AP® PHYSICS
2012 SCORING GUIDELINES

General Notes About 2012 AP Physics Scoring Guidelines

1. The solutions contain the most common method of solving the free-response questions and the allocation of points for this solution. Some also contain a common alternate solution. Other methods of solution also receive appropriate credit for correct work.

2. Generally, double penalty for errors is avoided. For example, if an incorrect answer to part (a) is correctly substituted into an otherwise correct solution to part (b), full credit will usually be awarded in part (b). One exception to this practice may occur in cases where the numerical answer to a later part should easily be recognized as wrong, for example, a speed faster than the speed of light in vacuum.

3. Implicit statements of concepts normally receive credit. For example, if the use of an equation expressing a particular concept is worth 1 point, and a student's solution contains the application of that equation to the problem but the student does not write the basic equation, the point is still awarded. However, when students are asked to derive an expression, it is normally expected that they will begin by writing one or more fundamental equations, such as those given on the AP Physics Exam equation sheets. For a description of the use of such terms as "derive" and "calculate" on the exams, and what is expected for each, see "The Free-Response Sections — Student Presentation" in the *AP Physics Course Description*.

4. The scoring guidelines typically show numerical results using the value $g = 9.8\ \text{m/s}^2$, but use of $10\ \text{m/s}^2$ is of course also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

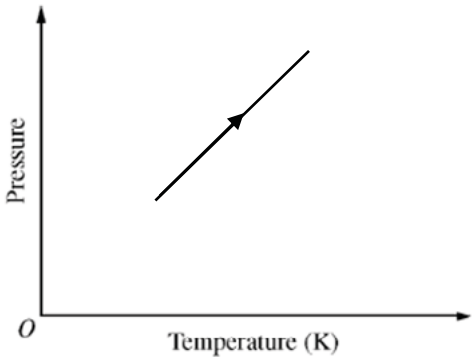
5. Strict rules regarding significant digits are usually not applied to numerical answers. However, in some cases answers containing too many digits may be penalized. In general, two to four significant digits are acceptable. Numerical answers that differ from the published answer owing to differences in rounding throughout the question typically receive full credit. Exceptions to these guidelines usually occur when rounding makes a difference in obtaining a reasonable answer. For example, suppose a solution requires subtracting two numbers that should have five significant figures and that differ starting with the fourth digit (e.g., 20.295 and 20.278). Rounding to three digits will eliminate the level of accuracy required to determine the difference in the numbers, and some credit may be lost.

AP® PHYSICS B
2012 SCORING GUIDELINES

Question 4

10 points total **Distribution of points**

(a) 3 points



For a graph showing pressure proportional to temperature (i.e., a straight line segment that, if extended, would pass through the origin) 1 point

For showing that the initial pressure and initial temperature are not zero 1 point

For a final state that is at a higher pressure and temperature than the initial state (regardless of the shape of the path) 1 point

(b) 2 points

For selecting "Moves down" 1 point

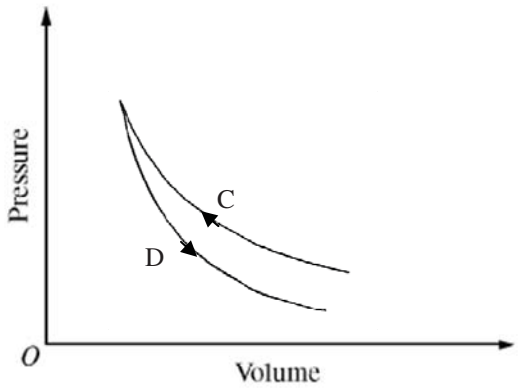
For recognition of the piston's mass, which is pulled down by the force of gravity 1 point

Note: One point could be earned for selecting "Remains stationary" with a clear explanation that the internal and external pressures are equal or that the system returned to the original pressure P_0

Question 4 (continued)

Distribution of points

(c) 5 points
and
(d) These two parts are closely linked; therefore they are scored as a unit.

