

## 2023 Science Challenger D3 Physical Science QUESTIONS

1. A 4 kg ball is thrown at a speed of 7 m/s. At the top of its trajectory, it has a speed of 5 m/s. What is the kinetic energy of the ball at the top of its trajectory?
  - a. 50 J
  - b. 98 J
  - c. 100 J
  - d. 147 J
2. Most galaxies outside of the Milky Way are moving away from us. When telescopes on Earth observe these galaxies, they appear “redder” than they actually are. What is this phenomenon called?
  - a. Server error
  - b. Gravitational error
  - c. Blueshift
  - d. Redshift
3. Express 0.000832 m/s in scientific notation.
  - a.  $8.32 \times 10^{-5}$  m/s
  - b.  $8.32 \times 10^{-4}$  m/s
  - c.  $8.32 \times 10^{-3}$  m/s
  - d.  $8.32 \times 10^{-2}$  m/s
4. Stomach acid consists mainly of this compound.
  - a. HNO<sub>3</sub>
  - b. HI
  - c. HBr
  - d. HCl
5. Which of the following quantities can be measured in moles?
  - a. The molarity of a solution
  - b. The number of atoms in a solution
  - c. The concentration of a solution
  - d. The pH value of a solution
6. A cannon fires a cannonball at 30 m/s on a flat soccer field. At which of the following angles above ground level will the cannonball travel the furthest distance?
  - a. 10°
  - b. 30°
  - c. 50°
  - d. 70°
7. A ballerina is spinning at 16 rad/s, with her arms extended outward. If a brick with non-negligible mass lands in her hand without exerting any torque on her, how does her rotation speed change, and why?
  - a. Her rotation speed decreases because her moment of inertia increases
  - b. Her rotation speed increases because her moment of inertia increases

- c. Her rotation speed stays the same because the brick follows the same trajectory as her
  - d. Her rotation speed cannot be determined
8. Suppose she drops the heavy brick and is now again spinning at 16 rad/s. If she pulls her arms inward, how does her rotation speed change?
- a. Her rotation speed decreases because her moment of inertia decreases
  - b. Her rotation speed increases because her moment of inertia decreases
  - c. Her rotation speed stays the same because the brick follows the same trajectory as her
  - d. Her rotation speed cannot be determined
9. What is the empirical formula of  $C_6H_{12}O_3$ ?
- a.  $C_2H_4O$
  - b.  $C_6H_{12}O_3$
  - c.  $C_3H_{11}O_3$
  - d.  $CH_2O_{.5}$
10. What is the name of the rightmost column of elements on the periodic table?
- a. Alkali metals
  - b. Alkaline earth metals
  - c. Noble gases
  - d. Halogens
11. Consider the following reaction:  $2 C_3H_7OH + 9 O_2 \rightarrow 6 CO_2 + 8 H_2O$ . If 3 moles of  $C_3H_7OH$  and an excess of  $O_2$  react, how many moles of  $CO_2$  will be produced?
- a. 6
  - b. 4
  - c. 9
  - d. 8
12. Two cars are traveling up a sloping road, each at a constant speed. The second car has twice the mass and twice the speed of the first car. What is the ratio of the power delivered by the second car engine to that delivered by the first? Ignore friction and other losses.
- a. 1
  - b. 2
  - c. 4
  - d. 8
13. An automobile and a truck have equal kinetic energies. Which has the larger speed? Which has the larger momentum? Assume that the truck has the larger mass.
- a. Truck; truck
  - b. Truck; automobile
  - c. Automobile; truck
  - d. Automobile; automobile
14. What is the moment of inertia of a uniform cylinder with height  $h$ , radius  $r$ , and mass  $m$ ?
- a.  $\frac{2}{3}mr^2$
  - b.  $\frac{1}{2}mhr$
  - c.  $\frac{1}{2}mr^2$
  - d.  $\frac{1}{2}mh^2$
15. What is the name of this phenomenon: when the frequency of light or sound increases/decreases due to the motion of the source and observer?

