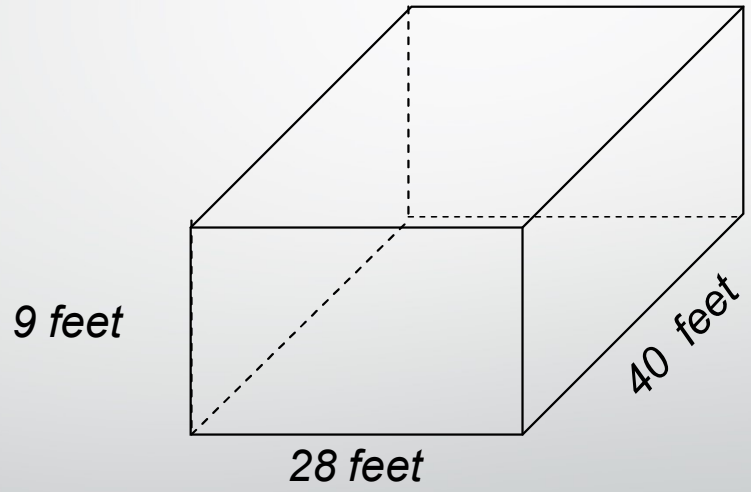
Solutions for problems from preparing for Water Operator License Exam

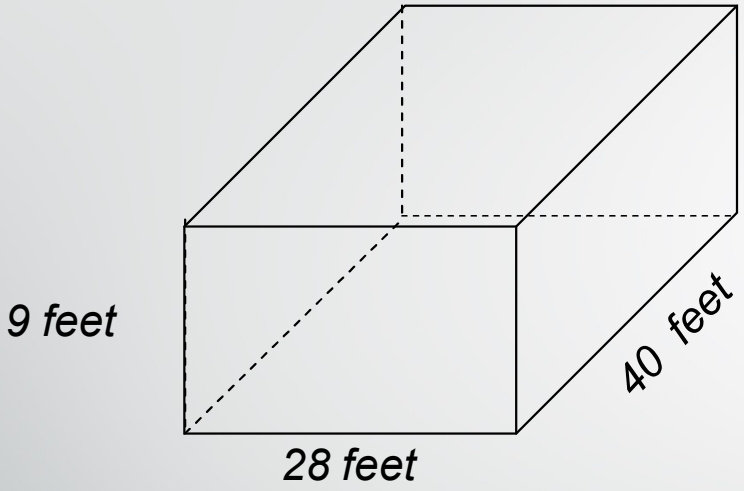
8/5/2024

Problem 1

An un-baffled clearwell measures 40 feet long, 28 feet wide and 9 feet deep. What is its capacity (how many gallons water will it hold)?

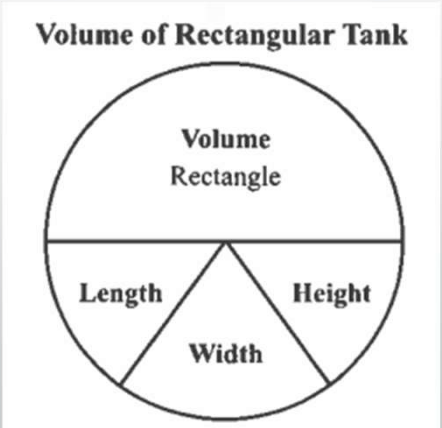


Problem 1



Volume=length x width x height.
= 9 x 28 x 40 = 10,080 ft^3
Need gallons = 10,080 x 7.48 gal/ft^3 = **75,398 gal**

Can also use pie wheel and then convert to gallons

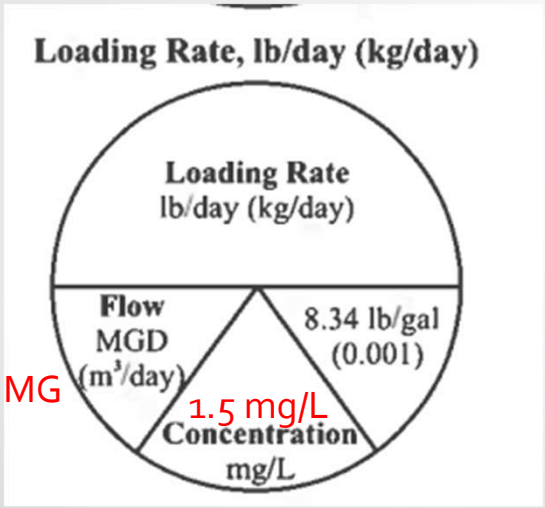


= 9 x 28 x 40 = 10,080 ft^3
Need gallons = 10,080 x 7.48 gal/ft^3
= **75,398 gal**

