

I. Competitive Equilibrium

1. (a) Suppose a competitive industry consists of two firms. One has a U-shaped average cost curve that reaches a minimum of \$1; the other has a U-shaped average cost curve that reaches a minimum of \$2. Show that the aggregate supply curve has at least one “gap” in it.
(b) If the aggregate supply curve in a market has a “gap” in it, there might be no market equilibrium. Explain carefully why.
2. Using graphs, prove the following proposition: “Suppose an industry is composed of two non identical firms. (Call them A and B) The two firms are competitive, and each has a U-shaped average cost curve. Then it may be impossible for demand to equal supply.” Explain your answer thoroughly.
3. (a) A competitive industry has only two firms, *A* and *B*. On the basis of Figure 1, what is the graph of the industry supply curve? Be sure to label the important points of the graph with numbers.
(b) Explain what is going on in Figure 2. (That is, explain why the supply curve may look as it does and what market price and quantity might be).
4. (a) Under what circumstances is the Long Run Average Cost curve U-shaped? When the Long Run Average Cost curve is U-shaped, will the Long Run Supply curve have a gap in it?
(b) Under what circumstances is the Short Run Average Variable Cost curve U-shaped? When the Short Run Average Variable Cost curve is U-shaped, will the Short Run Supply curve have a gap in it?
(c) Under what circumstances is the Short Run Average Total Cost curve U-shaped? When the Short Run Average Total Cost curve is U-shaped, will the Short Run Supply curve have a gap in it?
5. (a) Prove that all short-run average total cost curves are U-shaped. Part of your answer should involve sketching a short-run total cost curve.
(b) If a firm’s production function has increasing returns to scale, is its average cost curve falling, constant, rising, or none of the above? Exactly why is this so?

- (c) What sort of returns to scale does a firm have to have in order for its long-run average cost curve to be U-shaped? Why?
- (d) Graphically illustrate why U-shaped average cost curves might cause nonexistence of a competitive equilibrium.
6. A perfectly competitive firm has total costs TC of the form
- $$TC = q^2 + 1$$
- where q is the quantity of production by the firm. This implies a marginal cost curve of
- $$MC = 2q.$$
- (a) If price is \$4, what are the firm's profits or losses? (Hint: this firm has a U-shaped average cost curve. Figure out where $AC = MC$ and sketch a graph of AC and MC .)
- (b) Suppose the entire industry has only one other firm, which is identical to the first one. Sketch the market supply curve, giving the coordinates of at least two points on its rising portion.
7. Suppose there are 10 firms in a competitive industry, and each firm has a marginal cost curve

$$MC = q^2.$$

If the market demand curve is

$$P = 11 - Q,$$

find the equilibrium P and Q .

Hint. Depending on how you work the problem, it might come in handy to know that $x^2 + 10x - 11 = (x + 11)(x - 1)$, or that $x^2 + 100x - 1100 = (x + 110)(x - 10)$.

8. (a) Does Figure 2B represent an increasing-, decreasing-, or constant-cost industry? Why?
- (b) Suppose that the demand curve D in Figure 2B shifts downward to a new demand curve D' . (Draw D' .) Mark the new short-run equilibrium in Fig. 2B. Are the firm's profits in the new short-run equilibrium positive or negative or zero? Why?

- (c) Mark the new long-run equilibrium on Figure 2B. Draw the location of Figure 2A's average cost curve in the new long-run equilibrium. Explain how this makes sense in light of your answer to part (a).
- (d) What are the firm's profits in the new long-run equilibrium? Why?
- (e) Is the number of firms larger, smaller, or the same in the new long-run equilibrium compared with the old long-run equilibrium, or can you not tell? Why?
9. Using two diagrams, one for a typical firm and one for the industry as a whole, derive the shape of the very long run supply curve in a competitive increasing cost industry by assuming that an initial very long run equilibrium point is disturbed by a *fall* in demand. Assume that each firm has first increasing and then decreasing returns to scale.
10. Suppose a decreasing-cost industry is in very long run equilibrium, and that the demand curve suddenly shifts *DOWN*. By showing what happens in the market and what happens to each individual firm, derive the slope of the very long run supply curve.
11. By sketching a graph, show that one can have an increasing returns to scale firm in an increasing-cost industry, but that increasing returns to scale is inconsistent with very long run competitive equilibrium.
 Also show that one can have a decreasing returns to scale firm in an increasing-cost industry, but that decreasing returns to scale is inconsistent with very long run competitive equilibrium.
12. Is a production function of the form $Q = 3W^{1/3}F^{3/4}$ compatible with competitive very long run equilibrium? Why or why not?
 If the production function were $Q = W^\alpha F^\beta$, then what values of α and β would be compatible with competitive very long run equilibrium?
13. A competitive decreasing-cost industry is in long run competitive equilibrium at price P^* and quantity Q^* . Suppose the government establishes P^* as a price floor for this market. Why might the government be surprised at the very-long-run effect of its price floor if demand shifted down? Explain thoroughly with a graph. Be sure to include in your graph the initial and final short run supply curves if there is no

price floor, as well as all the other important curves. Trace out and explain the entire adjustment process if there were no price floor.

14. Suppose that for each firm in an industry, average costs are U-shaped and minimum average cost always occurs at $q = 1$. Also, take as given the following chart.

# Firms	Minimum Average Cost for each firm
5	15
10	10
15	15
20	20
25	25
30	40

(see Figure 1).

- (a) Sketch the very-long-run supply curve. Does this industry have constant-, increasing-, or decreasing-cost? What kinds of returns to scale does each firm have?
 - (b) Give the very-long-run equilibrium price, quantity and number of firms if the market demand curve is given by $P = 20 - Q$. Sketch the market demand curve and explain your answer.
15. (a) Sketch the total revenue curve and the very long run total cost curve of a perfectly competitive firm with constant returns to scale, assuming that the firm shuts down in the long run.
- (b) Suppose that in this example, the price of the firm's output is \$2/bushel and its average costs are \$3/bushel. What is the algebraic expression for the firm's total profit curve (profit π versus quantity Q)? Is marginal profit equal to zero at the firm's optimal choice of Q ? If not, what is its marginal profit at the optimal Q ?
16. Suppose that wheat is produced under perfectly competitive conditions. Individual wheat farmers have average cost curves as in Figure 1. If the market demand curve is given by

$$Q_D = 72 - 4P,$$

what is the very long run equilibrium price of wheat? What is the very long run equilibrium quantity of wheat produced by each firm? How many firms are there in very long run equilibrium?

17. Suppose there are 10 identical firms in an industry. The total cost curve of each firm is $TC = \frac{1}{2}q^2 + wq$ and the marginal cost of each firm is $MC = q + w$, where q is the production of each firm and w is the wage rate of workers in this industry. Suppose $w = 1.9Q$ where Q is the total industry production.
- Is this an increasing-, decreasing-, or constant-cost industry? Why?
 - Give the algebraic equation of the industry supply curve. (This should be Q as a function of p with no w involved.)
 - Suppose quantity demanded is given by $Q^D = 6 - p$. Find the equilibrium price, market quantity, and wage rate.
18. Suppose the long-run average cost curve for one competitive firm is given by $LRAC = (q - 10)^2 + 1 + N$, where N is the number of firms in the industry. Figure 6 is a sketch of this.
- Is this a decreasing-, constant-, or increasing-cost industry, or can you not tell?
 - What is the very long run equilibrium price, supposing that N is known?
 - What is the very long run equilibrium quantity of this one firm, q ? What is the very long run equilibrium quantity for the whole industry of N firms if all the firms are identical?
 - Suppose the market demand curve is given by $P = 100 - Q$. Find the very long run equilibrium P , Q , and q , if all the firms are identical.

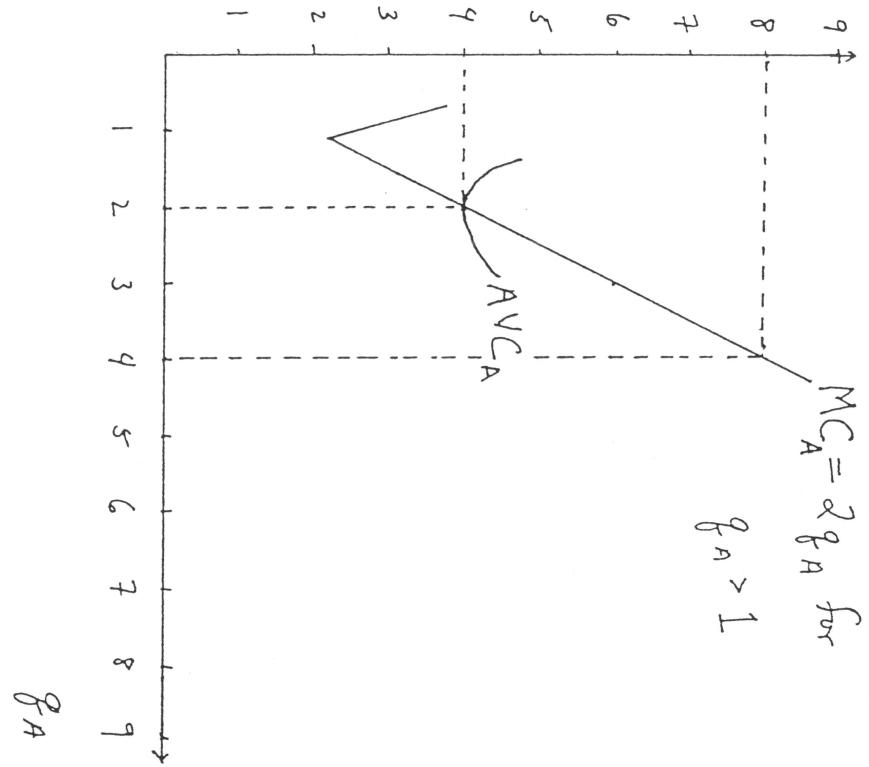
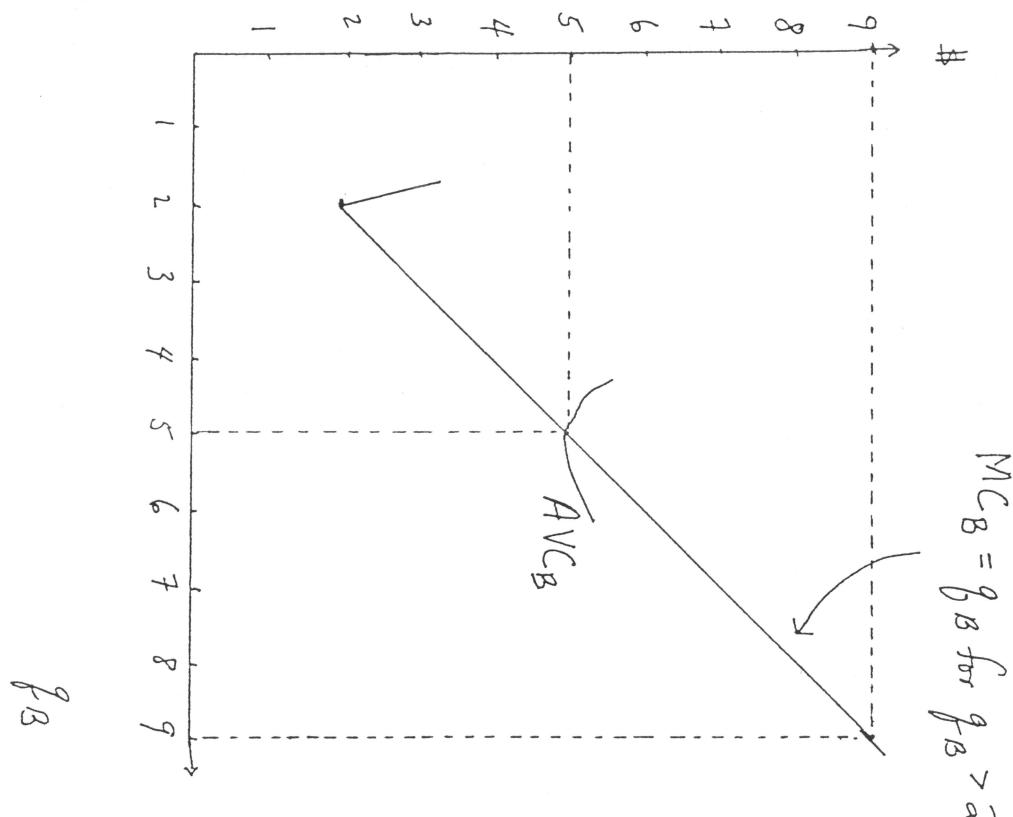


