



## 2018 State STEM Competition

# High School Science Test

### Student Instructions

- This test is for students in 9<sup>th</sup>, 10<sup>th</sup>, 11<sup>th</sup> and 12<sup>th</sup> grades. If you are not in one of those grades, work with a test proctor to find the appropriate test.
- Leave the test booklet closed and wait until the proctor tells you to start.
- The test period will be 45 minutes and this test contains 60 multiple choice questions.
- This test includes topics covered in all high school science classes. The questions range in difficulty from easy to very challenging. Most students will NOT be familiar with all of the material on their test.
- A periodic table and set of formulae are on the last two pages. You may tear this page off of the test.
- There is no penalty for skipping a problem or answering incorrectly.
- You may write on this test. If you need scratch paper, please raise your hand and ask for some.
- Your score will be determined by the number of correct answers. All ties will be broken by awarding the place to the student having the most consecutive correct answers from the start of the test.
- You will not be permitted to leave the room while the test is in progress. If you finish early, you must remain in the room quietly until the test is completed. Any student causing a disturbance will be disqualified.
- **LEGIBLY** write your name, grade, and school on the right side of the answer/Scantron sheet, as shown below -

NAME	Your First and Last Name		
SUBJECT	Your Grade	TEST NO.	Test Name
DATE	School Name	PERIOD	

- Answers must be marked on the answer/Scantron sheet with a number two pencil.
- All tests must be turned in at the end of the testing period. Tests may not be taken from the testing room.

**GOOD LUCK!**

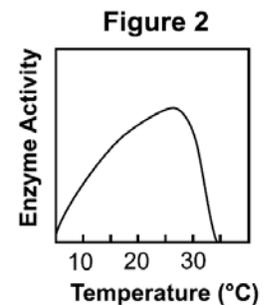
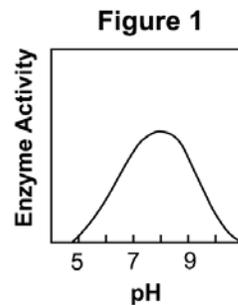
Answer the following questions by marking the **BEST** answer on the answer sheet.

- (1) In which of the following zones do phytoplankton most frequently occur?  
A) abyssal C) photic  
B) hadal D) benthic
- (2) What type of food is targeted by salivary amylase?  
A) protein C) glucose  
B) starch D) maltose
- (3) Which of the following statements is true for covalent bonding?  
A) involves oxidation and reduction reactions C) involves transfer of electrons  
B) always occurs between a metal and a non-metal D) involves sharing of electrons
- (4) What is the gram equivalent weight of  $\text{Al}_2\text{O}_3$ ?  
A) 17 grams C) 102 grams  
B) 54 grams D) 48 gram
- (5) The kinds of molecules that move across cell membranes most readily are  
A) large and hydrophobic molecules. C) large and polar molecules.  
B) small and hydrophobic molecules. D) monosaccharides.
- (6) A cell containing 40 chromatids at the start of mitosis would produce cells with how many chromosomes at the end of mitosis?  
A) 10 C) 40  
B) 20 D) 80
- (7) A pure sample contains 2.1 grams of nitrogen and 1.2 grams of oxygen. What is the empirical formula for the sample?  
A)  $\text{NO}_2$  C)  $\text{N}_2\text{O}_3$   
B)  $\text{N}_2\text{O}$  D)  $\text{NO}$
- (8) A current of 35 mA flows through a foot-long piece of wire for 3 seconds. How many electrons pass into the wire during this time?  
A)  $2.36 \times 10^{18}$  C)  $8.59 \times 10^{18}$   
B)  $6.03 \times 10^{19}$  D)  $6.56 \times 10^{17}$
- (9) A 5-kg block of wood is resting on an inclined plane which makes a  $40^\circ$  angle with the horizontal. The block is released 1.7 meters from the bottom of the inclined plane. How long does it take the block to reach the bottom of the incline if it was released from rest and the incline is frictionless?  
A) 0.73 s C) 1.26 s  
B) 0.87 s D) 1.39 s
- (10) The F–C–F bond angle in  $\text{CF}_4$  is closest to what value?  
A)  $101^\circ$  C)  $109.5^\circ$   
B)  $120^\circ$  D)  $135^\circ$

