Conceptual Physics Problems

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Introduction

Conceptual Physics Problems (CPP) are problems for a course of conceptual physics where the emphasis is on grasping a broad range of physics (intro physics and some modern physics) at the conceptual level with only light treatment of mathematical aspects.

The problems are grouped by topics in chapters: see Contents below. The chapters correspond to the chapters of Paul G. Hewitt's *Conceptual Physics*. There are multiple-choice problems and full answer problems. All the problems have will have complete suggested answers eventually. The answers may be the greatest benefit of CPP. The problems and answers can be posted on the web in pdf format.

At the end of the book is an appendix of answer tables for multiple choice questions.

CPP is currently under construction and whether it will grow to adequate size depends on whether I have any chance to teach conceptual physics again.

Everything is written in plain TEX in my own idiosyncratic style. The problems all have codes and keywords for easy selection electronically or by hand. The keywords will be on the problem code line with additional ones on the extra keyword line which may also have a reference for the problem A fortran program for selecting the problems and outputting them in quiz, assignment, and test formats is also available. Note the quiz, etc. creation procedure is a bit clonky, but it works. User instructors could easily construct their own programs for problem selection.

I would like to thank the Department of Physics & Astronomy of the University of Nevada, Las Vegas for its support for this work. Thanks also to the students who helped flight-test the problems.

Contents

Chapters

1 What is this Thing Science?
2 Classical Mechanics
3 Atoms
4 Solids
5 Liquids
6 Gases

Appendices

1 Multiple-Choice Problem Answer Tables

References

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Chapt. 1 What is this Thing Science?

Multiple-Choice Problems

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001 qmult 00070 1 4 5 easy deducto-memory: seven samurai

Extra keywords: not a serious question

1. "Let's play *Jeopardy*! For $100, the answer is: In Akira Kurosawa's film *The Seven Samurai* in the misremembering of popular memory, what the samurai leader said when one of the seven asked why they were going to defend this miserable village from a horde of marauding bandits."

   What is "____________," Alex?

   a) For honor. b) It is the way of the samurai. c) It is the Tao. d) For a few dollars more. e) For the fun of it.

---

001 qmult 00080 1 4 3 easy deducto-memory: Arabian Nights

Extra keywords: mathematical physics

2. "Let's play *Jeopardy*! For $100, the answer is: It is a story very much like a course in physics."

   What is ____________, Alex?

   a) the *Theogony* by Hesiod (circa 700 BCE)
   b) *The Odyssey* by Homer (circa 700 BCE?)
   c) *A Thousand Nights and a Night* by Anonymous (circa 800–900)
   d) *War and Peace* by Lev Tolstoy (1828–1910)
   e) *Ulysses* by James Joyce (1882–1941)

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001 qmult 00100 1 4 5 easy deducto-memory: science partially defined

3. "Let's play *Jeopardy*! For $100, the answer is: An activity that involves a study of objective reality and the scientific method."

   What is ____________, Alex?

   a) accounting b) poetry c) home repair d) homework e) science

---

001 qmult 00110 1 1 4 easy memory: scientific method described

Extra keywords: physci KB-24-1 but much altered

4. The scientific method can be schematically described as a/an:

   a) square of theorizing and experiment/observation. b) integrative process.
   c) reductive process. d) a cycle of theorizing and experiment/observation.
   e) a pointless pursuit.

---

001 qmult 00300 1 4 5 easy deducto-memory: Eratosthenes circumference

5. "Let's play *Jeopardy*! For $100, the answer is: He was the first person to measure the circumference of the Earth."

   Who is ____________, Alex?

a) Parmenides (early 5th century BCE) b) Democritus (c. 460–c. 370 BCE)
c) Aristotle (384–322 BCE) d) Aristarchus of Samos (c. 310–c. 230 BCE)
e) Eratosthenes (c. 276–c. 195 BCE)

---

001 qmult 00410 1 4 1 easy deducto-memory: heliocentrism deduction

6. "Let's play *Jeopardy*! For $100, the answer is: The theory that allowed the relative positions of the planets to be deduced."

   What is the ____________ solar system theory, Alex?

   a) heliocentric b) geocentric c) marsocentric d) lunacentric e) plutocentric

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Full-Answer Problems

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001 qfull 00100 1 3 0 easy math: science defined

7. Define science in one sentence. Now define science in a paragraph of a few sentences. Use your own words in both cases.

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001 qfull 00120 1 3 0 easy math: is the scientific method scientific?

8. Is the scientific method a scientific theory? Discuss.

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001 qfull 00220 1 3 0 easy math: SI base units

9. Briefly discuss the need for units and how units are set.

---

001 qfull 00310 1 3 0 easy math: describe Eratosthenes measurement

10. Describe Eratosthenes's measurement of the circumference of the Earth. In particular, discuss how his measurement was theory-laden: i.e., how it assumed certain theories in order to have the meaning that it did. You should use diagrams. Knowing the numbers Eratosthenes used is not needed. You have to describe the method. Write legibly.

---

001 qfull 00520 1 3 0 easy math: pinhole projection of the Sun

11. Use pinhole projection to observe the Sun. You will need the Sun in a clear sky region. About how big an image can create? Can you see sunspots? Incidentally, can you see narrow dark and bright fringes just near the edges of shadows (e.g., of a pencil)? You need to look really closely. A magnifying glass might help.

Chapt. 2 Classical Mechanics

Multiple-Choice Problems

002 qmult 00100 1 4 4 easy deducto-memory: mechanics defined

12. "Let's play *Jeopardy*! For \$100, the answer is: It is the branch of physics dealing with the motions of bodies."

    What is ____________, Alex?

    a) electromagnetism b) thermodynamics c) engineering d) mechanics
    e) chemical reactions

002 qmult 00110 1 1 1 easy memory: classical mechanics defined

13. ________________ is the only mechanics theory known before about 1900 and then thought to be the fundamental physics of motion. Nowadays we know it is an approximate theory valid for size scales much larger than atomic, size scales much smaller than cosmological, speeds much slower than the vacuum light speed, and gravity much weaker than black holes. Within its realm of validity it is a very accurate theory and, in fact, in the inner region of that realm no experimental discrepancies can be detected. The center of that realm—which might be tricky to defined exactly—can be called the classical limit. In the classical limit, one can describe the theory as an exact true emergent physics—and many would consider this the useful way to describe rather than as an approximate theory. As one departs form the classical limit, the theory progressively becomes more and more approximate and eventually becomes inadequate as a theory of motion.

    a) Classical mechanics b) Quantum mechanics c) Quantum field theory
    d) Relativistic physics e) Aristotelian physics

002 qmult 00200 1 4 5 easy deducto-memory: geometry defined

14. "Let's play *Jeopardy*! For \$100, the answer is: The branch of mathematics concerned with shapes in space and the properties of space."

    What is ____________, Alex?

    a) real analysis b) number theory c) calculus d) algebra e) geometry

002 qmult 00210 1 1 3 easy memory: Euclidean geometry

15. The geometry of everyday life 3-dimensional space and a vast realm beyond everyday life 3-dimensional space is:

    a) hyperspherical. b) hyperbolic. c) Euclidean. d) curved. e) very curved.

002 qmult 00250 1 1 2 easy memory: 2-d curved space of a sphere

16. The 2-dimensional surface of a sphere is not a flat space (i.e., not a Euclidean 2-dimensional space). One sign of this is that lines parallel at an equator:

    a) never meet. b) meet at the poles. c) meet 3 times.
    d) diverge from each other away from the equator. e) meet at the equator.

002 qmult 00300 1 4 1 easy deducto-memory: displacement defined

17. "Let's play *Jeopardy*! For $100, the answer is: It is the vector quantity specifying position relative to some origin. It has length which is the straightline distance from the origin to the position and a direction which is the direction from the origin to the position."

What is ____________, Alex?

a) displacement b) velocity c) acceleration d) force e) time

---

002 qmult 00330 1 3 3 easy math: displacements in Vegas 1
Extra keywords: physci

18. You are in Las Vegas at the intersection of the Strip and Tropicana (where the MGM Grand, New York, New York, Excalibur, and Tropicana are). You go about **1 mile north** on the east side of the Strip to the Harley-Davidson Cafe, cross the Strip to the west side, and go about **half a mile south** to the Monte Carlo and there lose **most** of your of $100 stake at the roulette table.

a) Your total travel distance is about **1.5 miles**, total displacement about **1 mile north**, and you have **more** than $50 left.
b) Your total travel distance is about **1.5 miles**, total displacement about **0.5 miles north**, and you have **more** than $50 left.
c) Your total travel distance is about **1.5 miles**, total displacement about **0.5 miles north**, and you have **less** than $50 left.
d) Your total travel distance is about **1.5 miles**, total displacement about **1.5 miles north**, and you have **more** than $50 left.
e) Your total travel distance is about **0.5 miles**, total displacement about **1.5 miles north**, and you have havn't got **bus fare** left.

---

002 qmult 00332 1 3 2 easy math: displacements in Vegas 2
Extra keywords: physci

19. You are in Las Vegas where the streets are almost all laid out in a rectangular grid. Assume the grid is exactly aligned with the cardinal directions. You drive 2 miles north on the Strip, turn right on Flamingo at the Harley-Davidson Cafe, drive east 3 miles to Maryland, turn south on Maryland and drive 1 mile to Tropicana, and, finally, turn right on Tropicana and drive 3 miles. Where are you? How many miles have traveled? What is your total **DISPLACEMENT**? **HINT:** Draw a diagram.

a) On the Strip (at the MGM Grand for what it's worth), 9 miles, and **1 MILE**.
b) On the Strip (at the MGM Grand for what it's worth), 9 miles, and **1 MILE NORTH**.
c) On the Strip (at the MGM Grand for what it's worth), 1 mile, and **9 MILES NORTH**.
d) On the Strip (at the MGM Grand for what it's worth), 1 mile, and **9 MILES**.
e) On the Strip (at the Hard Rock Cafe), 9 miles, and **9 MILES**.

---

002 qmult 00430 1 1 3 easy memory: clocks defined

20. A system exhibiting a periodic motion (i.e., a repeating motion where the repetitions take equal amounts of time) can be used as a ____________. Some physical theory is needed to guarantee that the motion is periodic.

a) motion sensor b) meter stick c) clock d) crock e) hourglass

---

002 qmult 00530 1 1 3 easy math: travel time from distance/speed: Knoxville 1
Extra keywords: physci

21. You have just traveled the back roads from Knoxville to Nashville. Your average speed was 60 mi/h, but you occasionally hit an instantaneous speed of 130 mi/h. (Could be you're hauling white lightning.) Your odometer travel distance is 250 miles. How long have you been on the road?

a) 1/4 hours. b) 10 hours. c) 4.17 hours. d) 6 hours. e) about 2 hours.

---

002 qmult 00532 1 3 2 easy math: average speed on round trip: Knoxville 2
Extra keywords: a round trip to Knoxville

22. You have just traveled at total distance of 400 km on a trip to Knoxville and back. It took 8 hours. Your average **SPEED** was:

    a) 0 km/h. b) 50 km/h. c) 100 km/h. d) 200 km/h. e) 400 km/h.

---

002 qmult 00534 1 3 1 easy memory: average velocity: Knoxville 3

23. You have just traveled 400 km on a trip to Knoxville and back. Knoxville is due east of your starting point. It took 8 hours. Your average **VELOCITY** (with velocity definitely meaning a vector here) was:

    a) 0 km/h with an indeterminate direction. b) 50 km/h west. c) 100 km/h east.
    d) 200 km/h west. e) 400 km/h north.

---

002 qmult 00600 1 4 5 easy deducto-memory: acceleration defined

24. "Let's play *Jeopardy*! For $100, the answer is: It is the rate of change of velocity with respect to time. It is important to note that it is a vector and since velocity is a vector, the quantity is non-zero if velocity changes in either or both magnitude and direction."

    What is ____________, Alex?

    a) time b) force c) displacement d) velocity e) acceleration

---

002 qmult 00620 1 1 3 easy memory: magnitudes of x,v,a

25. The magnitudes of displacement, velocity, and acceleration are usually called distance, speed, and:

    a) acceleration speed. b) deceleration. c) acceleration. d) accelmag.
    e) the unnameable.

---

002 qmult 00700 1 1 4 easy memory: inertial frame defined

26. A/An ____________ is a physics-defined frame of reference in which accelerations are caused by forces. In modern theory, this kind of frame is **NOT** accelerated relative to the local frame that participates in the mean expansion of the universe.

    a) accelerated frame b) rotating frame c) non-inertial frame d) inertial frame
    e) decelerated frame

---

002 qmult 00800 1 1 1 easy memory: force defined

27. A/An ____________ is the cause of accelerations of bodies relative to inertial frames. In modern physics, we understand ____________s to be themselved caused by fields which are continuous functions of space. Fields themselves are often caused by bodies nearby to the body being affected the ____________ they cause. So one often speaks of ____________ as relationships between bodies omitting as a simplification mention of the mediating field. This is especially true in classical mechanics discussions.

    a) force/forces. b) displacement/displacements c) velocity/velocities
    d) acceleration/accelerations e) momentum/momenta

---

002 qmult 00810 1 5 3 easy thinking: what forces do

28. Forces can cause accelerations relative to inertial frames or cancel other forces. Another manifestation (which actually follows from their property of causing acceleration) is that they can cause:

    a) velocity (without causing acceleration).) mass.
    c) bodies to distort: i.e., flex, compress, stretch, etc. d) bodies to live.
    e) bodies to rule.

---

002 qmult 00900 1 4 5 easy deducto-memory: mass defined

29. "Let's play *Jeopardy*! For $100, the answer is: It is the quantity of resistance to the acceleration caused by a force. It is often called the quantity of matter, but this definition doesn't seem to add much to our understanding. It's true that the quantity in question is in many cases approximately proportional to the number of protons and neutrons in a body. If you consider number of protons and neutrons, the quantity of matter then the quantity in question is a measure of the quantity in question."

What is __________, Alex?

a) displacement b) velocity c) acceleration d) weight e) mass

---

002 qmult 01000 1 4 5 easy deducto-memory: center of mass defination 1

30. "Let's play *Jeopardy*! For $100, the answer is: It is the mass-weighted mean position of an object."

What is __________, Alex?

a) center of weight b) the ordinary mean position c) acceleration d) mass e) center of mass

---

002 qmult 01010 1 1 4 easy memory: center of mass definition 2

31. The center of mass is the:

a) position-weighted mean mass of the an object.
b) object-weighted mean mass of the position.
c) mean of mass an weighted object position of.
d) mass-weighted mean position of an object.
e) simple center of the object.

---

002 qmult 01020 1 4 2 easy deducto-memory: center of mass, reference frame

32. The center of mass (i.e., the actual physical position of the center of mass in space relative to the physical system it is the center of mass of) is:

a) a function of the coordinate system.
b) independent of the coordinate system.
c) dependent on the coordinate system.
d) both independent of and a function of the coordinate system.
e) neither independent of nor a function of the coordinate system.

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002 qmult 01040 1 1 3 easy memory: cm at geometric center 1

33. An object with symmetric in three dimensions about a geometric center has its center of mass at its:

a) center of mass b) outer surface c) geometric center d) inner surface e) nowhere

---

002 qmult 01042 1 4 5 easy deducto-memory: cm at geometric center 2

34. If an object is symmetric in 3 dimensions about some point (i.e., its geometric center), its center of mass must be:

a) outside of the object.
b) neither inside nor outside the object.
c) at the point about which the object is symmetric in 2 of the dimensions, but not in the 3rd.
d) at the point about which the object is symmetric in 1 of the dimensions, but not in the other 2.
e) at the geometric center.

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002 qmult 01044 1 5 5 easy thinking: hoop center of mass

35. Where is the center of mass of a hoop?

a) At the end of the hoop.
b) At the top of the hoop.
c) At the left side of hoop.
d) Nowhere since a center of mass must be physically inside an object to be a center of mass.
e) On the axis of the hoop at the geometrical center of the hoop.

---

002 qmult 01050 1 4 5 easy deducto-memory: hanging center of mass

36. "Let's play *Jeopardy*! For $100, the answer is: If one hangs a rigid object from a freely turning pivot point and lets it come to stable static equilibrium, the center of mass is directly below the pivot point. Thus, center of mass can be found from the intersection of two lines through the object that start at two points used as pivot points and that go in the direction through the object that was downward when each of the points was the pivot point. The method fails if the two pivot points and the center of mass happen to be collinear."

a) What is an **EMPIRICAL** method for finding gravitational torque, Alex?
b) What is a **THEORETICAL** method for finding gravitational torque, Alex?
c) What is gravitational torque, Alex?
d) What is a center of mass, Alex?
e) What is an **EMPIRICAL** method for finding the center of mass of a rigid object, Alex?

---

002 qmult 01052 1 5 5 easy thinking: hanger center of mass

37. Where, roughly speaking, is the center of mass of a coat hanger? **HINT:** Imagine letting it hang from two different free pivot points: this is called a Gedanken (thought) experiment in physics speak. If you arn't in a test *mise en scène*, you could actually do the experiment.

a) At the end of the hook.
b) At the top of the hook.
c) At the left end of the triangular loop.
d) Nowhere since a center of mass must be physically inside an object to be a center of mass.
e) Oh, somewhere not so far from the middle region of the triangular loop.

---

002 qmult 01100 1 4 2 easy deducto-memory: dynamics defined 1

38. "Let's play *Jeopardy*. For $100, the answer is: The branch of physics that explains motion and acceleration in terms of forces and masses."

What is ____________, Alex?

a) kinematics b) dynamics c) statics d) economics e) cinematics

---

002 qmult 01110 1 1 2 easy memory: dynamics defined 3

39. The area of physics dealing with the motions and forces is called:

a) statics. b) dynamics. c) kinematics. d) kinesiology. e) cinema.

---

002 qmult 01120 2 4 3 moderate deducto-memory: inertial frames

40. Velocity and acceleration in, respectively, Newton's 1st and 2nd laws of motion are referenced to:

a) rotating frames. b) accelerated frames. c) inertial frames.
d) non-inertial frames. e) picture frames.

---

002 qmult 01130 1 1 3 easy memory: number of Newton's laws

41. How many laws of motion did Newton posit?

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

---

002 qmult 01132 1 1 3 easy memory: the number of Newton's laws 2

Extra keywords: physci

42. Newton once thought about having six laws of motion (or so the instructor seems to recall), but eventually settled on:

a) one. b) two. c) three. d) four. e) three and half.

---

002 qmult 01140 3 5 3 tough thinking: 1st law redundant

43. Newton's 1st law is.

a) **PHYSICALLY INDEPENDENT** of the other two laws of motion and **CANNOT** be dispensed with as an axiom of Newtonian physics.
b) **PHYSICALLY INDEPENDENT** of the other two laws of motion, but nonetheless it **CAN** be dispensed with as an axiom of Newtonian physics.
c) actually a **SPECIAL CASE** of the **2ND LAW**. The case when the net force is zero. Therefore logically we need only two laws of motion. Perhaps for clarity Newton formulated his explicit 1st law and perhaps for the same reason physicists have retained it.
d) actually a **SPECIAL CASE** of the **3RD LAW**. The case when the net force is zero. Therefore logically we need only two laws of motion. Perhaps for clarity Newton formulated his explicit 1st law and perhaps for the same reason physicists have retained it.
e) is **INCORRECT**, but is kept in the books for historical reasons.

---

002 qmult 01150 1 1 3 easy memory: Newton's 2nd law: 1

44. Newton's 2nd law is:

a) $m = \vec{F}_{\rm net}\vec{a}$.
b) $\vec{a} = m\vec{F}_{\rm net}$.
c) $\vec{F}_{\rm net} = m\vec{a}$.
d) For every force there is an equal and opposite force.
e) For every acceleration there is an equal and opposite acceleration.

---

002 qmult 01152 1 1 1 easy memory: Newton's 2nd law: 2

45. Newton's 2nd law is:

a) $\vec{F} = m\vec{a}$. b) $m\vec{F} = \vec{a}$. c) $E = mc^2$. d) $E = mc^3$. e) $m = Ec^2$.

---

002 qmult 01154 1 4 5 easy deducto-memory: center of mass in Fnet=ma

46. "Let's play *Jeopardy*! For $100, the answer is: The mass-weighted average position of a system of particles: a system being any specified set of material mass elements. This position's acceleration obeys $\vec{F}_{\rm net} = m\vec{a}$, where $\vec{F}_{\rm net}$ is the net force (and also the net external force) acting on the system."

What is the ____________, Alex?

a) center b) bottom end c) top end d) left end e) center of mass

---

002 qmult 01156 1 1 5 easy memory: net external forces and center of mass
Extra keywords: anticipates later chapters, but that's OK

47. If you know nothing about the internal forces of a body and only know the net external force that acts on the body and not where on the body the particular external forces act, then, by itself, Newton's 2nd law for a non-point mass only allows you to predict:

a) the **VELOCITY** of the body.
b) the **VELOCITY** of the center of mass of the body. You can know nothing about internal motions of the body or its rotational behavior.
c) the **ACCELERATION** of the top point of the body.
d) the **ACCELERATION** of the bottom point of the body.
e) the **ACCELERATION** of the center of mass of the body. You can know nothing about internal motions of the body or its rotational behavior.

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002 qmult 01158 1 1 5 easy memory: newton defined

48. The base SI unit of force is the:

a) farad (F); $1\,\mathrm{F} = 1\,\mathrm{kg\,m/s^2} \approx 0.22481\,\mathrm{lb} \approx 1/5\,\mathrm{lb}$.
b) henry (H); $1\,\mathrm{H} = 1\,\mathrm{kg\,m/s^2} \approx 0.22481\,\mathrm{lb} \approx 1/5\,\mathrm{lb}$.
c) watt (W); $1\,\mathrm{W} = 1\,\mathrm{kg\,m/s^2} \approx 0.22481\,\mathrm{lb} \approx 1/5\,\mathrm{lb}$.
d) joule (J); $1\,\mathrm{J} = 1\,\mathrm{kg\,m/s^2} \approx 0.22481\,\mathrm{lb} \approx 1/5\,\mathrm{lb}$.
e) newton (N); $1\,\mathrm{N} = 1\,\mathrm{kg\,m/s^2} \approx 0.22481\,\mathrm{lb} \approx 1/5\,\mathrm{lb}$.

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002 qmult 01162 1 5 1 easy thinking: acceleration and third law
Extra keywords: also physci KB-59-15

49. If Newton's 3rd law is true, why then does anything accelerate at all?

a) The equal and opposite forces **DO NOT** have to be on the same body.
b) The equal and opposite forces **DO** have to be on the same body.
c) Nothing moves at all as Parmenides argued in the 5th century BC. Motion is but seeming. Anyway Parmenides seems to have been a pretty smart guy since he's credited with the spherical Earth theory and the discovery that the Moon shines by reflected light.
d) Acceleration has nothing do with forces.
e) Forces have nothing do with acceleration.

