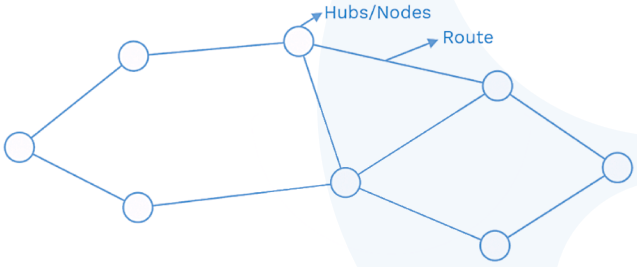
# 7 Routes and Networks

## Introduction

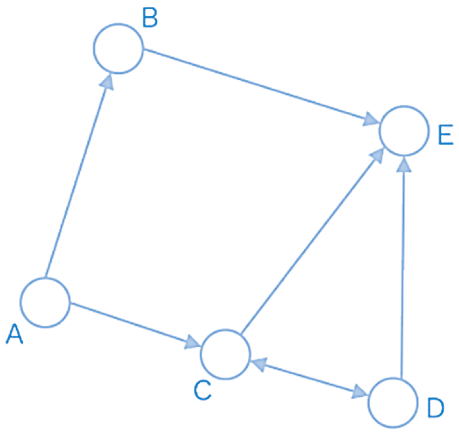
Routes and Network questions are more like puzzles than typical DI sets. A complex route diagram between two particular places is given and the test-taker is asked to identify the total number of distinct routes or the total amount of a particular product flow from one place to another. Other variations include complex questions that involve calculation of the shortest distance, time taken to reach based on speed calculations, etc. The important point of this topic is to learn a graphical representation of data and find out all the possible outcomes.

### General Format




In the above figure, the circles are called hubs or nodes, and the line connecting two circles is called a route.

Routes can be uni-directional or bi-directional, as shown in the diagram given below:




In the above figure, five cities A, B, C, D, and E are connected through routes where some routes are uni-directional, and some routes are bi-directional.

Uni-directional routes are (A–B), (B–E), (A–C), (C–E), and (D–E).

Bi-directional routes is/are (C–D).

## Types of Routes and Networks

In this concept, two methods namely, network diagram-based routes and track flow-based routes can be used.

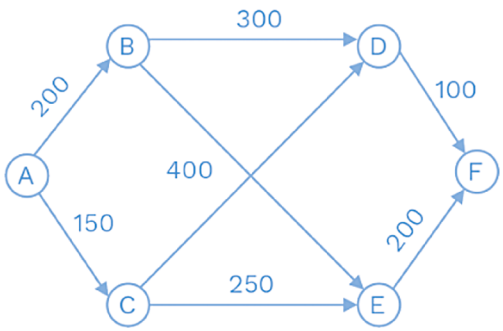
### Network Diagram

Suppose one has to find routes of travelling from A to F.

So, to find all possible routes from A to F, a table-based approach will be very useful.

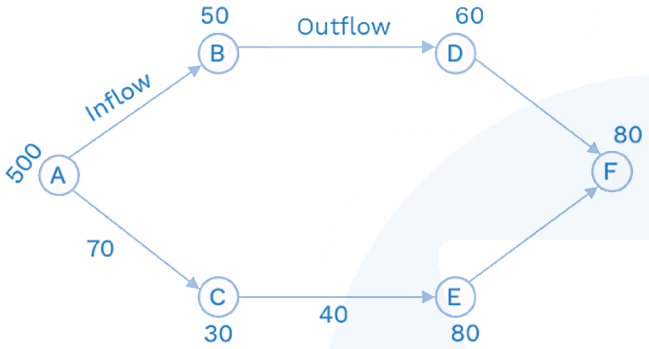
| No. of Routes | Routes |
|---|---|
| 1 | A – B – D – F |
| 2 | A – B – E – F |
| 3 | A – C – D – F |
| 4 | A – C – E – F |

Now, suppose six cities A, B, C, D, E, and F are connected, and the fare is given for travelling from one city to another. So, if someone has to find the cost of each route and also to find the cheapest route, then the table-based technique is widely used.



| Routes | Cost |
|---|---|
| A – B – D – F | (200 + 300 + 100) = 600 |
| A – B – E – F | (200 + 400 + 200) = 800 |
| A – C – D – F | (150 + 400 + 100) = 650 |
| A – C – E – F | (150 + 250 + 200) = 600 |

From the above table, one can see that the two routes, namely, (A – B – D – F) and (A – C – E – F) are the cheapest.




**Track Flow**

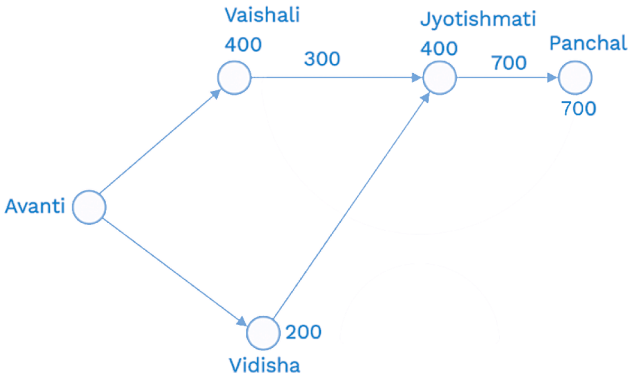
Suppose six water tanks namely, A, B, C, D, E, and F are connected through a pipeline, and the capacity of each water tank is given. If one needs to find out the amount of water coming in and going out through the tank, the same can be calculated using the formula given below:

Inflow = capacity + outflow

This can be better understood with the example given below.

**Example 1:**

The following sketch shows the pipelines carrying material from one location to another. Each location has a demand for the material. The demand at Vaishali is 400 km, at Jyotishmati is 400 km, at Panchal is 700 km, and at Vidisha is 200 km. Each arrow indicates the direction of material flow through the pipeline. The flow from Vaishali to Jyotishmati is 300 km. The quantity of material flow is such that the demands at all these locations are exactly met. The capacity of each pipeline is 1,000.




**1.** What is the free capacity available in the Avanti-Vidisha pipeline?

(A) 300
(B) 200
(C) 100
(D) 0

**Solution: (D)**

It is given that demands on all these locations are exactly met. It means the flow from Jyotishmati to Panchal is 700.

Now, suppose inflow from Vidisha to Jyotishmati is $x$.

