UNITED STATES ACADEMIC DECATHLON®

SCIENCE

LEVEL TEST 2- MEDIUM DIFFICULTY LEVEL

2014-2015

INSTRUCTIONS: On your answer sheet, mark the lettered space (a, b, c, d, or e) corresponding to the answer that BEST completes or answers each of the following test items.

1. How many BTU(s) are in 504 calories?

   a. 1.0
   b. 2.0
   c. 2.5
   d. 4.0
   e. 4.5

2. If a power plant's efficiency increases, which of the following scenarios is MOST likely taking place at the power plant?

   a. More fuel is being consumed.
   b. More electricity is produced.
   c. a greater consumption of fuel resources to produce electricity
   d. More electricity is produced with same amount of fuel.
   e. a greater production of electricity as fuel consumption rises

3. What is the wattage of a toaster that consumes 7,200 joules of energy over the course of 60 seconds?

   a. 60
   b. 140
   c. 120
   d. 100
   e. 240

4. A generator produces 10 kW. How many generators do you need if you are building two 600 kilowatt powerplants?

   a. 240
   b. 140
   c. 60
   d. 100
   e. 120

5. Consider a drop of water about to leave the flume and fall onto an overshot water wheel. What is the typical energy sequence of this drop of water falling over a water wheel?

a. potential energy → kinetic energy
b. kinetic energy → electrical energy
c. rotational energy → kinetic energy
d. kinetic energy → rotational energy
e. potential energy → electrical energy

6. If two objects contacting each other are in thermodynamic equilibrium, which of the following MUST be TRUE?

a. Thermal expansion is occurring.
b. Heat transfer between the objects is zero.
c. Convection is occurring.
d. Heat is transferring from the object with greater enthalpy.
e. Heat is transferring from the object with greater entropy.

7. Generally, the mass of 100 protons can be approximated as

a. 100 AU
b. 100 Ag
c. 100 Da
d. 1 AU
e. 1 Da

8. According to the ideal gas law, holding all other parameters constant, increasing temperature will cause pressure to

a. stay the same
b. decrease asymptotically to zero
c. increase exponentially
d. increase linearly
e. decrease

9. If the root mean square velocity is decreasing, what can be said about the temperature (assuming all other parameters remain constant)?

a. Temperature is decreasing.
b. V_{rms} is independent of temperature.
c. Temperature is constant.
d. Temperature is increasing.
e. Temperature is increasing exponentially.

10. If a system operates at a high temperature of 400 K and a low temperature of 300 K, what is the maximum efficiency of the system?

a. 5%
b. 10%
c. 12.5%
d. 25%
e. 75%

11. According to Coulomb's Law, how are the coulomb's force and distance related?

a. F_c inversely proportional to the distance.
b. F_c proportional to the distance squared.
c. F_c inversely proportional to the distance to the ½ power.
d. F_c inversely proportional to the distance squared.
e. F_c proportional to the distance.

12. Which of the following is NOT used to determine Lorentz force?

a. Q, charge
b. E, electric field
c. v, velocity
d. B, magnetic field
e. r, distance

13. In a generator, what is the purpose of changing the magnetic field with time?

a. to induce dipoles on the electrons
b. to directly create an electromotive force which in turn generates an electric field
c. to induce an electric field which in turn creates an electromotive force
d. to prevent the flow of electrons
e. to create charge separation

14. When a gas expands adiabatically, what does this mean?

a. It absorbs energy from surroundings.
b. It does not transfer heat to surroundings.
c. Its volume does not change.
d. Its pressure does not change.
e. Its internal power remains the same.

15. How would you expect the mean free path to change if a gas occupies a larger volume but its mass remains the same (and all other environmental conditions remain the same)?

a. decrease
b. increase
c. stay the same
d. change with time
e. cannot be determined

16. Which of the following is ignored in regards to the ideal gas law?

a. temperature
b. density
c. volume
d. pressure
e. van der Waals forces

17. Which of the following BEST describes why asphalt roads buckle and crack?

a. isothermal material properties of road materials
b. isobaric compression of road materials
c. adiabatic expansion of road joints
d. thermal expansion of road materials
e. destructive Carnot losses of road materials

18. Silicon belongs to which of the following groups?

a. metalloids
b. metals
c. non-metals
d. noble gases
e. halogens

19. An atom has 35 neutrons in its nucleus. Which element does this correspond to?

a. hydrogen
b. helium
c. argon
d. chlorine
e. impossible to determine

20. What explains why it is impossible to know where an electron is and its velocity at the same time?

a. Bohr model
b. Schrodinger equation
c. ultraviolet catastrophe
d. Heisenberg Uncertainty Principle
e. quantization

21. What proposes that electrons behave as waves rather than just particles?

a. quantization
b. Heisenberg Uncertainty Principle
c. Schrodinger equation
d. Bohr model
e. ultraviolet catastrophe

22. Why was the Bohr model replaced?

a. It failed to explain the wave nature of electrons.
b. It did not explain the three dimensional electron orbital structure.
c. It incorporated the Heisenberg Uncertainty Principle.
d. It failed to include quantized energy levels of electron orbitals.
e. It did not include the photoelectric effect.

