Introduction to Carbon Capture and Storage
(이산화탄소 포집 및 저장 개론) (38535)

- 2021 Final Examination -

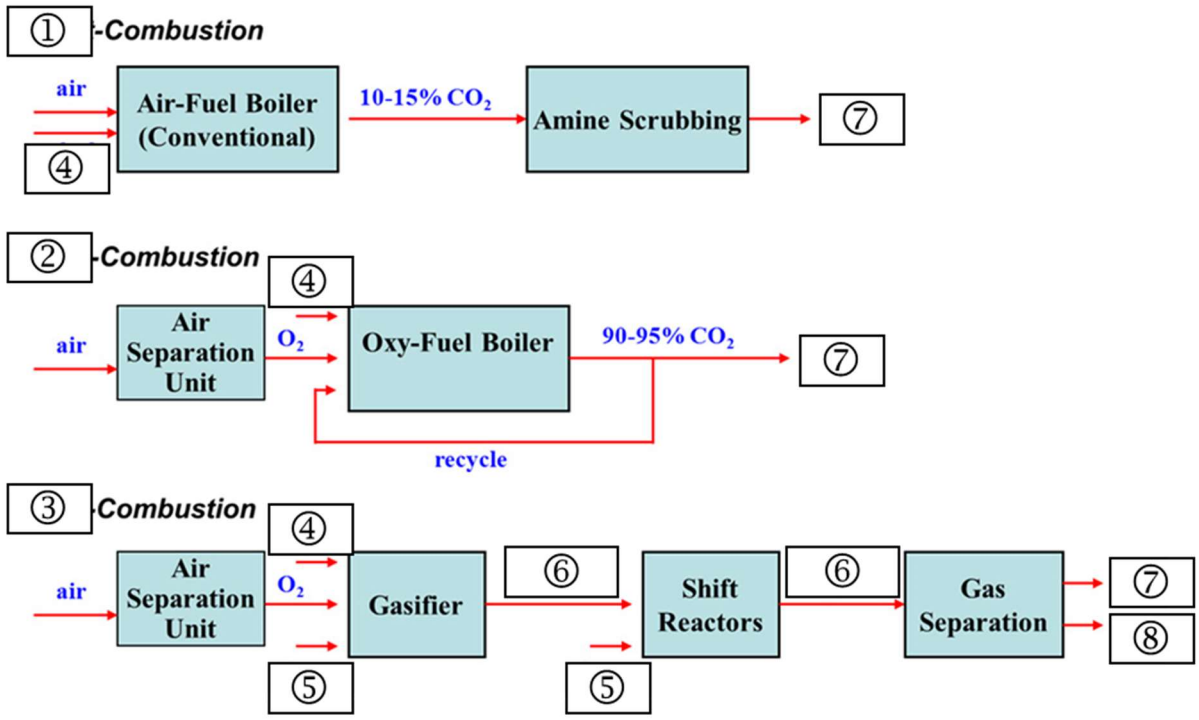
Student ID: **Name:**

Notice

- Fill your name below and write the whole sentence in your answer sheet:
  "I, _____, swear I solve all problems by myself in this final examination.
  I will take any disadvantages if any dishonesty such as cheating is acted on my solution."
  5 points will be deducted from your total score if you do not fill in your name above.
- **You MUST solve each problem by hand.**
- Submission Deadline: 14:00~15:30 PM, June 2, 2021.
- No late submission is accepted.
- Submit your solution as *.pdf or *.word file on the cyber campus.
- Please follow the format that gives a name to your solution file:
  (Final)-(Student ID)-(Last name)-(First name)
  For example, the file name must be Final-XXXXXXX-Min-Baehyun.

Problem 1.

1-1. Fill in the blanks from ① to ⑧. [16 pts.].



1-2. For the pre-combustion CO_2 capture from power generation, provide the chemical reaction of steam reforming of coke to give water gas. Is steam reforming endothermic or exothermic? [5 pts.]

1-3. For the pre-combustion CO_2 capture from power generation, provide the chemical reaction of water-gas shift reaction. Is this shift reaction endothermic or exothermic? [5 pts.]

1-4. List up four solvents that are useful to absorb CO_2 for post-combustion CO_2 capture [4 pts.].

Problem 2.

Fill in the blanks from ① to ⑤. [10 pts.].

2-1. (①), (②), and (③) CO_2 is desirable for CO_2 transportation [6 pts.].

2-2. CO_2 concentration greater than or equal to (④) % is recommended for CO_2 transportation [2 pts.].

2-3. Water concentration less than or equal to (⑤) ppm is recommended for CO_2 transportation [2 pts.].

Problem 3.

Solve Problem 3 under the following conditions.

- A 800 MW coal fired power plant in Korea emits 6 million tonnes of CO_2 annually. This plant costs $1,200 million to build and the annual operating cost is $100 million. This plant has no decommissioning cost.
- Another plant with CCS also sends out 800 MW but emits 0.5 million tonnes of CO_2 annually. The extra CCS equipment adds $800 million to the capital cost and $80 million to the annual operating cost. This plant costs $100 million to decommission.
- 2 years are required for construction of each plant. 2 years are also required for decommissioning the plant with CCS. Both plants operate for 25 years (7,000 hours each year).
- Thus, the total period is as follows: 29 years = construction for 2 years + operation for 25 years + decommissioning for 2 years.
- Assume a 10% discount rate.
- For all answers, you MUST round off all values (e.g., discount factor) to the second decimal place for this problem (최종 답은 소수 둘째자리까지 구하시오.).

