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## Numeric Response Practice (AP Review Notebook)

## Numeric Response

Questions 1-2 refer to the process of sodium and potassium transport. See the following equation.

$$
\begin{array}{ccc}
\text { ATP } & & \text { ADP } \\
+\mathrm{H}_{2} \mathrm{O} & & +\mathrm{H}_{2} \mathrm{PO}_{4}^{-} \\
+3 \mathrm{Na}^{+}{ }_{\text {INSIDE CELL }} & -> & +3 \mathrm{Na}^{+}{ }_{\text {oUTSIDE CELL }} \\
+2 \mathrm{~K}^{+}{ }_{\text {outSIIDE CELL }} & & +2 \mathrm{~K}^{+}{ }_{\text {INSIDE CELL }}
\end{array}
$$

1. How many molecules of ATP are required for the transport of 600 sodium ions out of the cell?
2. How many potassium ions can be transported into the cell with the hydrolysis of 200 ATP molecules?
3. At this moment your heart is pumping about 70 mL of blood per heartbeat and your heart is beating at a rate of 72 beats per minute. How many liters of blood will you pump in the next hour? (Answer to the nearest tenth).

Question 4 refers to the following graph.

4. Use the graph to calculate the mean rate of population growth per day between days 4 and 8 . Give your answers to the nearest whole number.
5. The loss of water by evaporation from the leaf openings is known as transpiration. The transpiration rates of various plants are shown below.


How many liters of water per week are lost by a coconut palm?
Questions 6-8 refer to the following graph of allele frequencies in a hypothetical population of tropical insects. Their color is determined by a single gene with two alleles. M (red) is dominant to m (black). Allele frequencies over 35 years are summarized as follows.

6. In 2005 , what percentage of the population is expected to be red?
7. In 1980, what percentage of red insects are heterozygous?
8. In 2005 , what percentage of the population is expected to be homozygous?
9. Based on the pedigree below, what is the probability that a male child born to individuals 6 and 7 will be color-blind?

10. A population of deer mice on an island has a carrying capacity of 350 individuals. If the maximum rate of increase is 1.0 per individual per year and the population size is 275 , determine the logistic population growth rate to the nearest mouse.

Questions 11-13 refer to the data below. The alleles show complete dominance (the heterozygote has the dominant phenotype). The population from which the data were taken has random mating. Assume all individuals are diploid.

| Generation | Number of Individuals <br> with the dominance <br> phenotype | Number of <br> individuals with the <br> recessive phenotype |
| :---: | :---: | :---: |
| 1 | 880 | 120 |
| 2 | 800 | 200 |
| 3 | 740 | 260 |
| 4 | 710 | 290 |
| 5 | 660 | 340 |
| 6 | 650 | 350 |
| 7 | 655 | 345 |

11. Estimate the number of recessive alleles in generation 1 of the population.
12. What is the change in the recessive allele frequency between generations 1 and 7 ? Provide your answer to the ones place (zero decimal places).
13. What percentage of the population in generation 5 is heterozygous? Provide your answer to the ones place (zero decimal places).
14. After seven days of growth, a plant's weight was 14.3 grams. The percent biomass of that plant was determined to be 23.1 percent. What amount of energy (in kcal) is stored in the plant, if the amount of stored energy $=(\mathrm{g}$ biomass) x 4.35 kcal ?
15. Simple cuboidal epithelial cells line the ducts of certain human exocrine glands. Various materials are transported into or out of the cell by diffusion. (The formula for the surface area of a cube is $6 \mathrm{x}^{2}$, and the formula for the volume of a cube is $S^{3}$, where $S=$ the length of a side of the cube.) How many of the small cell could fit inside the larger cell?

16. A cell is in equilibrium with its surroundings. The molarity of the surrounding solution is 0.8 M . Calculate the solute potential of the surrounding solution.

The equation for solute potential is: $\Psi_{s}=-i C R T$
where:
$\mathrm{i}=$ ionization constant (assume that it is 1 )
$\mathrm{C}=$ molar concentration
$\mathrm{R}=$ pressure constant $(\mathrm{R}=0.00831$ liter $\mathrm{MPa} /$ mole K$)$
$\mathrm{T}=$ temperature in Kelvin (assume a room temperature of 293 K )
17. If the pH of a solution is calculated using the equation $\mathrm{pH}=-\log \left[\mathrm{H}^{+}\right]$, what is the pH of a solution with a hydrogen ion concentration of $1.33 \times 10^{-8}$ ?
18. Glutamine is formed from glutamic acid by adding an ammonium molecule to glutamine. The overall reaction is endergonic, requiring $3.4 \mathrm{kcal} / \mathrm{mole}$. The energy for the reaction comes from the exergonic splitting of a phosphate from ATP to form ADP, which releases $7.3 \mathrm{kcal} / \mathrm{mole}$. What is the free energy change for this coupled reaction?
19. Potato cores were placed in solutions of varying concentrations and were found to neither gain nor lose mass in a sucrose solution of 0.32 M . Use this information to calculate the solute potential of the potato cores. The temperature of the solution is $22^{\circ} \mathrm{C}$.
20. The bacteria that cause pimples can be grown in the lab using a suitable nutrient broth, where they will eventually achieve exponential growth. Using the graph that follows, calculate the mean rate of growth, in millions of bacteria per hour, during their exponential phase.