Problem 2

How many pounds of chlorine would be needed to treat 0.5 MG of water with 1.5 mg/L of chlorine?

Problem 2



0.5 MG

1.5 mg/L

Loading rate = flow x concentration x 8.34
= 0.5 x 1.5 x 8.34 **=<u>6.26 lb</u>**

Note that this works for lb without the day portion, just loading & volume of flow

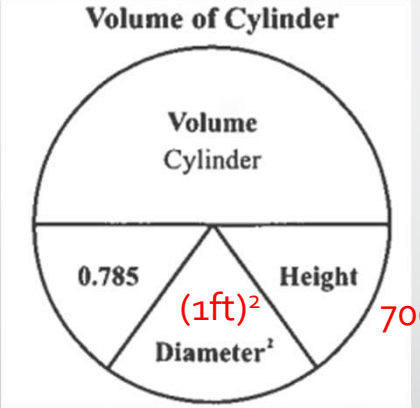
Problem 3

- *A 250-gpm pump conveys water via a 12-inch line from the well house to the first connection, a distance of 700 ft. What is the detention time (minutes) of water in this line?*

Problem 3

This problem divides the volume by the flow rate of 250 gpm. First we need the volume of water in the pipe (gallons) and then divide by 250 gpm.

A pipe is a cylinder, in this case 12 inch diameter (1 ft) and 700 ft "height"



Volume = 0.785 x 1^2 x 700 = 549.5 ft^3
Need gallons = 549.5 x 7.48 gal/ft^3 = 4,110 gal

4,110 gal / 250 gpm = **16.4 minutes**

Problem 4

Water is being pumped to a 30,000-gallon water storage tank at a rate of 125 gpm. What is the fill time (hours) of water in the tank?

Problem 4

Fill time is volume divided by pumping rate
= 30,000 gal / 125 gpm = 240 minutes.

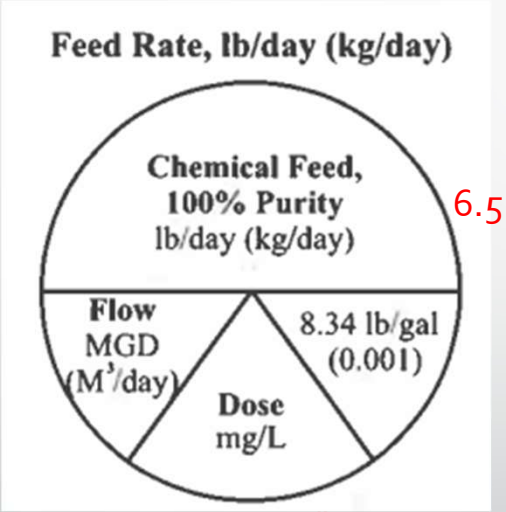
However, the answer must be in hours –
so 240 min / 60 min per hr = **4 hr**

Problem 5

- A dissolved-air flotation (DAF) treatment plant uses 6.5 #/day of chlorine gas for disinfection. If the chlorine demand is 2.3 mg/L and the chlorine residual is 1.0 mg/L, how many gallons per day are produced?

Problem 5

The wrinkle in this problem is the dose: we need 2.3 mg/l to address the chlorine demand, but also want to have 1.0 mg/l residual, so the dose is 2.3 + 1.0 = 3.3 mg/L. We then solve for flow (MGD) but have to report answer in gallons.



