Master Diver – Physics Revision Sheet

Facts

Sea water weights 64 lbs / cubic ft.
Fresh water weights 62.4 lbs / cubic ft.
Sea water exerts 1 ATM. pressure every 33 ft.
Fresh water exerts 1ATM. pressure every 34 ft.
Atmospheric Pressure @ sea level = 1 ATM or 14.7 p.s.i.
Absolute Pressure = Water Pressure + Atmospheric Pressure
Absolute Temperature
^{o}Kelvin = ^{o}Celsius + 273
^{o}Rankin = ^{o}Fahrenheit + 460
Air = 78.084% N2 + 20.946% O2 + 0.033% CO2 + 0.934 Inert gases

Equations

1. Absolute Pressure (ATA) = ($^{depth}/_{33}$) + 1 (or *34* if fresh water)
2. Wet weight = Dry weight – Buoyancy
3. Buoyancy = volume x *64* (or *62.4* if fresh water)
4. Surface Air Consumption (SAC) = $^{rate\ at\ depth}/_{ATA}$
5. Consumption Rate at depth = SAC x ATA
6. Cylinder contents = ($^{contents\ in\ psi}/_{working\ pressure}$) x Cylinder size in cubic ft
7. Cylinder contents = ($^{contents\ in\ cubic\ ft}/_{cylinder\ size}$) x working pressure in psi
8. Partial Pressure (pp) of a gas at depth = pp at surface x ATA

(note – No 7 and 8 - working pressure in commonly 3000 psi and cylinder size is commonly 80 Cubic ft.)

Gas Laws

Boyles Law – Pressure and volume of a gas in a flexible or open container are inversely proportional.

$P1\ V1 = P2\ V2$ (assuming temperature is constant)

Charles Law – Temperature and volume of a gas are directly proportional

$V1/T1 = V2/T2$ (assuming pressure is constant)

Amontons Law (also known as Lussacs Law) – Temperature and pressure are directly proportional

$P1/T1 = P2/T2$ (assuming volume is constant)

General Gas Law

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

** **always use absolute temperature and absolute pressure in the above equations**

Archimedes' Principle : an object partially or wholly immersed in a fluid is buoyed up by a force equal to the weight of the fluid displaced by that object.

Henry's Law: The amount of gas that will dissolve into solution is directly proportional to the partial pressure of the gas and inversely proportional to the absolute temperature.

Dalton's Law: The pressure exerted by a mixed gas is equal to the sum of the partial pressures of its components. (The partial pressure of a gas is the pressure it would exert if it alone occupied the entire volume of a mixture.)

Sample Questions.

Q1. What is the difference in weight between 5 cubic ft of sea water and 5 cubic ft of fresh water?

A1. Using the facts

Sea water weights 64 lbs / cubic ft.
Fresh water weights 62.4 lbs / cubic ft.

5 cubic ft of sea water weights 5 x 64 = 320 lbs
5 cubic ft of fresh water weights 5 x 62.4 = 312 lbs

therefore the difference is 320 – 312 = 8 lbs

Q2. How many 50 lb lift bags are required to recover an anchor from the ocean with a dry weight of 320 lbs and a volume of 2 cubic ft.?

A2. Using the following equations

2. Wet weight = Dry weight – Buoyancy
3. Buoyancy = volume x *64*

Buoyancy = 2 x 64 = 128 lbs
Wet weight = 320 – 128 = 192

Therefore total number of 50lb lift bags = $^{192}/_{50} = 4$

Q3. What is the absolute pressure at 57 ft of sea water?

A3.

Using the equation

1. Absolute Pressure (ATA) = ($^{depth}/_{33}$) + 1

ATA = ($^{57}/_{33}$) + 1 = 2.727 ATA

Q4. A balloon has a volume of 12 cubic inches at 33 fsw (feet of sea water) what is the volume at 132 fsw?

A4. Using equation

1. Absolute Pressure (ATA) = ($^{depth}/_{33}$) + 1

Absolute Pressure @ 33fsw (P1) = ($^{33}/_{33}$) + 1 = 2 ATA
Absolute Pressure @ 132fsw (P2) = ($^{132}/_{33}$) + 1 = 5 ATA

And then using Boyles Law

P1 V1 = P2 V2

2 x 12 = 5 x V2

V2 = $^{(2 \times 12)}/_{5}$ = 4.8 cubic inches

Q5. How much is an air consumption rate of 40 psi/min using a standard 3000psi / 80 Cubic ft tank in cubic ft per min.

A5. Using equation

6. Cylinder contents = ($^{\text{contents in psi}}/_{\text{working pressure}}$) x Cylinder size in cubic ft

Rate in cubic ft / min = ($^{40}/_{3000}$) x 80 = 1.067 cubic ft / min

Q6. If you have a SAC rate of 25 psi / min how long will a tank charged to 3000 psi last at 90ft if the diver wishes to start the asent with 1000 psi.

A6 Using equation

2. Absolute Pressure (ATA) = ($^{depth}/_{33}$) + 1

ATA @ 90ft = ($^{90}/_{33}$) + 1 = 3.7 ATA

And then

5. Consumption Rate at depth = SAC x ATA

Consumption Rate at 90ft = 25 x 3.7 = 92.5

The diver has 3000 psi but wishes to asend with 1000 remaining therefore we need to calculate how long 3000 – 1000 = 2000 psi will last

$^{2000}/_{92.5}$ = 21 mins. (approx.)

Q6. How much air (in cubic feet) is in a 3000 psi / 80- cubic ft tank when the guage reads 2400 psi ?

A6. Using equation

6. Cylinder contents = $(^{\text{contents in psi}}/_{\text{working pressure}})$ x Cylinder size in cubic ft

Cylinder contents in cubic ft = $(^{2400}/_{3000})$ x 80 = 64 cubic ft.

Q7. What is the ppO2 (partial pressure of oxygen) in ATA at 50ft

A7. Using equation

1. Absolute Pressure (ATA) = $(^{\text{depth}}/_{33})$ + 1

ATA = $(^{50}/_{33})$ + 1 = 2.5

And then

Air = 78.084% N2 + 20.946% O2 + 0.033% CO2 + 0.934 Inert gases
8. Partial Pressure (pp) of a gas at depth = pp at surface x ATA

ppO2 @ 50ft = .20946 x 2.5 = .52365 ATA

Q8. A diver is at 20ft in a lake, the temperature is 75 ^{o}F, she has 4 liters of air in her BC. She descends to 60ft where the temperature is 55 ^{o}F, how many liters of air is in her BC now ?

A8. Using **General Gas Law**

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

Remember to convert all pressures and temperatures to ABSOLUTE values, and note this is a LAKE .. so this must be FRESH water.

P1 = $(^{20}/_{34})$ + 1 = 1.59
V1 = 4 (** liters is a measure of volume)
T1 = 75 + 460 = 535
P2 = $(^{60}/_{34})$ +1 = 2.76
V2 = ??
T2 = 55 + 460 = 515

$$\frac{1.59 \times 4}{535} = \frac{2.76 \times V2}{515}$$

$$V2 = \frac{1.59 \times 4 \times 515}{535 \times 2.76} = 2.21$$