

Wonderforge — Activity Book

A Spark & Anvil activity book — puzzles, questions, and fun from Wonderforge.

Write in the book, circle your answers, and check the Answer Key at the back.

1. Optical Illusions

Circle the correct answer

1. What part of your eye detects light and sends signals to your brain?
(A) Iris (B) Pupil (C) Retina (D) Cornea
2. What is the name of the small dark opening in the center of your eye that lets light in?
(A) Pupil (B) Lens (C) Retina (D) Optic nerve
3. What do we call a picture or pattern that tricks your brain into seeing something that is not really there?
(A) Hologram (B) Optical illusion (C) Mirage (D) Hallucination
4. What is the name of the nerve that carries visual signals from your eye to your brain?
(A) Optic nerve (B) Facial nerve (C) Spinal cord (D) Auditory nerve
5. Why do two lines of the same length look different when one has arrows pointing outward and the other has arrows pointing inward?
(A) The ink from the arrows makes one line darker and appear longer (B) The arrows physically stretch and compress the lines (C) Your eyes cannot see straight lines correctly (D) Your brain uses the arrow direction as a depth cue and misjudges the line length
6. When you stare at a spinning spiral and then look at your hand, your hand appears to move. Why does this happen?
(A) Your brain's motion-detecting neurons become tired and fire the opposite signal when you look away (B) Your hand is actually moving because of muscle tremors (C) The spiral permanently changes how your eyes focus (D) Light from the spiral reflects off your hand

Write the answer

7. Why does the moon appear much larger when it is near the horizon than when it is high in the sky, even though its size does not actually change?

Answer: _____

8. Why do movies appear to show smooth motion when they are actually a series of still images shown very quickly?

Answer: _____

9. How do two identical circles of the same color appear different when one is placed on a dark background and the other on a light background?

Answer: _____

10. In the Ponzo illusion, two identical horizontal lines are drawn between converging railroad tracks. Why does the upper line appear longer?

Answer: _____

Match each question to its answer

1. You stare at a red circle for 30 seconds, then look at a blank white wall. You see a green circle. How could you use this knowledge to create an afterimage of a blue shape? →

2. A magician wants the audience to think a ball disappears. She throws it upward twice, and on the third throw she secretly keeps it in her hand but looks up. The audience 'sees' the ball go up. Which optical illusion principle is she using? →

3. You want to create a spinning disk that shows a rainbow of colors. The disk is painted with only black and white patterns. When spun at the right speed, faint colors appear. How would you explain this to a friend? →

4. You are designing a poster for a school event. You want one word to seem closer to the viewer and another to seem farther away, using only flat paper. How could you apply what you know about depth cues? →

5. A friend shows you a picture where a vase shape also looks like two faces looking at each other. Your friend insists it is just a vase. Using your knowledge of perception, how would you explain why you both see different things? →

(A) Your brains are deciding differently which part is the figure and which is the background, and both interpretations are valid

(B) Different parts of your retina respond at slightly different speeds to the flickering black and white, creating the perception of color

(C) Stare at an orange or yellow shape for 30 seconds, since blue is the complementary afterimage color for those hues

(D) Make the 'closer' word larger and brighter, and the 'farther' word smaller and lighter in color

(E) She is using expectation and eye tracking — the audience's brains predict the ball's path based on the first two throws

2. Kitchen Chemistry

Circle the correct answer

11. What gas is produced when baking soda is mixed with vinegar?
(A) Carbon dioxide (B) Oxygen (C) Hydrogen (D) Nitrogen
12. What property of a liquid determines whether an object sinks or floats in it?
(A) Taste (B) Color (C) Temperature (D) Density
13. When lemon juice is used as invisible ink and the paper is heated, what causes the writing to appear?
(A) The paper changes color everywhere except where the lemon juice is (B) The heat melts the lemon juice into a visible liquid (C) The heat causes the acids in lemon juice to break down and turn brown before the paper does (D) The lemon juice evaporates and leaves behind yellow dye
14. In a density tower experiment, honey sinks to the bottom, water stays in the middle, and oil floats on top. What determines this layering order?
(A) Each liquid has a different density, and they stack from most dense at the bottom to least dense at the top (B) The liquids are poured in a specific order and stay where they land (C) Heavier colors like dark honey always sink below lighter colors (D) The thickest liquids always sink and the thinnest always float
15. Why does adding dish soap to a plate of milk with food coloring cause the colors to swirl and scatter dramatically?
(A) The soap heats up the milk, making the colors move faster (B) The soap is magnetic and pulls the food coloring toward it (C) The soap chemically changes the food coloring into new colors (D) Dish soap breaks apart the fat molecules in milk, and the movement of the fat creates currents that push the food coloring around
16. Why does a raisin dropped into a glass of clear soda repeatedly sink and then float back up?
(A) The raisin is alive and swims up and down on its own (B) The raisin absorbs soda and gets lighter, then releases it and gets heavier (C) The soda pushes the raisin up with waves and then gravity pulls it back down (D) Carbon dioxide bubbles attach to the rough raisin surface, making it buoyant, then pop at the surface, causing it to sink again

Write the answer

17. When red cabbage juice is added to baking soda dissolved in water, it turns blue-green. When added to vinegar, it turns pink. Why does the same juice change to different colors?

Answer: _____

18. When you dissolve sugar in hot water and then let it cool slowly with a string dangling in it, sugar crystals grow on the string over several days. Why does this happen?

Answer: _____

19. If you mix cornstarch and water to make a non-Newtonian fluid, it feels solid when you punch it but flows like a liquid when you slowly dip your hand in. Why does this mixture behave differently depending on force?

Answer: _____

20. When you pour vinegar on a raw egg and leave it for 24 hours, the eggshell dissolves completely. Why does this happen?

Answer: _____

Match each question to its answer

1. You want to make a lava lamp using oil, water, and an effervescent tablet. You notice the colored water blobs rise through the oil and then sink back down. How would you make the blobs rise more frequently? →

2. You built a density tower with honey, dish soap, water, vegetable oil, and rubbing alcohol. A grape sinks through the oil but floats on the dish soap. Where would a small plastic bead that floats on water but sinks in oil end up? →

3. You are doing the baking soda and vinegar volcano experiment at a science fair. Your volcano produces a small fizz but you want a much bigger eruption. What change would most increase the reaction? →

4. You want to write a secret message that only appears when someone breathes on the paper. Which kitchen ingredient would work best, and how would you reveal it? →

5. You are making rock candy and notice that crystals grow larger on a rough cotton string than on a smooth fishing line placed in the same sugar solution. How could you apply this observation to grow even bigger crystals? →

(A) Use a string with an even rougher texture or tie small seed crystals to it, giving the sugar more starting points to build on

(B) Add more pieces of the effervescent tablet to produce more carbon dioxide bubbles that carry the water blobs upward

(C) At the boundary between the water layer and the oil layer

(D) Use more baking soda and vinegar so there are more reactant molecules available to produce carbon dioxide

(E) Write with a sugar-water solution — breathing on it causes moisture to condense

on the sugar residue, making it briefly visible

3. States of Matter

Circle the correct answer

21. What is the name for the process when a solid changes directly into a gas without becoming a liquid first?

(A) Condensation (B) Evaporation (C) Melting (D) Sublimation

22. What is dry ice made of?

(A) Frozen hydrogen (B) Solid nitrogen (C) Frozen water mixed with salt (D) Solid carbon dioxide

23. What are the three most common states of matter?

(A) Hard, soft, and invisible (B) Solid, liquid, and gas (C) Heavy, medium, and light (D) Frozen, melted, and evaporated

24. What is the fourth state of matter, found in lightning, stars, and neon signs?

(A) Plasma (B) Crystal (C) Vapor (D) Ether

25. When dry ice is placed in warm water, a thick fog forms above the surface. Why does the fog sink to the ground instead of rising like steam?

(A) The fog is cold carbon dioxide gas mixed with tiny water droplets, and this cold mixture is denser than the surrounding warm air, so it sinks (B) The warm water pushes the fog down with its steam pressure (C) Gravity pulls all fog downward because fog is a liquid (D) The fog is made of heavy carbon dioxide atoms that weigh more than any gas

26. Why does a balloon inflated with air shrink when placed in a freezer for several minutes, even though no air escapes?

(A) Cold removes some of the air molecules through the balloon wall (B) Cold temperatures cause gas molecules to slow down and move closer together, reducing the volume they occupy inside the balloon (C) The air inside the balloon freezes into a solid (D) The cold causes the rubber to shrink, squeezing the air into a smaller space

Write the answer

27. Why can you smell perfume across a room even though no one carried it to you?

Answer: _____

28. Mothballs slowly shrink over time in a closet without ever getting wet or leaving a puddle. What phase change explains this?

Answer: _____

29. A non-Newtonian fluid like oobleck feels solid when you squeeze it fast but flows like liquid when you pour it slowly. What does the word 'non-Newtonian' tell you about how this fluid differs from regular liquids?

