Conceptual Physics NAME:

Homework 2d Gases Homeworks are due usually a day after the corresponding textbook part/lecture is completed. Due dates will be announced in class. Multiple-choice problems will all be marked. **USE** the answer table for these problems. The rest of the homeworks will be marked for apparent completeness and some full-answer problems will/may be marked in detail. Make the full-answer solutions sufficiently detailed that the grader can follow your reasoning. Solutions will be posted eventually after the due dates. The solutions are intended to be (but not necessarily are) super-perfect and often go beyond full answers. For an argument or discussion problem, there really is no single right answer. The instructor's answer reflects his long experience in physics, but there could be objections to his arguments, assumptions, nuances, style, facts, etc.

NAME:

Answer Table for the Multiple-Choice Questions

	a	b	c	d	e		a	b	c	d	e
1.	O	O	O	O	O	26.	O	O	O	O	O
2.	O	O	O	O	O	27.	O	O	O	O	O
3.	O	O	O	O	O	28.	O	O	O	O	O
4.	O	O	O	O	O	29.	O	O	O	O	O
5.	O	O	O	O	O	30.	O	O	O	O	O
6.	O	O	O	O	O	31.	O	O	O	O	O
7.	O	O	O	O	O	32.	O	O	O	O	O
8.	O	O	O	O	O	33.	O	O	O	O	O
9.	O	O	O	O	O	34.	O	O	O	O	O
10.	O	O	O	O	O	35.	O	O	O	O	O
11.	O	O	O	O	O	36.	O	O	O	O	O
12.	O	O	O	O	O	37.	O	O	O	O	O
13.	O	O	O	O	O	38.	O	O	O	O	O
14.	O	O	O	O	O	39.	O	O	O	O	O
15.	O	O	O	O	O	40.	O	O	O	O	O
16.	O	O	O	O	O	41.	O	O	O	O	O
17.	O	O	O	O	O	42.	O	O	O	O	O
18.	O	O	O	O	O	43.	O	O	O	O	O
19.	O	O	O	O	O	44.	O	O	O	O	O
20.	O	O	O	O	O	45.	O	O	O	O	O
21.	O	O	O	O	O	46.	O	O	O	O	O
22.	O	O	O	O	O	47.	O	O	O	O	O
23.	O	O	O	O	O	48.	O	O	O	O	O
24.	O	O	O	O	O	49.	O	O	O	O	O
25.	O	O	O	O	O	50.	O	O	O	O	O

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

1. "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

   SUGGESTED ANSWER: (e)

   Wrong answers:

   d) Jean Baptiste van Helmont (1579–1644) invented gas and blas: the former caught on and the latter didn't. Both terms were rather vague in van Helmont usuage.

   Redaction: Jeffery, 2012jan01

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

2. 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) gass d) air e) blas

   SUGGESTED ANSWER: (c)

   Wrong answers:

   e) Jean Baptiste van Helmont (1579–1644) invented gas and blas: the former caught on and the latter didn't. Both terms were rather vague in van Helmont usuage.

   Redaction: Jeffery, 2012jan01

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

3. 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.

   SUGGESTED ANSWER: (c)

   Wrong answers:

   d) It's mostly nitrogen.

   Redaction: Jeffery, 2012jan01

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006 qmult 00210 1 1 4 easy memory: air composition

4. 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

SUGGESTED ANSWER: (d)

Wrong answers:
c) Noble gases are already ruled out by the question.

Redaction: Jeffery, 2012jan01

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

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

a) 1.2041 kg/m^3. b) 1204.1 kg/m^3. c) 1000 kg/m^3. d) 7.874 kg/m^3. e) 7874 kg/m^3.

SUGGESTED ANSWER: (a) From Wikipedia: density of air.

Wrong answers:
c) This is the density of water at 4°C and 1 atm (Wikipedia: water).
e) This is the density of iron at about room temperature and air pressure (Wikipedia: iron).

