ECONOMICS 238 OC1 FINAL EXAM – VERSION A

Dr. Karen Huff December 10, 2016
TIME ALLOWED: 2 Hours CALCULATORS PERMITTED

SECTION A: Multiple Choice – **Circle the best alternative answer on the exam paper**. Each correct answer is worth one mark. [15 marks total]

1. Suppose there are two firms in an industry with marginal abatement cost curves:

$MAC_A = 500 - 0.5E_A$
$MAC_B = 800 - E_B$

If the government regulator has chosen a target level of total emissions to be 600 units per year, _____ permits will need to be issued and they will trade for _____ per permit.
*A. 600; $400
B. 600; $200
C. 1,200; $400
D. 1,200; $200

2. When marginal damages for a pollutant vary by region, time of day, or season, a(n) _____ will not be socially efficient but _____that set the MAC curve equal to each MDC curve are socially efficient.
A. ambient standard; uniform standards
*B. uniform standard; individual standards
C. individual standard; uniform standards
D. technology-based standard; uniform standards

3. A polluter will _____ its emissions and sell its excess permits on the market if the market price is _____ or equal to its MAC at its chosen emission level.
A. increase; less than
B. increase; greater than
C. reduce; less than
*D. reduce; greater than

4. Constraints and difficulties facing environmental policymaking under the Canadian parliamentary system of government include all of the following except _____?
*A. frequent conflicts arise between the legislative and executive branches of government.
B. the party with a majority government controls the policy agenda.
C. there is no mandate for external review of government policies.
D. there are few checks and balances in the system.

5. _____waterborne pollutants undergo a variety of biological, chemical, and physical processes that change their characteristics after emission until they are assimilated by the water body into which they are released.
A. Persistent
B. Accumulative
*C. Degradable
D. Inorganic

6. In Ontario, the phasing in of technology-based standards to cover agricultural practices, focusing particularly on storage of waste and the use of manure on fields is a response to _____.
A. the discovery of Trichloroethylene in the water supply in Beckwith Township near Ottawa
B. new federal drinking water guidelines issued by the CCME
*C. E. coli contamination of the water supply in Walkerton
D. a study commissioned by MISA

7. The argument that the marginal abatement costs of existing plants are higher than those of new plants used as a justification for less restrictive emission standards for the former than for the latter is known as _____.
A. old-source bias
B. cost-effectiveness
C. the non-degradation dilemma
*D. new-source bias

8. Because dioxans and furans _____ the impact of banning these substances on environmental quality is _____.
A. biodegrade; uncertain
B. biodegrade; a success story
C. bioaccumulate; a success story
*D. bioaccumulate; uncertain

9. Revenues from British Columbia's hazardous waste permit fee system are placed in _____ which is used to address environmental problems and develop _____.
*A. the Sustainable Environment Fund; environmental protection projects
B. the Sustainable Environment Fund; a superfund for the cleanup of orphan sites
C. general revenues; a superfund for the cleanup of orphan sites
D. general revenues; environmental protection projects

10. According to the textbook, _____ make(s) up the largest percentage of all materials, by weight, recycled in Canada at close to 29%.
A. Cardboard and boxboard
B. Newsprint
*C. Organics
D. Glass

11. The Canadian province with the highest greenhouse gas emissions is _____.
A. Saskatchewan
B. Ontario
C. British Columbia
*D. Alberta

12. Employing a global CO_2 price to contain mean projected warming to a specific target at least cost is an example of _____.
A. a cap and trade system
*B. a climate stabilization goal
C. an emission trading system
D. a fiscal dividend

13. Environment Canada's quota system to phase out ozone depleting chemicals did not restrict the supply of specific CFCs or halons; rather it was set in terms of _____ allowing for flexibility in meeting the target.
A. total allowable ozone
B. marginal damage cost
*C. ozone-depleting potential
D. marginal abatement cost

14. Canadian federal policies to reduce GHG emissions include _____.
A. subsidies to renewable energy
B. moral suasion to induce people to voluntarily reduce their emissions
C. incentives to increase energy efficiency
*D. all of the choices are correct

15. Under a(n) _____ system, credits are given to polluters who document a reduction in emissions which they can sell to other firms to use in order to comply with regulations.
A. cap and trade
*B. baseline and credit
C. substance trading
D. emission-rights

SECTION B: Answer the remaining questions **in the booklet provided**. Numbers in brackets indicate mark values for each question.