---

002 qmult 01164 1 1 4 easy memory: internal force pairwise cancellation

50. Why do internal forces not affect the center of mass acceleration of a system? Because:

a) they cancel out in threesomes. b) they are all zero. c) we just ignore them. d) they cancel out pairwise. e) the external force cancels them out.

---

002 qmult 01170 1 4 5 easy deducto-memory: force laws needed

51. "Let's play *Jeopardy*! For $100, the answer is: Laws that prescribe forces for physical systems. They must exist independent of Newton's 3 laws of motion in order for Newtonian physics to be useful."

What are ____________, Alex?

a) Newton's 3 laws b) accelerations c) velocities d) force inequalities e) force laws

---

002 qmult 01180 1 4 3 easy deducto-memory: classical point particles defined

52. "Let's play *Jeopardy*! For $100, the answer is: They have no size, but do have mass, and obey classical mechanics."

What is ____________, Alex?

a) any solid object b) quantum mechanical particles c) classical point particles d) any blob of fluid e) any blob of gas

---

002 qmult 01200 1 5 1 easy thinking: statics defined

53. The area of physics dealing with **ONLY** cases of balanced forces (or equilibrium) is called:

a) statics. b) dynamics. c) kinematics. d) kinesiology. e) cinema.

---

002 qmult 01210 1 4 3 easy deducto-memory: equilibria defined

54. "Let's play *Jeopardy*! For $100, the answer is: Stable, unstable, neutral, and metastable."

What are ____________, Alex?

a) forces b) disequilibria c) equilibria d) laws of motion e) horses

---

002 qmult 01230 1 1 1 easy memory: normal force calculation

55. A uniform cylinder of density ρ, height h, and horizontal area A has normal force ____________ at a height y above the ground.

a) $(h-y)A\rho$ b) $yA\rho$ c) $(y/A)\rho$ d) $[(h-y)/A]\rho$ e) $1/(yA\rho)$

---

002 qmult 01250 1 3 5 easy math: F=ma to find a brick's mass to find a force
Extra keywords: physci KB-60-23

56. A 50 N net force gives a brick an acceleration of 5 m/s. What net force is need to give it an acceleration of 10 m/s?

a) 50 N. b) 5 N. c) 10 N. d) 200 N. e) 100 N.

---

002 qmult 01300 1 1 3 easy memory: weight defined

57. The force of gravity on an object is, by usual definition, the object's:

a) acceleration due to gravity. b) mass. c) weight. d) momentum. e) velocity.

---

002 qmult 01310 1 1 3 easy memory: gravitational field

58. The force of gravity on an object is given by

$$\vec{F} = m\vec{g} ,$$

where m is the object mass and g is the ____________ at the object and assumed here to be uniform over the extend of the object.

a) magnetic field b) electric field c) gravitational field d) gravitational constant e) 9.8 N/kg

---

002 qmult 01312 1 1 5 easy memory: g near Earth's surface

59. Near the surface of the Earth, the magnitude of the gravitational field (usually just written g and often called little g) has fiducial (or reference value):

a) 1.62 N/kg. b) 4.2 N/kg. c) 7.8 N/kg. d) 8.8 N/kg. e) 9.8 N/kg.

---

002 qmult 01330 1 1 5 easy memory: gravitational field and acceleration

60. If gravity is only force acting on a body, the body's acceleration equals:

a) its weight. b) 1.62 m/s^2. c) 9.8 m/s^2. d) m, the body's mass. e) $\vec{g}$, the local gravitational field.

---

002 qmult 01332 1 4 2 easy deducto-memory: free fall

61. "Let's play *Jeopardy*! For $100, the answer is: When a body is acted on only by the force of gravity or in a second meaning acted on only by the forces of gravity and drag."

What is ____________, Alex?

a) motion b) free fall c) terminal velocity d) relative velocity e) relative acceleration

---

002 qmult 01340 1 3 1 easy math: free-fall speed in 3 seconds

62. How fast is a person falling after 3 s starting from rest? Recall the acceleration due to gravity is $g = 9.8\,\text{m/s}^2$ (which is the fiducial value). Neglect air drag.

a) 29.4 m/s. b) 44.1 m/s. c) 9.8 m/s. d) 88.2 m/s. e) At the speed of light.

---

002 qmult 01342 1 3 1 easy math: kinematic equations: free fall distance
Extra keywords: in 3 seconds

63. A human falls off some high scaffolding. About how far does he/she fall in 3 seconds? (Neglect air drag.)

a) 44 m. b) 88 m. c) 22 m. d) 9.8 m. e) 4.9 m.

---

002 qmult 01344 1 3 2 easy math: falling in 4 seconds

64. How far does a person fall in 4 s starting from **REST**? (Neglect air drag.)

a) 39.2 m. b) 78.4 m. c) 9.8 m. d) 156.8 m. e) From the Earth to the Moon.

---

002 qmult 01350 1 4 3 easy deducto-memory: terminal velocity defined
Extra keywords: physci

65. "Let's play *Jeopardy*! For $100, the answer is: It occurs to a dense falling object falling near the Earth's surface when the force of gravity and the force of air drag (AKA air resistance) cancel to give no net force on an object."

What is ____________, Alex?

a) acceleration upward b) acceleration downward c) terminal velocity
d) initial velocity e) parabolic motion

---

002 qmult 01360 3 1 2 easy math: travel time, human terminal velocity 1
Extra keywords: physci

66. The terminal velocity of a human in air is about 120 mi/h. At this speed how long does it take to fall 2 miles.

a) 2 minutes. b) 1 minute. c) 1 hour. d) 2 hours. e) 1 second.

---

002 qmult 01362 1 2 3 easy deduction: human terminal velocity 2
Extra keywords: physci

67. What is approximately the terminal velocity of a human in air? **HINT:** You don't have to know the answer; you can deduce it.

a) 10 km/h. b) 1 km/h. c) 200 km/h. d) 0.1 km/h. e) 3×10^5 km/s.

---

002 qmult 01364 1 4 5 easy deducto-memory: cat fall
Extra keywords: mathematical physics

68. "Let's play *Jeopardy*! For $100, the answer is: These features allow cat victims of the high-rise syndrome (i.e., the propensity to taking flying leaps into oblivion—cats being so darn smart you know) to survive falls of more than ~ 20 m without major injuries—sometimes that is."

What are ____________, Alex?

a) feline insouciance, savoir-faire, panache, et je-ne-sais-quoi.
b) the cat **WRONGING** reflex and relatively **LOW** terminal velocity when spread-eagled
c) the cat **WRONGING** reflex and relatively **HIGH** terminal velocity when spread-eagled
d) the cat **RIGHTING** reflex and relatively **HIGH** terminal velocity when spread-eagled
e) the cat **RIGHTING** reflex and relatively **LOW** terminal velocity when spread-eagled

---

002 qmult 01380 1 4 2 easy deducto-memory: projectile motion

69. "Let's play *Jeopardy*! For $100, the answer is: Without qualifications, one usually means the non-powered flight of an object in the air or through space. The simplest in-air case is the one in which air drag is neglected. The science of such motions is ballistics.

What is ____________, Alex?

a) apparent motion b) projectile motion c) one-dimensional motion
d) trigonometric motion e) unstoppable motion

---

002 qmult 01382 2 1 1 mod. deducto-mem.: gravity is always downward on Earth
Extra keywords: physci

70. A ball is tossed into the air and falls to the ground some distance away. Consider its motion in the vertical direction only and neglect air drag.

a) The ball has a constant acceleration downward.
b) The ball first accelerates **UPWARD** on its rising path and then accelerates **DOWNWARD** on its falling path.

c) The ball first accelerates **DOWNWARD** on its rising path and then accelerates **UPWARD** on its falling path.
d) The ball does not accelerate at all.
e) The ball is always accelerating in the upward direction.

---

002 qmult 01384 1 5 2 moderate thinking: projectile parabolic arc

71. Which best describes the path of a ball thrown on level ground at an angle 30° above the horizontal as seen from a side view.

a) Two straight lines that meet at an apex: one for the rising phase; one the declining phase. The rising phase line is **TWICE** the length of the declining phase line.
b) A smooth curve that rises and falls with distance. As far as the eye can tell, the curve could be parabolic.
c) Two straight lines that meet at an apex: one for the rising phase; one the declining phase. The rising phase line is **HALF** the length of the declining phase line.
d) A smooth curve that rises and falls with distance, but suddenly breaks off and descends vertically.
e) A smooth curve that rises and falls with distance and then rises and falls again with distance. A Bactrian camel curve.

---

002 qmult 01400 1 1 5 easy memory: definition of vector momentum

72. Momentum (or linear momentum) is given by the formula:

a) $\vec{p} = \dfrac{m}{\vec{v}}$. b) $\vec{p} = \dfrac{\vec{v}}{m}$. c) $\vec{p} = \dfrac{1}{2}mv^2$. d) $\vec{p} = \dfrac{1}{2}m\vec{v}$. e) $\vec{p} = m\vec{v}$.

---

002 qmult 01420 1 1 3 easy memory: momentum is not energy
Extra keywords: physci KB-93-15

73. Linear momentum is **NOT**:

a) a physical quantity. b) dependent on velocity. c) a kind of energy. d) dependent on mass. e) given by $p = mv$ for one-dimensional cases.

---

002 qmult 01430 2 5 1 moderate thinking: KE change and momentum change
Extra keywords: physci KB-94-13

74. If the kinetic energy of an object is doubled, the momentum magnitude changes by a factor of:

a) $\sqrt{2}$. b) 2. c) 1/2. d) $1/\sqrt{2}$. e) 1.

---

002 qmult 01440 1 1 2 easy memory: conservation of momentum
Extra keywords: physci

75. For a system on which no net external force acts, momentum is:

a) not conserved. b) conserved. c) zero. d) never zero. e) always negative.

---

002 qmult 01450 1 1 2 easy memory: conservation of momentum, Thor
Extra keywords: physci

76. The mighty Thor is trapped in the eternal vacuum of gravity-free space with nothing to push on. But he sees Asgard glittering **YONDER** (i.e., over there). Having taken introductory physics in his young Viking days, he realizes that he will soar straight to Asgard if, with awesome strength, he throws his hammer:

a) yonder. b) anti-yonder. c) any which way. d) left. e) in a parabolic arc.

---

002 qmult 01480 1 1 1 easy memory: operation of rocket
Extra keywords: physci KB-92-9

77. The operation of a rocket in space is based on:

a) conservation of momentum. b) conservation of angular momentum. c) jet fuel pushing on the vacuum. d) starlight pressure. e) running an internal treadmill.

---

002 qmult 01500 1 4 5 easy deducto-memory: energy definition

78. "Let's play *Jeopardy*! For $100, the answer is: It is the conserved essence of structure and transformability."

    What is ____________, Alex?

    a) the gravitational field b) momentum c) matter d) momentum
    e) a suggested definition of energy

---

002 qmult 01510 1 1 3 easy memory: energy generality utility

79. Virtually all physical processes (and mamy biological and societal processes too) can be partially (and usually only partially) described as transformations of ____________. This is what gives the concept of ____________ its great generality and power.

    a) velocity b) momentum c) energy d) acceleration e) nuclear fusion

---

002 qmult 01410 1 1 1 easy memory: history of energy

80. Aristotle (384–322 BCE) introduced energy (in Greek energeia) as a vague philosophical concept that even he admitted was hard to define. It lingered in philosophical discourse until Thomas Young (1773–1829) gave a definite meaning as what we now call kinetic energy. In the course, of the 19th century other forms of energy were discovered all connected by the fact that that each one was tranformable into any of the others and the amount of energy overall was conserved. The process of finding new energy forms can be reached a high point when Albert Einstein (1879–1955) in 1905 discovered the equation:

    a) $E = mc^2$. b) $E = mc^3$. c) $KE = (1/2)mv^2$. d) $PE = mgy$.
    e) $E = KE + PE$.

---

002 qmult 01520 1 1 3 easy memory: conservation of energy 1

81. The principle of conservation of energy is that energy is never:

    a) adequately defined. b) destroyed, but can be created. c) created or destroyed.
    d) created, but can be destroyed. e) destroyed.

---

002 qmult 01522 1 1 4 easy memory: conservation of energy 2
Extra keywords: physci

82. In the physics, the conservation of energy means energy:

    a) shouldn't be wasted on cars. b) is never destroyed. c) is never created.
    d) is never created or destroyed. e) is perpetually created.

---

002 qmult 01530 1 1 1 easy memory: dimensions of energy

83. The physical dimensions of energy are:

    a) $\mathrm{ML^2/T^2}$. b) $\mathrm{ML/T^2}$. c) $\mathrm{ML^2}$. d) $\mathrm{ML^2/T}$. e) $\mathrm{M/T^2}$.

---

002 qmult 01532 1 1 1 easy memory: unit of energy, the joule
Extra keywords: physci

84. The standard SI unit of energy and of work is the:

    a) joule (J). b) newton (N). c) kelvin (K). d) bassingthorp (B).
    e) trufflehunter (T).

---

002 qmult 01540 2 1 1 moderate memory: energy necessity and sufficiency
Extra keywords: physci

85. That one has enough energy for a certain job or transformation that requires energy E is a ______________ condition, but **NOT** a ______________ condition for the job or transformation.

a) necessary; sufficient b) sufficient; necessary c) inevitable; necessarily so
d) harmonious; ceremonious e) forbidden; given

---

002 qmult 01550 1 4 5 easy deducto-memory: energy and money
Extra keywords: physci

86. "Let's play *Jeopardy*! For \$100, the answer is: Because of its protean nature, energy is very much like this thing in everyday human life which, however, unlike energy is not conserved."

What is/are ____________, Alex?

a) furs b) assignats c) shells d) gold e) money

---

002 qmult 01590 1 5 5 easy thinking: energy riddle: Frodo
Extra keywords: The Riddler Strikes Again III

87. The Riddler strikes again:

I am always only me,
but never the same,
sometimes I'm just—well—PE,
and where is the shame,
the change artist triumphs again—
and I'm like money—but I don't inflate—
paid—and on the due of the date,
from light unto dark, hot unto cold,
as Joule, my prophet, has foretold,
but all riddle games—and so it goes—
must end—so speak it—as in Frodo's.

a) Hamlet.
b) The Sun.
c) The Tao.
d) Poetry—no, wait, aaaAAAHHHhhh...
e) Energy.

---

002 qmult 01600 1 4 2 easy deducto-memory: work defined

88. "Let's play *Jeopardy*! For \$100, the answer is: In physics, it is a macroscopic process of energy transfer."

What is ____________, Alex?

a) energy b) work c) force d) weight e) sloth

---

002 qmult 01602 1 1 2 easy memory: differential work formula

89. The differential work formula is:

a) $dW = \vec{F}\,d\vec{s}$. b) $dW = \vec{F}\cdot d\vec{s}$. c) $dW = \vec{F}/d\vec{s}$. d) $dW = F\,ds$.
e) $dW = \vec{F}\times d\vec{s}$.

---

002 qmult 01604 1 1 3 easy memory: work formula for a constant force 2
Extra keywords: For the vector and dot product literate

90. A constant force $\vec{F}$ acts on a body while that body moves a distance $\Delta\vec{s}$. The work W done on the body by the force is given by:

a) $W = \vec{F}/\Delta\vec{s}$. b) $W = \vec{F}$. c) $W = \vec{F}\cdot\Delta\vec{s}$. d) $W = \vec{F}\cdot\vec{F}\cdot\Delta\vec{s}$.
e) $W = \vec{F}\cdot\Delta\vec{s}\cdot\Delta\vec{s}$.

---

002 qmult 01610 1 3 1 easy math: work lifting 100 kg load
Extra keywords: physci KB-95-3

91. How much work is done by a lifter lifting a 100 kg load straight upward 10 m without acceleration?

a) 9800 J. b) 100 J. c) 1000 J. d) 10 J. e) 980 J.

---

002 qmult 01612 1 3 1 easy math: work lifting ostrich
Extra keywords: physci KB-93-21

92. The work done by the lifting force of a person lifting a 30 kg ostrich to a height of 30 m without acceleration is about:

a) 9000 J. b) 900 J. c) 300 J. d) 3 J. e) 4500 J.

---

002 qmult 01614 1 5 5 easy thinking: no macroscopic work done
Extra keywords: physci KB-95-1

93. A person holds 10 kg grouse at 2.0 m above the ground for 30 s. How much macroscopic net work is done by the person on the grouse?

a) 600 J. b) 20 J. c) 300 J. d) 60 J. e) 0 J.

---

002 qmult 01630 1 1 3 easy memory: kinetic energy definition
Extra keywords: physci

94. Kinetic energy is:

a) the energy of **POSITION** with formula $KE = mgy$. b) the energy of **MOTION** with formula $KE = mgy$. c) the energy of **MOTION** with formula $KE = (1/2)mv^2$. d) the energy of **POSITION** with formula $KE = (1/2)mv^2$. e) heat energy.

---

002 qmult 01640 1 1 3 easy memory: work-kinetic-energy theorem

95. The work-kinetic-energy theorem is:

a) $KE = \frac{1}{2}mv^2$. b) $\Delta E = W_{\text{non}}$. c) $\Delta KE = W$. d) $\Delta KE = \frac{1}{2}W$. e) $\Delta KE = \frac{1}{2}mv^2$.

---

002 qmult 01650 2 5 4 moderate math: friction killing KE
Extra keywords: physci KB-95-9

96. A moving object has initial $KE = 100$ J and is subjected to a friction force of magnitude 2 N and no other forces. How far does the object go before coming to a stop?

a) 100 m. b) 2 m. c) 1000 m. d) 50 m. e) 0 m.

---

002 qmult 01652 2 5 2 moderate math: friction killing KE 2
Extra keywords: physci KB-95-9

97. A moving object initially has $KE = 200$ J and slides to a stop on a horizontal surface. How much work has been done by gravity, the normal force, and the friction force?

a) 0, 0, 200 J. b) 0, 0, -200 J. c) 9.8 J, -9.8 J, 200 J. d) 9.8 J, -9.8 J, -200 J. e) -9.8 J, 9.8 J, 200 J.

---

002 qmult 01700 1 1 2 easy memory: potential energy definition
Extra keywords: physci

98. Potential energy is:

a) the energy of position: it exists for nonconservative forces.
b) the energy of position: it exists for conservative forces.
c) the energy of motion: its formula is $PE = (1/2)mv^2$.
d) the energy of position: its formula is $PE = (1/2)mv^2$.
e) heat energy.

---

002 qmult 01702 2 1 3 moderate memory: paths and a conservative force

99. The work done by a conservative force on an object while the object moves on a path between two endpoints is:

a) **INDEPENDENT** of the path and endpoints.
b) **DEPENDENT** on the path.
c) **INDEPENDENT** of the path between the endpoints.
d) **DEPENDENT** on the path, but **NOT** on the endpoints.
e) equal to the path length.

---

002 qmult 01704 1 4 1 easy deducto-memory: general potential energy formula

100. "Let's play *Jeopardy*! For \$100, the answer is: $\Delta PE = -W$."

a) What is the formula relating **POTENTIAL** energy change in a conservative force field to work done by the conservative force (i.e., what is the general potential energy formula), Alex?
b) What is Faraday's law, Alex?
c) What are capacitors, Alex?
d) What is ... no, no wait ... what is unicorn circular motion, Alex?
e) What is the formula relating **KINETIC** energy change in a conservative force field to work done by the conservative force (i.e., what is the work-kinetic-energy theorem), Alex?

---

002 qmult 01710 1 4 2 easy deducto-memory: energy and heat
Extra keywords: physci KB-73

101. British American Benjamin Thompson (1753–1814), while employed as director of the Bavarian arsenal, noticed that in boring cannon (but not causing cannon ennui) that the boring motion and friction seemed to produce unlimited amounts of heat. He concluded:

a) heat was a substance of which there could only be so much of in any object.
b) that heat was somehow generated by motion and friction. This conclusion eventually led to the recognition of heat as another form of energy that could be converted from or converted into, e.g., mechanical or chemical energy.
c) that heat had no relation to motion and friction and was somehow spontaneously generated by cannon.
d) that cannon could be the plural of cannon.
e) that the biergartens in Munich were much better than the taverns in Boston and that Sam Adams, patriot-founding-father notwithstanding, could have learnt a thing or two about brewing beer.

---

002 qmult 01720 1 4 1 easy deducto-memory: work-energy theorem

102. "Let's play *Jeopardy*! For \$100, the answer is: $\Delta E = W_{\text{nonconservative}}$."

What is the ____________, Alex?

a) work-energy theorem b) work-kinetic-energy theorem
c) potential-energy-work formula d) work-potential-energy theorem
e) kinetic energy formula

---

002 qmult 01722 1 1 4 easy memory: mechanical energy conservation
Extra keywords: physci

103. Mechanical energy is the sum of kinetic energy and potential energy. It is a conserved quantity:

a) always.
b) whenever it has both kinetic and potential energy components.
c) if all the forces that do net work are **NONCONSERVATIVE**.
d) if all the forces that do net work are **CONSERVATIVE**.
e) whenever it is positive.

---

002 qmult 01724 1 1 1 easy memory: conservation of mechanical energy 2

104. Interpreting the symbols in the most **STRAIGHTFORWARD WAY** and without mental qualifications (e.g., this is really the inverse or the absolute value of a quantity or a change in a quantity or this is for a special case), the formula for conservation of mechanical energy for a particle or a system that can be treated as a particle (i.e., is described by its center of mass behavior) is:

a) $\Delta KE = -\Delta PE$. b) $\Delta KE = \Delta PE$. c) $KE = PE$. d) $KE = 1/PE$. e) $\Delta KE = -1/\Delta PE$.

---

002 qmult 01730 1 3 5 easy math: dog drops brick mech. energy conserved
Extra keywords: physci

105. A brick has mass 1 kg. A dog (from a joke that I'll tell you someday) drops the brick (which it was holding in its mouth or, one might say, with its jowl) 1 m. What is the kinetic energy of the brick just before it hits the ground? **HINT:** The calculator is superfluous.

a) 9.8 watts. b) 9.8 gems. c) 9.8 newtons. d) 9.8 jowls. e) 9.8 joules.

---

002 qmult 01732 1 3 3 easy math: dog drops brick mech. energy conserved 2
Extra keywords: physci

106. A brick has mass 2.0 kg. A dog (from a joke that I'll tell you someday) drops the brick (which it was holding in its mouth or, one might say, with its jowl) 2.0 m. The brick started from rest and air drag is negligible. What is the kinetic energy of the brick just before it hits the ground?

a) 9.8 J. b) 19.6 J. c) 39.2 J. d) about 50 J. e) about 160 J.