Answer: _____

30. Why does a frozen water bottle crack or bulge, even though most other substances shrink when they freeze?

Answer: _____

Match each question to its answer

1. You want to create a dramatic fog effect for a school play using dry ice and water. The fog starts thick but fades quickly. How would you keep the fog going throughout a 10-minute scene? →

2. You are making oobleck for a science demonstration. The mixture is too runny and flows even when you hit it. What adjustment would make it behave more like a solid under force? →

3. You have a glass of ice water at exactly 0 degrees Celsius. You want to make it colder without adding any ice or putting it in a freezer. How could you lower the temperature using only salt? →

4. You want to demonstrate that gas particles take up more space than the same substance as a liquid. Using only a pot, water, and a stove, how would you show this? →

5. You are comparing two experiments: dropping a coin into oobleck slowly versus quickly. In the slow drop, the coin sinks in. In the fast drop, the coin bounces off. How would you use these results to explain shear-thickening to a younger student? →

(A) Add salt to the ice water — salt lowers the freezing point of water, allowing the mixture to reach temperatures well below 0 degrees Celsius

(B) Add new pieces of dry ice to the warm water at regular intervals, since the sublimation slows as the water cools and the dry ice shrinks

(C) Measure a small amount of water, boil it completely away, and explain that the steam now fills the entire room — far more volume than the liquid occupied

(D) Add more cornstarch to increase the ratio of solid particles to water, making the jamming effect stronger

(E) Explain that the tiny particles in oobleck move aside for slow, gentle things but lock together like a wall when something hits fast and hard

4. Chemical Reactions

Circle the correct answer

31. What do we call a chemical reaction that releases heat energy into its surroundings?

- (A) Exothermic (B) Hypothermic (C) Endothermic (D) Isothermic

32. What type of chemical reaction occurs when iron is exposed to oxygen and water over time, forming a reddish-brown coating?

- (A) Photosynthesis (B) Combustion (C) Fermentation (D) Oxidation (rusting)

33. What is a catalyst in a chemical reaction?

- (A) A substance that provides the energy to start a reaction (B) A substance that speeds up a reaction without being used up in the process (C) A substance that slows down a reaction (D) A substance that is created as a product of the reaction

34. What is the main evidence that a chemical reaction has occurred rather than just a physical change?

- (A) The material is mixed with another material, and this has been consistently demonstrated in practice (B) New substances with different properties are formed, such as different colors, gases, or precipitates (C) The material changes shape or size, and this has been consistently demonstrated in practice (D) The material dissolves in water, making this the most widely accepted explanation

35. When hydrogen peroxide is mixed with potassium iodide in the 'elephant toothpaste' experiment, a huge foam erupts. Why does the foam come out so fast?

- (A) The potassium iodide acts as a catalyst that rapidly decomposes the hydrogen peroxide into water and oxygen gas, which creates the foam (B) The potassium iodide heats the hydrogen peroxide until it boils (C) The two chemicals combine to form a new explosive compound (D) The potassium iodide is a compressed gas that expands on contact

36. When you mix baking soda (a base) with red cabbage juice indicator and it turns blue-green, then add vinegar (an acid) and it turns pink, what is happening to the solution chemically?

- (A) The temperature change from the reaction causes the color to shift (B) The pH of the solution changes from basic to acidic as the vinegar neutralizes the baking soda and makes the solution acidic, shifting the indicator color (C) The vinegar dyes the solution pink while the baking soda dyes it blue (D) The cabbage juice is reacting chemically with both substances to form new pigments

Write the answer

37. Glow sticks work by mixing two chemicals separated by a thin glass tube. When you bend the stick, the tube breaks and the chemicals mix, producing light. Why does the glow stick not produce heat like a light bulb?

Answer: _____

38. When you place a steel wool pad in vinegar for a day, it turns the vinegar a dark brownish-green color. Why does the color change?

Answer: _____

39. In the 'fire snake' experiment, baking soda mixed with sugar is lit on fire, and a black snake-like column grows out of the flame. The black material is much larger than the original mixture. Where does the extra volume come from?

Answer: _____

40. When copper sulfate solution is mixed with iron nails, the nails turn coppery-orange and the blue solution fades. Why do the nails change color?

Answer: _____

Match each question to its answer

1. You are performing the elephant toothpaste experiment and want the foam to be taller. You have the option to increase the concentration of hydrogen peroxide or to add more dish soap. Which change would produce a taller foam column? →

2. You want to use a chemical reaction to inflate a balloon without blowing into it. You have baking soda, vinegar, and a plastic bottle. Describe how you would set this up. →

3. You want to demonstrate an endothermic reaction at a science fair. You have citric acid and baking soda. How would you dramatically show that the reaction absorbs heat? →

4. You accidentally mix two unknown clear liquids in science class and the mixture suddenly turns bright yellow and gets warm. What TWO pieces of evidence indicate a chemical reaction occurred? →

5. You want to make a glow stick glow brighter but not last as long. Based on how chemical reactions work with temperature, what would you do? →

(A) The color change to yellow and the temperature increase both indicate new substances formed through a chemical reaction

(B) Warm the glow stick in hot water, because higher temperature speeds up the chemical reaction, making it release light faster but run out sooner

(C) Increasing the hydrogen peroxide concentration, because it produces more oxygen gas which is the driving force behind the foam volume

(D) Mix citric acid and baking soda in water inside a small container sitting on a wet paper towel — the container gets cold enough to freeze the paper towel to it

(E) Put vinegar in the bottle, put baking soda inside the balloon, stretch the balloon over the bottle opening, then lift the balloon to dump the baking soda into the

5. Physics Phenomena

Circle the correct answer

41. What is the scientific term for an object's tendency to resist changes in its motion?

- (A) Friction (B) Inertia (C) Gravity (D) Momentum

42. What principle states that faster-moving air exerts less pressure than slower-moving air?

- (A) Archimedes' principle (B) Bernoulli's principle (C) Newton's third law (D) Pascal's principle

43. What is the point where all of an object's weight appears to be concentrated called?

- (A) Fulcrum (B) Center of mass (C) Pivot point (D) Center of gravity

44. According to Newton's Third Law, what happens when you push against a wall with your hand?

- (A) The wall pushes back on your hand with an equal force in the opposite direction
(B) The wall absorbs your force without responding (C) The wall pushes back with a greater force to stop your hand (D) The wall stores your force and releases it later

45. A magician pulls a tablecloth from under dishes without disturbing them. Why do the dishes stay in place?

- (A) The dishes have inertia — they resist the change in motion, and the quick pull minimizes the friction time between cloth and dishes (B) The tablecloth is coated with a frictionless material (C) The dishes are secretly glued to the table underneath (D) The magician uses invisible wires to hold the dishes down

46. When you blow air between two ping pong balls hanging from strings, they move toward each other instead of apart. Why does this happen?

- (A) The fast-moving air between the balls creates a low-pressure zone, while the higher air pressure on the outer sides pushes the balls together (B) The balls become statically charged by the moving air and attract each other (C) The air current pushes both balls toward the center like a river (D) The air between the balls heats up and creates a vacuum

Write the answer

47. A balancing bird toy can balance perfectly on your fingertip by its beak, even though most of its body extends behind the balance point. How does this work?

Answer: _____

48. When a car stops suddenly, passengers lurch forward. Why does this happen?

Answer: _____

49. A magician hangs a heavy ball from a string and attaches another identical string below the ball. When the bottom string is pulled slowly, the top string breaks. When pulled quickly with a sharp jerk, the bottom string breaks. Why do different pulling speeds break different strings?

Answer: _____

50. If you hold a sheet of paper horizontally and blow across the top surface, the paper rises. Why does the paper lift upward?

Answer: _____

Match each question to its answer

1. You want to demonstrate inertia to your class using a stack of coins and a ruler. How would you set up this demonstration? →

2. You want to levitate a ping pong ball using only a hair dryer. How would you position the hair dryer and why does the ball stay in the air stream? →

3. You notice that when you swing a bucket of water in a vertical circle fast enough, the water does not fall out at the top. How would you use this same principle to explain why passengers on a roller coaster loop do not fall out at the top? →

4. You want to demonstrate that a tablecloth can be pulled from under a full place setting. You try it at home and the dishes slide off the table. What adjustment would improve your success? →

5. You can balance a fork and spoon on the edge of a glass by interlocking them with a toothpick. The utensils hang seemingly in midair beyond the glass edge. How would you use center of gravity to explain this to someone who thinks it is impossible? →

(A) Use a smooth, unhemmed tablecloth and pull with a swift downward motion rather than horizontally, to minimize the friction time between cloth and dishes

(B) At the top of both the bucket and the loop, the inward centripetal acceleration exceeds gravity, so the water and passengers are pushed against the bottom of their containers by the circular motion

(C) Explain that the combined center of gravity of the fork, spoon, and toothpick system is directly above or below the point where the toothpick contacts the glass rim, creating stable balance

(D) Stack coins on a table with one coin at the bottom slightly separated, then flick the bottom coin out with the ruler — the stack stays in place due to inertia

(E) Point the hair dryer straight up — the ball floats because the fast air creates low

pressure around it, and any sideways drift into slower air pushes it back to center

6. Electricity and Magnetism

Circle the correct answer

51. What type of magnet can be turned on and off by controlling an electric current?

(A) Permanent magnet (B) Refrigerator magnet (C) Electromagnet (D) Compass needle

52. What is the name for the buildup of electric charge on the surface of an object?

(A) Current electricity (B) Thermal energy (C) Magnetic force (D) Static electricity

53. What did Michael Faraday discover about the relationship between moving magnets and electricity?

(A) Electricity destroys magnetism when they interact (B) A changing magnetic field can induce (create) an electric current in a nearby conductor (C) Magnets can store electrical energy like a battery (D) Only permanent magnets can produce electricity

54. What particle moves from one object to another to create static electricity?

(A) Protons (B) Photons (C) Electrons (D) Neutrons

55. When you rub a balloon on your sweater and hold it near a thin stream of water from a faucet, the water bends toward the balloon. Why does the water stream bend?

