

CH365 Chemical Engineering Thermodynamics

Lesson 2 Fundamentals 2

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Work

When a force acts over a distance, work is force times displacement:

force is F and displacement is dl

Eq. 1.2

$$dW = F dl$$

positive (+) if F and dl are in the same direction

negative (-) if F and dl are in the opposite direction

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Take Notes!

Energy and Work Overview

Slide 3

$$dW = F dl = ma dl \quad \text{Eq. 1.2}$$

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Take Notes!

Heat

“Flows” from region of higher T to region of lower T

Take Notes Here!

Temperature difference is the “driving force” for the flow of energy as heat

Take Notes Here!

The driving force analogy comes from physics:

- voltage difference drives current flow in an electrical circuit
- gravitational potential drives free fall of an object
- pressure difference drives fluid flow in a horizontal pipe
- concentration difference drives molecular diffusion

Heat exists only in transit between the system and its surroundings.

Take Notes Here!

1 calorie raises the temperature of 1 gram of water 1 deg C

1 Btu raises the temperature of 1 lb_m of water 1 deg F

Take Notes Here!

Lesson 2 Problems

Problem 1.11

Liquids that boil at relatively low temperatures are often stored as liquids under their vapor pressures, which at ambient temperature can be quite large. Thus, n-butane stored as a liquid/vapor system is at a pressure of 2.581 bar for a temperature of 300 K. Large-scale storage ($>50\text{m}^3$) of this kind is sometimes done in spherical tanks. Suggest two reasons why.

Problem 1.12

The first accurate measurements of the properties of high-pressure gases were made by E.H. Amagat in France between 1869 and 1893. Before developing the dead-weight gauge, he worked in a mine shaft, and used a mercury manometer for measurements of pressure to more than 400 bar. Estimate the height of the manometer required.

Émile Hilaire Amagat (2 January 1841 – 15 February 1915) was a French physicist, famous for his work on isotherms and pressure measurement. Amagat's Law, named in his honor, states that the volume of an ideal gas mixture is equal to the sum of the component volumes of each individual component in the gas mixture at the same temperature and total pressure of the mixture

Problem 1.18

A gas is confined in a 1.25-ft-diameter cylinder by a piston, on which rests a weight. The mass of the piston and weight together is 250lb_m . The local acceleration of gravity is $32.169\text{ (ft/s}^2\text{)}$, and the atmospheric pressure is 30.12 inches of Hg.

(a) What is the force in lb_f exerted on the gas by the atmosphere, the piston, and the weight, assuming no friction between the piston and the cylinder?

(b) What is the pressure of the gas in psia?

(c) If the gas in the cylinder is heated, it expands, pushing the piston and weight upward. If the piston and weight are raised 1.7 ft, what is the work done by the gas in $\text{ft}\cdot\text{lb}_f$? What is the change in potential energy of the piston and the weight?