It is known that:

Inflow = outflow + capacity

$\Rightarrow x + 300 = 700 + 400$

$\Rightarrow x = 800$

Now, assume inflow from Avanti to Vaishali is $y$.

$\Rightarrow y = 400 + 300 = 700$

Again, assume inflow from Avanti to Vidisha is $z$.

$\Rightarrow z = 200 + 800 = 1{,}000$

The maximum capacity at the Avanti-Vidisha pipeline is 1, 000.

Inflow is also 1,000.

$\therefore$ The free capacity available is 0.

Hence, option (D) is correct.

**2.** What is the free capacity available at the Avanti-Vaishali pipeline?

(A) 0
(B) 100
(C) 200
(D) 300

**Solution: (D)**

The capacity is 1,000.

Now, assume inflow from Avanti to Vaishali is $y$.

$\Rightarrow y = 400 + 300 = 700$

$\therefore$ Free capacity $= 1{,}000 - 700 = 300$

Hence, option (D) is correct.

**3.** What is the quantity moved from Avanti to Vidisha?

(A) 200
(B) 800
(C) 700
(D) 1,000

**Solution: (D)**

Assume inflow from Avanti to Vidisha is $z$.

$\Rightarrow z = 200 + 800 = 1{,}000$

Hence, the quantity moved from Avanti to Vidisha is 1,000.

Hence, option (D) is correct.

## Practice Exercise

### Level of Difficulty - 1

### Set 1

**Directions for Questions 1 to 5: Answer the following questions based on the information given below.**

Metro city X has a road structure as follows:

**i)** All the roads are either north-south roads or east-west roads.

**ii)** All north-south roads are parallel to each other, and all east-west roads are parallel to each other.

**iii)** North-south roads are named in alphabetical order as A, B, C,... starting from the westernmost street as 'A'.

**iv)** East-west roads are named as numbers in ascending order starting from 1 as the southernmost road.

**v)** Every junction of the roads is called a square, and all such squares are named as the combination of letters and numbers of the roads connecting at that square. That is, the square which is the junction of road C and road 5 is named C5. Distance between any two consecutive junctions is the same, i.e., 1 km.

**vi)** All the roads are currently two-way but based on the traffic situation the government can change them to one-way in any direction.

**vii)** No U-turn can be taken at any square.

**1.** What is the minimum distance that a woman needs to travel if she wants to go to B2 from H6, visiting her friend at D4 on the way?

(A) 10
(B) 12
(C) 16
(D) 8

**2.** A person starts from G2 and reaches his destination by travelling 6 km. Which of the following cannot be his destination?

(A) E4
(B) I5
(C) H5
(D) G2

**3.** All the even-numbered roads are changed to one way to travel only towards the west, and all the odd-numbered roads are changed to one way to travel only towards the east. Also, roads D and F are changed to one way only towards north and south, respectively. At which of the following squares the person heading towards east cannot be present?

(A) E3
(B) D3
(C) D4
(D) F1

**4.** If all the even-numbered roads are changed to one way to travel only towards the west and all the odd-numbered roads are changed to one way to travel only towards the east. D and F are changed to one way only towards north and south, respectively, Car P starts from D1, and Car Q starts from E4 with equal speeds. At which of the following square can they meet if each of them has travelled 4 km?

(A) E3
(B) F3
(C) C3
(D) D4

**5.** If all the even-numbered roads are changed to one way to travel only towards the west and all the odd-numbered roads are changed to one way to travel only towards the east. D and F are changed to one way only towards north and south, respectively. A person has to go from D2 to F4. In how many different ways can he go by travelling the least distance?

## Set 2

**Directions for Questions 6 to 9: Answer the following questions based on the information given below.**

A pharmaceutical company has certain warehouses carrying Remdesivir vaccines in eight locations named P, Q, R, S, T, U, V, and W (called storage locations). These vaccines are to be carried to the hospital for further processing by a driver. Various paths connecting different locations as well as the number of injections stored at different locations are shown in the diagram given below. The driver can take only one of the paths given in the diagram and can travel only along the direction of the arrow. For example, the driver can travel from V to U, but not from U to V.

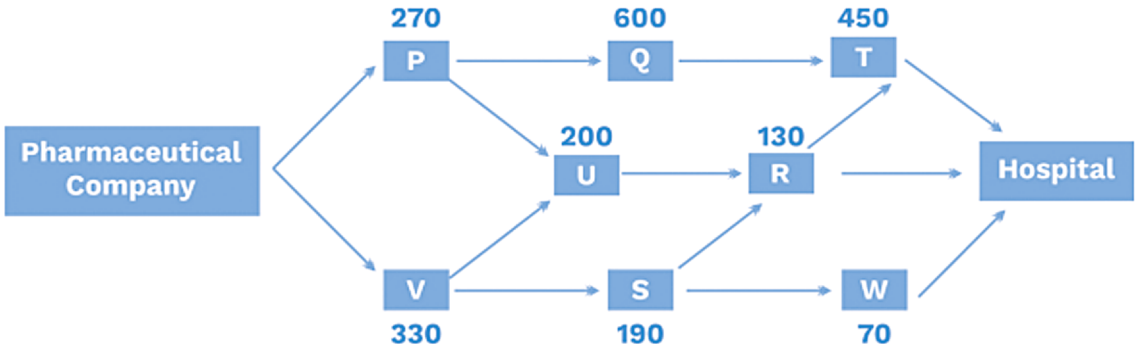
The driver starts with a box from the pharmaceutical company, follows one of the possible routes, visits all the storage locations along that route, puts all the vaccines at that location in the box, and finally drops all the vaccines at the hospital.