(A) The charged balloon polarizes the water molecules — their positive ends rotate toward the balloon's negative charge, and the attraction pulls the stream sideways (B) The balloon creates a small wind current that blows the water sideways (C) The balloon's charge evaporates some water molecules, making the stream thinner and easier to move (D) The balloon pushes air molecules into the water stream, deflecting it

56. Why does wrapping more turns of wire around a nail make a stronger electromagnet?

(A) More wire weighs more, and heavier magnets are always stronger (B) More wire insulates the nail from heat, making the magnet work better (C) The extra wire creates friction that converts to magnetic energy (D) Each loop of wire contributes its own magnetic field, and more loops means more overlapping fields that add together to create a stronger total field

Write the answer

57. When you drop a strong magnet through a copper tube, it falls much more slowly than a non-magnetic object of the same weight. Copper is not magnetic, so why does the magnet slow down?

Answer: _____

58. A Van de Graaff generator makes a person's hair stand straight up when they touch it. Why does each strand of hair move away from the others?

Answer: _____

59. How does a simple electric motor convert electrical energy into rotational motion?

Answer: _____

60. A magician seems to levitate a thin aluminum ring above an electromagnet. The ring floats without touching anything. What electromagnetic principle makes this possible?

Answer: _____

Match each question to its answer

1. You want to build the strongest possible electromagnet for a science fair using a battery, wire, and a nail. What three changes would maximize its strength? →

2. You want to demonstrate electromagnetic induction to your class using only a bar magnet and a coil of wire connected to a sensitive meter. How would you produce the largest reading on the meter? →

3. You want to demonstrate that a charged balloon can attract objects without touching them. You have a balloon, wool cloth, and small aluminum foil pieces. What steps would you take, and what will the audience see? →

4. Your electromagnet can pick up paper clips when the battery is connected but drops them instantly when you disconnect the battery. However, you notice the nail stays slightly magnetic even after disconnection. How would you use this observation to make a simple permanent magnet? →

5. You want to slow a strong magnet's fall down a copper tube without touching it. You currently have one layer of copper tubing. How could you make the magnet fall even slower using only additional copper material? →

(A) Use more turns of wire around the nail, use a thicker iron nail as the core, and use a battery with higher voltage to increase the current

(B) Leave the electromagnet energized for an extended period — the sustained magnetic field gradually aligns the iron domains in the nail, and some remain aligned even after the current is removed

(C) Rub the balloon on the wool to charge it, then hold it near the foil pieces — they will jump up and stick to the balloon, then some will pop off moments later as they acquire the same charge

(D) Push the magnet into the coil as quickly as possible — faster motion means a

faster-changing magnetic field, which induces a stronger current

(E) Use a thicker-walled copper tube — more copper means larger induced eddy currents, creating stronger opposing magnetic fields that slow the magnet more

7. Biology Surprises

Circle the correct answer

61. What is the scientific term for organisms that produce their own light through chemical reactions?

(A) Fluorescence (B) Photosynthesis (C) Bioluminescence (D) Phosphorescence

62. What type of symbiotic relationship benefits both organisms involved?

(A) Mutualism (B) Predation (C) Parasitism (D) Commensalism

63. What are organisms called that can survive in extreme environments like boiling hot springs, frozen ice, or highly acidic conditions?

(A) Decomposers (B) Parasites (C) Extremophiles (D) Endangered species

64. What is the term for an animal's ability to blend in with its surroundings by matching colors and patterns?

(A) Camouflage (B) Warning coloration (C) Mimicry (D) Hibernation

65. Fireflies produce light through bioluminescence. Why is their light production so efficient compared to a light bulb, which wastes most energy as heat?

(A) The firefly's chemical reaction converts nearly 100% of energy into light with almost no heat, while light bulbs lose up to 90% of energy as heat from a hot filament
(B) Fireflies store sunlight during the day and release it at night (C) Fireflies are smaller so they need less energy to produce the same amount of light (D) Firefly light is actually very dim but our eyes are extra sensitive to it

66. The bombardier beetle defends itself by spraying a boiling-hot chemical mixture from its abdomen. The chemicals are stored separately and only react when mixed. Why is the separate storage important for the beetle's survival?

(A) Separate storage makes the spray travel farther when combined, and this principle applies across similar situations (B) The chemicals need to be kept at different temperatures to stay active, as this directly follows from the underlying principles (C) Storing the reactive chemicals separately prevents the explosive exothermic reaction from occurring inside the beetle's body until it is deliberately triggered for defense (D) Mixing the chemicals ahead of time would make them weaker over time, and this is the standard approach used in most cases

Write the answer

67. Clownfish live among the stinging tentacles of sea anemones without being harmed. Why are clownfish immune to the anemone's sting while other fish are not?

Answer: _____

68. Tardigrades (water bears) can survive being frozen to -272 degrees Celsius, heated to 150 degrees Celsius, exposed to radiation, and even the vacuum of space. How do they survive these extreme conditions?

Answer: _____

69. The mimic octopus can change its body shape, color, and behavior to resemble over 15 different species including lionfish, flatfish, and sea snakes. How does this differ from ordinary camouflage?

Answer: _____

70. Deep-sea anglerfish have a glowing lure dangling from their heads to attract prey in the pitch-black ocean depths. The light comes from symbiotic bacteria living in the lure. What type of symbiosis is this?

Answer: _____

Match each question to its answer

1. You learn that some bacteria thrive in Yellowstone's hot springs at 80 degrees Celsius. Your friend says bacteria can only live in moderate temperatures like the human body. How would you design a simple experiment to show that microorganisms can survive extreme conditions? →

2. You observe that certain deep-sea creatures near hydrothermal vents are bright white or red despite living in total darkness where color seems useless. How would you explain why these organisms have not evolved to be colorless? →

3. The pistol shrimp can snap its claw so fast that it creates a bubble that collapses with a temperature of 4,700 degrees Celsius — almost as hot as the sun's surface. You want to explain this to a younger student. How would you describe the physics behind it in simple terms? →

4. Electric eels can produce shocks of up to 860 volts. You want to demonstrate the basic principle of bioelectricity to your class. How could you show that living cells produce electricity using only a lemon, two different metals (copper and zinc), and a small LED? →

5. You discover that a species of frog has bright red and blue coloration. Another species in the same habitat is dull brown. Without knowing anything else, you want to predict which frog is likely toxic. How would you apply your knowledge of warning coloration? →

(A) Collect samples from different extreme environments (hot water, very salty water, acidic vinegar), culture them on nutrient plates at their original temperature, and compare growth to samples cultured at room temperature

(B) The bright red and blue frog is more likely toxic — vivid contrasting colors often serve as warning signals (aposematism) telling predators the organism is dangerous to eat

(C) In total darkness, there is no selective pressure for or against color — color may be a side effect of their body chemistry (like hemoglobin making blood red) rather than an adaptation for visibility

(D) Push the copper and zinc strips into the lemon, connect wires from each metal to the LED — the acid in the lemon creates an electrochemical reaction between the different metals, generating enough voltage to light the LED

(E) The claw snaps so fast it creates a bubble of near-vacuum, and when the surrounding water crashes in to fill the void, the compression heats the tiny space to extreme temperatures for a split second

8. Engineering & Invention Magic

Circle the correct answer

71. What is the defining characteristic of a Rube Goldberg machine?

(A) It uses only electronic components to perform tasks (B) It is designed to be the most efficient way to complete a job (C) It accomplishes a simple task through an overly complicated chain reaction (D) It must contain at least twenty separate moving parts

72. In a hydraulic system, what substance is typically used to transmit force?

(A) Compressed air stored in a tank (B) An incompressible liquid such as oil or water (C) Electrical current through copper wires (D) A series of interconnected gears

73. What is the key difference between a hydraulic system and a pneumatic system?

(A) Hydraulic systems use liquid while pneumatic systems use compressed gas (B) Pneumatic systems can only push while hydraulic systems can push and pull (C) Hydraulic systems require electricity but pneumatic systems do not (D) Hydraulic systems are always larger than pneumatic systems

74. What are automata in the context of engineering and invention?

(A) Self-operating mechanical devices designed to follow a predetermined set of movements (B) Robots controlled by computer programs and artificial intelligence (C) Any machine that requires human input to operate continuously (D) Electronic circuits that process information like a calculator

75. A hydraulic car lift uses a small piston to push fluid into a larger piston that lifts the car. Which scientific principle explains why a small force on the small piston creates a larger force on the big piston?