23. Reduction takes place at the platinum terminal. The original oxidation state of the platinum ion was +2. Which of the following could be its new oxidation state if reduction occurs?

a. +1
b. +3
c. +4
d. +5
e. +6

24. Oxidation takes place at the copper terminal. The original oxidation state of the copper ion was -2. Which of the following could be its new oxidation state if oxidation occurs?

a. -1
b. -2
c. -3
d. -4
e. -5

25. Holding all other parameters constant, increasing the temperature will cause the electric potential of a cell to

a. increase
b. increase exponentially
c. stay the same
d. decrease
e. increase by 50%

26. What is the standard reduction potential of the SHE?

a. +1.692 V
b. 0.000 V
c. -0.447 V
d. -1.000 V
e. -1.662 V

27. When a catalyst is used in a reaction, which of the following is occurring?

a. lowering the electric potential
b. decreasing the system's entropy
c. system is unchanged by catalyst
d. increasing the ionization energy required
e. lowering the activation energy

28. Which of the following is an example of a homogenous catalyst?

a. hydrogen(g), helium(g) reactants; gas catalyst
b. gold(s), silicon(s); gas catalyst
c. chlorine(l), helium(g); solid catalyst
d. copper(s), argon(g); solid catalyst
e. ruthenium(s), titanium(s); liquid catalyst

29. Which of the following is an example of a heterogeneous catalyst?

a. hydrogen(g), argon(g) reactants; gas catalyst
b. gold(s), silicon(s); solid catalyst
c. chlorine(l), helium(l); solid catalyst
d. copper(s), iron(s); solid catalyst
e. ruthenium(s), titanium(s); solid catalyst

30. You have an element that has no neutrons in the nucleus. What element do you have?

a. helium
b. gold
c. hydrogen
d. uranium
e. plutonium

31. According to the law of reflection, if the angle of incident is 40 degrees, what is the reflected angle?

a. 0 degrees
b. 40 degrees
c. 80 degrees
d. 120 degrees
e. 160 degrees

32. The index of refraction in the upper atmosphere of Earth is n_1. The index of refraction in water is n_2. Which of the following statements is TRUE?

a. $n_1 = n_2$
b. $n_1 > n_2$
c. $n_1 / n_2 = 1$
d. $n_2 * n_1 = 1$
e. $n_1 < n_2$

33. Which of the following is approximately the speed of light in a vacuum?

a. 2×10^2 m/s
b. 2×10^5 m/s
c. 3×10^5 m/s
d. 3×10^6 m/s
e. 3×10^7 m/s

34. Maxwell's fourth equation states that a static electric field can be created with what?

a. charge density
b. magnetic field
c. induced dipole moment
d. self-induction
e. dynamic electric field

35. If the resistance is 20 ohms and the voltage is 500 volts, what is the current?

a. 5 A
b. 10 A
c. 15 A
d. 25 A
e. 50 A

36. If the current is 200 amperes and the applied voltage is 120 volts, what is the resistance?

a. 0.2 ohms
b. 0.4 ohms
c. 0.6 ohms
d. 1.0 ohms
e. 1.2 ohms

37. Which of the following is an example of a semiconductor found in solar cells?

a. copper
b. gold
c. germanium
d. titanium
e. argon

38. Which of the following is the MOST commonly used thin film photovoltaic today?

a. amorphous silicon
b. germanium
c. silicone
d. organic solar cells
e. multi-junction solar cells

39. Which of the following is a typical efficiency for polycrystalline solar cells?

a. 95%
b. 55%
c. 25%
d. 10%
e. 1.0%

40. What are the electric carriers found in photovoltaic cells?

a. electrons
b. electrons and holes
c. holes
d. photons
e. photons and electrons

41. Which of the following is NOT a disadvantage of nuclear energy?

a. can be used to produce nuclear weapons
b. requires large capital costs
c. produces highly unstable waste elements
d. produces large carbon emissions
e. radiation is harmful to the environment and human health

42. What percentage of electricity generation in the U.S. comes from nuclear power?

a. 10%
b. 19%
c. 25%
d. 27%
e. 29%

43. If the decay constant is equal to 0.693 for an element, what is its half-life $t_{1/2}$?

a. 0.1
b. 0.5
c. 1.0
d. 2.0
e. 10

44. If an element has a half-life of 50 years, and you start with 1,000 nuclei, how many still exist after 100 years?

a. 500
b. 250
c. 100
d. 1,000
e. 0

45. Which of the following is an example of ionizing radiation?

a. visible light
b. gamma rays
c. visible
d. infrared
e. radio waves

46. How is ionizing radiation harmful to human health?

a. results in mercury poisoning over time
b. generates blood clots
c. leads to vitamin deficiencies
d. lead poisoning from gamma rays
e. damages cell DNA leading to cancer

47. How are energy and mass related to each other as described by Einstein's famous mass-energy equation?

a. directly proportional
b. inversely proportional
c. not related
d. each equal to the speed of light squared
e. equal

48. Which item listed below would NOT typically be found in the nacelle of a wind turbine?

a. brake
b. low-speed shaft
c. gearbox
d. transformer
e. generator

49. Globally, what percentage of electricity is produced using wind turbines?

a. 0.1%
b. 1.5%
c. 2.5%
d. 10%
e. 25%

50. Which of the following is NOT a disadvantage of biofuels?

a. damaging to rubber seals
b. limited use at low temperatures
c. wears out engines faster
d. high carbon emissions
e. damaging to gaskets