National Exams December 2015

04-Geol-A2, Hydrogeology

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.
3. FIVE(5) questions constitute a complete exam paper.
4. Each question is of equal value.
5. Most questions require an answer in essay format. Clarity and organization of the answer are important. Please show your work.
6. Unless otherwise specified, use water density = 1000 kg/m^3, water viscosity = 0.001 kg/m-sec, and g = 9.81 m/s^2

Marking Scheme

1. (a) 5 marks (b) 2 marks (c) 3 marks (d) 2 marks (e) 5 marks (f) 3 marks
2. (a) 10 marks (b) 10 marks
3. (a) 5 marks (b) 5 marks (c) 5 marks (d) 5 marks
4. (a) 8 marks (b) 8 marks (c) 4 marks
5. (a) 10 marks (b) 10 marks

04-Geol-A2, Hydrogeology

Question 1

a) Answer **True** or **False** to the following questions. Please note for a statement to be true it must ALWAYS be true!

I. ____An aquitard is a high permeability layer, usually separating aquifers.

II. ____Evaporation is part of the hydrologic cycle

III. ____Hydraulic conductivity is a function of soil only

IV. ___A groundwater divide is a streamline

V. ____Slug tests require a pumping well and an observation well

b) A soil has a bulk density of 1.96 g/cm3 and a porosity of 0.35. Determine the soil solid particle density.

c) An unconfined aquifer has a specific yield of 0.07 and is rectangular in shape with a width of 900 m and a length of 2200 m. What volume of water would be released □from the aquifer if the water table was lowered by 1.2 m?

d) A fully confined aquifer has a specific storativity of 1.1×10^{-6} m^{-1}, a thickness of 50 m a width of 1500 m and a length of 2500 m. What volume of water would be pumped to □lower the piezometric head in the aquifer by 2.5 m. □

e) Three wells (A, B, and C) are drilled in an aquifer. Well B is 250m directly north of Well □A. Well C is 250 m directly east of Well A. The water level in Well A is 180 m.a.s.l., in Well B it is 195 m.a.s.l. In Well C the water level is 180 m.a.s.l. Estimate the magnitude and direction of the hydraulic head in the aquifer. Include a sketch showing the basis for your calculations. □□

f) The water pressure head at the top of a 10 m thick aquitard is 162 m. The water pressure head at the bottom of the aquitard is 175 m. Determine the hydraulic head gradient and the direction of water flow across the aquitard.

04-Geol-A2, Hydrogeology

Question 2

a) An aquitard consists of two layers of soil, each 5 m thick. If the water pressure at the top of the aquitard is 105 kPa, and the water pressure at the bottom of the aquitard is 210 kPa, determine the magnitude and direction of the Darcy velocity across the aquitard if the aquitard contains water with a density of 1000 kg/m^3 and a viscosity of 0.001 kg/m·sec. The top soil layer has a hydraulic conductivity of 10^{-8} cm/sec and the lower soil layer has a hydraulic conductivity of 10^{-6} cm/sec.□

b) Repeat part a) if the aquitard contained briny water with a density of 1150 kg/m^3 and a viscosity of 0.001 kg/m·sec.

Question 3

Two wells are drilled in a 2500 m wide unconfined aquifer that has a hydraulic conductivity of 3 x 10^{-3} cm/sec, 150 m apart, one directly downstream from the other. The bottom of the aquifer is 30 m below the ground surface. The water level is 8 m below the ground surface at one well, and 10 m below the ground surface at the second well. The aquifer porosity is 0.33. Aquifer recharge is negligible.

a) Determine the total flow through the aquifer.

b) Determine the head at a point halfway between the wells.

c) Determine the pore water (linear) velocity at the halfway point.□

d) If the vertical recharge to the aquifer is 0.25 m/year and all other conditions are unchanged determine the head at a point halfway between the wells.

Question 4

A well pumps water from a confined aquifer at a rate of 15 l/s. The aquifer has a transmissivity of 10^{-2} m^2/s, a storativity of 10^{-4}, and a hydraulic conductivity of 10^{-3} cm/sec. The aquitard above the aquifer has a thickness of 5 m. □

a) Determine the drawdown at an observation well 150 m from the pumping well after 24 hours of pumping if the aquitard was impermeable

b) Determine the drawdown at an observation well 150 m from the pumping well if the aquitard had a hydraulic conductivity of 10^{-6} cm/sec. □

c) If the aquitard storativity was significant would the drawdown be larger or smaller than the value you have calculated?