- (A) Archimedes' Principle — an object in fluid experiences an upward buoyant force
(B) Pascal's Law — pressure applied to a confined fluid is transmitted equally in all directions
(C) Newton's Third Law — every action has an equal and opposite reaction
(D) Bernoulli's Principle — faster-moving fluid creates lower pressure

76. In a Rube Goldberg machine, a marble rolls down a ramp and strikes a row of dominoes. What energy transformation occurs when the marble rolls down the ramp?

- (A) Gravitational potential energy converts to kinetic energy
(B) Kinetic energy converts to thermal energy
(C) Chemical energy converts to electrical energy
(D) Elastic potential energy converts to sound energy

Write the answer

77. Why does squeezing the handle of a hydraulic gripper cause the jaws to close, even though they are far from your hand?

Answer: _____

78. A mechanical automaton uses a cam — a rotating piece with an irregular shape — attached to a shaft. What does the cam do as it rotates?

Answer: _____

79. Why are pneumatic systems often preferred over hydraulic systems for operating tools like nail guns and dental drills?

Answer: _____

80. In a Rube Goldberg machine, a fan blows a paper sail attached to a cart, which rolls forward and pulls a string. What type of energy transfer occurs when the fan moves the sail?

Answer: _____

Match each question to its answer

1. You want to build a hydraulic robotic arm that can lift heavy objects. If you increase the diameter of the output piston from 2 cm to 4 cm while keeping the input piston the same size, how does the lifting force change? →

2. You are designing a Rube Goldberg machine and need a step that converts rotational motion into linear motion. Which mechanism would accomplish this? →

3. You are building a pneumatic launcher for a ping-pong ball. You can either use a large air tank at low pressure or a small air tank at high pressure. Both contain the same total amount of compressed air. Which design choice would launch the ball farther, and why? →

4. You want an automaton to raise its arm smoothly upward and then drop it quickly back down. What cam profile shape would you use? →

5. Your Rube Goldberg machine uses a pendulum to knock over a tower of blocks. You need the pendulum to swing with more force. Without changing the pendulum's weight, what should you do? →

(A) Release the pendulum from a greater height so it has more gravitational potential energy to convert

(B) The lifting force increases by four times because area scales with the square of the diameter

(C) The small tank at high pressure, because higher pressure creates a greater initial burst of force on the ball

(D) A rack and pinion system where a spinning gear moves a toothed bar in a straight line

(E) A cam with a gradual rising slope and a steep drop-off back to the base

9. Physical Science

Circle the correct answer

81. What is the speed of light in a vacuum?

(A) About 300,000 km/s (B) About 300 km/s (C) About 30,000 km/s (D) About 3,000,000 km/s

82. What type of mirror curves inward like the inside of a spoon?

(A) Flat mirror (B) Plane mirror (C) Concave mirror (D) Convex mirror

83. What are the three primary colors of light?

(A) Cyan, magenta, and yellow (B) Red, orange, and violet (C) Red, yellow, and blue (D) Red, green, and blue

84. What is the bending of light as it passes from one medium to another called?

(A) Absorption (B) Diffraction (C) Reflection (D) Refraction

85. What device splits white light into a rainbow of colors?

(A) A prism (B) A lens (C) A filter (D) A mirror

86. What term describes the bouncing of light off a surface?

(A) Reflection (B) Refraction (C) Diffraction (D) Transmission

Write the answer

87. Why does a pencil appear bent when placed in a glass of water?

Answer: _____

88. Why do objects appear different colors?

Answer: _____

89. How does a convex lens form a magnified image?

Answer: _____

90. Why does a rainbow form after it rains?

Answer: _____

Match each question to its answer

1. What happens to light when it hits an opaque object? →

2. A flashlight beam hits a mirror at a 35-degree angle to the normal. At what angle does it reflect? →

3. You need to start a fire using sunlight. Which type of lens would you use to focus sunlight to a point? →

4. A photographer wants to reduce glare from a lake's surface. What should they use? →

5. If you mix red and green light together, what color do you see? →

(A) Yellow

(B) 35 degrees

(C) It is absorbed and/or reflected but not transmitted through

(D) A convex lens

(E) A polarizing filter

10. Physical Science

Circle the correct answer

91. What is the chemical formula for water?

(A) NaCl (B) CO₂ (C) H₂O (D) O₂

92. What is the pH value of a neutral substance?

(A) 7 (B) 14 (C) 1 (D) 0

93. What gas do humans exhale that plants use for photosynthesis?

(A) Nitrogen (B) Carbon dioxide (C) Hydrogen (D) Oxygen

94. What is the common name for sodium chloride?

(A) Sugar (B) Table salt (C) Baking soda (D) Vinegar

- 95.** Which element makes up the majority of Earth's atmosphere?
(A) Hydrogen (B) Carbon dioxide (C) Oxygen (D) Nitrogen
- 96.** What are the three common states of matter?
(A) Solid, liquid, and gas (B) Hot, cold, and warm (C) Heavy, medium, and light (D) Metal, wood, and plastic

Write the answer

- 97.** Why does baking soda fizz when mixed with vinegar?
Answer: _____
- 98.** Why does an iron nail rust when left outside?
Answer: _____
- 99.** Why does sugar dissolve faster in hot water than in cold water?
Answer: _____
- 100.** Why does milk eventually spoil even when refrigerated?
Answer: _____

Match each question to its answer

1. Why does adding salt to icy roads help melt the ice? →
 2. You have red cabbage juice, which turns pink in acids and green in bases. You add juice to a soap solution and it turns green. Is the soap acidic or basic? →
 3. A recipe calls for baking soda, but you only have baking powder. Which statement is true? →
 4. You want to slow down the rusting of a metal fence. What is the most effective approach? →
 5. You dissolve sugar in water and then boil away all the water. What remains? →
- (A) Baking powder already contains an acid, so you may need to adjust other acidic ingredients
- (B) Paint or coat the fence to prevent contact with water and oxygen
- (C) The sugar, because dissolving is a physical change
- (D) Basic
- (E) Salt lowers the freezing point of water, causing ice to melt at temperatures below 0 degrees C
-

11. Physical Science

Circle the correct answer

101. What are the two poles of a magnet called?

(A) Positive and negative (B) Top and bottom (C) East and west (D) North and south

102. What happens when you bring two north poles of magnets together?

(A) Nothing happens (B) They repel each other (C) They attract each other (D) They stick together permanently

103. What material is most commonly attracted to magnets?

(A) Copper (B) Plastic (C) Wood (D) Iron

104. What is an electromagnet?

(A) A magnet created by running electric current through a coil of wire (B) A permanent magnet found in nature (C) A magnet that only works in space (D) A magnet powered by solar energy

105. What instrument uses a magnetized needle to show direction?

(A) A protractor (B) A compass (C) A barometer (D) A thermometer

106. What scientist discovered the connection between electricity and magnetism using a compass near a wire?

(A) Albert Einstein (B) Hans Christian Oersted (C) Thomas Edison (D) Isaac Newton

Write the answer

107. Why does a compass needle point north?

Answer: _____

108. Why is an electromagnet useful compared to a permanent magnet?

Answer: _____

109. Why can you magnetize a steel paperclip by rubbing it with a magnet?

Answer: _____

110. Why does wrapping more coils of wire around an electromagnet make it stronger?

Answer: _____

Match each question to its answer

1. Why does dropping or heating a magnet weaken it? →

2. You want to build a stronger electromagnet for a science project. What should you do? →

3. You need to pick up iron scraps from a workshop floor and then release them into a bin. Which type of magnet is best suited? →

4. A generator at a power plant uses magnets and coils of wire to produce electricity. What principle does this rely on? →
5. You cut a bar magnet in half. How many poles do the two pieces have in total? →
- (A) The energy from impact or heat disrupts the alignment of magnetic domains
 - (B) Electromagnetic induction: a changing magnetic field induces an electric current in a wire
 - (C) An electromagnet, because you can turn it off to release the scraps
 - (D) Four (each piece becomes a complete magnet with its own north and south pole)
 - (E) Increase the number of wire coils and use a stronger current
-

12. Physical Science

Circle the correct answer

111. What is sound caused by?
(A) Chemical reactions (B) Light waves (C) Vibrations (D) Magnetic fields
112. What is the unit used to measure the loudness of sound?
(A) Decibel (dB) (B) Watt (W) (C) Meter (m) (D) Hertz (Hz)
113. What is the term for the number of vibrations per second?
(A) Speed (B) Amplitude (C) Frequency (D) Wavelength
114. Through which type of material does sound travel fastest?
(A) Liquids (B) Gases (C) Vacuum (D) Solids
115. Can sound travel through a vacuum (empty space)?
(A) No, sound requires a medium to travel through (B) Yes, but it becomes light instead (C) Yes, but only very loud sounds (D) Yes, sound travels fastest in a vacuum
116. What is the approximate speed of sound in air at room temperature?
(A) About 34 meters per second (B) About 300,000 kilometers per second (C) About 3,000 meters per second (D) About 343 meters per second

