Introduction to Carbon Capture and Storage
(이산화탄소 포집 및 저장 개론) (38535-01)

- 2020 Final Examination -

Student ID: **Name:**

Notice

- Fill your name below:

  "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.

Problem 1.

1-1. Explain main differences between post-combustion CO_2 capture and oxy-combustion CO_2 capture with three sentences. [5 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.]

Problem 2.

Solve Problem 2 under the following conditions.

- A 800 MW coal fired power plant in Korea emits 5 million tonnes of CO_2 annually. This plant costs $1,000 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.
- Assume a 10% discount rate and 2 years each for construction and decommissioning for the plant with CCS. Both plants operate for 25 years (7,000 hours each year).
- Total period: 29 years = construction for 2 years + operation for 25 years + decommissioning for 2 years.
- 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.)

2-1. How much is the COE ($/MWh) of the power plant without CCS? [10 pts.]

2-2. How much is the COE ($/MWh) of the power plant with CCS? [10 pts.]

2-3. How much is the CCS cost in $ per tonne CO_2 avoided? [10 pts.]

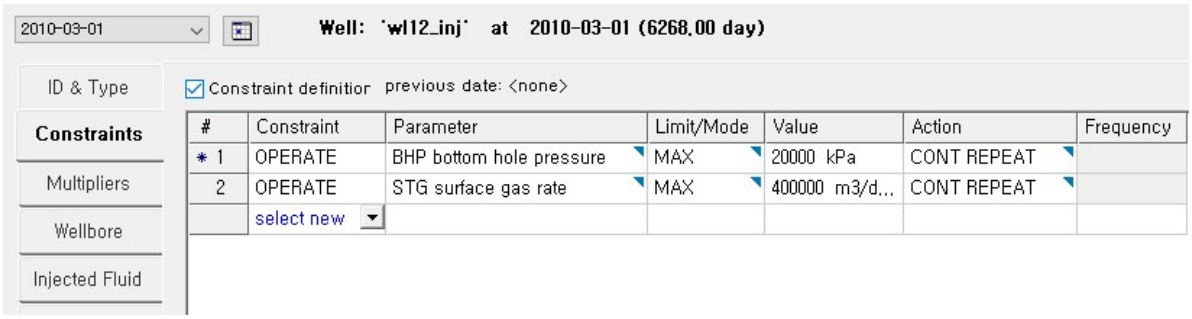
Problem 3.

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 4.

Describe operating conditions for a CO_2 injection well, as shown in the figure below. What will happen if the wellbore pressure reaches 20,000 kPa? [5 pts.]