- (11) What is the control center for human temperature regulation?  
A) hypothalamus  
B) medulla oblongata  
C) pons  
D) cerebral cortex
- (12) What is electrophoresis mainly used for?  
A) differentiate the biological sample  
B) to perform the human specific presumptive tests  
C) to isolate DNA from biological material  
D) separates the molecules
- (13) What color will fluorescence examination of seminal stains be?  
A) pink color  
B) blue color  
C) white color  
D) red color
- (14) In the context of forensic science, luminol is used because it is sensitive to the presence of extremely small amounts of what?  
A) blood  
B) cuticle  
C) hair  
D) carbon dioxide
- (15) RFLP is a technique in which organisms may be differentiated by analysis of patterns derived from cleavage of their DNA. If two organisms differ in the distance between sites of cleavage of a particular restriction endonuclease, the length of the fragments produced will differ when the DNA is digested with a restriction enzyme. Which of the following are possible applications of RFLP?  
A) RFLPs can be used in paternity cases or criminal cases to determine the source of a DNA sample.  
B) RFLPs can be used determine the disease status of an individual.  
C) RFLPs can be used to measure recombination rates.  
D) All of the above are correct answers.
- (16) An object of mass 10.0 kg is initially at rest. A 100 N force causes it to move horizontally through a distance of 6.00 m. What is the change in the kinetic energy of this object?  
A) 60.0 Joules  
B) 200 Joules  
C) 600 Joules  
D) 1000 Joules
- (17) How many spatial orbitals exist for a  $g$  sub-energy level?  
A) 9  
B) 7  
C) 5  
D) 3
- (18) Which of the following is a true statement concerning the potential energy of two like charges?  
A) depends on the sign of the charge  
B) decreases as the charges are separated  
C) is proportional to the square of the relative speed  
D) is inversely proportional to the square of the separation
- (19) What is the term for metabolic pathways that release stored energy by breaking down complex molecules?  
A) anabolic pathways  
B) fermentation pathways  
C) catabolic pathways  
D) thermodynamic pathways

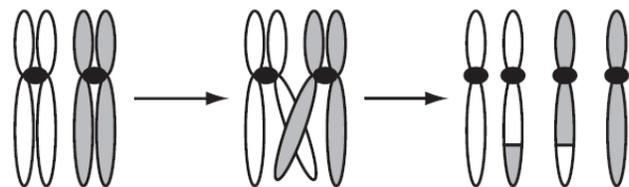
- (20) Which of the following defines a genome?
- A) representation of a complete set of a cell's polypeptides
  - B) the complete set of an organism's polypeptides
  - C) the complete set of a species' polypeptides
  - D) the complete set of an organism's genetic material
- (21) In ecosystems, why is the term cycling used to describe material transfer, whereas the term flow is used for energy exchange?
- A) Both material and energy flow in a never-ending stream within an ecosystem.
  - B) Materials are repeatedly used, but energy flows through and out of ecosystems.
  - C) Both material and energy are recycled and are then transferred to other ecosystems as in a flow.
  - D) Materials are cycled into ecosystems from other ecosystems, but energy constantly flows within the ecosystem.
- (22) How is it that the open ocean produces the highest net primary productivity of Earth's ecosystems, yet net primary productivity per square meter is relatively low?
- A) Ocean ecosystems have less species diversity.
  - B) Oceans have the largest area of all the ecosystems on Earth.
  - C) Oceans receive a lesser amount of solar energy per unit area.
  - D) Oceans contain greater concentrations of nutrients compared to other ecosystems.
- (23) What is the formula weight of potassium dichromate ( $K_2Cr_2O_7$ )?
- A) 107.09 amu
  - B) 242.18 amu
  - C) 255.08 amu
  - D) 294.18 amu
- (24) Sodium bicarbonate is reacted with concentrated hydrochloric acid at  $25.0^\circ C$  and 1.50 atm. The reaction of 7.75 kg of bicarbonate with excess hydrochloric acid under these conditions will produce how much  $CO_2$  gas?
- A)  $1.50 \times 10^3$  L
  - B)  $1.82 \times 10^3$  L
  - C)  $1.82 \times 10^4$  L
  - D)  $2.85 \times 10^4$  L
- (25) In which one of the following pairs is the atomic radius of the second atom greater than that of the first atom?
- A) Be, B
  - B) Cl, Ar
  - C) B, F
  - D) Ar, K
- (26) How many structural isomers are possible for the molecular formula of  $C_4H_{10}O$ ?
- A) 4
  - B) 5
  - C) 7
  - D) 8
- (27) A fuel/oxidant system consisting of *N,N*-dimethylhydrazine,  $(CH_3)_2NNH_2$ , and dinitrogen tetroxide,  $N_2O_4$ , (both liquids) is commonly used in space rocket propulsion. The components are mixed stoichiometrically so that  $N_2$ ,  $CO_2$  and  $H_2O$ , all gases under the reaction conditions, are the only products. How many moles of gas are produced from 1 mol of  $(CH_3)_2NNH_2$ ?
- A) 8
  - B) 9
  - C) 10
  - D) 11