Write the answer

117. Why does a guitar string produce a higher-pitched sound when tightened?
Answer: _____
118. Why does thunder arrive after lightning even though they happen at the same time?
Answer: _____

119. Why does your voice sound different to you in a recording compared to how you hear it when speaking?

Answer: _____

120. Why is a concert hall designed with curved walls and special panels?

Answer: _____

Match each question to its answer

1. Why does sound get quieter as you move farther from the source? →

2. You see a lightning flash and hear thunder 5 seconds later. Approximately how far away was the lightning? →

3. You want to soundproof a room for recording music. Which materials would be most effective on the walls? →

4. A dog whistle produces sound that humans cannot hear but dogs can. What can you infer about the frequency of this sound? →

5. You stretch a rubber band between two pegs and pluck it. How could you make it produce a higher-pitched sound? →

(A) The sound energy spreads out over a larger area as it travels, reducing intensity

(B) It is above 20,000 Hz (ultrasonic), which is beyond human hearing range but within a dog's range

(C) About 1,715 meters (approximately 1.7 km)

(D) Soft, porous materials like acoustic foam, heavy curtains, or fiberglass panels

(E) Stretch it tighter or use a shorter or thinner rubber band

13. Optical Illusions

Circle the correct answer

121. Why do two lines of the same length look different when one has arrows pointing outward and the other has arrows pointing inward?

(A) Your brain uses the arrow direction as a depth cue and misjudges the line length
(B) The ink from the arrows makes one line darker and appear longer (C) Your eyes cannot see straight lines correctly (D) The arrows physically stretch and compress the lines

122. A website claims you can make a 'real magnet' by rubbing a needle with a lemon. You know that rubbing a needle with a magnet works. Evaluate whether the lemon claim is scientifically plausible.

(A) It is not plausible because needles cannot become magnets at all (B) It is plausible because the acid in lemons magnetizes metal (C) It is plausible because

lemons contain iron, which is magnetic (D) The lemon claim is not plausible for making a magnet — lemons have no magnetic field to align the needle's domains, unlike an actual magnet

123. You observe that a puddle of water on a sidewalk disappears on a hot sunny day even though it never reached 100 degrees Celsius. A student says water can only become gas at its boiling point. How would you analyze this claim?

(A) The sun's UV rays broke the water molecules apart rather than evaporating them (B) The water did not become gas — it seeped into the ground instead (C) The claim is correct, so the puddle must have actually reached 100 degrees C (D) The claim is wrong — evaporation occurs at any temperature when surface molecules gain enough energy to escape into the air, even well below boiling point

124. When you place a steel wool pad in vinegar for a day, it turns the vinegar a dark brownish-green color. Why does the color change?

(A) The acetic acid in vinegar reacts with the iron in steel wool, forming iron acetate — a new compound with a different color than either starting material (B) The steel wool rusts and the rust flakes change the vinegar's color (C) The vinegar absorbs light from the steel wool, darkening its appearance (D) The vinegar dissolves the paint coating on the steel wool

125. When you blow air between two ping pong balls hanging from strings, they move toward each other instead of apart. Why does this happen?

(A) The air between the balls heats up and creates a vacuum (B) The air current pushes both balls toward the center like a river (C) The fast-moving air between the balls creates a low-pressure zone, while the higher air pressure on the outer sides pushes the balls together (D) The balls become statically charged by the moving air and attract each other

126. Your electromagnet can pick up paper clips when the battery is connected but drops them instantly when you disconnect the battery. However, you notice the nail stays slightly magnetic even after disconnection. How would you use this observation to make a simple permanent magnet?

(A) Leave the electromagnet energized for an extended period — the sustained magnetic field gradually aligns the iron domains in the nail, and some remain aligned even after the current is removed (B) Heat the nail while the electromagnet is on to melt the magnetism into it permanently (C) Connect two batteries in opposite directions to double-lock the magnetic domains (D) Wrap the nail in plastic after removing it from the coil to seal the magnetism in

Write the answer

127. You observe that certain deep-sea creatures near hydrothermal vents are bright white or red despite living in total darkness where color seems useless. How would you explain why these organisms have not evolved to be colorless?

Answer: _____

128. Some engineers argue that Rube Goldberg machines, despite being impractical, are among the best tools for teaching engineering principles. Evaluate this claim by identifying what specific engineering skills are practiced when building one.

Answer: _____

129. A museum exhibit lets visitors walk through rooms with various floor and wall patterns. In one room, a flat floor appears to have a giant hole in it. In another room, straight walls appear to be wavy. If you were the exhibit designer, which TWO principles would be most important to get right?

Answer: _____

130. Design a kitchen experiment to test whether temperature affects how fast sugar dissolves in water. Describe what you would keep the same and what you would change.

Answer: _____

Match each question to its answer

1. Why can you smell perfume across a room even though no one carried it to you? →
2. When hydrogen peroxide is mixed with potassium iodide in the 'elephant toothpaste' experiment, a huge foam erupts. Why does the foam come out so fast? →
3. You want to demonstrate inertia to your class using a stack of coins and a ruler. How would you set up this demonstration? →
4. You want to demonstrate electromagnetic induction to your class using only a bar magnet and a coil of wire connected to a sensitive meter. How would you produce the largest reading on the meter? →
5. Fireflies produce light through bioluminescence. Why is their light production so efficient compared to a light bulb, which wastes most energy as heat? →

(A) Push the magnet into the coil as quickly as possible — faster motion means a faster-changing magnetic field, which induces a stronger current

(B) The firefly's chemical reaction converts nearly 100% of energy into light with almost no heat, while light bulbs lose up to 90% of energy as heat from a hot filament

(C) The potassium iodide acts as a catalyst that rapidly decomposes the hydrogen peroxide into water and oxygen gas, which creates the foam

(D) Perfume molecules enter the gas state and spread out through the air by diffusion, moving from areas of high concentration to low concentration

(E) Stack coins on a table with one coin at the bottom slightly separated, then flick the bottom coin out with the ruler — the stack stays in place due to inertia

14. Optical Illusions

Circle the correct answer

131. When you stare at a spinning spiral and then look at your hand, your hand appears to move. Why does this happen?

(A) Your brain's motion-detecting neurons become tired and fire the opposite signal when you look away (B) Light from the spiral reflects off your hand (C) Your hand is actually moving because of muscle tremors (D) The spiral permanently changes how your eyes focus

132. A student performs the milk and food coloring experiment with dish soap. She tries it with skim milk and then with whole milk. The colors swirl much more dramatically in whole milk. Why would the fat content matter?

(A) Whole milk is heavier, so the colors sink and swirl more (B) Skim milk has more water, which dilutes the food coloring (C) Dish soap's primary action is breaking apart fat molecules, so more fat means more molecular disruption and more dramatic color movement (D) Whole milk is warmer, causing the colors to move faster

133. A science show claims that liquid nitrogen (at -196 degrees C) can instantly freeze a banana so hard that you can hammer a nail with it. Your friend says this is fake because fruit cannot become as hard as metal. Evaluate both claims.

(A) Both are wrong — the banana would dissolve in liquid nitrogen (B) Your friend is right — organic material cannot become hard enough under any conditions (C) The show is lying because liquid nitrogen is not cold enough to freeze fruit (D) The show's claim is plausible — at -196 degrees C the water in the banana freezes so thoroughly that it becomes extremely rigid, though it is still softer than actual metal

134. Design a demonstration to show your class that atmospheric pressure is strong enough to hold a card against the open end of an upside-down glass of water. Describe the setup and explain the physics.

(A) Tape the card to the glass and flip it to show it stays attached, and this principle applies across similar situations (B) Fill a glass with water to the brim, place a flat card on top leaving no air bubbles, hold the card and flip the glass upside down, then release the card — atmospheric pressure pushing up on the card exceeds the weight of the water pushing down, so the card stays (C) Use a vacuum pump to remove air from the glass before flipping, which is the most common explanation for this phenomenon (D) Freeze the water in the glass so it acts as a solid plug, as this is what research and standard practice suggests

135. A student says, 'Electromagnets are always better than permanent magnets because you can control them.' Evaluate whether this is a fair comparison.

(A) The student is wrong because permanent magnets are always stronger than electromagnets (B) The student is correct because electromagnets are newer technology (C) It oversimplifies — electromagnets offer control but require electricity and can overheat. Permanent magnets need no power and never fail from outages. The best choice depends on the application (D) The student is correct because controllability is the only factor that matters

136. Tardigrades (water bears) can survive being frozen to -272 degrees Celsius, heated to 150 degrees Celsius, exposed to radiation, and even the vacuum of space. How do they survive these extreme conditions?

