



Roll No.

**PRESIDENCY UNIVERSITY
BENGALURU**

SCHOOL OF ENGINEERING

TEST 1

Sem & AY: Odd Sem. 2019-20

Course Code: CIV 308

Course Name: GROUNDWATER HYDROLOGY

Program & Sem: B.Tech (Civil) & V

Date: 27.09.2019

Time: 11.00AM to 12.00PM

Max Marks: 40

Weightage: 20%

Instructions:

- (i) Read all the questions carefully.
- (ii) Answer all the questions.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries two marks. (5Qx2M=10M)

1. Write the name of the major processes involved in hydrological cycle? Differentiate between infiltration and percolation. (C.O.NO.1) [Knowledge]
2. Define residence time. (C.O.NO. 1) [Knowledge]
3. Define watershed and watershed divide? (C.O.NO. 1) [Knowledge]
4. What is the difference between perched aquifer and leaky aquifer (C.O.NO.1) [Knowledge]
5. Define transmissibility. Write the SI unit of transmissibility. (C.O.NO. 1) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries four marks. (3Qx4M=12M)

6. Define Specific Retention. Specific yield for a soil is 22%. Porosity is given as 39%. Estimate Specific retention. (C.O.NO.1) [Comprehension]

7. Differentiate between Aquiclude and Aquitard. If the Darcy velocity for groundwater through a medium having porosity as 20% is given as 0.00014 cm/sec. Calculate seepage velocity. (C.O.NO. 1) [Comprehension]

8. Define flowing and non-flowing well, effluent and influent stream.

(C.O.NO. 1) [Comprehension]

Part C [Problem Solving Questions]

Answer all the Questions. Each Question carries six marks.

(3Qx6M=18M)

9. Watershed at a site on a stream has an area of 3000ha. Mean annual rainfall at this place is 750mm. If 15% of the rainfall reaches the basin outlet as stream flow. Find (i) the annual stream flow rate in (m³/sec) (ii) abstraction or losses (in m³)

(C.O.NO.1) [Comprehension]

10. The following data were recorded in a constant head permeability test. Internal diameter of permeameter= 7.5cm, head lost over a sample length of 18cm is 24.7cm. Quantity of water collected in 60 sec is 626 ml. Porosity of the soil sample was 44%. Calculate the coefficient of permeability of the soil and discharge velocity during the test. (C.O.NO.1) [Comprehension]

11. The permeability of individual layers P, Q and R of a soil in three layer system is in the ratio 2, 3 and 1 respectively. The ratio of the thickness of the layers P, Q and R are 2, 1 and 2 respectively. Estimate the average permeability perpendicular to the bedding planes. (C.O.NO.1) [Comprehension]



SCHOOL OF ENGINEERING

Semester: 05

Course Code: CIV308

Course Name: Groundwater Hydrology

Date: 27-09-2019

Time: 11am-12pm

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	1	Module 1	2									
2	1	Module 1	2									
3	1	Module 1	2									
4	1	Module 1	2									
5	1	Module 1	2									
1	1	Module 1				4						
2	1	Module 1				4						
3	1	Module 1				4						
1	1	Module 1				6						
2	1	Module 1				6						
3	1	Module 1				6						

	Total Marks		10			30						40
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K = Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I here certify that All the questions are set as per the above lines Aashi Agarawal]

Annexure- II: Format of Answer Scheme



SCHOOL OF ENGINEERING

SOLUTION

Semester: 05

Course Code: CIV 308

Course Name: Groundwater Hydrology

Date: 27-09-2019

Time:

Max Marks: 40

Weightage: 20%

Part A

(5Q x 2M = 10Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	Major processes in water cycle/hydrological cycle are 1. Precipitation 2. Evaporation	1+1	2 minutes

	<p>3. Evapotranspiration</p> <p>4. Infiltration</p> <p>5. Groundwater Flow/Base Flow</p> <p>6. Runoff</p> <p>Infiltration is the movement of water into the earth surface while percolation is the vertical downward movement of water from one layer of soil zone to other layer</p>		
2	<p>It is the average time taken by a particle of water to pass through a certain phase of hydrological cycle</p> <p>Residence time = Volume of water in that phase/ Average flow rate in that phase</p>	1+1	2 minutes
3	<p>Watershed- An area of land that collects water and drains it through an outlet or mouth.</p> <p>Watershed divide- Ridge line that divide one valley or drainage from the other. The imaginary line that connects the highest points of elevation is called watershed divide.</p>	1+1	2 minutes
4	<p>Perched aquifer- A perched aquifer is a very small,</p>	1+1	2 minutes

