

TOSS-UP

1) EARTH AND SPACE SCIENCE *Short Answer* What are the two forces that counteract each other and when in balance produce a geostrophic wind, which acts parallel to isobars?

ANSWER: PRESSURE GRADIENT FORCE AND CORIOLIS FORCE

TOSS-UP

2) CHEMISTRY *Multiple Choice* Which of the following intermolecular forces is a van der Waals interaction?

- W) ion-ion
- X) ion-dipole
- Y) dipole-dipole
- Z) dipole-induced-dipole

ANSWER: Z) DIPOLE-INDUCED-DIPOLE

TOSS-UP

3) PHYSICS *Short Answer* Suppose you exert a steady force of magnitude 210 N on a stalled car and push it a distance of 18 m. The car also has a flat tire, so to make the car track straight you must push at an angle of 60° to the direction of motion. How much work do you do?

ANSWER: 1890 JOULES

TOSS-UP

4) BIOLOGY *Multiple Choice* In which of the following 4 types of cell signaling are secretions destroyed by extracellular enzymes or removed from the extracellular fluid and are therefore restricted to cells which are in the immediate vicinity of the releasing cell?

- W) direct contact
- X) paracrine signaling
- Y) endocrine signaling
- Z) synaptic signaling

ANSWER: X) PARACRINE SIGNALING

TOSS-UP

5) MATHEMATICS *Multiple Choice* At which of the following points for x is there a relative maximum for the function $f(x) = \frac{1}{2}x - \sin x$ in the interval $(0, 2\pi)$?

- W) $x = 0$
- X) $x = \frac{\pi}{3}$

$$Y) x = \frac{5\pi}{3}$$

$$Z) x = 2\pi$$

$$\text{ANSWER: } Y) x = \frac{5\pi}{3}$$

TOSS-UP

6) ENERGY *Short Answer* Two forms of carbon are graphite, a soft, black material, and diamond, a hard gemstone. Assuming that the enthalpy of combustion for graphite is -394 kJ/mol, and the enthalpy of combustion for diamond is -396 kJ/mol, calculate ΔH for the conversion of graphite to diamond.

ANSWER: 2 kJ

TOSS-UP

7) EARTH AND SPACE SCIENCE *Short Answer* In the discovery of head-tail radio galaxies, in which lobes form an apparent “tail” behind the main component of the galaxy, scientists find compelling evidence for what phenomenon, which involves superhot diffuse intergalactic matter, known to emit X-ray radiation, filling the space between galaxies?

ANSWER: INTRACLUSTER GAS

TOSS-UP

8) CHEMISTRY *Short Answer* Given the following set of quantum numbers, identify the number of radial and angular nodes, respectively: (3, 1, -1)

ANSWER: RADIAL: 1; ANGULAR: 1

TOSS-UP

9) PHYSICS *Short Answer* Consider a photocell with a metal plate E, the emitter, connected to the negative terminal of a variable power supply. Another metal plate C, the collector, is maintained at a positive potential by the power supply. Indicate, by number, all of the following 3 statements that is/are TRUE regarding this photoelectric effect apparatus:

1: If there is a large potential difference ΔV between plates E and C, the current through the circuit reaches a maximum value

2: the current for $-\Delta V$ is equal to the current for ΔV

3: the stopping potential $-\Delta V_s$ is independent of the radiation intensity

ANSWER: 1 AND 3

TOSS-UP

10) BIOLOGY *Short Answer* What sequential stage in prophase I of meiosis, which is the transition stage into metaphase, includes the ceasing of transcription and the recondensing of chromosomes?

ANSWER: DIAKINESIS

TOSS-UP

11) MATHEMATICS *Multiple Choice* Consider the polar function $3 + \sin \theta$. Which of the following types of limaçon curves will this graph of this function display?

- W) looped limaçon
- X) cardioid
- Y) dimpled limaçon
- Z) convex limaçon

ANSWER: Z) CONVEX LIMAÇON

TOSS-UP

12) ENERGY *Short Answer* Indicate, by name or number, all of the following 3 atoms or molecules which would have a molar heat capacity of $\frac{5}{2}R$ at constant volume:

- 1: H₂
- 2: H₂O
- 3: O₂

ANSWER: 1 ONLY

TOSS-UP

13) EARTH AND SPACE SCIENCE *Multiple Choice* Which of the following statements is NOT true with the passage of a cold front?