---

002 qmult 01800 1 1 1 easy memory: power definition
Extra keywords: physci

107. Work per unit time or energy transformed per unit time is:

a) power. b) might. c) oomph. d) strength. e) pay.

---

002 qmult 01820 1 5 3 easy thinking: sunlight power
Extra keywords: physci KB-99-17

108. If you could capture it all for useful work, the energy sunlight delivers to a square meter of ground would run one or two ordinary incandescent light bulbs. The power delivered by the Sun to a square meter of ground on average is to order or magnitude:

a) 1 W. b) 10 W. c) 100 W. d) 10^6 W. e) 1 MW.

---

002 qmult 01822 2 5 2 moderate thinking: boy running up stairs
Extra keywords: physci KB-93-23

109. A 50 kg boy runs up a flight of stairs of 5 m in height in 5 s at a constant rate. His power output just to work against gravity is:

a) 50 W. b) 490 W. c) 980 W. d) 10^6 W. e) 1 MW.

---

002 qmult 01824 2 5 2 moderate thinking: mountain climber power output
Extra keywords: physci KB-95-7

110. A 100 kg mountain climber climbs 4000 m in 10 hours. What is his power output going into gravitational potential energy? What is his total power output?

a) 3.92×10^6 W and 3.92×10^6 W.
b) The power going into gravitational potential energy is 109 W. His total power output cannot be exactly calculated since a lot of power must go into waste heat due to frictional forces and into the body heat which is lost to the environment. All one can easily say is that 109 W is a **LOWER BOUND** on the total power output.
c) The power going into gravitational potential energy is 3.92×10^6 W. His total power output cannot be exactly calculated since a lot of power must go into waste heat due to frictional

forces and into the body heat which is lost to the environment. All one can easily say is that 3.92×10^6 W is a **LOWER BOUND** on the total power output.

d) The power going into gravitational potential energy is 3.92×10^6 W. His total power output cannot be exactly calculated since a lot of power must go into waste heat due to frictional forces and into the body heat which is lost to the environment. All one can easily say is that 3.92×10^6 W is an **UPPER BOUND** on the total power output.

e) The power going into gravitational potential energy is 109 W. His total power output cannot be exactly calculated since a lot of power must go into waste heat due to frictional forces and and into the body heat which is lost to the environment. All one can easily say is that 109 W is an **UPPER BOUND** on the total power output.

---

002 qmult 02000 1 4 2 easy deducto-memory: Newton gravitation law

111. "Let's play *Jeopardy*! For $100, the answer is: He/she discovered the gravitation law (AKA universal law of gravitation) of classical physics. This law shows that the same gravity that holds on Earth also holds throughout the space—insofar as classical physics applies."

Who is ____________, Alex?

a) Galileo (1564–1642) b) Isaac Newton (1643–1727)
c) James Clark Maxwell (1831–1879) d) Albert Einstein (1879–1955)
e) Emmy Noether (1882–1935)

---

002 qmult 02002 1 1 3 easy memory: Newton's Apple

112. William Stukeley (1687–1765) recorded a conversation with Newton at Kensington, 1726 April 15 (less than year before Newton's death at 84):

"when formerly, the notion of gravitation came into his mind. It was occasioned by the fall of a/an __________, as he sat in contemplative mood. Why should that ____________ always descend perpendicularly to the ground, thought he to himself. Why should it not go sideways or upwards, but constantly to the earth's centre."

a) peach b) pear c) apple d) orange e) sparrow

---

002 qmult 02010 1 1 1 easy memory: gravity attracts always
Extra keywords: physci

113. Gravity is the force between systems with mass and it is:

a) always attractive. b) always **REPULSIVE**, except perhaps in some cosmological applications. c) either attractive or **REPULSIVE**. d) neither attractive nor **REPULSIVE**. e) neither fish nor fowl.

---

002 qmult 02020 1 1 4 easy memory: Newton's law of gravity

114. Newton's law of gravity (or the universal law of gravity) for the force exerted by point mass 1 on point mass 2 (where from 1 to 2 is indicated by subscript 12) is:

a) $\vec{F}_{12} = -Gm_1m_2r^2\hat{r}_{12}$. b) $\vec{F}_{12} = -\frac{Gm_1}{m_2}r^2\hat{r}_{12}$. c) $\vec{F}_{12} = -\frac{Gm_1}{m_2}r\hat{r}_{12}$.
d) $\vec{F}_{12} = -\frac{Gm_1m_2}{r^2}\hat{r}_{12}$. e) $\vec{F}_{12} = -\frac{Gm_1m_2}{r^3}\hat{r}_{12}$.

---

002 qmult 02022 1 1 2 easy memory: 3rd law of motion and gravity

115. Newton's law of gravity is:

a) inconsistent with Newton's 3rd law of motion.
b) consistent with Newton's 3rd law of motion.
c) violates Newton's 3rd law of motion. d) Newton's 3rd law of motion.
e) Newton's 2nd law of motion.

---

002 qmult 02024 1 4 5 easy deducto-memory: gravitational constant

116. "Let's play *Jeopardy*! For \$100, the answer is: It is the gravitational constant with MKS units $\mathrm{N\,m^2/kg^2}$ It is actually the poorest known of the fundamental constants because gravity is such a weak force between laboratory size objects which are used to measure it."

What is ____________, Alex?

a) $1.000\ldots$ b) $2.99792458 \times 10^{-8}$ c) 2.99792458×10^{8} d) $6.67384(80) \times 10^{11}$
e) $6.67384(80) \times 10^{-11}$

---

002 qmult 02030 1 1 5 easy memory: fiducial gravitational force

117. A fiducial gravitational force is the force between two non-overlapping spherically symmetric objects each of mass 1 kg with the center-to-center distance one meter. The magnitude of this force is:

a) 1. b) 1/2. c) 6.67428×10^{11}. d) 1.67×10^{-11}. e) 6.67384×10^{-11}.

---

002 qmult 02032 1 3 3 easy math: gravity force calculation

118. Using Newton's gravitation law

$$\vec{F}_{12} = -\frac{Gm_1m_2}{r^2}\hat{r}_{12}$$

($G = 6.67384(80) \times 10^{-11}\,\mathrm{N\,m^2/kg^2}$: e.g., Wikipedia 2011sep11) calculate the magnitude of the force between two 3 kg objects 3 m apart. The answer is:

a) $60.1 \times 10^{-11} \approx 12 \times 10^{-11}$ lb. b) $20.0 \times 10^{-11} \approx 4 \times 10^{-11}$ lb.
c) $6.674 \times 10^{-11}\,\mathrm{N} \approx 1.5 \times 10^{-11}$ lb. d) $2.224 \times 10^{-11}\,\mathrm{N} \approx 0.5 \times 10^{-11}$ lb.
e) $0.741 \times 10^{-11}\,\mathrm{N} \approx 0.15 \times 10^{-11}$ lb.

---

002 qmult 02040 2 1 3 mod. memory: mass and weight above Earth
Extra keywords: physci KB-59-25

119. An object has mass x and weight y on the Earth's surface. What is its mass and weight at 2 Earth radii above the Earth's surface? Note **ABOVE** the Earth's surface, not **FROM** the Earth's center.

a) x and $y/2$. b) $x/2$ and $y/2$. c) x and $y/9$. d) x and $y/4$.
e) $x/9$ and $y/9$.

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002 qmult 02110 1 1 3 easy memory: free fall in orbit

120. In orbit, you are weightless, not because gravity has turned off—it can actually be quite strong—but because you are:

a) going circles. b) in a relaxed state. c) in free fall. d) hallucinating.
e) in outer space.

Chapt. 3 Matter

Multiple-Choice Problems

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003 qmult 00100 1 4 3 easy deducto-memory: birth of natural philosophy

121. "Let's play *Jeopardy*! For $100, the answer is: The of natural philosophy—the explanation of nature in terms of general principles or axiom instead of mythological anthropomorphic dieties—began circa ____________ by the earlier Greek philosophers (the Presocratics). It should be said that the distinction between natural philosophy and and mythology is not altogether clearcut Many mythologies begin with rather impersonal dieties who are rather like forces or elements of nature."

    What is ____________, Alex?

    a) 3000 BCE b) 1000 BCE c) 600 BCE d) 250 BCE e) 150 CE

---

003 qmult 00110 1 1 4 easy memory: founders of atomism

122. Atomism was introduced by the Greek Presocratic philosophers Leucippus (first half of 5th century BCE) and Democritus (c. 460–c. 370 BCE) and incorporated into the philosophy of ____________. The later Latin poet Lucretius (c. 99–c. 55 BCE) gave a famous exposition of atomism in his poem *De Rerum Natura* (*On the Nature of Things*). The association of atomism with atheism led to a certain degree of dislike for atheism by other philosophical schools in Greco-Roman antiquity. Actually, the atomists were not atheists—they just believe the gods did not interfere in the world—slacker gods.

    a) Socraties (c. 469–399 BCE) b) Plato (c. 425–c. 348 BCE)
    c) Aristotle (384–322 BCE) d) Epicurus (341–270 BCE)
    e) Zeno (c. 334–c. 262 BCE)

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003 qmult 00120 1 1 4 easy memory: atomism revived in 17th century

123. Atomism, invented in Greco-Roman antiquity, was never forgotten and in the 17th century (in the Scientific Revolution), it was revived, mostly importantly by René Descartes (1596–1650) and ____________. The ideas about atomism by the 17th century atomists were useful important in stimulating scientific advances, but the 17th century atomists failed to make atomism a convincing scientific theory: i.e., a theory that made exact predictions that were testable and thereby made atomism falsifiable. The great authority achieved by ____________ probably helped to keep atomism in mind during the 18th century.

    a) Thomas Harriot (1560–1621) b) Galileo (1564–1642)
    c) Jeremiah Horrocks (1618–1641) d) Isaac Newton (1643–1727)
    e) Edmond Halley (1656–1742)

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003 qmult 00130 1 4 2 easy deducto-memory: John Dalton

124. "Let's play *Jeopardy*! For $100, the answer is: His theory of that atoms of each type of element had definite masses and that atoms combined in definite ratios to make compounds explained by compounds are always made of definite ratios by mass of the elements that make them up."

    Who is ____________, Alex?

a) Antoine Lavoisier (1743–1794) b) John Dalton (1766-1844)
c) Thomas Young (1773–1829) d) Humphrey Davy (1778–1829)
e) Michael Faraday (1791–1867)

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003 qmult 00140 1 4 4 easy deducto-memory: J. J. Thomson and electron

125. "Let's play *Jeopardy*! For $100, the answer is: He and his colleagues in 1896 concluded that the electron was particle of definite mass and charge although they could only measure the charge-to-mass ratio accurately. The electron was present in all types of matter and eventually it was concluded that it was probably subatomic: i.e., a constituent of all atoms."

Who is ____________, Alex?

a) Michael Faraday (1791–1867) b) Johann Christian Poggendorff (1796–1877)
c) George FitzGerald (1851–1901) d) J.J. Thomson (1856–1940)
e) Ernest Rutherford (1871–1937)

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003 qmult 00150 1 1 3 easy memory: early atomic models

126. J.J. Thomson (1856–1940) in 1904 proposed a ____________ model of the atom in which the electrons were embedded in clump of positive charge that kept the atom neutral or nearly neutral. In 1911, Ernest Rutherford (1871–1937) discoved that the positive charge of an atom must clumped in a ____________ much smaller than the atom. Niels Bohr (1885–1962) in 1913 proposed an orbital model for the electrons in an atom based on Rutherford discovery and now called the ____________.

a) toffee; Odysseus; Dalton atom b) gelato; DNA; Poggendorff atom
c) plum pudding; nucleus; Bohr atom d) cheesecake; chromosome; Rutherford atom
e) apple cobbler; Proteus; Thomson atom

---

003 qmult 00160 1 1 1 easy memory: Bohr atom wrong

127. The ____________ proposed in 1913 has some correct features. It posits quantized atomic energy states for electrons with the electrons in motion about an atomic nucleus. The electrons have angular momentum. It requires that photons can only be absorbed or emitted on transitions between the quantized states. However, the ____________ is essentially wrong. In particular, it cannot be generalized to atoms of more than one electron. So it is important historically and pedagogically, but not otherwise.

a) Bohr atom b) plum pudding atom c) Rutherford atom d) round atom
e) cubic atom

---

003 qmult 00170 1 1 5 easy memory: quantum mechanics discovered

128. ____________ was discovered in 1925–1926 by Erwin Schrödinger (1887–1961) and independently by Werner Heisenberg (1901–1976) et al. It is the correct microscopic physics insofar as we know.

a) The Bohr atom b) Classical mechanics c) Continuum mechanics
d) Electromagnetism e) Quantum mechanics

---

003 qmult 00200 1 1 3 easy memory: quantum mechanics

129. Discovered in 1925–1926, ____________ is the correct microscopic physics insofar as we know. It has never been found to be wrong and it has been extensively verified in pure science and in technology. Your cellphone would not work if it were not correct. There are, of course, mistakes in calculations and experiments. There are also many approximations in applications of ____________. Finding solutions from ____________ any real system (including atoms) involves many approximations and in many cases only crude solutions can be found. Advanced mathematical techniques and the use of supercomputers have extended the range of exact solutions. It must be mentioned that ____________ also presents mysteries that despite decades of study remain unsolved.

a) fluid dynamics b) classical mechanics c) quantum mechanics
d) thermodynamics e) acoustics

---

003 qmult 00210 1 1 3 easy memory: modern theory of atoms

130. The modern theory of atoms is based on quantum mechanics. In this theory, the atom consists of tiny central nucleus and swarm of electrons which surround the nucleus. An electron does not exist in a single position. It is in a continuum superposition of positions simultaneously. Only quantized energy states exist for the electrons, most with angular momentum, but some without. The overall state of the electrons is described by a ____________ (usually symbolized by Greek captial letter Ψ) which among other things gives the probability density for finding (or measuring) an electron at any point in space.

Atoms have no sharp edges. The ____________ formally goes to zero only at infinity relative to the nucleus. However, in fact the ____________ is negligibly different from zero at only a few angstroms ($1\,\text{Å} = 10^{-10}\,\text{m}$) from the nucleus. Various kinds of mean or characteristic radii are used to characterize the effective size of atoms.

It is rather difficult to picture atoms because of the complex spatial behavior of the ____________. Schematic representations that only reveal certain aspects are useful. The old chemistry textbook images of atoms as spheres that can overlap to form molecules are pretty useful. Actual images of atoms taken with modern techniques only reveal limited views of their structure, and so do not at all give the perfect way of pictureing atoms.

a) potential b) particle function c) wave function d) splash function
e) probability

---

003 qmult 00220 1 1 1 easy memory: atomic and nuclear size scale

131. The size scale of an atom is ____________ and the size scale of a nucleus is ____________.

a) $1\,\text{Å} = 10^{-10}\,\text{m}$; 1 fermi $= 10^{-15}\,\text{m}$ b) $1\,\text{Å} = 10^{-8}\,\text{m}$; 1 fermi $= 10^{-13}\,\text{m}$
c) $1\,\text{Å} = 10^{-6}\,\text{m}$; 1 fermi $= 10^{-7}\,\text{m}$ d) $1\,\text{Å} = 10^{-3}\,\text{m}$; 1 fermi $= 10^{-4}\,\text{m}$
e) $1\,\text{Å} = 10^{-15}\,\text{m}$; 1 fermi $= 10^{-20}\,\text{m}$

---

003 qmult 00230 1 1 3 easy memory: atomic mass range

132. Atomic mass is measured in the atomic mass unit (abbrevation AMU with symbol u or the obsolete amu). Often the unit symbol u is not written explicitly: it is understood. The modern definition of the AMU is

$$1\,\text{u} = \frac{1}{12}(\text{mass of a unperturbed ground-state carbon-12 atom}\ .$$

The ground state of a system is its lowest energy state. It is not possible to have an exactly unperturbed ground state, but one get arbitrarily close to it in principle and in practice so close that it is the best way to define a mass standard by far. Why carbon-12? Oh some good experimental reason. Maybe its just the easiest atom to make measurements with. Protons and neutrons are both slightly heavier than an AMU. The range of atomic masses is:

a) ~ 0.1–$2500\,\text{u}$. b) ~ 0.1–$250\,\text{u}$. c) ~ 1–$250\,\text{u}$. d) ~ 4–$400\,\text{u}$. e) ~ 4–$40\,\text{u}$.

---

003 qmult 00232 1 1 3 easy memory: Avogadro's number and moles

133. The atomic mass unit in grams is given by

$$1\,\text{u} = 1.660538921(73)\times 10^{-24}\,\text{g}$$

where the number in parenthesis is, as usual, the uncertainty in the last digits of the number. The AMU is only approximately known in grams though it is known to high accuracy. In the not so distant future, the gram may be defined as exactly so many AMUs. The number of AMUs in a gram is Avogadro's number or 1 mole:

$$N_A = \frac{1\,\text{g}}{1.660538921(73)\times 10^{-24}\,\text{g}} = 6.02214179(30)10^{23}\ .$$

The number of atoms in any sample of mass m of an element of atomic mass A is

$$N = \frac{m}{A\,\mathrm{u}} = \left(\frac{m}{A \times 1\,\mathrm{g}}\right)(1\,\mathrm{g} \times 1\,\mathrm{u}) = \left(\frac{m}{A \times 1\,\mathrm{g}}\right) N_A \ .$$

In moles, the sample is

$$\frac{N}{N_A} = \frac{m}{A \times 1\,\mathrm{g}} \ .$$

One mole of an element has mass $A \times 1\,\mathrm{g}$ (usually just written A) which is called the element's:

a) atomic mass. b) atomic weight. c) gram atomic mass.
d) gram glen atomic mass. e) grammatical atomic mass.

---

003 qmult 00236 1 1 1 easy memory: H2O moles

134. Hydrogen has an atomic mass of about 1 and oxygen of about 16. Approximately how many moles of water molecules are there in 9 g of water?

a) 1/2. b) 1. c) 18. d) 9. e) −2.

---

003 qmult 00238 1 1 1 easy memory: CO2 moles

135. Carbon has an atomic mass of about 12 and oxygen of about 16. Approximately how many moles of carbon dioxide (CO_2) molecules are there in 9 g of dry ice (solid phase CO_2)?

a) 1/5. b) 44. c) 1/16. d) 32. e) −2.

---

003 qmult 00250 1 1 5 easy memory: empty atom

136. Atoms are sometimes described as mostly empty. But this is inexact. They have a low density spherical or nearly spherical region occupied by electrons and a high density ____________ occupied by protons and neutrons.

a) zone b) chromosome c) core d) valence shell e) nucleus

---

003 qmult 00252 1 1 5 easy memory: density of an atom

137. Given that an atom mass is of order an AMU ($1\,\mathrm{u} = 1.660538921(73) \times 10^{-24}\,\mathrm{g}$) and the atom radius is of order 1 Å, what is the order of atomic density?

a) $10\,\mathrm{g/cm}^{14}$. b) $10^3\,\mathrm{g/cm}^3$. c) $100\,\mathrm{g/cm}^3$. d) $10\,\mathrm{g/cm}^3$. e) $1\,\mathrm{g/cm}^3$.

---

003 qmult 00254 1 1 1 easy memory: density of a nucleus

138. Given that an atomic nucleus mass is of order an AMU ($1\,\mathrm{u} = 1.660538921(73) \times 10^{-24}\,\mathrm{g}$) and the nuclear radius is of order 1 fermi $= 10^{-13}$ cm, what is the order of nuclear density?

a) $10^{15}\,\mathrm{g/cm}^3$. b) $10^3\,\mathrm{g/cm}^3$. c) $100\,\mathrm{g/cm}^3$. d) $10\,\mathrm{g/cm}^3$. e) $1\,\mathrm{g/cm}^3$.

---

003 qmult 00270 1 1 4 easy memory: identical atoms

139. Atoms of the same type (meaning same element and isotope) are ____________ in their properties. This result follows from quantum mechanics the most trusted of all physical theories. It means among other things that there is no way to tell whether an atom is young or old. In fact, atoms of the same type lose their identities when their wave functions overlap. There is no way in theory to tell which was which during the overlap phase or afterward. Perhaps, one could say that atoms of given type at a given time were partially caused by atoms of that type at earlier times. But that is just to awkward for anyone.

a) elaborate b) indistinct c) distinct d) identical e) ghostly

---

003 qmult 00300 1 1 3 easy memory: elementary unit of charge e

140. The elementary unit of charge is

$$e = 1.602176565(35) \times 10^{-19}\,\mathrm{C} \ .$$

where C stands for coulomb, the macroscopic unit of charge. Insofar as we can tell, the charge a proton is exactly e, the charge of a neutron is exactly 0, and the charge of an electron is exactly:

a) e. b) 0. c) $-e$. d) $(1/3)e$. e) $(2/3)e$.

---

003 qmult 00300 1 1 1 easy memory: likes repel, unlikes attract

141. Like charges ____________ and unlike charges ____________.

a) repel; attract b) repel; repel c) attract; repel d) attract; attract
e) are non-interacting; attract

---

003 qmult 00310 1 1 1 easy memory: nearly neutral universe

142. On all size scales above the atomic size scale, the universe is usually ____________. This because insofar as we can tell the universe has equal amounts of positive and negative charge and because of the nature of the electric force and charged particles. Of course, net charge buildups of various sizes do occur, but this because something overcomes the neutralizing tendency.

a) nearly neutral b) exactly neutral c) positive d) negative
e) both positive and negative

---

003 qmult 00320 1 1 3 easy memory: strong force bind nuclei

143. The nuclear strong force bonds the protons in the ____________ against their mutual electric force repulsion. The nuclear strong force is thus a very strong force. But is very short range acting between nucleons (i.e., protons and neutrons) over distances of order 1 $rmfermi10^{-15}$ m. Thus, in ordinary terrestrial environments nuclei are mutually repelled and do not react with each other. The nuclei must be given high kinetic energy in order ram close enough to one another for nuclear reactions to occur.

a) atom b) molecule c) nucleus d) chromosome e) photon

---

003 qmult 00320 1 1 5 easy memory: no collapse of atom because of QM

144. The short answer why the electrons of atoms don't just collapse into the nucleus is that ____________ forbids. Thus, there is no neutralization at the atomic or smaller scales. Actually, electrons and protons do react to create neutrons and that process goes on all the time in nature, but in most environments at a very low rate.

a) statics b) dynamics c) electromagnetism d) classical mechanics
e) quantum mechanics

---

003 qmult 00330 1 1 2 easy memory: nucleus described a bit

145. For nuclear force reasons, all stable nuclei and virtually unstable nuclei must have both protons and neutrons, except for the ordinary hydrogen nucleus which consists of a single proton. (The common name for proton and neutron is nucleon.) The number of protons in the nucleus is the atomic number Z, the number of neutrons is neutron number N, and the number of nucleons $(Z+N)$ is the atomic mass number A. There is some confusion since the symbol A is also used for the atomic mass (which is not an integer) which is not the same as atomic mass number although they are usually pretty close. The proton and neutron have approximately an atomic mass unit of mass (and this makes atomic mass number and atomic mass pretty close), but they are both a bit more massive than the AMU: the neutron is slightly more massive than the proton. Also when protons and neutrons are bonded together some mass is lost due to lost binding energy. Recall $E = mc^2$. If energy is lost in binding, mass is lost. For example, helium-4 is 0.7 % less massive than two isolated proton plus two isolated neutrons. Stable nuclei have $N \gtrsim Z$ with N tending to get relatively larger as Z increases.