	<p>unconfined aquifer that doesn't contain much water and is only recharged by local precipitation. A well drilled into a perched aquifer usually yields only enough water for a single household.</p> <p>Leaky Aquifer- It is a type of confined aquifer in which water is confined between a semi permeable layer i.e. aquitard on the bottom and impermeable layer i.e. aquiclude on the top or vice-versa.</p>		
5	<p>The rate at which water flows through unit width of aquifer under unit hydraulic gradient.</p> <p>$Q = K * i * A$</p> <p>If Area of aquifer = aquifer thickness (B) * unit width</p> <p>Hydraulic gradient, $i = 1$ unit</p> <p>$Q = T = k * B$</p> <p>Where T = transmissivity</p> <p>SI unit of T is m^2/day. Dimension is $[L^2T^{-1}]$.</p>	2	2 minutes

Part B

(3Q x 4M = 12Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	Volume of water retained against gravity in the soil after saturation is	2+2	6 minutes

	<p>called specific retention. $S_y + S_r = \text{Porosity}$ Where $S_y =$ specific yield $S_r =$ specific retention</p> <p>Given, Porosity = 39% S_y (Specific yield) = 22% S_r (Specific retention) = Porosity - specific yield = 39% - 22% = 17% $S_r = 17\%$</p>		
2	<p>Aquiclude- A geological formation that is completely impermeable. E.g. clay</p> <p>Aquitard- Relatively semi permeable geological formation. e.g. sandy clay</p> <p>Darcy velocity = 0.00014cm/sec Porosity = 20% Seepage velocity = Darcy velocity / porosity = 0.00014 / 0.20 = 0.0007cm/sec</p>	2+2	6 minutes
3	<p>Flowing Well- Whenever piezometric surface is above the ground level, water from a well drilled in a confined aquifer gushes out, such a well is called flowing well.</p>	2 + 2	7 minutes

	<p>Non- Flowing Well- Well drilled in a confined aquifer but groundlevel is above the piezometric surface, water doesnot gushes out , such a well is non flowing well.</p> <p>Effluent Stream- when water level in the stream is lower than the groundwater table, groundwater discharges the stream. Such a stream is called effluent stream or gaining stream.</p> <p>Influent Stream- When water level in the stream is higher than the groundwater table, stream loses water to groundwater. Such a stream is called influent stream or losing stream.</p>		
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Part C

(3Q x 6M = 18Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	<p>Given area of catchment = 3000ha, rainfall = 750mm and runoff = 0.15of rainfall Annual Runoff = 0.15* 750 =112.5mm Streamflow rate= $\{(112.5/1000)*(3000*10000)\}/(365*24*60*60)$ = 0.107m3/sec Losses= 750mm- 112.5mm =637.5mm</p>	3+3	10 minutes

	Losses(in m3) = $(637.5/1000)*(3000*10000)$ = 19125000m3		
2	$i = h/L$ $= 24.7/18 = 1.37$ $n = 0.44$ $Q = KiA$ $626/60 = k * 1.37 * (3.14/4) * (7.5^2)$ $K = 0.172 \text{ cm/sec}$ Discharge velocity, $V = K * i$ $= 0.172 * 1.37$ $= 0.236 \text{ cm/sec}$	4+2	8 minutes
3	Let the permeability and thickness of soil layer $P = k_1, z_1$ layer $Q = k_2, z_2$ $R = k_3, z_3$ $K_1 : k_2 : k_3 = 2 : 3 : 1$ $Z_1 : z_2 : z_3 = 2 : 1 : 2$ $K_{\text{vertical}} =$ $\frac{\sum_{i=1}^n Z_i}{\sum_{i=1}^n (Z_i)/(k_i)}$ $= (2+1+2) / \{ (2/2) + (1/3) + (2/1) \}$ $= 1.5 \text{ units}$	3+3	8 minutes