Fig. 1



Question 3's Fig. 1

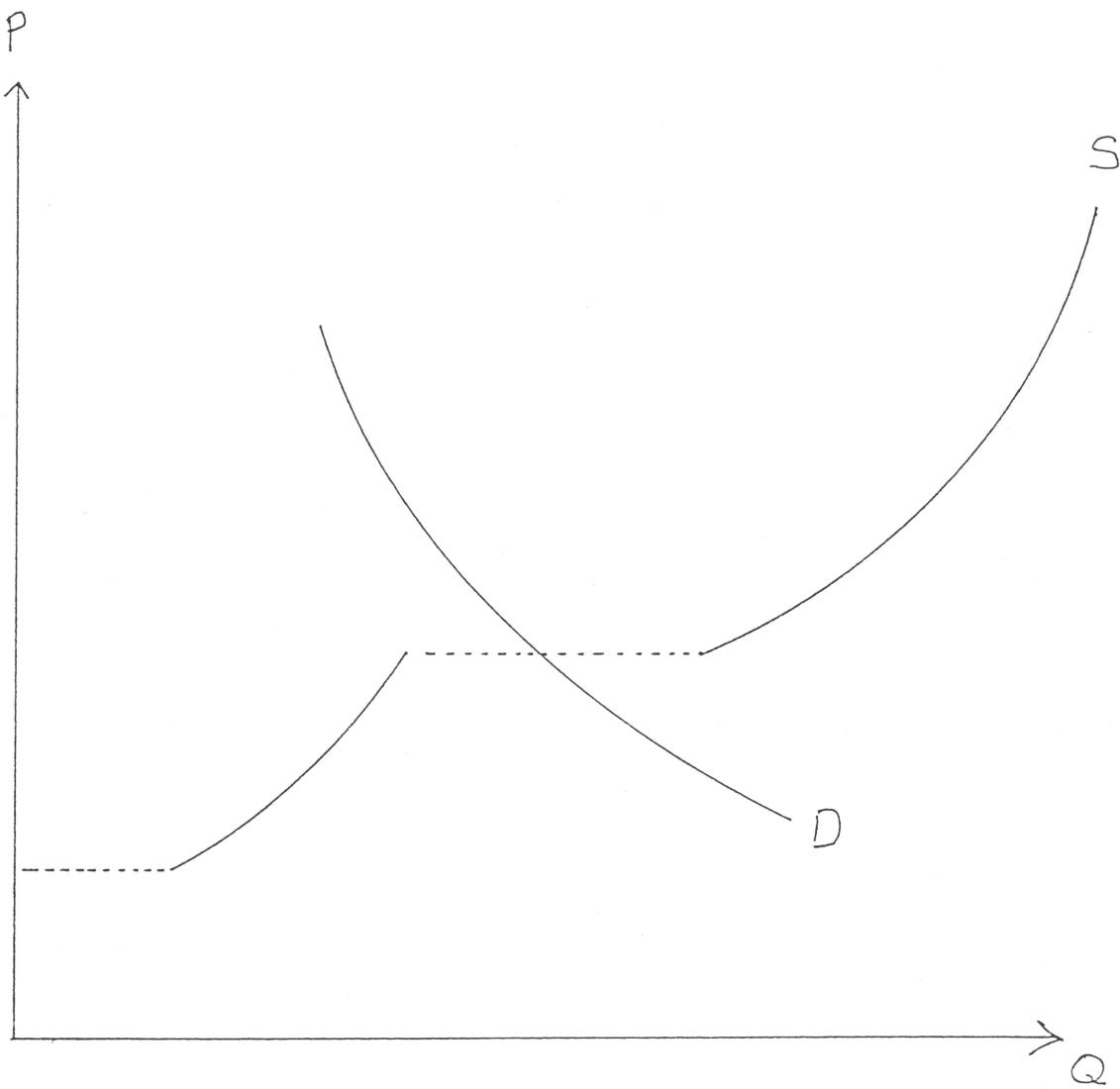
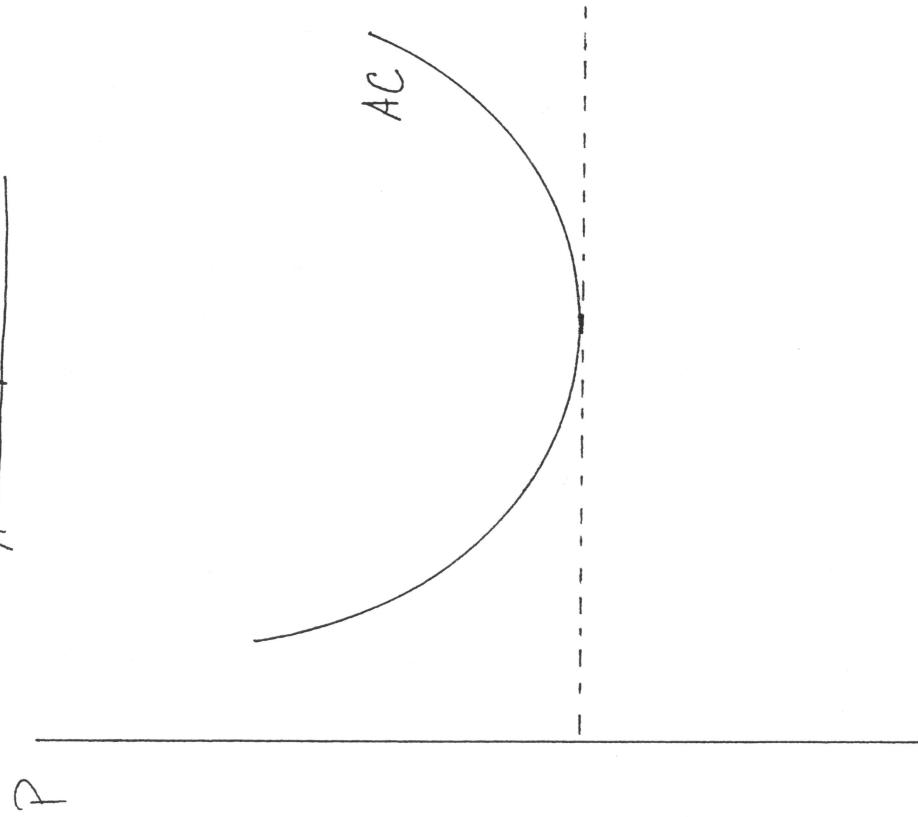


Fig. 2

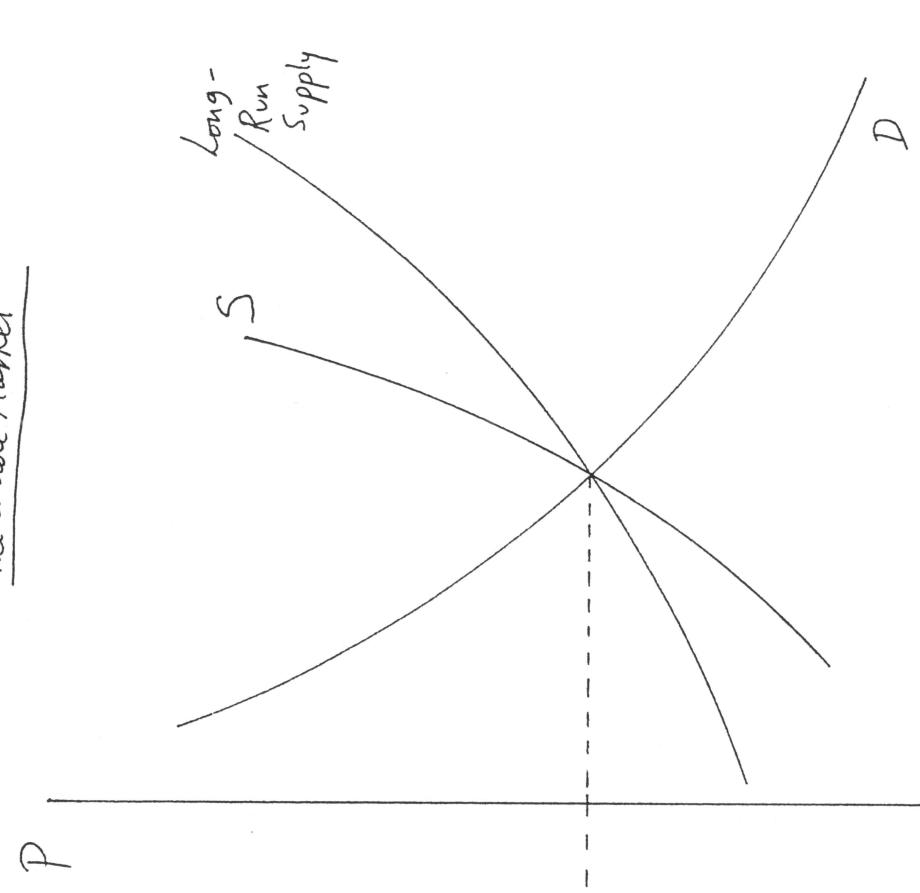
Question 3's Fig. 2

Figure 2.