- (28) The figures to the right show the reaction rate of a specific enzyme at different temperatures and different pHs. What can be concluded about the enzyme?
- A) The enzyme works best at a pH of 8 and a temperature of 25°C.  
 B) The enzyme only works at a pH of 8 and a temperature of 25°C.  
 C) The enzyme is used up at a pH of 11 and a temperature of 35°C.  
 D) The enzyme works better at a pH of 8 than a temperature of 25°C.



- (29) What happens to water molecules in a swimming pool as they absorb energy?
- A) The molecules occupy less volume.  
 B) The kinetic energy of the atoms decreases.  
 C) The molecules begin to move more slowly.  
 D) The rate of collision between molecules increases.
- (30) Which of the following is the name of the compound  $\text{HClO}_4$ ?
- A) hydrogen perchlorite  
 B) perchloric acid  
 C) chloric acid  
 D) hypochloric acid
- (31) A jet engine gets its thrust by taking in air, heating, and compressing it and then ejecting it at a high speed. If a jet engine takes in 20 kilograms of air per second at 100 meters per second, and ejects it at 500 meters per second, what is the thrust of the engine in Newtons (N)?
- A) 760 N  
 B) 8,000 N  
 C) 9,100 N  
 D) 10,500 N
- (32) A scientist finds an unknown species of big cat. The scientist believes that it is most closely related to either a panther or a lynx. How can the scientist provide the evidence needed to correctly classify the cat?
- A) measure the length of the tail and compare it to the other big cat species  
 B) determine which habitat of the big cat species is closest to the unknown species  
 C) compare the size of the teeth of the unknown species to the other big cat species  
 D) determine which big cat species has the closest DNA sequence to the unknown species

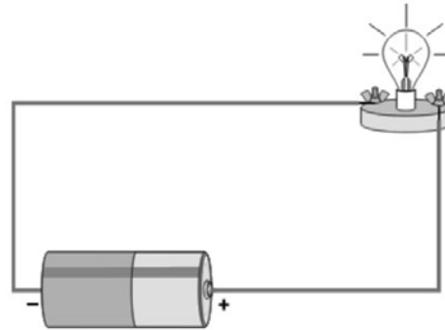
- (33) The process of crossing over during meiosis is illustrated in the diagram to the right. What is the effect of crossing over?



- A) It increases the number of genetic combinations in gametes.  
 B) It allows diploid cells to form after fertilization.  
 C) It decreases the likelihood of mutations in gametes.  
 D) It ensures that the chromosome number stays the same.

- (34) Photosynthetic organisms are organisms that use energy from the Sun to build glucose molecules. What else do photosynthetic organisms need to build glucose molecules?
- A) carbon dioxide  
B) lipids  
C) amino acids  
D) oxygen

- (35) Ryanna constructed the simple circuit shown to the right. What will occur if the student replaces the light bulb with a higher resistance light bulb?
- A) The voltage will increase.  
B) The current will decrease.  
C) The battery will gain stored electrical energy.  
D) The light bulb will go out due to a short circuit.

