KEY

AP Biology Calculations Grid-Ins Review 2014-2015

A Reminder Regarding the Test Format:

The AP Biology Exam is approximately 3 hours in length. There are two sections.

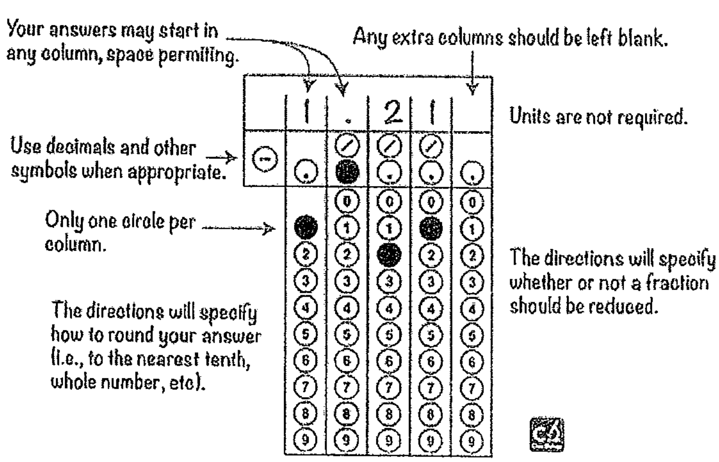
1. Section I is 90 minutes and consists of 63 multiple-choice questions and 6 grid-in questions accounting for 50 percent of the final score.

2. Section II is 90 minutes and consists of 2 long free-response questions and 6 short free-response questions accounting for 50 percent of the final score. It begins with a 10-minute reading period to read the questions and plan your answers. The remaining 1 hour and 20 minutes is for writing. The 2 long free-response questions should require about 20 minutes each to answer. Questions 3 through 8 are short free-response questions and should require about 6 minutes each to answer.

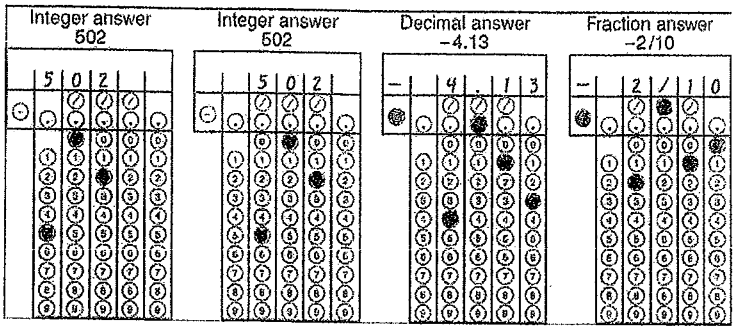
Calculation Grid-In Tips:

1. If a diagram is provided, analyze the diagram before you start calculating. You have to know what you are looking for!
2. They won't ask you for units in your answers on the calculation questions, but they may on the short / long response questions. However, looking at the units may give you a hint as to which term in the equation you are being asked to find.
3. Don't round your work until you get to the answer!
4. Read the directions carefully for each question you answer. The question will indicate whether you should round to the nearest whole number, tenth, hundredth, etc. If you round to a different place, your answer will be scored as INCORRECT!
5. With your four function calculator, there is no exponent function. You must use the "old school" method of multiplying a number by itself to square it.
   Example: $2^3 = 2 \times 2 \times 2 = 8$
6. You must be able to convert back and forth between scientific notation and whole numbers.
   Examples:
   - $5.1 \times 10^3 = 5100$
   - $6.2 \times 10^{-4} = 0.00062$
   - $442 = 4.42 \times 10^2$
   - $0.008 = 8.0 \times 10^{-3}$
7. If you want to "get rid" of an exponent on the variable you are solving for, take each side of the equation to the power of the inverse of the exponent
   Example: $X^{1/3} = 5$ can be adjusted to $(X^{1/3})^3 = (5)^3$ to isolate "X" and further simplified to $X = 125$

The "Grid-In Chart"



Acceptable Grid-In Responses:



AP Biology Formula Sheet – Page 1

Statistical Analysis and Probability

3 **Standard Error**

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

1 **Mean**

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

2 **Standard Deviation**

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$$

4 **Chi-Square**

$$\chi^2 = \sum \frac{(o-e)^2}{e}$$

Chi-Square Table

	Degrees of Freedom							
p	1	2	3	4	5	6	7	8
0.05	3.84	5.99	7.82	9.49	11.07	12.59	14.07	15.51
0.01	6.64	9.32	11.34	13.28	15.09	16.81	18.48	20.09

s = sample standard deviation (i.e., the sample based estimate of the standard deviation of the population)

$\bar{x}$ = mean

n = size of the sample

o = observed individuals with observed genotype

e = expected individuals with observed genotype

Degrees of freedom equals the number of distinct possible outcomes minus one.