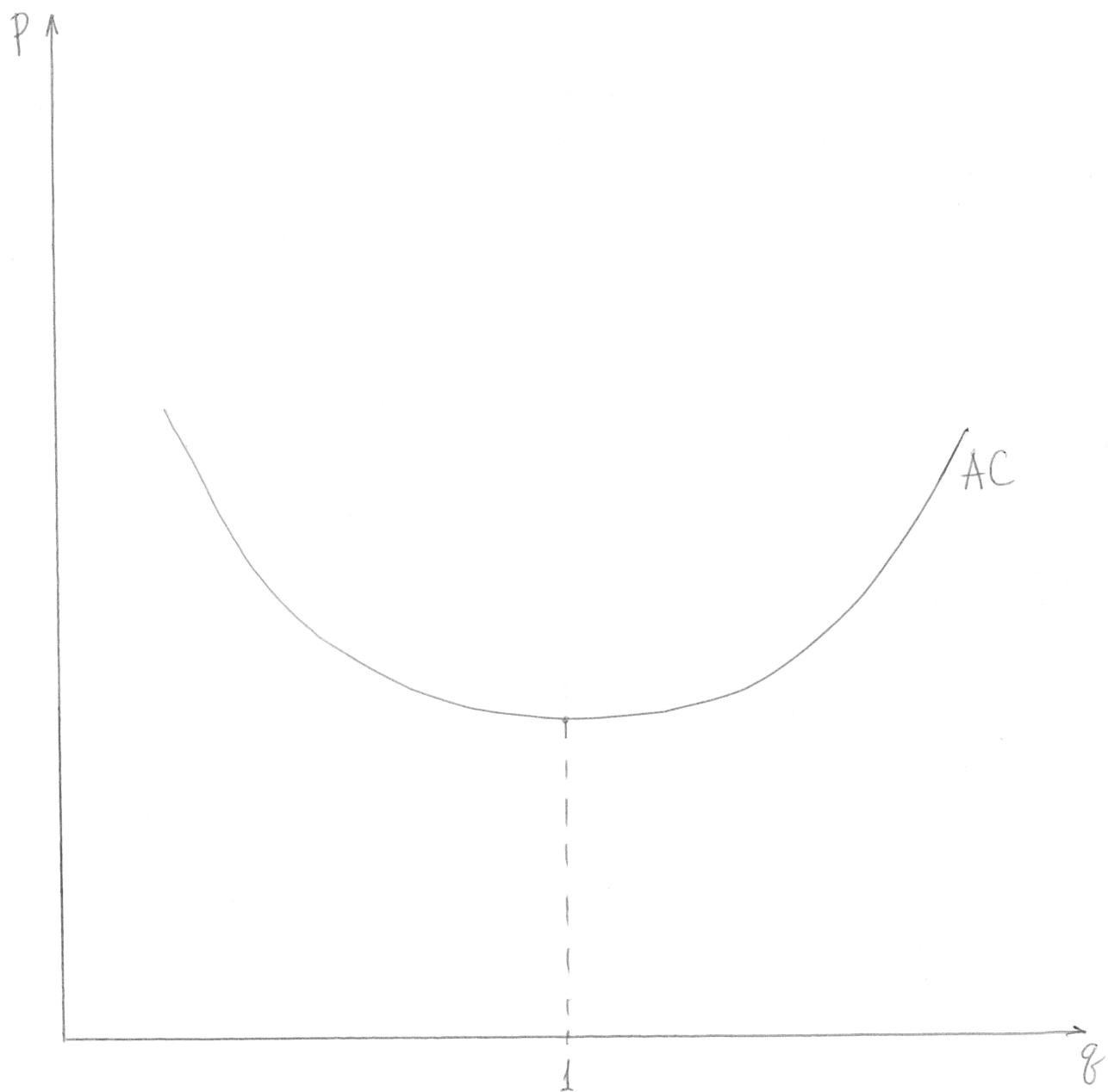
One Typical Competitive Firm



The Whole Market



Question 8's Fig 2



Question 14's Fig. 1

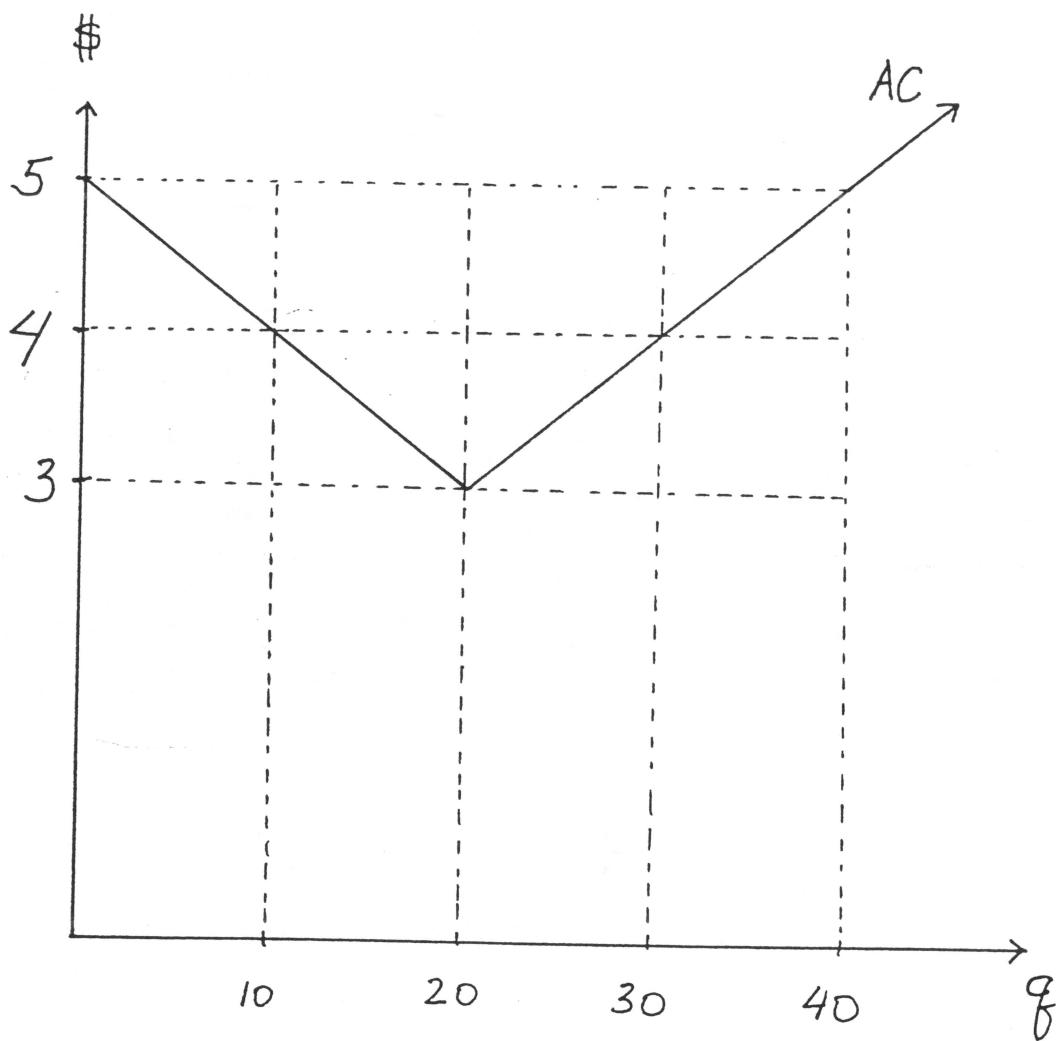


Figure 1.

Question 16's Fig. 1

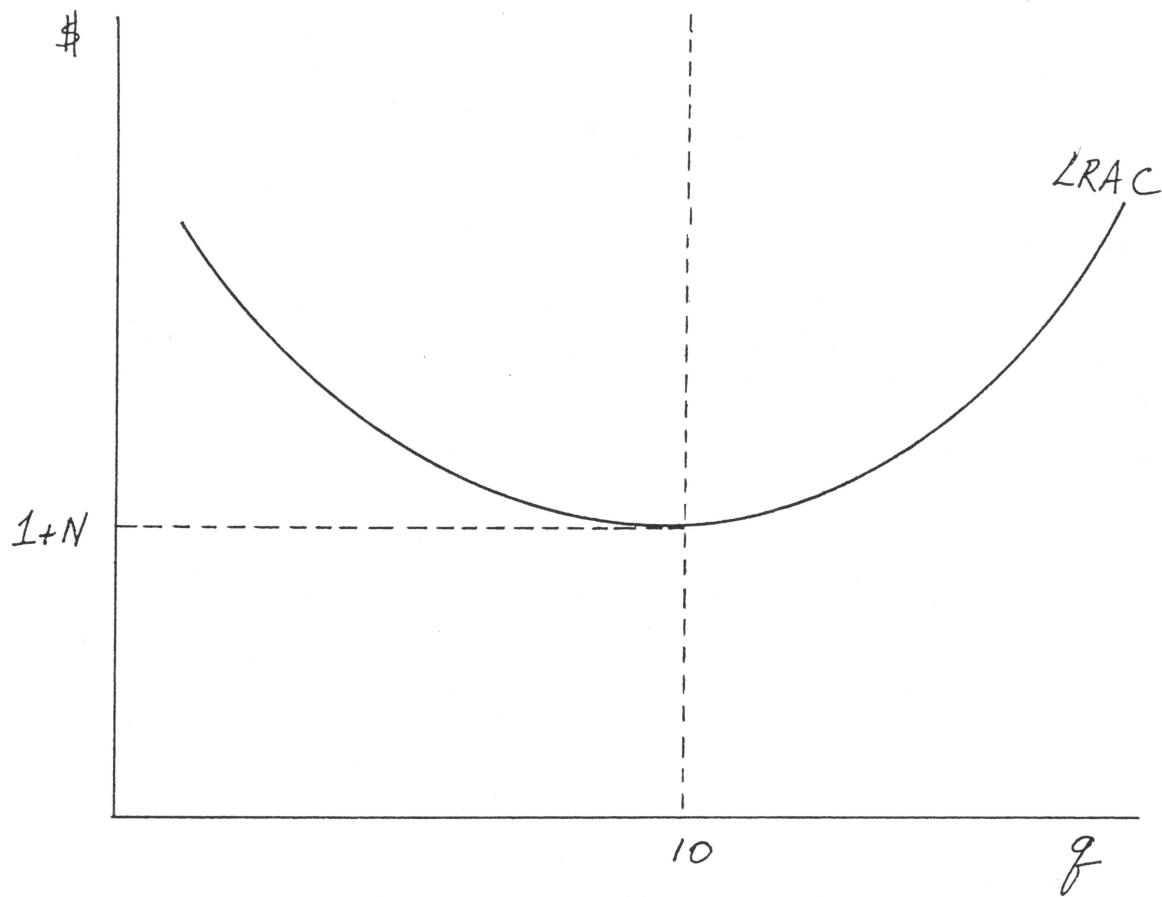
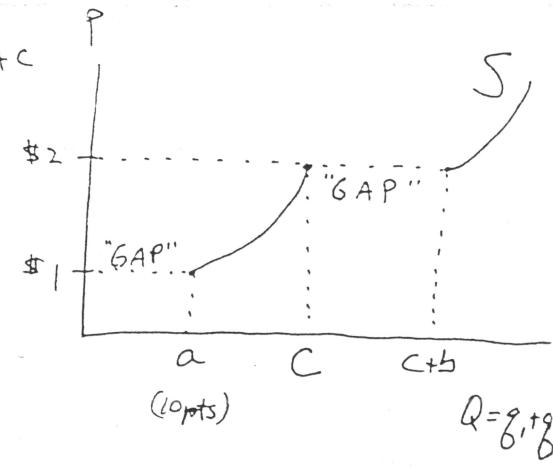
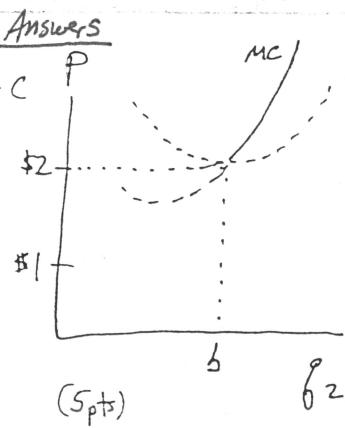
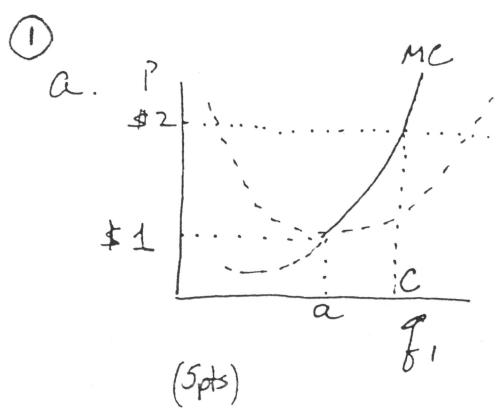


Figure 6

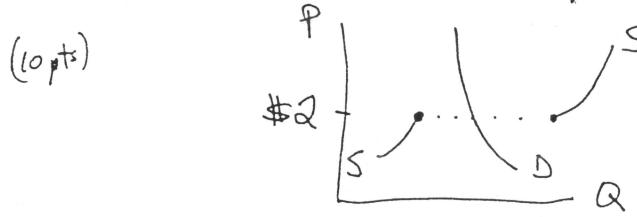
Question 18's Fig. 6



This is a process of constructing the aggregate supply curve from the MC curves of two firms. At $p < \$1$,

$q_1 = 0$ and $q_2 = 0$, so $Q = 0$. At $p = \$1$, $q_1 = 0$ or a and $q_2 = 0$, so $Q = 0$ or a . * Between $p = 1$ and $p = 2$, $q_2 = 0$ and q_1 is between a and c . At $p = 2$, $q_1 = c$ and $q_2 = 0$ or b , so $Q = c$ or $b + c$. Above $p = 2$, $q_1 > 0$ and $q_2 > 0$.

b. The market demand curve might go through the "gap":



At $p \geq 2$, $S > D$; at $p < 2$, $D > S$; at $p = 2$, either $S < D$ or $D < S$, depending on which point the firms choose to produce.