**6.** How many routes can a driver take from the pharmaceutical company to the hospital so that it carries at most 1,100 Remdesivir vaccines?
(A) 4
(B) 5
(C) 6
(D) 7

**7.** What is the maximum difference between the number of vaccines carried by drivers along the route that visits maximum storage locations and that of a route that visits minimum storage locations between pharmaceutical companies and hospitals?
(A) 490
(B) 520
(C) 625
(D) 730

**8.** What is the number of possible paths taken by the driver between the pharmaceutical company and the hospital such that the number of vaccines carried by it is between 550 and 700?
(A) 1
(B) 2
(C) 3
(D) 4

**9.** What is the difference between the number of vaccines on the route that carried a maximum number of vaccines and the route that carried a minimum number of vaccines?
(A) 500
(B) 600
(C) 700
(D) 730



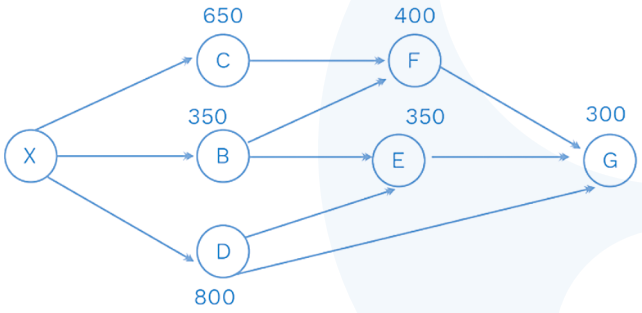
## Set 3

**Directions for Questions 10 to 14: Answer the following questions based on the information given below.**

Seven oil depots X, B, C, D, E, F, and G are connected by pipeline. The maximum oil flow through each pipeline is 1,500 units. Fuel flows to a depot only when the demand at the depot which is ahead of the depot in the network is completely met.

Slack = Capacity of the pipeline – Actual flow of fuel through the pipeline

X is the main source of fuel. Fuel is pumped through the pipeline only in the directions mentioned. It has to be pumped such that the demand mentioned alongside each depot is just met and the constraint for each pipeline compiled.




**10.** What is the maximum flow through the pipeline connecting X and D?
(A) 1,450
(B) 1,400
(C) 1,500
(D) 1,150

**11.** If the flow in the pipeline from B to F is zero units, then what is the maximum slack in the pipeline connecting X and B?
(A) 900
(B) 1,200
(C) 1,150
(D) 500

**12.** Due to maintenance work, the maximum capacity of the pipeline connecting X and B is reduced to 60% of its original capacity. Find the minimum slack in the pipeline connecting F and G.
(A) 1,000
(B) 1,200
(C) 1,400
(D) 1,500

**13.** If the requirement at G is increased, then what is the minimum possible slack in all the pipelines together?

**14.** What is the minimum possible flow in the pipeline connecting D and G?

## Level of Difficulty - 2

### Set 1

**Directions for Questions 1 to 4: Answer the following questions based on the information given below.**

Mr. Sandip of PTPC courier wanted to finish his delivery job as early as possible on a certain day. On that day he was asked to make a delivery of five parcels, one each to five people named P, Q, R, S, and T, each having a different address. He had to take possession of the parcels from the office of PTPC at 9.30 am when the office opened. With the help of Google Maps, Mr. Sandip found the distance (in kilometres) between the addresses to be as follows:

| Distance in km | P | Q | R | S | T |
|---|---|---|---|---|---|
| **P** | 0 | 12 | 6 | 6 | 2 |
| **Q** | 12 | 0 | 4 | 14 | 16 |
| **R** | 6 | 4 | 0 | 10 | 8 |
| **S** | 6 | 14 | 10 | 0 | 6 |
| **T** | 2 | 16 | 8 | 6 | 0 |
| **PTPC courier office** | 8 | 14 | 10 | 12 | 6 |

It is also known that Mr. Sandip drives his bike at a constant speed of 24 km/hour and takes 2 minutes at each address to make the delivery.

**1.** If Mr. Sandip takes possession of the parcels exactly at 9.30 am, what is the earliest time by which he can complete all the deliveries?
(A) 12:00 noon
(B) 11:50 a.m.
(C) 11:30 a.m.
(D) 10:50 a.m.

**2.** What is the difference between the earliest and latest time that Mr. Sandip takes to make all the deliveries?
(A) 65 min
(B) 60 min
(C) 58 min
(D) 38 min

**3.** If on that very day the employees of a company located on the 2 km stretch of road connecting addresses of P and T had blocked the road by sitting for a dharna, what would be the earliest time now to complete all the deliveries?
(A) 10:50 a.m.
(B) 11:00 a.m.
(C) 11:15 a.m.
(D) 11:16 a.m.

**4.** At the last moment (before 9:30 a.m.), Mr. Sandip found out that he had to make two more urgent deliveries to the addresses of Q and R, by 10:24 a.m.. What is the minimum time taken by Mr. Sandip to make the urgent delivery on time, along with the parcels?
(A) 75 min
(B) 95 min
(C) 90 min
(D) 115 min

### Set 2

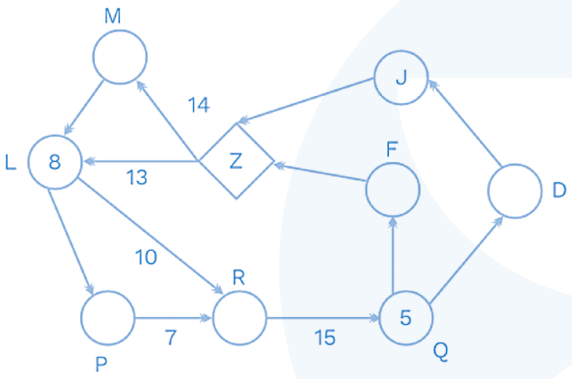
**Directions for Questions 5 to 8: Answer the questions based on the information given below**

A food delivery company, represented by Z in the following diagram, has exactly two riders who travel to various sectors of the city to deliver food. In the diagram, M through J represents the sectors at which foods were delivered on a certain day. The arrow represents the routes (along with the directions) that the riders took that day while travelling between sectors. The riders did not necessarily travel along the same routes, but each

route (represented by an arrow) was taken by at least one rider on that day.

Each rider stopped at every sector that he came across on that day and at least one food item was delivered by each rider at every sector that he stopped. Further, the riders returned to the company after they had delivered all the food items that they carried.

The numbers given in the circles, at some of the sectors, represent the total number of food items delivered at the respective sectors by the rider(s) who visited that sector. The number mentioned alongside some of the arrows represents the total number of food items carried by the rider(s) who travelled along the respective routes.




**5.** What is the number of food items delivered at P?
(A) 1
(B) 9
(C) 11
(D) Cannot be determined

**6.** What is the total number of food items carried by the rider(s) who travelled between sectors L and P?

**7.** What is the maximum number of food items that could have been delivered at D?

**8.** In which sector except D was the maximum number of food items delivered by both the riders together?
(A) F
(B) J
(C) Q
(D) Cannot be determined

## Set 3

**Directions for Questions 9 to 13: Answer the following questions based on the information given below.**

A city has the top five hospitals—Fortis, Apollo, Max, Park, and Kailash—connected by different modes of transport as follows.