Redaction: Jeffery, 2008jan01

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

6. The density of air at 20° and 1 atm pressure is 1.21 kg/m^3 (HRW-323). (For comparison, water density under the same conditions is 998 kg/m^3 (HRW-323) which is nearly the frequently quoted 1000 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.

SUGGESTED ANSWER: (a) See HRW-323 for the densities.
Behold:

$$m = \rho V = 1.21 \times 60 = 72.6\,\mathrm{kg}\ ,$$

which is about the mass of a typical male person.

Wrong answers:
e) As Lurch would say: "Aaaarh."

Redaction: Jeffery, 2001jan01

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

7. 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.

SUGGESTED ANSWER: (a)

Wrong answers:
e) As Lurch would say: "Aaaarh."

Redaction: Jeffery, 2001jan01

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

8. 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

   SUGGESTED ANSWER: (b)

   Wrong answers:
   e) Now is this likely?

   Redaction: Jeffery, 2008jan01

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

9. 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 $9.8\,\mathrm{N/kg}$, 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 $10^5\,\mathrm{Pa}$ and $1.2\,kg/m^3$.

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

   SUGGESTED ANSWER: (c)

   At the top of the atmosphere, the pressure should go to zero since there is no air above that point to support. So for the top altitude, we solve as follows:

$$0 = P = P_0 - \rho g y$$

$$y = \frac{P_0}{\rho g} \approx \frac{10^5}{10} = 10^4\,\mathrm{m} = 10\,\mathrm{km} \ .$$

   Wrong answers:
   a) A nonsense answer.

   Redaction: Jeffery, 2012jan01

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

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

    What 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)

    SUGGESTED ANSWER: (b)

    The barometer is one invention where it seems clear there was single inventor at a definite point in time. But even here one could quibble. There are forerunners who had some part of the idea.

    Wrong answers:
    a) Inventor of the vacuum pump and a citizen and sometime mayor of Magdeburg—he somehow survived the massacre of Magdeburg in 1631. Who could ever forget his demonstration with two teams of eight horses trying to pull apart a sphere of two hemispheres sealed by vacuum? They must have been feeble beasts.

    Redaction: Jeffery, 2012jan01

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

11. "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

SUGGESTED ANSWER: (e)

Wrong answers:

a) As Lurch would say AAAARGH.

Redaction: Jeffery, 2012jan01

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006 qmult 00340 1 4 2 easy deducto-memory: pressure in straw

Extra keywords: physci KB-131-5

12. "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

SUGGESTED ANSWER: (b) This is not really a case of Pascal's principle (HRW-328) since there must be a non-gravitational pressure gradient in the water.

Wrong answers:

a) Exactly wrong.

Redaction: Jeffery, 2001jan01

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

13. "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

SUGGESTED ANSWER: (b)

Wrong answers:

e) This one will have to reported to the Arch-Prig.

Redaction: Jeffery, 2012jan01

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

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

    What 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)

SUGGESTED ANSWER: (a)

Other kinds of pumps existed going back to Greco-Roman antiquity, but von Guericke seems to be the man for the true vacuum pump. Von Guericke was a citizen and sometime mayor of Magdeburg—he somehow survived the massacre of Magdeburg in 1631. Who could ever forget his demonstration with two teams of eight horses trying to pull apart a sphere of two hemispheres sealed by vacuum? They must have been feeble beasts.

Wrong answers:

b) No, he had the barometer.

Redaction: Jeffery, 2012jan01

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

15. 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.

SUGGESTED ANSWER: (e)

I used to just hope Arthur C. Clarke (1917–2008) and Stanley Kubrick (1928–1999) were right about this. Clarke was a diver as well as a space guru: so supposedly he knew all about it. But the web comes through with the authoritative discussion which I won't repeat. See http://www.aerospaceweb.org/question/atmosphere/q0291.shtml .

Yes, Bowman can do it.