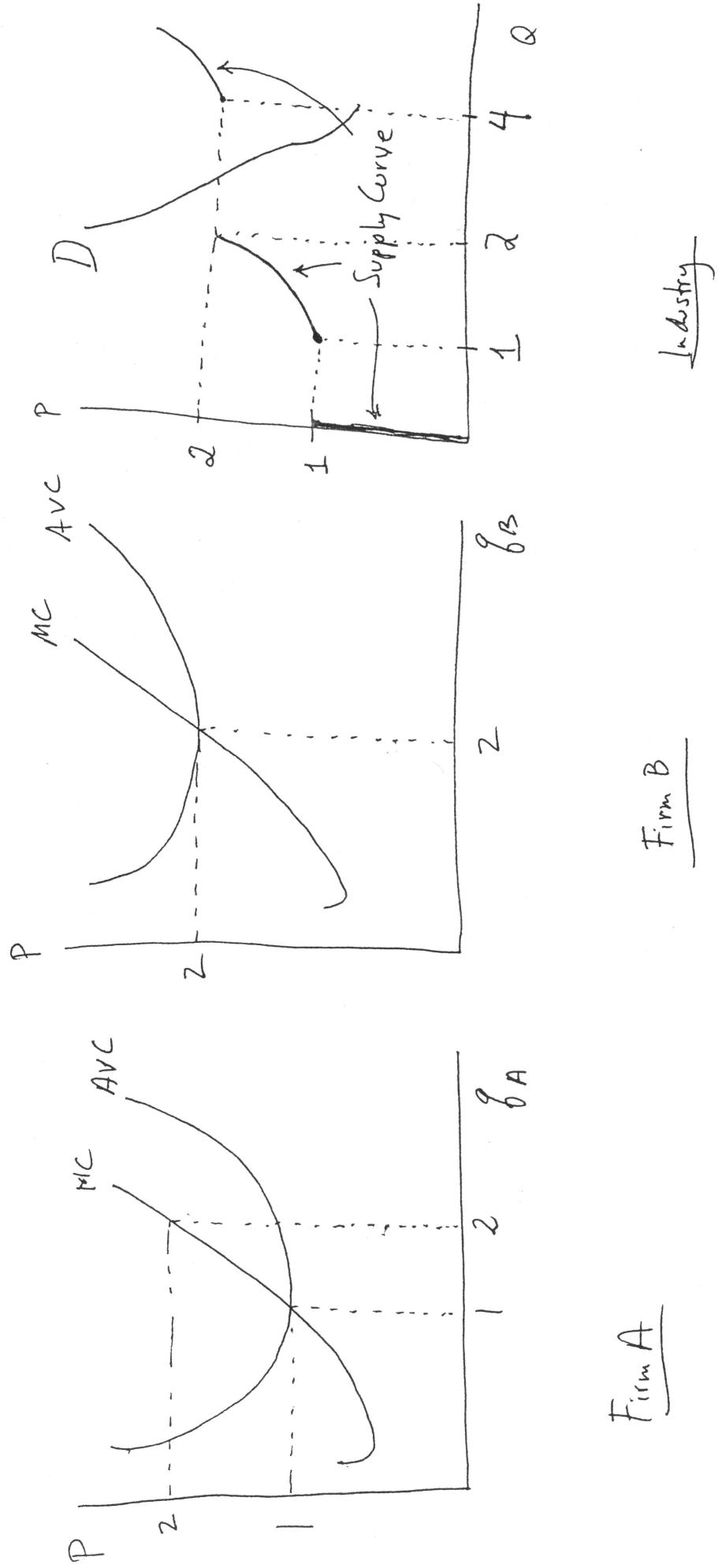
*Reason: To go from p to q , you know that p will equal MR (marginal revenue) — so MR is a horizontal line at p . Where this horizontal line intersects MC, that is the profit-maximizing q , unless that q results in $AC > p$. If it does result in $AC > p$, then some other q (perhaps $q = 0$) will be profit-maximizing.

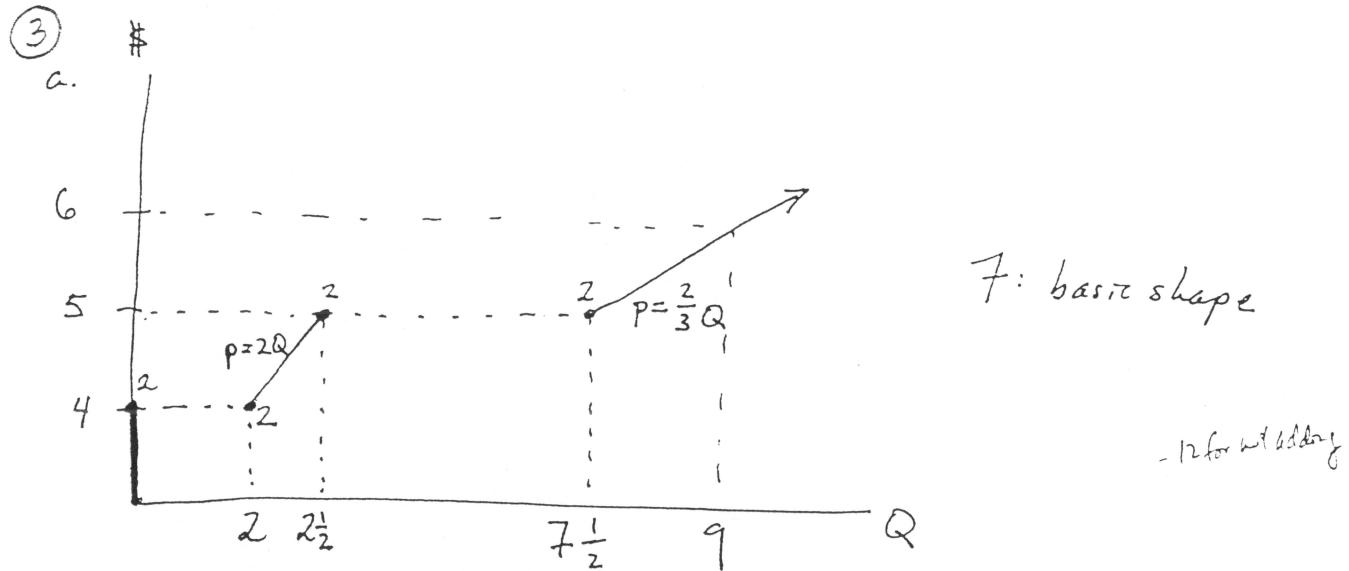
②

Given AVC curves as in the first two figures on the next page,
Industry Supply looks as in last figure.* If the market demand
curve is in the position shown, then there's no way to
get supply equal to demand: At prices just under \$2,
 $g_A \approx 2$ and $g_B = 0$. At prices just over \$2, $g_A \approx 2$, $g_B \approx 2$,
so $Q \approx 4$. At \$2 exactly, $g_A = 2$ and $g_B = 0$ or 2, so
 Q is 2 or 4. Hence there's no way to get a Q strictly between
2 and 4.

This is also true if the demand curve is in the gap between $Q=0$ and
 $Q=1$.

* For the reasoning, see the answer to the previous question.





b. U-shaped average costs : firms enter with a large minimum quantity once price hits min AC [10]

P will probably be at the "----" line, and Q at the L of this line since if a firm entered to bring Q to the R point on the line, it could not sell all its production. Q at the L of the line would be a permanent state of excess demand. [5]

The supply curve has a gap : { in the short run, when there is an initial region of increasing returns ;
in the long run, when there is an initial region of increasing returns to scale.

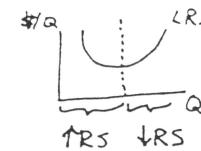
In both these cases, firms either produce zero or they produce at least a certain minimum quantity which is strictly positive.

Let \hat{P} denote the price at which the D curve intersects the dotted line in the figure given in the question. If price were greater than \hat{P} there would be excess supply. If price were less than \hat{P} there would be excess demand. At \hat{P} there is either excess supply or excess demand. So there is no equilibrium price. The best guess as to what would happen would be a price of \hat{P} and production at the left end of the dotted line (permanent excess demand), because the opposite possibility — permanent excess supply — would lead to the absurdity of ever-increasing inventories. Another possibility is alternating in time between production at the left and right sides of the dotted line, but this wasn't discussed in class.

(4)

- a) LRAC is U-shaped if the firm has increasing returns to scale for small Q
 and decreasing returns to scale for large Q .

3pts

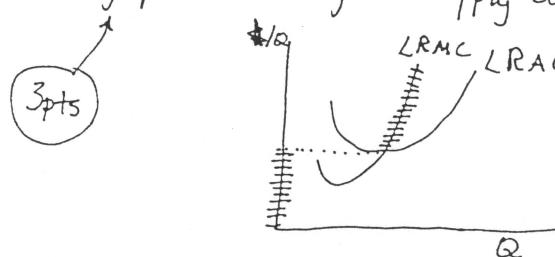


(This is

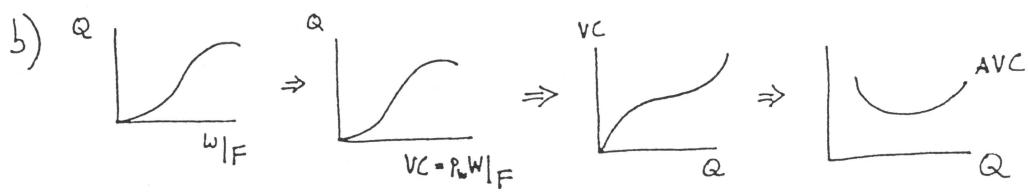
explanation:
1 pt

because \uparrow RS implies that as Q doubles, costs less than double, so $AC = \frac{\text{cost}}{Q}$ falls; similarly for why \downarrow RS implies rising LRAC.) (Also: 

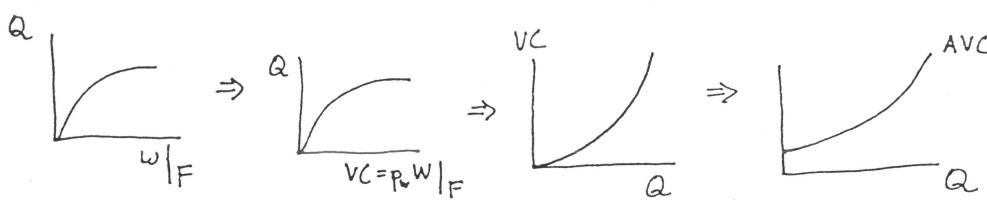
There is a gap in the Long Run Supply curve, which looks like this:



is the supply curve, LRMC above
the bottom of LRAC



explanation:
4 pts

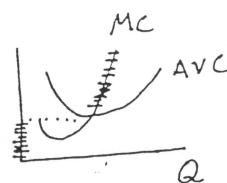


4 pts

The top series of four graphs shows that if the law of diminishing returns does not take hold immediately, so the cross section of the production

function is not concave, then SRAVC is U-shaped. The bottom series of four graphs shows that if the law of diminishing returns does take hold immediately, then SRAVC is not U-shaped. (Notice that the shape of SRVC in the top series is the same as the shape of LRTC in part (a); both gave rise to U-shaped average cost curves.)

