Write your name here:

This exam counts 20% of your grade for this course; your instructions are as follows:

1) You have 75 minutes to finish this exam.
2) No books, notes, or discussion is allowed. If you have questions please ask the proctor.
3) It is your responsibility to communicate your understanding of the subject matter.
4) State any, and all, assumptions that you make in answering these questions.
5) Please remember the importance that your instructor attaches to units and significant figures.

Section 1: (2 points each, 20 points total)

Multiple guess; answer 10 and only 10 of the questions in this section by clearly circling the single best answer. Clearly mark the questions that you don’t want graded. No partial credit will be given.

1) The TDS of oceanic water in milligrams per liter is approximately:
   a) 0   c) 35,000
   b) 3000  d) 100,000

2) Fluid pressures in the vadose zone are expected to be:
   a) zero   b) positive
   c) negative  d) there is no fluid in the vadose zone

3) Given a pure groundwater sample with a temperature of 25˚ and [OH\(^-\)] concentration of \(10^{-6.5}\), then pH is expected to be:
   a) 0   b) 6.5   c) 7.0   d) 7.5

4) Elevated levels of tritium in groundwater result from:
   a) greenhouse effect   c) nuclear testing
   b) global warming   d) ozone depletion

5) The main reason that Canada has serious problems with acid rain is:
   a) lack of carbonate rocks   c) high latitude ozone depletion
   b) cold climate   d) lack of environmental regulations

6) A mixing process that occurs in response to a concentration difference.
   a) absorption   c) diffusion
   b) mechanical dispersion   d) advection
8) In a hydrophilic soil located above the water table, air will most likely be found in:

   a) the smallest pores
   b) the largest pores
   c) evenly distributed through the soil
   d) there can be no air in the soil under these conditions

8) Which of the following contaminants is most likely to be found floating on the water table

   a) acid rain
   b) DNAPL
   c) LNAPL
   d) brine

9) Carbonate rocks such as limestone are generally more soluble in cold/warm water.

10) Dissolution of salt in water is an example of a reversible/irreversible reaction.

11) H$_2$, O$^{18}$, C$^{13}$, S$^{34}$ are examples of stable/unstable isotopes.

Section 2: (5 points each, 50 points total)

Answer 10 and only 10 of the questions in this section. Clearly mark the question that you don’t want graded.

1) Give the two primary reasons why deep groundwater is usually high in TDS; be specific.

2) Explain the phrase ‘freshwater lens’ in the context of an oceanic island.
3) How will the hydraulic conductivity of soil change when it becomes unsaturated; explain your answer

4) In coastal aquifers, the interface between fresh and sea water is assumed to be a sharp line; concisely explain two significant reasons why the physical reality is likely to differ from this assumption.

5) Is the Theis equation expected to correctly/under/over (pick one) predict drawdown in an unconfined (water table) aquifer? Why?
6) Why is water in the unsaturated zone at a negative pressure?

7) Briefly describe how glacial sediments affect the occurrence and flow of groundwater.

8) Explain why groundwater sampling in the vadose zone is a difficult problem.

9) Given a groundwater sample of pH = 5.7 calculate [H+] and [OH−]
10) What is the significance of the Common Ion Effect with respect to groundwater chemistry problems?

11) Briefly describe the relationship between geology and groundwater for a tectonic valley such as the Las Vegas valley.

12) Limestone and sandstone are both layered sedimentary rocks; what are the primary differences between the two with respect to groundwater occurrence and flow?
Section 3: (5 points each, 10 points total)

Answer two and only two of the following questions regarding Cadillac Desert by Mark Reisner

1) Reisner describes a memorandum that was written by the USGS regarding possible problems with the site of the Teton Dam. What reason does he give for the memo being 'toned down'?

2) Reisner suggests that irrigated desert land was a common factor among the great civilizations of antiquity. Name at least three reasons why such a location would be beneficial, and discuss the possible hydrologic cause that Reisner suggests for the downfall of such civilizations?

3) Reisner discusses three long term consequences of damming rivers for irrigation. Explain two of them.
Section 4: (10 points each, 20 points total)

Answer 2 and only 2 of the questions in this section. Clearly mark the question that you don’t want graded.

1) The following graph shows well test data plotted on semi-logarithmic paper; the data was collected from an observation well located 1000 feet from a well pumping at a steady rate of 40,000 ft³/day. Calculate Transmissivity (T) and Storativity (S) using the Jacob straight-line method. Make sure to show where you took data off of the graph.
2) The graphs shown below present data from observation wells that fully penetrate two different aquifers. In words (do not make any calculations) interpret these two plots.
Table 1

<table>
<thead>
<tr>
<th>Ionic Species</th>
<th>mg/L</th>
<th>formula weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca(^{2+})</td>
<td>43.12</td>
<td>40.08</td>
</tr>
<tr>
<td>Na(^+)</td>
<td>87.15</td>
<td>22.99</td>
</tr>
<tr>
<td>K(^+)</td>
<td>3.22</td>
<td>39.10</td>
</tr>
<tr>
<td>Mg(^{2+})</td>
<td>15.22</td>
<td>24.31</td>
</tr>
<tr>
<td>Fe(^{2+})</td>
<td>2.13</td>
<td>55.85</td>
</tr>
<tr>
<td>SO(_4^{2-})</td>
<td>13.22</td>
<td>96.06</td>
</tr>
<tr>
<td>Cl(^-)</td>
<td>123.89</td>
<td>35.45</td>
</tr>
<tr>
<td>HCO(_3^-)</td>
<td>213.7</td>
<td>61.01</td>
</tr>
<tr>
<td>NO(_3^-)</td>
<td>3.23</td>
<td>62.01</td>
</tr>
</tbody>
</table>

3) Graph data from Table 1 on the attached Piper diagram. If you need to do intermediate calculations or add explanation, please do so below, or on the back of the diagram.

4) Graph data from Table 1 on the attached Stiff diagram. If you need to do intermediate calculations or add explanation, please do so below, or on the back of the diagram.
Cations (MEQ/L) | Anions (MEQ/L)

- Na + K
- Ca
- Mg
- Fe
- Cl
- HCO₃
- SO₄
- CO₃