Laws of Probability

If A and B are mutually exclusive, then P (A or B) = P(A) + P(B)

13 If A and B are independent, then P (A and B) = P(A) x P(B)

Hardy Weinberg Equations

10 $p^2 + 2pq + q^2 = 1$ p = frequency of the dominant allele in a population

$p + q = 1$ q = frequency of the recessive allele in a population

Metric Prefixes

Factor	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p

Mode = value that occurs most frequently in a data set

Median = middle value that separates the greater and lesser halves of a data set

Mean = sum of all data points divided by number of data points

Range = value obtained by subtracting the smallest observation (sample minimum) from the greatest (sample maximum)

Rate and Growth

5 **Rate**
dY/dt

Population Growth
dN/dt=B-D

14 **Exponential Growth**

$$\frac{dN}{dt} = r_{max}N$$

Logistic Growth

$$\frac{dN}{dt} = r_{max}N\left(\frac{K-N}{K}\right)$$

dY= amount of change

t = time

B = birth rate

D = death rate

N = population size

K = carrying capacity

r_{max} = maximum per capita growth rate of population

Water Potential (Ψ)

$\Psi = \Psi_P + \Psi_S$

Ψ_P = pressure potential

Ψ_S = solute potential

The water potential will be equal to the solute potential of a solution in an open container, since the pressure potential of the solution in an open container is zero.

12 **The Solute Potential of the Solution**

$\Psi_S = -iCRT$

i = ionization constant (For sucrose this is 1.0 because sucrose does not ionize in water)

C= molar concentration

R= pressure constant (R = 0.0831 liter bars/mole K)

T = temperature in Kelvin (273 + °C)

7 **Temperature Coefficient Q_{10}**

$$Q_{10} = \left(\frac{k_2}{k_1}\right)^{\frac{10}{t_2-t_1}}$$

Primary Productivity Calculation

8 mg O_2/L x 0.698 = mL O_2/L

mL O_2/L x 0.536 = mg carbon fixed/L

t_2 = higher temperature

t_1 = lower temperature

k_2 = metabolic rate at t_2

k_1 = metabolic rate at t_1

Q_{10} = the *factor* by which the reaction rate increases when the temperature is raised by ten degrees

Surface Area and Volume

Volume of Sphere
$V = 4/3\,\pi r^3$

Volume of a cube (or square column)
V = l w h

Volume of a column
11 $V = \pi r^2 h$

Surface area of a sphere
$A = 4\pi r^2$

Surface area of a cube
A = 6 a

Surface area of a rectangular solid
A = Σ (surface area of each side)

r = radius

l = length

h = height

w = width

A = surface area

V = volume

Σ=Sum of all

a = surface area of one side of the cube

Dilution - used to create a dilute solution from a concentrated stock solution

6 $C_iV_i = C_fV_f$

i=initial (starting) C = concentration of solute
f=final (desired) V = volume of solution

Gibbs Free Energy

15 $\Delta G = \Delta H - T\Delta S$

ΔG = change in Gibbs free energy

ΔS = change in entropy

ΔH = change in enthalpy

T = absolute temperature (in Kelvin)

9 **pH** = $-\log [H^+]$

#1: Mean

Why use this formula?

Use the mean formula when you want to calculate the average of a set of values (data points).

Formula

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Additional Information from the Formula Sheet

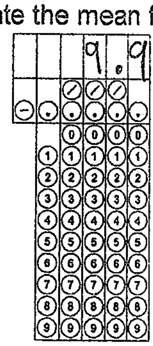
$\bar{x}$ = mean

n = size of the sample

Table 1. Combined Lengths of Crofton Weed Radicles and Shoots after One Week in the Dark and the Light

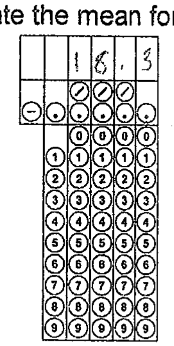
Petri Dish	Dark x_1(mm)	Light x_2(mm)
1	12	18 ✓
2	8 ✓	22 ✓
3	15 ✓	17 ✓
4	13 ✓	23 ✓
5	6 ✓	16 ✓
6	4 ✓	18
7	13 ✓	22 ✓
8	14 ✓	12 ✓
9	5 ✓	19 ✓
10	6 ✓	17 ✓
11	13 ✓	17 ✓

1. Calculate the mean for the weeds in the dark. Record your answer to the nearest tenth.



109/11 = 24.0

2. Calculate the mean for the weeds in the light. Record your answer to the nearest tenth.



201/11 = 18.3

3. Using the formula sheet calculate the median, mode, and range for the light and dark samples.

Dark Plants

Median: 12

Mode: 13

Range: 15 - 4 = 11

Light Plants

Median: 18

Mode: 17

Range: 23-12 = 11

#2: Standard Deviation

Why use this formula?

