

BASIS PEORIA PACKET

TOSS-UP

1) BIO– *Multiple Choice* What receptors are present at the postganglionic ends of parasympathetic nerves?

W) Nicotinic Acetylcholine Receptor
X) Muscarinic Acetylcholine Receptor
Y) Alpha Adrenergic Receptor
Z) Beta Adrenergic Receptor

ANSWER: X) Muscarinic Acetylcholine Receptor

BONUS

1) BIO– *Short Answer* As end-diastolic volume increases, the stroke volume increases due to an increased contraction strength of the heart. What is the name for the law that describes this principle?

ANSWER: Frank - Starling Law (ACCEPT: Starling's Law of the Heart)

TOSS-UP

2) CHEM– *Multiple Choice* When the following components are mixed in equivalent amounts, which solution would have the highest buffer capacity?

W) 1 M H_2SO_4 (aq) and 1M NaOH (aq)
X) 0.3 M HCl (aq) and 0.5M NH_3 (aq)
Y) 2 M $HC_2H_3O_2$ (aq) and 2.7 M KOH (aq)
Z) 1.2 M HF (aq) and 1.1 M NaF (aq)

ANSWER: Z) 1.2 M HF (aq) and 1.1 M NaF (aq)

BONUS

2) CHEM– *Short Answer* The equilibrium constant for the autoionization of water at a certain temperature is 1.0 x 10 ^ -12. If the pKa of a certain acid is 3.4 then what is the pKb of its conjugate base in the solution to 2 significant figures.

ANSWER: 8.6

TOSS-UP

3) PHYSICS – *Short Answer* Sand drops vertically at a very small velocity at a rate of 6 kg/s into a moving cart. You apply a force to the cart in order to keep it moving at a constant speed 5 m/s. How much energy is lost to friction per unit time?

ANSWER: 75 J/S

BONUS

3) PHYSICS – *Multiple Choice* What is the name of the magnetic analog of Ohm's Law?

W) Lorentz force law
X) Biot-Savart law
Y) Ampere's law
Z) Hopkinson's law

ANSWER: Z) HOPKINSON'S LAW

TOSS-UP

4) MATH– *Short Answer* How many distinct ways can four people be seated around a table if 2 of the people cannot be seated next to each other?

ANSWER: 2

BONUS

4) MATH– *Short Answer* Sanjay and Ne are playing a game. In the first round of the game, they each have a ½ chance of winning. The winner of each round has his chances of winning halved for the next round. Expressing your answer as a fraction in lowest terms, what is the chance that Ne wins at least 1 of the first 4 rounds?

ANSWER: 1023/1024

TOSS-UP

5) ESS– *Multiple Choice* The Farallon Plate was one of three large tectonic plates that made up the great "all sea" Panthalassa before the breakup of Pangaea. Which of the following plates is not a remnant of the Farallon Plate?

W) Mariana Plate
X) Explorer Plate
Y) Nazca Plate
Z) Gorda Plate

ANSWER: W) MARIANA PLATE

BONUS

5) ESS– *Short Answer* When mica-containing rocks undergo metamorphism and become foliated, they may turn into one of three different types of rock: phyllite, slate, or schist,

depending on how large the resultant mica flakes are. Order these three rock types from largest flake average flake size to smallest average flake size.

ANSWER: SCHIST, PHYLLITE, SLATE

TOSS-UP

6) ENERGY – *Short Answer* The MicroBooNE experiment at SLAC National Accelerator Lab has found evidence that sterile neutrinos may not be necessary to explain prior anomalous data. Sterile neutrinos would differ from active neutrinos in what property?

ANSWER: CHIRALITY (ACCEPT ISOSPIN)

BONUS

6) ENERGY – *Short Answer* Researchers at Princeton Plasma Physics Laboratory are studying magnetic reconnection in black holes and neutron stars. Magnetic reconnection in black holes and neutron stars is caused by what type of instability in plasma?

ANSWER: MAGNETOROTATIONAL INSTABILITY

TOSS-UP

7) BIO– *Multiple Choice* According to the Island Equilibrium Model, which of the following island parameters would experience the greatest amount of immigration?

W) Small, Close to Mainland
X) Small, Far from Mainland
Y) Large, Close to Mainland
Z) Large, Far from Mainland

ANSWER: Y) Large, Close to Mainland

BONUS

7) BIO– *Short Answer* Identify all of the following 4 hormones that are secreted by the thyroid gland: (1) Triiodothyronine, (2) Parathyroid Hormone, (3) Calcitonin, (4) Thyroxine.

ANSWER: 1, 3, and 4

TOSS-UP

8) CHEM– *Short Answer* A reaction has a zero order reaction rate. If the first halflife of the reaction was 500 seconds, how long is the second halflife?

