ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2022
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR WATER ENGINEERING

Date	: October 9, 2022
Total Marks	: 100
Writing Time	: 150 minutes (2.5 hours)
Reading Time	: 15 minutes (prior to writing time)

GENERAL INSTRUCTIONS:

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
   - **SECTION A** has two parts: Part I - 30 Multiple Choice Questions
Part II - 4 Short Answer Questions
   - **SECTION B** consists of FIVE questions and all are compulsory.
     All questions under SECTION A and SECTION B are COMPULSORY.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part on a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You must hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **7 printed pages**, including this instruction page.

GOOD LUCK

SECTION A

PART I: Multiple Choice Questions [30 marks]

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. What percentage of the world's water is potable?
   a) less than 3%
   b) about 15%
   c) about 25%
   d) more than half

2. When is World Water Day observed?
   a) 22nd May
   b) 22nd March
   c) 2nd June
   d) 22nd September

3. Which goal out of the 17 Sustainable Development Goals (SDGs) mentions "Ensure availability and sustainable management of water and sanitation for all"?
   a) SDG 17
   b) SDG 13
   c) SDG 6
   d) SDG 7

4. Pick up the correct equation from the following:
   a) Run off = Surface run off + Ground water flow
   b) Run off = Surface run off - Ground water flow
   c) Run off = Surface run off / Ground water flow
   d) Run off = Surface run off x Ground water flow

5. Runoff is measured in
   a) cubic meters.
   b) cubic meters per sec.
   c) cubic meters per minute.
   d) cubic meters per hour.

6. For determination of average annual precipitation in a catchment basin, the best method is
   a) Thiessen's mean method.
   b) Arithmetical method.
   c) Isohyetal method.
   d) None of the above

7. In Bhutan, rainfall is recorded by:
   a) National Environment Commission
   b) National Center for Hydrology and Meteorology
   c) National Biodiversity Center
   d) Ministry of Works and Human Settlement

8. A hyetograph is a graphical representation of
   a) rainfall intensity and time.
   b) discharge and time.
   c) cumulative rainfall and time.
   d) rainfall depth and time.

9. The time required by rainwater to reach the outlet of the drainage basin is generally called
   a) time of concentration.
   b) duration of rainfall.
   c) time of overland flow.
   d) detention time.

10. Which source of water among the following is not a surface source?
   a) ocean
   b) river
   c) well
   d) lake

11. Which one of the following is **NOT** a geological factor governing the occurrence of groundwater?
   a) Porosity of the soil
   b) Permeability of the soil
   c) Transmissibility of the soil
   d) Elasticity of the soil

12. The quantity of water available from an infiltration gallery depends upon the
   a) the yield of the aquifer source.
   b) size of gallery.
   c) the efficiency of the drain pipes.
   d) All of the above

13. Sharp crested weirs are generally used for
   a) small flows.
   b) large flows.
   c) streams carrying high sediment loads.
   d) rivers carrying floating debris.

14. Generally, the weir is aligned at right angles to the direction of the main river current because
   a) it gives a better discharging capacity.
   b) it ensures less length of the weir.
   c) it is economical large flows.
   d) All of the above

15. Per capita demand of water is calculated in liters
   a) per person per year.
   b) per person per month.
   c) per person per day.
   d) None of the above

16. Per capita water demand is defined as the liters of water consumed daily by each person over a period of
    a) 24 hours.
    b) one month.
    c) one year.
    d) 10 years.

17. As per the Bhutan Drinking Water Quality Standard 2016, water is microbiologically safe if *E.coli* (in CFU/100ml sample) is within the following permissible limit:
    a) 0
    b) 1 - 5
    c) 6 - 10
    d) None of the above

18. pH value of water indicates its:
    a) acidity
    b) alkalinity
    c) both (a) and (b)
    d) None of above

19. The most ideal disinfectant used for drinking water throughout the world is_____________.
    a) alum
    b) chlorine
    c) nitrogen
    d) lime

20. Disinfection efficiency of chlorine treatment
    a) is highest when pH of water is 7.
    b) is decreased at higher pH of water.
    c) is increased at higher pH of water.
    d) is unaffected by pH of water.

