Problems for a Course
On Energy in Physics and Society

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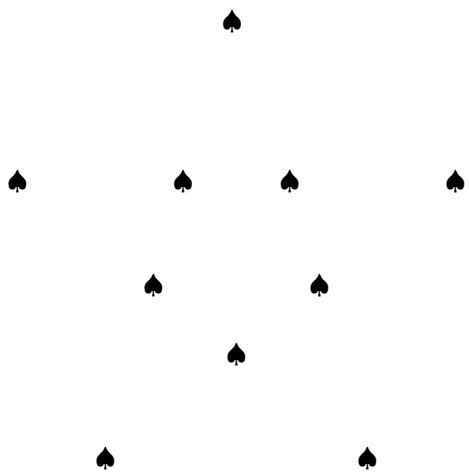

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Introduction

Problems for a Course on Energy and in Physics and Society (EPS) is a problem source book for a course on energy in physics an society. The book is available in electronic form to instructors by request to the author. It is free courseware and can be freely used and distributed, but not used for commercial purposes.

The problems are grouped by topics in chapters: see Contents below. Almost all the problems have complete suggested answers. The answers may be the greatest benefit of EPS The questions and answers can be posted on the web in pdf format.

The problems have been suggested by many sources, but have all been written by me. Given that the ideas for problems are the common coin of the realm, I prefer to call my versions of the problems redactions.

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

EPS is still at an early stage of development. It only has enough questions for about a third of course. It was developed for a course module of about a third of course.

Everything is written in plain TEX in my own idiosyncratic style. The questions are all have codes and keywords for easy selection electronically or by hand. 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.

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Chapt. 1 The Concept of Energy in Physics

Multiple-Choice Problems

000 qmult 00100 1 4 5 easy deducto-memory: energy not simply defined
Extra keywords: EPS Not a serious question.

1. "Let's play *Jeopardy*! For $100, the answer is: A quantity that defies simple explanation."

   What is _____, Alex?

   a) money b) love c) fishing d) energy e) all of the above

001 qmult 00110 1 4 5 easy deducto-memory: energy defined

2. "Let's play *Jeopardy*! For $100, the answer is: It is usefully, if inadequately defined, as the capacity for change or the quantified capacity for change."

   What is _____, Alex?

   a) momentum b) entropy c) enthalpy d) effigy e) energy

001 qmult 00112 1 1 2 easy memory: energy defined 2

3. A useful, but very limited, definition of energy is:

   a) Energy is everything.
   b) Energy is the quantified capacity for change.
   c) Energy is the magnitude of momentum.
   d) Energy is force.
   e) Energy is a vector.

001 qmult 00120 1 4 2 easy deducto-memory: pure energy not
Extra keywords: EPS

4. Pure energy (i.e., energy without any other characteristics than those ascribed to energy alone):

   a) is common. b) does not exist it seems. c) is rare. d) is medium.
   e) is well-done.

001 qmult 00130 1 1 2 easy memory: SI unit of energy

5. The standard metric system or SI unit of energy,

   which has the special name of joule (J)
   and that rhymes with drool
   and that honors James Joule (1818–1889)
   which rhymes with bowel
   and that starts with b . . .,

   is a derived unit whose formula is:

   a) $\mathrm{kg\,m/s^2}$. b) $\mathrm{kg\,m^2/s^2}$. c) $\mathrm{kg\,m/s}$. d) $\mathrm{m/s^2}$. e) m/s.

001 qmult 00140 1 4 4 easy deducto-memory: kinetic energy defined
Extra keywords: EPS

6. "Let's play *Jeopardy*! For $100, the answer is: The energy of motion with formula $KE = (1/2)mv^2$, where m is the object's mass and v is the object's speed."

   What is _____, Alex?

   a) joule b) force c) momentum d) kinetic energy e) potential energy

---

001 qmult 00142 1 3 1 easy math: kinetic energy calculation

7. An object has kinetic energy 24 J and mass 3 kg. What is its speed?

   a) 4 m/s. b) 16 m/s. c) 256 m/s. d) 24 m/s. e) 0 m/s.

---

001 qmult 00144 1 1 4 easy memory: velocity from KE

8. An object has mass m and kinetic energy KE. What is its speed?

   a) $v = \sqrt{\dfrac{vKE}{m}}$. b) $v = \sqrt{\dfrac{2vKE}{m}}$. c) $v = \sqrt{\dfrac{2m}{KE}}$. d) $v = \sqrt{\dfrac{2KE}{m}}$.
   e) $v = \sqrt{\dfrac{KE}{m}}$.

---

001 qmult 00150 1 5 5 easy deducto-memory: vector has mag. and direction
Extra keywords: EPS

9. A vector is a physical quantity with:

   a) no direction. b) no magnitude. c) three directions.
   d) three and half directions. e) a magnitude and a direction.

---

001 qmult 00200 1 1 3 easy memory: conservation of energy

10. The conservation-of-energy law means that the total energy of a closed system will:

    a) be totally lost. b) change. c) not change. d) increase. e) decrease.

---

001 qmult 00210 1 4 5 easy deducto-memory: conservation of energy 2
Extra keywords: EPS

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

    What is _____, Alex?

    a) less than b) the conservation of energy c) 3 d) energy e) the change in total energy of a closed system

---

001 qmult 00220 1 4 2 easy deducto-memory: Noether's theorem
Extra keywords: EPS

12. "Let's play *Jeopardy*! For $100, the answer is: A theoretical proof of the conservation of energy."

    What is _____, Alex?

    a) Pythagoras's theorem b) Noether's theorem c) Birkhoff's theorem
    d) Newton's corollary e) Noether's conjecture

---

001 qmult 00310 1 5 3 easy deducto memory: energy analysis

13. One of the great boons of using the energy concept in the prediction of the behaviors of systems is that it (i.e., the energy concept) often gives you limited, but very useful information:

    a) with impossible difficulty. b) never. c) easily. d) with zero probability.
    e) not.

---

001 qmult 00320 1 4 2 easy deducto-memory: energy limits
Extra keywords: EPS

14. "Let's play *Jeopardy*! For $100, the answer is: This feature of an isolated physical system sets a limit to the amount of change that system can undergo."

What is _____, Alex?

a) nothing b) the total energy c) something d) the total kinetic energy
e) the total potential energy

---

001 qmult 00400 1 1 1 easy memory: Aristotle and energy

15. The word energy was apparently coined by:

a) Aristotle (384–322 BCE). b) Gottfried Wilhelm von Leibniz (1646–1716).
c) Thomas Young (1773–1829). d) Emmy Noether (1882–1935).
e) Richard Feynman (1918–1988).

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001 qmult 00600 1 4 3 easy deducto-memory: Einstein and special relativity

Extra keywords: EPS

16. "Let's play *Jeopardy*! For $100, the answer is: He was the discoverer of special relativity."

Who was _____, Alex?

a) Isaac Newton (1643–1727) b) James Clerk Maxwell (1831–1879)
c) Albert Einstein (1879–1955) d) Erwin Schrödinger (1887–1961)
e) Louis de Broglie (1892–1987)

---

001 qmult 00610 1 1 3 easy memory: light speed

Extra keywords: EPS

17. According to special relativity, the vacuum speed of light is (with some qualifications we needn't go into):

a) dependent on the observer. b) 3 m/s. c) the highest possible physical speed.
d) the lowest possible physical speed. e) negligible.

---

001 qmult 00620 1 4 5 easy deducto-memory: E=mc**2

Extra keywords: EPS

18. "Let's play *Jeopardy*! For $100, the answer is: It is the mass-energy equivalence equation or the Einstein equation."

What is _____, Alex?

a) $E = \frac{1}{2}mv^2$ b) $E = mv$ c) $E = mc^4$ d) $E = mc^3$ e) $E = mc^2$

---

001 qmult 00640 1 3 2 easy math: E=mc**2 calculation

19. What is the energy equivalent in joules of 1 kg? Recall the vacuum speed of light is approximetely 3.00×10^8 m/s.

a) 9×10^8 J. b) 9×10^{16} J. c) 3×10^{16} J. d) 3×10^8 J. e) 1.