The atomic number determines the chemistry of the atom since it fixes the number of electrons in the ____________.

a) nucleus b) neutral atom c) molecule d) solid e) liquid

---

003 qmult 00340 1 1 3 easy memory: decay and half-life

146. Some nuclei are stable. They will last forever unless some force acts on them. Most nuclei are unstable (i.e., radioactive). They will spontaneously decay (i.e., change) into another nucleus (or in alpha-decay or fission) into multiple nuclei. (Most nuclei in type are unstable. In actual population of all nuclei, most nuclei are stable.)

The decay process is random. A radioactive nucleus may decay in an instant or in unlimited time in the future. But they is no way to tell from nucleus when it will decay. All nuclei of a given type are identical in their properties. There is, however, a sort of characteristic lifetime for an unstable nucleus called a ____________. For a given sample of a radioactive nuclei, half will have decayed after one ____________ on average. Thus, every ____________, the population of a radioactive nuclei decreases by half on average. For example after 10 ____________, only $1/2^{10} = 1/1024$ of the original number are left on average. Note the word "average". In any actual case, there are fluctuations from average that grow relatively small as the sample size increases. So the fact that the average number of survivors is not an integer in general is not a problem. If the average survivor number is less then 1, it just means that in some cases there are zero survivor number is zero and in others it is 1 or more.

a) period/periods b) quarter-life/quarter-lives c) half-life/half-lives
d) whole-life/whole-lives e) mean lifetime/mean lifetimes

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003 qmult 00342 1 4 1 easy deducto-memory: half-life

147. A half-life is:

a) the time it takes for **HALF** a sample of a radioactive species (i.e., a radioactive nuclide) to decay to a daughter nuclide.
b) the time it takes for **a QUARTER** of a sample of a radioactive nuclear species (i.e., a radioactive nuclide) to decay to a daughter nuclide.
c) the time between star and planet formation.
d) the age of the Sun.
e) the nuclear fuel burning life-time of the Sun.

---

003 qmult 00344 1 1 4 easy memory: half-life probability

148. Say you have a radioactive nucleus with half-life $t_{1/2}$. You've observed it for n half-lives. What is the probability that it will decay in the next half-life? **HINT:** Think about tossing coins.

a) 1. b) 0. c) $1 - 1/2^{n+1}$. d) $1/2$. e) $1 - 1/2^n$.

---

003 qmult 00346 1 1 3 easy memory: radioactive sample after n half-lives 2

149. Say you had a pure sample of radioactive material at time zero. After n half-lives the fraction of the sample that is still the radioactive material is:

a) $1/2$. b) 2. c) $1/2^n$. d) $1/2^{n-1}$. e) $1/2^{n+1}$.

---

003 qmult 00348 1 1 5 easy memory: radioactive decay paradox

150. A sample of radioactive material decreases by 1/2 in one half-life in the sense that half of the radioactive nuclei decay to daughter radioactive nuclei in that time. But nuclei are discrete. Now most initial samples of radioactive nuclei will not consist of an exact power of 2. Thus, in general the predicted number of nuclei after any number of half-lives will not be a whole number, but will be some decimal number with a non-zero decimal fraction. Most dramatically at some point predicted number of nuclei will be less than 1. But nuclei are discrete. There is paradox: the number of nuclei are descrete, but the half-life decay rule predicts non-whole numbers of nuclei. The resolution of the paradox is:

a) the half-life rule is just crude approximation.
b) the half-life rule is an excellent approximation for **LARGE** samples that can be treated as consisting of continuous number of nuclei, but fails for fails for **SMALL** numbers of nuclei.

c) the half-life rule is an excellent approximation for **SMALL** samples that can be treated as consisting of continuous number of nuclei, but fails for fails for **LARGE** numbers of nuclei.
d) that there is no resolution. The whole idea of half-life is a crock.
e) the half-life rule makes an average prediction. For example, if you started with a set of many samples of radioactive nuclei, the average number of nuclei for a sample in the set after n half-lives would be predicted by the half-life decay rule. Average numbers of discrete items don't have to be discrete: e.g., the average American family proverbially has 2.3 children—but there is no 0.3 of child out there.

---

003 qmult 00350 1 1 2 easy memory: isotopes

151. Atoms of the same atomic number, but different neutron number are ____________ of each other. ____________ are nearly chemically identical. The ____________ of a particular atom is specified by giving the atom name followed by a hyphen and the ____________ atomic mass number: e.g., carbon-12 for the carbon atom with 6 neutrons. The difference in mass of ____________ does affect reactions slightly and difference in nucleus may very slightly affect electronic structure. However, ____________ are quite distinct in nuclear reactions. Generally, there are only a few stable or no stable ____________ per element. All elements beyond lead in atomic number have no stable ____________ although some ____________ of these elements have half-lives of billions years. Some elements have only one stable ____________: e.g., beryllium which only has stable ____________ beryllium-9. Tin has the most stable ____________, 10. Generally, the further an unstable ____________ is in neutron number from stable ____________, the more unstable it is: i.e., the shorter its half-life. Some super unstable ____________ may have such short half-lives that they are never observed in nature or the lab and only exist in conception.

a) isobar/isobars b) isotope/isotopes c) allotrope/allotropes d) trope/tropes
e) dope/dopes

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003 qmult 00352 1 1 1 easy memory: carbon-14 calculation

152. Radioactive carbon-14 decays with a half-life of 5730(40) years. Living creatures acquire carbon-14 from the air: plants get the carbon from the air and animals from eating plants. The fraction of their carbon which is carbon-14 is that of the air at the time that they are living. But after death, no new carbon-14 is acquired and the carbon-14 decays away. By knowing the ratio of the carbon-14 fraction of dead organic material to the fraction of that material when living, you can:

a) calculate the age of the organic material. b) tell nothing.
c) know what organism the material came from. d) tell the cause of death.
e) konw waht ogsinram teh mtraiael cmae form.

---

003 qmult 00354 1 3 1 easy math: radioactive dating/decay K-40

153. You have a sample of rock in which the ratio of ^{40}K (radioactive potassium) to ^{40}Ca (stable calcium-40) is 1 to 1. The half-life of ^{40}K is about 1.3 billion years. Assuming the rock was calcium-free at formation, what is the approximate time since the rock was formed?

a) 1.3 billion years. b) 2.6 billion years. c) Only a few years at most.
d) 13 billion years. e) 4.6 billion years.

---

003 qmult 00356 1 3 1 easy math: radioactive dating, half-life U-238

154. A sample is initially pure radioactive $^{238}_{92}$U (isotope uranium-238). After four half-lives how much $^{238}_{92}$U is left?

a) 1/16. b) 1/2. c) 1/4. d) 1/10. e) None.

---

003 qmult 00358 1 5 3 easy thinking: radioactive dating, half-life

155. A sample was initially pure radioactive $^{238}_{92}$U (isotope uranium-238). The half-life of $^{238}_{92}$U is 4.5 billion years. Currently, only 1/128 of the sample is ^{238}U. How old is the sample?

a) 4.5 billion years old.

b) 4.5 million years old.
c) 31.5 billion years old. This is older than the currently estimated age of the universe ∼ 10–20 billion years old. Clearly there is an inconsistency.
d) 35 billion years old. This is older than the currently estimated age of the universe ∼ 10–20 billion years old. Clearly there is an inconsistency.
e) 15 billion years old. This age puts a lower limit on the age of the universe (i.e., the time since the Big Bang).

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003 qmult 00400 1 1 3 easy memory: element defined and discussed

156. A/An ____________ is a substance made up of only one type of atom as defined by atomic number. A/An ____________ and its constituting type of atom have the same name: e.g., carbon means ____________ carbon and atom carbon. The term ____________ is often used for atoms of its constituting type collectively. For example, one can say this material is 50 ____________ X or atom X. So although ____________ and atom are not formally synonyms, they can be used interchangeably in many contexts. A/An ____________ in solid form can come in different bonding structures called allotropes. For example, carbon can come as graphite (hexagonal array of bonded atoms in layers that are loosely bonded to each other, diamond (tetrahedral bonding repeating without fixed limit), fullerenes (pure carbon molecules), graphene (a single layer of graphite), carbon nanotubes (graphene rolled up into tube), and other forms.

In nature almost all ____________ have have more than one stable isotope of atom come a mixtures of the isotopes. This is because it is very difficult to separate isotopes of the same ____________ by chemical or other means. (One often says that ____________ cannot be separated into components by chemical means, but this is not strictly true although it is almost always practically true.) The relative isotopic compostion of an lsample is an important clue about its nuclear formation history.

a) compound/compounds b) mixture/mixtures c) element/elements
d) Urstoff/Urstoffen e) basic/basics

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003 qmult 00410 1 1 2 easy memory: fissionable uranium

157. Uranium in nature comes in 3 isotopes uranium-238 (99.2742 %), uranium-235 (0.7204 %), and uranium-234 (0.0054 %). For fission in nuclear bombs, one needs uranium enriched in uranium-235 (fissionable uranium). The uranium should be 85 % or more uranium-235 for high-grade bombs, though lower amounts will work for less efficient bombs. The stumblingblock in making nuclear bombs has, in fact, always been enrichment in uranium-235 since this cannot be done by ordinary chemical means since uranium-238 and uranium-235 are nearly ____________. Obtaining uranium ore and bomb designs is comparatively not difficult. In fact, it takes a major industrial setup to enrich in uranium-235, and so only nations willing to devote considerable resources to the process have made nuclear weapons. This is a good thing since otherwise nuclear proliferation would probably be unstoppable and nuclear bombs would likely have used many times.

a) chemically distinct b) chemically identical c) nuclearly identical
d) nuclearly distinct e) antimatter with respect to each other

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003 qmult 00420 1 1 2 easy memory: nucleosynthesis

158. The creation of the elements is called nucleosynthesis. In modern theory, most hydrogen and helium and some of lithium, beryllium, and maybe boron were produced in the Big Bang about 13.7 gigayears ago. These are the lightest elements. Then carbon through oxygen are mainly produced in stars and ejected into the interstellar medium by strong stellar winds in late phases of star life. Heavier elements are produced in ____________ or pre-____________ evolution and ejected by the ____________ explosion into the interstellar medium. There are also minor nucleosynthesis sites. Out of the interstellar medium, new generations of stars are formed. The universe is undergoing a continuing enrichment in heavy elements.

a) moons b) supernovae c) planets d) pulsars e) black holes

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003 qmult 00500 1 1 3 easy memory: periodic table

159. The elements/atoms are organized according to their electronic structure (dictated by the electron wave function and which dictates their chemical properties) into the:

a) secular table. b) aperiodic table. c) periodic table. d) periodic oscillation. e) aperiodic chair.

---

003 qmult 00510 1 1 3 easy memory: electronic structure and orbitals

160. The wave function of electrons in an atom can be described as consisting of a combination single-particle wave functions called orbitals each of which has specific quantized energy, angular momentum, and spin (which we won't go into). By the Pauli exclusion principle (which is really a quantum mechanics result, not an independent law) only one electron at most can occupy an orbital. The word "occupy" requires considerable qualification that is beyond our scope to go into. In the ground state of an atom (which is where atoms in most environments spend most of their time and which is the main determinant of the atom's chemistry), the electrons occupy the lowests orbitals they can consistent with Pauli exclusion principle. The orbitals themselves are organized into groups called subshells and shells by their energy, angular momentum, and spin quantities. The shells run 1, 2, 3, etc. and each has subshells s, p, d, f, g, etc. in alphabetic order. Only shells up to 7 are needed for all atom ground states. The higher energy an orbital, subshell, or shell, the further out from the nucleus its electrons are on average. Everything would be simple if the subshells and shells filled in there reference order. But it is more complicated than that, and so we have to skirt that difficulty In any case, the outermost electrons, called the valence electrons, actually determine most of the chemistry. It is all rather complicated, but those atoms with full (or closed) s and p subshells on the outside are particularly unreactive and are called noble gases. (Helium is a special case with only two electrons. It is noble gas with only the outermost s subshell filled.) Atoms with one or two more less electrons in the outermost s and p subshells are particularly reactive.

The electronic structure and chemistry of the atoms is summarized in the ____________. The rows of a ____________ are called periods (or rows) and the columns are called groups (or columns). The elements are entered by increasing atomic number Z going across a row which ends with a noble gas. Then a new row is started. The groups contain elements with similar outer electron structure. and so are somewhat chemically alike in general. But as Z gets higher different kinds of outer electron structure are possible, and so new groups have to be introduced. The 1st row has two groups, the 2nd and 3rd 8 groups, the 4th and 5th rows 18 groups, and the 6th and 7th rows have 32 groups. In order to keep the ____________, to a manageable 18 columns wide, the 14 new groups of the 6th row (the lanthanides) and the 7th row (the actinides) are stuck in footnotes. Currently, the ____________ ends with element 118 which a very unstable laboratory-created element temporarily called ununoctium (Uuo) for one-one-eight. Its chemical properties are unknown, except from theory. It formally falls in group 18, but may not act like noble gas.

a) secular table. b) aperiodic table. c) periodic table. d) periodic oscillation. e) aperiodic chair.

---

003 qmult 00600 1 4 4 easy deducto-memory: compound defined

161. "Let's play *Jeopardy*! For \$100, the answer is: It is a homogeneous substance made from a combination of two or more elements in which the atom numbers have a definite ratios and definite chemical bonding structure (when in solid form). The physical and chemical properties of the substance are usually quite different from those of the constituent elements."

What is a ____________, Alex?

a) molecule b) liquid c) mixture d) compound e) solid

---

003 qmult 00610 1 4 5 easy deducto-memory: chemical mixture

162. ____________ are homogeneous or inhomogeneous substances made from a combination of two or more elements. ____________ can often be separated by physical (e.g., evaporation or filtering) rather than chemical means. They can also often be created by chemical rather than physical means. However, some ____________ do chemically bind the elements: most obviously alloys. In an alloy, different metal elements are bonded together, but there is no definite ratio of the atom numbers. The ratios can be varied continuously and the properties of the alloys vary continuously with the ratios.

a) G/gases b) S/solutions c) M/molecules d) C/compounds
e) M/mixtures

---

003 qmult 00620 1 1 1 easy memory: molecule defined

163. A ____________ is a group of atoms covalently bonded together with a definite atom number for each kind of atom and a definite bounding structure. Covalent bonds are those in which atoms are bonded by sharing a pair of electrons. An indefinitely largeg structure is not considered a ____________ even if all the bonds are covalent: e.g., diamond which is called a network solid. ____________ can consist of only one atom type like H_2 (molecular hydrogen which is just ordinary hydrogen gas) or O_2 (molecular oxygen which is just ordinary oxygen gas). Such ____________ are not considered to form compounds. ____________ of two or more atom types do form compounds. Many ordinary solids are usually not made of ____________ since the bonding is ionic. For example, sodium chloride (NaCl) consists of alternating sodium and chlorine atoms on a cubic lattice. But there is no special grouping of a sodium atom and chlorine atom: there is no ____________ NaCl. (When sodium chloride melts, the sodium and chlorine atoms are not rigidly bonded to each other.) However, there molecular solids such as water ice (H_2O) and dry ice (solid CO_2).

a) molecule/molecules b) nano/nanos c) gas/gases d) quark/quarks
e) monad/monads

---

003 qmult 00700 1 1 3 easy memory: chemical reaction

164. When chemical bonds are changed (formed or broken), one has a:

a) nuclear reaction. b) solid reaction. c) chemical reaction. d) chain reaction.
e) chain-gang reaction.

---

003 qmult 00800 1 1 2 easy memory: antiparticle

165. For every particle in modern physics, there is a/an:

a) photon b) antiparticle c) proton d) atom e) molecule

---

003 qmult 00810 1 1 3 easy memory: positron

166. The antiparticle of the electron is the:

a) quark b) magnitron c) positron d) electron itself e) photon

---

003 qmult 00900 1 1 5 easy memory: dark matter

167. Observations of the motions of galaxies and clusters of galaxies tell us that there must be ____________ that we cannot see. Big bang theory tells us that the ____________ cannot be ordinary matter.

a) faint matter b) luminous energy c) dark energy d) luminous matter
e) dark matter

Full-Answer Problems

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003 qfull 00130 1 3 0 easy math: Dalton's chemical atom theory

168. Was Dalton's theory about atoms in compounds falsifiable? Discuss.

Chapt. 4 Solids

Multiple-Choice Problems

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004 qmult 00100 1 1 3 easy memory: solids definition

169. Solids are formed by atoms or molecules held together by:

  a) external pressure. b) chemical bonds that allow the particles to slide over one. c) fairly rigid chemical bonds. d) gravity. e) internal pressure.

---

004 qmult 00230 1 1 1 easy memory: polycrystal

170. Most macroscopic samples of crysalline solids are ____________: i.e., are fused small crystals (called ____________) of order a few nanometers to a few millimeters in size scale. The boundaries of the "whatevers" can be complex.

  a) polycrystalline; crystallites or grains b) monocrystalline; crystallites or grains c) tricrystalline; crystallites or grains d) triglyceridic; tris or glys e) polycrystalline; bitty crystals

---

004 qmult 00310 1 1 5 easy memory: density discussed

171. The quantity

$$\rho = M/V$$

for an object of mass M and volume V is its mean ____________. A homogeneous substance has nearly uniform ____________: i.e., the ____________ of small samples above the atomic scale is nearly constant.

  a) enthalpy b) entropy c) temperature d) pressure e) density

---

004 qmult 00340 1 1 3 easy memory: density of liquid water

172. The density of liquid water at ordinary human-scale temperature and pressure conditions is nearly exactly:

  a) $1000\,\mathrm{g/cm^3}$. b) $1\,\mathrm{kg/m^3}$. c) $1\,\mathrm{g/cm^3}$. d) $22.59\,\mathrm{g/cm^3}$. e) $22.56\,\mathrm{g/cm^3}$.

---

004 qmult 00350 1 1 2 easy memory: density math problem

173. An object consists of three parts: part 1 has mass 50 kg and volume $2\,\mathrm{m^3}$, part 2 has mass 30 kg and volume $5\,\mathrm{m^3}$, and part 3 has mass 20 kg and volume $3\,\mathrm{m^3}$. What is its mean density?

  a) $0.01\,\mathrm{kg/m^3}$. b) $0.01\,\mathrm{g/cm^3}$. c) $0.02\,\mathrm{g/cm^3}$. d) $0.03\,\mathrm{kg/m^3}$. e) $0.03\,\mathrm{g/cm^3}$.

---

004 qmult 00400 1 4 2 easy deducto-memory: elasticity defined

174. "Let's play *Jeopardy*! For $100, the answer is: It is the property of a material that causes the material to return to its original shape after being deformed by an applied external force (which in this context is called a stress). The relative deformation is called strain."

  What is ____________, Alex?

  a) plasticity b) elasticity c) masticity d) tricity e) squishiness

---

004 qmult 00420 1 1 4 easy memory: Hooke's law force and SHM

175. For a material to be elastic, it must have internal restoring force on every physical bit of the sample. A restoring force is one that drives a bit back to its equilibrium position where the bit has no net internal force on it and, in particular, the restoring force is zero. For small displacements from equilibrium, the restoring force in almost all cases is linear displacement. For example for a 1-dimensional cases, linear restoring force is

$$F = -kx \ .$$

where $x = 0$ is the equilibrium and k is a constant. This force law is called Hooke's law. An object acted only by the Hooke's law force exhibits:

a) square wave motion. b) zero motion in all cases. c) irregular oscillations.
d) simple harmonic motion. e) aperiodic motion.

---

004 qmult 00500 1 1 4 easy memory: tension, compression, shearing

176. The stretching deformation of a body is ____________ (which is a word actually more often used to mean the restoring force magnitude of a body in ____________), the squeezing deformation of a body is ____________, and the deformation of parallel layers of body sliding relative to each other is ____________. These three categories of deformation are the usual ones in physics for analyzing deformation.

a) tension; shearing; compression b) stretch; squish; slide
c) compression; tension; shearing d) tension; compression; shearing
e) slide; stretch; squish

---

004 qmult 00550 1 1 3 easy memory: neutral layer

177. When a beam is bent, the convex side has parallel layers in tension and the concave side has parallel layers in compression. By continuity between the tensed and compressed layers there must must a layer that neither tensed nor compressed although it is under a shearing strain. This layer is called the:

a) neutral zone. b) twilight zone. c) neutral layer.
d) untensed-uncompressed layer. e) cake layer.

---

004 qmult 00600 1 4 5 easy deducto-memory: lintel

178. "Let's play *Jeopardy*! For $100, the answer is: In architecture, a load-bearing or ornamental horizontal beam such as above door, window, or trilithon."

What is a/an ____________, Alex?

a) arch b) ark c) alembic d) limbeck e) lintel

---

004 qmult 00630 1 1 2 easy memory: catenary arch

179. The maximum strength shape for an arch that has to support its own weight is a ____________— a word apparently coined by Thomas Jefferson (1743–1826). This shape is also that of a rope or chain hanging from two points.

a) catenation b) catenary c) catena d) cantina e) Cat-Astrophe

---

004 qmult 00700 1 1 3 easy memory: isometric scaling and square-cube law

180. Isometric scaling (or just scaling for short) is when every length element of an object is varied by the same factor. Results that follow for isometric scaling of an object are

$$A \propto \ell^2 \ , \qquad V \propto \ell^3 \ , \qquad V^2 \propto A^3 \ , \qquad V \propto A^{3/2} \ ,$$

where ℓ is any length element, A is surface area, and V is volume. The first two formula collectively and the latter two individually are all formulations of:

a) Kleiber's law. b) the inverse-square law. c) the square-cube law.
d) Hooke's law. e) Gresham's law.

004 qmult 00710 1 1 3 easy memory: square-cube law and strength

181. Since the bonding strength of solids across any surface is proportional to the number of chemical bonds and that is proportional to area of the surface, the bonding strength is proportional to surface area. However, the mass of any body part is proportional to the volume of that body part. Now if you isometrically scale up a body, the strength of the body's structure declines in relative to its needs to maintain itself against gravity or to accelerate its parts. This is because the ratio of surface area of any part to volume of that part are related by:

a) Kleiber's law. b) the inverse-square law. c) the square-cube law.
d) Hooke's law. e) Gresham's law.