6.5 lb/day

3.3 mg/L

Flow = 6.5 /(3.3 x 8.34) = 0.236 MGD
In gallons = **236,175 gallons**

Problem 6

- *A tank with a circular base rests on a concrete slab. How many gallons of paint will be needed to paint the outside of the tank with 2 coats of paint if:*
  - *the tank measures 30 ft diameter and 25 ft tall*
  - *each gallon of paint covers 150 ft^2 of surface area*

Surface Area – Paint the Tank Problem

First, calculate paintable surface area outside the tank:

$$Surface\ Area\ of\ closed\ cylinder\ = 2\pi r(h + r)$$

$$= (2)(3.14)(15ft)(25ft + 15ft)$$

$$= (2)(3.14)(15ft)(40ft) = 3{,}768ft^2$$

Remember, this *3,768 ft²* per coat of paint includes the outside bottom of the tank, which can't be reached because the tank is resting on a concrete slab. To obtain the correct paintable surface area of the outside of the tank, subtract the surface area of the outside bottom of the tank.

Surface Area – Paint the Tank Problem

Because the tank diameter is 30 ft, the area of the bottom is:

$$Area\ of\ bottom\ of\ tank\ = 0.785\ \times d\ \times d$$

$$= 0.785\ \times 30ft\ \times 30ft\ = 706.5\ ft^2$$

So, the paintable surface area (per coat) of the outside of the tank is:

$$3{,}768ft^2\ - 706.5\ ft^2 = 3061.5\ ft^2$$

So, the total number of ft^2 the paint must cover to put two coats of paint on the outside of the tank is:

$$3061.5\ ft^2 + 3061.5\ ft^2 = 6{,}123\ ft^2$$

Surface Area – Paint the Tank Problem

Each gallon of paint will cover $150\ ft^2$ of surface area, the number of gallons needed to paint the tank is:

$$6{,}123 ft^2 \div 150\ ft^2/gal = 40.82\ gallons\ of\ paint$$

Since it is not possible to purchase $40.82\ gallons\ of\ paint$, the total number of gallons needed to paint the tank is:

$$\boldsymbol{41\ gallons\ of\ paint}$$

Problem 7

- What is the Locational Running Annual Average (LRAA) for sample site #1 if:
  - Jan 2022: TTHM – 0.045 mg/L
  - Apr 2022: TTHM – 0.055 mg/L
  - Jul 2022: TTHM – 0.082 mg/L
  - Oct 2022: TTHM – 0.071 mg/L

Problem 7

$$\text{Average (arithmetic mean)} = \frac{\text{Sum of All Terms}}{\text{Number of Terms}}$$

Average = $\frac{0.045 + 0.055 + 0.082 + 0.071}{4}$

= **0.063 mg/L – Note that this does not exceed the regulatory compliance of 0.080 mg/L**

Problem 8

- What is the Locational Running Annual Average (LRAA) for sample site #1 after collecting a new sample in Jan 2023:

  Jan 2023: TTHM – 0.052 mg/L

  - Jan 2022: TTHM – 0.045 mg/L
  - Apr 2022:TTHM – 0.055 mg/L
  - Jul 2022: TTHM – 0.082 mg/L
  - Oct 2022:TTHM – 0.071 mg/L

Problem 8

$$\text{Average (arithmetic mean)} = \frac{\text{Sum of All Terms}}{\text{Number of Terms}}$$

Average = $\frac{0.055 + 0.082 + 0.071 + 0.052}{4}$

= **0.065 mg/L – still below the regulatory compliance of 0.080 mg/L**

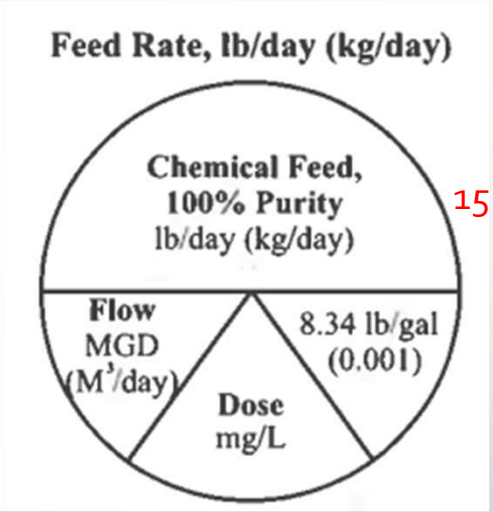
The information to know on this problem is that the LRAA is the most recent 4 quarterly measurements, so the newest measurement, Jan 2023, replaces the oldest measurement, Jan 2022.