---

001 qmult 00680 1 5 5 easy deducto-memory: nuclear reaction energy scale

Extra keywords: EPS

20. Since the early days of radioactivity, people have been (as Beatrix Potter [1866–1943] once said in another context) " 'ticed by quantities" when contemplating the fact that the energy scale of nuclear reactions is of order _____ times the energy scale of chemical reactions.

a) 2 b) 6 c) 10 d) 10^{-6} e) 10^6

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001 qmult 00910 1 1 5 easy memory: book review essay

21. Have you already thought of a book for your book review essay?

a) Yes. b) No. c) Maybe. d) Next Tuesday. Thursday at the latest.
e) The essay is already written.

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001 qmult 01000 1 5 5 easy thinking: energy riddle: Frodo

Extra keywords: The Riddler Strikes Again III

22. The Riddler strikes again:

I am always only me,
but never the same,
sometimes I'm just potential i.e.,
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.

Full-Answer Problems

001 qfull 00100 1 5 0 easy thinking: student info

Extra keywords: EPS

23. For developing and teaching this course, the instructor is interested in learning something about the students and is asking the students for help. Responses are **VOLUNTARY**. The instructor would appreciate it if the student taking this quiz provided some or any of the following information: name, year, major or possible major, and a sentence or so on why you took this course.

001 qfull 00102 1 3 0 easy math: permission for online grade posting

24. If you would like to have your grades posted online at the course website under an anonymous alias, please provide an alias that only you can recognize—no student number, no social security number, nothing anyone else would know, and nothing objectionable. The alias can consist of letters (small or capitals), numbers, and the special symbols ,-."%*@#. There is a limit of about 15 symbols.

Posting of grades is **VOLUNTARY**. It is very useful though. You can check your grades at any time. Note NAU permits posting of grades by anonymous alias with student permission (see http://home.nau.edu/enrollmentservices/FERPA_for_Faculty.asp). But NAU does **NOT** permit grade notification by email or telephone since confidentiality is not guaranteed. So if

you don't give permission for anonymous posting, you will have to talk to me in person or write a signed and dated letter for your current grades.

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001 qfull 00200 1 5 0 easy thinking: participation

25. The proposal for this course called for some participation of some kind. But it did not specify what kind. As a light-hearted, but explicit, participation, students are required to form essay discussion groups of 2 to 4 persons.

The essay discussion group members will confer with each other about books that are of interest to them. There will be quiz time later for a further discussion. The essay discussion group members will also read each other's module essay book reviews and give friendly, constructive advice to the writer before submission.

This question asks you to write down the members (including yourself) of your group. This is a collaborative question. If necessary, introduce yourself to others in the class and decide on engroupment. The instructor will circulate and help/distract in the group-making process. This is a marked question. Full marks for a group and—less than full marks for no group.

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001 qfull 00300 1 5 0 easy thinking: participation book

Extra keywords: The group discusses their essay book possibilities

26. The essay discussion groups will confer about what books or topics for books are of interest to people. It is suggested that groups aim for diversity in topics rather than uniformity. The answer is a sentence or so about what kind of book the student has in mind at the moment or what book the student has chosen. The instructor will circulate and help/distract in the group-discussion process. This is a marked question.

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001 qfull 00400 1 5 0 easy thinking: book blurbs

27. In judging a book by its cover page, the book blurbs are a factor. What would you think of three books with the blurbs:

i) "Workman-like prose ... valuable addition to any academic's shelf."

ii) "Thrilling reading ... it would be astonishing if this theory were true."

iii) "Mind-broadening for the expert and the layperson ... authoritative ... remarkable clarity of expression."

There's no right or wrong, of course. Full marks for any **COMMENT**. No marks for **NO** comment. This is not, **NOT** a multiple-choice problem.

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001 qfull 00500 1 5 0 easy thinking: essay exchange

28. One of the requirements for the book review essay is that discussion group members review each other's essays and offer advice—friendly, constructive advice. Please arrange for some kind of hand over of the essays among group members with adequate time for review. Are you going to do this by hardcopy, email attachment, or either depending????

Remember you will be meeting up after the module instructor is history. But the essay in **HARDCOPY** is still due by 2009 November 6, Friday, 4:00 pm in the historical instructor's office EP 315. Email attachments will be accepted only if I can decode them. PDF files usually work OK.

Chapt. 2 Force, Work, Kinetic Energy, Potential Energy

Multiple-Choice Problems

002 qmult 00100 1 4 4 easy deducto-memory: force in everyday speech
Extra keywords: EPS

29. "Let's play *Jeopardy*! For $100, the answer is: A push or a pull in everyday speech."

    What is a/an _____, Alex?

    a) acceleration b) velocity c) momentum d) force e) angular momentum

002 qmult 00110 1 1 3 easy memory: force defined
Extra keywords: EPS

30. This thing can be defined (but only incompletely) as a physical relationship between bodies that can cause an acceleration and/or cancel other things of the same kind and/or cause a deformation of the bodies. The thing is:

    a) acceleration. b) velocity. c) force. d) momentum. e) maneuver.

002 qmult 00120 1 1 1 easy memory: short- and long-range forces
Extra keywords: EPS

31. Forces in physics can be categorized in various ways. One way is as:

    a) short- and long-range forces. b) right and wrong forces. c) good and evil forces.
    d) short and tall forces. e) avant-garde and reactionary forces.

002 qmult 00130 1 4 2 easy deducto-memory: field force

32. "Let's play *Jeopardy*! For $100, the answer is: It is a force caused by a field: it can also be called a body force, but that expression seems to be somewhat pass/'e nowadays. A field is a thing that permeates all space at least within some region and has a well defined value at each point. To cause a force, a field must be a vector field. This means at each point in space it has magnitude and direction. If a force is caused by a field it is usually considered a long-range force since such forces between bodies don't require the bodies to be touching in a macroscopic sense. Actually at the microscopic level all forces are caused by fields."

    What is a _____, Alex?

    a) contact force b) field force c) branching force d) truth force
    e) back force

002 qmult 00140 1 1 3 easy memory: contact force

33. A short-range force is usually one that requires the interacting bodies to be touching in a macroscopic sense. Such forces nowadays are usually called:

    a) truth forces. b) branching forces. c) contact forces. d) back forces.
    e) forth forces.

002 qmult 00150 1 4 2 easy deducto-memory: unit of force
Extra keywords: EPS

34. "Let's play *Jeopardy*! For $100, the answer is: It is the standard SI unit of force."

    What is the _____, Alex?

    a) pound lb b) newton (N) c) joule (J) d) watt (W)
    e) kilowatt-hour (kWh)

---

002 qmult 00200 1 4 5 easy deducto-memory: work in everyday speech
Extra keywords: EPS

35. "Let's play *Jeopardy*! For $100, the answer is: Expending energy and moving things around and getting things done."

    What is _____, Alex?

    a) resting b) force c) common sense d) staring out the window e) work

---

002 qmult 00210 1 4 1 easy deducto-memory: work formula
Extra keywords: EPS

36. "Let's play *Jeopardy*! For $100, the answer is: The formula

$$W = Fd \ ,$$

    where d is displacement moved for a body and F is the component along the direction of motion of a constant force acting on the body.

    What is the _____, Alex?

    a) work formula b) kinetic energy formula c) potential energy formula
    d) energy formula e) rest formula

---

002 qmult 00220 1 1 3 easy memory: work unit, the joule
Extra keywords: EPS

37. The derived standard SI unit of work is the:

    a) pound (lb). b) newton (N). c) joule (J). d) watt (W).
    e) kilowatt-hour (kWh).

---

002 qmult 00230 1 3 2 easy math: work calculation
Extra keywords: EPS

38. You have pushed an object of in straight line for 10 m with 10 N of force aligned with the direction of motion. The work you have done on the object is:

    a) 10 J. b) 100 J. c) 20 J. d) 13 J. e) none of the above.

---

002 qmult 00240 1 1 1 easy memory: work-kinetic-energy theorem

39. The work-kinetic-energy theorem is:

    a) $\Delta KE = W$. b) $\Delta KE = \frac{1}{2}W$. c) $\Delta KE = \frac{1}{3}W$. d) $\Delta KE = \frac{1}{W}$.
    e) $\Delta KE = \frac{1}{2W}$.