(A) They produce antifreeze chemicals that keep their cells from freezing, making this the most widely accepted explanation (B) They rapidly reproduce so some always survive no matter what, as this directly follows from the underlying principles (C) They have extremely thick skin that protects them like armor, and this is the standard approach used in most cases (D) They enter a state called cryptobiosis where they lose almost all their water, curl into a 'tun,' and their metabolism drops to nearly zero until conditions improve

Write the answer

137. You want to build a hydraulic robotic arm that can lift heavy objects. If you increase the diameter of the output piston from 2 cm to 4 cm while keeping the input piston the same size, how does the lifting force change?

Answer: _____

138. A student claims that optical illusions prove you cannot trust your eyes. Do you agree with this conclusion, or is there a more accurate way to think about it?

Answer: _____

139. You are doing the baking soda and vinegar volcano experiment at a science fair. Your volcano produces a small fizz but you want a much bigger eruption. What change would most increase the reaction?

Answer: _____

140. You have a glass of ice water at exactly 0 degrees Celsius. You want to make it colder without adding any ice or putting it in a freezer. How could you lower the temperature using only salt?

Answer: _____

Match each question to its answer

1. In a flame test experiment, different metal salts produce different colored flames: copper makes green, lithium makes red, and sodium makes yellow. A student says the fire itself is changing colors. What is actually happening at the atomic level? →
2. You notice that when you swing a bucket of water in a vertical circle fast enough, the water does not fall out at the top. How would you use this same principle to explain why passengers on a roller coaster loop do not fall out at the top? →
3. You want to build the strongest possible electromagnet for a science fair using a battery, wire, and a nail. What three changes would maximize its strength? →
4. Scientists discovered bacteria living 3 kilometers underground in gold mine rocks, surviving on radioactive energy rather than sunlight or chemical nutrients from the surface. This challenges the assumption that all life depends on the sun. What broader implication does this have for the search for life beyond Earth? →
5. A Rube Goldberg machine has five steps: (1) a ball rolls down a ramp, (2) the ball hits a lever, (3) the lever launches a marble, (4) the marble lands in a cup on a pulley, and (5) the descending cup pulls a string that rings a bell. A student notices the marble in step 3 does not reach the cup. What is the most systematic approach to fixing this? →

(A) At the top of both the bucket and the loop, the inward centripetal acceleration exceeds gravity, so the water and passengers are pushed against the bottom of their containers by the circular motion

(B) Analyze the energy at each transfer point to find where the marble loses too much speed or direction

(C) Use more turns of wire around the nail, use a thicker iron nail as the core, and use a battery with higher voltage to increase the current

(D) It suggests life could exist on other planets or moons even without sunlight, surviving on geochemical or radioactive energy deep underground, dramatically expanding where we should look for extraterrestrial life

(E) The heat excites electrons in each metal atom to higher energy levels, and when they fall back down, they release energy as specific colors of light unique to each element

15. Optical Illusions

Circle the correct answer

141. Your friend says that the baking soda and vinegar reaction creates new matter because you end up with gas that was not there before. Is this claim correct?

(A) No — the gas was not created from nothing. The atoms in the baking soda and vinegar rearranged to form carbon dioxide, water, and sodium acetate. Total matter is conserved (B) No, because the gas is just air that was already in the room (C) Yes,

the bubbles are proof that matter was created by the reaction, and this is the standard approach used in most cases (D) Yes, new matter is created whenever a chemical reaction produces gas, as this directly follows from the underlying principles

142. You accidentally mix two unknown clear liquids in science class and the mixture suddenly turns bright yellow and gets warm. What TWO pieces of evidence indicate a chemical reaction occurred?

(A) The yellow color means the liquids contained yellow food coloring (B) The warmth means one liquid dissolved in the other (C) The fact that both liquids were clear and the mixture stayed liquid (D) The color change to yellow and the temperature increase both indicate new substances formed through a chemical reaction

143. Design a simple classroom experiment to demonstrate how bioluminescence works using a glow-in-the-dark reaction. You have hydrogen peroxide, luminol powder, a copper sulfate catalyst, and a dark room. Describe the setup and explain the connection to biological light production.

(A) Dissolve the luminol in water and add food coloring to make it glow different colors, as this is what research and standard practice suggests (B) Charge the luminol under a bright light and then turn off the lights to see it glow, which is why this approach is recommended by experts (C) Mix luminol with hydrogen peroxide and add a tiny amount of copper sulfate catalyst in a dark room — the solution will glow blue, demonstrating chemiluminescence, the same chemical-to-light conversion that organisms use in bioluminescence (D) Mix all chemicals together and heat them until they emit light, and this principle applies across similar situations

144. What are automata in the context of engineering and invention?

(A) Electronic circuits that process information like a calculator (B) Any machine that requires human input to operate continuously (C) Self-operating mechanical devices designed to follow a predetermined set of movements (D) Robots controlled by computer programs and artificial intelligence

145. Why do movies appear to show smooth motion when they are actually a series of still images shown very quickly?

(A) Your eyes move so fast they blur the separate images together (B) Your brain blends rapidly displayed images together, filling in the gaps to perceive continuous movement (C) The camera captures actual motion between frames (D) Movie screens vibrate to create the illusion of movement

146. Freeze-dried foods like astronaut ice cream are made by freezing food and then removing the water through sublimation in a vacuum. Why is the vacuum necessary for sublimation to occur efficiently?

(A) The vacuum removes oxygen so the food does not spoil during drying (B) The vacuum heats the food to make the ice evaporate faster (C) The vacuum lowers the

air pressure enough that ice can sublime directly to vapor without melting first, preserving the food's structure (D) The vacuum compresses the ice crystals until they disappear

Write the answer

147. A balancing bird toy can balance perfectly on your fingertip by its beak, even though most of its body extends behind the balance point. How does this work?

Answer: _____

148. A magician seems to levitate a thin aluminum ring above an electromagnet. The ring floats without touching anything. What electromagnetic principle makes this possible?

Answer: _____

149. You discover that a species of frog has bright red and blue coloration. Another species in the same habitat is dull brown. Without knowing anything else, you want to predict which frog is likely toxic. How would you apply your knowledge of warning coloration?

Answer: _____

150. A city is choosing between a hydraulic elevator system and a pneumatic tube mail delivery system for a new building. Evaluate which engineering principles should guide the decision for each application.

Answer: _____

Match each question to its answer

1. In the Ponzo illusion, two identical horizontal lines are drawn between converging railroad tracks. Why does the upper line appear longer? →

2. You want to make a lava lamp using oil, water, and an effervescent tablet. You notice the colored water blobs rise through the oil and then sink back down. How would you make the blobs rise more frequently? →

3. A student performs two experiments: mixing baking soda with vinegar (which fizzes) and mixing baking soda with water (which does not fizz). Both mixtures are clear liquids after the reactions settle. Why does this comparison help prove that the fizzing was caused by a chemical reaction and not just by dissolving? →

4. According to Newton's Third Law, what happens when you push against a wall with your hand? →

5. When you rub a balloon on your sweater and hold it near a thin stream of water from a faucet, the water bends toward the balloon. Why does the water stream bend? →

- (A) Add more pieces of the effervescent tablet to produce more carbon dioxide bubbles that carry the water blobs upward
 - (B) The wall pushes back on your hand with an equal force in the opposite direction
 - (C) The charged balloon polarizes the water molecules — their positive ends rotate toward the balloon's negative charge, and the attraction pulls the stream sideways
 - (D) Because baking soda dissolves in both liquids, but only the vinegar produces gas bubbles, showing the gas comes from a chemical reaction between the acid and the base, not from dissolving alone
 - (E) The converging lines make your brain interpret the image as a 3D scene where the upper line seems farther away, so your brain scales it up
-

16. Optical Illusions

Circle the correct answer

151. Hand warmers contain iron powder, salt, and activated carbon. When you open the package and expose it to air, the hand warmer heats up for hours. A student says this must be the same reaction as iron rusting. Analyze whether this comparison is valid.

- (A) The comparison is wrong because rusting only happens with water, not air
- (B) The comparison is valid because both reactions produce light and heat
- (C) The comparison is valid — both are oxidation of iron, but the hand warmer uses fine powder, salt catalyst, and carbon to dramatically speed up the same slow rusting reaction
- (D) The comparison is wrong because hand warmers use combustion, not oxidation

152. What is the scientific term for an object's tendency to resist changes in its motion?

- (A) Momentum
- (B) Gravity
- (C) Inertia
- (D) Friction

153. Your Rube Goldberg machine uses a pendulum to knock over a tower of blocks. You need the pendulum to swing with more force. Without changing the pendulum's weight, what should you do?

- (A) Paint the pendulum a darker color to increase its thermal absorption
- (B) Attach the pendulum to a stiffer string to increase the force transmitted
- (C) Use a longer string so the pendulum swings in a wider arc at the same height
- (D) Release the pendulum from a greater height so it has more gravitational potential energy to convert

154. A magician wants the audience to think a ball disappears. She throws it upward twice, and on the third throw she secretly keeps it in her hand but looks up. The audience 'sees' the ball go up. Which optical illusion principle is she using?