Problem 9

- A membrane filtration treatment plant uses 15 #/day of chlorine gas for disinfection. If the chlorine dose is 1.5 mg/L how many gallons per day are produced?

Problem 9

This problem is similar to # 5 above



15 lb/day

1.5 mg/L

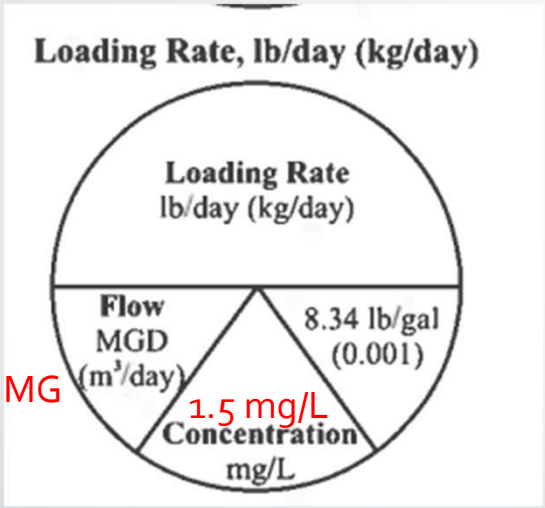
Flow = 15 /(1.5 x 8.34) = 1.199 MGD
In gallons = **1,199,041 gallons**

Problem 10

- *How many pounds of chlorine would be needed to treat 0.5 MG of water with 1.5 mg/L of chlorine?*

  A: 0.6 #
  B: 3.6 #
  C: 6.3 #
  D: 63 #

Problem 10



0.5 MG

1.5 mg/L

Loading rate = flow x concentration x 8.34
= 0.5 x 1.5 x 8.34 **=<u>6.26 lb</u>**

Note that this works for lb without the day portion, just loading & volume of flow. Also note that this is very similar to #2 above because it is the same numbers …

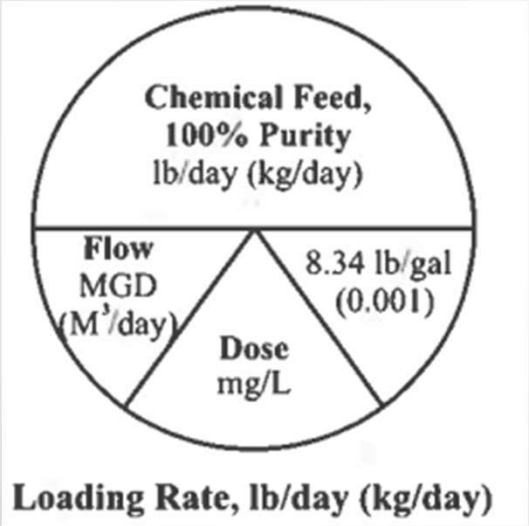
Problem 11

- *5 pounds of chlorine was used to treat 0.3 MG of water. What was the dosage of chlorine in mg/L?*

Problem 11

5 lb

0.3 MGD



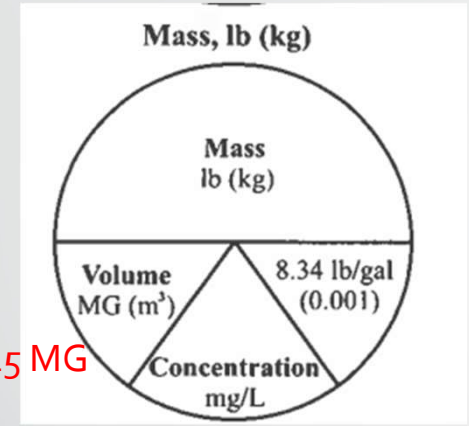
Dose = 5/(0.3 x 8.34 **=2.0 mg/L**

Problem 12

- *A 250,000-gallon water tank must be disinfected with 50 mg/L of chlorine. How many pounds of* chlorine *would be needed to accomplish this?*