**i)** Fortis and Apollo are connected by metro rail as well as local rail.
**ii)** Park and Max hospitals are connected by bus and metro rail.
**iii)** Apollo and Kailash are connected by subway only.
**iv)** Fortis and Max are connected by metro rail only.
**v)** Kailash and Max are connected by local rail and bus.

**9.** Which mode of transport would help one reach Max, starting from Apollo, but without changing the mode of transport?
(A) Metro rail
(B) Local rail
(C) Bus
(D) Subway

**10.** If, a person visits each of the places starting from Fortis and gets back to Fortis, which of the following places must he visit twice?
(A) Apollo
(B) Park
(C) Max
(D) Kailash

**11.** Which one of the following pairs of hospitals is connected by direct routes, i.e., one need not visit any third hospital to travel between the hospitals given in the pairs?
(A) Fortis and Kailash
(B) Kailash and Park
(C) Apollo and Park
(D) None of these

**12.** If the metro fare between two hospitals is ₹22, the bus fare between two hospitals is ₹18 and the local rail fare between two hospitals is ₹12, then what will be the difference between the maximum fare and minimum fare if one has to travel from Kailash to Fortis hospital? (Given subway cost is zero.)

(A) ₹20
(B) ₹28
(C) ₹32
(D) ₹12

**13.** Between which of the following pairs of hospitals are the maximum travel options possible?

(A) Apollo and Park
(B) Fortis and Max
(C) Fortis and Kailash
(D) Apollo and Max

## Level of Difficulty - 3

### Set 1

**Directions for Questions 1 to 5: Answer the following questions based on the information given below.**

A milk van has to deliver milk to different cities from M to T. For all these locations required predecessor is also given in the below table. For example, location S can only be reached if location R had been visited immediately before it.

Also, the table gives the duration (in hours) taken to travel to a location from each of its predecessors.

| Location | Required predecessor | Duration |
|---|---|---|
| M | None | |
| N | M | 3 |
| O | M | 2 |
| P | M | 4 |
| Q | P | 5 |
| R | O | 3 |
| R | P | 5 |
| S | R | 4 |
| T | N | 6 |
| T | S | 6 |
| T | Q | 3 |

**Note:** Whenever a node is shown to have more than one predecessor, it implies that the node can be reached from either of the predecessors.

For example, node R can be reached from both node O and node P.

**1.** If, while travelling from M to T via P, the milk van decides to halt at P for an hour, then what is the minimum time required for the milk van to reach T from M?
(A) 10
(B) 12
(C) 13
(D) 14

**2.** If another milk van decides to use the M – O – R – S – T and the distance between M and O is 4 km, O and R is 7,500 m, R and S is 8,400 m and S and T is 10 km, then what is the average speed of the milk van (in m/min)?
(A) 55.46
(B) 41.38
(C) 23.40
(D) 33.22

**3.** In how many ways can the milk van reach its destination?
(A) 3
(B) 4
(C) 5
(D) 6

**4.** Which is the longest route in terms of the time taken to travel and how long does it take the milk van to reach the destination using that route?
(A) M – N – T, 8 hours
(B) M – P – R – S – T, 19 hours
(C) M – P – Q – T, 13 hours
(D) M – P – Q – T, 14 hours

**5.** If the route P – Q is blocked, then what should be the minimum average speed for the milk van from M to T if it is known that the distance from M to T for any route is 45 km.
(A) 3 km/hr
(B) 4.2 km/hr
(C) 2.36 km/hr
(D) 5 km/hr

## Set 2

**Direction for Questions 6 to 10: Answer the following questions based on the information given below.**

The diagram below shows various routes between ten mobile stores:

M, N, O, P, Q, R, S, T, U, and V in a city and the distance of the routes (in km).

There are no other routes between the two mobile stores except those given in the diagram.

**6.** A customer wants to visit from M to V, such that he visits as many stores as possible along the way. How many stores (including M and V) will be visited during his trip?

**Note:** He does not wish to visit any store more than once.

(A) 4
(B) 6
(c) 10
(D) 8

**7.** Another customer who wants to visit all the 10 stores believes that the essence of a trip is in the journey itself. So, he decides to take the longest possible route; such that he goes through all the mobile stores exactly once. How much distance (in kilometres) does the customer cover?

(A) 26 km
(B) 22 km
(C) 25 km
(D) More than 28 km

**8.** Another customer wants to travel from Q to R, such that he passes through exactly two other stores (i.e., stores excluding Q and R) along the way. How many such routes are possible?

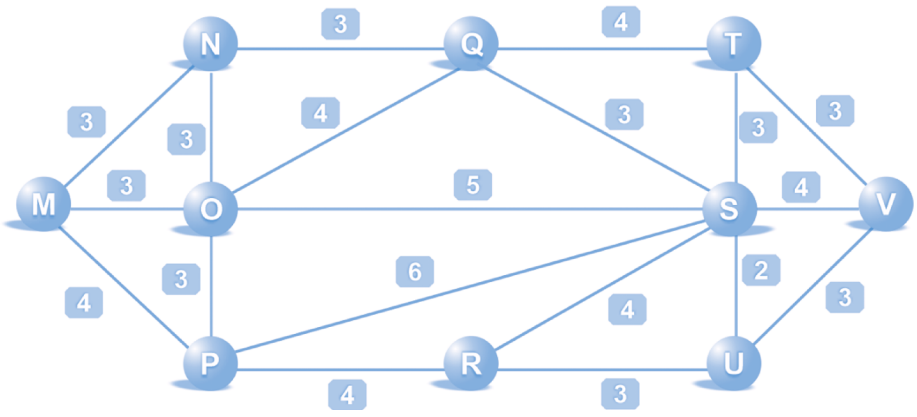
(A) 2
(B) 4
(C) 5
(D) 6

**9.** A customer starts his journey from store M and walks at a constant speed of 5 km/hr. What will be the maximum time required by him to reach store V, such that he passes through only two stores other than M and V?

(A) 1 hour and 40 minutes
(B) 2 hour and 48 minutes
(C) 3 hours and 5 minutes
(D) 2 hours and 20 minutes

**10.** A customer wants to travel from P to T, such that he gets to visit exactly three other stores (excluding P and T) along the way. He decides that he would pick the shortest route from among all the routes that obey the earlier condition. How many such shortest routes are possible?