---

002 qmult 00250 1 1 2 easy memory: change in kinetic energy
Extra keywords: EPS

40. The work done (W) by a net force on an object equals:

    a) the object's total kinetic energy of the body (KE). b) the object's change in kinetic energy of the body (ΔKE). c) 1 joule.
    d) joules. e) the heat absorbed by the body (ΔQ).

---

002 qmult 00260 1 1 4 easy math: work-KE calculation
Extra keywords: EPS

41. A body starts from **REST** and is acted on by a single force. The total work done on the body is 100 J. The body's mass is 1 kg. Approximately what is the body's final speed?

    a) 100 m/s. b) 200 m/s. c) 1 m/s. d) 14 m/s. e) 4000 m/s.

---

002 qmult 00270 2 3 1 moderate math: work and waste heat
Extra keywords: EPP

42. You pushed a piano along its path of motion on a level surface with 500 N (i.e., about 112 lb) of force for 100 m. At the end of that haul, the piano is at **REST**. How much work did you do on the piano and where did the energy go that you expended?

    a) 5×10^4 J. It went into waste heat.
    b) 1.12×10^4 J. It went into the gravitational potential energy of the piano.
    c) 500 J. It went into waste heat.
    d) 100 J. It went into the gravitational potential energy of the piano.
    e) 5×10^4 J. It went into the kinetic energy of the piano.

---

002 qmult 00300 1 4 5 easy deducto-memory: force of gravity
Extra keywords: EPS

43. "Let's play *Jeopardy*! For $100, the answer is: The force of gravity near the Earth's surface."

    What is _____, Alex?

    a) $F = mgy$ b) $KE = \frac{1}{2}mv^2$ c) $W = Fd$ d) $F = \frac{m}{g}$ e) $F = mg$

---

002 qmult 00310 1 1 3 easy memory: the value of g
Extra keywords: EPS

44. The constant g in the gravity force law for near the Earth's surface is

    a) exactly 9.8 m/s^2.
    b) defined to be exactly 9.8 m/s^2.
    c) 9.8 m/s^2, but this is only a standard reference (or fiducial) value since g varies by a small amount with location.
    d) 9.8 m/s^2, but this is only a standard reference (or fiducial) value since g varies by more 30 % from this value depending on location on Earth.
    e) 9.8 m/s^2, but this is only a standard reference (or fiducial) value since $g = 9.1$ m/s^2 actually.

---

002 qmult 00320 1 4 2 easy deducto-memory: PE formula
Extra keywords: EPS

45. "Let's play *Jeopardy*! For $100, the answer is: It is the formula for the change in gravitational potential energy near the Earth's surface."

    What is _____, Alex?

    a) $KE = \frac{1}{2}mv^2$ b) $\Delta PE = mg\Delta y$ c) $F = mg$ d) $F = mgy$ e) $W = Fd$

---

002 qmult 00330 1 4 3 easy deducto-memory: PE zero-point
Extra keywords: EPS

46. "Let's play *Jeopardy*! For $100, the answer is: This form of energy has no physically determined zero-level or zero-point. The zero-level is chosen for mental or calculational convenience in any particular physical system."

    What is _____, Alex?

    a) kinetic energy b) thermal energy c) potential energy d) red-hot energy
    e) cinematic energy

---

002 qmult 00340 1 1 4 easy memory: cell phone trajectory

Extra keywords: EPS

47. In a moment of euphoria, you toss your cell phone straight up in the air—sort of like Mary Richards in the *Mary Tyler Moore Show* (1970–1977)—except, not having a cell phone, it was her hat. Take the starting point where it leaves your hand as the zero level for gravitational potential energy (PE). For the cell phone, the initial energy just after release was all _____; the top-of-the-trajectory energy was all _____; the final energy just before you catch it at the same height you released it was all _____.

    a) KE; KE; PE b) KE; KE; KE c) PE; KE; PE d) KE; PE; KE e) PE; KE; KE

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002 qmult 00350 2 3 2 moderate math: hill-climb energy and power

Extra keywords: EPS

48. You have a mass of 70 kg and have just hiked up 400 m in elevation in 30 minutes. Approximately what is the total energy you have put into your gravitational potential energy in your climb. Approximately what was your average power output to gravitational potential energy? Your total power output was more because some energy went into keeping your body going and some ultimately into _____. Recall $g = 9.8\,\mathrm{m/s^2}$.

    a) 2.8×10^5 J; 2.8×10^5 W; waste heat b) 2.8×10^5 J; 150 W; waste heat c) 2.8×10^4 J; 150 W; waste heat d) 2.8×10^5 J; 10^4 W; electrical potential energy e) 2.8×10^4 J; 10^4 W; chemical energy

Scientific Notation, Energy and Power Units, Some Energy And Power Examples, The R/P Ratio

Multiple-Choice Problems

003 qmult 00110 1 3 4 easy math: hundred million billion in sci. not.
Extra keywords: physci

49. Write a hundred million billion miles in scientific notation.

a) 10^2 mi. b) 10^6 mi. c) 10^9 mi. d) 10^{17} mi. e) 10^{-9} mi.

---

003 qmult 00120 1 3 3 easy math: sci-not. multiplication
Extra keywords: EPS

50. What is $3.0 \times 10^7 \times 7.0 \times 10^3$?

a) 21×10^{11}. b) 2.1×10^{10}. c) 2.1×10^{11}. d) 3×10^{10}. e) 7×10^4.

---

003 qmult 00122 1 3 1 easy math: sci-not. multiplication
Extra keywords: EPS

51. What is $3.0 \times 10^7 \times 4.0 \times 10^4$?

a) 1.2×10^{12}. b) 1.2×10^{11}. c) 1.2×10^4. d) 1.2×10^3. e) 12×10^4.

---

003 qmult 00130 1 3 4 easy math: sci-not. division
Extra keywords: EPS

52. What is $(6.0 \times 10^7)/(2.0 \times 10^{14})$?

a) 1.2×10^{22}. b) 1.2×10^{21}. c) 12.0×10^{21}. d) 3.0×10^{-7}. e) 3.0×10^7.

---

003 qmult 00132 1 3 4 easy math: sci-not. division
Extra keywords: EPS

53. What is $(9.0 \times 10^7)/(2.0 \times 10^{21})$?

a) 1.8×10^{29}. b) 1.8×10^{-13}. c) 4.5×10^{-13}. d) 4.5×10^{-14}.
e) 1.8×10^{-14}.

---

003 qmult 00220 1 4 1 easy deducto-memory: megajoule
Extra keywords: EPS

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

What is _____, Alex?

a) 10^6 J b) 10^{-6} J c) 10^3 J d) 10^9 J e) 10^{24} J

---

003 qmult 00230 1 4 5 easy deducto-memory: decimeter scale
Extra keywords: EPS guinea pig

55. "Let's play *Jeopardy*! For \$100, the answer is: It is a creature whose size scale is of order a decimeter."

What is a/an _____, Alex?

a) human b) wolf c) blue whale d) E. coli bacterium e) guinea pig

---

003 qmult 00240 2 5 3 moderate deducto-memory: 1000 food calories
Extra keywords: EPS

56. The food calorie is a weird unit. **1 FOOD CALORIE** is actually 1000 calories or 1 kcal. Now **1000 FOOD CALORIES** is about:

a) 4 J. b) 4 kJ. c) 4 MJ. d) 4 ZJ. e) 4 YJ.

---

003 qmult 00320 1 5 3 easy deducto-memory: horsepower
Extra keywords: EPS

57. What is 1 electrical horsepower in SI units? **HINT:** Think about light bulb power or small household electrical motor power.

a) 746 cW. b) 7.46 W. c) 746 W. d) 746 MW. e) 746 GW.

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003 qmult 00330 2 3 5 moderate math: power per capita
Extra keywords: EPS

58. Circa year 2009, humankind numbered about 6.8 billion and used about 16 TW of commercial power. Approximately what was/is the power per capita?

a) 0.5 W. b) 2 W. c) 30 W. d) 200 W. e) 2000 W/capita.

---

003 qmult 00332 1 1 2 easy memory: power per capita

59. Circa 2009, the world commercial power per capita is about:

a) 1 watts/capita. b) 2000 watts/capita. c) 2000 joules/capita.
d) 12000 joules/capita. e) 16×10^{12} watts/capita.