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**PRESIDENCY UNIVERSITY
BENGALURU**

SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem. 2019-20

Date: 16.11.2019

Course Code: CIV 308

Time: 11:00 AM to 12:00 PM

Course Name: GROUNDWATER HYDROLOGY

Max Marks: 40

Program & Sem: B.Tech (CVE) & V DE

Weightage: 20%

Instructions:

- I. Read all the questions carefully.
 - II. Answer all the questions.
-

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries two marks. (5Qx2M=10M)

1. State the differences between confined and unconfined aquifer. (C.O.NO.2) [Knowledge]
2. Define radius of influence. (C.O.NO.2) [Knowledge]
3. Explain Theis recovery. (C.O.NO.2) [Knowledge]
4. What is the difference between steady and unsteady flow? (C.O.NO.2) [Knowledge]
5. Define specific capacity. Write the SI unit of specific capacity. (C.O.NO.2) [Knowledge]

Part B [Thought Provoking Questions]

Answer both the Questions. Each Question carries six marks. (2Qx6M=12M)

6. Draw a neat sketch showing a single well penetrating through a confined aquifer and write the expression for permeability for that aquifer and name all the terms involved. (C.O.NO.2) [Comprehension]
7. Explain well losses with the types. (C.O.NO.2) [Comprehension]

Part C [Problem Solving Questions]

Answer both the Questions. Each Question carries nine marks. (2Qx9M=18M)

8. Two wells of 20cm diameter are spaced at 120m distance and penetrate fully a confined aquifer of 12m thickness. Calculate the discharge when only one well is discharging under a drawdown of 3m. What will be the percentage decrease in the discharge of this well, if both the wells are discharging under the same drawdown of 3m? Assume the radius of influence of well is 200m and permeability of aquifer is 40m/day. (C.O.NO.2) [Comprehension]
9. A 45cm well penetrates an unconfined aquifer of saturated thickness 30m completely. Under a steady pumping rate for a long time the drawdowns in two observation wells 15m and 30m from the well are 5.0m and 4.2 m respectively. If the permeability of the aquifer is 20m/day. Determine the discharge and the drawdown at the pumping well. (C.O.NO.2) [Comprehension]



SCHOOL OF ENGINEERING

Semester: 05

Course Code: CIV308

Course Name: Groundwater Hydrology

Date 16-11-2019

Time: 11am-12pm

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	2	Module 2	2									
2	2	Module 2	2									
3	2	Module 2	2									
4	2	Module 2	2									
5	2	Module 2	2									
1	2	Module 2				6						
2	2	Module 2				6						
1	2	Module 2				9						
2	2	Module 2				9						
	Total Marks		10			30						40

K = Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.



SOLUTION

Date: 16-11-2019

Time: 11:00am – 12:00pm

Semester: 05

Max Marks: 40

Course Code: CIV 308

Course Name: Groundwater Hydrology

Weightage: 20%

Part A

(5Q x 2M = 10Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	<p>A confined aquifer is an aquifer below the land surface that is saturated with water. Layers of impermeable material are both above and below the aquifer, causing it to be under pressure so that when the aquifer is penetrated by a well, the water will rise above the top of the aquifer.</p> <p>Water is under pressure.</p> <p>A water-table--or unconfined--aquifer is an aquifer whose upper water surface (water table) is at atmospheric pressure, and thus is able to rise and fall. Water-table aquifers are usually closer to the Earth's surface than confined aquifers are, and as such are impacted by drought conditions</p>	2	2 minutes

	sooner than confined aquifers. Water is not under pressure.		
2	Radius of Influence means the radial distance from the center of a well bore to the point where there is no lowering of the water table or potentiometric surface because of pumping of the well; the edge of the cone of depression.	2	2 minutes
3	A recovery test is a controlled field experiment performed at the end of a pumping test (constant-rate or step-drawdown) after pumping in the pumped (control) well has ended. Water-level response (residual drawdown) is measured after pumping has stopped in one or more surrounding observation wells and optionally in the control well itself.	2	2 minutes
4	If the flow properties are constant with respect to time, flow can be termed as steady flow.	2	2 minutes