ANSWER: 250 seconds

BONUS

8) CHEM– *Multiple Choice* Which of the following is true of free radicals?

W) Electron donating groups stabilize radicals by decreasing the total energy of the MO system and decreasing the energy of the SOMO
X) Electron donating groups stabilize radicals by decreasing the total energy of the MO system and increasing the energy of the SOMO
Y) Electron donating groups stabilize radicals by increasing the total energy of the MO system and decreasing the energy of the SOMO
Z) Electron donating groups stabilize radicals by increasing the total energy of the MO system and increasing the energy of the SOMO

ANSWER: X

TOSS-UP

9) PHYSICS – *Short Answer* Bell's theorem was introduced to resolve what paradox in quantum mechanics?

ANSWER: EPR PARADOX

BONUS

9) PHYSICS – *Short Answer* A car of length 1 m is going at relativistic speed 0.5c when it collides with a wall. Assuming all signals travel at the speed of light c, if you are stationary with respect to the wall, how far in meters do you measure the back end of the car to be from the wall the instant before it stops?

W) √(1/3)

X) √(3/4)

Y) √(4/3)

Z) √3

ANSWER: W) √(1/3)

TOSS-UP

10) MATH– *Short Answer* How many trailing zeros are in the binary representation of 25 factorial?

ANSWER: 22

BONUS

10) MATH– *Short Answer* What is the average value of sin^3(x)*cos^2(x) from x=0 to 2*pi?

ANSWER: ZERO

TOSS-UP

11) ESS– *Multiple Choice* Hot Jupiters are gas giant exoplanets that orbit extremely close to their stars. Which of the following processes is most likely responsible for the existence of Hot Jupiters?

W) Accretion of stellar wind material onto a rocky core
X) Drag on a pre-existing gas giant due to the protoplanetary disk
Y) Stellar capture of a sub-brown dwarf
Z) Removal of material from a binary companion by the host star

ANSWER: X) DRAG ON A PRE-EXISTING GAS GIANT DUE TO THE PROTOPLANETARY DISK

BONUS

11) ESS– *Short Answer* Wolf-Rayet stars that have lost most or all of their hydrogen and helium envelopes will explode as what specific type of supernova?

ANSWER: TYPE IC (TYPE ONE C)

TOSS-UP

12) ENERGY– *Short Answer* Scientists at Pacific Northwest National Laboratory are studying the role of unfolded proteins in the development of Middle Eastern Respiratory Syndrome, also known as MERS. The causative agent of MERS is a member of what group of RNA viruses?

ANSWER: CORONAVIRUSES

BONUS

12) ENERGY– *Short Answer* Researchers at Brookhaven National Laboratory have discovered a new sterol that is involved in the formation of oil droplets in plants. Unlike plants, which primarily utilize Beta-Sitosterol, fungi primarily utilize what sterol compound instead?

ANSWER: ERGOSTEROL

TOSS-UP

13) BIO– *Multiple Choice* Which of the following does not develop from the mesoderm?

W) Lymph Nodes
X) Dermis
Y) Heart
Z) Adrenal Medulla

ANSWER: Z) ADRENAL MEDULLA

BONUS

13) BIO– *Short Answer* Rank the following 4 molecules in order of increasing size: (1) Low-Density Lipoprotein, (2) Chylomicron, (3) High-Density Lipoprotein, (4) Very-Low Density Lipoprotein.

ANSWER: 3, 1, 4, 2

TOSS-UP

14) CHEM– *Short Answer* Rank the following three ionic salts assuming standard conditions and assuming identical solubility product constants with value less than 1, in order of increasing solubility: (1) NaCl, (2) AlCl3, (3) PbCl2

ANSWER: 1, 3, 2

BONUS

14) CHEM– *Multiple Choice* Which of the following is not a protecting group for amines?

W) Carboxybenzyl
X) Tetrahydropyranyl
Y) t-Butyloxycarbonyl
Z) Fluorenylmethyloxycarbonyl

ANSWER: X) Tetrahydropyranyl

TOSS-UP

15) PHYSICS – *Multiple Choice* A regular hexagon has a moment of inertia around a diameter of 24 kg m^2. What is the moment of inertia about a line perpendicular to its diameter and passing through the center of mass?

W) 24 kg m^2
X) 48 kg m^2
Y) 12 kg m^2
Z) 576 kg m^2

ANSWER: X) 48 kg m^2

BONUS

15) PHYSICS – *Multiple Choice* If a soap film is bounded by two circular rings, what shape will it assume?

W) Catenoid
X) Cylinder
Y) Troposkein
Z) Hyperboloid

ANSWER: W) CATENOID

TOSS-UP

16) MATH– *Short Answer* What is the divergence of the vector field x^2 i hat + y^2 j hat + z^3 k hat at the point (1,1,1)?