---

001 qmult 00334 1 1 3 easy memory: world population

60. Circa 2009, world population is about:

a) 550 million. b) 3.5 billion. c) 6.8 billion. d) 9.1 billion. e) 16 billion.

---

003 qmult 00410 1 1 3 easy memory: biosphere energy
Extra keywords: EPS from the Sun.

61. The overwhelmingly dominant source of energy for the biosphere (entire world of living things on Earth which somewhat patchily envelops the Earth in a thin sheath) is:

a) geothermal power. b) nuclear power stations. c) solar power. d) thermal power stations. e) horse power.

---

003 qmult 00420 1 1 1 easy memory: visible light

62. Visible light is:

a) only a small part of the electromagnetic spectrum.
b) not in the electromagnetic spectrum.
c) is the inverse of the electromagnetic spectrum.
d) is not electromagnetic radiation.
e) only green in color.

---

003 qmult 00422 1 1 4 easy memory: Sun power

63. The Sun's luminosity (or power output) is:

a) 1 MW. b) 16×10^{12} W. c) 16 TW. d) 3.846×10^{26} W. e) 10^{43} W.

---

003 qmult 00424 1 1 3 easy memory: solar spectrum peak

64. The Sun's emitted spectrum of electromagnetic radiation peaks in the:

a) X-ray. b) ultraviolet. c) visible. d) infrared. e) radio.

---

003 qmult 00430 1 5 4 deducto memory: solar constant, average insolation
Extra keywords: EPS

65. The solar constant is _____ on average (and it does not very much from average) and the average insolation is about _____.

a) 170 $\mathbf{W/m^2}$; 1366.5 $\mathbf{W/m^2}$ b) 170.5 $\mathbf{W/m^2}$; 170 $\mathbf{W/m^2}$
c) 1366.5 $\mathbf{W/m^2}$; 1370 $\mathbf{W/m^2}$ d) 1366.5 $\mathbf{W/m^2}$; 170 $\mathbf{W/m^2}$
e) 1366.5 $\mathbf{MW/m^2}$; 170 $\mathbf{MW/m^2}$

---

003 qmult 00432 1 1 1 easy memory: dryland biomass energy density

66. The power production averaged over time for dryland biomass has a maximum value of about:

a) 1 W/m^2. b) 150 W/m^2. c) 1366 W/m^2. d) 1 MW/m^2. e) 16 TW/m^2.

---

003 qmult 00440 1 4 5 easy deducto-memory: solar/commercial power ratio
Extra keywords: EPS

67. "Let's play *Jeopardy*! For $100, the answer is: Approximately the ratio of total solar power reaching the Earth's surface to total world commercial power circa year 2009."

What is _____, Alex?

a) 0.5 b) 2 c) 6 d) 550 e) 5500

---

003 qmult 00510 1 4 2 easy deducto-memory: basal metabolic rate
Extra keywords: EPS

68. "Let's play *Jeopardy*! For $100, the answer is: The rate of energy expended (i.e., power expended) by an animal in a state of complete rest, several hours after the last feeding (about 12 hours for humans) and in a comfortable temperature setting."

What is _____, Alex?

a) metabolic rate (MR) b) basal metabolic rate (BMR) c) metabolic scope (MS)
d) barometric metabolic rate (BMR) e) Basil Rathbone rate (BRR)

---

003 qmult 00520 2 5 1 mod. deducto memory: BMR and food power
Extra keywords: EPS

69. For typical humans, BMR is in range _____ and necessary food power is in the range _____.

a) 55–90 W; ~ 100–200 W b) ~ 100–200 W; 55–90 W c) 55–90 W; ~ 55–90 W
d) ~ 100–200 W; 100–200 W e) 1 hp; 2 hp

---

003 qmult 00522 1 1 5 easy memory: sedentary human energy per day in MJs

70. A typical sedentary human being needs about 2000 food calories per day. This is about:

a) 1000 W. b) 1 kilojoules per day. c) 8 kilojoules per day.
d) 1 megajoules per day. e) 8 megajoules per day.

---

003 qmult 00530 2 5 4 mod. deducto memory: metabolic scope
Extra keywords: EPS

71. What animal has the largest sustained metabolic scope?

a) Etruscan shrews. b) Guinea pigs. c) Humans.
d) Canids (i.e., wolves, Cairn terriers, etc.). e) Felids.

---

003 qmult 00550 2 4 2 mod-memory: ethanol energy content
Extra keywords: EPS

72. "Let's play *Jeopardy*! For $100, the answer is: It is approximately the energy content of ethanol (commonly called alcohol in alcoholic beveridges)."

What is _____, Alex?

a) 3 joules/hectogram b) 3 megajoules/hectogram c) 3 gigajoules/hectogram
d) 3 zetajoules/hectogram e) 3 yotajoules/hectogram

---

003 qmult 00600 1 5 3 easy deducto-memory: R/P ratio 1
Extra keywords: EPS

73. The resource reserve divided by the production rate of the resource for any resource is called the:

    a) PR quotient. b) PRDBP ratio. c) R/P ratio. d) P/R ratio.
    e) PR factor.

---

003 qmult 00610 1 4 5 easy deducto-memory: R/P ratio 2
Extra keywords: EPS

74. "Let's play *Jeopardy*! For $100, the answer is: If the values of the ratio calculation are accurate and the denominator a true constant, then it is the time until a resource reserve is exhausted."

    What is the _____, Alex?

    a) BMR b) PR factor c) P/R ratio d) fairy tale e) R/P ratio

---

003 qmult 00620 1 3 5 easy math: R/P for oil
Extra keywords: EPS

75. As of year 2009, the estimated reserve of oil (petroleum) is/was about 1300 Gbl (a Gbl is a gigabarrel). The annual rate of oil production/consumption (circa 2008) is/was about 30 Gbl/year. Approximately what is/was the current estimated R/P ratio for oil?

    a) 1300 years. b) 30 years. c) 1 week. d) 100 years. e) 43 years.

---

003 qmult 00630 3 3 4 tough math: R/P for oil hypothesis
Extra keywords: EPS For the EPS students this is tough.

76. As of year 2009, the estimated reserve of oil (petroleum) is/was about 1300 Gbl (a Gbl is a gigabarrel). The annual rate of oil consumption (circa 2008) in the U.S. is/was about 7.1 Gbl/year. The U.S.'s population is about 1/20 of the world population. If all countries consumed oil per capita at the U.S.'s per capita rate, what approximately would be the current estimated world R/P ratio for oil? Is it at all likely, that all countries can consume oil per capita at the U.S.'s per capita rate?

    a) 1300 years. Yes. b) 31 years. No. c) 1 week. Yes. d) 9 years. No.
    e) 43 years. Yes.

---

003 qmult 00640 1 3 4 easy math: R/P for coal
Extra keywords: EPS

77. Circa year 2006 the world proved coal reserve amounted to about 9×10^{14} kg. Much more coal probably exists, but not in the proved (i.e., very well verified) deposits. The annual rate of coal production/consumption (circa 2007) is/was about 6×10^{12} kg/year. Approximately what is/was the current estimated R/P ratio for coal?

    a) 9×10^{14} years. b) 6×10^{12} years. c) 6.7×10^{-3} years. d) 150 years.
    e) 15 years.

Full-Answer Problems

Chapt. 4 Thermodynamics

Multiple-Choice Problems

004 qmult 00100 1 4 5 easy deducto-memory: thermodynamics defined 1
Extra keywords: EPS

78. "Let's play *Jeopardy*! For $100, the answer is: It is the science of the thermodynamic state of systems. This state is characterized or defined or determined by thermodynamic variables which include heat energy (properly internal energy), temperature, pressure, volume, density, mass, entropy, phase, and many others too. These variables are functions of the thermodynamic state and are called state functions: they are independent of the history that resulted in the thermodynamics state. Energy transformation most importantly heat flow and macroscopic work done are part of the science. The science encompasses both thermodynamic equilibrium and non-equilibrium states. In modern version of the science, the average microscopic state of the system and how it determines the macroscopic variables mentioned above is included."

