Ans :

Congestion costs arise due to the fact that additional vehicles reduce the speed of the other vehicles and hence increase their journey time. Economic analysis shows that the traffic flow will be optimal at Q* if the costs of additional traffic (MSC) and the demand are equated. However, the individual user entering the road will typically consider only the costs he personally bears (MPC), i.e. marginal private cost and will thus operate at Q Therefore he takes the marginal private cost curve into consideration rather then the optimal marginal social cost curve (MSC) for the new trip-maker and the existing road users. The difference between the MPC and MSC curves reflects the dead-weight loss of excessive traffic congestion.

In a market system without transaction costs the other road users would be willing to pay the additional car the amount of their opportunity costs of time and additional fuel for not entering the road. As transaction costs have been obviously immense (if a perfect bargaining process would have been possible at all) so far, only an electronic pricing system can overcome the huge existing transaction costs between the road users.

To calculate the optimal limit for road traffic we have to consider the volume of the traffic (converting heterogeneous to homogeneous one), value of time and slope of speed.

The time cost per km of an average vehicle is simply the time per kilometre times the appropriate value of time. Since the time per kilometre is simply the reciprocal of the speed, this may be written:

Equation 1

$$t = \frac{b}{v}$$

where *v* is speed in km/h and *b* is the value of time for the average vehicle (i.e. it takes into account factors such as the value of time for the driver and occupants).
The total time costs per kilometre of a flow level q, measured in passenger car units (PCU) per hour is simply the time cost per kilometre times the flow: T = t * q.

Note that, because traffic flow in this equation is always measured in PCU values, the varying composition of traffic is automatically allowed for. Similarly, the differing effect of adding different type of vehicle to the traffic flow is given by multiplying the value of the marginal external cost of congestion as derived below by the PCU value of the vehicle in question. For example, the speed/size characteristics of a goods vehicle may mean that it has a PCU factor of 2, i.e. to convert to charges per vehicle the per PCU charge is doubled. Of course, this requires knowledge of the relevant set of PCU values to use, and substantial empirical work has derived factors for use in road traffic modelling.

The marginal cost of an additional vehicle is obtained by differentiating this expression by q,

Equation 2

$$\frac{dT}{dq} = t + q * \frac{dt}{dq}$$

In words, the marginal time cost of an extra vehicle is the cost it incurs itself (t), plus the increase in the average time cost, multiplied by the number of vehicles incurring that increase.

Differentiating equation 1 gives that the increase in time cost per vehicle is equal to the proportionate change in speed multiplied by the time (1/v) multiplied by the value of time:

Equation 3
$$\frac{dt}{dq} = -\frac{b}{v^2}\ \frac{dv}{dq}$$

And substituting equation 3 into equation 2 gives:

Equation 4
$$\frac{dT}{dq} = t - q\frac{b}{v^2}\frac{dv}{dq}$$

Clearly the first element in this equation, t, is the time cost (including congestion) borne by each user, including the marginal user, themselves (this is what we defined it as in equation 1). Therefore the second part of Equation 4 represents costs over and above those borne by the individual (i.e. by other road users), so the marginal external congestion cost (MCT), in terms of the value of time of other drivers and occupants is:

Equation 5
$$MCT = -q\frac{b}{v^2}\frac{dv}{dq}$$

It is clear that the marginal external cost of congestion will vary with:-

$\frac{dv}{dq}$	-	the slope of the speed/flow relationship, which varies with the type of road and volume of traffic
q	-	the volume of traffic (in PCUs)
v	-	the resulting speed, which varies with the type of road and volume of traffic
b	-	the value of time, which varies with the mix of journey purpose and income of the users

The value of time represents the maximum amount an individual is prepared to pay for a time saving or the minimum acceptable amount to compensate for an increase in journey time. The marginal value of time is made up of two components:

- the marginal utility of time; and,
- the marginal utility of money.

Equation 6 $\mathbf{V_B = (1 - r - p.q)MP + (1 - r)v_w + rv_l + MP_F}$

where:

V_B = value of business time savings
r is share of saved time used for leisure
p is share of saved time used productively
q is relative productivity of time saved that was used for work
MP is marginal productivity of labour
v_w is employee value of saved time otherwise spent in work
v_l is employee value of saved time otherwise spent in leisure
MP_F is the value of increased productivity from reduced fatigue