ANSWER: 7

BONUS

16) MATH– *Short Answer* Suppose a normalized bell curve is centered at the origin with a standard deviation of 5. What is the integral of the curve from x=-10 to x=10? Give your answer to 2 significant figures.

ANSWER: 0.95

TOSS-UP

17) ESS– *Short Answer* When rock is weathered off the edge of a continental shelf, it can become mixed with ocean water and flow as a muddy cloud down to the continental rise, where it can be deposited and lithified to form what type of clastic sedimentary rock?

ANSWER: TURBIDITE

BONUS

17) ESS– *Multiple Choice* Which of the following best explains why cumulonimbus clouds usually only extend to the tropopause and no further?

W) Stratospheric air is not dense enough to form clouds
X) Moist air parcels are too buoyant above the tropopause to extend the cumulonimbus cloud into the stratosphere
Y) Ozone in the stratosphere attacks water vapor and limits the moisture content of air parcels
Z) The temperature inversion in the stratosphere prevents moist air parcels from rising beyond the tropopause

ANSWER: Z) THE TEMPERATURE INVERSION IN THE STRATOSPHERE PREVENTS MOIST AIR PARCELS FROM RISING BEYOND THE TROPOPAUSE

TOSS-UP

18) ENERGY– *Short Answer* Researchers at Argonne National Laboratory are studying the composition of Earth's atmosphere following its impact with Theia. What process, in which gasses are emitted from inside the planet, is believed to be responsible for this atmosphere?

ANSWER: OUTGASSING

BONUS

18) ENERGY– *Multiple Choice* Researchers at Pacific Northwest National Laboratory are studying the Madden-Julian Oscillation, an eastward-moving weather pattern centered on the tropics. Which of the following is the structure of the Madden-Julian Oscillation?

W) High pressure zone to the west, low pressure zone to the east
X) High pressure zone to the east, low pressure zone to the west
Y) High pressure zone to the north, low pressure zone to the south
Z) High pressure zone to the south, low pressure zone to the north

ANSWER: W) HIGH PRESSURE ZONE TO THE WEST, LOW PRESSURE ZONE TO THE EAST

TOSS-UP

19) BIO– *Short Answer* Crohn's Disease and Ulcerative Colitis are both examples of what group of gastrointestinal diseases?

ANSWER: INFLAMMATORY BOWEL DISEASES (ACCEPT: IBD's)

BONUS

19) BIO– *Short Answer* Identify all of the following 4 diseases that follow an autosomal dominant inheritance pattern: (1) Marfan's Syndrome, (2) Rett's Syndrome, (3) Cystic Fibrosis, (4) Polydactyly.

ANSWER: 1 AND 4

TOSS-UP

20) CHEM– *Short Answer* Identify all of the following three that are true during the condensation of water at boiling temperature: (1)$\Delta G = 0$, (2)$\Delta H=\Delta S$, (3)$\Delta T=0$

ANSWER: 1 AND 3

BONUS

20) CHEM– *Multiple Choice* Which of the following elements has the lowest melting point?

W) Be [Beryllium]
X) Mg [Magnesium]
Y) Ca [Calcium]
Z) Sr [Strontium]

ANSWER: X) Mg

TOSS-UP

21) PHYSICS – *Multiple Choice* What is the term for the ratio of the focal length of a camera to the diameter of its entrance?

W) Radius of confusion
X) Relative aperture
Y) F-number
Z) Field stop

ANSWER: Y) F-NUMBER

BONUS

21) PHYSICS – *Short Answer* What is the capacitance of a spherical capacitor with outer radius 6 meters and inner radius 4 meters? Give your answer to 1 significant figure in scientific notation.

ANSWER: 1 x 10^-9 FARADS

TOSS-UP

22) MATH– *Short Answer* How many of the lattice points on the line x+y=7 in the first quadrant lie inside the circle with equation x^2+y^2=30?

ANSWER: 4

BONUS

22) MATH– *Multiple Choice* Suppose a monic cubic polynomial has last term +9, and roots a+bi, a-bi, and -1. Which of the following cannot be the value for a?

W) 1
X) 2
Y) 3
Z) 4

ANSWER: Z) 4

TOSS-UP

23) ESS– *Multiple Choice* Given that the center of mass of the Sun-Jupiter system is 750 thousand kilometers from the center of the Sun, which of the following is closest to the mass of the Sun as measured in Jupiter masses? Assume Jupiter orbits the sun in a circular path with a radius of 5 astronomical units.

W) 500
X) 1000
Y) 2000
Z) 4000

ANSWER: X) 1000

BONUS

23) ESS– *Short Answer* Identify all of the following three layers of the Sun in which the environmental lapse rate exceeds the adiabatic lapse rate of the material present in that layer: 1) Convective zone 2) Radiative zone 3) Core

ANSWER: 1 ONLY