[5 each] 1. Each of the following statements is either **True** or **False**. State which each is and briefly, but precisely explain your answer. Your explanation is the most important part of your answer.

(a) Marginal abatement cost curves tend to fall over time if polluters are regulated by a technology-based standard.

False, because a TBS dictates the specific pollution control technology to be used by firms, there is no incentive to develop cheaper alternatives to reducing emissions and the MAC curves do not fall over time as you would see with an emission standard.

(b) The provinces and federal government have established strict standards for Canadian drinking water through the Canadian Council of Ministers of the Environment.

False; the drinking water standards suggested by the CCME are not binding and the provinces only have to consider them as guidelines for the establishment of their own regulations which could be more or less strict than those suggested by the CCME.

[5 each] 2. Briefly define and explain **THREE** of the following concepts.

The answers to these can be found in the textbook and the MLS notes.

(a) bubble standard

(b) CAC Policies

(c) paramountcy

(d) Ozone Annex

(e) NPRI

(f) Montreal Protocol

3. The following table represents the business as usual (no abatement) situation for emissions of greenhouse gases in millions of tonnes (Mt) and the marginal abatement cost equations for three fictitious regions that are planning to participate in a joint Climate Change Initiative. The final column in the table shows each region's share of total emissions.

	E_0 (Mt)	MAC ($/tonne)	share of emissions (%)
Region 1	4,000	$MAC_1 = A_1$	50
Region 2	1,600	$MAC_2 = 1.25A_2$	20
Region 3	2,400	$MAC_3 = 5A_3$	30
Total	8,000	n/a	100

[6] (a) Calculate abatement, TAC and TCC for each region and the group of regions as a whole if they decide to achieve their emissions reduction target using a standard that requires each region to reduce their total greenhouse gas emissions by 25%.

Abatement is calculated as 25% of each region's initial emissions, TAC is calculated as the area under the MAC curves (the area of a triangle) for each region, and TCC is equal to TAC since this is a standard and regions just have to pay abatement costs.

	A (Mt)	**TAC (M$)**	**TCC (M$)**
Region 1	**1,000**	**= ½(1,000×1,000) = 500,000**	**500,000**
Region 2	**400**	**= ½(400×500) = 100,000**	**100,000**
Region 3	**600**	**= ½(600×3,000) = 900,000**	**900,000**
Total	**2,000**	**1,500,000**	**1,500,000**

[1] (b) Suppose that instead of a standard the Climate Change Initiative decided to implement a transferable emissions permit scheme to achieve the same total abatement as part a). How many permits would need to be issued?

Total abatement in part a) was 2,000 Mt, so we will need permits to cover the remaining emissions which will be 6,000 Mt. If each permit covers 1 Mt, we will need 6,000 permits.

[4] (c) For the transferable emissions permit scheme, assume that each region is initially given permits at no charge based on their share of initial emissions. Show the initial permit allocation and any permit purchases/sales needed to reach the final allocation of permits that will result from this scheme. What price will the permits be?

Under the permit trading scheme, the following conditions must be satisfied: 1) the equimarginal principle and 2) the adding up condition.

From 1) we get:

$$A_1 = 1.25A_2$$

and

$$5A_3 = 1.25A_2$$
$$A_3 = 0.25A_2$$

Substituting this into 2) yields:

$$1.25A_2 + A_2 + 0.25A_2 = 2{,}000$$

$$2.5A_2 = 2{,}000$$

$$A_2 = 800$$

$$A_1 = 1.25(800) = 1{,}000$$

$$A_3 = 0.25(800) = 200$$

Under the given allocation scheme, each region receives its share of initial emissions times the total number of permits. So for example, Region 1 receives 50% of 6,000 = 3,000 permits initially. Its remaining emissions are 3,000 Mt, so it has exactly the number of permits it needs.

