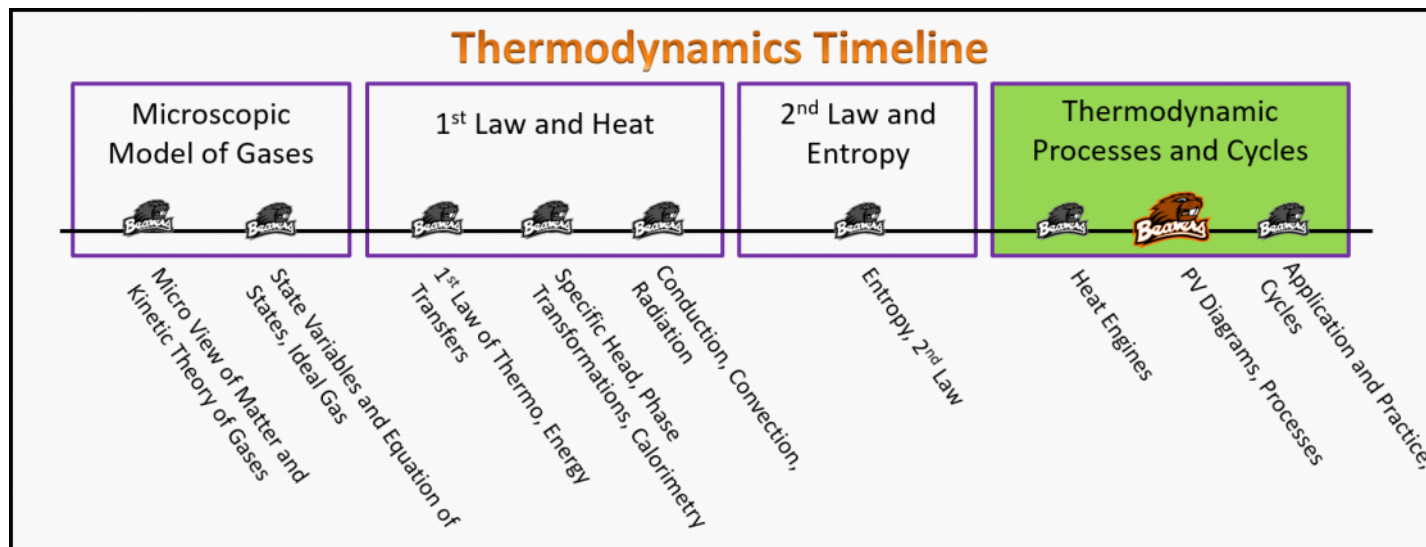


Thermodynamics

Foundation Stage (PC.2.L2)

Lecture 2 PV Diagrams, Processes



Textbook Chapters (* Calculus version)

- **BoxSand** :: KC videos ([Processes and PV-Diagrams](#))
- **Knight** (College Physics : A strategic approach 3rd) :: 12.3
- ***Knight** (Physics for Scientists and Engineers 4th) :: 18.7 ; 19.2
- **Giancoli** (Physics Principles with Applications 7th) :: 15-2

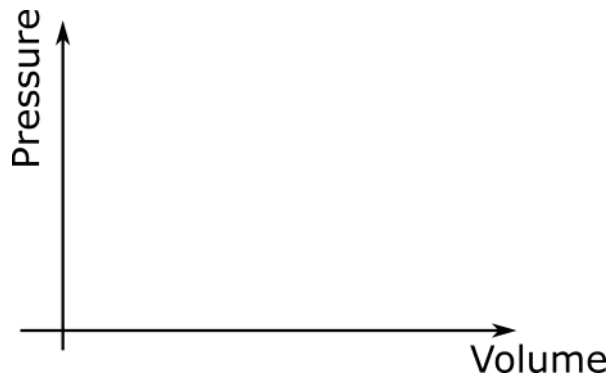
Warm up

PC.2.L2-1:

Description: Sketch any process that starts at one equilibrium state and ends at another.

Learning Objectives: [?] - Can you identify the objectives from the previous lecture, and this lecture, that this question is relevant to?

Problem Statement: On the PV diagram below, sketch any process that takes an ideal gas from one equilibrium state to a new equilibrium state. Basically, how are equilibrium states represented on a PV diagram and how are processes represented?



Selected Learning Objectives

1. Coming soon to a lecture template near you.

Key Terms

- Thermodynamic process
- Isochoric process
- Isothermal process
- Adiabatic process
- Isobaric process

Key Equations

Key Concepts

- Coming soon to a lecture template near you.