	When the flow properties are not constant with respect to time, it can be termed as non-steady flow.		
5	The amount of water furnished under a standard unit head : the amount of water that is furnished under unit lowering of the surface of the water in a well by pumping. SI unit m ³ /min/m [L ² /T]	2	2 minutes

Part B

(2Q x 6M = 12Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	$K = \frac{Q \ln \left(\frac{r_2}{r_1} \right)}{2\pi b (h_2 - h_1)}$ Where Q = pumping rate R1 and r2 radial distance from the centre of the well H1 and h2 are water level in the well B = saturated thickness of aquifer K= coeff of permeability	3+3	7 minutes
2	When water is pumped out of a well, the total drawdown caused includes not only that of the logarithmic drawdown curve at the well face, but also drawdown caused by flow	3+3	6 minutes

	<p>through well screen and axial movement within the well. The latter drawdown is called well loss. Since turbulent flow generally occur near the well face, this loss may be taken to be proportional to Q^n</p> <p>Formation well losses</p>	
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Part C

(2Q x 9M = 18Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	<p>$R= 200m$ $r_w = .10m$ $a= 120m$ $B= 12m$, $s=3m$ $k=40m/day$ Use $k = \frac{q \ln(R/r_w)}{(2\pi B s)}$ Putting all the values $Q= 1190m^3/day$ Again use $K = \frac{Q' \ln(R^2/r_w * a)}{(2\pi B s)}$ Putting all values , $Q' = 1117m^3/day$ $\% \text{ decrease} = \frac{1190-1117}{1190}$ $= 6.134\%$</p>	4.5 + 4.5	10 minutes
2	<p>$r_1= 15m$ $r_2 = 30m$ $s_1= 5m$ $s_2= 4.2m$ $k= 20m/day$ $r_w= 22.5cm = 0.225m$ use steady state eqn $k = \frac{Q \ln(r_2/r_1)}{(\pi (h_2^2 - h_1^2))}$ use $H= h+s$ putting all the values we get, $Q= 3683.90m^3/sec$ Again apply the eqn between R and r_w to get drawdown in the pumping well At $r = R$, $s = 0$ At $r = r_w$, $s=s_w$ Putting all the values in above eqn we get $S_w = 30-h_w = 10.54m$</p>	4.5 + 4.5	8 minutes



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**PRESIDENCY UNIVERSITY
BENGALURU**

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Sem. 2019 - 20

Date: 20 December 2019

Course Code: CIV 308

Time: 9:30 AM to 12:30 PM

Course Name: GROUND WATER HYDROLOGY

Max Marks: 80

Program & Sem: B.Tech (CIV) & V (DE-I)

Weightage: 40%

Instructions:

- (i) Read the all questions carefully and answer accordingly.
(ii) All the questions have to be attempted

Part A [Memory Recall Questions]

Answer all the sub Questions. Each sub Question carries 2 marks. (10Qx2M=20M)

1.
 - i. What are the various sources of groundwater pollution? (C.O.No.4) [Knowledge]
 - ii. Define flowing well and unsteady flow. (C.O.No.3) [Knowledge]
 - iii. Differentiate between aquitard and aquiclude. (C.O.No.2) [Knowledge]
 - iv. Mention the principle of seismic method of groundwater investigation (C.O.No.4) [Knowledge]
 - v. Write the various processes involved in a hydrological cycle. Relate them with a suitable equation. (C.O.No.1) [Knowledge]
 - vi. Runoff coefficient increases as a result of deforestation. Explain why.(C.O.No.1) [Knowledge]
 - vii. Explain specific yield and specific retention. (C.O.No.2) [Knowledge]
 - viii. Differentiate between seepage and darcy velocity. (C.O.No.3) [Knowledge]
 - ix. Mention how evaporation and atmospheric pressure affects groundwater level. (C.O.No.1) [Knowledge]
 - x. Mention any two strategies for groundwater management. (C.O.No.4) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries 5 marks.