Full-Answer Problems

Chapt. 5 Liquids

Multiple-Choice Problems

005 qmult 00110 1 4 5 easy deducto-memory: liquid defined

182. "Let's play *Jeopardy*! For \$100, the answer is: It is a standard phase of matter in which the atoms or molecules are non-rigidly bonded together. Its density is usually close to the solid phase of the substance. This means that it strongly resists compression like a solid and it does not freely expand like a gas to fill an entire container. It cannot resist a strong shearing force which makes it a fluid just as a gas is fluid. It can, however, resist small shearing forces through the property of surface tension or cohesion. A substance in this phase under sufficiently low pressure conditions will phase change to the gas phase and then it can freely expand to fill a container."

    What is a ____________, Alex?

    a) quur b) quasicrystal c) plasma d) blas e) liquid

005 qmult 00200 1 4 5 easy deducto-memory: pressure defined

183. "Let's play *Jeopardy*! For \$100, the answer is: It is the scalar thermodynamic variable p that determines the normal force exerted by matter in any phase on a compressing surface. The surface can be just a layer of the same matter. A precise formula for p is:

$$d\vec{F} = p\,d\vec{A}$$

where $d\vec{F}$ is a normal force exerted by matter at point where p is defined and $d\vec{A}$ is differential vector area that points into the compressing surface at the normal force is exerted and in the normal force direction. The variable p is isotropic in ordinary definition: i.e., it has the same value for all directions. In solids and moving fluids, differences from isotropy are accounted for by the stress tensor."

    What is ____________, Alex?

    a) temperature b) entropy c) density d) enthalpy e) pressure

005 qmult 00250 1 1 3 easy memory: pascal unit of pressure

184. The MKS unit of pressure is the pascal (Pa) defined by

$$1\,\mathrm{Pa} = 1\,\mathrm{N/m^2}\ .$$

The pascal for the human environment is a rather small unit other units are used for convenience. A common standard unit is the standard atmophere (atm) which is mean sea-level pressure defined in some way. Another common unit is the psi or pounds per square inch. For convenience, we can write some relationships:

a) $1\,\mathrm{atm} = 101325\,\mathrm{Pa} = 101325\,\mathrm{kPa} = 14.696\,\mathrm{psi}$.
b) $1\,\mathrm{atm} = 101325\,\mathrm{Pa} = 101.325\,\mathrm{kPa} = 1.000\,\mathrm{psi}$.
c) $1\,\mathrm{atm} = 101325\,\mathrm{Pa} = 101.325\,\mathrm{kPa} = 14.696\,\mathrm{psi}$.
d) $1\,\mathrm{atm} = 101325\,\mathrm{Pa} = 100\,\mathrm{kPa} = 14.696\,\mathrm{psi}$.
e) $1\,\mathrm{atm} = 1013.25\,\mathrm{Pa} = 101.325\,\mathrm{kPa} = 14.696\,\mathrm{psi}$.

---

005 qmult 00300 1 1 2 easy memory: pressure distribution

185. The pressure distribution fof an incompressible fluid of density ρ at rest given a reference pressure p_0 at height $y = 0$ is:

a) $p = p_0 - \rho y$. b) $p = p_0 - \rho g y$. c) $p = p_0 - g y$. d) $p = p_0 - \rho g$.
e) $p = p_0 - \rho g / y$.

---

005 qmult 00350 1 1 4 easy memory: atmosphere height

186. The pressure distribution fof an incompressible fluid of density ρ at rest given a reference pressure p_0 at height $y = 0$ is

$$p = p_0 - \rho g y \ ,$$

where y is measured positive upward. Now air is not an incompressible fluid, but let's we assume that it is. Given surface air pressure of about 10^5 Pa and surface air density of about $1.2\,\mathrm{kg/m^3}$, what is the height of the atmosphere (i.e., the point at which pressure goes to zero)? About:

a) 1200 m. b) 12 m. c) 10 m. d) 10 km. e) 1.18 km.

---

005 qmult 00400 1 4 2 easy deducto-memory: Archimedes principle

187. "Let's play *Jeopardy*! For \$100, the answer is: The buoyancy force magnitude equals the weight of the fluid displaced or as formula:

$$F_{\mathrm{b}} = m_{\mathrm{dis}} g \ ,$$

where m_{dis} is the mass of the displaced fluid and g is the gravitational field near the Earth's surface with fiducial value 9.8 N/kg."

What is ____________, Alex?

a) Pascal's principle b) Archimedes's principle c) Bernoulli's principle
d) D'Alembert's principle e) Bob's principle

---

005 qmult 00420 1 1 3 easy memory: triple scalar product

188. The extra normal force acting on an object of mass m sitting on the solid bottom of some fluid container is given by ____________ in magnitude. The extra force is the force the solid needs to exert to support the object in addition to what it has to exert to support the fluid if there were no object present.

a) $F = m_{\mathrm{dis}} g$. b) $F = (m_{\mathrm{dis}} - m) g$. c) $F = (m - m_{\mathrm{dis}}) g$. d) $F = mg$.
e) $F = (m - m_{\mathrm{dis}})/g$.

---

005 qmult 00420 1 1 1 easy memory: floating at an interface

189. The basic condition for floating is that

$$F_{\mathrm{b}} = mg \ ,$$

where $F_{\mathrm{b}} = m_{\mathrm{dis}} g$ is the buoyancy force and m is the mass of the floating object. If the object is floating at the interface of two fluids 1 (the lower fluid) and 2 (the upper fluid), then the floating condition becomes

$$\rho_1 V_1 + \rho_2 V_2 = \rho V \ ,$$

where ρ_1 is the density of fluid 1, ρ_2 is the density of fluid 2, ρ is the mean density of floating object, V_1 is volume occupied in fluid 1 by the object, V_2 is volume occupied in fluid 2 by the object, and $V = V_1 + V_2$ is the total volume of the object. The last formula can be rearranged to give the usual diagnostic formula ____________ for floating which simplifies to ____________ when ρ_2 is negligible.

a) $\dfrac{\rho - \rho_2}{\rho_1 - \rho_2} = \dfrac{V_1}{V}$; $\dfrac{\rho}{\rho_1} = \dfrac{V_1}{V}$ b) $\dfrac{\rho - \rho_2}{\rho_1 - \rho_2} = \dfrac{V_2}{V}$; $\dfrac{\rho}{\rho_1} = \dfrac{V_2}{V}$ c) $\dfrac{\rho - \rho_1}{\rho_2 - \rho_1} = \dfrac{V_1}{V}$; $\dfrac{\rho}{\rho_2} = \dfrac{V_1}{V}$
d) $\dfrac{\rho_1 - \rho_2}{\rho - \rho_2} = \dfrac{V_1}{V}$; $\dfrac{\rho_1}{\rho} = \dfrac{V_1}{V}$ e) $\dfrac{\rho - \rho_2}{\rho_1 - \rho_2} = 1$; $\dfrac{\rho}{\rho_1} = 1$

---

005 qmult 00500 1 4 3 easy deducto-memory: Blaise Pascal

190. "Let's play *Jeopardy*! For $100, the answer is: This 17th century scientist, writer, and theologian is the discoverer of the eponymous principle:

> A change in pressure at any point in an enclosed incompressible liquid is transmitted to all other points in the liquid. One is thinking of a liquid at rest or in relatively slow flow. The transmission is not instantaneous, but is roughly at the speed of sound in the liquid. There is probably some oscillation in pressure all over the liquid after the applied change until dissipation of kinetic energy to waste heat brings the liquid relaxes to its new state.

The person in question was also inventor of early calculating device (and has been honored by having a computer language named for him) and the game of roulette—which has led to honor in casinos ever since. He also had a knack for writing quotes: e.g.,

> We have an incapacity for proof which no amount of dogmatism can overcome. We have an idea of truth which no amount of skeptism can overcome."

Who is ____________, Alex?

a) Otto von Guericke (1602–1686) b) Evangelista Torricelli (1608–1647)
c) Blaise Pascal (1623–1662) d) Robert Boyle (1627–1691)
e) Robert Hooke (1635–1703)

---

005 qmult 00600 1 1 3 easy memory: cohesion and surface tension

191. Ideal liquids cannot resist any shearing force (i.e., a force that tends to deform them without changing their volume). But actual liquids to have a small about of resistance to shearing forces called cohesion. The atoms/molecules of the liquid are weakly attracted to each other. But the manifestations of the force of cohesion are subject to the square-cube law effect. The larger the sample of liquid, the relatively less important cohesion is in determing the liquid's state. For example, a large volume of water just placed on a solid surface spreads out unable to resist the flattening shearing force of gravity, but a small drop stays relatively unflattened. Of course, even a large quantity of water doesn't spread out forever. Eventually, the water sample is so thin that cohesion is able to resist gravity and a curved boundary later forms.

The manifestation of cohesion at a liquid's surface is to pull surface atoms/molecules inward relative to the liquid and try to minimize the surface area. This manifestation is called:

a) adhesion. b) surface cohesion. c) surface tension. d) surface adhesion.
e) slurp.

---

005 qmult 00700 1 1 1 easy memory: adhesion and capillarity

192. Adhesion is the attraction of unlike atoms/molecules. Adhesion plus cohesion causes liquids to be pulled into small tube or tube-like structures of solids. The tubes have to be pretty narrow or the cohesion will not resist the shearing effect of gravity. The energy to pull the liquid against gravity comes from the binding energy of the liquid atoms/molecules to the solid surface. The overall effect of adhesion plus cohesion is called:

a) capillarity. b) hilarity. c) a capella. d) capacity. e) capillian.

Full-Answer Problems

Chapt. 6 Gases

Multiple-Choice Problems

006 qmult 00100 1 4 5 easy deducto-memory: gas defined

193. "Let's play *Jeopardy*! For $100, the answer is: It is one of the three classical phases of matter. It is fluid phase in that the material has very little resistance to shear stresses (i.e., forces that try to change shape without changing volume. In comparison to liquids (which are also fluids), the resistance to shear stresses is tiny to vanishing. Unlike liquids, the phase in question has its atoms/molecules far apart and only touching during collisions. Consequently, the phase in question is usually much lower in density than solids or liquids and much more compressible. When pressure and temperature exceed certain values called the critical values, there is no distinction between the phase in question and liquid: no interface can be formed separating two phases. This kind of fluid is called a supercritical fluid."

    What is a ____________, Alex?

    a) spirit b) concrete c) plasma d) blas e) gas

006 qmult 00130 1 1 3 easy memory: raising temperature to make gas

194. If one continually raises the temperature of a material at constant pressure, it will become and stay a ____________. Note here, we consider plasma just an ionized ____________.

    a) solid b) liquid c) gas d) air e) blas

006 qmult 00200 1 1 3 easy memory: Earth's atmosphere

195. The Earth's atmosphere is an ocean of gas with the Earth's surface (solid and liquid) at the bottom. The gas (which is called air) is:

    a) a compound. b) a monatomic gas. c) a mixture. d) mostly oxygen. e) helium.

006 qmult 00210 1 1 4 easy memory: air composition

196. The table below gives the composition of dry air.

Dry Air Composition of Air

Order	Substance	Percentage by Number	Percentage by Mass
1	N_2 (molecular nitrogen)	77	75.52
2	O_2 (molecular oxygen)	21	23.14
3	Ar (argon)	0.99	1.29
4	CO_2 (carbon dioxide)	0.033	0.05
5	Ne (neon)	0.0018	0.0013
6	He (helium)	5.2×10^{-4}	7×10^{-5}
7	CH_4 (methane)	1.5×10^{-4}	1×10^{-4}
8	Kr (krypton)	1.1×10^{-4}	3×10^{-4}
7	H_2 (molecular hydrogen)	5×10^{-5}	...
8	O_3 (ozone)	4×10^{-5}	...

9	N_2O (nitrous oxide)	3×10^{-5}	...
10	CO (carbon monoxide)	1×10^{-5}	...
11	NH_3 (ammonia)	1×10^{-6}	...
...	H_2O (water vapor)	typically 1 to 4 at the Earth's surface	

NOTE.—Since water vapor is very variable, it is not included in the dry air composition with the other substances, and so they add up to 100 % without water vapor. Dry air composition for the major components is fairly constant everywhere in the atmosphere.

All the substances in the table have some importance for the biosphere, except probably for the noble gases argon, neon, and krypton is chemically nearly inert. For example, ____________ is directly essential for photosynthesis.

a) N_2 b) O_2 c) Ar d) CO_2 e) Ne

---

006 qmult 00212 1 1 1 easy memory: most abundant air substances

197. The four most abundant air substances in decreasing order by both number and mass are:

a) N_2, O_2, Ar, CO_2. b) O_2, N_2, Ar, CO_2. c) O_2, N_2, CO_2, Ar.
d) N_2, O_2, Ne, CO_2. e) H_2, He, Ar, CO_2.

---

006 qmult 00214 1 1 1 easy memory: density of air

198. At 20°C and 1 atm (101.325 kPa) pressure, dry air has a density of:

a) $1.2041\,\mathrm{kg/m^3}$. b) $1204.1\,\mathrm{kg/m^3}$. c) $1000\,\mathrm{kg/m^3}$. d) $7.874\,\mathrm{kg/m^3}$.
e) $7874\,\mathrm{kg/m^3}$.

---

006 qmult 00216 1 3 1 easy math: air mass in a room
Extra keywords: physci KB-132-9

199. The density of air at 20° and 1 atm pressure is $1.21\,\mathrm{kg/m^3}$ (HRW-323). (For comparison, water density under the same conditions is $998\,\mathrm{kg/m^3}$ (HRW-323) which is nearly the frequently quoted $1000\,\mathrm{kg/m^3}$ which is its density at 4° and 1 atm (CJ-322]).) There is a room 5 m long, 4 m wide, and 3 m high filled with air. What is the mass of air in the room?

a) 72.6 kg. b) 1.21 kg. c) 998 kg. d) 0 kg. e) −998 kg.

---

006 qmult 00220 1 4 1 easy deducto-memory: Earth atmosphere pressure
Extra keywords: physci KB-129-3

200. The pressure of the Earth's atmosphere at any level is caused by:

a) the weight of the overlying air mass. b) respiration by living things.
c) evaporation of sea water. d) glaciers. e) squid.

---

006 qmult 00222 1 1 2 easy memory: constant air pressure

201. Because of its low density, ____________ pressure varies slowly with height and can usually can be taken as a constant over changes of height of a few meters or even hundreds of meters depending on how accurate you want to be.

a) water b) air c) mercury d) iron e) lead

---

006 qmult 00230 1 1 3 easy memory: approximate top of atmosphere altitude

202. The pressure distribution formula for an incompressible fluid at rest near the Earth's surface is

$$P = P_0 - \rho g y \ ,$$

where P_0 is the zero-point pressure at $y = 0$, ρ is the fluid density, g is the gravitational field magnitude near the Earth's surface (with fiducial value 9.8 N/kg, and y is height with upward positive. Now air is not an incompressible fluid, but if we so approximate it, we can find a value for the altitude of the top of the atmosphere. Find this value. Note air pressure and density at the Earth's surface are, respectively, about 10^5 Pa and $1.2\,kg/m^3$.

a) 10 m. b) 1 km. c) 10 km. d) 10000 km. e) 100 km.

---

006 qmult 00300 1 4 2 easy deducto-memory: Torricelli invents barometer

203. "Let's play *Jeopardy*! For $100, the answer is: This 17th century scientist who invented the barometer in 1643.

Who is ____________, Alex?

a) Otto von Guericke (1602–1686) b) Evangelista Torricelli (1608–1647)
c) Blaise Pascal (1623–1662) d) Robert Boyle (1627–1691)
e) Robert Hooke (1635–1703)

---

006 qmult 00310 1 4 5 easy deducto-memory: barometer defined

204. "Let's play *Jeopardy*! For $100, the answer is: It is a device for measuring gas pressure."

What is a/an ____________, Alex?

a) diving rod b) thermometer c) altimeter d) voltmeter e) barometer

---

006 qmult 00340 1 4 2 easy deducto-memory: pressure in straw
Extra keywords: physci KB-131-5

205. "Let's play *Jeopardy*! For $100, the answer is: This causes water to rise in a sucked on straw."

What is ____________, Alex?

a) higher-than-room-air-pressure pressure inside the straw b) lower-than-room-air-pressure pressure inside the straw c) the electric force d) the magnetic force e) the speed of light

---

006 qmult 00350 1 4 2 easy deducto-memory: container for low/high pressure fluids

206. "Let's play *Jeopardy*! For $100, the answer is: The shape feature of containers for low and high pressure fluids. This feature allows container to rely more compressive and tensile strength of its material than on its shear strength than otherwise. Compressive and tensile strengths for many materials are greater than shear strength."

What is ____________, Alex?

a) cubicalness b) roundedness c) squarishness d) sofaness e) priggishness

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006 qmult 00400 1 4 1 easy deducto-memory: von Guericke invents the vacuum pump

207. "Let's play *Jeopardy*! For $100, the answer is: This 17th century scientist who invented the vacuum pump in 1654.

Who is ____________, Alex?

a) Otto von Guericke (1602–1686) b) Evangelista Torricelli (1608–1647)
c) Blaise Pascal (1623–1662) d) Robert Boyle (1627–1691)
e) Robert Hooke (1635–1703)

---

006 qmult 00450 1 5 5 easy thinking: 2001: A Space Odyssey
Extra keywords: physci

208. In *2001: A Space Odyssey*, astronaut David Bowman finds himself trapped without his helmet in a space pod. The computer Hal has locked the direct pod-to-spaceship airlock. Bowman decides to "breathe vacuum"—to go sans helmet through space to an outside airlock—and then deal with Hal. Why doesn't Bowman explode due to his internal body pressure in the nearly zero pressure of space?

a) He is too quick to explode.
b) He holds his breath.
c) Hal has not anticipated Bowman's maneuver or at least has no contingency plan.
d) Sheer plot requirement.

e) Most of the body's internal pressure is supplied by nearly incompressible (and therefore nearly non-expandable) fluid and solid: these parts won't explode under decompression. Bowman does **NOT** hold his breathe, and so air pressure in his internal cavities drops very quickly and rupturing does not occur. He has 10 to 15 seconds before losing consciousness.

---

006 qmult 00500 1 4 4 easy deducto-memory: Boyle's law discovered

209. "Let's play *Jeopardy*! For \$100, the answer is: This 17th century scientist who is credited with establishing Boyle's law in about 1662.

Who is ____________, Alex?

a) Otto von Guericke (1602–1686) b) Evangelista Torricelli (1608–1647)
c) Blaise Pascal (1623–1662) d) Robert Boyle (1627–1691)
e) Robert Hooke (1635–1703)

---

006 qmult 00510 1 4 2 easy deducto-memory: Boyle's law specified

210. "Let's play *Jeopardy*! For \$100, the answer is: For given amount of gas at constant temperature, pressure is inversely proportional to volume. As a formula, the law is

$$p \propto \frac{1}{V} ,$$

where p is pressure and V is volume. The law strictly holds only for an ideal gas, but it approximates the behavior of real gases to high accuracy and becomes exact in the limit of zero density."

What is ____________, Alex?

a) Hooke's law b) Boyle's law c) Towneley-Power law d) von Guericke's law
e) Pascal's principle

---

006 qmult 00520 1 1 1 easy memory: Boyle's law calculation 1

211. If the volume of a gas sample is doubled isothermally, its pressure:

a) halves. b) doubles. c) triples. d) bifurcates. e) stays the same.

---

006 qmult 00520 1 1 2 easy memory: Boyle's law calculation 2

212. If the volume of a gas sample is halved isothermally, its pressure:

a) halves. b) doubles. c) triples. d) bifurcates. e) stays the same.

---

006 qmult 00550 1 1 3 easy memory: ideal gas law

213. The formula

$$PV = nRT$$

(where P is pressure, V is volume, n is number of moles of gas, R is the ideal gas constant, and T is temperature on the Kelvin scale) is:

a) Boyle's law. b) Charles's law. c) the ideal gas law.
d) the zero-temperature degenerate gas equation of state. e) regrettable.

---

006 qmult 00610 1 1 5 easy memory: buoyancy in the air

214. For an object to float in air, not rising or sinking, the following must hold:

a) $\rho_{\text{object}} = \rho_{\text{air}}/2$. b) $\rho_{\text{object}} = 2\rho_{\text{air}}$. c) $\rho_{\text{object}} > \rho_{\text{air}}$. d) $\rho_{\text{object}} < \rho_{\text{air}}$.
e) $\rho_{\text{object}} = \rho_{\text{air}}$.

---

006 qmult 00700 1 1 4 easy memory: Bernoulli's principle

215. The formula for incompressible, inviscid fluid

$$P + \rho g y + \frac{1}{2}\rho v^2 = \text{a constant along a streamline}$$

(where P is the moving fluid's pressure, ρ is fluid density, g is the gravitation field magnitude near the Earth's surface, y is height, and v is fluid speed) is:

a) Boyle's law. b) Hooke's law. c) Pascal's principle. d) Bernoulli's principle.
e) Heisenberg's uncertainty principle.

---

006 qmult 00710 1 1 3 easy memory: Bernoulli's principle derivation

216. Bernoulli's principle can be derived from ____________ of classical mechanics. It can be thought of as the conservation of an energy quantity $p + \rho g y + \frac{1}{2}\rho v^2$ in the absence of viscosity.

a) Newton's 2nd law b) Newton's 3rd law c) the work-energy theorem
d) Newton's 1st law e) the conservation of momentum

---

006 qmult 00810 1 1 3 easy memory: aerodynamic lift, plane lift

217. The force that holds aircraft up in the air is aerodynamic lift which is actually a combination of the ____________ and the ____________.

a) momentum lift; Pascal lift b) reaction lift; Pascal lift
c) reaction lift; Bernoulli lift d) momuntum lift; Bernoulli lift
e) reaction lift; Boyle lift

---

006 qmult 00820 1 5 5 easy easy thinking: paper and lift

218. Take this quiz and ...—no, no not that. Take this quiz—or some single sheet of paper if you arn't in a quiz *mise en scène*—in your fingers with your fingers on either side of one of narrow ends. Hold this end **JUST BELOW** your lips and blow a strong gust.

a) Nothing happens, because you've blown too hard.
b) Nothing happens, because you've blown too softly and you've never succeeded in blowing up a balloon in your life.
c) You spit.
d) The instructions are unintelligible.
e) The paper rises because you've created a high-speed, low-pressure zone above the paper. This is the Bernoulli lift which is part of aerodynamic lift by which airplanes fly. Of course, if you put the paper above your lips and blow the paper rises too. This time the rise is caused by the reaction lift which is the other part of aerodynamic lift. The blown air is deflected down by the paper, but for every force there is an equal and opposite force and so the air pushes up on the paper too.