  A: 100 #
  B: 125 #
  C: 12,500 #
  D: 12,500,000 #

Problem 12



0.25 MG

50 mg/L

Mass (lb) = 0.25 x 50 x 8.34)
= 104 #

This answer is not an option, so what is the "best" answer? 100 # would not fully disinfect, so probably justifies answer B **125 #**

A: 100 #
B: 125 #
C: 12,500 #
D: 12,500,000 #

Problem 12.A

- *A 250,000-gallon water tank must be disinfected with 50 mg/L of chlorine. How many pounds of HTH (70% available chlorine) would be needed to accomplish this?*

A: 73.0 #
B: 104.3 #
C: 148.9 #
D: 184.9 #

Problem 12.A

Problem 12 provided the answer of 104 # for 100% purity. The key to this problem is to account for only 70 % purity, which is 0.70.

Answer is to divide by the purity: 104 # / 0.70 = **148.9 #, answer B**

A: 73.0 #
B: 104.3 #
C: 148.9 #
D: 184.9 #

Problem 13

- *The specific gravity of one manufacturer's 12.5% NaOCl is 1.169. How much does one gallon of the solution weigh?*

Problem 13

From page 4 of the Formula/Conversion Table

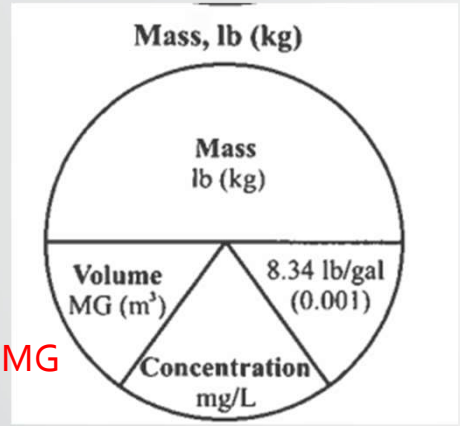
$$\text{Specific Gravity} = \frac{\text{Specific Weight of Substance, lb/gal}}{8.34 \text{ lb/gal}}$$

1.169 = specific weight /8.34 lb/gal
Therefore, the specific weight of one gallon = 1.169 x 8.34 = **9.75 lb**

Problem 14

- *How many gallons of 12.5% NaOCl (10.0 lbs/gal) would be needed to treat 2.5 MG of water with 1.5 mg/L of chlorine?*

Problem 14



2.5 MG

1.5 mg/L

First, find the mass of 12.5 % NaOCl needed

Mass (lb) = 2.5 x 1.5 x 8.34)
= 31.28 lb

Given that each gallon 12.5 %NaOCl weighs 10 #:
=31.28 lb / 10 lb per gallon
= 3.13 gal of 12.5 % NaOCl

Problem 15

- A rapid rate filter has a surface area of 400 sq ft. What is the filtration rate in gallons per minute per square ft if the flow is 1.15 MGD ?

A: 1.8 gpm/sq ft
B: 2.0 gpm/sq ft
C: 2.6 gpm/sq ft
D: 4.0 gpm/sq ft

Problem 15

This problem is solved with units – gpm per ft^2.

First get gpm from MGD:

1.15 MGD = 1,150,000 gal/day

Knowing 1440 minutes per day, gpm = (1,150,000 gal/day) / (1440 min/day) = 798.6 gpm.

Now – divide 798.6 gpm/400 sq ft **= 2.0 gpm/sq ft ANSWER B**

A: 1.8 gpm/sq ft

B: 2.0 gpm/sq ft

C: 2.6 gpm/sq ft

D: 4.0 gpm/sq ft

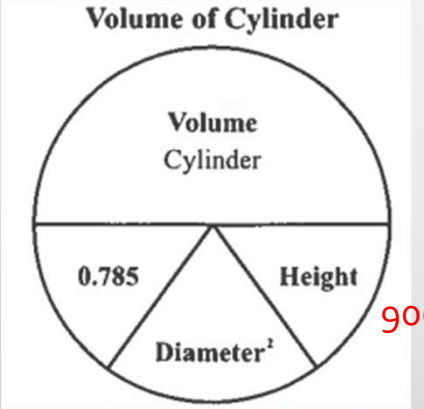
Problem 16

- How many gallons are needed to fill an 8-inch diameter waterline that is 900 ft long?

