

## WISC Round 6

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### TOSS-UP

1) Physics – *Multiple Choice* Which of the following is the efficiency of a Carnot engine operating between a hot reservoir at 800 Kelvins and a cold reservoir at 600 Kelvins? [SA]

- W) 15%
- X) 20%
- Y) 25%
- Z) 30%

ANSWER: Y) 25%

### BONUS

1) Physics – *Short Answer* By name or number, order the following three stages of a Carnot cycle chronologically after isothermal expansion has occurred: 1) Adiabatic compression, 2) Isothermal compression, 3) Adiabatic expansion. [SA]

ANSWER: 3 2 1 (ADIABATIC EXPANSION, ISOTHERMAL COMPRESSION, ADIABATIC COMPRESSION).

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### TOSS-UP

2) Biology – *Short Answer* By name or number, select all of the following four hormones whose receptors are located in the nucleus: 1) Epinephrine; 2) Thyroxine; 3) Dopamine; 4) Aldosterone.

ANSWER: 2 AND 4 (ACCEPT: THYROXINE AND ALDOSTERONE)

### BONUS

2) Biology – *Short Answer* By name or number, select all of the following four hormones that are secreted by the hypothalamus: 1) ACTH; 2) GH; 3) Oxytocin; 4) Dopamine.

ANSWER: 4 ONLY (ACCEPT: DOPAMINE)

### TOSS-UP

3) Earth and Space – *Multiple Choice* The rapid neutron-capture, or r process, is estimated to create about half of the heavy elements in our universe, but only occurs in very high energy environments. In which of the following circumstances would the r-process most likely occur? [JI]

- W) Collapse of a red giant into a white dwarf
- X) Core of a blue supergiant
- Y) Neutron star merger
- Z) Accretion disc of a supermassive black hole

ANSWER: Y) NEUTRON STAR MERGER

### BONUS

3) Earth and Space – *Short Answer* To two significant figures and in kilometers per second, what is the radial velocity of a star with an observed redshift of 0.008? [CJ]

ANSWER:  $2.4 \times 10^3$  KM/S



### TOSS-UP

4) Math – *Multiple Choice* Which of the following numbers is a factor of 2021? [SA]

- W) 37
- X) 39
- Y) 41
- Z) 43

ANSWER: Z) 43

### BONUS

4) Math – *Short Answer* What is the sum of all the positive factors of the number 2025? [SA]

ANSWER: 3751

### TOSS-UP

5) Chemistry – *Multiple Choice* Which of the following is closest to the change in entropy in joules per kelvin for the isochoric heating of a system with a constant-volume heat capacity of 10 joules per kelvin from 200 to 544 kelvin? [JI]

- W) 0.032
- X) 10
- Y) 58
- Z) 270

ANSWER: X) 10

### BONUS

5) Chemistry – *Multiple Choice* Using the Bohr model, which of the following is closest to the energy of an electron in the third energy level of a Hydrogen atom? [SA]

- W) -13.6 electron volts
- X) -3.4 electron volts
- Y) -1.51 electron volts
- Z) -0.85 electron volts

ANSWER: Y) -1.51 electron volts

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### TOSS-UP

6) Energy – *Short Answer* Scientists at MIT have developed an atomic clock that is more precise than current ones. They used atoms that are related by what quantum phenomenon to reduce the variability in the oscillation frequencies of the atoms? [SA]

ANSWER: QUANTUM ENTANGLEMENT (ACCEPT: ENTANGLEMENT)

### BONUS

6) Energy – *Multiple Choice* Scientists at MIT have used gaseous atoms of this element in the atomic clock. The oscillation frequencies of this element are as high as that of visible light, which allows for higher precision in the clock. They used which of the following lanthanide elements with atomic number 70 that is used in x-ray machines and stainless steel? [SA]

- W) Ytterbium
- X) Erbium
- Y) Curium
- Z) Holmium

ANSWER: W) YTTERBIUM

### TOSS-UP

7) Physics – *Short Answer* Given that the time constant of an RC circuit is 5 seconds and that the capacitor has a capacitance of 200 millifarads, what is the resistance of the circuit in ohms?  
[SA]

ANSWER: 25

### BONUS

7) Physics – *Multiple Choice* Given an RL circuit with a resistance of 5 ohms, an inductance of 100 millihenries, and a time constant  $\tau$ , which of the following is incorrect about the circuit?  
[SA]

W) The time constant  $\tau$  is equal to 0.02 seconds.

X) The power dissipated by the resistor is proportional to the square of the current.

Y) After every  $\tau$  seconds since the inductor is discharged, the current in the circuit is multiplied by a factor of 0.632.

Z) The magnitude of energy stored by the inductor in the magnetic field is proportional to the square of current.

ANSWER: Y) AFTER EVERY  $\tau$  SECONDS SINCE THE INDUCTOR IS DISCHARGED, THE CURRENT IN THE CIRCUIT IS MULTIPLIED BY A FACTOR OF 0.632.



### TOSS-UP

8) Biology – *Short Answer* Systemic Lupus Erythematosus (ear-uh-theme-a-tos-is), commonly known as lupus, is an autoimmune condition caused by the production of antibodies against what class of DNA binding proteins?

