kos has to send signal to Hok, then it sends through how many other towers?
 (A) Four (B) Three
 (C) Five (D) Two
7. If the tower Luna sends signal to Hok, then it must send through
 (A) Lot (B) Net
 (C) Dot (D) Kos
8. If tower Luna fails to send messages for a day, then how many towers will also fail in sending messages to any other tower?
 (A) Three (B) Four (C) Two (D) One
9. The tower Hok can never send messages to more than one tower, if which of the following towers is destroyed?
 (A) Lot (B) Luna (C) Dot (D) Net
10. Which of the following pairs of towers can send the messages through exactly two other towers?
 (A) Kos to Dot (B) Dot to Hok
 (C) Kos to Set (D) Tos to Luna

Directions for questions 11 to 15: These questions are based on the data given below.

Eight cities J, K, L, M, N, O, P and Q are connected by three modes of transport, Roadways, Airways and Railways. The routes which are connected by roadways are two-way whereas the routes which are connected by Air and Rail are one way. The cities which are connected by roadways are J and P, Q and P, L and Q. Whereas the cities which are connected by airways are from P to K, Q to M, N to M and L. The cities connected by railways are from K to Q, L to J, P to O, and O to K.

11. If a person wants to go from city O to city M, then which of the following modes of transport he need not have to go by?
(A) Road (B) Rail
(C) Air (D) Rail and Air
12. If a person wants to go from city L to city K by travelling the longest possible route then how many cities will he visit?
(A) One (B) Two (C) Three (D) Four
13. If a person wants to go from city J to city L, then in how many possible ways can he reach such that he uses all the available modes of transport every time?
(A) Three (B) Two (C) One (D) Five
14. To which of the following cities a person can never reach by any means of transport?
(A) M alone (B) L alone
(C) N alone (D) M and N
15. In which of the following pairs of cities, can a person use all the given means of transport by passing through no city more than once from the first to the last city?
(A) L and O (B) L and K
(C) P and M (D) K and Q

Directions for questions 16 to 20: These questions are based on the following data.

Nine cities – A through I - are connected with two-way roads, which are between A & B; A & D; B & C; B & E; C & F; D & E; D & G; E & H; E & F; F & I; G & H and H & I. Each road is 10 km in length.

16. If a person wants to go from A to I, by travelling through the least number of cities, then how many ways are available to him?
(A) 4 (B) 6
(C) 8 (D) None of these
17. If a person wants to visit all the towns, each being visited exactly once, and if he wants to start at A, then how many ways are available to him?
(A) 6 (B) 8
(C) 10 (D) None of these
18. In how many ways can a man reach D, starting from A?
(A) 5 (B) 9
(C) 7 (D) None of these
19. What is the longest possible distance to reach D, starting from A? Assume that no city can be visited twice.
(A) 60 km (B) 70 km
(C) 80 km (D) None of these

20. Starting from B, if a person has to visit all the cities, each being visited exactly once, how many ways are available?
(A) 8 (B) 6
(C) 4 (D) Not possible

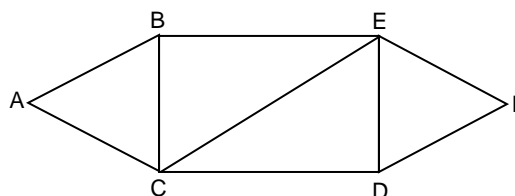
Directions for questions 21 to 23: These questions are based on the following information.

There are six cities A, B, C, P, Q and R which are connected directly or indirectly by either a one-way route or a two-way route. The one-way routes are from A to B, C to A, B to C, B to P, P to Q and R to C. The two way routes are between P and C, and Q and R.

21. How many different routes exist between any two cities in such a way that a city can be reached from any other city by passing through the rest of the cities only once?
(A) 3 (B) 4 (C) 6 (D) 7
22. Which of the following cities have only one outgoing route?
(A) Only A and C (B) Only A and Q
(C) Only A, Q and C (D) Only A, Q and R
23. Which cities have more number of incoming routes than the number of outgoing routes?
(A) Only Q, C and B
(B) Only Q
(C) Both Q and C
(D) Only P and A

Directions for questions 24 to 26: These questions are based on the following information.