Questions

Act I: Isochoric

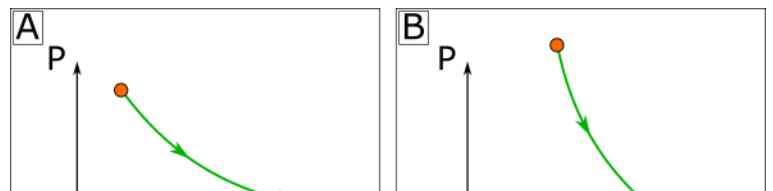
PC.2.L2-2:

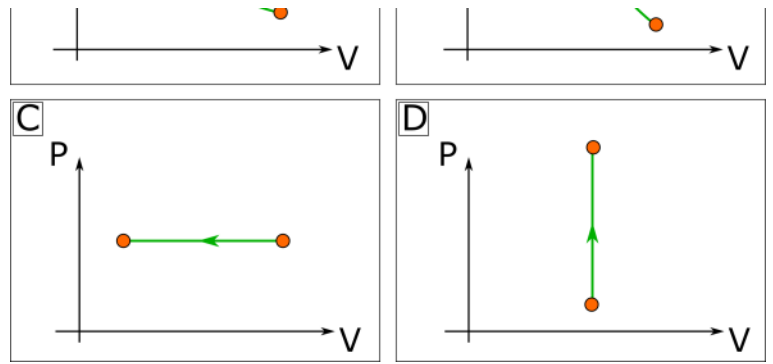
Description: Identify which PV diagram represents an isochoric process. (2 minutes + 2 minutes)

Learning Objectives: [1, 12, 13]

Problem Statement: Consider the 4 PV diagrams below.

(a) Which diagram shows an isochoric process?





(b) What are the other diagrams called?

PC.2.L2-3:

Description: Proportional reasoning with ideal gas law. (3 minutes)

Learning Objectives: [1, 12, 13]

Problem Statement: Consider one mole of an ideal monatomic gas that undergoes an isochoric process from one equilibrium state to another. If the pressure is increased by a factor of 4, by what factor does the temperature change by?

- (1) 1/16
- (2) 1/4
- (3) 1
- (4) 4
- (5) 16

PC.2.L2-4:

Description: Determine signs of first law quantities. (5 minutes)

Learning Objectives: [1, 12, 13]

Problem Statement: Which of the following are the correct signs for an isochoric increase in temperature?

- (1) ΔE^{TH} (+) , W (+) , Q (+)

Process	ΔE^{TH}	W	Q
---------	-----------------	-----	-----

- (2) $\Delta E^{TH} (+)$, $W (0)$, $Q (+)$
- (3) $\Delta E^{TH} (+)$, $W (0)$, $Q (-)$
- (4) $\Delta E^{TH} (-)$, $W (-)$, $Q (-)$
- (5) $\Delta E^{TH} (-)$, $W (0)$, $Q (-)$

Isochoric increase in temp			
Isochoric decrease in temp			
Isothermal expansion			
Isothermal compression			
Adiabatic expansion			
Adiabatic compression			
Isobaric expansion			
Isobaric compression			

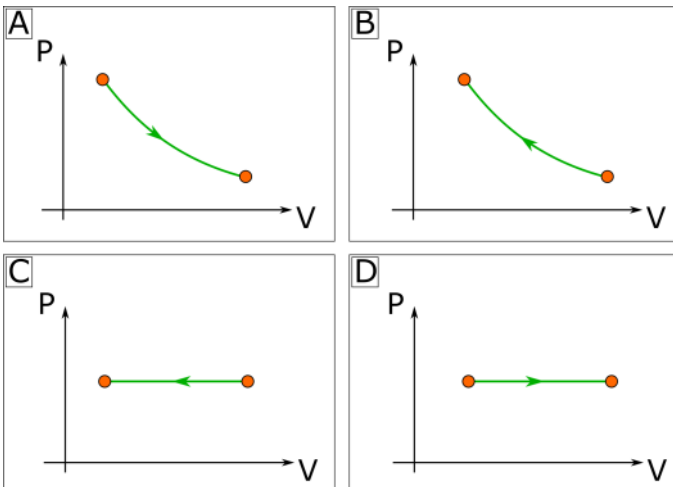
Act II: Isothermal

PC.2.L2-5:

Description: Identify which diagram represents an isothermal process. (2 minutes)

Learning Objectives: [1, 12, 13]

Problem Statement: Which of the following P-V diagrams represents an isothermal compression?



PC.2.L2-6:

Description: Proportional reasoning with ideal gas law. (2 minutes + 4 minutes)

Learning Objectives: [1, 12, 13]

Problem Statement: Consider one mole of an ideal monatomic gas that undergoes an isothermal process from one equilibrium state to another.

(a) How is the pressure related to the volume?

- (1) Linear
- (2) Quadratic
- (3) Inversely
- (4) Inverse squared
- (5) No relation

(b) The pressure starts at 400 kPa and goes to 100 kPa. If the volume started at 0.5 m^3 , what is the final volume?