04-Geol-A2, Hydrogeology

Question 5

A fully penetrating well installed in a 30m thick fully confined aquifer with a specific storativity of 2.3 $x10^{-5}$ m^{-1} and a hydraulic conductivity of $1.2x10^{-5}$ m sec , is pumped at $50m^3$/hr for 24 hours. The pumping well is 200m west of a river that recharges the aquifer sufficiently to maintain a constant head in the aquifer below the river.

a) Calculate the drawdown at an observation well located 60m directly south of the pumping well after 24 and 36 hours.

b) If there was an impermeable boundary instead of the river, determine the drawdown in the aquifer at an observation well located 200 m south from the pumping well 36 hours after the start of the pump test.

Table 5.1
Values of $W(u)$ for values of u (from Wenzel, 1942)

u	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
$\times 1$	0.219	0.049	0.013	0.0038	0.0011	0.00036	0.00012	0.000038	0.000012
$\times 10^{-1}$	1.82	1.22	0.91	0.70	0.56	0.45	0.37	0.31	0.26
$\times 10^{-2}$	4.04	3.35	2.96	2.68	2.47	2.30	2.15	2.03	1.92
$\times 10^{-3}$	6.33	5.64	5.23	4.95	4.73	4.54	4.39	4.26	4.14
$\times 10^{-4}$	8.63	7.94	7.53	7.25	7.02	6.84	6.69	6.55	6.44
$\times 10^{-5}$	10.94	10.24	9.84	9.55	9.33	9.14	8.99	8.86	8.74
$\times 10^{-6}$	13.24	12.55	12.14	11.85	11.63	11.45	11.29	11.16	11.04
$\times 10^{-7}$	15.54	14.85	14.44	14.15	13.93	13.75	13.60	13.46	13.34
$\times 10^{-8}$	17.84	17.15	16.74	16.46	16.23	16.05	15.90	15.76	15.65
$\times 10^{-9}$	20.15	19.45	19.05	18.76	18.54	18.35	18.20	18.07	17.95
$\times 10^{-10}$	22.45	21.76	21.35	21.06	20.84	20.66	20.50	20.37	20.25
$\times 10^{-11}$	24.75	24.06	23.65	23.36	23.14	22.96	22.81	22.67	22.55
$\times 10^{-12}$	27.05	26.36	25.96	25.67	25.44	25.26	25.11	24.97	24.86
$\times 10^{-13}$	29.36	28.66	28.26	27.97	27.75	27.56	27.41	27.28	27.16
$\times 10^{-14}$	31.66	30.97	30.56	30.27	30.05	29.87	29.71	29.58	29.46
$\times 10^{-15}$	33.96	33.27	32.86	32.58	32.35	32.17	32.02	31.88	31.76

Table 5.2
Values of *W(u r/B)* (after Hantush, 1956)*

u \ r/B	0.01	0.015	0.03	0.05	0.075	0.10	0.15	0.2	0.3	0.4
0.000001										
0.000005	9.4413									
0.00001	9.4176	8.6313								
0.00005	8.8827	8.4533	7.2450							
0.0001	8.3983	8.1414	7.2122	6.2282	5.4228					
0.0005	6.9750	6.9152	6.6219	6.0821	5.4062	4.8530				
0.001	6.3069	6.2765	6.1202	5.7965	5.3078	4.8292	4.0595	3.5054		
0.005	4.7212	4.7152	4.6829	4.6084	4.4713	4.2960	3.8821	3.4567	2.7428	2.2290
0.01	4.0356	4.0326	4.0167	3.9795	3.9091	3.8150	3.5725	3.2875	2.7104	2.2253
0.05	2.4675	2.4670	2.4642	2.4576	2.4448	2.4271	2.3776	2.3110	1.9283	1.7075
0.1	1.8227	1.8225	1.8213	1.8184	1.8128	1.8050	1.7829	1.7527	1.6704	1.5644
0.5	0.5598	0.5597	0.5596	0.5594	0.5588	0.5581	0.5561	0.5532	0.5453	0.5344
1.0	0.2194	0.2194	0.2193	0.2193	0.2191	0.2190	0.2186	0.2179	0.2161	0.2135
5.0	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011

u \ r/B	0.5	0.6	0.7	0.8	0.9	1.0	1.5	2.0	2.5
0.000001									
0.000005									
0.00001									
0.00005									
0.0001									
0.0005									
0.001									
0.005									
0.01	1.8486	1.5550	1.3210	1.1307					
0.05	1.4927	1.2955	1.2955	1.1210	0.9700	0.8409			
0.1	1.4422	1.3115	1.1791	1.0505	0.9297	0.8190	0.4271	0.2278	
0.5	0.5206	0.5044	0.4860	0.4658	0.4440	0.4210	0.3007	0.1944	0.1174
1.0	0.2103	0.2065	0.2020	0.1970	0.1914	0.1855	0.1509	0.1139	0.0803
5.0	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0010	0.0010	0.0009

*Trans. Amer. Geophys. Union, 37, p. 702–714. Copyright by Amer. Geophys. Union.