Six cities A, B, C, D, E and F are connected by two-way routes as shown below. The distance between any two cities is different with the maximum distance being from C to E.



Further the following information is known;

1. For a continuous journey between any two cities the first 10 km it costs ₹30 and the charge is reduced to ₹ $\frac{1}{2}$ per km up to the next ten kilometers, the cost is further reduced by 20% per km for further journey undertaken.
2. The distance between cities A & C and B & E is 10 km and 15 km respectively.
3. The distance between D & E is one km less than the distance between E & F.
4. The cost of travel between F & D, through E and F & C through D is ₹37 and ₹45 respectively.
5. The cost of travel between any two cities from among ABC is the same and an integer and the average of cost per km between any two cities among ABC is ₹4 per km.

6. The difference of the distance between the cities A & F when travelling through only B & E, and that of only C & D is the maximum possible.
7. The cost of travel from E to C is ₹39.
24. What is the distance between B and C?
 (A) 6 (B) 4
 (C) 7.5 (D) Either (A) or (C)
25. If the difference between the cost of travel between D & F and C & D is ₹2.0 which of the following is definitely false?
 (A) The Difference in distances between C & D, and D & F is 5.
 (B) The difference between the fares from C to D and E to C can be ₹2.
 (C) The difference between the fares from E to C is 2 or 4 less than that from C to D.
 (D) There are four pairs of distances between any two directly connected cities such that one of the distances is twice the other.
26. The number of routes when a person starts his journey from A and reaches F passing through both C and E? (assume the person never comes back to the same city during his journey).
 (A) 6 (C) 7 (C) 8 (D) 9
- Directions for questions 27 to 30:** These questions are based on the following information.
- Seven cities A, B, C, D, E, F and G are inter-connected two-way by way of different modes of transport.
- A and G are connected by only bus.
 - C and D are connected by only train
 - A and B are connected by only air transport.
 - E and F are connected by only bus.
 - G and E are connected by ferry.
 - B and C are connected by only bus.
 - D and E are connected by only air.
 - F and C are connected by only train.
27. If a person, in a single travel, has travelled through three cities using only one mode of transport, then which of the following places can he not visit?
 (A) D (B) F (C) A (D) C
28. What is the maximum number of modes of transports that one must use to reach city A from D?
 (A) Four (B) Three (C) Two (D) One
29. If each of the four modes of transport are used only once to travel from one city to the other such that no city is traversed through more than once, then which is the third city that is on this route?
 (A) Only D
 (B) Either D or F
 (C) Either C or F
 (D) Cannot be determined
30. It is later known that two of the given seven cities are on an island. Which of the following has the higher chances to be one of the two?
 (A) A (B) B (C) C (D) D

Key

Exercise – 9(a)

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|------|-------|-------|-------|-----------|--------|
| 1. A | 6. D | 11. A | 16. B | 21. 40 km | 26. 10 |
| 2. A | 7. A | 12. B | 17. A | 22. 49 km | 27. A |
| 3. A | 8. A | 13. A | 18. D | 23. 8 | 28. D |
| 4. D | 9. D | 14. D | 19. A | 24. 1 | 29. C |
| 5. D | 10. C | 15. A | 20. B | 25. 2 | 30. B |

Exercise – 9(b)

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|------|-------|-------|-------|-------|-------|
| 1. C | 6. A | 11. A | 16. B | 21. D | 26. D |
| 2. A | 7. A | 12. C | 17. B | 22. B | 27. C |
| 3. C | 8. D | 13. C | 18. D | 23. C | 28. B |
| 4. D | 9. C | 14. C | 19. B | 24. C | 29. A |
| 5. A | 10. B | 15. B | 20. D | 25. C | 30. A |