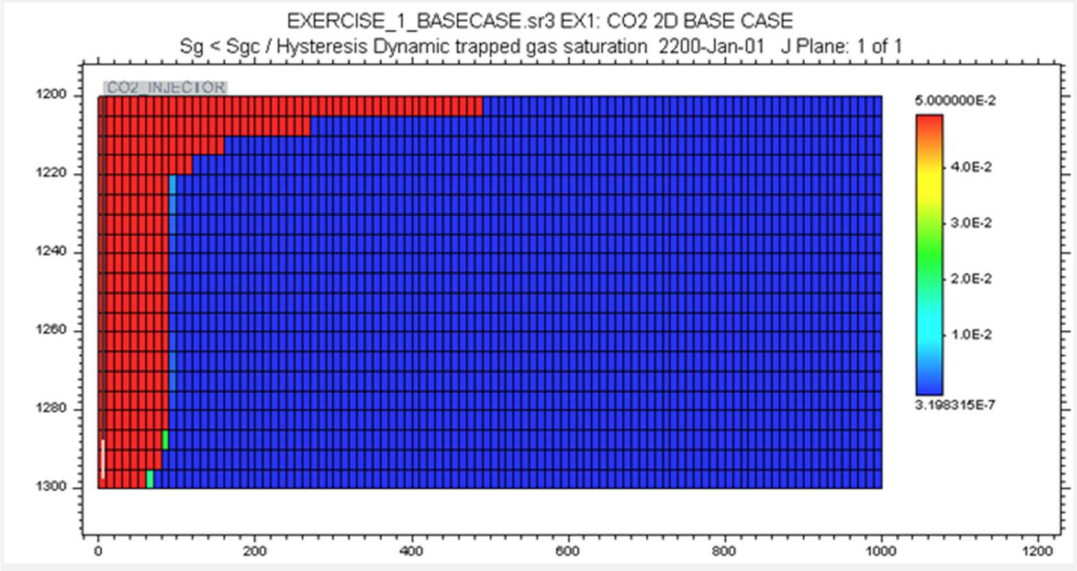


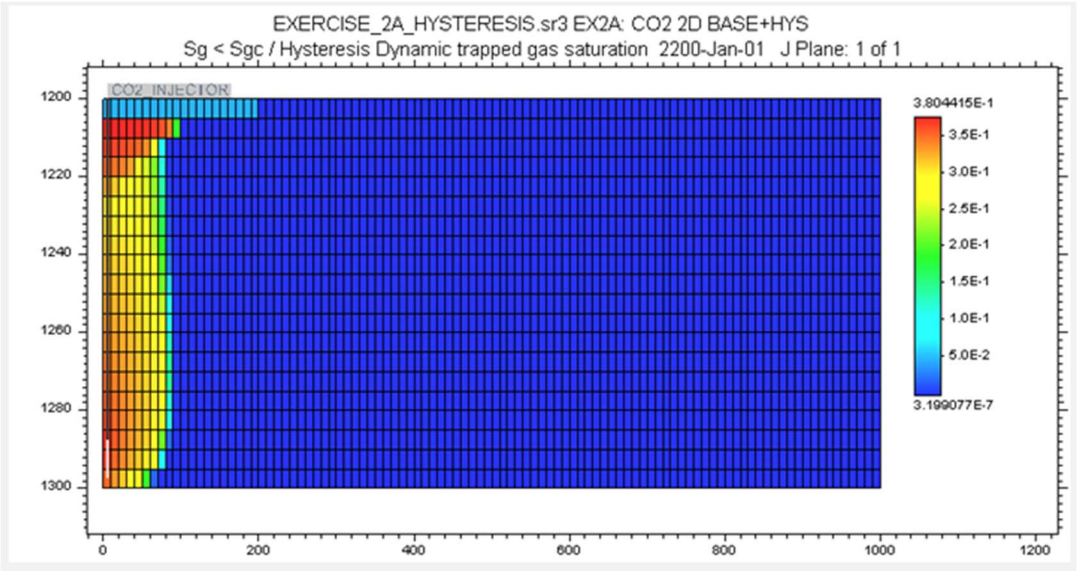
Problem 5.

Below are figures to show simulation results of structural trapping and hysteresis trapping mechanisms where CO_2 has been injected for 1 year (2000-2001) and migrated for subsequent 199 years (2001-2200) under the following conditions:

- Each figure shows the distribution of trapped gas saturation 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 each figure.
- Boundary condition: a closed boundary condition
- Initial gas saturation = 0.00
- Critical gas saturation = 0.05
- Residual gas saturation = 0.40

Interpret the results based on your engineering knowledge [10 pts].