	A	Remaining E	Initial # permits	# permits purchased	Final # permits
Region 1	**1,000**	**3,000**	**= 0.5×6,000 = 3,000**	**0**	**3,000**
Region 2	**800**	**800**	**= 0.2×6,000 = 1,200**	**(400)**	**800**
Region 3	**200**	**2,200**	**= 0.3×6,000 = 1,800**	**400**	**2,200**
Total	**2,000**	**6,000**	**6,000**	**0**	**6,000**

The permits will trade for the MAC associated with the level of abatement in each region which will be \$1,000 ($MAC_1 = MAC_2 = MAC_3 = 1{,}000$).

[6] (d) Calculate abatement, permit costs, TAC and TCC for each region and the group of regions as a whole under this scheme.

Abatement will be the cost effective allocation found in part b) and TAC is the area under each region's MAC curve. TCC will equal TAC plus permit acquisition costs.

	A (Mt)	Permit cost (M$)	TAC (M$)	TCC (M$)
Region 1	**1,000**	**0×1,000 = 0**	**½(1,000×1,000) = 500,000**	**500,000**
Region 2	**800**	**(400)×1,000 = (400,000)**	**½(800×1,000) = 400,000**	**0**
Region 3	**200**	**400×1,000 = 400,000**	**½(200×1,000) = 100,000**	**500,000**
Total	**2,000**	**0**	**1,000,000**	**1,000,000**

[3] (e) How would a tax that achieved the same total level of abatement compare in terms of TAC and TCC to the standard and the permit scheme as described above? It is not necessary to do any calculations, just comment on how a tax would rank relative to the standard and the permit scheme in terms of TAC and TCC for all three regions combined.

A carbon tax of $1,000 per tonne would result in the same TAC and allocation of abatement as the permit scheme. So the carbon tax is also cost-effective. However, since each region would be paying the tax times their remaining emissions, the TCC of this scheme would be higher than either the permits or standard scheme. So the three policies would rank as follows in terms of TAC and TCC:

$$\mathbf{TAC_{tax} = TAC_{permits} < TAC_{standards}}$$

$$\mathbf{TCC_{tax} > TCC_{standards} > TCC_{permits}}$$

4. The following table summarizes the marginal abatement cost functions for an industry with two firms, B and Z, each with two different sources of pollution. Note that the MAC functions are given as functions of emissions.

Source	Marginal Abatement Cost
B1	$MAC_{B1} = 750 - 0.25E_{B1}$
B2	$MAC_{B2} = 6{,}000 - 2E_{B2}$
Z1	$MAC_{Z1} = 1{,}500 - 0.5E_{Z1}$
Z2	$MAC_{Z2} = 3{,}000 - E_{Z2}$

[4] (a) Compute initial emissions for each source.

Initial emissions can be found at the point where MAC is equal to zero. So for each source we get:
B1: $0 = 750 - 0.25E_{B1}$ which results in $E_{B1} = 3{,}000$
B2: $0 = 6{,}000 - 2E_{B2}$ which results in $E_{B2} = 3{,}000$
Z1: $0 = 1{,}500 - 0.5E_{Z1}$ which results in $E_{Z1} = 3{,}000$
Z2: $0 = 3{,}000 - E_{Z2}$ which results in $E_{Z2} = 3{,}000$
Each source has the same initial emissions of 3,000 units.

[6] (b) Compute emissions, abatement and total abatement cost for each firm by source and in total if the regulator imposed a uniform standard requiring each source of pollution to reduce emissions by 30 percent. Show your work and present your results in a table.

In this case, each source abates 30% of its initial emissions or .3×3,000 = 900. TAC is calculated as the area under the MAC curve for each source.