    What is _____, Alex?

    a) kinematics b) cinematics c) dynamics d) dynastics e) thermodynamics

004 qmult 00110 1 1 3 easy memory: thermodynamics defined 2
Extra keywords: EPS

79. The brief description of this thing is the science of heat energy and temperature. The thing is:

    a) thermostatics. b) thermosonics. c) thermodynamics. d) thermometrics.
    e) thermostrics.

004 qmult 00120 1 4 2 easy deducto-memory: internal energy
Extra keywords: EPS

80. "Let's play *Jeopardy*! For $100, the answer is: It is the sum of all microscopic forms of energy: these include kinetic energy, potential energy, electromagnetic radiation energy, and magnetic field energy. Microscopic means that these energies do not manifest themselves in macroscopic ordered structures."

    What is _____, Alex?

    a) kinetic energy b) internal or heat energy c) potential energy
    d) elastic energy e) cinematic energy

004 qmult 00200 1 1 4 easy memory: thermodynamic variables
Extra keywords: EPS

81. They are macroscopic observables that are functions of the thermodynamic state of matter. Observable means that the quantity can be measured by means in which we have complete theoretical confidence. After all we do not measure, for example, temperature directly, but rather, for example, the volume of alcohol in an alcohol thermometer. To be deeply philosophical for a moment, we only observe our sense perceptions directly and everything else depends on our theoretical understanding of what we perceive. In the jargon of the philosophy of science, observations are theory laden. Nevertheless, by custom we say we observe things where we have complete confidence in the theory of those things. Where our theoretical confidence is less

than complete, we sometimes talk model-dependent results or indirect observations. To end this digression, the observables we were talking about are sometimes called state functions, but the author prefers:

a) quantum mechanical observables. b) factors. c) global factors.
d) thermodynamic variables. e) thermodynamic temperatures.

---

004 qmult 00210 1 1 1 easy memory: thermodynamic variable examples
Extra keywords: EPS

82. Three well known thermodynamic variables (i.e., state functions) are volume, density, and:

a) pressure. b) force. c) work. d) relaxation. e) recreation.

---

004 qmult 00300 1 4 3 easy deducto-memory: temperature defined
Extra keywords: EPS

83. "Let's play *Jeopardy*! For $100, the answer is: In one definition, it is a measure of the average internal energy per degree of freedom of a single particle (e.g., an atom, molecule, electron, or photon [though they are a bit of a special case])."

What is _____, Alex?

a) pressure b) volume c) temperature d) entropy e) entity

---

004 qmult 00310 1 1 1 easy memory: 3 temperature scales
Extra keywords: physci

84. The three common temperature scales are:

a) Fahrenheit, Celsius, and Kelvin. b) Fahrenheit, Celsius, and Newton.
c) Fahrenheit, Vesuvius, and Kelvin. d) Fahrenheit, Celsius, and Calvin.
e) Gesundheit, Vesuvius, and Calvin.

---

004 qmult 00320 1 4 2 easy deducto-memory: kelvin/absolute temperature
Extra keywords: physci

85. "Let's play *Jeopardy*! For $100, the answer is: This temperature scale is considered to be the absolute temperature scale and its zero-point is absolute zero."

What is the _____ scale, Alex?

a) Fahrenheit b) Kelvin c) Celsius d) thermometer e) Hobbes

---

004 qmult 00330 1 1 1 easy memory: absolute zero temperature
Extra keywords: EPS

86. When all the removable kinetic energy of a system (e.g., a sample of material) has been removed, the system is at:

a) absolute zero temperature. b) relative zero temperature. c) $-40°$C.
d) $-40°$F. e) 273.15 K.

---

004 qmult 00340 1 1 1 easy memory: 273.15 K conversion to Celsius
Extra keywords: EPS

87. The temperature 273.15 K on the Celsius scale is

a) 0°C. b) 273.15°C. c) 100°C. d) $-273.15°$C. e) 200°C.

---

004 qmult 00500 1 1 2 easy memory: heat and internal energy
Extra keywords: EPS

88. Formally, it is a internal energy transfer. But many people use it as a synonym for internal energy at least when speaking loosely. We are speaking of:

a) work. b) heat. c) force. d) entropy. e) pressure.

---

004 qmult 00510 1 4 3 easy deducto-memory: 3 modes of heat transfer 1
Extra keywords: physci

89. The three common heat transfer processes are:

a) conduction, invection, and radiative transfer. b) induction, convection, and radiative equilibrium. c) conduction, convection, and radiative transfer. d) conduction, invection, and radiative equilibrium. e) introduction, insurrection, and radiative hibernation.

---

004 qmult 00520 1 4 5 easy deducto-memory: 3 forms of heat transfer 2
Extra keywords: physci

90. The three most commonly known forms of heat tranfer are:

a) conduction, convection, hyperventilation. b) conduction, contrition, contemplation. c) conduction, neutrinos, gravitational radiation. d) crenelation, navigation, mutation. e) conduction, convection, radiative transfer.

---

004 qmult 00550 1 4 4 easy deducto-memory: thermodynamic equilibrium
Extra keywords: EPS

91. "Let's play *Jeopardy*! For $100, the answer is: It is a state of a system of unchanging thermodynamic behavior at the macroscopic level: i.e. pressure, temperature, density, phase, and entropy are unchanging. Entropy is in fact at the maximum allowed by the nature and the available internal energy. At the microscopic level, there is continual change going on. But the atoms and molecules have a distribution of behavior, but the distribution itself is unchanging, and in particular the average behavior is unchanging. The state is a timeless state that could be called at dead state since life (as we know it) cannot exist in this state when it is fully enforced."

What is _____, Alex?

a) hydrostatic equilibrium b) mimimum entropy c) heat flow d) thermodynamic equilibrium e) ennui

---

004 qmult 00600 1 5 1 easy thinking: zeroth law of thermodynamics
Extra keywords: EPS

92. If two bodies are in thermodynamic equilibrium with a third body, they are in thermodyamic equilibrium with each other. By being in thermodyamic equilibrium, we mean that if put in thermal contact where heat flows can occur, no macroscopic heat flows will occur and no thermodynamic variables will change. The first statement is the:

a) zeroth law of thermodynamics. b) first law of thermodynamics. c) second law of thermodynamics. d) third law of thermodynamics. e) fourth law of thermodynamics.

---

004 qmult 00610 1 5 3 easy thinking: thermometer in zeroth law
Extra keywords: EPS

93. In the the zeroth law of thermodynamics, the third body acts in part like _____ since it acts as a measurer of thermodynamic equilibrium states.

a) a rock b) a power station c) a thermometer d) a turbine e) the Third Man

---

004 qmult 00700 1 4 2 easy deducto-memory: 1st law of thermodynamics
Extra keywords: EPS

94. "Let's play *Jeopardy*! For $100, the answer is: It is the 1st law of thermodynamics (in less than most general form), as expressed as formula."

What is _____, Alex?

a) $W = Q + \Delta E$ b) $\Delta E = Q - W$ c) $E = \frac{1}{2}mv^2$ d) $E = mv^2$ e) $E = mc^2$

---

004 qmult 00710 1 1 2 easy memory: pressure work
Extra keywords: EPS

95. When one discusses work in thermodynamics, one usually means work done by:

a) entropy. b) pressure. c) temperature. d) density. e) horses.

---

004 qmult 00810 1 1 3 easy memory: gas pressure
Extra keywords: EPS

96. Gas pressure is caused by the _____ of atoms and/or molecules.

a) cohesion b) suction c) collisions d) chemical bonds e) neutrons

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004 qmult 00840 2 1 5 moderate memory: aerodynamic lift
Extra keywords: EPS

97. Aerodynamic lift is an non-static-air air pressure effect with two main identifiable components:

a) a wing and a prayer. b) entropy and reaction lift. c) entropy and temperature.
d) reaction lift and Carnot lift. e) reaction lift and Bernoulli lift.

---

004 qmult 00842 1 5 5 easy easy thinking: paper and lift
Extra keywords: Not fair so some students with disabilities.

98. 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. Below the paper is normal pressure. The pressure force inequality will push the paper upward against the force of gravity. The overall effect 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 it is 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.

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004 qmult 00870 1 5 5 easy thinking: 2001: A Space Odyssey
Extra keywords: physci

99. 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-space-ship 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. The solid and liquid parts are strong enough it seems to keep the air in the body cavities contained. One **HOLDS** one's breath and one hopes one's eardrums don't rupture.