- a. Doppler effect
  - b. Constructive/Destructive interference
  - c. Superposition
  - d. Polarization
16. What does Archimedes' Principle state?
- a. The flow of a fluid in will equal the flow out.
  - b. The buoyant force on an immersed body has the same magnitude as the weight of the fluid displaced by the body.
  - c. An increase in the speed of a fluid occurs simultaneously with a decrease in static pressure or a decrease in the fluid's potential energy.
  - d. Fluid in contact with a wall will have the same velocity as the wall.
17. If a ray makes an angle of 20 degrees with the surface of a mirror, what is the angle of incidence?
- a. 20 degrees
  - b. 25 degrees
  - c. 160 degrees
  - d. 70 degrees
18. A resistor of 10 ohms connected to a battery produces 0.4 W of Joule heat. If we replace this resistor with a 20 ohm resistor, what will be the rate of production of heat?
- a. 0.8 W
  - b. 0.4 W
  - c. 0.2 W
  - d. 0.16 W
19. Which of the following formulas is correct?
- a.  $F = qv \times B$ , where  $F$  is the force vector,  $q$  is charge,  $v$  is the velocity vector,  $\times$  denotes the cross product of two vectors, and  $B$  is the magnetic field vector
  - b.  $F = qvB$ , where  $F$  is the force vector,  $q$  is the charge,  $v$  is the magnitude of the velocity, and  $B$  is the magnitude of the magnetic field
  - c.  $F = qv - B$ , where  $F$  is the force vector,  $q$  is charge,  $v$  is the velocity vector, and  $B$  is the magnetic field vector
  - d.  $F = qv \cdot B$ , where  $F$  is the force vector,  $q$  is charge,  $v$  is the velocity vector,  $\cdot$  denotes the dot product of two vectors, and  $B$  is the magnetic field vector
20. The higher the pH of a solution, the more \_\_\_\_ it is.
- a. Acidic
  - b. Basic
  - c. Polar
  - d. Nonpolar
21. An automobile with initial velocity  $v$  brakes to a stop with constant deceleration in a time  $t$ . If the initial velocity were twice as large but the constant deceleration were half as large, the time to stop would be:
- a.  $8t$
  - b.  $4t$
  - c.  $2t$
  - d.  $.5t$

22. An amount of work  $W$  is performed to stretch a spring by a distance  $d$  from equilibrium. How much work is performed to further stretch the spring from  $d$  to  $2d$  ?
- $2W$
  - $3W$
  - $4W$
  - $W$
23. A marble with velocity  $v$  strikes a stationary, identical marble elastically and head-on. The final velocities of the shot and struck marbles are, respectively:
- $\frac{1}{2}v$  and  $\frac{1}{2}v$
  - $v$  and  $2v$
  - $-\frac{1}{2}v$  and  $\frac{1}{2}v$
  - $0$  and  $v$
24. A car has a mass  $m$  and a speed  $v$  as it moves around the track of radius  $R$ . Which of the following expressions can be used to find the value of the coefficient of friction between the tires and the road?
- $\mu = gR/v$
  - $\mu = gv/R$
  - $\mu = vgR$
  - $\mu = v^2/gR$
25. A 2 kg wooden block rests on a ramp inclined at  $30^\circ$  above the horizontal. The frictional force between the block and the plane is most nearly?
- 20 N
  - 17 N
  - 12 N
  - 10 N
26. A satellite is in orbit around the earth. Consider the following quantities:
- distance from the center of the earth*
  - mass of the earth*
  - mass of the satellite*
- The gravitational acceleration felt by the satellite,  $g$ , depends on which of the above?
- I only
  - I and II
  - III only
  - I and III only
27. A 5 kg wooden block rests on a ramp inclined at  $45^\circ$  above the horizontal. The coefficient of static friction between the block and the plane is most nearly?
- 0.5
  - 1
  - 0.6
  - Can not be determined

28. A large wooden crate of mass 20 kg is being pulled across a floor of non-negligible friction by a string at an angle of  $37^\circ$  above the horizontal. The tension in the string is 150N and the coefficient of kinetic friction between the crate and the floor is 0.5. The acceleration of the crate is most nearly?
- 1.1  $\text{m/s}^2$
  - 3.4  $\text{m/s}^2$
  - 6.0  $\text{m/s}^2$
  - 7.5  $\text{m/s}^2$
29. The gravitational force of the moon on a person standing on its surface is  $F$ . Ignoring the effect of any other planets or stars, what would be the gravitational force if the radius of the moon is doubled assuming the same uniform density as before?
- $F/4$
  - $F/2$
  - $F$
  - $2F$
30. A hula-hoop, a solid spherical ball, a hollow spherical ball, and a cylinder are released at the top of a ramp. Which object reaches the bottom of the ramp first?
- Hula-Hoop
  - Solid ball
  - Hollow ball
  - Cylinder