Questions 21-22 refer to the following graphs.

21. Calculate the activation energy $\left(\mathrm{E}_{\mathrm{A}}\right)$ of the process represented in graph A .
22. Calculate the free energy change $(\Delta \mathrm{G})$ of the process represented in graph B .
23. The following chart shows the energy products produced in various stages of the breakdown of glucose.

| Process | ATP <br> Produced | NADH/FADH <br> 2 |
| :---: | :---: | :---: |
| Produced |  |  |$|$| Glycolysis | 2 | NADH |
| :---: | :---: | :---: |
| Pyruvate Oxidation <br> (per molecule of pyruvate) |  | 1 NADH |
| Citric Acid (Krebs) Cycle <br> per molecule of pyruvate | 1 | $3 \mathrm{NADH}_{2}$ |

Each molecule of NADH results in approximately 2.5 molecules of ATP, whereas each molecule of FADH 2 results in approximately 1.5 molecules of ATP when these molecules are fed into the electron transport chain.

What is the difference in the total number of ATP molecules produced between three molecules of glucose that undergo fermentation compared to three molecules of glucose that undergo aerobic respiration?
24. What is the water potential for a solution that is 0.1 M ? The solution is in an open container. The equation for water potential is:
water potential $(\Psi)=\operatorname{pressure}$ potential $\left(\Psi_{p}\right)+$ solute potential $\left(\Psi_{s}\right)$
The equation for solute potential is:
$\Psi_{\mathrm{s}}=-\mathrm{iCRT}$
where:
$\mathrm{i}=$ ionization constant (assume that it is 1 )
$\mathrm{C}=$ molar concentration
$\mathrm{R}=$ pressure constant $(\mathrm{R}=0.00831$ liter $\mathrm{MPa} / \mathrm{mole} \mathrm{K})$
$\mathrm{T}=$ temperature in Kelvin (assume a room temperature of 293 K )
25. An enzyme in the liver removes a phosphate group from glucose so the glucose molecule can enter the bloodstream, providing energy for cellular respiration to the cells of the body. The rate of enzyme activity can be monitored by measuring the phosphate concentration over time.

Data from the experiment:

| Time <br> $(\mathbf{m i n})$ | Phosphate <br> Concentration <br> $(\boldsymbol{\mu m o l} / \mathbf{m L})$ |
| :---: | :---: |
| 0 | 0 |
| 5 | 10 |
| 10 | 90 |
| 15 | 180 |
| 20 | 270 |