(4Qx5M=20M)

2. Explain the Dupuit assumptions made while deriving steady flow equations for confined and unconfined aquifer? (C.O.No.3) [Knowledge]
3. Explain groundwater cycle. (C.O.No.1) [Knowledge]
4. Define sea-water intrusion. List any two causes for the occurrence of this intrusion. Develop a relationship between the freshwater depth and interface depth. (C.O.No.4) [Knowledge]
5. Explain all the four types of aquifers with neat sketch. (C.O.No.2) [Knowledge]

Part C [Problem Solving Questions]

Answer all the Questions. Each Question carries 10 marks.

(4Qx10M=40M)

6. The plan area of reservoir is 1sq km. The water level in the reservoir is observed to be decline by 20cm in a certain period. During this period the reservoir receives a surface inflow of 10 hectare meters and 20 hectare meters are taken out from the reservoir for various purposes. Evaporation from the reservoir is 8.40cm and rainfall recorded during the same period is 3cm. Calculate the seepage loss from the reservoir in hectare-meters. (C.O.No.1) [Comprehension]
7. A 30cm well gives 300 lpm under a drawdown of 2m penetrates an aquifer 3m thick. For the same drawdown, what would be the probable discharge in litres per minute for 20cm well and 40cm well. Assume the radius of influence of 500m in all cases. (C.O.No.3) [Comprehension]
8. Determine the ratio of vertical hydraulic conductivity to horizontal hydraulic conductivity for a given three layered soil if the length of the soil specimen is 200m. (C.O.No.2) [Comprehension]

$$\begin{array}{ll} K_1 = 0.005\text{m/s} & d_1 = 3\text{m} \\ K_2 = 0.009\text{m/s} & d_2 = 6\text{m} \\ K_3 = 0.001\text{m/s} & d_3 = 3\text{m} \end{array}$$

9. A well is penetrated into a 26m thick layer of sand which is underlain by a rock layer. Water is pumped out of well at a constant rate of 550000litres/hr. water level in the two observation wells situated at 25m and 50m from the test well are found to be 4.7m and 3.6m respectively below the groundwater table. Find the coefficient of permeability of soil. (C.O.No.3) [Application]



SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Extract of question distribution [outcome wise & level wise]

Q.NO	C.O.NO (% age of CO)	Unit/Module Number/Unit /Module Title	Memory recall type	Thought provoking type	Problem Solving type [Marks allotted]	Total Marks
			[Marks allotted]	[Marks allotted]		
			Bloom's Levels	Bloom's Levels		
			K	C	A	
1 i	4	Module 3	2			
ii	3	Module 2	2			
iii	2	Module 1	2			
iv	4	Module 3	2			
v	1	Module 1	2			
vi	1	Module 1	2			
vii	2	Module 1	2			
viii	3	Module 2	2			
ix	1	Module 1	2			
X	4	Module 3	2			
2	3	Module 2		5		
3	1	Module 1		5		
4	4	Module 3		5		
5	2	Module 1		5		
6	1	Module 1			10	
7	3	Module 2			10	
8	2	Module 1			10	
9	3	Module 2			10	
Total marks			20	20	40	80

K = Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I hereby certify that all the questions are set as per the above guidelines.

Faculty Signature:

Reviewer Comment:

Format of Answer Scheme



SCHOOL OF ENGINEERING

SOLUTION

Semester: Odd Sem. 2019-20
Course Code: CIV 308
Course Name: GROUNDWATER HYDROLOGY
Program & Sem: B.Tech Civil 7th Semester

Date: 20.12.2019
Time: 3 HRS
Max Marks: 80
Weightage: 40%

Part A

(10Q x 2M = 20Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1 i	Sources of pollution- Septic tanks Landfill sites Agricultural sources Saline water intrusion Seepage from canals Hazardous waste	2	2MIN
ii	Flowing well is that well for which Piezometric pressure is above the groundwater level. Unsteady flow is that flow in which flow properties like depth, velocity, discharge changes with respect to time.	2	2MIN
iii	Aquitard- geological formation which is semi permeable but porous Aquiclude is that geological formation which is porous but completely impermeable.	2	2MIN
iv	Principle- measurement of velocity of shock waves through different material is different.	2	2MIN
v	Precipitation Runoff Infiltration Percolation Base flow Evaporation Evapotranspiration P-R-E-I-ET = Change In Storage	2	2MIN
vi	As deforestation increases, vegetative cover reduces in an area and thus reduces the infiltration and thus runoff increases therefore runoff coefficient increases.	2	2MIN
vii	Specific yield- the amount of water that can be extracted from a given aquifer per unit volume of aquifer against gravity is specific yield	2	2MIN