When SRAVC is U-shaped, then:

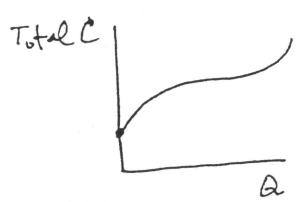


MC is the supply curve, MC above the bottom of AVC

So the supply curve has a gap.

3 pts

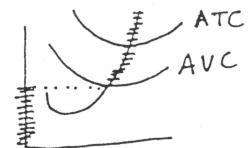
c) Total Cost = Variable Cost + Fixed Cost. For the top series of graphs in part (b),



so

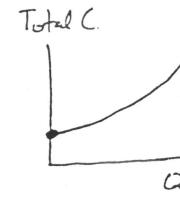


and

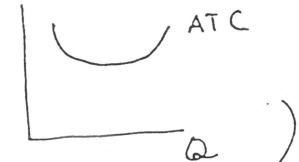


For the bottom series of graphs in part (b),

4 pts



so



In other words, SRATC is always U-shaped.

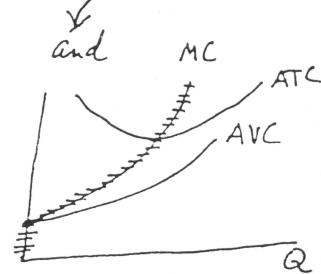
Explanation: 5 pts

In some of these cases the supply curve has a gap in it

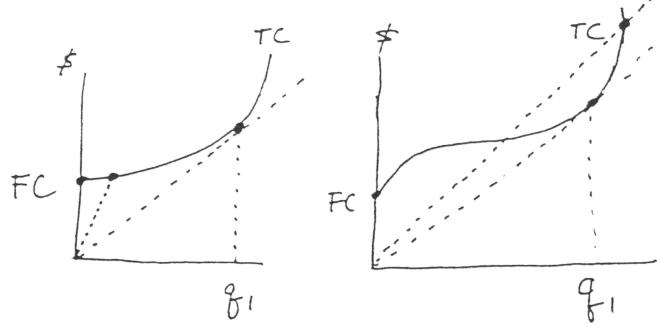
(that is the case for graphs from the top series from part (b)), but in other cases, like this one,

there is no gap in the supply curve even though ATC is U-shaped.

S curve gap:
6 pts



⑤ a)



All SRTC curves have fixed

4pts \rightarrow costs FC. Also, they all

eventually become convex,

because of the Law of \downarrow ^{3 pts} Diminishing Returns. So the two basic shapes are as drawn. Both these shapes give rise to U-shaped \downarrow ^{3 pts} AC curves; the bottoms of the AC curves would be at the points labelled q_1 . Below q_1 , AC is falling; above q_1 , AC is rising. This is demonstrated by the slopes of the dotted lines in the two graphs, showing a fall in AC in the first graph and a rise in AC in the second. (Of course the first graph has AC rising beyond q_1 , and the second graph has AC falling before q_1 .)

b) \uparrow RS \Rightarrow doubling inputs leads to more than doubling output Q. But

doubling inputs always leads to doubling costs. Hence

$$AC = \frac{\overbrace{TC}^{\leftarrow \text{DOUBLED}}}{\overbrace{Q}^{\leftarrow \text{MORE THAN DOUBLED}}} \quad \begin{array}{l} \text{must fall} \\ \text{4pts} \\ \text{1pt} \end{array}$$

c) $\uparrow RS \Rightarrow AC$ falling, from part b. Similarly,
 $\downarrow RS \Rightarrow AC$ rising, and

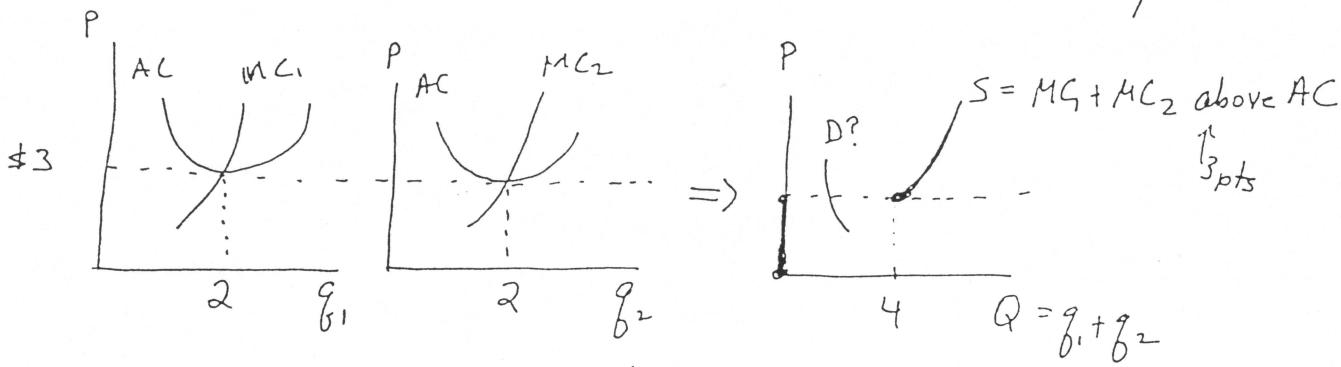
$CRS \Rightarrow AC$ constant.

A U-shaped AC curve has AC first falling, then constant (for one g), then rising, so it must first have $\uparrow RS$, then CRS , then $\downarrow RS$.

3 pts

3 pts

d) Suppose there are two identical competitive firms with U-shaped AC curves.



So there is a gap in the market supply curve. If D passes through this gap,

as in the example shown, then there is no competitive equilibrium.

3 pts

$$\textcircled{6} \quad TC = g^2 + 1$$

$$MC = 2g$$

a) The quickest way: $P = MC \Rightarrow 4 = 2g \Rightarrow g = 2$

$$TC(g=2) = 2^2 + 1 = 5$$

$$TR(g=2) = Pg = 4(2) = 8$$

$$\pi(g=2) = 8 - 5 = 3 > 0 \text{ so the firm will not shut down.}$$

A graphical way:

$$ATC = \frac{TC}{q} = \frac{q^2 + 1}{q} = q + \frac{1}{q}$$

Points: $g^* = 2 : 6$

$AC \text{ or } TC : 6$

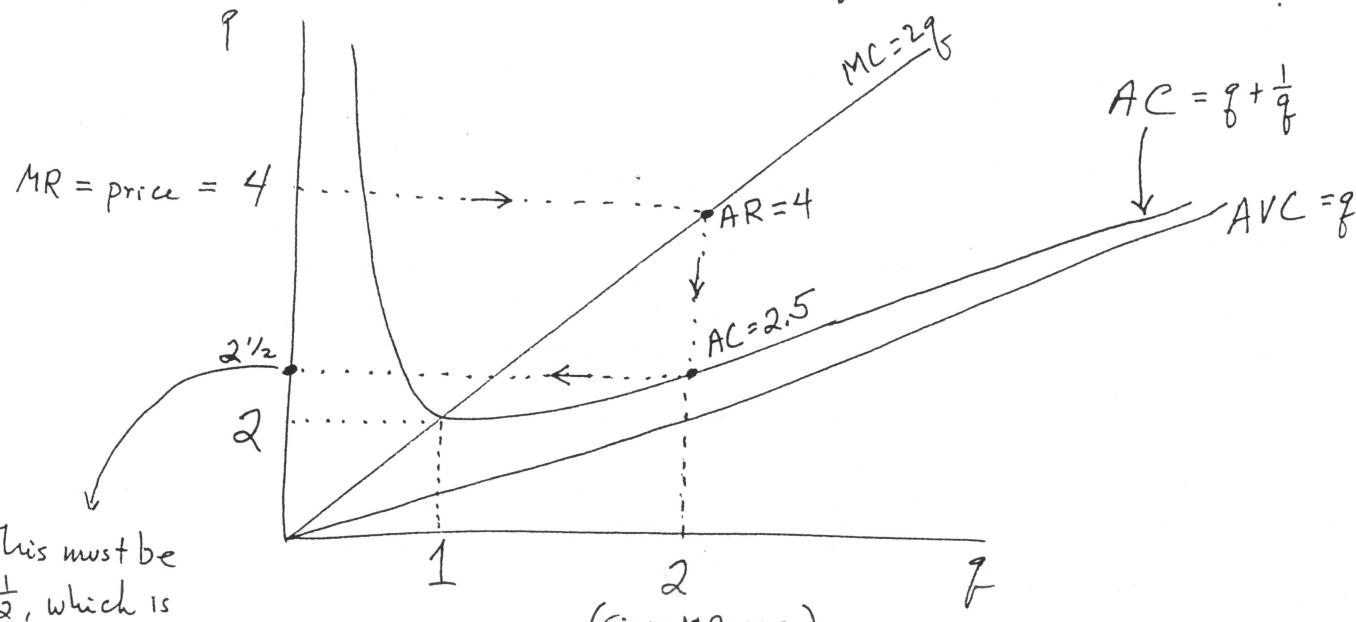
$P(\text{or } AR) \text{ or } TR : 5$

$\pi : 1$

$$ATC = MC \text{ at } q + \frac{1}{q} = 2q$$

$$q^2 + 1 = 2q^2$$

$$1 = q^2 \Rightarrow q = 1. \text{ If } q = 1 \text{ then } AC = MC = 2.$$



$$\pi = (AR - AC) q^*$$

$$= (4 - 2\frac{1}{2})(2)$$

= 3. Since $\pi > 0$, there's no need to check the shut-down rule.

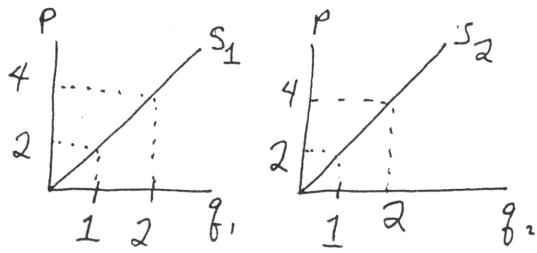
b) $FC = TC(q=0) = 1$

$$VC = TC - FC = q^2 + 1 - 1 = q^2$$

$$AVC = \frac{q^2}{q} = q, \text{ since } AVC = \frac{VC}{q}. \text{ So (see the above graph)}$$

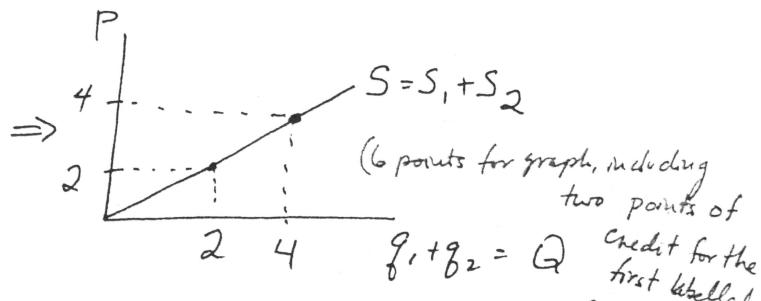
MC is always above AVC (except at zero, where they equal). Hence

the supply curve of each firm is its entire MC curve. (9 points)



$$P = 2q_1$$

$$P = 2q_2$$



$$\text{So } q_1 = \frac{1}{2}P, \quad q_2 = \frac{1}{2}P,$$

$$\text{and } Q = q_1 + q_2$$

$$= \frac{1}{2}P + \frac{1}{2}P$$

$= P$. So the market supply curve is $P = Q$, with a slope of 1.