What is the rate of phosphate formation per minute from 5 to 15 minutes?
26. In a certain species of plant, the allele to produce green melons (G) is dominant over the allele to produce yellow melons (g). A student performed a cross between a plant that produced green melons and a plant that produced yellow melons. When the student observed the next generation, the 94 seeds that were produced from the cross matured into 53 plants with green melons and 41 plants with yellow melons. Calculate the chi-squared value for the null hypothesis that the green-melon parent was heterozygous for the melon-color gene.
27. A certain mutation found in fruit flies (Drosophila melagaster) is hypothesized to be autosomal recessive. The experimenter crossed two Drosophila flies that were heterozygous for the trait. The next generation produced 80 wild-type males, 65 wild-type females, 26 males with the mutation, and 40 mutant females. Calculate the chi-square value for the null hypothesis that the mutation is autosomal recessive.
28. Calculate the number of different gametes that can be produced by a plant that is heterozygous for seed shape and color, flower color, and stem length.
29. In E. coli the DNA is $24 \%$ adenine. Based on this, what percentage of this DNA is guanine?
30. In pea plants $\mathrm{T}=$ tall, $\mathrm{t}=$ dwarf, $\mathrm{R}=$ round seeds, and $\mathrm{r}=$ wrinkled seeds. If a TtRr plant is crossed with a Ttrr plant, what fraction of the offspring will be tall and wrinkled?
31. On average, there is a 90 percent reduction of productivity for each trophic level. Based on this information, 10,000 pounds of grass should be able to support how many pounds of crickets?
32. In a population of king snakes the banded pattern $(B)$ is dominant to no banding $(b)$. If $12 \%$ of the population shows no banding, what percentage of the population, to the nearest tenth, is heterozygous for banding?
33. Results of a Drosophila mating between $\mathrm{F}_{1}$ flies resulted in 58 flies showing red eyes (a dominant trait) and 42 flies showing sepia eyes (recessive). Calculate the Chi-square value for the hypothesis that both $\mathrm{F}_{1}$ flies were heterozygous for eye color. Give your answer to the nearest tenth.
34. In a population of turtles, the allele that causes a yellow shell $(\mathrm{Y})$ is dominant to the allele that results in a red shell (y). If the dominant allele is present in the population at the 0.72 level and the population is in Hardy-Weinberg equilibrium, what percent of the population would be expected to have a red shell? Express your answer to the nearest tenth of a percent.
35. A cross of a red-flowered snapdragon produced 95 pink plants and white plants. What is the chi-square value for this result if the probability that the result was due to chance is $1 \%$.
36. Compare the number of $\mathrm{H}+$ ions in a solution with a pH of 2 to a solution with a pH of 6 . If appropriate, include a negative sign in your answer.
37. In snapdragon plants that display intermediate dominance, the allele $\mathrm{C}^{\mathrm{R}}$ produces red flowers and $\mathrm{C}^{\mathrm{W}}$ produces white flowers. In a homozygous red-flowered snapdragon is crossed with a homozygous white-flowered snapdragon, what will the percentage of pink offspring be?
38. The figure provides information about radiometric dating. Note that the radioactive "parent" isotope decays to a daughter "isotope" at a constant rate. The age of artifacts containing wood can be dated accurately to about 75,000 years old using carbon dating. The half-life of radioactive decay of carbon-14 to carbon-12 is about 5,730 years. In a sample to be analyzed, the carbon-14 to carbon-12 is $1 / 8$. What is your estimate of the age of the artifact to the nearest year?

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39. In a diploid organism with the genotype AaBbCCDDEE , how many genetically distinct kinds of gametes would be produced?
40. In fruit flies gray body is dominant to black body and normal wings are dominant to vestigial wings. Flies heterozygous for both gray bodies and normal wings were crossed with flies that had black bodies and vesigial wings. The following results were obtained:

| Phenotype | Number of Flies |
| :---: | :---: |
| Gray body/Normal wings | 482 |
| Black body/Vestigial wings | 472 |
| Black body/Normal wings | 92 |
| Gray body/Vestigial wings | 103 |

The results indicate that the genes for wings and body color are on the same chromosome. The recombinant offspring are a result of crossing over. How many map units (expressed as a percent) apart are the two genes? The formula for calculating recombination frequency is:

Recombination frequency $=$ number of recombinants/total number of offspring $x 100$
41. Ecologists often cannot count all the individuals in a population. In such cases, the mark-recapture method may be used to estimate population size. An ecologist wished to estimate the population of snapping turtles in an isolated farm pond. On the first trapping 19 turtles were caught and marked with a harmless mark on the top of the shell. Two weeks later a second trapping was conducted where 22 turtles were caught, of which 9 were marked using the formula
$\mathrm{N}=s n / x$
where $\mathrm{N}=$ population size estimate, $\mathrm{s}=$ number of turtles marked in the first trapping, $\mathrm{n}=$ number of turtles caught in the second trapping, and $\mathrm{x}=$ number of turtles that were marked in the second trapping, what is the population estimate of snapping turtles to the nearest hundredth?
42. Twenty people decide to start a new population, totally isolated from anyone else. Two of the individuals are heterozygous for a recessive allele, which in homozygotes causes cystic fibrosis. Assuming this population is in Hardy-Weinberg equilibrium, what fraction (expressed as a decimal) of people in this new population will have cystic fibrosis?

Questions 43-44 refer to the following table.

| Location | Substrate | Product | NADH | FADH $_{2}$ | ATP |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Cytosol | Glucose | 2 pyruvate | 2 | 0 | 2 |
| Mitochondria | Pyruvate | Acetyl-CoA $+\mathrm{CO}_{2}$ | 1 | 0 | 0 |
| Mitochondria | Acetyl-CoA | $2 \mathrm{CO}_{2}$ | 3 | 1 | 1 |
| Mitochondria | Palmitoyl-CoA | 8 Acetyl-CoA | 7 | 7 | 0 |

43. According to the table, how many NADH are produced from the complete oxidation of 1 molecule of palmitoyl-CoA to 16 carbon dioxide molecules?
44. How many pruvate molecules need to be completely oxidized to carbon dioxide to produce 24 NADH molecules?
45. A population of 20 bobcats was introduced to a barrier island to help control the large rodent population. The bobcat population's birth rate is 0.48 bobcats/year per capita, and the death rate is 0.21 bobcats/year per capita. Given the initial bobcat population, predict the population size after 2 years on the island. (Round to the nearest whole number).