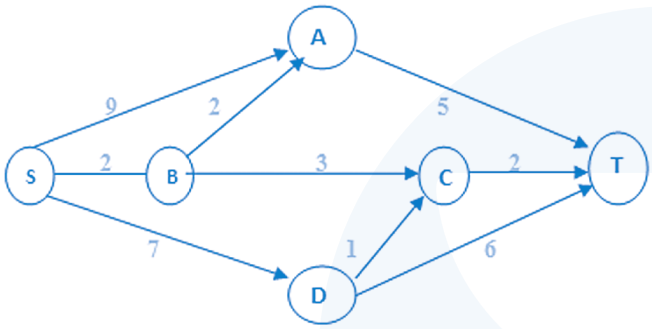
(A) 1
(B) 2
(C) 3
(D) 4



## Set 3

**Directions for Questions 11 to 14: Answer the following questions based on the information given below.**

In the city of Venice, travellers can go from location S to T, using the network of canals, as shown in the diagram below. Points A, B, C, and D are junctions in the network of canals, and the arrows mark the direction of traffic flow. The fuel cost (in euros) for travelling along a street is indicated by the number adjacent to the arrow representing the street.




**Additional points**

Motorists travelling from point S to point T would take the route for which the total cost of travelling is the *minimum*.

If two or more routes have the same least travel cost, then motorists are indifferent between them. Hence, the *traffic gets evenly distributed among all the least-cost* routes.

The city administration can control the flow of traffic only by levying appropriate toll at each junction.

**11.** What is the maximum cost of travelling from point S to T, if there are no tolls at any junction?

(A) 14
(B) 13
(C) 12
(D) 16

**12.** If the city administration wants to ensure that all boats travelling from S to T get divided equally between routes S-B-A-T and S-B-C-T, which of the following toll charges should be levied at the junctions A, B, C, and D, respectively?

(A) 2, 5, 3, 2
(B) 1, 1, 3, 2
(C) 1, 2, 4, 2
(D) None of these

**13.** If the city administration wants to ensure that the traffic at S gets evenly distributed along streets from S to A, from S to B, and from S to D, then a feasible set of tolls charged (in euros) at junctions A, B, C, and D, respectively, to achieve this goal is:

(A) 0, 5, 4, 1
(B) 0, 5, 2, 2
(C) 1, 5, 3, 3
(D) 1, 5, 3, 2

**14.** If the city administration wants to ensure that all boats travelling from S to T pay the same amount (fuel costs and toll combined) regardless of the route they choose and the street from B to C is under repairs (and hence unusable), then a minimum feasible set of toll charged (in euros) at junctions A, B, C, and D, respectively, to achieve this goal is:

(A) 2, 5, 3, 2
(B) 0, 5, 3, 1
(C) 1, 5, 3, 2
(D) 2, 3, 5, 1

## Level of Difficulty - 1

**1. (A)**

The road structure of the city is as shown in the diagram below.


To go to B2 from H6, the person will have to walk 6 steps in the westward direction and 4 steps in the southward direction, no matter what route she takes.

So, she will travel through the following squares:

H6 – D6 – D4 – B4 – B2

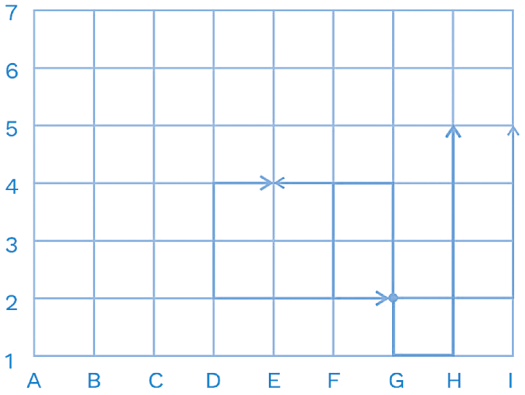
Or

H6 – H4 – D4 – B4 – B2

(There can be a few more ways with the same total distance to be travelled.)

Hence, option (A) is correct.

**2. (B)**




The trick to solve this question is *identifying the minimum number of steps* to go from starting point to the destination.

If the minimum number of steps is even, then the next value of the possible steps (to go from the same starting point to the same destination) will also be even.

For example, if we start from G2, the minimum number of steps required to be taken to reach to E4 is 4. So, one can go from G2 to E4 taking 4 steps or 6 steps or 8 steps, and so on.

Similarly, for the other destination options, the minimum number of steps are mentioned below:

I5 – 5

H5 – 4

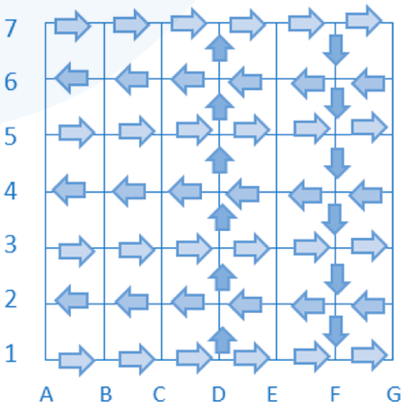
G2 – 0

Since I5 can be reached in a minimum of 5 steps, the next possible value for the number of steps to reach I5 will be 7, 9, and so on.

So, one cannot reach I5 from G2 in 6 steps.

Hence, option (B) is correct.

**3. (C)**




Let's consider each option one by one.

Option A, i.e., E3 -> Since road 3 is made one way towards east, this is possible.

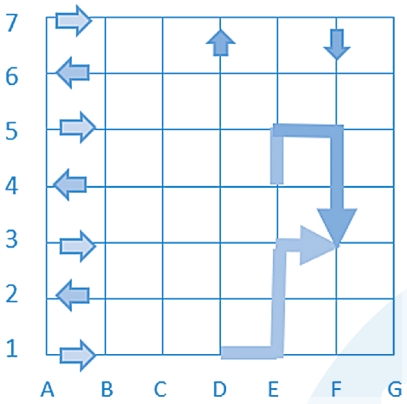
Option B, i.e., D3 -> Since road 3 is made one way towards the east, this is a possible position.

Option C, i.e., D4 -> Since road 4 is made one way towards the west, this is not possible.

Option D, i.e., F1 -> Since road 1 is made one way towards east, this is possible.

Hence, option (C) is correct.

**4. (B)**




Once again, let's consider each option one by one.

Option A, i.e., E3 -> Minimum travelling distance between D1 and E3 is 3 km (an odd number). So, it cannot be covered by travelling 4 km (an even number).

