Outline

Equipartition of energy
Work and volume change
First Law of thermodynamics
Adiabatic expansion

Problem 8-22/23

A balloon contains 3 moles of helium at sea level where p=101 kPa. It rises to the stratosphere where p=30 kPa, while maintaining a constant 300 K temperature. How much work is done during this isothermal expansion?

How much heat flowed into the balloon from outside?

Worked Problems

18.15
18.16
18.19
18.22

DONE w/ Clickers

Final Exam
Workman 101, 1:30 pm

Grade update Friday class

Grading scheme:
http://www.physics.nmt.edu/~rsonnenf

Will attend recit.

First Law of Themodynamics

$$\Delta U = Q - W = Q - p\,dV$$

ΔU Change in internal energy (change in temperature)

Q Heat transferred TO the system

W Is work done BY the system

$\Delta U = nC_v \Delta T$ Fundamental

$\Delta Q = nC_v \Delta T$ Derived

Molar specific heats

	c (J/kg K)	M (kg/mol)	C (J/mol K)
Al	910	0.027	24.6
Cu	390	0.064	24.8
Pb	130	0.207	26.9
H20	4190	0.018	75.4
He	3120	0.004	12.5
Ar	312	0.040	12.5
H2	10000	0.002	20.4

Equipartition of energy (section 18.3)

All materials have an internal energy of

$$U_{internal} = \frac{\frac{1}{2}k_B T}{\text{degree of freedom}}$$

$$R = 8.4 \frac{J}{kg \cdot K}$$

$$R = k_B N_A$$

$$\Delta U = \frac{1}{2} d k_B N \Delta T$$

$$C_v = \frac{1}{2} d \times R$$

Figure 18.17

First Law of Themodynamics

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Figure 18.6

$\Delta V = A\Delta x$

Area A

Final piston position

Δx

Original piston position

(a)

$\Delta W = p\Delta V$ is the work done when the volume increases by ΔV . . . . . . and the work done going from V_1 to V_2 is the area under the entire curve.

p

V_1 ΔV V_2

V

(b)

Q18.2

This *pV*–diagram shows two isotherms for the same amount of an ideal gas.

Which isotherm corresponds to the *higher* temperature?

A. curve #1

B. curve #2

C. answer depends on the particular temperatures in question

D. answer depends on the particular quantity of gas

E. both C. and D. are correct

1st Law of Themodynamics -- Interp.

As ever, be careful to identify the system. Applies to all systems, but some more useful than others.

First law is really a statement of conservation of energy.

U can be temperature OR chemical (nuclear, electrical) energy
W is ALWAYS mechanical work
Q is ALWAYS heat

W is "useful" energy
Heat is either wasted, or can only be used with some limited efficiency. Heat can be conducted, radiated or convected.

Final Exam

Some clicker questions
Some HW questions
Original questions
   Goal is to demonstrate you can synthesize material (combine multiple concepts/formulae to apply to a new situation)

Crisis can be good

Allows young people to put forth new solutions.

Allows advance and growth in new directions.

Solutions to crises aren't in books. The books are written by the people who fix the crisis.

Old learning, synthesized in new ways, can (and should) inspire the solution to new crises

Education and independence of mind

Imagination is more important than knowledge.
-- Albert Einstein

He who has imagination without learning has wings
but no feet. -- Joseph Joubert

To invent, you need a good imagination and a pile of
junk. -- Thomas Edison

If you want to get laid, go to college. If you want an
education, go to the library. -- Frank Zappa

Heat Transfer
You can remove heat from an object by conduction, convection, or radiation.

conduction

$$H = \frac{\Delta Q}{\Delta t} = -kA \frac{\Delta T}{\Delta x}$$

radiation

$$P = H = \epsilon \sigma A T^4$$

$$\sigma = 5.67 \times 10^{-8} \ \frac{W}{m^2 K^4}$$