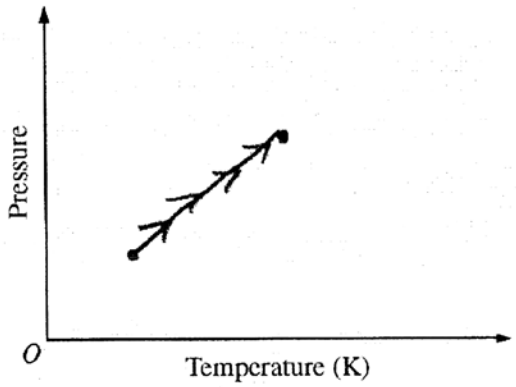


For drawing curve C as concave up, with a negative slope	1 point
For drawing curve D as concave up, with a negative slope	1 point
For drawing the final state of curve C and the initial state of curve D as the only point where the two curves intersect	1 point
For drawing curve C above curve D	1 point
For correct labels and directions of arrows on both processes	1 point

4. (10 points)

A cylindrical container is fitted with a frictionless piston that is initially locked in place. The cylinder contains a fixed amount of an ideal gas that is initially at room temperature and atmospheric pressure.

(a) The cylinder is placed in a hot-water bath. On the axes below, sketch a graph of pressure versus temperature for the process the gas undergoes as a result, and indicate the direction of the process on the graph.

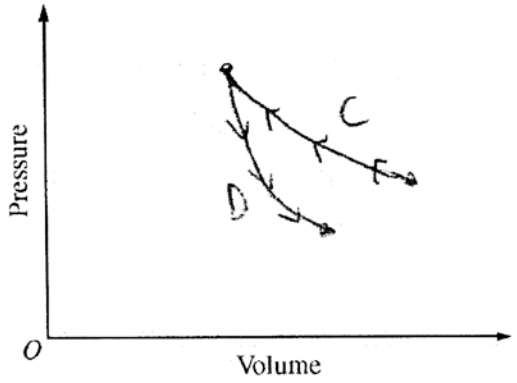


(b) The cylinder is removed from the hot-water bath. After equilibrium is reached, the lock is removed so the piston is free to move. Indicate whether the piston moves up, moves down, or remains stationary.

____ Moves up ___X___ Moves down ____ Remains stationary

Justify your answer.

(c) When the system is again at equilibrium, the piston is pushed down very slowly. On the axes below, sketch a graph of pressure versus volume for the process the gas undergoes as a result, and indicate the direction of the process on the graph. Label this process "C."

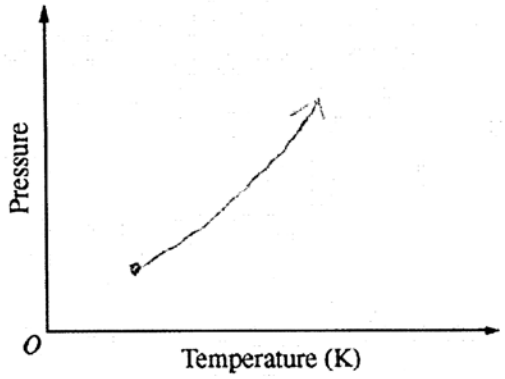


(d) Now the piston is pulled up quickly, so no heat is added to or removed from the gas during the process. On the axes above, sketch a graph of pressure versus volume for the process the gas undergoes as a result, and indicate the direction of the process on the graph. Label this process "D."

4. (10 points)

A cylindrical container is fitted with a frictionless piston that is initially locked in place. The cylinder contains a fixed amount of an ideal gas that is initially at room temperature and atmospheric pressure.

(a) The cylinder is placed in a hot-water bath. On the axes below, sketch a graph of pressure versus temperature for the process the gas undergoes as a result, and indicate the direction of the process on the graph.



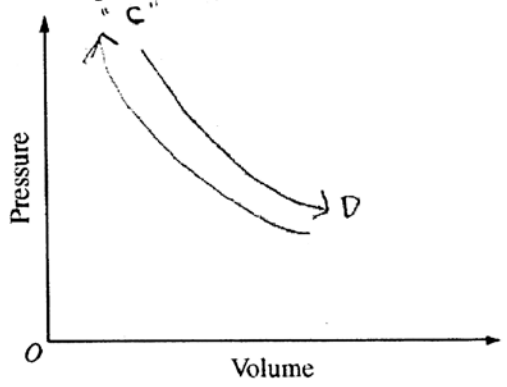
(b) The cylinder is removed from the hot-water bath. After equilibrium is reached, the lock is removed so the piston is free to move. Indicate whether the piston moves up, moves down, or remains stationary.

____ Moves up ____ Moves down ____ Remains stationary

Justify your answer.