PC.2.L2-7:

Description: Determine signs of first law quantities. (5 minutes)

Learning Objectives: [1, 12, 13]

Problem Statement: Which of the following are the correct signs for an isothermal compression?

- (1) ΔE^{TH} (+) , W (+) , Q (+)
- (2) ΔE^{TH} (+) , W (-) , Q (-)
- (3) ΔE^{TH} (0) , W (+) , Q (-)
- (4) ΔE^{TH} (0) , W (+) , Q (+)
- (5) ΔE^{TH} (0) , W (-) , Q (+)

Process	ΔE^{TH}	W	Q
Isochoric increase in temp			
Isochoric decrease in temp			
Isothermal expansion			
Isothermal compression			
Adiabatic expansion			
Adiabatic compression			
Isobaric expansion			
Isobaric compression			

Act III: Adiabatic

PC.2.L2-8:

Description: Identify which statements best represents an adiabatic curve on PV diagram (3 minutes)

Learning Objectives: [1, 12, 13]

Problem Statement: Which student do you agree with the most?

- (1) I think adiabatic PV lines are curvy and less steep than isotherms.
- (2) I agree that they are curvy, but they are more steep than isotherms, right?
- (3) Nah, you're both wrong, they are straight lines with a slope that depends on whether the gas is expanding or contracting.

PC.2.L2-9:

Description: Identify proportionality for adiabatic process. (3 minutes)

Learning Objectives: [1, 12, 13]

Problem Statement: Which of the following statements could be true for monatomic ideal gases that go through an adiabatic process?

- (1) Pressure is proportional to $1/V$
- (2) Pressure is proportional to $1/V^{0.5}$
- (3) Pressure is proportional to $1/V^{1.5}$
- (4) 42

PC.2.L2-10:

Description: Determine signs of first law quantities. (5 minutes)

Learning Objectives: [1, 12, 13]

Problem Statement: Which of the following are the correct signs for an adiabatic expansion?

- (1) ΔE^{TH} (+) , W (+) , Q (+)
- (2) ΔE^{TH} (0) , W (-) , Q (+)
- (3) ΔE^{TH} (-) , W (-) , Q (0)
- (4) ΔE^{TH} (+) , W (-) , Q (0)
- (5) ΔE^{TH} (+) , W (+) , Q (0)

Process	ΔE^{TH}	W	Q
Isochoric increase in temp			
Isochoric decrease in temp			
Isothermal expansion			
Isothermal compression			
Adiabatic expansion			
Adiabatic compression			
Isobaric expansion			
Isobaric compression			

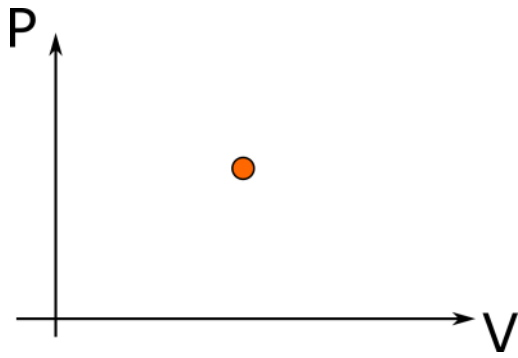
Act IV: Isobaric

PC.2.L2-11:

Description: Sketch an isobaric process. (2 minutes)

Learning Objectives: [1, 12, 13]

Problem Statement: Use the provided PV diagram and initial equilibrium state to sketch an isobaric expansion.



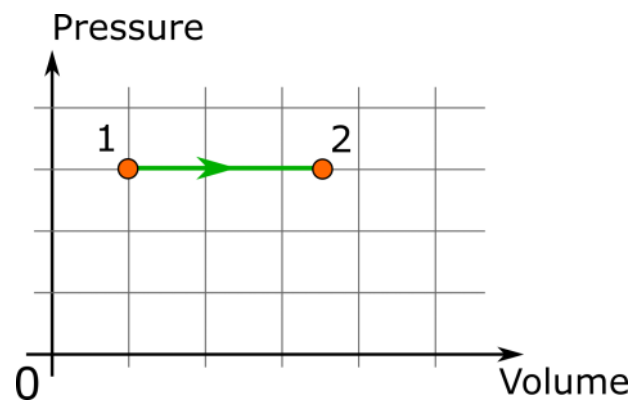
PC.2.L2-12:

Description: Proportional reasoning with ideal gas law. (4 minutes)

Learning Objectives: [1, 12, 13]

Problem Statement: Below shows an isobaric process. By what factor does the temperature change by?

- (1) $1/2.5$
- (2) $2/3$
- (3) 1
- (4) $3/2$
- (5) 2.5
- (6) $7/2$



PC.2.L2-13:

Description: Determine signs of first law quantities. (5 minutes)

Learning Objectives: [1, 12, 13]

Problem Statement: Which of the following are the correct signs for an isobaric expansion?