---

004 qmult 00900 1 4 4 easy deducto-memory: Clausius and entropy 1

Extra keywords: discoverer of the entropy concept

100. "Let's play *Jeopardy*! For $100, the answer is: He introduced the concept of entropy."

Who is _____, Alex?

a) Ptolemy (circa 100–175 CE) b) Nicolaus Copernicus (1473–1543)
c) Isaac Newton (1642/3–1727) d) Rudolf Clausius (1822–1888)
e) Stephen Hawking (1942–)

---

004 qmult 00902 1 1 4 easy memory: Clausius and entropy 2

101. Rudolf Clausius (1822–1888):

a) discovered temperature. b) proved the existence of density.
c) was wrong about heat engines. d) introduced the concept of entropy.
e) wrote the famous memoir *I, Clausius*.

---

004 qmult 00910 1 1 3 easy memory: entropy defined

Extra keywords: EPS

102. The thermodynamic variable entropy is a quantitative measure of:

a) order. b) microscopic order. c) microscopic disorder.
d) macroscopic disorder. e) temperature.

---

004 qmult 00920 1 4 5 easy deducto-memory: cause of entropy

Extra keywords: EPS

103. "Let's play *Jeopardy*! For $100, the answer is: They are the cause of increasing disorder."

What are _____, Alex?

a) Rambo or Rambolizing processes b) rambling or rambilizing processes
c) rotational or rotationalizing processes d) rational or rationalizing processes
e) random or randomizing processes

---

004 qmult 01000 1 4 3 easy deducto-memory: 2nd law of thermodynamics stated

Extra keywords: EPS

104. "Let's play *Jeopardy*! For $100, the answer is: The entropy of a thermodynamically closed (or isolated) system never decreases. Random processes if present will in fact drive a closed system to the state of maximum entropy allowed by the system's nature and available internal energy."

What is _____, Alex?

a) zeroth law of thermodynamics b) first law of thermodynamics
c) second law of thermodynamics d) third law of thermodynamics
e) fourth law of thermodynamics

---

004 qmult 01010 2 5 2 mod. deducto-memory: 2nd law of thermo consequence hot to cold

Extra keywords: EPS consequences and/or connections

105. The second law of thermodynamics **FORBIDS**:

a) heat to flow spontaneously from hot to cold.
b) heat to flow spontaneously from cold to hot.
c) entropy to increase in a closed system.
d) entropy to increase in an open system.
e) entropy to decrease in **ALL** cases.

---

004 qmult 01100 1 1 4 easy memory: 3rd law of thermodynamics

Extra keywords: EPS

106. As a system's temperature approaches absolute zero, its entropy (and thus its maximum possible entropy) approaches zero or at least a minimum value possible for the system. This rule is called

the _____. The _____ implies somehow that absolute zero temperature cannot be reached for a macroscopic system.

a) zeroth law of thermodynamics. b) 1st law of thermodynamics.
c) 2nd law of thermodynamics. d) 3rd law of thermodynamics.
e) 4th law of thermodynamics

---

004 qmult 01210 1 4 4 easy deducto-memory: 3 main phases
Extra keywords: EPS

107. "Let's play *Jeopardy*! For $100, the answer is: Solid, liquid, gas."

What are _____, Alex?

a) the three laws of thermodynamics b) the last three real substances c) the chemical categories d) the three main phases of matter e) the three least important phases of matter

---

004 qmult 01220 1 1 1 easy memory: least dense phase
Extra keywords: EPS

108. The least dense phase of matter at a given temperature and pressure is usually:

a) gas. b) liquid. c) solid. d) none of the above. e) all of the above.

---

004 qmult 01310 1 1 5 easy memory: phase change, temperature
Extra keywords: EPS pressure

109. Bulk phase changes (i.e., not just changes at the surfaces of samples) for pure substances happen at definite temperatures which are:

a) all above 273.15 K. b) all below 273.15 K. c) all below 273.15 K and independent of pressure. d) independent of pressure. e) dependent on pressure in general.

---

004 qmult 01340 2 1 3 moderate memory: dry ice
Extra keywords: EPS

110. A common substance that has no liquid phase at ordinary air pressure is carbon dioxide (CO_2). The solid phase is commonly called:

a) impossible green. b) sublimium. c) dry ice. d) marsh gas. e) Irish dirt.

---

004 qmult 01360 1 4 5 easy deducto-memory: water cycle
Extra keywords: EPS

111. "Let's play *Jeopardy*! For $100, the answer is: It is the movement of water through the Earth's atmosphere and on its land and water surfaces and subsurfaces. An outline of the process is as follows. Solar energy evaporates liquid water from the water surfaces and causes convection and vertical and horizontal movement in the atmosphere of water vapor. The vapor precipitates out as rain or snow or hail. Usuually as a liquid water flows downhill then and at least some of it reaches the oceans. There are also large amounts of water in the form of ice some of which is also flowing slowly downhill. The whole process is also called the hydrological cycle."

What is the _____, Alex?

a) heat engine cycle b) bicycle c) ice cycle d) last real cycle e) water cycle

---

004 qmult 01380 2 1 2 moderate memory: triple point
Extra keywords: EPS

112. The three main phases of matter for a single substance can exist together **IN THERMODYNAMIC EQUILIBRIUM** only:

a) at absolute zero. b) at a triple point. c) below 273.15 K. d) above 273.15 K.
e) with Macaques.

---

004 qmult 01390 1 4 5 easy deducto-memory: humans sweat
Extra keywords: EPS

113. "Let's play *Jeopardy*! For $100, the answer is: Among mammals, not the largest (the blue whale), not the smallest (the Etruscan shrew), not the fastest (the cheetah), nor the slowest (the sloth), not the most magnificent (the lion), not the noblest (the horse), not the most good-natured (the llama), nor the proudest (the camel), not the busiest (the beaver), not the growliest (the grizzly bear), not the tallest (the giraffe), not even the most sexed (the bonobo), nor the least (the giant panda), not the smelliest (the skunk beating out the billygoat), not the most loyal (the dog though this may be an over-rating), nor the most self-satisfied (the domestic cat [felis silvestris catus smugisimus]), not the lonesome flyer (the bat), nor the most spade-handed (the mole), not the wiliest (the coyote, but maybe they are only faux wily), nor the least (the guinea pig), not the flittiest (the gazelle), not the shyest (the wild deer), nor the most shattering (the proverbial bull in a china shop: AKA Raging Bull), not the most playful (the otter or the dolphin: take your pick), not the most clever (the fox who is also most into chicken coops and sour grapes), not the prickliest (the porcupine), not even the most thieving (the raccoon), and certainly not the most moon-child (the opossum)—

not the most cheese-loving (the mouse),
nor the quiestest (the church mouse),
not the maddest (the March Hare on the authority of Alice),
not the most obstinate (the mule: but maybe hybrids don't count),
not the most alpha-male (the He-Gorilla),
not the cheekiest (the squirrel),
nor the most hypocritical (we've all heard of weasel words)

—not the most striped (the zebra), nor the spottiest (the leopard), and not the most orange (the orangutan—provided artificial means are ruled out), not the most north polar (the muskox), nor the most Himilayan (the yak), not the most burning bright in the forest of the night (the tiger), nor even the most omnivorous (the pig probably), not the loneliest (the Lone Wolf), nor the most wère (the She-Wolf of London), not the most left-over from another age (the platypus), not the most conformist (the sheep), nor the least (the Rogue Male Elephant), perhaps the brainiest (but we'll see at the end of the day), not the most extremely bipedal (the kangaroo), not the closest cousin (the Neanderthal), nor the smallest cousin (Homo Floresiensis)—

not the most mythical (the unicorn),
nor the most binatured (the centaur),
nor yet the most sublime (the gryphon though you'd never know it),
not the most alluring/fatale singer on the rocks (the siren),
not the most selfish elfish (the elf),
and not the most alto soprano in the choir (the angel),
nor yet the most fallen (the devil—though a close second by all accounts),
not the most Irish (the leprechaun),
not the most respectable (the hobbit),
nor yet the most bare-bottomed (the cherub)

—not the most rodent-like non-rodent (the chihuahua), not the most disgustingly hairless (the Mexican hairless), nor the only one without a tail (the Manx cat sometimes), not the most pointed (the stag), not the longest horned (the narwhal—in fact, not horned at all), not the most hunted horn (the rhinoceros), not the best wallower (the water buffalo), not the most extinct (the mammoth), nor the least (the rat), not the most sacrificial (el toro in the arena), nor the most tender (the dams of all species caressing their young)—but the sweatiest."