(A) She is moving so fast that the ball becomes a blur (B) She is using ultraviolet light to make the ball invisible (C) She is using expectation and eye tracking — the audience's brains predict the ball's path based on the first two throws (D) She is using a mirror to reflect a fake ball image

155. You built a density tower with honey, dish soap, water, vegetable oil, and rubbing alcohol. A grape sinks through the oil but floats on the dish soap. Where would a small plastic bead that floats on water but sinks in oil end up?

(A) At the very bottom, below the honey (B) At the very top of the tower, above the alcohol (C) At the boundary between the water layer and the oil layer (D) Exactly in the middle of the oil layer

156. What is the fourth state of matter, found in lightning, stars, and neon signs?

(A) Plasma (B) Ether (C) Vapor (D) Crystal

Write the answer

157. You want to make a glow stick glow brighter but not last as long. Based on how chemical reactions work with temperature, what would you do?

Answer: _____

158. The relationship between mycorrhizal fungi and plant roots has been called the 'Wood Wide Web.' The fungi extend the plant's root network, helping it access water and nutrients, while the plant provides sugars to the fungi. Scientists also discovered that trees use the fungal network to share nutrients with neighboring trees. What does this sharing behavior suggest about competition in forests?

Answer: _____

159. In a density tower experiment, honey sinks to the bottom, water stays in the middle, and oil floats on top. What determines this layering order?

Answer: _____

160. What are the three most common states of matter?

Answer: _____

Match each question to its answer

1. You can balance a fork and spoon on the edge of a glass by interlocking them with a toothpick. The utensils hang seemingly in midair beyond the glass edge. How would you use center of gravity to explain this to someone who thinks it is impossible? →

2. What is the scientific term for organisms that produce their own light through

chemical reactions? →

3. Why does squeezing the handle of a hydraulic gripper cause the jaws to close, even though they are far from your hand? →

4. A friend shows you a picture where a vase shape also looks like two faces looking at each other. Your friend insists it is just a vase. Using your knowledge of perception, how would you explain why you both see different things? →

5. In a Rube Goldberg machine, a fan blows a paper sail attached to a cart, which rolls forward and pulls a string. What type of energy transfer occurs when the fan moves the sail? →

(A) Kinetic energy of moving air transfers to kinetic energy of the cart through force on the sail

(B) Explain that the combined center of gravity of the fork, spoon, and toothpick system is directly above or below the point where the toothpick contacts the glass rim, creating stable balance

(C) Bioluminescence

(D) Squeezing increases the fluid pressure, which travels through the tube and pushes the jaw piston outward

(E) Your brains are deciding differently which part is the figure and which is the background, and both interpretations are valid

Riddle & Joke Break

Guess the answer, then check the key!

161. Why did the science magician get good grades?

162. What did the hypothesis say to the experiment?

163. Why did the density tower feel superior?

164. What do you call a magician who uses real science?

165. Why was the light ray such a great performer?

166. What did the magnet say during the levitation trick?

Answer Key

1. C — Retina

2. A — Pupil

3. B — Optical illusion
4. A — Optic nerve
5. D — Your brain uses the arrow direction as a depth cue and misjudges the line length
6. A — Your brain's motion-detecting neurons become tired and fire the opposite signal when you look away
7. Your brain compares the moon to nearby objects on the horizon and misjudges its size
8. Your brain blends rapidly displayed images together, filling in the gaps to perceive continuous movement
9. Your brain judges brightness by comparing objects to their surroundings, so the same color looks lighter on a dark background and darker on a light one
10. The converging lines make your brain interpret the image as a 3D scene where the upper line seems farther away, so your brain scales it up
Matching (Optical Illusions): 1→C, 2→E, 3→B, 4→D, 5→A
11. A — Carbon dioxide
12. D — Density
13. C — The heat causes the acids in lemon juice to break down and turn brown before the paper does
14. A — Each liquid has a different density, and they stack from most dense at the bottom to least dense at the top
15. D — Dish soap breaks apart the fat molecules in milk, and the movement of the fat creates currents that push the food coloring around
16. D — Carbon dioxide bubbles attach to the rough raisin surface, making it buoyant, then pop at the surface, causing it to sink again
17. Red cabbage juice is a natural pH indicator — its color changes depending on whether the solution is acidic or basic
18. Hot water holds more dissolved sugar than cold water, so as it cools the excess sugar comes out of solution and forms crystals on the string
19. When force is applied quickly, the cornstarch particles lock together and resist movement, but slow force lets them slide past each other
20. Vinegar is an acid that reacts with the calcium carbonate in the eggshell,

breaking it down into soluble compounds and carbon dioxide gas

Matching (Kitchen Chemistry): 1→B, 2→C, 3→D, 4→E, 5→A

21. D — Sublimation
 22. D — Solid carbon dioxide
 23. B — Solid, liquid, and gas
 24. A — Plasma
 25. A — The fog is cold carbon dioxide gas mixed with tiny water droplets, and this cold mixture is denser than the surrounding warm air, so it sinks
 26. B — Cold temperatures cause gas molecules to slow down and move closer together, reducing the volume they occupy inside the balloon
 27. Perfume molecules enter the gas state and spread out through the air by diffusion, moving from areas of high concentration to low concentration
 28. Sublimation — the solid mothball material converts directly to gas and disperses into the air
 29. A non-Newtonian fluid changes its resistance to flow depending on the force applied, unlike regular Newtonian fluids like water that always flow the same way
 30. Water expands when it freezes because its molecules form a crystal structure with more space between them than in liquid water
- Matching (States of Matter): 1→B, 2→D, 3→A, 4→C, 5→E
31. A — Exothermic
 32. D — Oxidation (rusting)
 33. B — A substance that speeds up a reaction without being used up in the process
 34. B — New substances with different properties are formed, such as different colors, gases, or precipitates
 35. A — The potassium iodide acts as a catalyst that rapidly decomposes the hydrogen peroxide into water and oxygen gas, which creates the foam
 36. B — The pH of the solution changes from basic to acidic as the vinegar neutralizes the baking soda and makes the solution acidic, shifting the indicator color
 37. Glow sticks produce light through chemiluminescence — a chemical reaction that converts energy directly into light rather than heat

38. The acetic acid in vinegar reacts with the iron in steel wool, forming iron acetate — a new compound with a different color than either starting material
39. The heat decomposes the baking soda and sugar, producing carbon dioxide gas that gets trapped in the carbon residue, puffing it up like a sponge
40. Iron displaces copper from the solution in a single displacement reaction, depositing metallic copper onto the nail surface
Matching (Chemical Reactions): 1→C, 2→E, 3→D, 4→A, 5→B
41. B — Inertia
42. B — Bernoulli's principle
43. D — Center of gravity
44. A — The wall pushes back on your hand with an equal force in the opposite direction
45. A — The dishes have inertia — they resist the change in motion, and the quick pull minimizes the friction time between cloth and dishes
46. A — The fast-moving air between the balls creates a low-pressure zone, while the higher air pressure on the outer sides pushes the balls together
47. Weights in the wingtips shift the center of gravity forward to directly above the beak's contact point, creating a stable balance
48. The passengers' bodies have inertia — they continue moving forward at the car's previous speed while the car decelerates beneath them
49. A slow pull gradually increases tension throughout, breaking the weaker top string which bears the ball's weight. A quick jerk breaks the bottom string because the ball's inertia prevents the force from reaching the top string in time
50. The fast air over the top creates lower pressure above the paper, while the still air beneath maintains higher pressure, pushing the paper up
Matching (Physics Phenomena): 1→D, 2→E, 3→B, 4→A, 5→C
51. C — Electromagnet
52. D — Static electricity
53. B — A changing magnetic field can induce (create) an electric current in a nearby conductor
54. C — Electrons
55. A — The charged balloon polarizes the water molecules — their positive ends

rotate toward the balloon's negative charge, and the attraction pulls the stream sideways

56. D — Each loop of wire contributes its own magnetic field, and more loops means more overlapping fields that add together to create a stronger total field
57. The moving magnet induces electric currents in the copper, which create their own magnetic fields that oppose the magnet's motion — this is Lenz's law
58. The generator transfers charge to the person, giving each hair strand the same type of charge. Since like charges repel, the strands push away from each other
59. Current flowing through a coil in a magnetic field creates a force on the wire that pushes it in one direction, and a commutator reverses the current each half-turn to keep the coil spinning
60. An alternating current in the electromagnet induces eddy currents in the ring, which create a magnetic field that repels the electromagnet's field, pushing the ring upward
Matching (Electricity and Magnetism): 1→A, 2→D, 3→C, 4→B, 5→E
61. C — Bioluminescence
62. A — Mutualism
63. C — Extremophiles
64. A — Camouflage
65. A — The firefly's chemical reaction converts nearly 100% of energy into light with almost no heat, while light bulbs lose up to 90% of energy as heat from a hot filament
66. C — Storing the reactive chemicals separately prevents the explosive exothermic reaction from occurring inside the beetle's body until it is deliberately triggered for defense
67. Clownfish produce a special mucus coating that chemically prevents the anemone's stinging cells from firing, allowing them to live safely among the tentacles
68. They enter a state called cryptobiosis where they lose almost all their water, curl into a 'tun,' and their metabolism drops to nearly zero until conditions improve
69. Ordinary camouflage matches the background environment, but the mimic octopus actively impersonates specific dangerous animals to scare predators away — this is dynamic mimicry, not just blending in