Use standard deviation formula to determine the amount by which your values (data points) typically differ from the mean value. In other words, the standard deviation determines the amount of variation in your data.

Helpful Videos

Bozeman Biology – Standard Deviation:
http://www.youtube.com/watch?v=09kiX3p5Vek&list=PLllVwaZQkS2omBpLjQm_BAQKsQ7lq86ku

Formula

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$$

Additional Information from the Formula Sheet

$\bar{x}$ = sample mean

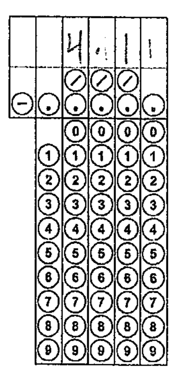
n = size of the sample

s = sample standard deviation (i.e., the sample-based estimate of the standard deviation of the population)

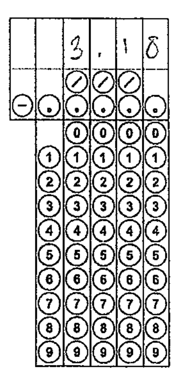
4. Calculate the standard deviation for the light and dark weeds in the data set below. Give the answer in mm to the hundredths

Petri Dish	Dark x_1(mm)	Light x_2(mm)
1	12 4.41	18 .09
2	8 3.61	22 13.69
3	15 26.01	17 1.69
4	13 9.61	23 22.09
5	6 15.21	16 5.29
6	4 34.81	18 .09
7	13 9.61	22 13.69
8	14 16.81	12 39.69
9	5 24.01	19 1.69
10	6 15.21	17 1.69
11	13 9.61	17 1.69

Dark



Light



Dark
Σ = 168.91 / 10
= √16.891
= 4.11

Light
Σ = 101.87 / 10
= √10.187
= 3.18

5. What does the standard deviation tell you about the data collected?

more [illegible] dark

#3: Standard Error

Why use this formula?

Use the standard error formula to determine the precision of the mean value. In other words, we are determining how confident we are in our mean value by considering both the standard deviation (s) and the number of data points (n). Typically, when we have more data points, we can be more confident in our data (i.e. a lower standard error).

Helpful Videos

Bozeman Biology – Standard Error: http://www.youtube.com/watch?v=BwYj69LAQOI

Formula

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

Additional Information from the Formula Sheet

$\bar{x}$ = sample mean

n = size of the sample

s = sample standard deviation (i.e., the sample-based estimate of the standard deviation of the population)

6. Calculate the standard error/standard error of the mean for the data set given in #1. Give the answer in mm to the nearest tenth.

Petri Dish	Dark x_1(mm)	Light x_2(mm)
1	12	18
2	8	22
3	15	17
4	13	23
5	6	16
6	4	18
7	13	22
8	14	12
9	5	19
10	6	17
11	13	17

Dark: 1.24

Light: .96

Dark

$SE_{\bar{x}} = \frac{4.11}{\sqrt{11}}$

$= \frac{4.11}{3.32}$

$= 1.24$

$\bar{X} = 9.9$

Light

$SE_{\bar{x}} = \frac{3.18}{\sqrt{11}}$

$= \frac{3.18}{3.32}$

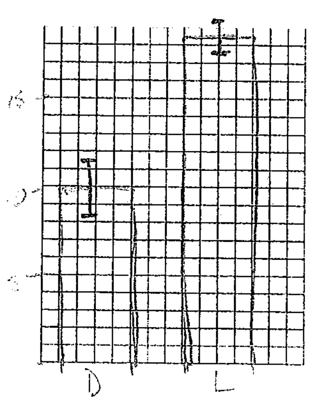
$= .96$

$\bar{X} = 18.3$

7. What does the standard error mean for this set of data?

Less variation in light

8. Use error bars to graph the standard error of the mean for the data set

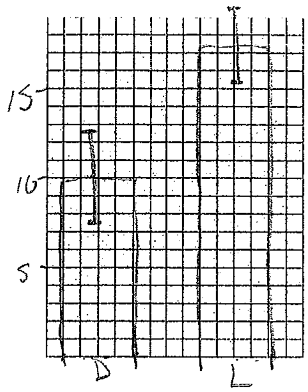


9. Graph the 95% confidence intervals for this set of data.
You can estimate the 95% confidence interval by making the bars twice as big as the standard error—this is a fairly accurate approximation for large sample sizes, but for small samples the 95% confidence intervals are actually more than twice as big as the SEMs.