What is the _____, Alex?

a) hedgehog b) lemur c) monkey d) satyr e) human

004 qmult 01386 1 4 1 easy deducto-memory: canids tongue loll
Extra keywords: EPS

114. "Let's play *Jeopardy*! For $100, the answer is: They evaporatively cool mainly by panting and tongue lolling."

What are _____, Alex?

a) canids b) cats c) horses d) cows e) humans

Chapt. 5 Heat Engines, Refrigerators, and the Carnot Engine

Multiple-Choice Problems

005 qmult 00100 1 4 2 easy deducto-memory: heat engine defined
Extra keywords: EPS

115. "Let's play *Jeopardy*! For $100, the answer is: It is a machine that operates in a cycle using a working fluid. In each cycle, the working fluid absorbs heat from a hot bath and turns some of it into macroscopic work and rejects the rest of it to a cold bath. The rejected heat must be enough make the entropy of the whole system increase or at least stay constant on average over a cycle. This requirement is a consequence of the second law of thermodynamics."

What is a/an _____, Alex?

a) refrigerator b) heat engine c) heat pump d) thermometer
e) electric generator

005 qmult 00110 2 1 2 moderate memory: ideal maximum efficiency
Extra keywords: EPS

116. The ideal maximum efficiency $F_{\text{eff,max}}$ of a heat engine working with a hot bath of temperature T_{H} and a cold bath of temperature T_{C} (where the temperatures are on the Kelvin scale) is:

a) $1 - \dfrac{T_{\text{H}}}{T_{\text{C}}}$. b) $1 - \dfrac{T_{\text{C}}}{T_{\text{H}}}$. c) $\dfrac{T_{\text{C}}}{T_{\text{H}}}$. d) $\dfrac{T_{\text{H}}}{T_{\text{C}}}$. e) $T_{\text{C}} \times T_{\text{H}}$.

005 qmult 00120 1 3 4 easy math: ideal efficiency calculation
Extra keywords: EPS

117. Given that ideal maximum efficiency $F_{\text{eff,max}} = 1 - T_{\text{C}}/T_{\text{H}}$ for a heat engine with with a hot bath of temperature T_{H} and a cold bath of temperature T_{C} (where the temperatures are on the Kelvin scale), what is the efficiency of a heat engine with $T_{\text{H}} = 900\,\text{K}$ and $T_{\text{C}} = 300\,\text{K}$.

a) 1 or 100 %. b) 1/3 or 33 %. c) 3. d) 2/3 or 67 %. e) 2.7×10^5.

005 qmult 00130 2 3 4 moderate math: ideal efficiency calculation 2
Extra keywords: EPS moderate math for the EPS students.

118. Given that ideal maximum efficiency $F_{\text{eff,max}} = 1/2 = 50\,\%$ for a heat engine with with a hot bath of temperature $T_{\text{H}} = 600\,\text{K}$, what is the cold bath of temperature T_{C}?

a) 600 K. b) 0.5 K. c) 1200 K. d) 300 K. e) 2 K.

005 qmult 00140 1 4 3 easy deducto-memory: Hero of Alexandria

119. "Let's play *Jeopardy*! For $100, the answer is: He/she is the inventor of the first known steam engine: the aeolipile."

Who is _____, Alex?

a) Democritus of Abdera (c. 460 – c. 370 BCE) b) Aristotle (384–322 BCE)
c) Hero of Alexandria (c. 10–70 CE) d) Ptolemy (c. 100– c. 170 CE)
e) Hypatia of Alexandria (c. 360–415 CE)

005 qmult 00150 1 4 1 easy deducto-memory: 3 kinds of heat engine

Extra keywords: EPS

120. "Let's play *Jeopardy*! For $100, the answer is: Examples of this machine are the reciprocating steam engine (also known as a piston-and-cylinder engine), the steam turbine (which is actually a kind of steam engine, but not usually so called), and the internal combustion engine."

What is the _____, Alex?

a) heat engine b) heat machine c) heat generator d) heat refrigerator
e) reverse refrigerator

---

005 qmult 00160 1 5 5 easy deducto-memory: simplest turbine

Extra keywords: EPS

121. The simplest turbine is a _____ with some sort of assembly to drive some kind machine.

a) rationalizer b) rotarian c) senator d) stator e) rotor

---

005 qmult 00170 1 5 3 easy deducto-memory: cooling tower

Extra keywords: EPS

122. One of the most conspicuous structures visible from the outside of modern **NUCLEAR** power stations are the:

a) nuclear fuel rods. b) coal hoppers. c) cooling towers.
d) pillars of radioactive fire. e) grasshoppers.

---

005 qmult 00300 1 4 1 easy deducto-memory: refrigerator defined

Extra keywords: EPS

123. "Let's play *Jeopardy*! For $100, the answer is: It is a machine that operates in a cycle using a working fluid. In each cycle, the working fluid absorbs heat from a **COLD** bath and using an input of macroscopic work and rejects the heat and the work equivalent of thermal energy to a **HOT** bath. The work converted to thermal energy must be enough make the entropy of the whole system increase or at least stay constant on average over a cycle. This requirement is a consequence of the second law of thermodynamics."

What is a/an _____, Alex?

a) refrigerator b) heat engine c) heat sump pump d) thermometer
e) electric generator

---

005 qmult 00500 1 4 2 easy deducto-memory: Sadi Carnot

124. "Let's play *Jeopardy*! For $100, the answer is: He/she theoretically invented the Carnot engine."

Who is _____, Alex?

a) Lazare Carnot (1753–1823) b) Sadi Carnot (1796–1832)
c) Carnivorous Carnot (1800–1882) d) Casamassivia Carnot (1850–1955)
e) Buster Carnot (1887–1960)

---

005 qmult 00520 1 1 3 easy memory: reversible engine

125. Carnot argued that a reversible thermodynamic engine (one that could work both as a heat engine and a refrigerator) with the same hot-bath heat, cold-bath heat, and work in both modes must be the:

a) most efficient heat engine and least efficient refrigerator.
b) least efficient heat engine and refrigerator.
c) most efficient heat engine and refrigerator.
d) least efficient heat engine and most efficient refrigerator.
e) most undesirable of all engines.

---

005 qmult 00530 1 1 1 easy memory: Carnot's key argument

126. Carnot preceded most of classical thermodynamics and the entropy concept. Thus, he did not use and could not used the entropy arguments to to prove that the reversible thermodynamic engine was the most efficient thermodynamic engine imaginable. He (at least the ideal Carnot if maybe not the Carnot of history) instead argued it must be most efficient because of the empirical facts no one had ever seen in a cyclic process in which thermal energy got converted entirely into macroscopic work with no rejection of heat to a cold bath and no one had ever seen in a cyclic process heat flow:

a) spontaneously from cold to hot. b) spontaneously from hot to cold.
c) from hot to cold with input macroscopic work.
d) from cold to hot with input macroscopic work. e) without a steam working fluid.

---

005 qmult 00540 1 1 5 easy memory: Carnot engine existence

127. A Carnot engine:

a) cannot exist even approximately.
b) can exist exactly and they are everywhere: you've just never noticed.
c) can exist exactly, but no one's ever built one.
d) can be built, but is dreadfully dangerous. e) can exist approximately.

---

005 qmult 00550 1 1 4 easy memory: Carnot engines low power

128. Approximate Carnot engines, despite their very high theoretical efficiency, are not used extensively because they are:

a) can't actually be built. b) can actually be built. c) dreadfully dangerous.
d) very low power. e) very high power.

Chapt. 6 World Energy Resources and Consumption

Multiple-Choice Problems

006 qmult 00100 1 1 1 easy memory: energy production equals consumption

129. World energy production and world energy consumption are:

a) about equal. b) in a 2 to 1 ratio. c) in a 1 to 2 ratio. d) in a 3 to 1 ratio. e) in a 1 to 3 ratio.