Full-Answer Problems

Chapt. 7 Entangling Space

Multiple-Choice Problems

Full-Answer Problems

Chapt. 8 Electrostatics

Multiple-Choice Problems

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014 qmult 00100 1 4 5 easy deducto-memory: electromagnetism 1

219. "Let's play *Jeopardy*! For \$100, the answer is: It is the realm of physics concerned with electrical and magnetic phenonema: i.e., electricity and magnetism. Electricity and magnetism are, in fact, two manifestations of the same underlying realm: i.e., the realm in question."

What is ____________, Alex?

a) mechanics b) waves c) thermodynamics d) magnetoelectricity
e) electromagnetism

---

014 qmult 00102 1 1 4 easy memory: electromagnetism 2
Extra keywords: physci

220. The electricity and magnetism are now understood to be a united set of phenomena which we call:

a) magnoelectrism. b) magmaelectrism. c) electromagi-ism.
d) electromagnetism. e) electromagnanimousism.

---

014 qmult 00150 1 1 5 easy memory: Ben Franklin named charges
Extra keywords: physci KB-137

221. Who named positive and negative electric charge?

a) George Washington (1732–1799). b) John Adams (1735–1826).
c) Benedict Arnold (1741–1801). d) Aaron Burr (1756–1836).
e) Benjamin Franklin (1706–1790).

---

014 qmult 00200 1 1 1 easy memory: electric charge definition, incomplete
Extra keywords: physci

222. Electric charge is:

a) a fundamental property of matter: it comes in invariant quantized amounts of size $\pm e$.
b) a derived property of matter: it comes in somewhat variable quantized amounts of size $\pm e$ more or less.
c) a fundamental property of matter which comes in a continuum of quantities: there is no smallest bit of charge.
d) a derived property of matter which comes in a continuum of quantities: there is no smallest bit of charge.
e) amber.

---

014 qmult 00210 1 1 3 easy memory: electric charge causes electric force

223. Electric charge is a cause (but not the only one in direct sense) of the electric field. The electric field is the direct cause of the electric force in the modern conception of electromagnetism. Thus, in a indirect sense, charge is a cause of:

a) the Hooke's law force b) the gravitational force. c) the electric force.
d) short circuits e) electric bills.

---

014 qmult 00220 1 1 3 easy memory: two kinds of electric charge

224. There are two kinds of electric charge:

a) black and white. b) north and south. c) positive and negative.
d) left and right. e) up and down.

---

014 qmult 00222 1 1 1 easy memory: like repel, unlike attract

225. Like charges ____________ and unlike charges ____________.

a) repel; attract b) attract; repel c) repel; repel d) attract; repel
e) compel; detract

---

014 qmult 00224 1 1 4 easy memory: net charge conserved

226. Net charge is ____________. Positive are and negative charge are ____________.

a) not conserved; conserved b) not conserved; not conserved
c) conserved; conserved d) conserved; not conserved
e) sometimes conserved; not conserved

---

014 qmult 00230 1 1 1 easy memory: elementary charge 1
Extra keywords: physci KB-169-1

227. The absolute value of the smallest nonzero physical amount of electric charge (not considering quarks) is:

a) e or $1.602\ldots\times 10^{-19}\,\text{C}$. b) $1\,\text{C}$. c) indefinitely small. d) indefinitely large.
e) indeterminate.

---

014 qmult 00232 1 4 5 easy deducto-memory: elementary charge 2
Extra keywords: physci KB-169-1

228. In nature, the electric charge is quantized in amounts of:

a) 1 coulomb. b) $e = 2.71828\ldots$. c) $\varepsilon_0 = 8.854\ldots\times 10^{-12}\,\text{F/m}$.
d) $k = 8.987\ldots\times 10^{9}\,\text{N-m}^2/\text{C}^2$. e) $e = 1.602\ldots\times 10^{-19}\,\text{C}$.

---

014 qmult 00240 1 4 5 easy deducto-memory: ordinary matter neutral
Extra keywords: physci

229. "Let's play *Jeopardy*! For \$100, the answer is: It is usually approximately electrically neutral."

What is ____________, Alex?

a) an electron b) a proton c) highly charged matter
d) highly negatively charged matter
e) ordinary, terrestrial matter above the atomic scale

---

014 qmult 00242 1 4 5 easy memory: no microscopic charge neutralization
Extra keywords: physci

230. Why don't positive and negative charge largely neutralize each other at the microscopic level just like they mostly do at the macroscopic level? The short answer is it is forbidden in most circumstances by ____________.

a) classical physics b) James Clerk Maxwell c) Michael Faraday
d) Ben Franklin e) quantum mechanics

---

014 qmult 00242 1 1 3 easy memory: positively charged matter
Extra keywords: physci KB-169-9

231. Ordinary matter is positively charged whenever protons:

a) outnumber neutrons. b) outvote electrons. c) outnumber electrons.
d) are fewer than electrons. e) are absent.

---

014 qmult 00250 1 1 2 easy memory: electrons not permanently bound
Extra keywords: physci KB-169-7

232. Electrons in an atom are:

a) permanently bound to the atom. b) **NOT** permanently bound to the atom. c) confined to the nucleus. d) more massive than the nuclues. e) green.

---

014 qmult 00252 1 1 5 easy memory: electron or proton removal
Extra keywords: physci KB-171-3

233. Which of electrons, protons, neutrons are easier to remove from an atom?

a) Protons. b) They are all irremovable. c) They are equally easily removable. d) Neutrons. e) Electrons.

---

014 qmult 00260 2 3 3 moderate math: charge on 1 g of protons
Extra keywords: physci KB-173-1

234. Given the mass of a proton is 1.67×10^{-24} g and the elementary charge is 1.602×10^{-19} C, what approximately is the total charge of 1 g of protons (i.e., pure protons)?

a) 1.67×10^{-24} C. b) 1.602×10^{-19} C. c) 10^5 C. d) 2.5×10^{-43} C. e) zero.

---

014 qmult 00300 1 4 5 easy deducto-memory: Coulomb's law

235. "Let's play *Jeopardy*! For \$100, the answer is:

$$F = \frac{kq_1q_2}{r^2} ,$$

where $k = 8.987\ldots \times 10^9$ in MKS units is Coulomb's constant, q_1 is the charge on object 1, q_2 is the charge on object 2, r is the distance between the objects, and F is the magnitude of force between the objects. This formula holds for objects which are must smaller in size scale than r or are spherically symmetric and not overlapping."

What is ____________, Alex?

a) Volta's law b) Ohm's law c) Ampere's law d) Franklin's law e) Coulomb's law

---

014 qmult 00302 1 1 1 easy memory: Coulomb's law scalar form
Extra keywords: physci

236. The formula

$$F_{12} = \frac{kq_1q_2}{r_{12}^2} ,$$

where $k = 8.987\ldots \times 10^9\,\mathrm{N\,m^2/C^2}$, is ________ law in scalar form.

a) Coulomb's b) Faraday's c) Ampère's d) Biot-Savart's e) Gauss's

---

014 qmult 00304 1 1 5 easy memory: category of Coulomb's law
Extra keywords: physci KB-169-5

237. Coulomb's law is a:

a) societal law. b) law of thermodynamics. c) law of motion. d) conservation law. e) force law.

---

014 qmult 00306 1 1 2 easy memory: net charge and force
Extra keywords: physci KB-172-9 This is a simplified version.

238. For two **POINT** masses to exert a Coulomb force on each other:

a) both must be uncharged. b) both must be charged. c) one must charged and the other uncharged. d) their charges must both be greater than 1 C. e) their charges must both be less than 1 C.

---

014 qmult 00310 1 1 5 easy memory: Coulomb's law is an inverse-square law

239. Coulomb's law is an:

a) cube law. b) square law. c) inverse-sine law. d) inverse-cube law.
e) inverse-square law.

---

014 qmult 00312 1 1 2 easy memory: Coulomb's law calculation 1

240. If you **DOUBLE** the distance between charged particles, the force between them:

a) increases by a factor of 4. b) decreases by a factor of 4.
c) decreases by a factor of 2. d) increases by a factor of 2.
e) decreases by a factor of 9.

---

014 qmult 00314 1 1 5 easy memory: Coulomb's law calculation 2

241. If you **TRIPLE** the distance between charged particles, the force between them:

a) increases by a factor of 4. b) decreases by a factor of 4.
c) decreases by a factor of 2. d) increases by a factor of 2.
e) decreases by a factor of 9.

---

014 qmult 00316 2 3 1 moderate math: Coulomb's law calculation 3
Extra keywords: physci KB-171-29

242. If the distance between charges is changed by a **MULTIPLICATIVE** factor of 1/4, the magnitude of electric force between the charges changes by a **MULTIPLICATIVE** factor of:

a) 16. b) 4. c) 1. d) 1/4. e) 1/16.

---

014 qmult 00320 1 1 2 easy memory: electric and gravity force inverse-square
Extra keywords: physci KB-140 sort of

243. The electrostatic force and gravity are both ____________ force laws.

a) inverse-linear b) inverse-square c) inverse-cube d) linear e) quadratic

---

014 qmult 00322 3 3 3 hard math: Coulomb and gravitational force
Extra keywords: physci KB-171-5

244. Coulomb's law and the point-mass gravitational formula in scalar form are, respectively:

$$F_{\rm C} = \frac{kq_1q_2}{r^2} \qquad \text{and} \qquad F_{\rm G} = \frac{Gm_1m_2}{r^2} \ ,$$

where $k = 8.98755179 \times 10^9\,{\rm N\,m^2/C^2}$, $G = 6.67428(67) \times 10^{-11}$ in MKS units, q stands for charge, m for mass, 1 and 2 for particles 1 and 2, and r is the distance between the particles. The mass of electrons is $9.1093826 \times 10^{-31}\,$kg and their electric charge is $1.60217653 \times 10^{-19}\,$C. Approximately, what is the ratio of the magnitude of gravitational force to the magnitude of the electrical force between two electrons (i.e., $F_{\rm G}/F_{\rm C}$) for any distance r?

a) 1. b) 10. c) 3×10^{-43}. d) 3×10^{43}. e) 10^{-19}.

---

014 qmult 00400 1 1 3 easy memory: electric field

245. The electric field is a vector field. At each point in space it has a magnitude and a direction. The direction is in real space. The extent of the electric field vector is in its own abstract space. The electric field is the direct cause of:

a) gravitational force. b) magnetic force. c) electric force. d) charge.
e) pressure.

---

014 qmult 00410 1 1 3 easy memory: electric field and force

246. The general formula for the electric force on a point charge q caused by an electric field $\vec{E}$ is:

a) $\vec{F} = q/\vec{E}$. b) $\vec{F} = \vec{E}/q$. c) $\vec{F} = q\vec{E}$. d) $\vec{F} = q^2\vec{E}$. e) $\vec{F} = \vec{E}/q^2$.

---

014 qmult 00420 1 4 4 easy deducto-memory: electric field lines

247. "Let's play *Jeopardy*! For $100, the answer is: These curves are tangent to the electric field vector at every point along then. They point in the direction of the electric field. On positive charge, they only start; on negative charge they only end. They can extend to infinity or, when caused by the Maxwell-Faraday law of induction, form closed loops. They can never cross since a vector cannot point two ways at once, except they can cross when the electric field goes to zero since a zero vector has an indeterminate direction."

What are ____________, Alex?

a) zigzags. b) equipotential lines c) magnetic field lines d) electric field lines e) dipole field lines

---

014 qmult 00450 1 1 4 easy memory: electric field lines at conductors

248. In electrostatic cases, the electric field lines at a conductor surface are always ____________ to the surface.

a) outward b) randomly oriented c) parallel d) normal e) inward

---

014 qmult 00500 1 1 4 easy memory: conduction classes
Extra keywords: physci

249. There are four main charge conduction categories for material:

a) insulator, conductor, demiconductor, orchestra conductor.
b) insulator, conductor, semiconductor, infraconductor.
c) insulator, conductor, semiconductor, Superman-conductor.
d) insulator, conductor, semiconductor, superconductor.
e) insulator, conductor, semiconductor, demisemiconductor.

---

014 qmult 00510 1 4 2 easy deducto-memory: conductors defined
Extra keywords: physci

250. "Let's play *Jeopardy*! For $100, the answer is: These materials allow an electric current to flow through them easily."

What are ____________, Alex?

a) insulators b) conductors c) vacuum states d) solids e) crystals

---

014 qmult 00512 1 4 1 easy deducto-memory: insulators defined
Extra keywords: physci

251. "Let's play *Jeopardy*! For $100, the answer is: These materials do **NOT** allow an electric current to flow through them easily."

What are ____________, Alex?

a) insulators b) conductors c) vacuum states d) solids e) crystals

---

014 qmult 00600 1 4 5 easy deducto-memory: conductors in E-fields

252. "Let's play *Jeopardy*! For $100, the answer is: In electrostatic cases, these materials have no macroscopic electric field in their interiors, have electric field normal to their surfaces, have no macroscopic net charge in their interiors, and have any net charge on their surfaces. In the macroscopic picture we are using, the surface is an infinitely thin, inpenetrable barrier."

What are ____________, Alex?

a) insulators b) superconductors c) gases d) liquids e) conductors

---

014 qmult 00650 1 1 1 easy memory: Faraday cage

253. A good conductor in an electrostatic case will have no electric field in any cavity caused by charges in the conductor or by an external applied field. Thus, the conductor shields the cavity from external fields. Although perfect shielding is only guaranteed in exactly electrostatic cases with the cavity having no holes to the outside, in practice, the shielding is often pretty good for even pretty rapidly varying external electric fields and for cavities with quite a few holes. Thus, practical structures for very general shielding are easy to make and, in fact, are ubiquitous in technology. These structures are called:

a) Faraday cages. b) Faraday traps. c) Faraday shields. d) Ampere traps. e) Coulomb traps.

---

014 qmult 00720 1 1 4 easy memory: two-ball charging 1

254. Two uncharged **CONDUCTING** balls A and B are mounted on insulating stands. The balls **ARE** touching. A positively charged rod is brought from infinity to near B, but **NOT** so near A. The balls are then separated and the rod is put back at infinity. The charges on A and B are, respectively:

a) positive and positive. b) negative and negative. c) negative and positive. d) positive and negative. e) zero and zero.

---

014 qmult 00322 1 1 1 easy memory: two-ball charging 2

255. Two uncharged **CONDUCTING** balls A and B are mounted on insulating stands. The balls **ARE** touching. A positively charged **CONDUCTING** rod is brought from infinity to near B, but not near A. The rod **TOUCHES** B. Then the rod is then removed and then the balls are separated. The charges on A and B are ____________.

a) both positive b) both negative c) negative and positive d) positive and negative e) both zero

---

014 qmult 00750 1 1 3 easy memory: polarization

256. Charge separation in an object is called:

a) rasterization. b) pasteurization. c) polarization. d) north polarization. e) miniaturization.

---

014 qmult 00770 3 5 4 hard thinking: neutral finite body attract-repel
Extra keywords: physci-172-9 This is the hard version

257. Can two finite bodies each electrically neutral overall ever attract or repel each other?

a) No.
b) Always.
c) Always and no.
d) **YES**. For example, consider two small, non-conducting balls attached by a non-conducting bar: give one ball a positive charge (uniformly spread) and the other ball a negative charge (uniformly spread) of the same magnitude. The structure is an electric dipole that is overall neutral. Now consider a second identical dipole. Align the two with unlike ends closest and then with like ends closest. The distance between the balls is a fixed distance a in both cases. The force between the two unlike ends is attractive and between the like ends is repulsive. What of the other forces between the balls? We can make the bars as long as we like. The other forces between the balls get smaller and smaller as we make the bars longer and longer. Eventually the other forces become negligible and the closest ball forces dominate.
e) They can **REPEL**, but never **ATTRACT**. That is the valid conclusion of answer (d).

---

014 qmult 00800 1 1 3 easy memory: electric potential

258. Electric potential (AKA voltage) is the electric potential energy:

a) period. b) divided by the electric field magnitude. c) per unit point charge.
d) always negative. e) always positive.

---

014 qmult 00810 1 1 5 easy memory: symbol and unit for potential

259. The standard symbol for electrical potential is ____________ and the MKS unit is ____________.

a) J; joule (J) b) V; joule (J) c) V; joule (J) d) V; volt (V) e) V; volt (V)

Full-Answer Problems

Chapt. 9 Current

Multiple-Choice Problems

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015 qmult 00100 1 1 3 easy memory: short current definition 1

260. Current is the:

 a) flow of negative charge. b) flow of positive charge. c) flow of net charge. d) oscillation of charge. e) reflection of charge.

---

015 qmult 00102 1 1 1 easy memory: short current definition 2
Extra keywords: physci

261. An electrical current, partially defined, is:

 a) moving charge. b) static charge. c) electrical potential. d) moving water. e) static water.

---

015 qmult 00104 1 4 5 easy deducto-memory: long current definition 1

262. "Let's play *Jeopardy*! For $100, the answer is: It is the rate of charge per unit time passing or flowing through a specified surface in a specified sense and we'll call this quantity flow for the nonce (i.e., for the rest of this answer). By 'charge' without qualification, one means the net charge (i.e., positive plus negative charge or positive charge minus the absolute value of negative charge). By 'specified sense', one means that one defines one side of the surface as the positive side where all charge flows to that side are added and all charge flows to the other side are subtracted. This means that added positive charge or subtracted negative charge both increase flow and added negative charge and positive subtracted charge both decrease flow. The above specifications for adding up the contributions to the flow make perfect sense if one considers the net charge in a box into which charge is flowing. For example, positive inflows and negative outflows increase charge in the box and positive outflows and negative inflows decrease charge in the box. Integrated flow as we have defined it gives the change in the box charge.

 Positive and negative flows can occur. Usually one chooses one's conventions so that the flows are positive, but obviously in cases where the flow can reverse or where you don't know the direction of flow initially, negative flows can arise."

 What is electrical ____________, Alex?

 a) swarm b) tide c) flux d) tirade e) current

---

015 qmult 00106 1 4 5 easy deducto-memory: long current definition 2

263. "Let's play *Jeopardy*! For $100, the answer is: The rate of net charge flow per unit time through a surface is this quantity for that that surface. The quantity direction can be defined as either of the two directions allowed by the surface. If the actual flow is opposite the defined direction, the quantity is negative."

 What is ____________, Alex?

 a) negative charge b) light c) pressure d) motion e) current

---

015 qmult 00110 1 1 2 easy memory: ampere defined

264. The SI unit of current is the:

a) ampère: $1\,\text{A} = 1\,\text{C}\,\text{s}$. b) ampere: $1\,\text{A} = 1\,\text{C/s}$. c) ampere: $1\,\text{A} = 1\,\text{C/s}^2$.
d) ampère: $1\,\text{A} = 1\,\text{C/s}^2$. e) volt: $1\,\text{V} = 1\,\text{C/s}$.

---

015 qmult 00112 1 1 2 easy memory: ampere named
Extra keywords: physci

265. The MKS unit of current is the:

a) coulomb (C). b) ampere (A). c) volt (V). d) watt (W). e) joule (J).

---

015 qmult 00114 1 1 2 easy memory: ampere abbreviated to amp

266. In common parlance, the current unit ampere is often abbreviated to:

a) ant. b) amp. c) aunt. d) aump. e) ahmp.

---

015 qmult 00116 1 1 4 easy memory: milliamp 1

267. One thousandth of an amp is a:

a) kiloamp. b) hectoamp. c) deciamp. d) milliamp. e) microamp.

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015 qmult 00118 1 1 4 easy memory: milliamp 2

268. A milliamp is:

a) b) c) d) $10^3\,\text{A}$. e)

---

015 qmult 00120 1 1 1 easy memory: charge carrier charge

269. In general, the current charge carriers can be:

a) positive or negative. b) positive only. c) negative only.
d) neither positive nor negative. e) neutral.

---

015 qmult 00122 1 1 1 easy memory: electron charge carriers in metals 1

270. In metals, the charge carriers are:

a) electrons. b) protons. c) positrons. d) positive ions. e) negative ions.

---

015 qmult 00124 1 1 4 easy memory: electron charge carriers in metals 2

271. The charge carriers in metals are:

a) tightly bound electrons. b) bound electrons. c) positrons. d) free electrons.
e) holes.

---

015 qmult 00126 1 4 1 easy deducto-memory: blame Ben Franklin

272. "Let's play *Jeopardy*! For $100, the answer is: This person is to blame for naming positive positive and negative negative in the 18th century. If he/she had just done it the other way around, the most common charge carriers in technological application, electrons, would flow from 'positive' to 'negative'. This would have made our mental picture of conduction in metals simpler although it makes no difference in principle or practice as long as one sticks to the proper definition of current. Of course, there was not way in the 18th for him/her to have known the sign of the carriers. Still he/she could have been luckier."

Who is ____________, Alex?

a) Ben Franklin (1706–1790) b) Benedict Arnold (1741–1801)
c) Abigail Adams (1744–1818) d) John Paul Jones (1747–1792)
e) Betsy Ross (1752–1836)

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015 qmult 00150 2 3 3 moderate math: electrons in a current
Extra keywords: physci KB-173-9

273. A current of $2\,\text{A}$ flows past a point in a wire. How many electrons flow past per second? (More exactly what is the net flow of electrons per second?)

a) 3.2×10^{-19} electrons/s. b) 2 electrons/s. c) 1.25×10^{19} electrons/s.
d) 2×10^{19} electrons/s. e) none.

---

015 qmult 00200 1 1 3 easy memory: current cause

274. Current is caused:

a) only by the electric field. b) only in force-free cases. c) in any number of ways.
d) conveyor belts. e) by pressure.

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015 qmult 00202 1 1 1 easy memory: current direction

275. In the wires of electrical circuits, current (speaking more carefully, current density) flows in the direction of the electric field since positive charge will be pushed in that direction and negative charge pushed in the opposite direction. However, most of the time the electrical force only gives rise to an average velocity (i.e., the drift velocity). Electrical resistance (which is caused by collisions) prevents continual acceleration. But it is ____________ that current always flows in the direction of the electric field. Current is just a net flow of charge. A net flow can happen for beam of charged particles flying in a vacuum with no external forces acting on the particles. Or charged particles forming a current may be carried along on a conveyor belt as in a Van der Graaf generator without out any net force on them or in such a way that the current flows opposite to the electric field.

a) not true b) true c) correct d) corresponding e) the objective correlative

---

015 qmult 00210 1 1 2 easy memory: emf

276. In many current cases, the current is conceptualized as being ultimately caused by a/an ____________ which is actually a work per unit charge. The ____________ causes a potential difference which drives a current. The potential difference, of course, can be considered just a measure of the electric field effect that drives the current.

a) enf b) emf c) epf d) epa e) tva

---

015 qmult 00220 1 1 2 easy memory: battery voltage

277. The voltage difference between the terminals of a battery ideal equals the battery emf no matter what current flows through the battery. In reality, the voltage usually:

a) increases slowly with increasing current.
b) decreases slowly with increasing current. c) drops to zero with any current.
d) doubles with any current. e) oscillates with any current

---

015 qmult 00230 1 1 5 easy memory: circuit defined

278. The electricity term circuit can be defined in somewhat different ways. But a common way is that it is closed loop or network of closed loops of:

a) wires. b) capacitors. c) magnets. d) resistors. e) conducting elements.