- (1) ΔE^{TH} (+) , W (+) , Q (+)
- (2) ΔE^{TH} (-) , W (-) , Q (+)
- (3) ΔE^{TH} (-) , W (-) , Q (-)
- (4) ΔE^{TH} (+) , W (-) , Q (+)
- (5) ΔE^{TH} (-) , W (+) , Q (-)

Process	ΔE^{TH}	W	Q
Isochoric increase in temp			
Isochoric decrease in temp			
Isothermal expansion			
Isothermal compression			
Adiabatic expansion			
Adiabatic compression			
Isobaric expansion			
Isobaric compression			

Act III: Other processes

PC.2.L2-14:

Description: Identify the process type. Proportional reasoning with ideal gas law. (2 minutes + 4 minutes + 2 minutes + 1 minute)

Learning Objectives: [1, 12, 13]

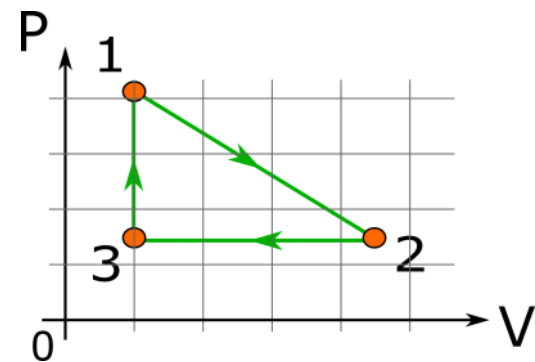
Problem Statement: Consider the PV diagram shown below with 3 processes that form a complete cycle.

(a) What type of process is represented from equilibrium states 1 \rightarrow 2 ?

- (1) Isochoric
- (2) Isothermal
- (3) Adiabatic
- (4) Isobaric
- (5) None of the above

(b) Considering the stage from 1 \rightarrow 2, by what factor does the temperature change by?

- (1) 3/8
- (2) 9/5
- (3) 27/16
- (4) 9/2

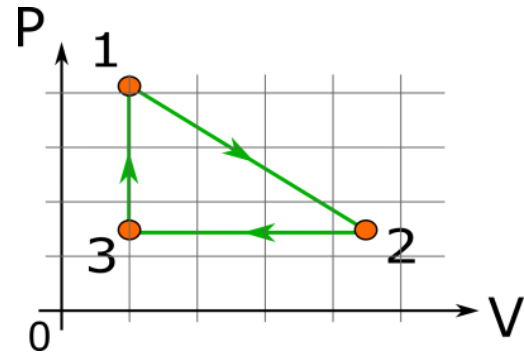


(c) What is the sign of the net work on the gas after going through all three processes sequentially?

- (1) Positive
- (2) Negative
- (3) Zero

(d) What is the sign of ΔE^{TH} of the gas after going through all three processes sequentially?

- (1) Positive
- (2) Negative
- (3) Zero



PC.2.L2-15:

Description: Determine which processes has a larger value of heat flowing into system. (2 minutes + 2 minutes + 3 minutes)

Learning Objectives: [1, 12, 13]

Problem Statement: Consider the two different processes shown on the PV diagram below.

(a) How does the change in temperature compare between process A and process B?

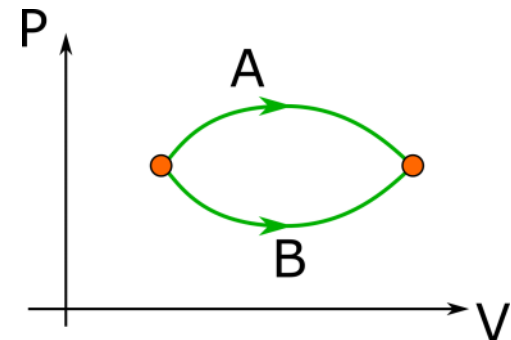
- (1) $\Delta T_A > \Delta T_B$
- (2) $\Delta T_A < \Delta T_B$
- (3) $\Delta T_A = \Delta T_B$

(b) Which process does more work on the environment?

- (1) A
- (2) B
- (3) A and B do equal work on the environment.

(c) Which processes has a larger value of heat?

- (1) $Q_A > Q_B$
- (2) $Q_A < Q_B$
- (3) $Q_A = Q_B$



Conceptual questions for discussion

1. **Coming soon.**
-

Hints

PC.2.L2-1: No hints.

PC.2.L2-2: No hints.

PC.2.L2-3: No hints.

PC.2.L2-4: No hints.

PC.2.L2-5: No hints.

PC.2.L2-6: No hints.

PC.2.L2-7: No hints.

PC.2.L2-8: No hints.

PC.2.L2-9: No hints.

PC.2.L2-10: No hints.

PC.2.L2-11: No hints.

PC.2.L2-12: No hints.

PC.2.L2-13: No hints.

PC.2.L2-14: No hints.