A: 316 gallons
B: 2,350 gallons
C: 28,200 gallons
D: 45,200 gallons

Problem 16

A pipe is a cylinder, in this case 8-inch diameter (8/12 ft = 0.67 ft) and 900 ft "height"
Diameter^2 = 0.67 x 0.67 = 0.44 ft^2



900 ft

(0.44 ft)^2

Volume = 0.785 x 0.44 x 900 = 310.9 ft^3
Need gallons = 310.9 x 7.48 gal/ft^3 = 2,325 gal

A: 316 gallons
B: 2,350 gallons
C: 28,200 gallons
D: 45,200 gallons

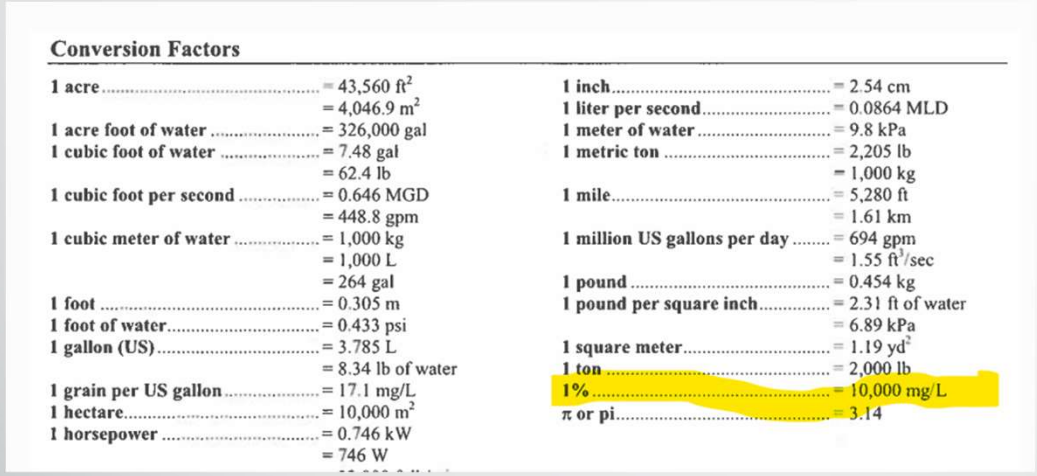
Problem 17

- A solution is 80,350 ppm. What percent is this solution?

A: 0.8%
B: 8.0%
C: 18%
D: 80%

Problem 17

Page 6 of Formula/Conversion Table, 1% is 10,000 mg/L. mg/L is equivalent to ppm



Conversion Factors

1 acre	= 43,560 ft^2
	= 4,046.9 m^2
1 acre foot of water	= 326,000 gal
1 cubic foot of water	= 7.48 gal
	= 62.4 lb
1 cubic foot per second	= 0.646 MGD
	= 448.8 gpm
1 cubic meter of water	= 1,000 kg
	= 1,000 L
	= 264 gal
1 foot	= 0.305 m
1 foot of water	= 0.433 psi
1 gallon (US)	= 3.785 L
	= 8.34 lb of water
1 grain per US gallon	= 17.1 mg/L
1 hectare	= 10,000 m^2
1 horsepower	= 0.746 kW
	= 746 W
1 inch	= 2.54 cm
1 liter per second	= 0.0864 MLD
1 meter of water	= 9.8 kPa
1 metric ton	= 2,205 lb
	= 1,000 kg
1 mile	= 5,280 ft
	= 1.61 km
1 million US gallons per day	= 694 gpm
	= 1.55 ft^3/sec
1 pound	= 0.454 kg
1 pound per square inch	= 2.31 ft of water
	= 6.89 kPa
1 square meter	= 1.19 yd^2
1 ton	= 2,000 lb
1%	= 10,000 mg/L
π or pi	= 3.14

=80,350 ppm / 10,000 mg/L = 8.04 %

A: 0.8%
B: 8.0%
C: 18%
D: 80%

Problem 18

- If a pump discharges 10,350 gallons in 3 hours and 45 minutes, what is the pumping rate in gpm?

