

## Sample Quiz 2

Each sub-question is worth of 10 points.

1. A competitive refining industry produces one unit of waste for each unit of refined product. The industry disposes of the waste by releasing it into the atmosphere and hurts the residents in the neighborhood. The inverse demand curve for the defined product is  $P^d = 24 - Q$ , where  $Q$  is the quantity consumed when the price consumers pay is  $P^d$ . The inverse supply curve (also the marginal private cost curve) for refining is  $MPC = 2 + Q$ , where  $MPC$  is the marginal private cost when the industry produces  $Q$  units. The marginal cost which inflicts the residents is  $MC = Q$ , where  $MC$  is the marginal cost imposed on the residents when the industry releases  $Q$  units of waste.
  - (a) What are the equilibrium price and quantity for the refined product when there is no correction for the externality?
  - (b) How many products should the industry supply at the social optimum?
  - (c) What is the deadweight loss due to the externality?
  - (d) Suppose the government imposes an emission fee of  $T$  per unit of emissions. How large should the emission fee be if the industry is to produce the social optimal amount of the product?
  - (e) How will your answers to the above questions change if the industry is a monopoly?
  
2. Assume an economy of two firms and two consumers. The two firms pollute. Firm one has a abatement cost function of  $AC_1(e) = \frac{1}{2}e^2 - 5e$  where  $e$  is the quantify of emissions from the firm. Firm two has a abatement cost function of  $AC_2(e) = e^2 - 8e$ . Each of the two consumers has marginal damage  $MD(e) = e$ , where  $e$  in this case is the total amount of emissions the consumer is exposed to.
  - (a) Derive the marginal saving function for each firm and the aggregate marginal saving function. (*Hint:  $MS = -MAC$ .)*
  - (b) Derive the aggregate marginal damage.
  - (c) What is the social optimal level of pollution and the appropriate Pigovian fee?
  - (d) Under the social optimal level, calculate the emissions from each firm.
  
3. The Fireyear and Goodstone Rubber Companies are two firms located in the rubber capital of the world. These factories produce finished rubber and sell that rubber into a highly competitive world market at the fixed price of 60 per ton. The process of producing a ton of rubber also results in a ton of air pollution that affects the rubber capital of the world. This 1:1 relationship between rubber output and pollution is fixed and immutable at both factories. Consider the following information regarding the cost of producing rubber at the two factories ( $Q_F$  and  $Q_G$ ):

Firm	Variable Cost	Marginal Cost
Fireyear	$300 + 2Q_F^2$	$4Q_F$
Goodstone	$500 + Q_G^2$	$2Q_G$

Total pollution emissions generated are  $E_F + E_G = Q_F + Q_G$ . Marginal damage from pollution is equal to 12 per ton of pollution.

- (a) In the absence of regulation, how much rubber would be produced by each firm? What is the profit for each firm?
- (b) The local government decides to impose a Pigovian tax on pollution in the community. What is the proper amount of such a tax per unit of emissions? What are the postregulation levels of rubber output and profits for each firm?
- (c) Suppose instead of the emission tax, the government observes the outcome in part (a) and decides to offer a subsidy to each firm for each unit of pollution abated. What is the efficient per unit amount of such a subsidy? Again calculate the levels of output and profit for each firm.
4. Assume the steel industry is a monopoly and it produces smoke. Suppose the demand function is  $P = 2 - 0.5Q$ , where  $P$  is the price of steel and  $Q$  is the quantity consumed. The marginal private cost of producing steel is 0.3 while the marginal damage is 0.3.
- (a) Ignoring pollution, what is the unregulated steel output level? Derive the deadweight loss.
- (b) Taking pollution into consideration, what is the socially optimal output of steel? Derive the deadweight loss from unregulated monopolist.
- (c) If we impose an Pigovian tax on the smoke generation, what is the private marginal cost? Derive the steel output level with Pigovian tax.
- (d) Show in a figure and calculate the extra deadweight loss from Pigovian fee.
5. Consider a situation involving Finch's Footwear and Millie's Muffins. Finch's Footwear produces shoes (S) at a cost  $C_S(S) = S^2 + 8$  and the Millie's Muffins produces baked goods (B) at a cost of  $C_B(B, S) = B^2 + BS + 4$ . Note that costs for the Millie's Muffins depend on output of the shoe company, because of the pollution associated with making shoes (more money has to be spent by Millie to keep things clean). The price of baked goods  $p_B$  is 10 while the price of shoes  $p_S$  is 14.
- (a) Calculate how much footwear and muffins will be produced if the two firms merge, assuming profit maximizing behavior.
- (b) If Finch's Footwear has rights to pollute, how much baked goods and footwear will be produced?
- (c) If Millie's Muffins has a right to clean air, how much baked goods and footwear will be produced? What will Millie receive for compensation?
6. Review the analysis of pure emission fees or pure quantity regulation with uncertain control costs. But this time, let us assume the marginal damage is uncertain. Discuss and illustrate the losses for each kind of regulation.