	Specific retention- the amount of water that is retained in the pores of the soil and can not be taken out through pumping is specific retention.		
viii	Seepage velocity is velocity of groundwater through the pores of the soil specimen Darcy velocity is the actual velocity through the cross sectional area of the soil specimen	2	2MIN
ix	As evaporation increases, groundwater level reduces As atmospheric pressure increases, water level in the well reduces	2	2MIN
x	Strategies- artificial recharge Rainwater harvesting Recharge wells Injection wells	2	2MIN

Part B

(4Q x 5M = 20 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
2	ASSUMPTIONS- Flow Is Laminar and darcy law is valid- explanation of darcy law Aquifer is homogenous and isotropic- explanation of the terms Well is a fully penetrating well- penetrates through the entire thickness of the aquifer Flow is radial and steady- flow towards the well and constant wrt time. Coefficient of permeability is constant through the aquifer- isotropic nature Saturated thickness is constant After long hours of pumping, drawdown is constant.	5 EACH ASSUMPTION CARRYING 1 MARK	10MINS
3	It is a sun driven process. 1. Water from the ocean evaporates due to the heat energy provided by the solar radiation. This water vapour moves upwards and form clouds condense and fall back on the ocean as rain. 2. A part of precipitation may evaporate back to the atmosphere while some part may be intercepted by buildings and settlement present on the ground surface. 3. After reaching the ground surface some portion of the water may enter into the soil surface through the process called infiltration and later joins the groundwater table. Infiltration is the movement of water into the earth surface while percolation is the vertical downward movement of water from one layer of soil zone to other layer. 4. Vegetation also sends a portion of groundwater from the earth's surface to the atmosphere by the process called transpiration. 5. Some of the infiltrated water may enter the surface water bodies by process called interflow. 6. After filling all the depression storages and detention ponds, the remaining water appears as runoff/ surface runoff/overland flow and ultimately joins the bigger water bodies such as rivers, oceans etc and thus the cycle continues.	5 EACH STEP CARRYING 1 MARK	10MINS

4	<p>Saltwater intrusion is the movement of saline water into freshwater aquifers, which can lead to contamination of drinking water sources and other consequences. Saltwater intrusion occurs naturally to some degree in most coastal aquifers, owing to the hydraulic connection between groundwater and seawater. Because saline water has a higher mineral content than freshwater, it is denser and has a higher water pressure. As a result, saltwater can push inland beneath the freshwater.</p> <p>Causes-</p> <ul style="list-style-type: none"> Subsidence Decrease in recharge Increase in pumping Climate change Rising of sea water level Changes in the precipitation <p>Control- injection barrier and recharge continuous monitoring of GW</p> <p>Density of fresh water = 1g/cc Density of sea water = 1.025g/cc Relation – height of freshwater above mean sea level = 40* height of sea water below msl upto interface</p>	1+2+1+1	10MINS
5	<p>A confined (artesian) aquifer is an aquifer bounded both at the bottom and at the top by an impermeable stratum (aquiclude) and fully filled with water which is usually under (artesian) pressure.</p> <p>2. An unconfined (free, phreatic) aquifer is an aquifer underlain by an impermeable stratum, but the top of the the aquifer consists of soil layers that are permeable enough to provide easy passage of water, at least in vertical sense. Such an aquifer has a free water table or phreatic surface.</p> <p>3. A perched aquifer is separated from another water-bearing stratum by an impermeable layer. Since this type of aquifer occurs above the regional (original) water table, in the unsaturated zone, the aquifer is called a perched aquifer. a perched aquifer is a very small, unconfined aquifer that doesn't contain much water and is only recharged by local precipitation. A well drilled into a perched aquifer usually yields only enough water for a single household.</p> <p>4. Leaky Aquifer- It is a type of confined aquifer in which water is confined between a semi permeable layer i.e. aquitard on the bottom and impermeable layer i.e. aquiclude on the top or vice-versa</p>	1+1.5+1+1.5	10MINS