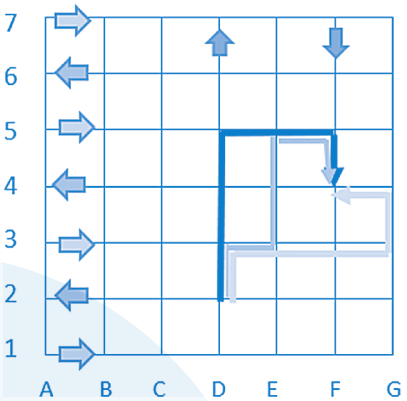
Option B, i.e., F3 -> Minimum travelling distance between D1 and F3 (an even number) is 4 km and the minimum travelling distance between E4 and F3 is 2 km (an even number). So, it can be covered by travelling 4 km (an even number) as shown in the figure.

Option C, i.e., C3 -> Minimum travelling distance between D1 and C3 is 3 km (an odd number). So, it cannot be covered by travelling 4 km (an even number).

Option D, i.e., D4 -> Minimum travelling distance between D1 and D4 is 3 km (an odd number). So, it cannot be covered by travelling 4 km (an even number).

Hence, option (B) is correct.

**5. 3**




The minimum distance from D2 to F4 is 6 km with one-way restrictions. So, we have to figure out different ways with which we can travel 6 km to reach from D2 to F4.

As shown in the figure, it can be done in three ways.

Hence, the answer is 3.

**6. (C)**

Based on the information given, the following table can be prepared for the possible paths and the number of vaccines.

So, a total of six routes can be taken by the driver (from the pharmaceutical company to the hospital) such that it carries at most 1,100 Remdesivir vaccines.

Hence, option (C) is correct.

| Starting Point | Path | End Point | Number of Vaccines |
|---|---|---|---|
| Pharmaceutical Company | (i) P → Q → T | Hospital | 1320 |
| | (ii) P → U → R | | 600 |
| | (iii) P → U → R → T | | 1050 |
| | (iv) V → S → W | | 590 |
| | (v) V → U → R | | 660 |
| | (vi) V → U → R → T | | 1110 |
| | (vii) V → S → R | | 650 |
| | (viii) V → S → R → T | | 1100 |

**7. (B)**

Based on the table prepared earlier, the required difference = 1,110 – 590 = 520

Hence, option (B) is correct.

**8. (D)**

Based on the table prepared earlier, a total of four paths can be taken by the driver such that the number of vaccines carried by it is between 550 and 700.

Hence, option (D) is correct.

**9. (D)**

Based on the table prepared earlier, the required difference = 1320 – 590 = 730

Hence, option (D) is correct.

**10. (A)**

The maximum possible flow through pipelines X and D occurs if the requirements at D, E, and G are met exclusively from this pipeline, i.e., 800 + 350 + 300 = 1,450.

Hence, option (A) is correct.

**11. (C)**

The slack in X-B is maximum when the flow is minimum. The required units at C, F, and G can be sent through pipeline X-C, and the requirement—at D and E can be sent through pipeline X-D. But the requirement at B has to go through X-B, i.e., a minimum of 350 units must flow through the pipeline X-B.

Therefore, the maximum slack is (1,500 – 350) = 1,150 units.

Hence, option (C) is correct.

**12. (B)**

The minimum slack in pipeline F-G occurs when the flow through it is maximum. The flow is maximum when the requirement at G is met exclusively through F-G. If 1,350 (650 + 400 + 300) flows through X-C, 700 would flow through C-F and 300 through F-G. The maximum flow is 300; hence, the minimum possible slack is 1,200 units.

Hence, option (B) is correct.

**13. 6,550**

When the pipelines X-C, X-B, X-D are transporting at their full capacity, the total slack in the pipelines is minimum.

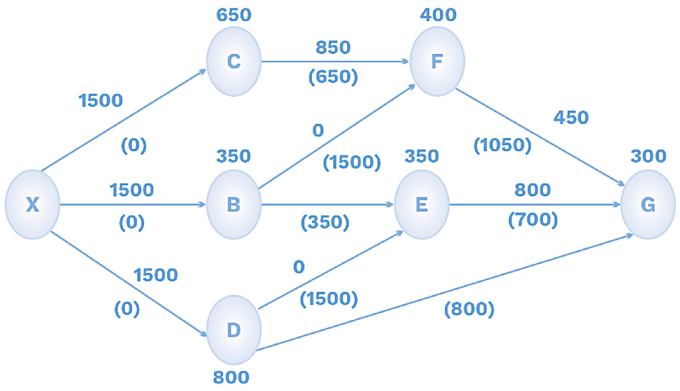
The total slack in all the pipelines taken together when the pipelines near the source are flowing to their maximum capacity is = 650 + 1500 + 350 + 1,500 + 800 + 1,050 + 700 = 6,550.

Hence, the answer is 6,550.

**14. 0**

The minimum flow through D to G is zero as the requirement at G can be supplied through the other pipelines.

Hence, the answer is 0.



## Level of Difficulty - 2

**1. (D)**

To make all the deliveries at the earliest, especially because Mr. Sandip can drive his bike at a constant speed only, he must select the shortest route.

On observation of the chart, we can conclude that:

- Mr. Sandip will go to the address of T first, as it is nearest to the PTPC office.
- From T's place he will go to P's place, as it is the nearest.
- From P's address he can go either to R or S's address as they are equidistant.
- Let us consider he has gone to R's address from P. Then in the next transit he will go to Q and then to S, who is the last. Distance covered from R = 4 + 14 = 18 km.
- Let us consider he has gone to S's address from P. Then in the next transit he will go to R and then Q, who is the last. Distance covered from S = 10 + 4 = 14 km, which is lower in value.

Hence, route followed by Mr. Sandip must be PTPC office – T – P – S – R – Q of total distance 6 + 2 + 6 + 10 + 4 = 28 km.

Time taken to transit = 28/24 = 1 hour 10 minutes.

Also, he takes 5 × 2 = 10 minutes for delivery.

So, the minimum time taken = 1 hour 20 minutes.

Hence, the earliest time taken to complete all the deliveries = 10:50 am

Hence, option (D) is correct.

**2. (A)**

For the maximum time to make all the deliveries, the route taken must be PTPC office – Q – T – R – S – P of total distance, 14 + 16 + 8 + 10 + 6 = 54 km.

For minimum time the distance, as calculated in answer 1 = 28 km.