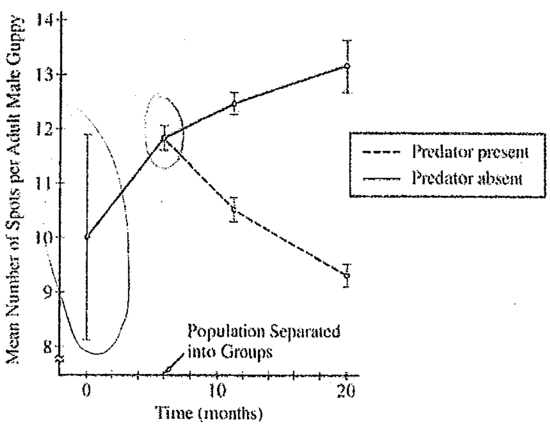
The actual formula for 95% CI = $\frac{2s}{\sqrt{n}}$ ** Not on the formula sheet

D: 2(1.24) = 2.48

L: 2(.96) = 1.92



10. What does the 95% Confidence Interval mean? variation



11. **Describe** the change in genetic variation in the population between 0 and 6 months and **provide** reasoning for your description based on the means and SEM.

0-6 months, variation decreased
Supported by the smaller error bars
at 6 months

#4: Chi Square

Why use this formula?

Use the Chi square formula to determine if there is a statistically significant difference between expected results (hypothesized results) and observed results (actually experimental data).

Helpful Videos

Bozeman Biology—Chi-squared Test:
https://www.youtube.com/watch?v=WXPBoFDqNVk

Formula

$$\chi^2 = \sum \frac{(o-e)^2}{e}$$

Additional Information from the Formula Sheet

CHI-SQUARE TABLE								
	Degrees of Freedom							
p	1	2	3	4	5	6	7	8
0.05	3.84	5.99	7.82	9.49	11.07	12.59	14.07	15.51
0.01	6.64	9.32	11.34	13.28	15.09	16.81	18.48	20.09

o = observed individuals with observed genotype
e = expected individuals with observed genotype

Degrees of freedom equals the number of distinct possible outcomes minus one.

$\frac{(o-e)^2}{e}$: 1 .17; 2 0; 3 .097; 4 .011 — χ^2 = .278

12. In pea plants, smooth seeds are dominant to wrinkled, and purple flowers are dominant to white. In a dihybrid cross where a 9:3:3:1 ratio is expected, the following data was collected:

    Smooth and Purple = 223
    Smooth and White = 84
    Wrinkled and Purple = 89
    Wrinkled and White = 33

    Determine the **chi-square value.** Round to nearest hundredths.

    3.90

13. Two Wisconsin fast plants are crossed. One has the recessive dwarf trait, but the normal pigment anthocyanin, while the other has the recessive anthocyaninless trait, but is on normal height. Their offspring consist of:

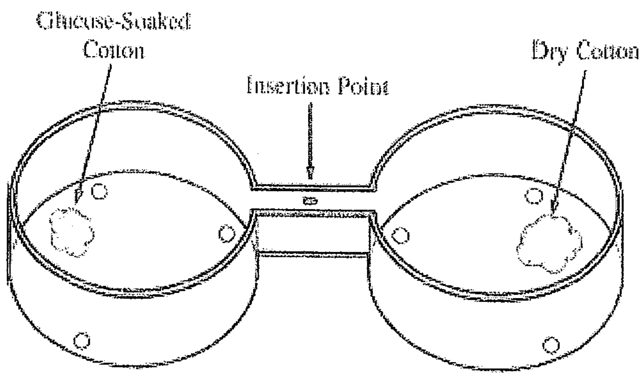
    89 plants of normal height and pigment = 93
    93 anthocyaninless plants and normal height = 93
    96 dwarf plants and normal pigment = 93
    94 anthocyaninless, dwarf plants = 93

    372 ÷ 4

    A student proposes that the parent plants' genotype must have been **ddAa** for the dwarf parent and **Ddaa** for the anthocyaninless parent. Calculate the **chi square value** that would be used to confirm this hypothesis. Round to nearest hundredths.

    .08

14.



Choice Chamber

In an investigation of fruit-fly behavior, a covered choice chamber is used to test whether the spatial distribution of flies is affected by the presence of a substance placed at one end of the chamber. To test the flies' preference for glucose, 60 flies are introduced into the middle of the choice chamber at the insertion point indicated by the arrow in the figure above. A cotton ball soaked with a 10% glucose solution is placed at one end of the chamber, and a dry cotton ball with no solution is placed at the other end. The positions of flies are observed and recorded every minute for 10 minutes.

(a) Predict the distribution of flies in the chamber after 10 minutes and justify your prediction. (2 points maximum) • even distribution

(b) Propose ONE specific improvement to each of the following parts of the experimental design and explain how the modification will affect the experiment.