Wrong answers:
a) Oh, c'mon.
b) False. That's the exactly wrong to do if you are in Bowman's predicament. Your lungs would rupture according to web discussion.
c) True, but not an answer.
d) The screenwriters could have got him out of that pod some other way. They stick at nothing.

Redaction: Jeffery, 2001jan01

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

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

What 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)

SUGGESTED ANSWER: (d)

Actually, Charles Towneley and Henry Power discovered Boyle's law in 1661. Boyle, assisted by Robert Hooke, confirmed the law and probably can be said to have fully established it. Boyle in his publication of 1662 called the law, Towneley's hypothesis. I guess since Boyle published the result first and probably did very detailed measurements to show its validity, he gets his name on it.

Wrong answers:
e) Actually, Hooke was working Boyle on gases and air pumps during the discovery period.

Redaction: Jeffery, 2012jan01

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

17. "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:

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

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

SUGGESTED ANSWER: (e)

Wrong answers:
c) Towneley and Power discovered Boyle's law and communicated this discovery to Boyle.

Redaction: Jeffery, 2012jan01

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006 qmult 00520 1 1 1 easy memory: Boyle's law calculation 1
18. If the volume of a gas sample is doubled isothermally, its pressure:

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

SUGGESTED ANSWER: (a) Boyle's law in action.

Redaction: Jeffery, 2012jan01

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006 qmult 00550 1 1 3 easy memory: ideal gas law
19. 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.

SUGGESTED ANSWER: (c)

Wrong answers:
b) Put Charles's law and Boyle's law together and you have the ideal gas law.
e) A nonsense answer.

Redaction: Jeffery, 2012jan01

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006 qmult 00610 1 1 5 easy memory: buoyancy in the air
20. For an object to float in air, not rising or sinking, the following must hold:

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

SUGGESTED ANSWER: (e)

The buoyancy force magnitude $F = m_{\rm dis}g$ must equal the gravity force magnitude $F = mg$ for floating. It follows that

$$\begin{aligned} mg &= m_{\rm dis}g \\ m &= m_{\rm dis} \\ \rho_{\rm object}V &= \rho_{\rm air}V \\ \rho_{\rm object} &= \rho_{\rm air} \ . \end{aligned}$$

Wrong answers:
a) Not likely.

Redaction: Jeffery, 2012jan01

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

21. 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.

SUGGESTED ANSWER: (d)

Wrong answers:
c) Not this time.

Redaction: Jeffery, 2012jan01

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

22. 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

SUGGESTED ANSWER: (c)

Wrong answers:
a) This is not the best answer. The work-energy theorem is good starting place for deriving Bernoulli's principle. Now it is true that one derives the work-energy theorem from Newton's 2nd law and so in a remote sense yes one can derive Bernoulli's principle from Newton's 2nd law.

Redaction: Jeffery, 2012jan01

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006 qmult 00810 1 1 3 easy memory: plane lift

23. 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

SUGGESTED ANSWER: (c)

Wrong answers:
a) A nonsense answer.

Redaction: Jeffery, 2012jan01

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

24. 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.

SUGGESTED ANSWER: (e)

The experiment should work and the answer obeys the longest-answer-is-right rule. How can anyone miss. You only have to be a real blowhard to do it.

The trick is an example of Bernoulli lift. Moving air above the paper is at lower pressure than stationary air below the paper as the Bernoulli equation suggests. (We derived the Bernoulli equation for incompressible fluids, but Bernoulli-like behavior for compressible fluids is to be expected.) The situation is actually pretty complex: the low pressure zone above the paper causes the high pressure below the paper to push the paper up. But the low pressure zone also causes air above the low pressure zone to lose pressure support and fall down, but I guess the downfalling air gets entrained by the blowing air. Oh, well someone probably knows exactly what everything is doing.

Wrong answers:

a) This seems to be distinctly wrong.
b) This could well be true.
c) It's been known to happen. Best not to aim at anyone.
d) Well I tried my best, but, as we say in science, one picture is worth 10^3 words.

Redaction: Jeffery, 2001jan01