- W) the temperature decreases sharply
- X) winds shift from the southern to the northern end of the front
- Y) pressure rises as the front approaches and falls as it passes
- Z) clear skies are replaced by clouds and precipitation

ANSWER: Y) PRESSURE RISES AS THE FRONT APPROACHES AND FALLS AS IT PASSES

TOSS-UP

14) CHEMISTRY *Short Answer* Consider an open-ended manometer. Giving your answer in torr, What is the pressure of the gas trapped in the container if the pressure of the atmosphere is 746 torr and the mercury levels from the bottom of the U are 50 mm in the closed arm and 200 mm in the open arm?

ANSWER: 896 TORR

TOSS-UP

15) PHYSICS *Short Answer* What is the important measure of a system that defines the conditions needed for a fusion reactor to reach ignition by giving the minimum value of the product of plasma ion density and plasma confinement time under which net power output in a fusion reactor is possible?

ANSWER: LAWSON'S CRITERION

TOSS-UP

16) BIOLOGY *Short Answer* What type of cell, which has a large vacuoles, thin walls, and an average of 14 sides at maturity, is the most abundant type of cell in plant primary tissues and to a lesser extent, secondary tissues as well? They are less specialized than other plant cells, while they do have many variations that have special functions, such as nectar and resin secretion, and storage of proteins and metabolic wastes.

ANSWER: PARENCHYMA

TOSS-UP

17) MATHEMATICS *Short Answer* Given the function $3x^3 + 2x^2 + x$, find the slope of the normal line at the point $(-2, -18)$.

ANSWER: $-\frac{1}{29}$

TOSS-UP

18) ENERGY *Multiple Choice* Which of the following stages of the Otto cycle directly corresponds to the power stroke of a gasoline engine?

- W) adiabatic compression
- X) isochoric heating
- Y) adiabatic expansion
- Z) isochoric cooling

ANSWER: Y) ADIABATIC EXPANSION

TOSS-UP

19) EARTH AND SPACE SCIENCE *Multiple Choice* Which of the following statements is NOT true regarding the Hayashi track?

- W) it follows a protostar's evolution into a main sequence star
- X) it leads to the upper right of the H-R diagram
- Y) it is often called the T Tauri phase

Z) it includes protostars which exhibit extremely dense protostellar winds

ANSWER: X) IT LEADS TO THE UPPER RIGHT OF THE H-R DIAGRAM

TOSS-UP

20) CHEMISTRY *Short Answer* Consider the following three molecules: a fluorine anion, a neutral neon atom, and a sodium cation. Arrange the three in order of increasing effective nuclear charge:

ANSWER: F⁻, Ne, Na⁺

TOSS-UP

21) PHYSICS *Short Answer* A siren on a tall pole radiates sound waves uniformly in all directions. At a distance of 2 m from the siren, the sound intensity is 54 W/m². At what distance is the intensity of radiation 6 W/m²?

ANSWER: 6 METERS

TOSS-UP

22) BIOLOGY *Multiple Choice* Which of the following immunoglobulin classes includes antibodies that promote the release of histamine and other agents that aid in attacking a pathogen?

- W) IgG
- X) IgD
- Y) IgA
- Z) IgE

ANSWER: Z) IgE

TOSS-UP

23) MATHEMATICS *Multiple Choice* The sequence 7, x , 19, y is an arithmetic progression. What is the value of $x + y$?

ANSWER: 38

TOSS-UP

24) ENERGY *Multiple Choice* Using Trouton's rule, which of the following would be closest to the standard enthalpy of vaporization diethyl ether, which boils at 307.5 K?

- W) 25 kJ
- X) 30 kJ
- Y) 35 kJ
- Z) 40 kJ

ANSWER: W) 25 kJ

TOSS-UP

25) EARTH AND SPACE SCIENCE *Short Answer* What soil-forming regime, which occurs primarily in areas where the vegetation has limited nutrients, the plant litter is acidic, and there is considerable leaching, is most prominent in mid-to-high latitude regions with coniferous forests and displays its characteristic grayish-colored soil?

ANSWER: PODZOLIZATION