---

015 qmult 00240 1 4 1 easy deducto-memory: circuit diagrams

279. "Let's play *Jeopardy*! For \$100, the answer is: They are conventionalized schematic diagrams of circuits. Common circuit elements are represented by conventionalized symbols. There are infinitely many ways of constructing a circuit represented by one of these diagrams—'do I put this wire here or there and do I lay it flat or do I make a cute curlicue of it or . . .'—but electrically the realizations should all behave the same to within some tolerance anyway."

What are ____________, Alex?

a) circuit diagrams b) current diagrams c) wire diagrams d) circuit images
e) wire images

---

015 qmult 00300 1 1 5 easy memory: Ohm's law 1

280. The ratio of voltage drop across a device (caused by the electrical resistance of the device) to current flow through it is its resistance

$$R = \frac{V}{I} \ .$$

The SI unit of resistance is the ohm with symbol Ω:

$$1\,\Omega = \frac{1\,\mathrm{V}}{1\,\mathrm{A}} \ .$$

If R is independent of V or I (which is the same thing as being independent of V), then ____________ is obeyed for the device. This law is usually written

$$V = IR \ .$$

a) Kirchhoff's voltage law b) Kirchhoff's current law c) Faraday's law
d) Joe's law e) Ohm's law

---

015 qmult 00302 2 4 4 moderate deducto-memory: Ohm's law 2
Extra keywords: physci KB-149

281. Ohm's law is:

a) $P = VI$. b) $C = q/V$. c) $V = I/R$. d) $V = IR$. e) $\oint \vec{E} \cdot d\vec{A} = \frac{q_{\rm enc}}{\varepsilon_0}$.

---

015 qmult 00320 1 1 4 easy math: current in toaster
Extra keywords: physci KB-171-32

282. What is the current in a toaster of 12 Ω with a DC potential (or voltage) drop across it of 120 V?

a) 0 A. b) 1440 A. c) 120 A. d) 10 A. e) 12 A.

---

015 qmult 00330 1 1 3 easy memory: single loop circuit

283. A single loop circuit has emf $\mathcal{E}$ and resistor R. It's current is:

a) $I = \mathcal{E}R$. b) $I = R/\mathcal{E}$. c) $I = \mathcal{E}/R$. d) $I = \mathcal{E}/R^2$. e) $I = \mathcal{E}R^2$.

---

015 qmult 00332 1 1 2 easy memory: single loop circuit calculation

284. A single loop circuit has emf $\mathcal{E} = 3.0\,\mathrm{V}$ and resistor $R = 6.0\,\Omega$. It's current is:

a) $I = 0.25\,\mathrm{A}$. b) $I = 0.50\,\mathrm{A}$. c) $I = 1.0\,\mathrm{A}$. d) $I = 1.5\,\mathrm{A}$. e) $I = 2.0\,\mathrm{A}$.

---

015 qmult 00400 1 4 1 easy deducto-memory: power defined

285. "Let's play *Jeopardy*! For $100, the answer is: In physics, it is energy transferred per unit time."

What is ____________, Alex?

a) power b) work c) force d) momentum e) density

---

015 qmult 00410 1 1 3 easy memory: unit of power

286. The SI unit of power is the joule per second with special name:

a) woo (W). b) wenn (W). c) watt (W). d) wye (W). e) woe (W).

---

015 qmult 00412 1 4 5 easy deducto-memory: electrical units
Extra keywords: physci KB-170-11

287. "Let's play *Jeopardy*! For $100, the answer is: They are, respectively, the units of power, current, potential, resistance."

What are ____________, Alex?

a) joule, watt, newton, pascal b) ohm, watt, volt, ampere
c) ambig, volte-face, omen, watkin d) ampere, volt, ohm, watt
e) watt, ampere, volt, ohm

---

015 qmult 00428 1 1 4 easy memory: world commercial power use
288. The world commercial power usage is about:

a) 10 kW. b) 15 MW. c) 15 GW. d) 15 TW. e) 10 PW.

---

015 qmult 00430 1 1 2 easy memory: DC electric power formula 1
289. For a DC electrical element, the power input (voltage rises in current direction) or output (voltage drops in current direction) is given by the formula:

a) $P = I/V$. b) $P = IV$. c) $P = V/I$. d) $P = IV^2$. e) $P = I^2V$.

---

015 qmult 00432 1 1 4 easy memory: DC electric power formula 2
Extra keywords: physci KB-151
290. The expression for DC power input/output by a current I through a potential rise/drop V is:

a) $P = I/V$. b) $P = V/I$. c) $P = V - I$. d) $P = IV$. e) $P = I^2V$.

---

015 qmult 00440 1 1 2 easy memory: energy lost in resistance
Extra keywords: physci KB-170-13
291. The electrical energy lost in a resistance is converted into:

a) electric field energy. b) heat energy. c) magnetic field energy.
d) macroscopic mechanical energy. e) gravitational potential energy.

---

015 qmult 00442 1 1 4 easy memory: power in resistance
292. The electrical power extracted in a resistance R with a potential drop V and a current I is:

a) $P = VIR = V/R = I/R$. b) $P = VIR = VR^2 = I^2R$.
c) $P = VI = VR^2 = I^2/R$. d) $P = VI = V^2/R = I^2R$. e) $P = VI = V/R = IR$.

---

015 qmult 00450 1 3 1 easy math: power calculation 1
Extra keywords: physci
293. A current of 10 A (an ampere is a coulomb per second) goes through a device with voltage difference of 10 V (a volt is joule per coulomb). What is the power (energy per unit time with MKS units of watts [symbol W]: i.e., joules per second) delivered to the device?
HINT: Do the units come out right from the math?

a) 100 W. b) 100 J. c) 10 W. d) 10 J. e) 1 W.

---

015 qmult 00460 1 1 3 easy memory: power in X-ray tube
294. An X-ray tube operates at a current of 7.0 **mA** and a potential difference of 80 **kV** (note kilovolts). The energy is going out of electrical potential energy into electron kinetic energy and then into X-ray energy. What is the X-ray tube's power in watts?

a) 0.56 W. b) 5.6×10^5 W. c) 560 W. d) 11.4 W. e) 1.14×10^7 W.

---

015 qmult 00500 1 4 5 easy deducto-memory: in series
295. "Let's play *Jeopardy*! For \$100, the answer is: It is an arrangement of circuit elements such that a single current flows consecutively through all of them."

What is ____________, Alex?

a) in rough b) in sequence c) in perpendicular d) in parallel e) in series

---

015 qmult 00510 1 4 4 easy deducto-memory: in parallel
296. "Let's play *Jeopardy*! For \$100, the answer is: It is an arrangement of circuit elements such that a current divides into separate currents to flow through the elements and then reunites after into the original current. The voltage change across all the elements is the same."

What is ____________, Alex?

a) in rough b) in sequence c) in perpendicular d) in parallel e) in series

---

015 qmult 00600 1 1 4 easy memory: DC and AC

297. DC (direct current) has a current flow in a single direction. AC has current that alternates its direction in a periodic manner. The usual AC current function with time is a:

a) sawtooth wave. b) square wave. c) catenary. d) sinusoid. e) cycloid.

Full-Answer Problems

Chapt. 10 Properties of Light

Multiple-Choice Problems

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018 qmult 00100 1 4 5 easy deducto-memory: light definition

298. "Let's play *Jeopardy*! For $100, the answer is: The word has two meaning which must be distinguished by context as usual:

   i) Visible light to which our eyes are sensitive.

   ii) The whole range of electromagnetic radiation which is called the electromagnetic spectrum."

   What is ____________, Alex?

   a) sound   b) radio   c) a wave phenomenon   d) the ether   e) light

---

018 qmult 00102 1 1 5 easy memory: visible light
Extra keywords: CK-90-1

299. ________________ is a form of electromagnetic radiation.

   a) Sound   b) Wien   c) Doppler   d) The atom   e) Visible light

---

018 qmult 00110 1 4 3 easy deducto-memory: IR light discovered

300. "Let's play *Jeopardy*! For $100, the answer is: He/she discovered the first form of non-visible light (infrared light) 1800feb11."

   Who is ____________, Alex?

   a) Ben Franklin (1706–1790)   b) Émilie du Châtelet (1706–1749)
   c) William Herschel (1738–1822)   d) Caroline Herschel (1750–1848)
   e) Thomas Young (1773–1829)

---

018 qmult 00120 1 1 2 easy memory: not an ancient known property of light

301. Which of the following property of light was **NOT** known since prehistory?

   a) ray-like propagation   b) wave propagation   c) reflection   d) refraction
   e) production by hot sources

---

018 qmult 00122 1 1 3 easy memory: Greeks begin systematic study of light general principles

302. The systematic study of light to establish general principles and results from those principles began (insofar as we know—which usually goes without saying) with the ancient:

   a) Sumerians, notably Utnapishtim (time of the Flood) and Gilgamesh (26 century BCE).
   b) Egyptians, notably Hatshepsut (1508–1458 BCE) and Akhenaten (14th century BCE).
   c) ancient Greeks, notably Euclid (fl. 300 BCE)and Ptolemy (c. 90–c. 170).
   d) Assyrians, notably Sennacherib (c. 730–681 BCE)
   e) Mayans, notably Sun god Kinich Ahau (eternal)

---

018 qmult 00124 1 1 2 easy memory: Medieval Islamic scientists

303. In regard to the science of light, medieval Islamic scientists

a) made no progress. b) made some progress. c) regressed.
d) discovered the telescope. e) invented eyeglasses.

---

018 qmult 00126 1 1 1 easy memory: Newton explains light

304. Isaac Newton (1643–1727) explained light as:

a) beams of classical particles—but he didn't use the word classical.
b) beams of photons. c) beams of continuous matter. d) ether waves.
e) electromagnetic waves.

---

018 qmult 00128 1 1 3 easy memory: wave nature of light

305. The wave nature of light was first posited by ____________ and later established as the generally accepted theory by ____________ along with Augustin-Jean Fresnel (1788–1827).

a) Euclid (fl. 300 BCE); Ptolemy (c. 90–c. 170).
b) Robert Hooke (1635–1703); Isaac Newton (1643–1727)
c) Christiaan Huygens (1629–1695); Thomas Young (1773–1829)
d) Blaise Pascal (1623–1662); Thomas Young (1773–1829)
e) Émilie du Châtelet (1706–1749); David Rittenhouse (1732–1792)

---

018 qmult 00130 1 1 1 easy memory: ray-like propagation of waves

306. Wave phenomena in many contexts propagate like rays (i.e., beams of continuous matter) if ____________, where λ is wavelength and ℓ is the characteristic size of obstacles or apertures in the path of the waves.

a) $\lambda/\ell << 1$ b) $\lambda/\ell \gtrsim 1$ c) $\lambda/\ell \approx 1$ d) $\lambda \gtrsim \ell$ e) $\lambda \approx \ell$

---

018 qmult 00132 1 1 2 easy memory: waves with interference and diffraction

307. Wave phenomena will exhibit conspicuous interference and diffraction effects if ____________, where λ is wavelength and ℓ is the characteristic size of obstacles or apertures in the path of the waves. Actually, no matter what λ and ℓ are, there will interference and diffraction effects, but they may be too small to be noticeable. Also if the system is complex (e.g., there are multiple sources), the interference and diffraction effects may be washed out.

a) $\lambda/\ell << 1$ b) $\lambda/\ell \gtrsim 1$ c) $\lambda < 1.0\,\text{m}$ and $\ell > 2.0\,\text{m}$ d) $\lambda > 1.0\,\text{m}$ and $\ell > 5.0\,\text{m}$
e) $\lambda > 10.0\,\text{m}$ and $\ell > 5.0\,\text{m}$

---

018 qmult 00134 1 1 3 easy memory: visible light and diffraction 1

308. Visible light (λ in range 400–700 nm) will show ____________ interference and diffraction effects for obstacles of $1\,\mu$m size.

a) no b) zero c) obvious d) very tiny e) atomic size

---

018 qmult 00136 1 1 3 easy memory: visible light and diffraction 2

309. Visible light (λ in range 400–700 nm) will show interference and diffraction effects for obstacles of 1 m size:

a) not at all. b) very obviously. c) if you examine shadow edges really **CLOSELY** and the effects are **NOT** washed out by multiple sources of light. d) if you examine shadow edges really **SLOPPILY** and the effects are washed out by multiple sources of light. e) without even looking.

---

018 qmult 00140 1 4 2 easy deducto-memory: classical electromagnetism discovered

310. "Let's play *Jeopardy*! For \$100, the answer is: In the 1860s, he unified electric and magnetic phenomena in what we now call classical electromagnetism. Classical electromagnetism is summarized in 4 equations (i.e., 4 mathematical laws) plus the electromagnetic force formula. The electric and magnetic properties of materials were taken as givens: their explanation required quantum mechanics which was not available before circa 1926. The 4 equations in

the absence of charge and current can be reduced to a wave equation with a unique vacuum phase velocity

$$v = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} \ ,$$

where ε_0 (vacuum permitivity) and μ_0 (vacuum permeability) are constants determined from electromagnetic phenomena. The numerical value of v was equal within experimental error with the vacuum speed of light. In one of the great eureka moments of history, Prof. X then concluded that light was electromagnetic waves."

Who is ____________, Alex?

a) Lord Kelvin (1824–1907) b) James Clerk Maxwell (1831–1879)
c) Lord Rayleigh (1842–1919) d) Oliver Heaviside (1850–1925)
e) George Francis FitzGerald (1851–1901)

---

018 qmult 00142 1 1 2 easy memory: maxwell equations explain all

311. Maxwell's equations plus the electromagnetic force law account for all classical electromagnetic phenomena provided one takes the electromagnetic properties of materials as ____________. Quantum mechanics is needed to understand these properties.

a) classically derivable results b) givens c) takens d) borrows e) nothings

---

018 qmult 00144 1 1 3 easy memory: Maxwell's prediction of EM waves
Extra keywords: speed of light

312. From his 4 equations, Maxwell was able to predict that light was:

a) made of particles that are now called photons.
b) electromagnetic waves with phase velocity $c = 1/\sqrt{LC}$.
c) light was electromagnetic waves with phase velocity $c = 1/\sqrt{\mu_0 \varepsilon_0}$.
d) made of particles that are now called fluxons.
e) electromagnetic waves with phase velocity $c = \sqrt{T/\mu}$.

---

018 qmult 00146 1 1 4 easy memory: Hertz discovers radio

313. In Maxwell's day it was already known that there were invisible forms of light (infrared and ultraviolet), but none of these form could be generated by macroscopic oscillations of charge. But one could—although I'm not sure if anyone did—predict that much lower frequency, longer wavelength electromagnetic radiation should exist and could be generated. In 1888, such electromagnetic radiation (which was soon called radio) was discovered by ____________. This was a tremendous verification of Maxwell's equations.

a) Galileo (1564–1642) b) Isaac Newton (1643–1727)
c) James Clark Maxwell (1831–1879) d) Heinrich Hertz (1857–1894)
e) Albert Einstein (1879–1955)

---

018 qmult 00150 1 1 4 easy memory: ether discussed

314. Classical electromagnetism gave a unique value for the phase velocity of electromagnetic radiation. The 19th century scientists assumed this phase velocity was relative to the ____________, a hypothetical medium of oscillation for electromagnetic waves. But velocity was ____________ was rather mysterious since it had no known properties other than being the medium of electromagnetic radiation. A famous attempt (the Michelson-Morley experiment of 1887) to measure the motion relative to the ____________ by detecting changes in the vacuum speed of light gave a null result. The vacuum speed of light seemed invariant. This was rather puzzling.

a) light stuff b) vacuum c) phlogiston d) ether e) either

---

018 qmult 00152 1 1 5 easy memory: Einstein's special relativity

315. In 1905, Albert Einstein (1879–1955) presented special relativity which was derived from two axioms: a) the relativity axiom which said the laws of physics should have the same formulae in all inertial frames of reference; b) the vacuum speed of light is the same relative to all inertial frames. The first axiom was well known; the second seemed bizarre since it violated ordinary notions of relative motions. Classical electromagnetism was consistent with the two axioms provided one uses the Lorentz transformations between inertial frames: these transformations are a part of special relativity. Einstein was guided to special relativity by the idea that classical electromagnetism had to be more fundamental than Newtonian physics and applied in all inertial frames and that no ether existed—electromagnetic waves were oscillations of the electromagnetic field all by itself without any medium required. Special relativity includes corrections to Newtonian physics and the results that length and time became frame-dependent quantities. These results have been very well verified, but are only observable with high relative velocities or extremely precise measurments. Special relativity also includes the Einstein equation:

a) $E = 2mc^2$. b) $E = m/c^2$. c) $E = (1/2)mc^2$. d) $E = mc$. e) $E = mc^2$.

---

018 qmult 00154 1 1 1 easy memory: Einstein and photons

316. Also in 1905, Einstein further developed the idea first introduced by Max Planck in 1900 that light came in packets. These packets are now called ____________ and are understood to be rest-massless quantum mechanical particles.

a) photons b) lightons c) lichtons d) protons e) electrons

---

018 qmult 00156 1 1 5 easy memory: photons
Extra keywords: CK-91-photon

317. The quantum or "particle" of light is called a/an:

a) proton. b) electron. c) quarkon. d) lighton. e) photon.

---

018 qmult 00158 2 4 3 moderate deducto-memory: waves and photons

318. Electromagnetic radiation (EMR) is:

a) a wave phenomenon. The propagation speed is that of sound.
b) a wave phenomenon. However, EMR also acts as if it came in packets called **protons**.
c) a wave phenomenon. However, EMR also acts as if it came in packets called **photons**.
d) a wave phenomenon. However, EMR also acts as if it came in packets called **electrons**.
e) a particle phenomenon.

---

018 qmult 00200 2 1 2 easy memory: electromagnetic radiation 1

319. Electromagnetic radiation (EMR) is:

a) a **WAVE PHENOMENON**. The EM waves, however, are **NOT EXCITATIONS OF A MEDIUM** as in most other familiar wave phenomena: e.g., sound waves are excitations of air; water waves of water. The EM waves are just self-propagating electromagnetic fields: any description of them as oscillations in a medium has turned out to be physically superfluous: i.e., adds nothing to physical understanding. Of course, EM waves can propagate through media such as air, water, glass, etc. The speed of light **IN VACUUM** is $2.99792458 \times 10^{10}\,\text{cm/s} \approx 3 \times 10^{10}\,\text{cm/s}$. In matter, the speed of light is always **HIGHER**.
b) a **WAVE PHENOMENON**. The EM waves, however, are **NOT EXCITATIONS OF A MEDIUM** as in most other familiar wave phenomena: e.g., sound waves are excitations of air; water waves of water. The EM waves are just self-propagating electromagnetic fields: any description of them as oscillations in a medium has turned out to be physically superfluous: i.e., adds nothing to physical understanding. Of course, EM waves can propagate through media such as air, water, glass, etc. The speed of light **IN VACUUM** is $2.99792458 \times 10^{10}\,\text{cm/s} \approx 3 \times 10^{10}\,\text{cm/s}$. In matter, the speed of light is always **LOWER**.
c) a **WAVE PHENOMENON**. The EM waves are excitations of the **ETHER**. The ether permeates all space and has no other effects than as the medium of the EM propagation.

Of course, EM waves at the same time as propagating in the ether can also propagate through media such as air, water, glass, etc. The speed of light **IN VACUUM** is $2.99792458 \times 10^{10}$ cm/s $\approx 3 \times 10^{10}$ cm/s. In matter, the speed of light is always **LOWER**.

d) a **WAVE PHENOMENON**. The EM waves are excitations of the **ETHER**. The ether permeates all space and has no other effects than as the medium of the EM propagation. Of course, EM waves at the same time as propagating in the ether can also propagate through media such as air, water, glass, etc. The speed of light **IN VACUUM** is $2.99792458 \times 10^{10}$ cm/s $\approx 3 \times 10^{10}$ cm/s. In matter, the speed of light is always **HIGHER**.

e) a **PARTICLE PHENOMENON** only.

---

018 qmult 00202 1 1 3 easy memory: electromagnetic radiation 2

320. Electromagnetic radiation consists of self-propagating:

a) magnetic fields. b) electric fields. c) coupled electric and magnetic fields.
d) waves in the either. e) beams of classical particles.

---

018 qmult 00210 1 1 3 easy memory: electromagnetic radiation directions

321. In a polarized electromagnetic radiation beam in vacuum, the electric and magnetic field are perpendicular to each other and ____________ the direction of propagation.

a) either are perpendicular to b) neither are perpendicular to
c) both are perpendicular to d) both are aligned with
e) are randomly oriented with respect to

---

018 qmult 00212 1 1 2 easy memory: electromagnetic waves are transverse 1

322. Electromagnetic waves in vacuum are:

a) oblique. b) transverse waves. c) neither transverse nor longitudinal waves.
d) longitudinal waves. e) both transverse and longitudinal waves.

---

018 qmult 00214 1 1 1 easy memory: electromagnetic radiation transverse 2

323. Electromagnetic waves are ____________ which means the oscillation is perpendicular to the propagation direction. The coupled electric and magnetic fields are also perpendicular to each other.

a) transverse b) longitudinal c) transverse-longitudinal d) matutinal
e) converse

---

018 qmult 00216 1 1 2 easy memory: polarized light

324. Natural light (which is just a name—there's no unnatural light) has an isotropic distribution of electric and magnetic field vector directions perpendicular to the propagation direction when looked at over space and time though not at one instant and place where, of course, the E-field and B-field vectors can only point in one direction. Light vectors that are not isotropically distributed are ____________ to one degree or another in one way or another.

a) marginalized b) polarized c) metabolized d) pasteurized
e) metastasized

---

018 qmult 00220 1 1 5 easy memory: frequency defined

325. In wave phenomena, frequency is the number of cycles (i.e., complete oscillations) per unit:

a) cycle. b) pressure. c) energy. d) length. e) time.