ANSWER: HISTONES

### BONUS

8) Biology – *Short Answer* What visual pigment do the rod cells of the eye contain?

ANSWER: RHODOPSIN

### TOSS-UP

9) Earth and Space – *Short Answer* What type of pelagic ooze is dominant below the carbonate compensation depth? [JI]

ANSWER: SILICEOUS OOZE

### BONUS

9) Earth and Space – *Short Answer* Gulfs have opened on either side of the Sinai Peninsula in the Middle East due to the rifting of what TWO tectonic plates? [JI]

ANSWER: AFRICAN AND ARABIAN PLATES



### TOSS-UP

10) Math – *Multiple Choice* The 3D point  $(2, -3, -5)$  belongs to what octant? [SA]

- W) Second
- X) Fourth
- Y) Sixth
- Z) Eighth

ANSWER: Z) EIGHTH

### BONUS

10) Math – *Short Answer* What is the sum of the coefficients of the polynomial  $(-5 + 3x)^9$ ? [SA]

ANSWER:  $-512$

### TOSS-UP

11) Chemistry – *Multiple Choice* Which of the following constants refers to the amount of electric charge in a mole of electrons? [SA]

- W) Boltzmann's constant
- X) Faraday's constant
- Y) Rydberg's constant
- Z) Coulomb's constant

ANSWER: X) FARADAY'S CONSTANT

### BONUS

11) Chemistry – *Short Answer* What is the molar solubility, in moles per liter, of the salt  $AB_2$  if its  $K_{sp}$  is  $3.2 \times 10^{-8}$ ? [JI]

ANSWER: 2 TIMES  $10^{-3}$  (ACCEPT: .002)

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### TOSS-UP

12) Energy – *Multiple Choice* Researchers at Pacific Northwest National Lab are studying how iron can be used to transform technetium into an insoluble form with less risk of contamination and ecological harm. The primary soluble form of technetium is the pertechnetate ion. What is the oxidation state of the technetium atom in the pertechnetate ion? [JI]

- W) -2
- X) +2
- Y) +5
- Z) +7

ANSWER: Z) +7

### BONUS

12) Energy – *Short Answer* Scientists at Pacific Northwest National Lab have found that anthropogenic aerosols may cause more severe weather such as larger hail. This may be related to what process by which precipitation can be created on ice nuclei in mixed-phase clouds that exist below freezing? [JI]

ANSWER: BERGERON PROCESS (ACCEPT: WEGENER-BERGERON-FINDEISEN PROCESS, COLD-RAIN PROCESS)

### TOSS-UP

13) Physics – *Short Answer* After crashing, Josh buys another Ferrari and speeds off at 60 m/s, but he doesn't notice a stopped car only 30 meters in front of him. If the combined mass of Josh and his Ferrari is about 1000 kg, what is the minimum braking force Josh needs to avoid a crash? [AT]

ANSWER: 60,000 NEWTONS

### BONUS

13) Physics – *Multiple Choice* A 5 kg ball moving east at a speed of 12 m/s collides elastically with a 4 kg ball moving west at a speed of 15 m/s. Which of the following CANNOT be true after the collision? [AT]

- W) The 4 kg ball is traveling directly north at a speed of 15 m/s
- X) The 5 kg ball is traveling directly west at a speed of 15 m/s
- Y) The 5 kg ball is traveling directly south at a speed of 12 m/s
- Z) The 4 kg ball is traveling east, while the 5 kg ball is traveling west

ANSWER: X) THE 5 KG BALL IS TRAVELING DIRECTLY WEST AT A SPEED OF 15 M/S



### TOSS-UP

14) Biology – *Multiple Choice* The breathing control centers in the medulla oblongata control the rate and depth of ventilation by directly responding to which of the following variables? [CJ]

- W) Plasma pCO<sub>2</sub>
- X) Cerebrospinal fluid pCO<sub>2</sub>
- Y) Plasma pH
- Z) Cerebrospinal fluid pH

ANSWER: Z) CEREBROSPINAL FLUID PH

### BONUS

14) Biology – *Short Answer* Arrange the following four groups from least to most closely related to seed plants: 1) Liverworts; 2) Monilophytes; 3) Mosses; 4) Lycophytes.

ANSWER: 1, 3, 4, 2 (LIVERWORT, MOSSES, LYCOPHYTES, MONILOPHYTES)

### TOSS-UP

15) Earth and Space – *Short Answer* Orbital resonances between asteroids and Jupiter have created areas in the asteroid belt that are almost entirely devoid of any asteroids. What are these areas called? [JI]

ANSWER: KIRKWOOD GAPS

### BONUS

15) Earth and Space – *Short Answer* Order the following four regions of the sun by decreasing proximity to the core: 1) Convection zone; 2) Photosphere; 3) Transition zone; 4) Chromosphere. [CJ]

ANSWER: 1, 2, 4, 3 (CONVECTION ZONE, PHOTOSPHERE, CHROMOSPHERE, TRANSITION ZONE)



### TOSS-UP

16) Math – *Short Answer* What is the angle, in degrees, between two vectors, if the product of their magnitudes is equal to twice their dot product? [SA]