[#points off for thinking that S_1 and S_2 started at $(1, 2)$ instead of at $(0, 0)$: 2 points
(if everything else is correct)]

(7)

$$MC = g^2 \quad (1)$$

$$MR = MC \quad (2) \quad \leftarrow 4 \text{ pts.}$$

$$\text{competitive industry} \Rightarrow P = MR \quad (3) \quad \leftarrow 6 \text{ pts.}$$

$$P = 11 - Q \quad (4) .$$

Using (1)-(4), we get $11 - Q = P = MR = MC = g^2$. Clearly,

$$10g = Q \quad (5). \quad \leftarrow 4 \text{ pts.}$$

Hence

$$11 - 10g = g^2 \quad \leftarrow 1 \text{ pts.}$$

$$g^2 + 10g - 11 = 0$$

$$(g + 11)(g - 1) = 0$$

$$\begin{array}{l} g = -11, \\ \text{impossible} \end{array} \quad \begin{array}{l} g = 1, \text{ possible.} \\ \leftarrow 5 \text{ pts.} \end{array}$$

$\leftarrow 2 \text{ pts.}$

$$\text{So } g = 1, Q = 10g = 10, \text{ and } P = 11 - Q = 11 - 10 = 1.$$

Another way to work this is to start at the " $11 - Q = g^2$ " step and

and use (5) to eliminate q :

$$11 - Q = \left(\frac{Q}{10}\right)^2$$

$$11 - Q = \frac{Q^2}{100}$$

$$1100 - 100Q = Q^2$$

$$Q^2 + 100Q - 1100 = 0$$

$$(Q+110)(Q-10) = 0$$

$$\begin{matrix} \swarrow \\ Q = -110, \\ \text{impossible} \end{matrix}$$

$$\begin{matrix} \searrow \\ Q = 10, \text{ possible.} \end{matrix}$$

So $Q = 10$ and $P = 11 - Q \Rightarrow$

$$P = 1.$$

One of your classmates pointed out quite correctly that we ought to make sure that $P > AVC$ at this solution. However, I did not give you enough information to work this out. What one needs to do is use calculus to infer from $MC = q^2$ that

$$TC = \frac{1}{3}q^3 + FC,$$

where FC is some fixed cost. Then you should be able to work it out this way:

$$VC = \frac{1}{3}q^3 \quad \text{and}$$

$$AVC = \frac{VC}{q} = \frac{1}{3}q^2.$$

We have $Q = 10$ ($\text{so } q = 1$), and $P = 1$. So $P > AVC$ if and only if

$$1 > \frac{1}{3}(1)^2$$

$$1 > \frac{1}{3} \quad (\text{true}).$$

So $P > AVC$ and the correct answer is as given above.

- 8 a. Increasing-cost industry, because the long-run supply curve is upward sloping.
- 2pts b. The new short-run equilibrium is at point $\textcircled{1}$ on the graph, where D' hits the short-run supply curve. This implies a short-run equilibrium price of P^* .

The line at P^* represents AR for a competitive firm; so $AR < AC$ for all q ,

and the firm makes losses. ↗ 4pts.

- c. The new long-run equilibrium is at point $\textcircled{2}$, where D' intersects the long-run supply curve. The price here is P^{**} . Since this is long-run equilibrium, AC must have shifted down to, say, AC_{NEW} , so that at P^{**} , profits are zero.

This makes sense because what happens between $\textcircled{1}$ and $\textcircled{2}$ is that the negative profits at $\textcircled{1}$ cause firms to exit. (This actually already answers part (e).)

- 4pts → In an increasing-cost industry, if the number of firms goes up, costs go up; so when, as in this case, the number of firms goes down, costs should go down — which is exactly what happened.

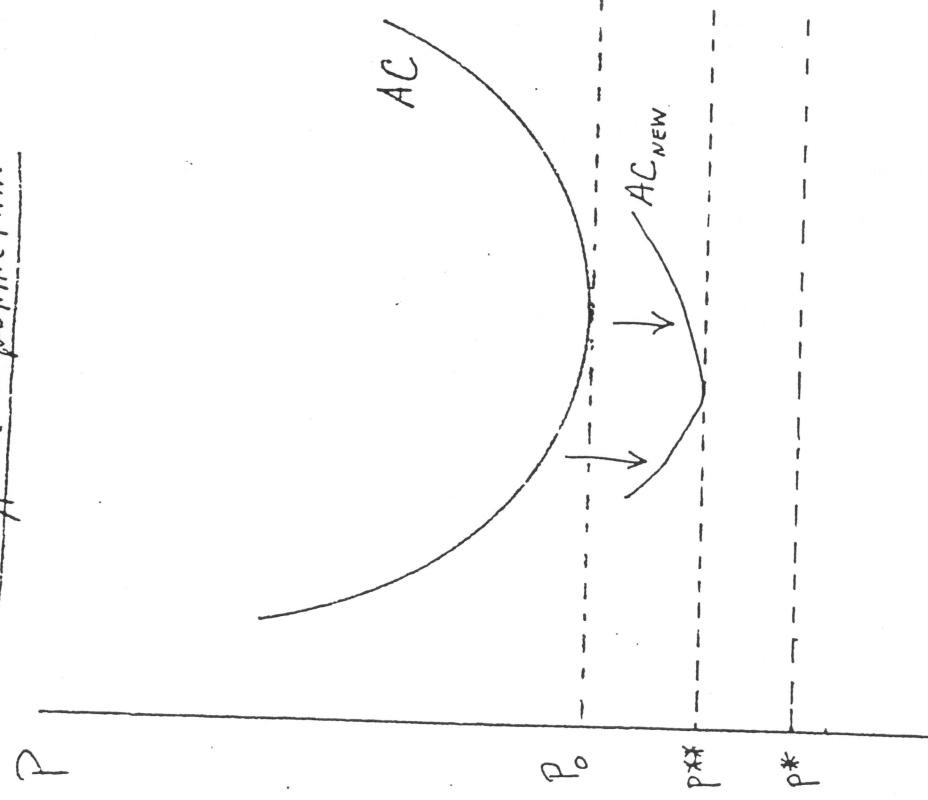
2pts → d) Zero, since by definition, in the long run profits are zero.

- e) Smaller — see part c for explanation.

4pts ↑

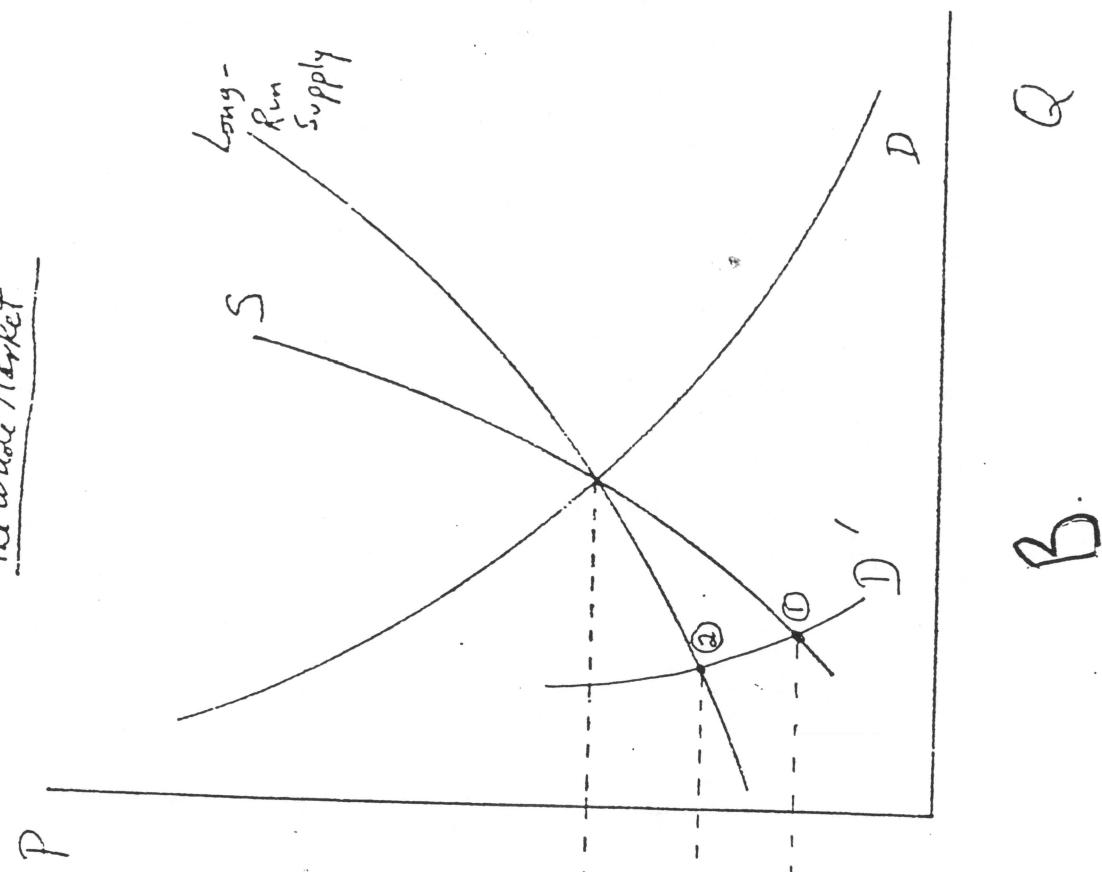
Figure 2.

One Typical Competitive Firm

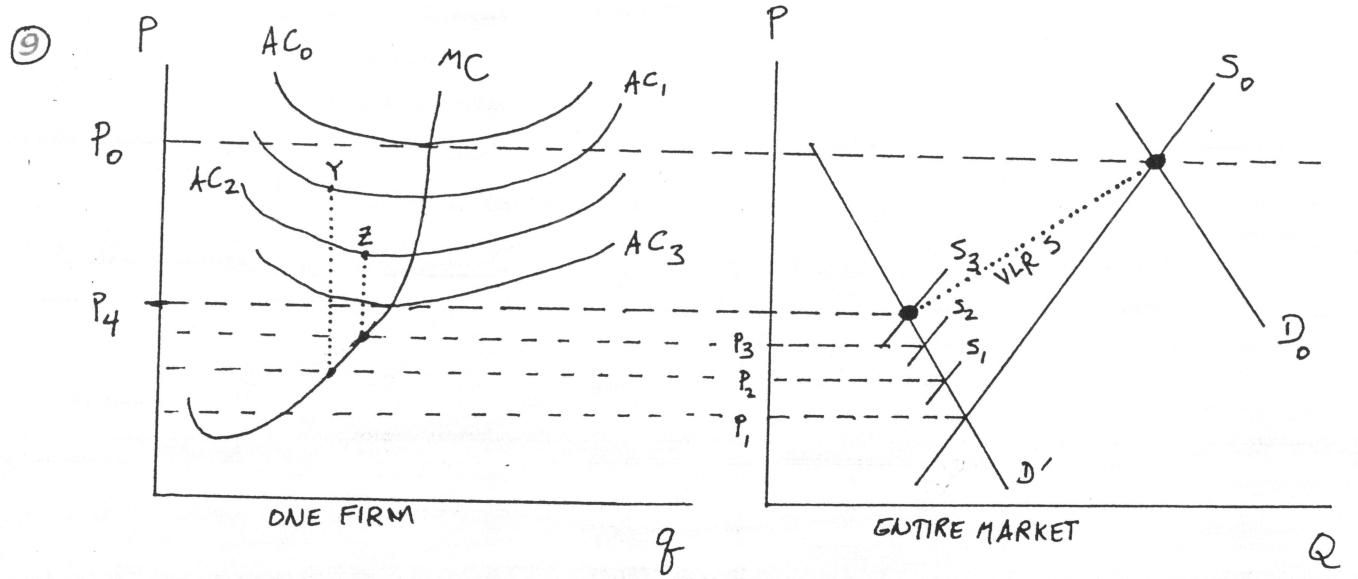


A.

The Whole Market



B.