---

018 qmult 00222 1 1 2 easy memory: fequency inverse

326. Frequency is the inverse of:

a) length. b) period. c) cycles per unit time. d) energy. e) temperature.

---

018 qmult 00224 1 1 2 easy memory: unit of frequency

327. The MKS unit of frequency is the inverse second (s^{-1}) which is given the special name:

a) freq (Fr). b) hertz (Hz). c) heinrich (Hr). d) insec (I). e) cyclon (C).

---

018 qmult 00230 1 1 1 easy memory: f X lambda=c 1

328. A well known formula relating frequency, wavelength, and vacuum light speed is:

a) $f\lambda = c$. b) $f/\lambda = c$. c) $\lambda/P = c$. d) $P\lambda = c$. e) $fc = \lambda$.

---

018 qmult 00232 1 4 2 easy deducto-memory: f X lambda=c 2
Extra keywords: physci

329. The relation between c, f, and λ is:

a) $c = f/\lambda$. b) $c = f\lambda$. c) $c = 1/\sqrt{f\lambda}$. d) $c = \sqrt{f\lambda}$. e) $c = f\lambda^2$.

---

018 qmult 00236 1 3 1 easy math: a radio wavelength calculation 1

330. AM radio typically broadcasts at about $1\,\text{MHz} = 10^6$ cycles per second. What is the approximate wavelength of this radiation? (Just use the vacuum speed of light $c = 2.99792458 \times 10^{10}$ cm/s for the calculation: it is good enough for the present purpose.)

a) $\sim 3 \times 10^4\,\text{cm} = 300\,\text{m}$. b) $\sim 1 \times 10^4\,\text{cm} = 100\,\text{m}$. c) $\sim 3 \times 10^{-4}\,\text{cm}$.
d) $\sim 3 \times 10^4\,\text{m}$. e) $\sim 3 \times 10^2\,\text{cm} = 3\,\text{m}$.

---

018 qmult 00238 1 3 1 easy math: a radio wavelength calculation 2
Extra keywords: physci KB-214-37

331. A radio station broadcasts at 600 kHz (kilohertz). Given that the speed of light in air is to good approximation 3.0×10^8 m/s, the wavelength of radio waves is

a) 500 m. b) 600 m. c) 0.002 m. d) 3.0×10^8 m. e) 0 m.

---

018 qmult 00240 1 4 4 easy deducto-memory: speed of light

332. "Let's play *Jeopardy*! For $100, the answer is: In modern physics, it is the highest physical speed: i.e., the highest speed at which an effect or information can propagate."

What is the speed of ____________, Alex?

a) sound b) thought c) rumor d) light in vacuum
e) rumor in an information vacuum

---

018 qmult 00242 1 4 2 easy deducto-memory: fireworks sound and flash

333. At fireworks displays, the explosions produce a light flash and sounds.

a) The sound is heard before the flash is seen.
b) The flash is seen before the sound is heard.
c) Sound and flash come simultaneously.
d) The sound is seen before the flash is heard.
e) Neither effect is noticed by the spectators.

---

018 qmult 00250 2 1 3 moderate memory: EMR spectrum

334. The electromagnetic spectrum is:

a) the distribution of electromagnetic radiation with respect to temperature.
b) the spectrum of radiation emitted by a non-reflecting (i.e., blackbody) object at a uniform temperature.
c) the entire wavelength range of electromagnetic radiation: i.e., the electromagnetic radiation range from zero to infinite wavelength, not counting the limit end points themselves.
d) the magnetic field of the Sun.
e) independent of wavelength.

---

018 qmult 00252 1 1 5 easy memory: electromagnetic spectrum continuum

335. As far as we know, electromagnetic radiation can have wavelength (or frequency) anywhere between 0 and infinity. Also as far as we know, the allowed wavelengths form a/an ____________

like real numbers. It may be that there are no processes to create or destroy electromagnetic radiation above or below a certain wavelength or in some bands, but we do not know of any regions of the electromagnetic spectrum that are absolutley ruled out.

a) set of 10^{10} b) set of 10^{100} c) finite discrete set d) infinite discrete set
e) continuum

---

018 qmult 00254 1 1 4 easy memory: short list of electromagnetic bands

336. A short list of the bands of the electromagnetic spectrum in order of increasing wavelength is γ ray, X-ray (typical wavelength 1 Å), ultraviolet (UV), visible (~ 0.4–$0.7\,\mu$m),:

a) cyan, indigo, radio. b) infrared red, radio. c) red, radio, infrared.
d) infrared (IR), microwave (typical wavelength 1 cm), radio.
e) radio, microwave (typical wavelength 1 cm), infrared (IR).

---

018 qmult 00256 2 1 2 moderate memory: EMR does not include protons

337. The electromagnetic spectrum includes all forms of electromagnetic radiation. Which of the following is **NOT** a form of electromagnetic radiation?

a) gamma-rays b) protons c) radio waves d) visible light e) ultraviolet light

---

018 qmult 00260 2 1 3 moderate memory: visible light range
Extra keywords: CK-91-key-3

338. The wavelength range of visible light is about:

a) 1–20 cm. b) 0.1–10 nm. c) 400–700 nm. d) 700–1000 nm.
e) 0.700–1000 microns.

---

018 qmult 00262 1 1 5 easy memory: visible light spectrum

339. Visible light is conventionally divided into:

a) violet, blue, green, yellow, orange, radio.
b) X-ray, violet, blue green, yellow, orange, tangerine, red.
c) Gamma-ray, X-ray, ultraviolet, visible, infrared, microwave, radio.
d) mauve, navy, forest lawn, goldenrod, tamarind, cerise.
e) violet, blue, green, yellow, orange, red.

---

018 qmult 00264 1 4 2 easy deducto-memory: colors of visible spectrum 2
Extra keywords: physci

340. The colors of the visible spectrum in order of **INCREASING** wavelength are:

a) red, orange, yellow, green, blue, violet.
b) violet, blue, green, yellow, orange, red.
c) violet, green, blue yellow, red, orange.
d) violet, blue, forest-lawn, yellow, tangerine, red.
e) violent, stripe, forest-lawn, mouse, tangerine, exhaust.

---

018 qmult 00266 1 1 3 easy memory: photopic and scotopic vision

341. Under well lit conditions, humans have ____________ vision and under dim condtions ____________ vision.

a) phinnish; scottish b) scotopic; photopic c) photopic; scotopic
d) telescopic; microscopic e) tele; vista

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018 qmult 00300 1 1 2 easy memory: resonance

342. Many systems (many macroscopic systems and virtually all molecules, atoms, and nuclei) have natural oscillation or excitation states called ____________. (The term is not used usually for many microscopic excitation states to which it can be applied in principle.) By natural, one

means that these systems readily absorb energy and go into the ____________ oscillation or excitation states. Therefore if there is a force or interaction that can transfer energy to these ____________ oscillation or excitation states, one will often find the system in one of these states. If a force or interaction is not such that can transfer energy to these ____________ oscillation or excitation states, the systems are often relatively unaffected by the force or interaction. The wording of this description is rather intricate in order to be general. There are many special cases that described more simply.

a) eminence/eminences b) resonance/resonances c) prominence/prominences
d) resound/resounds e) redoubt/redoubts

---

018 qmult 00310 1 1 3 easy memory: simple pendulum resonance frequency

343. The simple pendulum is a pendulum where the bob can be regarded as point mass. The simple pendulum has a single resonance frequency. In the limit of small-amplitude oscilations, the resonance frequency is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{\ell}}$$

where g is the graviational field and ℓ is the pendulum length. The period of resonance oscillation is given by:

a) $p = 2\pi\frac{g}{\ell}$. b) $p = 2\pi\frac{\ell}{g}$. c) $p = 2\pi\sqrt{\frac{\ell}{g}}$. d) $p = \frac{1}{2\pi}\sqrt{\frac{\ell}{g}}$. e) $p = 2\pi\sqrt{\frac{g}{\ell}}$.

---

018 qmult 00320 1 1 1 easy memory: standing waves on a string 1

344. A string held taut between two endpoints has resonances that are standing wave states of transverse waves. In standing wave states, the wave patterns do not propagate, they merely scale up and with time. The resonances exist only at a discrete set of frequencies. Off resonance (i.e., off the resonance frequencies), one has traveling waves. But traveling waves since they are not resonances are rather hard to excite and in many cases nearly cancel and give only relatively small up and down motions in many cases. The half wavelength shapes of a standing wave are called antinodes. A standing wave pattern can only exist when an integer number of antinodes can be fitted between the endpoints. Thus, the conditition for a standing wave state is

$$n\left(\frac{\lambda}{2}\right) = L ,$$

where $n = 1, 2, 3, \ldots$ is the integer number of antinodes, λ is the wavelength, and L is the string length. The phase velocity v for waves on a string is fixed by the string tension and the string mass per unit length. It follows that the formula resonance frequencies (i.e., the standing wave state frequencies) is:

a) $f = n\left(\frac{v}{2L}\right)$. b) $f = n\left(\frac{2L}{v}\right)$. c) $f = \frac{v}{2Ln}$. d) $f = n\left(\frac{2v}{L}\right)$. e) $f = \frac{v}{Ln}$.

---

018 qmult 00322 1 1 4 easy memory: standing waves on a string 2

345. A string held taut between two endpoints has resonances that are standing wave states of transverse waves. In standing wave states, the wave patterns do not propagate, they merely scale up and with time. The resonances exist only at a discrete set of frequencies. Off resonance (i.e., off the resonance frequencies), one has traveling waves. But traveling waves since they are not resonances are rather hard to excite and in many cases nearly cancel and give only relatively small up and down motions in many cases. The half wavelength shapes of a standing wave are called antinodes. A standing wave pattern can only exist when an integer number of antinodes can be fitted between the endpoints. Thus, the conditition for a standing wave state is ... where $n = 1, 2, 3, \ldots$ is the integer number of antinodes, λ is the wavelength, and L is the string length. The phase velocity v for waves on a string is fixed by the string tension and the

string mass per unit length. It follows that the formula resonance frequencies (i.e., the standing wave state frequencies) is:

a) $f = n\left(\frac{2v}{L}\right)$. b) $f = n\left(\frac{2L}{v}\right)$. c) $f = \frac{v}{2Ln}$. d) $f = n\left(\frac{v}{2L}\right)$. e) $f = \frac{v}{Ln}$.

---

018 qmult 00330 1 1 5 easy memory: light absorption

346. In materials, electromagnetic radiation is often absorbed by resonances. Metals are a special case since their free electrons allow strong absorption at any frequency lower than that of X-rays. The electromagnetic radiation energy that goes into a resonance can be dissipated to waste heat or emitted as different frequencies of electromagnetic radiation or emitted at the same frequency of the absorbed electromagnetic radiation. Resonance actually absorb over a band of electromagnetic radiation frequency: sometimes narrow, sometimes broad. Those materials, other than metals, with few or weak resonances in the visible are often ____________ in the visible.

a) prismatic b) red c) luminous d) opaque e) transparent

---

018 qmult 00350 2 5 3 moderate thinking: Canadian flag in red light
Extra keywords: physci KB-213-27

347. The Canadian flag in ordinary lighting is red and white. When viewed in red light it is:

a) all white. b) red and black. c) all red. d) all black.
e) red and white still.

Full-Answer Problems

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018 qfull 00110 1 3 0 easy math: brief history of optics

348. Give a brief summary of the history of the science of light (AKA optics) from prehistory to Maxwell's classical electromagnetism. **HINT:** You should mention the contributions of the ancient Greeks, Newton, and Maxwell.

Chapt. 11 Entangling Space

Multiple-Choice Problems

Full-Answer Problems

Chapt. 12 Entangling Space

Multiple-Choice Problems

Full-Answer Problems

Chapt. 13 Entangling Space

Multiple-Choice Problems

Full-Answer Problems

Chapt. 14 Entangling Space

Multiple-Choice Problems

Full-Answer Problems

Chapt. 15 Entangling Space

Multiple-Choice Problems

Full-Answer Problems

Appendix 16 Multiple-Choice Problem Answer Tables

Note: For those who find scantrons frequently inaccurate and prefer to have their own table and marking template, the following are provided. I got the template trick from Neil Huffacker at University of Oklahoma. One just punches out the right answer places on an answer table and overlays it on student answer tables and quickly identifies and marks the wrong answers

Answer Table for the Multiple-Choice Questions

	a	b	c	d	e		a	b	c	d	e
349.	O	O	O	O	O	6.	O	O	O	O	O
350.	O	O	O	O	O	7.	O	O	O	O	O
351.	O	O	O	O	O	8.	O	O	O	O	O
352.	O	O	O	O	O	9.	O	O	O	O	O
353.	O	O	O	O	O	10.	O	O	O	O	O

Answer Table for the Multiple-Choice Questions

	a	b	c	d	e		a	b	c	d	e
354.	O	O	O	O	O	11.	O	O	O	O	O
355.	O	O	O	O	O	12.	O	O	O	O	O
356.	O	O	O	O	O	13.	O	O	O	O	O
357.	O	O	O	O	O	14.	O	O	O	O	O
358.	O	O	O	O	O	15.	O	O	O	O	O
359.	O	O	O	O	O	16.	O	O	O	O	O
360.	O	O	O	O	O	17.	O	O	O	O	O
361.	O	O	O	O	O	18.	O	O	O	O	O
362.	O	O	O	O	O	19.	O	O	O	O	O
363.	O	O	O	O	O	20.	O	O	O	O	O

Answer Table for the Multiple-Choice Questions

	a	b	c	d	e		a	b	c	d	e
364.	O	O	O	O	O	16.	O	O	O	O	O
365.	O	O	O	O	O	17.	O	O	O	O	O
366.	O	O	O	O	O	18.	O	O	O	O	O
367.	O	O	O	O	O	19.	O	O	O	O	O
368.	O	O	O	O	O	20.	O	O	O	O	O
369.	O	O	O	O	O	21.	O	O	O	O	O
370.	O	O	O	O	O	22.	O	O	O	O	O
371.	O	O	O	O	O	23.	O	O	O	O	O
372.	O	O	O	O	O	24.	O	O	O	O	O
373.	O	O	O	O	O	25.	O	O	O	O	O
374.	O	O	O	O	O	26.	O	O	O	O	O
375.	O	O	O	O	O	27.	O	O	O	O	O
376.	O	O	O	O	O	28.	O	O	O	O	O
377.	O	O	O	O	O	29.	O	O	O	O	O
378.	O	O	O	O	O	30.	O	O	O	O	O

NAME:

Answer Table for the Multiple-Choice Questions

	a	b	c	d	e		a	b	c	d	e
379.	O	O	O	O	O	21.	O	O	O	O	O
380.	O	O	O	O	O	22.	O	O	O	O	O
381.	O	O	O	O	O	23.	O	O	O	O	O
382.	O	O	O	O	O	24.	O	O	O	O	O
383.	O	O	O	O	O	25.	O	O	O	O	O
384.	O	O	O	O	O	26.	O	O	O	O	O
385.	O	O	O	O	O	27.	O	O	O	O	O
386.	O	O	O	O	O	28.	O	O	O	O	O
387.	O	O	O	O	O	29.	O	O	O	O	O
388.	O	O	O	O	O	30.	O	O	O	O	O
389.	O	O	O	O	O	31.	O	O	O	O	O
390.	O	O	O	O	O	32.	O	O	O	O	O
391.	O	O	O	O	O	33.	O	O	O	O	O
392.	O	O	O	O	O	34.	O	O	O	O	O
393.	O	O	O	O	O	35.	O	O	O	O	O
394.	O	O	O	O	O	36.	O	O	O	O	O
395.	O	O	O	O	O	37.	O	O	O	O	O
396.	O	O	O	O	O	38.	O	O	O	O	O
397.	O	O	O	O	O	39.	O	O	O	O	O
398.	O	O	O	O	O	40.	O	O	O	O	O

NAME:

Answer Table for the Multiple-Choice Questions

	a	b	c	d	e		a	b	c	d	e
399.	O	O	O	O	O	26.	O	O	O	O	O
400.	O	O	O	O	O	27.	O	O	O	O	O
401.	O	O	O	O	O	28.	O	O	O	O	O
402.	O	O	O	O	O	29.	O	O	O	O	O
403.	O	O	O	O	O	30.	O	O	O	O	O
404.	O	O	O	O	O	31.	O	O	O	O	O
405.	O	O	O	O	O	32.	O	O	O	O	O
406.	O	O	O	O	O	33.	O	O	O	O	O
407.	O	O	O	O	O	34.	O	O	O	O	O
408.	O	O	O	O	O	35.	O	O	O	O	O
409.	O	O	O	O	O	36.	O	O	O	O	O
410.	O	O	O	O	O	37.	O	O	O	O	O
411.	O	O	O	O	O	38.	O	O	O	O	O
412.	O	O	O	O	O	39.	O	O	O	O	O
413.	O	O	O	O	O	40.	O	O	O	O	O
414.	O	O	O	O	O	41.	O	O	O	O	O
415.	O	O	O	O	O	42.	O	O	O	O	O
416.	O	O	O	O	O	43.	O	O	O	O	O
417.	O	O	O	O	O	44.	O	O	O	O	O
418.	O	O	O	O	O	45.	O	O	O	O	O
419.	O	O	O	O	O	46.	O	O	O	O	O
420.	O	O	O	O	O	47.	O	O	O	O	O
421.	O	O	O	O	O	48.	O	O	O	O	O
422.	O	O	O	O	O	49.	O	O	O	O	O
423.	O	O	O	O	O	50.	O	O	O	O	O

Answer Table

Name:

	a	b	c	d	e
424.	O	O	O	O	O
425.	O	O	O	O	O
426.	O	O	O	O	O
427.	O	O	O	O	O
428.	O	O	O	O	O
429.	O	O	O	O	O
430.	O	O	O	O	O
431.	O	O	O	O	O
432.	O	O	O	O	O
433.	O	O	O	O	O
434.	O	O	O	O	O
435.	O	O	O	O	O
436.	O	O	O	O	O
437.	O	O	O	O	O
438.	O	O	O	O	O
439.	O	O	O	O	O
440.	O	O	O	O	O
441.	O	O	O	O	O
442.	O	O	O	O	O
443.	O	O	O	O	O
444.	O	O	O	O	O
445.	O	O	O	O	O
446.	O	O	O	O	O
447.	O	O	O	O	O
448.	O	O	O	O	O
449.	O	O	O	O	O
450.	O	O	O	O	O
451.	O	O	O	O	O
452.	O	O	O	O	O
453.	O	O	O	O	O

	a	b	c	d	e
31.	O	O	O	O	O
32.	O	O	O	O	O
33.	O	O	O	O	O
34.	O	O	O	O	O
35.	O	O	O	O	O
36.	O	O	O	O	O
37.	O	O	O	O	O
38.	O	O	O	O	O
39.	O	O	O	O	O
40.	O	O	O	O	O
41.	O	O	O	O	O
42.	O	O	O	O	O
43.	O	O	O	O	O
44.	O	O	O	O	O
45.	O	O	O	O	O
46.	O	O	O	O	O
47.	O	O	O	O	O
48.	O	O	O	O	O
49.	O	O	O	O	O
50.	O	O	O	O	O
51.	O	O	O	O	O
52.	O	O	O	O	O
53.	O	O	O	O	O
54.	O	O	O	O	O
55.	O	O	O	O	O
56.	O	O	O	O	O
57.	O	O	O	O	O
58.	O	O	O	O	O
59.	O	O	O	O	O
60.	O	O	O	O	O

NAME:

Answer Table for the Multiple-Choice Questions

	a	b	c	d	e		a	b	c	d	e
454.	O	O	O	O	O	26.	O	O	O	O	O
455.	O	O	O	O	O	27.	O	O	O	O	O
456.	O	O	O	O	O	28.	O	O	O	O	O
457.	O	O	O	O	O	29.	O	O	O	O	O
458.	O	O	O	O	O	30.	O	O	O	O	O
459.	O	O	O	O	O	31.	O	O	O	O	O
460.	O	O	O	O	O	32.	O	O	O	O	O
461.	O	O	O	O	O	33.	O	O	O	O	O
462.	O	O	O	O	O	34.	O	O	O	O	O
463.	O	O	O	O	O	35.	O	O	O	O	O
464.	O	O	O	O	O	36.	O	O	O	O	O
465.	O	O	O	O	O	37.	O	O	O	O	O
466.	O	O	O	O	O	38.	O	O	O	O	O
467.	O	O	O	O	O	39.	O	O	O	O	O
468.	O	O	O	O	O	40.	O	O	O	O	O
469.	O	O	O	O	O	41.	O	O	O	O	O
470.	O	O	O	O	O	42.	O	O	O	O	O
471.	O	O	O	O	O	43.	O	O	O	O	O
472.	O	O	O	O	O	44.	O	O	O	O	O
473.	O	O	O	O	O	45.	O	O	O	O	O
474.	O	O	O	O	O	46.	O	O	O	O	O
475.	O	O	O	O	O	47.	O	O	O	O	O
476.	O	O	O	O	O	48.	O	O	O	O	O
477.	O	O	O	O	O	49.	O	O	O	O	O
478.	O	O	O	O	O	50.	O	O	O	O	O

	a	b	c	d	e
479.	O	O	O	O	O
480.	O	O	O	O	O
481.	O	O	O	O	O
482.	O	O	O	O	O
483.	O	O	O	O	O
484.	O	O	O	O	O
485.	O	O	O	O	O
486.	O	O	O	O	O
487.	O	O	O	O	O
488.	O	O	O	O	O
489.	O	O	O	O	O
490.	O	O	O	O	O
491.	O	O	O	O	O
492.	O	O	O	O	O
493.	O	O	O	O	O
494.	O	O	O	O	O
495.	O	O	O	O	O
496.	O	O	O	O	O
497.	O	O	O	O	O
498.	O	O	O	O	O
499.	O	O	O	O	O
500.	O	O	O	O	O
501.	O	O	O	O	O
502.	O	O	O	O	O
503.	O	O	O	O	O

	a	b	c	d	e
76.	O	O	O	O	O
77.	O	O	O	O	O
78.	O	O	O	O	O
79.	O	O	O	O	O
80.	O	O	O	O	O
81.	O	O	O	O	O
82.	O	O	O	O	O
83.	O	O	O	O	O
84.	O	O	O	O	O
85.	O	O	O	O	O
86.	O	O	O	O	O
87.	O	O	O	O	O
88.	O	O	O	O	O
89.	O	O	O	O	O
90.	O	O	O	O	O
91.	O	O	O	O	O
92.	O	O	O	O	O
93.	O	O	O	O	O
94.	O	O	O	O	O
95.	O	O	O	O	O
96.	O	O	O	O	O
97.	O	O	O	O	O
98.	O	O	O	O	O
99.	O	O	O	O	O
100.	O	O	O	O	O