70. Mutualism — the bacteria get a protected habitat with nutrients, while the anglerfish gets a glowing lure to attract food

Matching (Biology Surprises): 1→A, 2→C, 3→E, 4→D, 5→B

71. C — It accomplishes a simple task through an overly complicated chain reaction
72. B — An incompressible liquid such as oil or water
73. A — Hydraulic systems use liquid while pneumatic systems use compressed gas
74. A — Self-operating mechanical devices designed to follow a predetermined set of movements
75. B — Pascal's Law — pressure applied to a confined fluid is transmitted equally in all directions
76. A — Gravitational potential energy converts to kinetic energy
77. Squeezing increases the fluid pressure, which travels through the tube and pushes the jaw piston outward
78. It converts rotary motion into back-and-forth or up-and-down motion
79. Compressed air is lighter, cleaner, and allows faster repetitive motion than hydraulic fluid
80. Kinetic energy of moving air transfers to kinetic energy of the cart through force on the sail

Matching (Engineering & Invention Magic): 1→B, 2→D, 3→C, 4→E, 5→A

81. A — About 300,000 km/s
82. C — Concave mirror
83. D — Red, green, and blue
84. D — Refraction
85. A — A prism
86. A — Reflection
87. Light refracts as it moves between water and air
88. They absorb some wavelengths and reflect others
89. It refracts light rays so they converge, making nearby objects appear larger
90. Sunlight is refracted, reflected, and dispersed by water droplets in the air

Matching (Physical Science): 1→C, 2→B, 3→D, 4→E, 5→A

91. C — H₂O
92. A — 7
93. B — Carbon dioxide
94. B — Table salt
95. D — Nitrogen
96. A — Solid, liquid, and gas
97. An acid-base chemical reaction produces carbon dioxide gas
98. Iron reacts with oxygen and water in the air to form iron oxide (rust)
99. Higher temperature gives water molecules more energy to break apart sugar crystals
100. Bacteria slowly break down proteins and fats in the milk through chemical reactions
Matching (Physical Science): 1→E, 2→D, 3→A, 4→B, 5→C
101. D — North and south
102. B — They repel each other
103. D — Iron
104. A — A magnet created by running electric current through a coil of wire
105. B — A compass
106. B — Hans Christian Oersted
107. Earth has a magnetic field, and the compass needle aligns with it
108. Its magnetic field can be turned on and off by controlling the electric current
109. Rubbing aligns the magnetic domains in the steel so they all point in the same direction
110. Each additional coil adds to the total magnetic field produced
Matching (Physical Science): 1→A, 2→E, 3→C, 4→B, 5→D
111. C — Vibrations
112. A — Decibel (dB)
113. C — Frequency
114. D — Solids

115. A — No, sound requires a medium to travel through
116. D — About 343 meters per second
117. Tightening increases the string's vibration frequency
118. Light travels much faster than sound, so we see the lightning before the sound reaches us
119. When speaking, you hear through both air conduction and bone conduction, but a recording only captures air-conducted sound
120. To control how sound reflects and absorbs, ensuring even sound distribution and reducing echoes
Matching (Physical Science): 1→A, 2→C, 3→D, 4→B, 5→E
121. A — Your brain uses the arrow direction as a depth cue and misjudges the line length
122. D — The lemon claim is not plausible for making a magnet — lemons have no magnetic field to align the needle's domains, unlike an actual magnet
123. D — The claim is wrong — evaporation occurs at any temperature when surface molecules gain enough energy to escape into the air, even well below boiling point
124. A — The acetic acid in vinegar reacts with the iron in steel wool, forming iron acetate — a new compound with a different color than either starting material
125. C — The fast-moving air between the balls creates a low-pressure zone, while the higher air pressure on the outer sides pushes the balls together
126. A — Leave the electromagnet energized for an extended period — the sustained magnetic field gradually aligns the iron domains in the nail, and some remain aligned even after the current is removed
127. In total darkness, there is no selective pressure for or against color — color may be a side effect of their body chemistry (like hemoglobin making blood red) rather than an adaptation for visibility
128. They develop skills in energy transfer analysis, iterative testing and debugging, mechanical design, and understanding how subsystem failures cascade through connected systems
129. The viewing angle visitors use and the precise pattern of light and dark areas that create false depth cues
130. Use identical amounts of sugar and water in separate containers at different

temperatures (cold, warm, hot), stirring each the same way, and time how long each takes to dissolve completely

Matching (Optical Illusions): 1→D, 2→C, 3→E, 4→A, 5→B

131. A — Your brain's motion-detecting neurons become tired and fire the opposite signal when you look away
 132. C — Dish soap's primary action is breaking apart fat molecules, so more fat means more molecular disruption and more dramatic color movement
 133. D — The show's claim is plausible — at -196 degrees C the water in the banana freezes so thoroughly that it becomes extremely rigid, though it is still softer than actual metal
 134. B — Fill a glass with water to the brim, place a flat card on top leaving no air bubbles, hold the card and flip the glass upside down, then release the card — atmospheric pressure pushing up on the card exceeds the weight of the water pushing down, so the card stays
 135. C — It oversimplifies — electromagnets offer control but require electricity and can overheat. Permanent magnets need no power and never fail from outages. The best choice depends on the application
 136. D — They enter a state called cryptobiosis where they lose almost all their water, curl into a 'tun,' and their metabolism drops to nearly zero until conditions improve
 137. The lifting force increases by four times because area scales with the square of the diameter
 138. It is more accurate to say optical illusions show that your brain takes shortcuts when interpreting what your eyes see, and those shortcuts usually work well but can be fooled
 139. Use more baking soda and vinegar so there are more reactant molecules available to produce carbon dioxide
 140. Add salt to the ice water — salt lowers the freezing point of water, allowing the mixture to reach temperatures well below 0 degrees Celsius
- Matching (Optical Illusions): 1→E, 2→A, 3→C, 4→D, 5→B
141. A — No — the gas was not created from nothing. The atoms in the baking soda and vinegar rearranged to form carbon dioxide, water, and sodium acetate. Total matter is conserved
 142. D — The color change to yellow and the temperature increase both indicate new substances formed through a chemical reaction

143. C — Mix luminol with hydrogen peroxide and add a tiny amount of copper sulfate catalyst in a dark room — the solution will glow blue, demonstrating chemiluminescence, the same chemical-to-light conversion that organisms use in bioluminescence
144. C — Self-operating mechanical devices designed to follow a predetermined set of movements
145. B — Your brain blends rapidly displayed images together, filling in the gaps to perceive continuous movement
146. C — The vacuum lowers the air pressure enough that ice can sublime directly to vapor without melting first, preserving the food's structure
147. Weights in the wingtips shift the center of gravity forward to directly above the beak's contact point, creating a stable balance
148. An alternating current in the electromagnet induces eddy currents in the ring, which create a magnetic field that repels the electromagnet's field, pushing the ring upward
149. The bright red and blue frog is more likely toxic — vivid contrasting colors often serve as warning signals (aposematism) telling predators the organism is dangerous to eat
150. Hydraulic is better for the elevator because it provides high force for heavy loads, while pneumatic is better for mail tubes because lightweight capsules benefit from the speed and simplicity of air power
Matching (Optical Illusions): 1→E, 2→A, 3→D, 4→B, 5→C
151. C — The comparison is valid — both are oxidation of iron, but the hand warmer uses fine powder, salt catalyst, and carbon to dramatically speed up the same slow rusting reaction
152. C — Inertia
153. D — Release the pendulum from a greater height so it has more gravitational potential energy to convert
154. C — She is using expectation and eye tracking — the audience's brains predict the ball's path based on the first two throws
155. C — At the boundary between the water layer and the oil layer
156. A — Plasma
157. Warm the glow stick in hot water, because higher temperature speeds up the chemical reaction, making it release light faster but run out sooner

- 158. It suggests that forest ecosystems involve significant cooperation alongside competition — trees may benefit from keeping neighboring trees healthy to maintain the shared fungal network
- 159. Each liquid has a different density, and they stack from most dense at the bottom to least dense at the top
- 160. Solid, liquid, and gas
Matching (Optical Illusions): 1→B, 2→C, 3→D, 4→E, 5→A
- 161. Because every trick had a great reaction!
- 162. "I've been testing your patience!"
- 163. It was always on top of things!
- 164. A wizard of cause and effect!
- 165. It always knew how to reflect on its act!
- 166. "I find you very attractive!"

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