AC is U-shaped because of the returns to scale assumption. 3pts

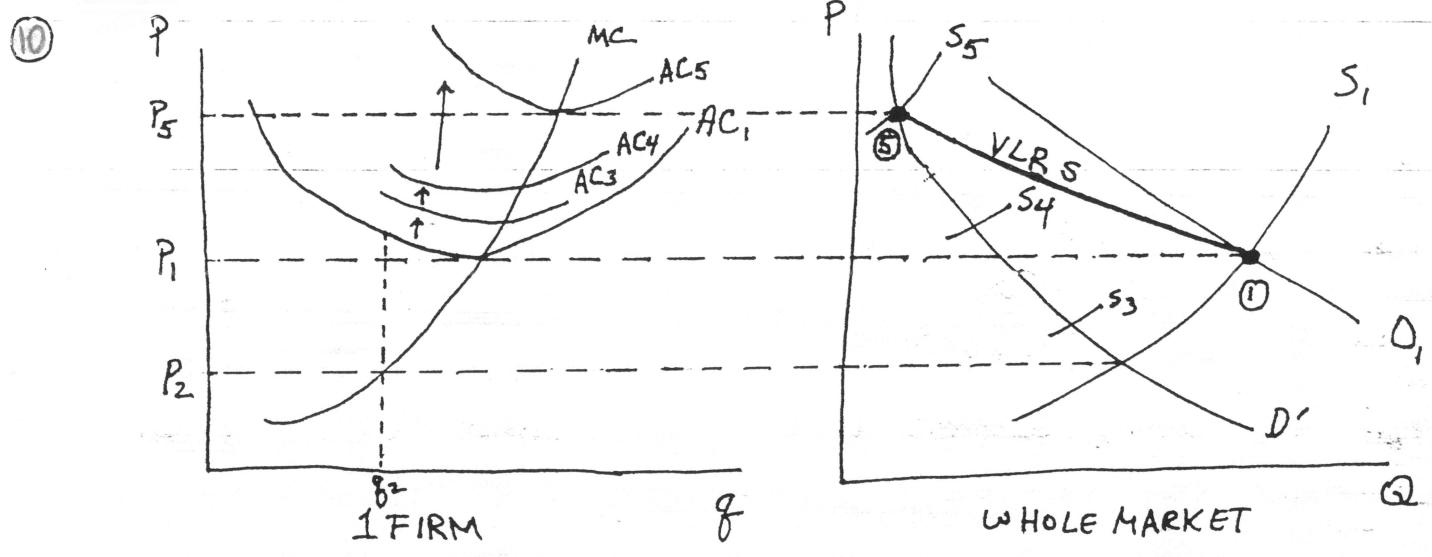
The initial very long run equilibrium price is P_0 , because there the firm is making zero profit. When demand shifts down to D' , price drops to P_1 , causing losses 2pts

3pts (because P_1 is less than AC_0). Firms begin to exit the industry, making supply shift back to S_1 , price rises to P_2 , and AC shift down to AC_1 6pts because this is an increasing-cost industry (so when the number of firms drops, the AC of each firm drops).

Comparing P_2 to the point on AC , where the firm would produce (this point is Y) shows there is still a loss. More firms leave, S moves back to S_2 , price rises to P_3 , AC falls to AC_2 , and there are still losses, but they are smaller than before (see Z).

5pts Finally, enough firms leave so that S moves back to S_3 , AC falls to AC_3 , and price rises to P_4 ; this is a new very-long-run equilibrium because the firms are making zero profit.

The Very Long Run Supply curve is labeled VLR S, and is formed by joining the two very long run equilibrium points. It is evidently upward sloping. 3pts

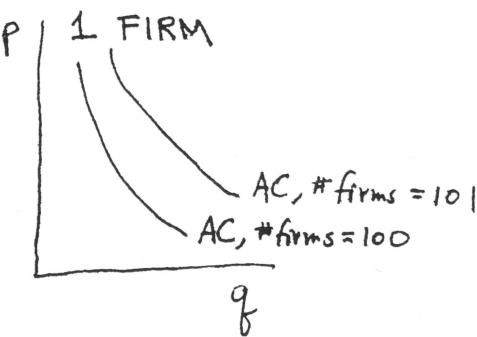


The original very long run equilibrium is at price P_1 , since profits = 0 there.

Then demand drops to D' , causing price to drop to P_2 , where firms make losses (at q_2 , firms' $AC > AR = P_2$). So firms start to leave, and S shifts back to S_3 , S_4, \dots, S_5 . As this happens, AC for each firm begins to rise ($\# \text{firms} \downarrow \Rightarrow \text{costs} \uparrow$ since in a decreasing-cost industry, $\# \text{firms} \uparrow \Rightarrow \text{costs} \downarrow$). This is shown by AC_3 , AC_4 , and AC_5 . Suppose entry finally stops when $S = S_5$. Then $AC = AC_5$, so that profits = 0, and price is P_5 . Joining the initial very long run equilibrium, ①, to the final very long run equilibrium, ⑤, yields the Very Long Run Supply Curve, which is downward-sloping.

Points
5 AC_1, P_1
5 P_2 and $\pi < 0$
6 S shifts back
6 AC rises
6 final position AC_5, P_5
5 VLR S curve

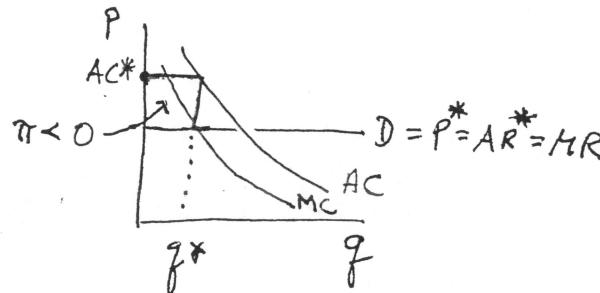
(11)



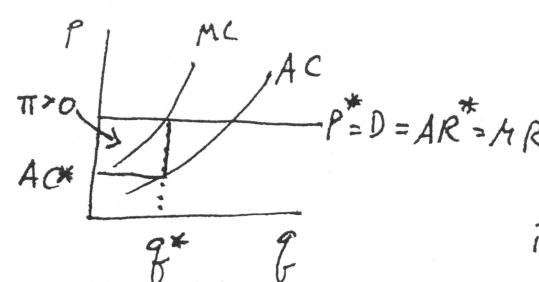
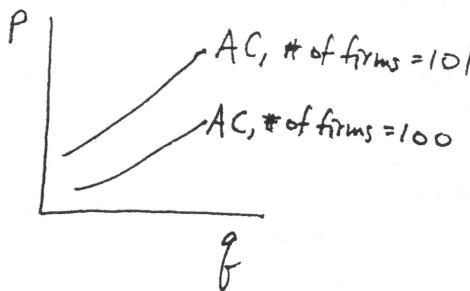
Increasing returns to scale means falling average cost curves. (This is because $AC = \frac{TC}{q}$, and doubling inputs doubles TC while more than doubling q , leading to $\downarrow AC$ as $q \uparrow$.) In this graph, falling AC is illustrated, but it is also shown that as the # of firms \uparrow (say from 100 to 101), AC of this typical firm goes up. This shows that the firm is in an increasing-cost industry (as the number of firms \uparrow , costs to each firm \uparrow). 5 pts

To show that competitive very long run equilibrium is impossible, note that such a state requires that profit π be equal to zero. However, an increasing-returns-to-scale firm always has negative π if

5 pts it sets $MR = MC$ (and infinite profit if it takes $q \rightarrow \infty$). So the zero-profit condition cannot be fulfilled.



5 pts The analysis for a decreasing returns to scale firm is similar. In this case, AC is upward sloping. If the industry is increasing-cost, the graph at the left shows what



happens as the number of firms changes. The graph on the right illustrates that in

competitive equilibrium, profits are always positive, violating the very long run condition of zero profits.

5 pts

Note: A graph is almost necessary to get credit for showing $\pi < 0$ and $\pi > 0$, respectively.

(12)

Check returns to scale: doubling inputs leads to

$$\text{new } Q = 3(2w)^{1/3} (2F)^{3/4} \leftarrow = 3 \cdot 2^{1/3} w^{1/3} \cdot 2^{3/4} F^{3/4} = 2^{\frac{1}{3} + \frac{3}{4}} 3 w^{1/3} F^{3/4}$$

$$= 2^{\frac{13}{12}} 3 w^{1/3} F^{3/4} = 2^{\frac{13}{12}} (\text{old } Q) > 2 (\text{old } Q) \text{ since } \frac{13}{12} > 1.$$

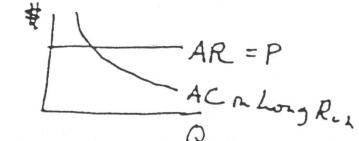
\uparrow algebra to here: 3 pts

3 pts

So the production function has increasing returns to scale. This is incompatible

\uparrow 3 pts

with competitive very long run equilibrium because it implies



\uparrow 1 pt
so the firm wishes to produce $Q = \infty$.

If $Q = w^\alpha F^\beta$ then checking for returns to scale by doubling the inputs,

$$\begin{aligned} \text{new } Q &= (2w)^\alpha (2F)^\beta = 2^\alpha w^\alpha 2^\beta F^\beta = 2^{\alpha+\beta} w^\alpha F^\beta \\ &= 2^{\alpha+\beta} (\text{old } Q). \end{aligned}$$

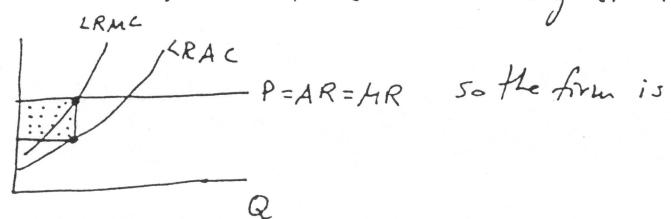
\uparrow algebra to here: 4 pts

\uparrow 3 pts

For competitive very long run equilibrium one needs constant returns to scale, implying $\alpha + \beta = 1$. If $\alpha + \beta > 1$ there are increasing returns to

\uparrow 5 pts

scale, which are disallowed as before. If $\alpha + \beta < 1$ there are decreasing returns to scale, which means that \rightarrow