Difference = 54 – 28 = 26 km

Time to transit 26 km = 26/24 = 1 hour 5 mins = 65 minutes

Hence, the difference between the earliest and latest time that Mr. Sandip takes to make all the deliveries = 65 minutes

Hence, option (A) is correct.

**3. (A)**

For the minimum time to make all the deliveries, but not being able to use the road between T and P, the route taken must be PTPC office – T – S – P – R – Q of total distance 6 + 6 + 6 + 6 + 4 = 28 km.

This distance is the same as the shortest route as in answer 1.

So, the time taken for delivery now also will be 10.50 am.

Hence, option (A) is correct.

**4. (C)**

For the minimum time to make all the deliveries, and also making the urgent deliveries to Q and R, the route taken must be PTPC Office – Q – R – P – T – S of the total distance of 14 + 4 + 6 + 2 + 6 = 32 km.

Time taken to transit for urgent delivery = 18/24 = 45 minutes.

Also, he takes 2 × 2 = 4 minutes for delivery.

So time taken for urgent delivery = 49 minutes.

So 10:24 am condition fulfilled.

Time taken to transit for complete assignment = 32/24 = 1 hour 20 minutes.

Also, he takes 5 × 2 = 10 minutes for delivery.

So minimum time taken = 1 hour 30 minutes = 90 minutes

Hence, option (C) is correct.

**5. (A)**

The total number of food items while leaving Z was 27 (14 + 13).

When they reached R, the total number of food items they had was 17 (10 + 7).

Therefore, they must have delivered 10 food items to sectors M, L and P.

Since they delivered at least one food item at each sector, they must have delivered one food item at M and the remaining food items at P.

So, a maximum of one item was delivered at P.

Hence, option (A) is correct.

**6. 8**

As explained earlier, the number of items delivered at P was 1. Also, items carried from P to R were 7. So, items carried from L to P should be 8.

Hence, the answer is 8.

**7. 8**

The riders had with them 10 and 7 food items, respectively, before stopping at R.

Since they delivered two food items at R, they would have had 9 and 6 food items, i.e. a total of 15 food items with them. If the maximum number of food items were to be delivered at D, only one package each must be delivered at F and J. Therefore, the maximum number of food items that can be delivered at D can be 15 – 5 – 1 – 1 = 8 items.

Hence, the answer is 8.

**8. (D)**

At F, D, and J the total number of food items that can be delivered will be 10.

Since they delivered at least one food item to each sector.

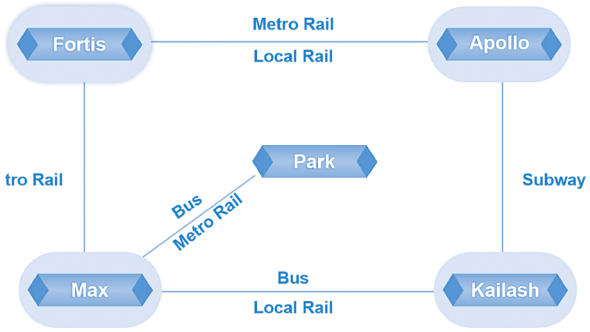
Therefore, at least one of F, D, and J can receive a maximum of 8 food items.

So, we cannot determine who among the following receives the maximum food items.

Hence, option (D) is correct.

**9. (A)**

The network between the five hospitals is as shown in the diagram:




The route from Apollo to Max is either Apollo – Fortis – Max or Apollo – Kailash – Max.

On the Apollo – Fortis – Max, the person can travel the entire distance by metro.

On the other hand, on the Apollo – Kailash – Max route, the person has to change from subway to bus or local rail.

So, if the person uses metro rail, he can reach Max from Apollo without changing the mode of transport.

Hence, option (A) is correct.

**10. (C)**

Since park is connected only to Max, the person has to first visit Max to reach park and then go back to Max from park.

So, if the person visits each of the places starting from Fortis and gets back to Fortis, he has to visit Max twice.

Hence, option (C) is correct.

**11. (D)**

None of the given pairs of hospitals is connected directly. At least one extra hospital has to be visited in each case.

Hence, option (D) is correct.

**12. (B)**

If one has to go from Kailash to Fortis, there are two routes possible.

Kailash – Apollo – Fortis **(Case 1)**
Kailash – Max – Fortis **(Case 2)**
(Kailash – Apollo) + (Apollo – Fortis)
= 0 + 22 (If Metro rail is used).
= ₹22

**Case 1:**
(Kailash – Apollo) + (Apollo – Fortis)
= 0 + 12 (If local rail is used)
= ₹12

**13. (A)**

The travel options possible for each pair of hospitals are shown in the table below.

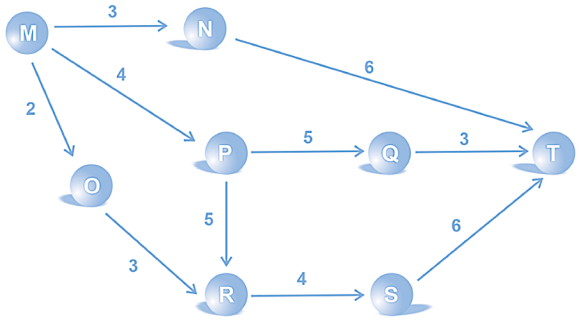
**Case 2:**
(Kailash – Max) + (Max – Fortis)
= 18 + 22 (If bus is used)
= ₹40
(Kailash - Max) + (Max – Fortis)
= 12 + 22 (If local rail is used)
= ₹34
Hence, required difference = 40 – 12 = ₹28
Hence, option (B) is correct.

| Pair | Routes | Ways | Total Ways |
|---|---|---|---|
| Apollo and Park | Apollo – Fortis – Max – Park | $2 \times 1 \times 2 = 4$ | $4 + 4 = 8$ |
| | Apollo – Kailash – Max – Park | $1 \times 2 \times 2 = 4$ | |
| Fortis and Max | Fortis – Max | 1 | $1 + 4 = 5$ |
| | Fortis – Apollo – Kailash – Max | $2 \times 1 \times 2 = 4$ | |
| Fortis and Kailash | Fortis – Apollo –Kailash | $2 \times 1 = 2$ | $2 + 2 = 4$ |
| | Fortis – Max – Kailash | $1 \times 2 = 2$ | |
| Apollo and Max | Apollo – Kailash – Max | $1 \times 2 = 2$ | $2 + 2 = 4$ |
| | Apollo – Fortis – Max | $2 \times 1 = 2$ | |

Thus, the maximum travel options are between Apollo and park, i.e., 8.
Hence, option (A) is correct.