The experiment described above is repeated with ripe bananas at one end and unripe bananas at the other end. Once again the positions of the flies are observed and recorded every minute for 10 minutes. The positions of flies after 1 minute and after 10 minutes are shown in the table below.

DISTRIBUTION OF FLIES IN CHOICE CHAMBER

Time (minutes)	Position in Chamber		
	End with Ripe Banana	Middle	End with Unripe Banana
1	21	18	21
10	45	3	12

(c)Perform a chi-square test on the data for the 10-minute time point in the banana experiment. Specify the null hypothesis that you are testing and enter the values from your calculations in the table below.

(d)Explain whether your hypothesis is supported by the chi-square test and justify your explanation.

PART (C): CHI-SQUARE CALCULATION

Null Hypothesis: Flies will be evenly distributed across the 3 parts of chamber

	Observed (o)	Expected (e)	$(o-e)^2/e$
End with ripe banana	45	20	31.25
Middle	3	20	14.45
End with unripe banana	12	20	3.2
Total	60	60	48.9

2° freedom

$p = .05 \rightarrow 5.99$

$X^2 = 48.9$

over, so I reject the null hypothesis

#5: Rate

Why use this formula?

Use the rate formula to determine how quickly a particular process is occurring over a given period of time.

Formula

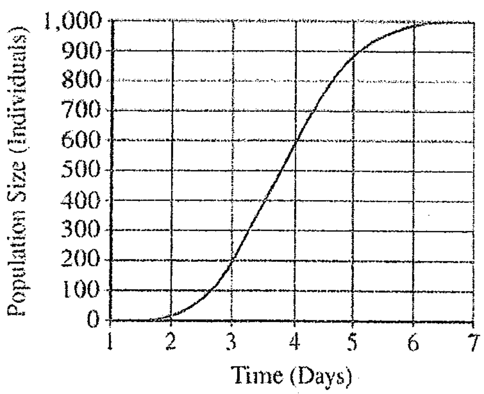
dY/dt

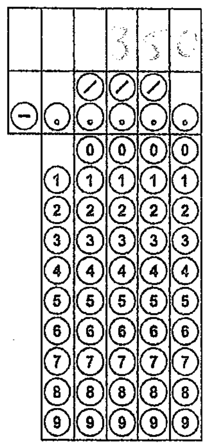
Additional Information from the Formula Sheet

dY= amount of change

t = time

15.





$\frac{900-200}{2}$

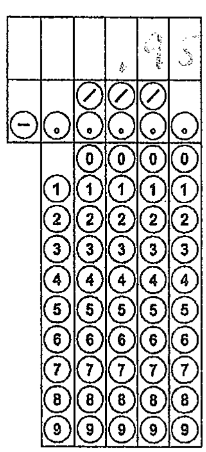
$\frac{700}{2} = 350$

Use the graph above to calculate the mean rate of population growth (individuals per day) between day 3 and day 5. Give your answer to the nearest whole number.

16.

Hydrogen peroxide is broken down to water and oxygen by the enzyme catalase. The following data were taken over 5 minutes. What is the **rate** of enzymatic reaction in mL/min from 2 to 4 minutes? Round to the <u>nearest hundreds.</u>

Time (mins)	Amount of O_2 produced (mL)
1	2.3
2	3.6
3	4.2
4	5.5
5	5.9



$\frac{5.5-3.6}{2} = .95$

#6: Dilution

Why use this formula?

Use this formula in the lab to create a dilute solution (high water, low solute) from a concentrated stock solution (low water, high solute).

Formula

$$C_i V_i = C_f V_f$$

Additional Information from the Formula Sheet

i = initial (starting)

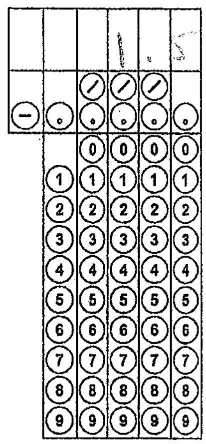
C = concentration of solute

f = final (desired)

V = volume of solution

17.

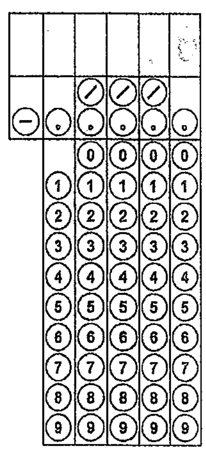
Joe has a 2 g/L solution. He dilutes it and creates 3 L of a 1 g/L solution. How much of the original solution did he dilute? Round to the nearest tenths.



2(V) = 1(3)

V = 1.5

18. Joe has 20 L of a 2 g/L solution. To this solution he adds 30 L of water. What is the final concentration of the solution? Round to the nearest tenth.



2(20) = C(50)

C = .8

#7: Q_{10}

Why use this formula?