ANSWER: 60 DEGREES

### BONUS

16) Math – *Short Answer* The line  $x - 2y = 40$  is rotated 45 degrees counterclockwise about the point (50, 5). What is the slope of the new line? [SA]

ANSWER: 3



### TOSS-UP

17) Chemistry – *Multiple Choice* The strength of the London dispersion potential between two particles varies with the distance between them to what power? [JI]

- W) 0
- X) -2
- Y) -3
- Z) -6

ANSWER: Z) -6

### BONUS

17) Chemistry – *Short Answer* Identify all of the following three statements which are true of a mixture if the ratio of R to S enantiomers is 1 to 1: 1) It is racemic; 2) It is optically active; 3) The net rotation of plane polarized light after passing through the mixture is 0 degrees. [JI]

ANSWER: 1 AND 3



### TOSS-UP

18) Energy – *Short Answer* Scientists at the Technical University of Munich are looking for alternatives to batteries to store energy. They have developed a super form of what electrical device that is used to store charge? [SA]

ANSWER: CAPACITOR

### BONUS

18) Energy – *Multiple Choice* The scientists at the Technical University of Munich have used graphene hybrids in their supercapacitors. The material combines graphene with nano-structured metal-organic frameworks, or MOFs. Which of the following is true about MOFs? [SA]

- W) They are non-porous
- X) They have a large internal surface area
- Y) They form a long chain structure
- Z) The metal and organic linker are held together by an ionic bond

ANSWER: X) THEY HAVE A LARGE INTERNAL SURFACE AREA

### TOSS-UP

19) Physics – *Short Answer* In lasers, what term describes the situation when the number of electrons in an excited state is higher than the number of electrons in the ground state? [SA]

ANSWER: POPULATION INVERSION

### BONUS

19) Physics – *Multiple Choice* Which of the following lasers is NOT correctly matched with its type? [SA]

- W) Helium-neon is gas type.
- X) Gallium nitride is semiconductor type.
- Y) Ytterbium-glass is fiber type.
- Z) Indium-Gallium-Arsenide is solid-state type.

ANSWER: Z) INDIUM-GALLIUM-ARSENIDE IS SOLID-STATE TYPE.

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### TOSS-UP

20) Biology – *Multiple Choice* Glycolysis converts glucose to pyruvate whereas gluconeogenesis converts pyruvate to glucose. Which of the following best describes why gluconeogenesis cannot proceed by following the same enzymatic pathway as glycolysis in reverse order?

- W) Glycolytic enzymes are unable to catalyze the reverse process without the presence of additional cofactors
- X) Certain steps of glycolysis are significantly exergonic and thus cannot proceed in reverse
- Y) Pyruvate directly inhibits the enzymes of glycolysis, making them ineffective for use in gluconeogenesis
- Z) The equilibrium of the conversion of glucose 6 phosphate to fructose 6 phosphate is heavily shifted to the right

ANSWER: X) CERTAIN STEPS OF GLYCOLYSIS ARE SIGNIFICANTLY EXERGONIC AND THUS CANNOT PROCEED IN REVERSE

### BONUS

20) Biology – *Short Answer* Identify all of the following three molecules that may enter gluconeogenesis by undergoing a conversion to pyruvate: 1) Glycerol; 2) Alanine; 3) Lactate.

ANSWER: 2 AND 3 (ACCEPT: ALANINE AND LACTATE)

### TOSS-UP

21) Earth and Space – *Short Answer* What term refers to the layer in a body of water where the density gradient is the largest? [JI]

ANSWER: PYCNOCLINE

### BONUS

21) Earth and Space – *Multiple Choice* Which of the following can not be expected at a stationary front? [JI]

- W) Winds in opposite direction on each side of the front
- X) Clear skies
- Y) Heavy precipitation
- Z) Purple line on a map

ANSWER: Z) PURPLE LINE ON A MAP



### TOSS-UP

22) Math – *Multiple Choice* What is the remainder when 52 factorial is divided by 53? [SA]

- W) 0
- X) 1
- Y) 22
- Z) 52

ANSWER: Z) 52

### BONUS

22) Math – *Short Answer* What are the last three digits of the number  $1999^{2000}$ ? [SA]

ANSWER: 001 (DO NOT ACCEPT: 1)

### TOSS-UP

23) Chemistry – *Multiple Choice* Which of the following statements about the photoelectric effect is incorrect? [SA]

- W) Increasing the frequency of light will increase the ejected electron's kinetic energy.
- X) Work function can be obtained by summing the photon's energy and the electron's kinetic energy.
- Y) Given that the frequency is above the threshold value, the current produced does not change if frequency of light is increased.
- Z) The energy of the incident photons can be found using Planck's equation.

ANSWER: X) Work function can be obtained by summing the photon's energy and the electron's kinetic energy

### BONUS

23) Chemistry – *Short Answer* A constant current is passed through a copper(II) sulfate solution and copper metal is deposited onto an electrode. After 5 minutes, 0.3 moles of copper is formed. To the nearest integer, what was the current in amperes that was used? [SA]

ANSWER: 193 AMPERES