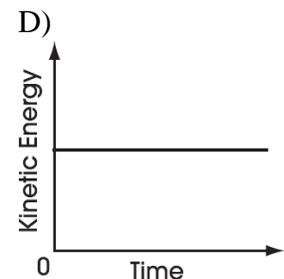
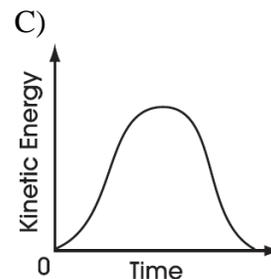
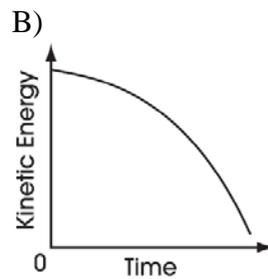
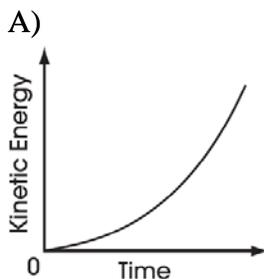


- (36) For the solids listed in the data table to the right, which seems to be true about the relationship between the speed of sound and density?
- A) The speed of sound decreases as density increases.  
B) The speed of sound increases as density increases.  
C) The speed of sound increases as density decreases.  
D) There is no apparent relationship between density and the speed of sound.

**Speed of Sound in Solids**

Solids	Density (g/cm <sup>3</sup> )	Speed (m/s)
cork	0.25	500
brick	1.80	3650
glass	2.24	4540
stainless steel	7.90	5000

- (37) The early development of the theory of plate tectonics was supported by which of these observations?
- A) matching fossils on the continents of Africa and South America  
B) glacier deposits far from existing continental glaciers  
C) sudden volcanic activity of long-dormant volcanoes  
D) thick sediment layers at the mouths of rivers
- (38) When the Falcon Heavy rocket is launched it accelerates for several minutes. Which graph below shows the kinetic energy of the rocket in the first few minutes of flight? (Note: At launch, Time = 0.)



- (39) What two gases make up most of Earth's atmosphere?
- A) oxygen and hydrogen  
B) nitrogen and oxygen  
C) carbon dioxide and oxygen  
D) silicon dioxide and oxygen

- (40) How do the cells of heterotrophic organisms get energy for cell processes?  
 A) by breaking down food molecules to produce ATP  
 B) by copying the genetic information and dividing into two daughter cells  
 C) by combining carbon dioxide and water in the presence of sunlight to form glucose  
 D) by transferring the genetic information from the nucleus to the ribosomes to make proteins
- (41) Antacid tablets are made of calcium carbonate ( $\text{CaCO}_3$ ). Calcium carbonate reacts with stomach acid according to the chemical reaction shown below.



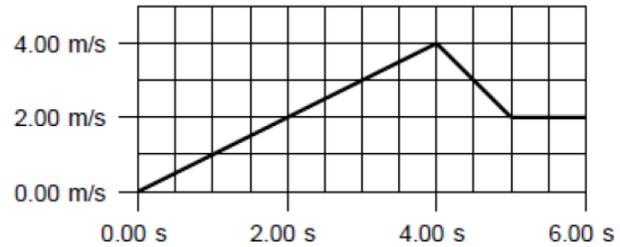
If a 1.2-g antacid tablet is 12% carbon by mass, what is the mass of carbon in the reaction products?

- A) 0.14 g  
 B) 1.10 g  
 C) 1.20 g  
 D) 1.30 g
- (42) Ruby Bean requires about 8,200 kJ of body energy from food per day to keep up with her volley ball and roller derby activities. Using the table below calculate the mass of glucose,  $\text{C}_6\text{H}_{12}\text{O}_6 (s)$ , required to provide this energy if it is generated by the metabolism of glucose with oxygen to produce water and carbon dioxide.

Compound	Standard enthalpy of formation ( $\Delta H_f^\circ$ kJ-mol <sup>-1</sup> )
$\text{C}_6\text{H}_{12}\text{O}_6 (s)$	-1273
$\text{CO}_2 (g)$	-394
$\text{H}_2\text{O} (l)$	-286