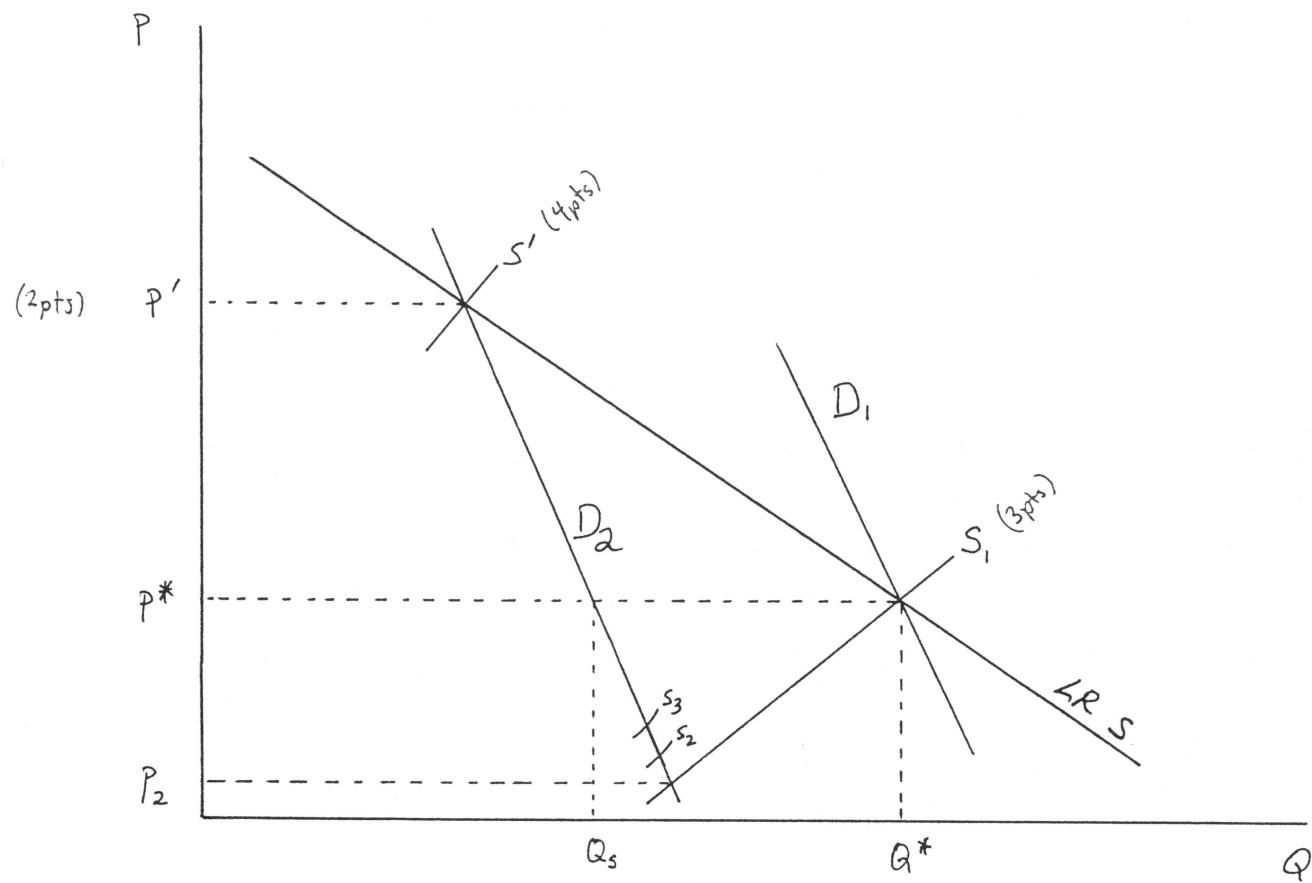


always making positive profit,

which is not allowed in the very long run.

\uparrow 1 pt

(13)



7pts \rightarrow Decreasing cost industry \Rightarrow LR S are downward sloping.

With no price floor:

4pts \rightarrow 1) Demand shifts down from D_1 to D_2 ; price drops from P^* to P_2 , causing negative profits

2) Firms start to leave the industry; S starts shifting back (to S_2, S_3, \dots).
Long Run

3) Equilibrium is re-established at S' and price P' .

6pts \rightarrow With a price floor, though, price cannot drop below P^* . Hence a

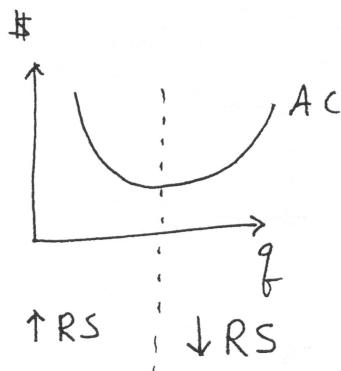
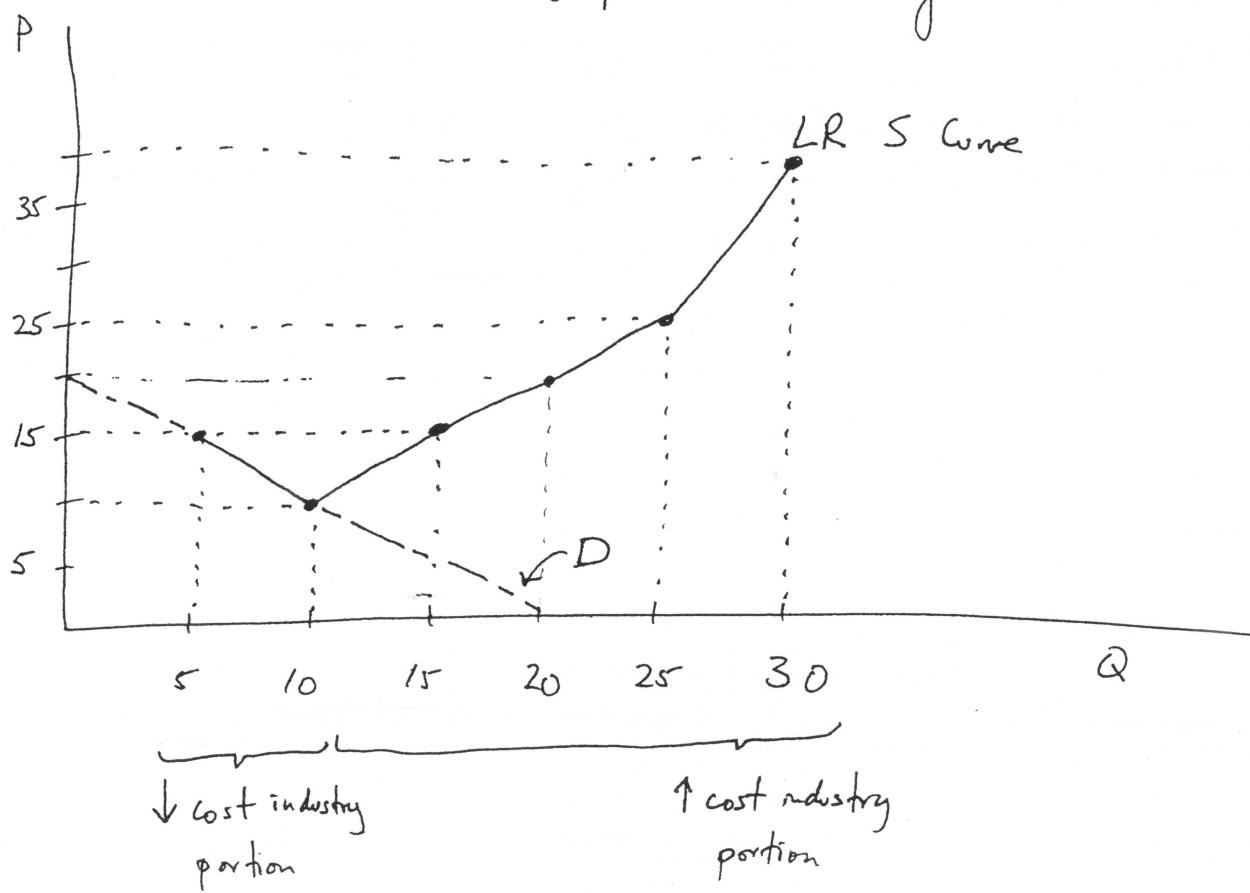
surplus of $Q^* - Q_s$ emerges, and price stays at P^* .

The government might be surprised because its goal is to keep prices up (why else have a price floor?). In the long run, with no price floor price will be P' , but with a floor it will be P^* , which is less than P' . If the government likes high long-run prices, then, it would have been better off not instituting a price floor. In short, the price floor did the opposite of what the government thought it would do in the long run. (Of course, the government might care mostly about the short run, in which case the price floor does prevent the price from dropping to P_2 .)

- (14) a. In the long run, each firm will produce at minimum average cost ($q^* = 1$), and price will equal minimum average cost. Hence we have

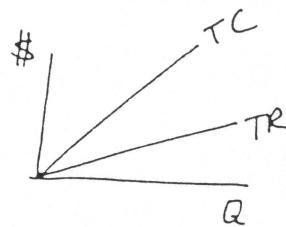
P	15	10	15	20	25	40
Industry Q	5	10	15	20	25	30

This is the long run supply curve. A graph is the following.



- b. The demand curve is sketched on the graph in part a. $S = D$ either at : $Q = 5$ ($\Rightarrow \# \text{firms} = 5$) and $P = 15$
or at : $Q = 10$ ($\Rightarrow \# \text{firms} = 10$) and $P = 10$
or anywhere in between.

⑯ a) competitive $\Rightarrow TR$ linear
 $\xrightarrow{3 \text{ pts}}$ constant returns to scale $\Rightarrow LTC$ linear

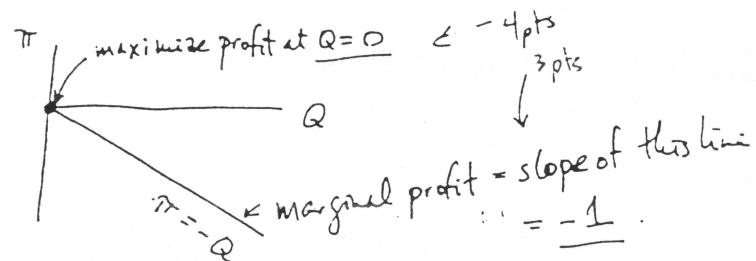


b) $TC = 3Q$.

$\xrightarrow{3 \text{ pts}}$

$$TR = 2Q$$

$$\Pi(Q) = TR(Q) - TC(Q) = 2Q - 3Q = -1Q, \text{ so } \boxed{\Pi = -Q}.$$



⑯ In LR, zero- π equilibrium, firms must be producing at the minimum point of a U-shaped or V-shaped AC curve.

(This is where $AC = MC$.) From Fig. 1, this point is $P = \$3$,

$$q = 20. \text{ If } P = \$3, Q_D = 72 - 4(3) = 60 : \text{this is market}$$

demand. If market demand is 60 and each firm produces 20,

there must be 3 firms in the market.

$$\left. \begin{array}{l} P = \$3 \\ q = 20 \\ Q_D = 60 \\ 3 \text{ firms} \end{array} \right\} \begin{array}{l} 7 \text{ pts. each} \\ 4 \text{ pts.} \end{array}$$

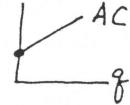
$$(17) \quad TC = \frac{1}{2} q^2 + wq$$

$$MC = q + w$$

$$w = 1.9Q$$

5 pts → a) There are two acceptable answers. One is that this is an increasing-cost industry, because as $Q \uparrow$, $w \uparrow$, raising firms' costs. The other acceptable answer is that one cannot tell if the industry is increasing-, decreasing-, or constant-cost, because neither MC nor TC depend explicitly on the number of firms.

(Indeed, the average cost curve here is $AC = \frac{1}{2}q + w$


4 pts, so the

firm has decreasing returns to scale and the very-long-run firm size is zero; therefore an increase in Q does not necessarily mean an increase in the number of firms in the very long run, because there is no meaningful very long run equilibrium.)

b) profit maximization $\Rightarrow P = MC$, so $P = q + w$, and $q = P - w$ (the supply curve of one firm)

$$\text{Supply for the industry} = 10q = 10(P - w) = 10P - 10w. \text{ Since } w = 1.9Q,$$

$$Q^S = 10P - 10(1.9Q)$$

$$Q = 10P - 19Q$$

$$20Q = 10P \Rightarrow Q^S = \frac{1}{2}P.$$

c) $Q^S = Q^D \Rightarrow \frac{1}{2}P = 6 - P$

1 pt

$$P = 12 - 2P$$

3 pts

$$3P = 12 \Rightarrow P = 4. \text{ Then } Q^S = \frac{1}{2}P = 2, Q^D = 6 - 4 = 2, \text{ which}$$

3 pts

3 pts

means $Q = 2$ and $w = 1.9(2) = 3.8$.

- (18) a) As the number of firms, N , increases, LRAC goes up. Therefore this is an increasing-cost industry.
- b) In the very long run, profits must be zero, so the price must be the minimum of the LRAC curve. This occurs at $P = 1 + N$.
- c) At the minimum of the LRAC curve, $q = 10$. Then $Q = 10 \cdot N$ for N identical firms.
- d)
- $$P = 100 - Q$$
- $$1 + N = 100 - (10 \cdot N)$$
- $$11N = 99$$
- $$\boxed{N = 9}, \boxed{Q = 10N = 90}, \boxed{P = 100 - Q = 10}$$
- 13 pts for the first variable
 3 " for the next "
 3 "
- From part (c), $\boxed{q = 10}$
- ↓
- 1 point