Source	Abatement	TAC*
B1	**900**	**TAC_{B1} = ½(900×225) = 101,250**
B2	**900**	**TAC_{B2} = ½(900×1,800) = 810,000**
Firm B Total	**1,800**	**911,250**
Z1	**900**	**TAC_{Z1} = ½(900×450) = 202,500**
Z2	**900**	**TAC_{Z2} = ½(900×900) = 405,000**
Firm Z Total	**1,800**	**607,500**

*** TAC is equal to the area of a triangle with base of 1,800 and height equal to the value of its MAC when E = 3,000 – 900 = 2,100.**

[8] (c) Compute emissions, abatement and total abatement cost for each firm by source and in total if instead of a uniform standard, the regulator allowed the firms to use a bubble standard to achieve the 30 percent reduction in emissions (i.e., each firm must abate 30 percent of its total emissions but can allocate abatement between its two sources in a cost-effective manner). Explain and show your work. Present your results in a table.

In this case, each firm abates 30% of its total initial emissions and will allocate abatement in a cost minimizing way. Firm B has total initial emissions of 6,000 units so it will need to abate 1,800 units leaving 4,200 in remaining emissions. The firm will abate in a cost-effective manner with a bubble standard, so it will abate such that the equimarginal principle and the adding up condition are satisfied. In other words, $MAC_{B1} = MAC_{B2}$ and $E_{B1} + E_{B2} = 4{,}200$. From the first condition we get:

$$750 - 0.25E_{B1} = 6{,}000 - 2E_{B2}$$
$$2{,}625 + 0.125E_{B1} = E_{B2}$$

Substituting this into the second condition we get:

$$E_{B1} + 2{,}625 + 0.125E_{B1} = 4{,}200$$
$$1.125E_{B1} = 1{,}575$$
$$E_{B1} = 1{,}575/1.125 = 1{,}400 \text{ implying } A_{B1} = 1{,}600$$
$$\text{and } E_{B2} = 2{,}625 + 0.125(1{,}400) = 2{,}800 \text{ implying } A_{B2} = 200$$

This is cost-effective because $MAC_{B1} = MAC_{B2} = 400$

For Firm Z, the analysis is very similar. The firm must abate a total of 1,800 units. It will abate in a way that satisfies both the equimarginal principle and the adding up condition. The first condition yields:

$$1{,}500 - 0.5E_{Z1} = 3{,}000 - E_{Z2}$$
$$1{,}500 + 0.5E_{Z1} = E_{Z2}$$

Substituting this into the adding up condition we get:

$$E_{Z1} + 1{,}500 + 0.5E_{Z1} = 4{,}200$$
$$1.5E_{Z1} = 2{,}700$$
$$E_{Z1} = 2{,}700/1.5 = 1{,}800 \text{ implying } A_{Z1} = 1{,}200$$
$$\text{and } E_{Z2} = 1{,}500 + 0.5(1{,}800) = 2{,}400 \text{ implying } A_{Z2} = 600$$

This is cost-effective because $MAC_{Z1} = MAC_{Z2} = 600$

TAC is calculated as the area under the MAC curve for each source.

Source	Abatement	TAC
B1	**1,600**	**TAC_{B1} = ½(1,600×400) = 320,000**
B2	**200**	**TAC_{B2} = ½(200×400) = 40,000**
Firm B Total	**1,800**	**360,000**
Z1	**1,200**	**TAC_{Z1} = ½(1,200×600) = 360,000**
Z2	**600**	**TAC_{Z2} = ½(600×600) = 180,000**
Firm Z Total	**1,800**	**540,000**

[2] (d) Briefly compare the total compliance cost of the two different standard schemes by firm and for the industry and explain any differences.

The following table summarizes the results of each type of standard by firm and the industry. The bubble allows each firm to save costs by abating in a cost-effective manner which sees them abate significantly more at their lower cost sources than at their higher cost sources. As a result, Firm B saves $551,250 and Firm Z saves $67,500 in total abatement costs. This results in a reduction of $618,750 in industry compliance costs.

Source	Uniform Standard	Bubble Standard
Firm B Total	**911,250**	**360,000**
Firm Z Total	**607,500**	**540,000**
Industry Total	**1,518,750**	**900,000**