- A) 276 g  
 B) 292 g  
 C) 526 g  
 D) 757 g
- (43) What is the result of an increase in the temperature of a system at equilibrium?  
 A) The endothermic reaction is favored, and the rate of this reaction decreases.  
 B) The exothermic reaction is favored, and the rate of this reaction decreases.  
 C) The endothermic reaction is favored, and the rate of this reaction increases.  
 D) The exothermic reaction is favored, and the rate of this reaction increases.
- (44) Which of the following is not an ionic compound?  
 A) ammonium nitrate,  $\text{NH}_4\text{NO}_3$   
 B) hydrogen fluoride, HF  
 C) potassium fluoride, KF  
 D) magnesium oxide, MgO
- (45) A flat coil of wire consisting of 20 turns, each with an area of  $50 \text{ cm}^2$ , is positioned perpendicularly to a uniform magnetic field that increases its magnitude at a constant rate from 2.0 T to 6.0 T in 2.0 s. If the coil has a total resistance of  $0.40 \Omega$ , what is the magnitude of the induced current?  
 A) 0.70 Amp  
 B) 0.50 Amp  
 C) 0.60 Amp  
 D) 0.80 Amp
- (46) Sound waves traveling in a material where the speed of sound is 1200 m/s enter another material in which the speed is 300 m/s. If the wavelength in the "fast material" is 20 cm, what is the wavelength in the "slow" material?  
 A) 5 cm  
 B) 20 cm  
 C) 10 cm  
 D) 40 cm

- (47) A graph of velocity as a function of time is shown to the right for the rectilinear motion of an object. What is the magnitude of the displacement of the object during the 6.0 s interval shown in the graph?



- A) 9.0 m  
B) 12 m  
C) 13 m  
D) 17 m
- (48) Mackenzie leaves the diving board rotating at 1.20 rad/s with her body configured in such a manner that the moment of inertia about the axis of rotation is  $30.0 \text{ kg}\cdot\text{m}^2$ . As the dive progresses, she reconfigures her body so her rate of rotation increases to 2.00 rad/s. What is Mackenzie's moment of inertia about the axis of rotation in the new configuration?
- A)  $10.8 \text{ kg}\cdot\text{m}^2$   
B)  $18.0 \text{ kg}\cdot\text{m}^2$   
C)  $72.0 \text{ kg}\cdot\text{m}^2$   
D)  $83.3 \text{ kg}\cdot\text{m}^2$
- (49) A 1-kg rock is suspended by a massless string from one end of a 1-m measuring stick. What is the mass of the measuring stick if it is balanced by a support force at the 0.25-m mark?
- A) 0.25 kg  
B) 0.5 kg  
C) 1 kg  
D) 2 kg
- (50) Which of the following is the principle most relevant to the operation of a hydraulic jack?
- A) Archimedes' principle  
B) Dalton's law of partial pressures  
C) Bernoulli's principle  
D) Pascal's principle
- (51) What is the net force which must act on a 2.50 kg object traveling around a circle of 4.00 m radius at constant speed of 20.0 m/s?
- A) zero Newtons  
B) 100 Newtons  
C) 200 Newtons  
D) 250 Newtons
- (52) A car accelerates from 10.0 m/s to 30 m/s at a rate of  $3.0 \text{ m/s}^2$ . How far does the car travel while accelerating?
- A) 80 m  
B) 117 m  
C) 133 m  
D) 226 m
- (53) Environmental resistance can result from
- A) unlimited environmental resources.  
B) the intrinsic rate of increase of a population.  
C) limited environmental resources.  
D) exponential growth.
- (54) Which describes dendrites?
- A) They receive incoming information from external sources.  
B) They conduct outgoing information towards the target cell.  
C) They are in the metabolic center of the nerve cell.  
D) They may be as long as 3 meters.

- (55) Where does the pancreas discharge its enzymes directly into?  
A) pyloric sphincter  
B) large intestine  
C) cardiac sphincter  
D) duodenum
- (56) Which of the following structures is absent in bacterial cells?  
A) nucleus  
B) cytoplasm  
C) nucleoid  
D) plasma membrane
- (57) When a virus takes over the machinery of a cell, it forces the cell to manufacture more  
A) mitochondria for energy for the virus.  
B) food particles.  
C) liposomes to isolate themselves from water.  
D) viral particles.
- (58) Which of the following invertebrate groups is characterized by radial symmetry in adults?  
A) Arthropoda  
B) Platyhelminthes  
C) Cnidaria  
D) Chordata
- (59) In the blood, bicarbonate ions  
A) help transport oxygen.  
B) are transported by hemoglobin.  
C) act as buffers that guard against pH changes.  
D) are poisonous and must constantly be removed.
- (60) Which of the following is involved in both aerobic and anaerobic metabolism?  
A) glycolysis  
B) the Krebs's cycle  
C) the electron transport chain  
D) the oxidation of pyruvic acid