The Q_{10} value represents the factor by which the rate of a reaction increases for every 10-degree rise in the temperature.

Helpful Videos

Bozeman Biology – Q10 – The Temperature Coefficient:
https://www.youtube.com/watch?v=UQWWSmGM0yQ

Formula

$$Q_{10} = \left(\frac{k_2}{k_1}\right)^{\frac{10}{t_2 - t_1}}$$

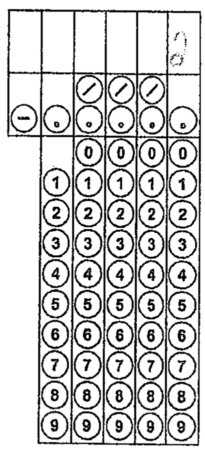
Additional Information from the Formula Sheet

t_2 = higher temperature
t_1 = lower temperature
k_2 = metabolic rate at t_2
k_1 = metabolic rate at t_1
Q_{10} = the *factor* by which the reaction rate increases when the temperature is raised by ten degrees

19.

Data taken to determine the effect of temperature on the rate of respiration in a goldfish is given in the table below. Calculate Q_{10} for this data. Round to the nearest whole number.

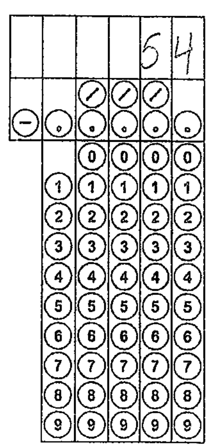
Temperature (C)	Respiration Rate (Min)
16	16
21	22



20. The rate of metabolism of a certain animal at 10°C, is 27 microliters O_2 $g^{-1}h^{-1}$. What is its rate of metabolism at 20°C if the Q10 is 2? Round to the nearest whole number.

$$2 = \left(\frac{k_2}{27}\right)^{\frac{10}{20-10}}$$

$k_2 = 54$



#8: Primary Productivity

Why use this formula?

The primary productivity formula can be used to determine the mass of carbon fixed to glucose during photosynthesis based on measurements of the amount of oxygen gas produced.

Formula

$mg\ O_2/L \times 0.698 = mL\ O_2/L$

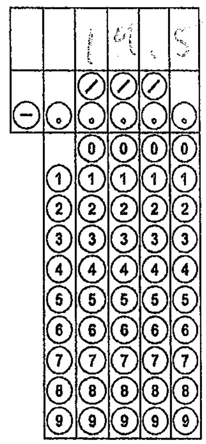
$mL\ O_2/L \times 0.536 = mg\ carbon\ fixed/L$

21. A scientist recorded the amount of dissolved oxygen produced by elodea, an underwater plant, as 52 mg O_2/L. How much carbon (in mg/L) was fixed by this plant? Round your answer to the nearest tenth.

52(.698) = 36.296

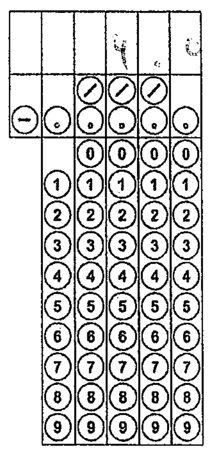
→ 36.296(.536)

= 19.45



22. An elodea plant fixed 1.5 mg carbon / L. How much dissolved oxygen (in mg / L) was produced by this plant?

$\frac{1.5}{.536}$ = $\frac{2.79}{.698}$ = 4.0



#9: pH

Why use this formula?

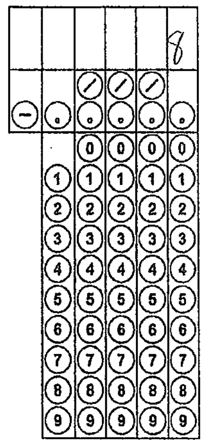
Use the hydrogen ion concentration of a solution to determine the pH or vice versa.

Formula

$$pH = -\log[H+]$$

23. What is the pH of a solution with a hydrogen ion concentration of 1.0×10^{-8}? Express your answer as a whole number.

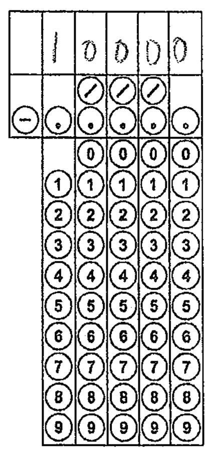
8



24. According to the Acid Rain Monitoring Project at the University of Mass, the pH measured at King Phillip Brook on April 10, 2012, was near 5, which the pH measured at Robbins Pond on that same date was near 9. Determine to the nearest whole number how many times greater the hydrogen ion concentration was at King Phillip Brook.

$9-5=4$

$10^4 = 10,000$



#10: Hardy Weinberg Equilibrium

Why use this formula?