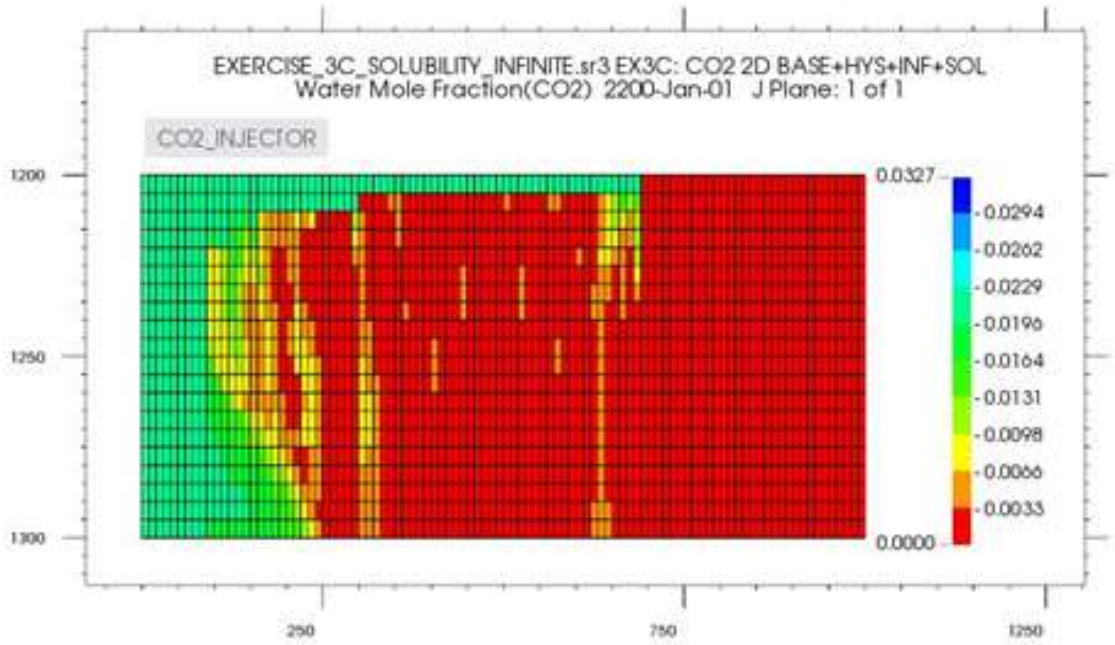


Problem 6.

CO_2 has been injected for 1 year (2000-2001) and migrated for subsequent 199 years (2001-2200) at 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.

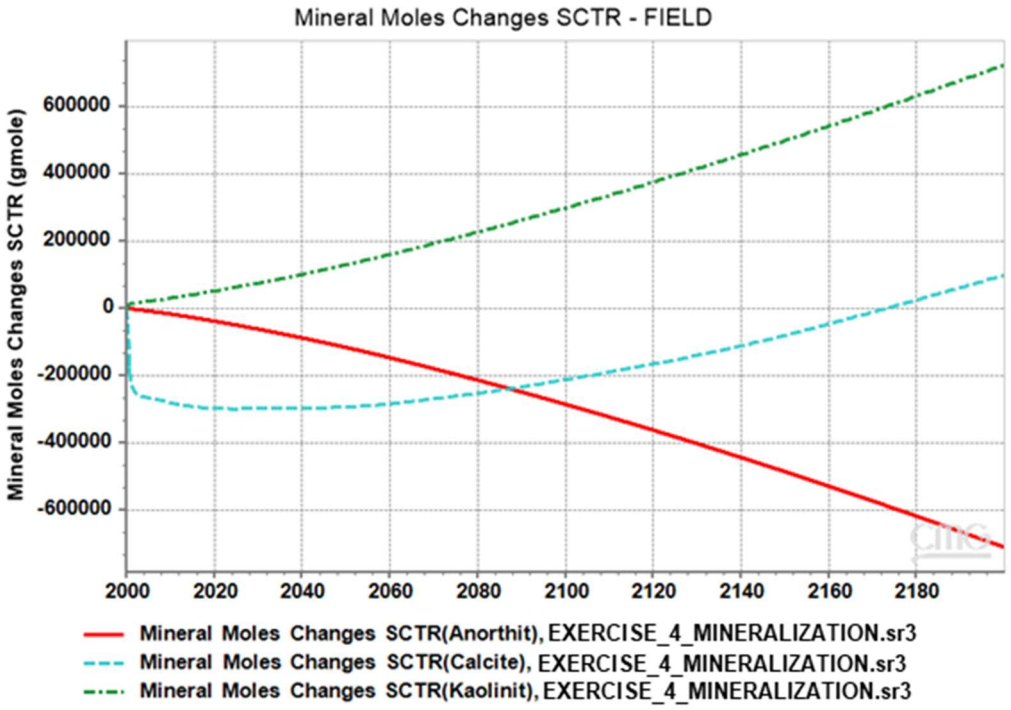
Interpret the injection and migration of CO_2 plume between 2000 and 2200 based on your engineering knowledge [15 pts].



Problem 7.

Assume that a CCS operator injects CO_2 for 1 year, stops the injection, and monitors the migration of CO_2 plume for 199 years at a saline aquifer. This aquifer consists of three facies (i.e., rock types): Anorthite, Calcite, and Kaolinite. The graph below shows a change of mineral mole fractions caused by the mineral trapping mechanism.

Interpret the graph with chemical formulae related to the mineral trapping mechanism (e.g., acid-base chemical reaction and aqueous phase reactions) [20 pts].



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