Part C

(4Q x 10M = 40Marks)

Q N o	Solution	Scheme of Marking	Max. Time required for each Question
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<p>6</p>	<p>Q 15) A = 1594m $\Delta S = 2.5 \text{ cm}$ $g = 10 \text{ km}$ $B = 20 \text{ km}$ $E = 8.4 \text{ cm}$ $P = 3 \text{ cm}$ $S = ?$</p> $(P+g) - (B+E+S) = \Delta S$ $\left(\frac{3}{100} \times 10^6 + 10 \times 10^4 \right) - \left(20 \times 10^4 + \frac{8.4}{100} \times 10^6 + S \right)$ $= -\frac{20}{100} \times 1 \times 10^6$ $13 \times 10^4 - 0.84 \times 10^4 - S = -20 \times 10^4$ $(13 - 0.84) \times 10^4 = S$ $S = 4.6 \times 10^4 \text{ ha m}^3$ $= 4.6 \text{ ha m}$	<p>10 1 MARK FOR WATER BUDGET EACH STEP CARRIES EQUAL MARKS</p>	<p>20MINS</p>
<p>7</p>	<p>Q 16) $r_w = 15 \text{ cm}$ $Q = 300 \text{ lpm}$ $\delta w = 2 \text{ m}$ $B = 3 \text{ m}$ $R = 500 \text{ m}$</p> <p>(a) for 20cm well, $Q = ?$</p> $Q = \frac{Q' \ln(R/r_w)}{2\pi B \delta w}$ $Q = \frac{300 \times \ln(500/0.15)}{2\pi \times 3 \times 2}$ $= 64.5 \text{ lpm per m}^2$ $64.5 = \frac{Q \ln(500/0.10)}{2\pi \times 3 \times 2}$ $Q = 285.71 \text{ lpm}$	<p>10 EACH STEP CARRIES EQUAL MARKS 2 MARKS FOR FORMULA</p>	<p>20MINS</p>

EACH STEP CARRIES EQUAL MARKS
2 MARKS FOR FORMULA

$$\begin{aligned} \text{a1)} \quad k_1 &= 0.005 \text{ m/s} & d_1 &= 3 \text{ m} \\ k_2 &= 0.009 \text{ m/s} & d_2 &= 6 \text{ m} \\ k_3 &= 0.001 \text{ m/s} & d_3 &= 3 \text{ m} \end{aligned}$$

$$k_A = \frac{k_1 d_1 + k_2 d_2 + k_3 d_3}{d_1 + d_2 + d_3}$$

$$k_U = \frac{d_1 + d_2 + d_3}{\frac{d_1}{k_1} + \frac{d_2}{k_2} + \frac{d_3}{k_3}}$$

$$k_A = \frac{0.005 \times 3 + 0.009 \times 6 + 0.001 \times 3}{3 + 6 + 3}$$

$$= \frac{0.015 + 0.054 + 0.003}{12}$$

$$= 0.006 \text{ m/s}$$

$$k_U = \frac{3 + 6 + 3}{\frac{3}{0.005} + \frac{6}{0.009} + \frac{3}{0.001}}$$

$$= \frac{12}{\left(\frac{600 + \frac{6}{0.009} + 600 \right)}$$

$$= 2.8125 \times 10^{-3} \text{ m/s}$$

$$\frac{k_U}{k_A} = \frac{2.8125}{0.006} = 0.46875$$

9

$$Q18) \quad B = 26m$$

$$Q = 550000 \text{ l/hr}$$

$$r_1 = 25m$$

$$r_2 = 50m$$

$$s_1 = 4.7m$$

$$s_2 = 3.6m$$

 $k = ?$

$$k = \frac{Q \ln(r_1/r_2)}{2\pi B (s_1 - s_2)}$$

$$k = \frac{55 \times 10^4 \times \ln(50/25)}{2\pi \times 26 \times 1.1}$$

$$= \frac{2121.49 \times 10^{-3} \text{ m}}{\text{hr}}$$

$$= 2.121 \text{ m/hr}$$

$$= 2.121 \text{ m/hr}$$

10

EACH STEP CARRIES EQUAL MARKS
2 MARKS FOR FORMULA

20MINS