The Hardy Weinberg formulas are used to determine the allele or genotype frequencies for a population of organisms that is not evolving.

Helpful Videos

Bozeman Biology – Solving Hardy Weinberg Problems

https://www.youtube.com/watch?v=xPkOAnK20kw

Formula

$p^2 + 2pq + q^2 = 1$

$p + q = 1$

Additional Information from the Formula Sheet

p = frequency of the dominant allele in a population

q = frequency of the recessive allele in a population

25. Express your answer to the question below as a whole number.

If 250 people out of a population of 1,000 are born with sickle-cell anemia, how many people in the population will be more resistant to malaria because they are heterozygous for the sickle-cell gene?

$q^2 = \frac{250}{1000} = .25$

$q = .5$

$p = .5$

$2pq = 2(.5)(.5) \times 1000$

$= 500$

500

26. Express your answer as a decimal between 0 and 1 to the nearest hundredth.

In a population of 250 peas, 16% of the peas are homozygous recessive wrinkled and the rest are smooth. What is the frequency of the dominant allele for smooth peas?

$q^2 = .16$

$q = .4$

$p = .6$

.6

#11: Surface Area and Volume

Why use this formula?

Biologists compare the surface area to volume ratio of cells of various shapes and sizes because this ratio is an indicator of the efficiency of transport across the cell membrane.

Formula

Volume of a Sphere

$V = 4/3\ \pi r^3$

Volume of a Cube (or Square Column)

$V = l\ w\ h$

Volume of a Column

$V = \pi r^2 h$

Surface Area of a Sphere

$A = 4\ \pi r^2$

Surface Area of a Cube

$A = 6\ a$

Surface Area of a Rectangular Solid

$A = \Sigma$ (surface area of each side)

r = radius

l = length

h = height

w = width

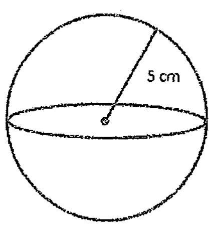
A = surface area

V = volume

Σ = Sum of all

a = surface area of one side of the cube

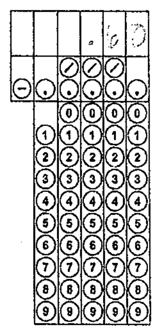
26. What is the SA/V for this cell? Round your answer to the nearest hundredth.



SA = $4\pi(5)^2$ = 314.159

V = $\frac{4}{3}\pi(5)^3$ = 523.598

$\frac{314.159}{523.598}$



27. A typical human lymphocyte has a radius of about 10 μm, while a typical bacterium (e.g., *S. pneumoniae*) has a radius of about 1 μm. Assuming that both cell types are perfectly spherical, how many times larger is the surface area of a typical human lymphocyte compared to the surface area of a typical bacterium?

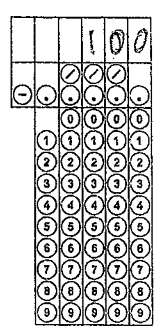
10   1

6a   6(1) = 6

6(10) = 60

$4\pi(10)^2$ = 1256 $4\pi(1)^2$ = 12.56

$\frac{1256}{12.56}$ = 100



#12: Water Potential and Solute Potential

Why use this formula?

The water potential and solute potential calculations help determine the direction of water movement (from a high water potential to a low / more negative water potential).

Helpful Videos

Bozeman Biology – Water Potential

https://www.youtube.com/watch?v=nDZud2g1RVY

Formula

Water Potential (Ψ)

$\Psi = \Psi p + \Psi s$

The Solute Potential of the Solution

$\Psi s = -iCRT$

Additional Information from the Formula Sheet

Ψp = pressure potential

Ψs = solute potential

The water potential will be equal to the solute potential of a solution in an open container, since the pressure potential of the solution in an open container is zero.

i = ionization constant (For sucrose this is 1.0 because sucrose does not ionize in water.)

C = molar concentration

R = pressure constant (R = 0.0831 liter bars/mole K)

T = temperature in Kelvin (273 + °C)

29. The molar concentration of a sugar solution in an open beaker has been determined to be 0.3M. Calculate the solute potential at 27 degrees Celsius. Round your answer to the nearest tenths.

		-	7	.	5

$\Psi s = -iCRT$

$= -(1)(.3)(.0831)(300)$

30. Scientists are trying to determine under what conditions a plant can survive. They collect the following data and would like to know the water potential of the plant cell. The solute potential is -0.6 MPa and the pressure potential is -1.0 MPa. What is the water potential? Round your answer to the nearest tenth.

$\Psi = \Psi p + \Psi s$

$= -1.0 + (-0.6) =$

$= -1.6$

		-	1	.	6

#13: The Laws of Probability

Why use this formula?