3-1. How much is the incremental cost of electricity (COE) ($/MWh) if CCS is implemented at this power plant? [10 pts.]

3-2. How much is the cost of CO_2 avoided ($/tonne)? [10 pts.]

Problem 4.

List the following procedures of CMG reservoir simulation in order. [5 pts.]

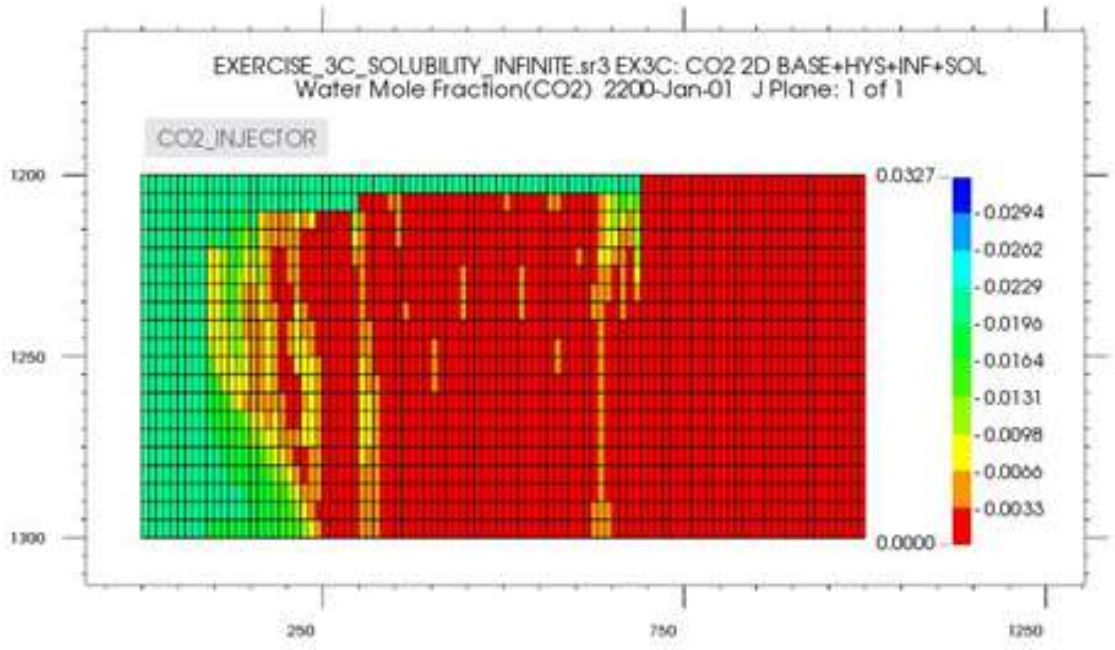
(A) Initialization Settings
(B) Reservoir Definition
(C) Fluid Definition
(D) Well Definition & Operation
(E) Rock-Fluid Information
(F) Numerical Controls
(G) Run & Results

Problem 5.

CO_2 has been injected for 1 year (2000-2001) and migrated for subsequent 199 years (2001-2200) in a saline aquifer under the following conditions:

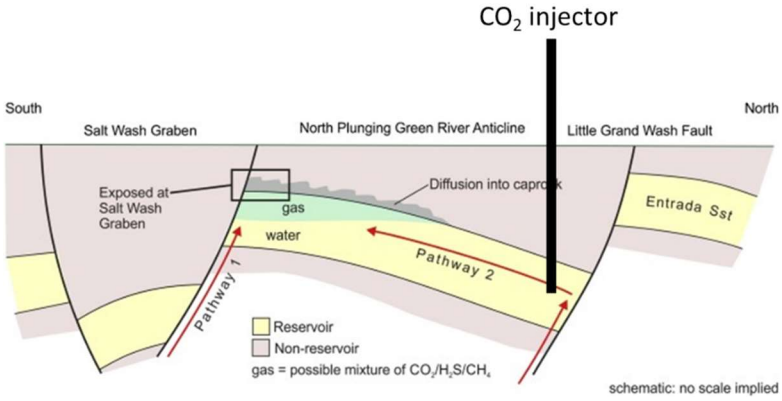
- Below figure shows the distribution of water mole fraction (CO_2) at the end of numerical simulation (date: January 1, 2200).
- A CO_2 injection well is installed to the left of the saline aquifer in the below figure.
- Boundary condition: Infinite acting aquifer is attached to the right of the saline aquifer in the figure.
- Initial gas saturation = 0.00
- Hysteresis and solubility trapping mechanisms are implemented in the numerical simulation.

Interpret the injection and migration of CO_2 plume between 2000 and 2200 based on your engineering knowledge [10 pts].



Problem 6.

Field operators plan to inject and store CO_2 permanently in a geological structure with rollover anticline and thrust-faults as follows:



6-1. Draw a fault-seal risk web and seal probability condition. [10 pts.]

6-2. Assess the overall trap potential of this storage site. The operators provide the following geological conditions in cooperation with geologists, geophysicists, and petroleum engineers:

- Caprock capacity = 0.9
- Caprock geometry = 0.9
- Caprock integrity = 0.7
- Juxtaposition property = 0.8
- Fault zone property = 0.5
- Post-injection reactivation = 0.6

Note that every geological condition above is a probability value ranging between 0 and 1. [10 pts.]

6-3. Based on your engineering knowledge on the overall trap potential, judge if this site is a good candidate for a geological carbon storage project. [5 pts.]

---------- This is the End of the Final Examination ----------