006 qmult 00110 1 1 3 easy memory: fraction of energy fossil fuel

130. What fraction of world energy production is in the form of fossil fuels circa 2009?

a) 0.01 %. b) 2 %. c) 86 %. d) 100 %. e) 150 %.

Full-Answer Problems

Appendix 7 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
131.	O	O	O	O	O	6.	O	O	O	O	O
132.	O	O	O	O	O	7.	O	O	O	O	O
133.	O	O	O	O	O	8.	O	O	O	O	O
134.	O	O	O	O	O	9.	O	O	O	O	O
135.	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
136.	O	O	O	O	O	11.	O	O	O	O	O
137.	O	O	O	O	O	12.	O	O	O	O	O
138.	O	O	O	O	O	13.	O	O	O	O	O
139.	O	O	O	O	O	14.	O	O	O	O	O
140.	O	O	O	O	O	15.	O	O	O	O	O
141.	O	O	O	O	O	16.	O	O	O	O	O
142.	O	O	O	O	O	17.	O	O	O	O	O
143.	O	O	O	O	O	18.	O	O	O	O	O
144.	O	O	O	O	O	19.	O	O	O	O	O
145.	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
146.	O	O	O	O	O	16.	O	O	O	O	O
147.	O	O	O	O	O	17.	O	O	O	O	O
148.	O	O	O	O	O	18.	O	O	O	O	O
149.	O	O	O	O	O	19.	O	O	O	O	O
150.	O	O	O	O	O	20.	O	O	O	O	O
151.	O	O	O	O	O	21.	O	O	O	O	O
152.	O	O	O	O	O	22.	O	O	O	O	O
153.	O	O	O	O	O	23.	O	O	O	O	O
154.	O	O	O	O	O	24.	O	O	O	O	O
155.	O	O	O	O	O	25.	O	O	O	O	O
156.	O	O	O	O	O	26.	O	O	O	O	O
157.	O	O	O	O	O	27.	O	O	O	O	O
158.	O	O	O	O	O	28.	O	O	O	O	O
159.	O	O	O	O	O	29.	O	O	O	O	O
160.	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
161.	O	O	O	O	O	26.	O	O	O	O	O
162.	O	O	O	O	O	27.	O	O	O	O	O
163.	O	O	O	O	O	28.	O	O	O	O	O
164.	O	O	O	O	O	29.	O	O	O	O	O
165.	O	O	O	O	O	30.	O	O	O	O	O
166.	O	O	O	O	O	31.	O	O	O	O	O
167.	O	O	O	O	O	32.	O	O	O	O	O
168.	O	O	O	O	O	33.	O	O	O	O	O
169.	O	O	O	O	O	34.	O	O	O	O	O
170.	O	O	O	O	O	35.	O	O	O	O	O
171.	O	O	O	O	O	36.	O	O	O	O	O
172.	O	O	O	O	O	37.	O	O	O	O	O
173.	O	O	O	O	O	38.	O	O	O	O	O
174.	O	O	O	O	O	39.	O	O	O	O	O
175.	O	O	O	O	O	40.	O	O	O	O	O
176.	O	O	O	O	O	41.	O	O	O	O	O
177.	O	O	O	O	O	42.	O	O	O	O	O
178.	O	O	O	O	O	43.	O	O	O	O	O
179.	O	O	O	O	O	44.	O	O	O	O	O
180.	O	O	O	O	O	45.	O	O	O	O	O
181.	O	O	O	O	O	46.	O	O	O	O	O
182.	O	O	O	O	O	47.	O	O	O	O	O
183.	O	O	O	O	O	48.	O	O	O	O	O
184.	O	O	O	O	O	49.	O	O	O	O	O
185.	O	O	O	O	O	50.	O	O	O	O	O

Answer Table

Name:

	a	b	c	d	e		a	b	c	d	e
186.	O	O	O	O	O	31.	O	O	O	O	O
187.	O	O	O	O	O	32.	O	O	O	O	O
188.	O	O	O	O	O	33.	O	O	O	O	O
189.	O	O	O	O	O	34.	O	O	O	O	O
190.	O	O	O	O	O	35.	O	O	O	O	O
191.	O	O	O	O	O	36.	O	O	O	O	O
192.	O	O	O	O	O	37.	O	O	O	O	O
193.	O	O	O	O	O	38.	O	O	O	O	O
194.	O	O	O	O	O	39.	O	O	O	O	O
195.	O	O	O	O	O	40.	O	O	O	O	O
196.	O	O	O	O	O	41.	O	O	O	O	O
197.	O	O	O	O	O	42.	O	O	O	O	O
198.	O	O	O	O	O	43.	O	O	O	O	O
199.	O	O	O	O	O	44.	O	O	O	O	O
200.	O	O	O	O	O	45.	O	O	O	O	O
201.	O	O	O	O	O	46.	O	O	O	O	O
202.	O	O	O	O	O	47.	O	O	O	O	O
203.	O	O	O	O	O	48.	O	O	O	O	O
204.	O	O	O	O	O	49.	O	O	O	O	O
205.	O	O	O	O	O	50.	O	O	O	O	O
206.	O	O	O	O	O	51.	O	O	O	O	O
207.	O	O	O	O	O	52.	O	O	O	O	O
208.	O	O	O	O	O	53.	O	O	O	O	O
209.	O	O	O	O	O	54.	O	O	O	O	O
210.	O	O	O	O	O	55.	O	O	O	O	O
211.	O	O	O	O	O	56.	O	O	O	O	O
212.	O	O	O	O	O	57.	O	O	O	O	O
213.	O	O	O	O	O	58.	O	O	O	O	O
214.	O	O	O	O	O	59.	O	O	O	O	O
215.	O	O	O	O	O	60.	O	O	O	O	O

Answer Table

Name:

	a	b	c	d	e		a	b	c	d	e
216.	O	O	O	O	O	38.	O	O	O	O	O
217.	O	O	O	O	O	39.	O	O	O	O	O
218.	O	O	O	O	O	40.	O	O	O	O	O
219.	O	O	O	O	O	41.	O	O	O	O	O
220.	O	O	O	O	O	42.	O	O	O	O	O
221.	O	O	O	O	O	43.	O	O	O	O	O
222.	O	O	O	O	O	44.	O	O	O	O	O
223.	O	O	O	O	O	45.	O	O	O	O	O
224.	O	O	O	O	O	46.	O	O	O	O	O
225.	O	O	O	O	O	47.	O	O	O	O	O
226.	O	O	O	O	O	48.	O	O	O	O	O
227.	O	O	O	O	O	49.	O	O	O	O	O
228.	O	O	O	O	O	50.	O	O	O	O	O
229.	O	O	O	O	O	51.	O	O	O	O	O
230.	O	O	O	O	O	52.	O	O	O	O	O
231.	O	O	O	O	O	53.	O	O	O	O	O
232.	O	O	O	O	O	54.	O	O	O	O	O
233.	O	O	O	O	O	55.	O	O	O	O	O
234.	O	O	O	O	O	56.	O	O	O	O	O
235.	O	O	O	O	O	57.	O	O	O	O	O
236.	O	O	O	O	O	58.	O	O	O	O	O
237.	O	O	O	O	O	59.	O	O	O	O	O
238.	O	O	O	O	O	60.	O	O	O	O	O
239.	O	O	O	O	O	61.	O	O	O	O	O
240.	O	O	O	O	O	62.	O	O	O	O	O
241.	O	O	O	O	O	63.	O	O	O	O	O
242.	O	O	O	O	O	64.	O	O	O	O	O
243.	O	O	O	O	O	65.	O	O	O	O	O
244.	O	O	O	O	O	66.	O	O	O	O	O
245.	O	O	O	O	O	67.	O	O	O	O	O
246.	O	O	O	O	O	68.	O	O	O	O	O
247.	O	O	O	O	O	69.	O	O	O	O	O
248.	O	O	O	O	O	70.	O	O	O	O	O

249.	O	O	O	O	O	71.	O	O	O	O	O
250.	O	O	O	O	O	72.	O	O	O	O	O
251.	O	O	O	O	O	73.	O	O	O	O	O
252.	O	O	O	O	O	74.	O	O	O	O	O