The piston will move down because after the lock is released the piston which is initially pushed up due to the increase in pressure will release and the piston will fall back down

(c) When the system is again at equilibrium, the piston is pushed down very slowly. On the axes below, sketch a graph of pressure versus volume for the process the gas undergoes as a result, and indicate the direction of the process on the graph. Label this process "C."

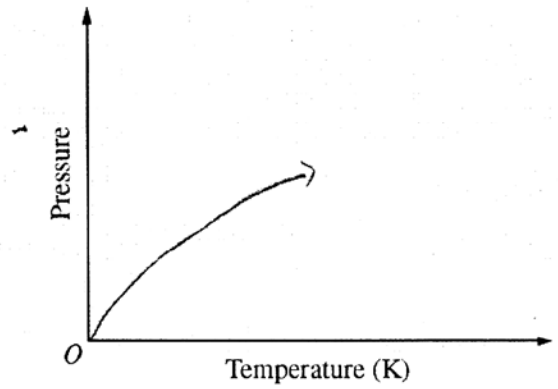


(d) Now the piston is pulled up quickly, so no heat is added to or removed from the gas during the process. On the axes above, sketch a graph of pressure versus volume for the process the gas undergoes as a result, and indicate the direction of the process on the graph. Label this process "D."

4. (10 points)

A cylindrical container is fitted with a frictionless piston that is initially locked in place. The cylinder contains a fixed amount of an ideal gas that is initially at room temperature and atmospheric pressure.

(a) The cylinder is placed in a hot-water bath. On the axes below, sketch a graph of pressure versus temperature for the process the gas undergoes as a result, and indicate the direction of the process on the graph.



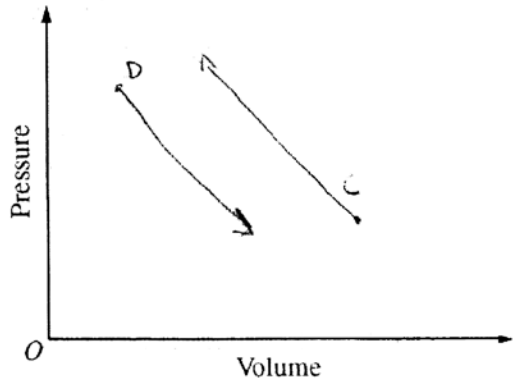
(b) The cylinder is removed from the hot-water bath. After equilibrium is reached, the lock is removed so the piston is free to move. Indicate whether the piston moves up, moves down, or remains stationary.

____ Moves up ___X___ Moves down ____ Remains stationary

Justify your answer.

The pressure increased moves the piston down

(c) When the system is again at equilibrium, the piston is pushed down very slowly. On the axes below, sketch a graph of pressure versus volume for the process the gas undergoes as a result, and indicate the direction of the process on the graph. Label this process "C."



(d) Now the piston is pulled up quickly, so no heat is added to or removed from the gas during the process. On the axes above, sketch a graph of pressure versus volume for the process the gas undergoes as a result, and indicate the direction of the process on the graph. Label this process "D."

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AP® PHYSICS B
2012 SCORING COMMENTARY

Question 4

Overview

This question assessed students' understanding of thermodynamics, specifically the relationship between pressure, volume, and temperature under isothermic, adiabatic, or isochoric conditions.

Sample: B4-A
Score: 9

Full credit was earned in parts (a), (c), and (d), all of which contain excellent graphs. The only point lost was in part (b) for the lack of a justification stating that the weight of the piston would cause the system to go down.

Sample: B4-B
Score: 6

In part (a) 2 points were earned for a non-zero starting pressure/temperature and the arrow pointing up and to the right, but the graph is not linear. One point was awarded in part (b) for choosing the correct answer, but the justification is invalid. In part (c) 3 of the 5 points were earned for the curve of the two lines and the labeling and directions of arrows. However, curve C is drawn below curve D, and there is no intersection of the end point of curve C and the initial point of curve D.

Sample: B4-C
Score: 4

One point was earned in part (a) for the direction of the graph. However, the graph is not linear, and it starts at the origin. In part (b) 1 point was awarded for selecting the correct answer, but the justification is invalid. In parts (c) and (d) 1 point was awarded for placing curve C above curve D, and 1 point was earned for the direction of arrows and labeling.