21. In Water Supply Engineering "meters water column" is frequently used as a unit of pressure (head) expressed as "mwc'' or "cm-wc". 10 m water column (mwc) is equivalent to:
    a) 0.1 bar
    b) 1 bar
    c) 10 bar
    d) 100 bar

22. In a hydraulic system, there are Elevation Head, Pressure Head, and Velocity Head. The Total Energy Head in a hydraulic system is equal to:
    a) Elevation Head - Pressure Head + Velocity Head
    b) Elevation Head - Pressure Head - Velocity Head
    c) Elevation Head + Pressure Head - Velocity Head
    d) Elevation Head + Pressure Head + Velocity Head

23. The Hydraulic Grade Line (HGL) is a graph of the pressure head _________ the pipe centerline.
    a) along
    b) below
    c) above
    d) near

24. The energy loss due to viscosity and friction along the straight length of the pipeline is called ______________ and accounts for most of the pressure drop.
    a) major loss
    b) minor loss
    c) apparent loss
    d) physical loss

25. As the water flows through valves, bends, and other tube fittings, there are additional losses due to turbulence which is called ____________.
    a) major loss
    b) minor loss
    c) apparent loss
    d) physical loss

26. Which of the following system/type is used in a water distribution network?
    a) dead end system
    b) radial system
    c) grid iron system
    d) all of the above

27. Pressure pipes are exclusively used for carrying water supplies because
    a) such pipes can go up and down the hills and valleys thus requiring a lesser length.
    b) such pipes are closed and hence not exposed to pollution.
    c) since water runs under pressure, pollution from the outside surrounding cannot enter even if some joints are loose.
    d) All of the above

28. The formula which is most appropriate to the design of pressure pipes is
    a) Mannings formula
    b) Darcy Weisbach formula
    c) Dupuit's formula
    d) Chezy's formula

29. Water hammer pressures can be reduced by using
    a) critically closing time valves.
    b) fast closing valves.
    c) slow closing valves.
    d) None of the above

30. Air valves are special kinds of valves that are generally placed at the ________ along the pipeline.
    a) summit
    b) bottom
    c) middle
    d) none of the above

PART II – Short Answer Questions [20 marks]

This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks.

1. What are the advantages of groundwater as a source of water supply over surface water?

2. Which factors should be considered while selecting a water supply source?

3. What are the factors governing the design period of a water supply system?

4. List the causes of high water losses in the distribution system.

SECTION B: Case Study [50 marks]

There are 5 Questions in this Section. Each Question carries 10 marks. All Questions are COMPULSORY. Refer to the list of formulas given at the end of this Section.

1. The annual average of the amount of water used for different activities in a household with 4 people is listed below:

ACTIVITY	FREQUENCY OF ACTIVITY	WATER CONSUMPTION/ACTIVITY (LITERS)
Toilet flushing	5 times per person per day	6
Bath	0.3 times per person per day	80
Shower	1.5 times per person per day	30
Dish washing	3 times per household per day	20
Cloth washing	4 times per household per week	60
Other outdoor use	50 times per household per year	50

   Calculate the average per capita domestic water demand.

2. A town with a population of 100,000 has a total per capita water demand of 100 Lpcd (liters per capita per day). Calculate
   (i) annual average daily demand (m^3/day).
   (ii) maximum daily demand (m^3/day).
   (iii)average hourly demand (m^3/hour).
   (iv) maximum hourly demand (m^3/hour).
   (v) maximum hourly demand of the maximum day (m^3/hour).

3. A water treatment plant is supplying 15 million m^3 of water per year to a city with a population of 300,000.
   The domestic demand is estimated to be 65% of the total water demand.
   Calculate (a) per capita total water demand and (b) per capita domestic water demand.

4. Determine the required diameter (d) of a pipe that will carry a discharge of 50 ML/d of water at a velocity of 3 m/s.

5. Water is flowing at a velocity of 2 m/s in a 200 mm diameter pipe. The pipe diameter is reduced to 100 mm at a constriction in the pipe.

   Determine the flow velocity in the constricted pipe section. Discuss the result.

FORMULAE

$Q = v \times A$

Average Daily Demand = P x q (lpcd)

Maximum Daily Demand = 1.8 x P x q (lpcd)

Maximum Hourly Demand of the Maximum Day = 1.5 x Maximum Daily Demand

Where, P = population and q = per capita water demand

Principle of continuity of flow, $Q_1 = Q_2$

TASHI DELEK