The Multiplication Law of Probabilities enables you to determine the probability that two events will occur simultaneously. The Addition Law of Probabilities enables you to determine the probability that one event OR another will occur.

Helpful Videos

Bozeman Biology – Probability in Genetics—Multiplication and Addition Rules:
https://www.youtube.com/watch?v=y4Ne9DXk_Jc

Formula

If A and B are mutually exclusive, then P (A or B) = P(A) + P(B)

If A and B are independent, then P (A and B) = P(A) x P(B)

31. A certain species of plant has four unlinked genetic loci, *W, X, Y,* and *Z*. Each genetic locus has one dominant allele and one recessive allele. For a plant with the genotype *WwXxYyZz*, what is the probability that the plant will produce a gamete with a haploid genotype of *Wxyz*? Give your answer as a fraction or as a value between 0 and 1, to four decimal places.

$$\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)\left(\frac{1}{2}\right) = .0625$$
$$= 1/16$$

.0625

32. In a population that is Hardy-Weinberg equilibrium, the frequency of the recessive allele is 0.3. What is the frequency of individuals that are homozygous and heterozygous for the dominant trait? Express your answer to the nearest hundredth.

$$q = .3$$
$$p = .7$$

$$p^2 + 2pq =$$
$$(.7)^2 + 2(.3)(.7) = .91$$

.91

#14: Population Growth

Why use this formula?

The population growth equations enable you to determine the rate of growth for population based on several factors including birth rate, death rate, carrying capacity (for logistic growth), etc.

Helpful Videos

Bozeman Biology – Exponential Growth
https://www.youtube.com/watch?v=c6pcRR5Uy6w
Bozeman Biology – Logistic Growth
https://www.youtube.com/watch?v=rXlyYFXyflM

Formula

Population Growth

$$dN/dt = B - D$$

Exponential Growth

$$\frac{dN}{dt} = r_{max} N$$

Logistic Growth

$$\frac{dN}{dt} = r_{max} N \left(\frac{K - N}{K} \right)$$

Additional Information from the Formula Sheet

B = birth rate
D = death rate
N = population size
K = carrying capacity
r_{max} = maximum per capita growth rate of population

33. A hypothetical population has a carrying capacity of 1,500 individuals and rmax is 1.0. What is the population growth rate for a population with a size of 1,600 individuals? Round your answer to the nearest ~~hundredth~~ tenth. What is happening to this population? declining

$$\frac{dN}{dt} = 1(1600)\left[\frac{1500-1600}{1500}\right]$$

$$= -106.67$$

-	1	0	6	.	7

34. (**Note**: For the question below, your answer should be expressed as ___.___ millions of people.)
In 2009, the US had a population of about 307 million people. If there were 14 births and 8 deaths per 1000 people, what was the country's net **population growth** that year (ignore immigration and emigration)? Round to nearest thousandths.

1	.	8	4	2

birth rate $= \frac{14}{1000} \times 307 = 4.298$

death rate $= \frac{8}{1000} \times 307 = 2.456$

$\frac{dN}{dt} = B - D = 4.298 - 2.456 = 1.842$ mill

35.
There are 2,000 mice living in a field. If 1,000 mice are born each month and 200 mice die each month, what is the per capita growth rate of mice over a month? Round your answer to the nearest tenth.

.	4

$\frac{\Delta N}{\Delta t} = B - D = 1000 - 200 = 800$

$\frac{\Delta N}{\Delta t} = r_{max} N$

$800 = r_{max}(2000)$

$r_{max} = .4$

#15: Gibbs Free Energy

Why use this formula?

Calculating the change in free energy enables you to determine whether the reaction is endergonic / anabolic (+ΔG, products have a higher free energy than reactants) or exergonic / catabolic (-ΔG, products have a lower free energy than reactants).

Helpful Videos

Bozeman Biology – Gibbs Free Energy

https://www.youtube.com/watch?v=DPjMPeU5OeM

Formula

$$\Delta G = \Delta H - T\Delta S$$

Additional Information from the Formula Sheet

ΔG = change in Gibbs free energy

ΔS = change in entropy

ΔH = change in enthalpy

T = absolute temperature (in Kelvin)

36. An experiment determined that when a protein unfolds to its denatured (D) state from the original folded (F) state, the change in **Enthalpy** is ΔH = H(D) – H(F) = 46,000 joules/mol. Also the change in **Entropy** is ΔS = S(D) – S(F) = 178 joules/mol. At a temperature of 20°C, calculate the change in Free Energy ΔG, in j/mol, when the protein unfolds from its folded state.

	-	6	1	5	4

$$\Delta G = \Delta H - T\Delta S$$

$$= 46,000 - (293)(178)$$

$$= 46,000 - 52,154$$

$$= -6,154$$