## Level of Difficulty - 3

**1. (C)**




The above figure shows relationships between various locations with their predecessors.

The route from M to T via P is either M – P – Q – T which takes 12 hours or M – P – R – S – T which takes 19 hours.

Hence, the shortest path is M – P – Q – T which takes 12 hours but halts at P for an hour.

The required time = 12 + 1 = 13 hours.

Hence, option (C) is correct.

**2. (D)**

The average speed of the milk van

$$= \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

$$= \frac{4000+7500+8400+10000}{15\times 60}$$

$$= \frac{29900}{900}$$

= 33.22 m/min (Approximately)

Hence, option (D) is correct.

**3. (B)**

The paths which the milk van can follow from M to T are:

**i)** M – N – T

**ii)** M – P – Q – T

**iii)** M – O – R – S – T

**iv)** M – P – R – S – T

Hence, there are four ways in which the milk van can travel from M to T.

Hence, option (B) is correct.

**4. (B)**

| Available Paths | Duration |
|---|---|
| M – N – T | 9 hours |
| M – P – Q – T | 12 hours |
| M – O – R – S – T | 15 hours |
| M – P – R – S – T | 19 hours |

Hence, the maximum time required by the milk van to reach the destination is 19 hours and the route is M – P – R – S – T.

Hence, option (B) is correct.

**5. (C)**

If the route P – Q is blocked, then there are three routes available from M to T.

**i)** M – N – T

**ii)** M – P – R – S – T

**iii)** M – O – R – S – T

For the minimum average speed, time should be maximum, and time is maximum for the routs M – P – R – S – T.

Thus, minimum average speed $= \frac{45}{19}$ = 2.36 km/hr (approx.)

Hence, option (C) is correct.

**6. (C)**

There are various routes to reach V from M, which covers all the 10 stores.

One such route is:

M – N – Q – T – S – O – P – R – U – V

Hence, option (C) is correct.

**7. (D)**

There are various routes between M and V which pass through all the stores exactly once.

Consider the route.

M – N – Q – T – S – O – P – R – U – V

The distance travelled on this route is:

3 + 3 + 4 + 3 + 5 + 3 + 4 + 3 + 3 = 31 km.

Hence, option (D) is correct.

**8. (C)**

Five such routes are possible as given below:

**i)** Q – O – P – R

**ii)** Q – S – U – R

**iii)** Q – T – S – R

**iv)** Q – O – S – R

**v)** Q – S – P – R

Hence, option (C) is correct.

**9. (B)**

There are only two routes such that the customer passes through only two stores other than M and V.

**i)** M – O – S – V = 3 + 5 + 4 = 12 km.

**ii)** M – P – S – V = 4 + 6 + 4 = 14 km.

He will require the maximum time if he chooses the second route.

$$\therefore \text{Time is taken} = \frac{\text{Distance}}{\text{Speed}}$$

$$= \frac{14}{5} = 2.8 \text{ hours}$$

= 2 hours and 48 minutes.

Hence, option (B) is correct.

**10. (A)**

Following are all the routes from P to T, such that they pass through exactly three stores:

- P – M – N – Q – T (14 km)
- P – M – O – Q – T (15 km)
- P – M – O – S – T (15 km)
- P – O – N – Q – T (13 km)
- P – O – Q – S – T (13 km)
- P – O – S – Q – T (15 km)
- P – O – S – V – T (15 km)
- P – S – O – Q – T (19 km)
- P – S – U – V – T (14 km)
- P – R – S – Q – T (15 km)
- P – R – U – S – T (12 km)
- P – R – U – V – T (13 km)
- P – R – S – V – T (15 km)

The shortest route among these is

P – R – U – S – T (12 km).

Hence, there is only one shortest route possible.

Hence, option (A) is correct.

**11. (A)**

This is a very simple question. You just need to identify the different routes and calculate the traveling cost. Also, there are no toll charges to be paid at the junctions.

It is easy to observe that route S-A-T has a maximum cost of 14 euros.

Hence, option (A) is correct.

**12. (B)**

The different available routes are SAT, SBCT, SBAT, SDT, and SDCT.

Let a, b, c, and d be the tolls levied at A, B, C, and D, respectively.

So the cost for different routes are:

SAT = 14 + a

SBCT = 7 + b + c

SBAT = 9 + b + a

SDT = 13 + d

SDCT = 10 + d + c.

Now, the city administration wants to ensure that all boats traveling from S to T get divided equally between roots S-B-A-T and S-B-C-T. So, the costs of these two routes should be equal and also the least. (As the traveller takes the route with the least cost).

So, 9 + b + a = 7 + b + c

So, c = a + 2 (i.e. toll at junction C should be € 2 more than that at junction A)

Of the given options, only option B satisfies the above condition.

By considering the toll charges given in option B, the route cost comes out to be

€ 11 which is equal, and minimum among all the routes.

Hence, option (B) is correct.

**13. (A)**

We need to ensure equal traffic from S to A, B, and D.

However, through B and D, there is more than one way from which the commuter can choose.

So, we need to restrict them to move through only one way from B and D.

This can be achieved if we increase the toll at C. So that passengers move through the route without the 'C' junction involved.

So, the routes involved will be SAT, SBAT, SDT, and the tolls of these should be the same.

So, $14 + a = 9 + b + a = 13 + d$.

i.e.$b = 5$, $d - a = 1$.

Now, we can keep $a = 0$ and $d = 1$. (As the options have value of $a = 0/1$ only, and if $a = 1$, $d = 2$ which is not there in option)

So, we have $a = 0$, $b = 5$, and $d = 1$. (We can stop here, as we have only 1 option satisfying this.)

If you need to find value of C,

We know that SBAT < SBCT, so, $14 < 12 + c$. $c > 2$.

Also, SDT < SDCT, so $14 < 11 + c$. So, $c > 3$.

So, $c > 3$.

Hence, option (A) is correct.

**14. (B)**

The available routes for the commuters are:

$SAT = 14 + a$

$SBAT = 9 + b + a$

$SDT = 13 + d$

$SDCT = 10 + d + c$.

To achieve the same minimum cost for all of the above routes, we can use the results obtained earlier

$b = 5$, and $d - a = 1$ (Do not consider $c = a + 2$, as the B-C route is closed)

Options B and C satisfies the given conditions. But since we want to keep the minimum cost for the routes, we will go with option B.

Hence, option (B) is correct.