A: 42 gpm
B: 46 gpm
C: 50 gpm
D: 58 gpm

Problem 18

3 hours and 45 minutes = 225 minutes.

10,350 gal / 225 minutes = 46 gpm

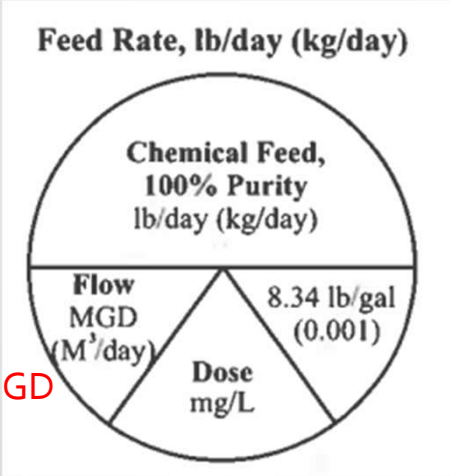
A: 42 gpm
B: 46 gpm
C: 50 gpm
D: 58 gpm

Problem 19

- A WTP treating 500,000 gpd. If the chlorine dose is 3.0 mg/L, how many lb/day of chlorine gas per day are used?

A: 10.0 lb/day
B: 12.5 lb/day
C: 12.9 lb/day
D: 15.5 lb/day

Problem 19



0.5 MGD

3.0 mg/L

= 0.5 x 3.0 x 8.34 = **12.5lb/day**

A: 10.0 lb/day

B: 12.5 lb/day

C: 12.9 lb/day

D: 15.5 lb/day

Problem 20

- If the passing score for a license is 70% and 38% of the 45 test takers passed, how many test takers passed?

A: 12
B: 17
C: 19
D: 31

Problem 20

The passing score for a license doesn't matter because we have the number of test takers (45) and 38% passed.

Multiply 0.38 x 45 = **17 passed**. One check is to see if half passed (0.5 x 45 =22; because 38% is fewer passing than 50%, so 17 is less than 22.

A: 12

B: 17

C: 19

D: 31

Problem 21

- Why do gas feeders not utilize a calibration chart?
  - A. Gas is a compressible fluid
  - B. The Virginia Department of Labor and Industry (DLOI) requires annual inspection of gas feeders
  - **C. Gas feeders have indicators that provide the amount (pounds) of chemical being fed**
  - D. Chlorine gas (3.2 kg/M^3) is heavier than air (1.2 kg/M^3)

Problem 22

- Which of the following is added by positive displacement pump in water treatment?
  A. Chlorine gas
  B. Polyaluminum chloride (liquid coagulant)
  C. Powdered activated carbon
  D. ALL of the above (A,B,C)

Problem 23

- What two water treatment processes are interdependent with sedimentation?

A. Absorption, adsorption
B. **Coagulation, flocculation**
C. Discrete, flocculent, zone, compression
D. Pre-oxidation, secondary disinfection

Problem 24

- What is the primary value of turbidity in sedimentation?

A. Identification of the presence of *Cryptosporidium* in sedimentation basin
B. Surrogate measure for water treatment effectiveness
C. Water quality parameter used by VDH to issue Notice of Alleged Violation penalties (NOAV)
D. Justification for installation of laser turbidimeters

Problem 25

- A public water system has two storage tanks within its distribution system. Tank 1 is a ground-level, rectangular tank (L = 25ft, W = 21ft, H = 17ft). Tank 2 is a ground-level, circular tank (D = 22ft, H = 17ft).

  Calculate the total volume of water potentially available in these storage tanks.

Problem 25

- A public water system has two storage tanks within its distribution system. Tank 1 is a ground-level, rectangular tank (L = 25ft, W = 21ft, H = 17ft). Tank 2 is a ground-level, circular tank (D = 22ft, H = 17ft).