Question 46 refers to the following data taken from osmosis experiments on potato cores.

46. What is the solute concentration of the potato cells? Record your answer to two decimal places (hundredth place).
47. In a population of grasshoppers, the allele for tan color is dominant to the allele for green color. A drastic increase in rainfall leads to selection against the tan phenotype. When the rainy season ends, 23 percent of the remaining grasshoppers have the green phenotype. If this population is now in Hardy-Weinberg equilibrium, what will the frequency of the tan allele be in the next generation?
48. In a population of trogons (a type of bird) tail banding $(B)$ is dominant to no tail banding $(b)$. If $68 \%$ of the population shows tail banding, what percentage of the population to the nearest tenth, is heterozygous for tail banding?
49. The trophic level efficiency of large herbivores such as elks is frequently only about 5 percent. In tons, what volume of plants would be required to maintain $24,000 \mathrm{lbs}$ of elk?
50. A linear strip of DNA has two restriction sites for the restriction enzyme EcoRI and three restriction sites for the restriction enzyme Hind III. If the strip of DNA was incubated with the restriction enzymes then the cut DNA was collected and run on an electrophoretic gel, how many bands would be expected on the gel?
51. If $\mathrm{C}_{\mathrm{i}} \mathrm{V}_{\mathrm{i}}=\mathrm{C}_{\mathrm{f}} \mathrm{V}_{\mathrm{f}}$, where $i$ is the initial solution concentration and $f$ is the final concentration, how many milliliters of a 0.5 M glucose solution would you need in order to make 250 milliliters of a 0.1 M glucose solution?
52. Treatment of tomato plants with a growth hormone yielded the following weights of tomatoes: $100 \mathrm{~g}, 86 \mathrm{~g}, 123 \mathrm{~g}$, $98 \mathrm{~g}, 104 \mathrm{~g}, 71 \mathrm{~g}$. What is the average weight of a tomato after treatment?
53. A woman with blood genotype $I^{A_{i}}$ and a man with blood genotype $I^{B i}$ have two children, both type $A B$. What is the probability that a third child will be blood type AB ?
54. Using the figure below, approximately how long ago did the last common ancestor for gibbons, orangutans, gorillas, chimpanzees, and humans diverge?

55. The radioisotope potassium- 40 can be used to date past events older than 60,000 years. Potassium- 40 has a half life of 1.3 billion years, decaying into Argon-40. If the igneous rock layer that scientists wish to date shows a ratio of Potassium-40 to Argon-40 at one-fourth the current ratio, what is the age of the rock layer? Express your answer in billions of years.
56. A yeast cell in the early portion of interphase of meiotic cell division has 24 fg of DNA ( $\mathrm{fg}=1 \times 10^{-15}$ grams). If the yeast cell completes meiotic division to form four haploid cells, how many fg of DNA would be expected in each haploid cell?
57. Determine the surface area-to-volume ratio for a cube that has a side length of 2.5 cm . The volume of a cube $=$ $(l)(w)(h)$. The surface area $=6 \mathrm{x}$ area of a single side.
58. Under favorable conditions, bacteria divide every 20 minutes. If a single bacterium replicated according to this condition, how many bacterial cells would one expect to find at the end of three hours?
59. A group of 100 Daphnia, small crustaceans known as water fleas, were placed in one of three culture jars of different sizes to determine their reproductive rate. The graph below shows the average number of offspring produced per female each day in each jar of pond water.


Key: (A) Water fleas in a 1-liter jar of pond water
(B) Water fleas in a 0.5 -liter jar of pond water
(C) Water fleas in a 0.25 -liter jar of pond water

What is the total number of offspring found in the 0.5 -liter jar on the twentieth day, assuming all survive?
60. An enzyme in the liver removes a phosphate group from glucose so the glucose molecule can enter the bloodstream, providing energy for cellular respiration to the cells of the body. The rate of enzyme activity can be monitored by measuring the phosphate concentration over time. In this experiment, liver cells were placed in a phosphate solution, and every 5 minutes cells were removed and the intracellular concentration of phosphate was measured. What is the rate of phosphate formation per minute from 15 to 20 minutes?

| Time <br> $(\mathbf{m i n})$ | Phosphate <br> Concentration <br> $(\boldsymbol{\mu m o l} / \mathbf{m L})$ |
| :---: | :---: |
| 0 | 0 |
| 5 | 10 |
| 10 | 90 |
| 15 | 180 |
| 20 | 270 |