Tank 1 Vol = 25 x 21 x 17 = 8925 ft^3 x 7.48gal/ ft^3 = 66,759 gal

Tank 2 Vol = 0.785 X 22^2 x 17 = 6,459 ft^3 x 7.48 gal/ ft^3 = 48, 313 gal

TOTAL Volume = 66, 759 gal + 48, 313 gal = 115,072 gal

Problem 26

- Water flow in a two-pipe piping system is constant at 1.0 ft^3/sec. Pipe 1 has a 4-inch diameter and pipe 2 has a 10-inch diameter.

A. Pipe 1 has greater velocity

B. Pipe 2 has greater velocity

C. Both pipes have the same velocity

D. Neither pipe has sufficient velocity for fire flow

Problem 26`

Flow Q = Area x velocity; $Q = A_{4\text{-inch}}V_{4\text{-inch}} = A_{10\text{-inch}}V_{10\text{-inch}}$.

Because $A_{4\text{-inch}} < A_{10\text{-inch}}$ then $V_{4\text{-inch}} > V_{10\text{-inch}}$

A. **Pipe $1_{(4\text{-inch})}$ has greater velocity**

B. Pipe 2 has greater velocity

C. Both pipes have the same velocity

D. Neither pipe has sufficient velocity for fire flow

If you wonder about answer D: 1 CFS = 448.8 gpm, which is sufficient for fire flow. This is on page 6

1 cubic foot per second ..... = 0.646 MGD
= 448.8 gpm

Problem 27

- Water flow in a two-pipe piping system is constant at 1.0 ft^3/sec. Pipe 1 has a 4-inch diameter and pipe 2 has a 10-inch diameter. What is the velocity in pipe 2

A. 0.785 ft/sec
B. 1.8 ft/sec
C. 3.14 ft/sec
D. 11.1 ft/sec

Problem 27

Velocity = flowrate (ft^3/sec) divided by cross-sectional area of the pipe (ft^2)

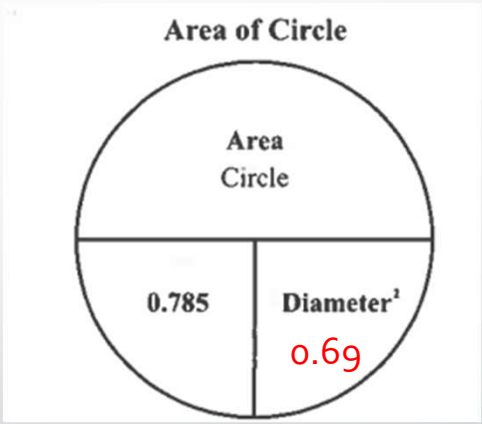
Diameter in ft is 10 inch/12 inch = 0.83. Diameter squared = 0.83 x 0.83 = 0.69 ft^2

A. 0.785 ft/sec

B. **1.8 ft/sec**

C. 3.14 ft/sec

D. 11.1 ft/sec



Area = 0.785 x 0.69 = 0.54 ft^2

1.0 ft^3/sec / 0.54 ft^2 = **1.85 ft/sec**

Problem 28

- The chemical symbol for calcium is:
  - **A. Ca**
  - B. Cl
  - C. Cr
  - D. Cu

Problem 29

- The Town of Spoon Gap needs to add 37.5 pounds of Fluoride (F) to its water supply every day. If they use NaF with 95% purity, how many pounds of NaF is added each day?

A. 16.0 lbs/day
B. 37.5 lbs/day
C. 39.5 lbs/day
D. 87.7 lbs/day

Problem 29

Two parts to address: how much of the NaF is F, and then the 95% purity.
From periodic table, the atomic weight of Na is 23 and for F is 19, with NaF = 42. So F is 19/42 = 45% of NaF by weight.
Need 37.5 lb/day of F, so need 37.5 / 0.45 = 82.89 lb/day of NaF.

Then need to divide by the purity: 82.89 lb/day / 0.95 = **87.7 lb/day, answer D**

A: 16.0 lb/day
B: 37.5 lb/day
C: 39.5 lb/day
D: 87.7 lb/day

Problem 30

- What are the two components that react to form disinfection byproducts (DBP)?

A. Coagulant, polymer

B. *Cryptosporidium*, sediment

C. Fluoride, total coliforms

D. **Organic material, chlorine**